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Editorial

Over the past one decade the world has experienced an enormous development in technological innovation. As a part of it many new technologies have been emerged which include artificial intelligence, machine learning, deep learning, drone technology, augmented reality, virtual reality, internet of things, block chain, etc. Though these technologies are new but also include older technologies and play a vital role to create significant benefits. These technologies have gained a significant importance in today's world due to their numerous applications, benefits, analysing the data quickly with less efforts, and many more.

Machine learning and deep learning technologies can be applied in healthcare, finance, marketing, cybersecurity, autonomous vehicles, etc. Similarly, drone or unmanned aerial vehicles (UAVs) technology can be used in agriculture and forest, defence, safety inspections, construction, surveillance, express shipping and delivery, aerial photography, and many more. Augmented and virtual reality technologies provide immersive and interactive experiences, enhance learning and visualization, and enable virtual communication and collaboration have a broad application in medical, virtual meetings, entertainment, mobile, tourism, engineering and robot, are few to mention.

The S. B. Jain Institute of Technology, Management & Research, Nagpur has organized 2day International Conference on Advancement in Science, Technology and Management 2023 (ICASTM- 2023) and created a platform to invite the authors to share latest advances in technologies and their applications.

The editorial board of IJTE has identified 46 papers of ICASTM- 2023 covering engineering, management and basic sciences to publish as August 2023 special issue. We believe that Vol. 46, August 2023 special issue of IJTE will be useful to the readers to enhance and update their knowledge.

New Delhi **Editor**

31st August 2023

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Caputo-Fabrizio Fractional Analysis in the Generalized Thermoelastic Problem of a Thick Circular Plate

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ABSTRACT

In this article, the generalised thermoelastic problem of an axisymmetric thick circular plate with height 2h in the framework of fractional order theory is taken into account. A circular plate is defined in the range $0 \leq r \leq \infty$, $-h \leq z \leq h$. The governing equations of heat conduction involve Caputo-Fabrizio fraction derivatives. To find the response in the transformed domain, Laplace and Hankel transforms are used. To invert the Laplace transform of the solutions, the Gaver- Stehfast approach to numerical inversion is used. Graphical representations of all the outcomes are shown for temperature, displacement, and stress.

KEYWORDS: *Thick circular plate, Caputo-Fabrizio derivative, Temperature, Stress, Fractional thermoelasticity, Integral transform*

INTRODUCTION

Studies on thermoelasticity incorporate both the equation for heat conduction and the science of elasticity. It should be noted that the classical theory of thermoelasticity presents a phenomenon rather than the actual physical characteristics of the medium and is an uncoupled illustration of thermoelasticity. The thermal equation has a parabolic form in classical theory and projects infinite heat wave propagation velocities. Several non-classical hypotheses have been put forward during the past few years to address these issues. These theories first present a modified version of the conventional using hyperbolic heat transport equations and Fourier's law of heat conduction that take into account thermal pulses with finite velocities. Additionally, each generalization of heat conduction resulted in formation of a generalised thermoelasticity theory. There are a few books by renowned authors like Biot [1], Shulman [2], Green & Lindsay [3], Suhubi [4], Dhaliwal and Sherief [5], Chandrasekariah [6], and Hetnarski and Ignaczak [7] that deeply describe the concept of generalised thermoelasticity.

Youssef [8, 9, 10, and 11] developed the problem of generalised thermoelasticity for a cylinder under the action of a moving heat source by adopting state-space two-temperature approaches. Zenkour [12, 13, 14, and 15] respectively discussed generalised thermoelastic problems without energy dissipation for beam and cylinder under thermal shock and variable thermal conductivity and found plane wave propogation thermoelastic semiconducting half space. Lamba [16] determines the stress function in a temperature-dependent FGM cylinder by the integral transform method. Recently, Lamba and Deshmukh [17, 18] and Verma et al. [19] analysed the memory hygrothermal effect by considering a cylindrical body.

Ezzat and Karamany [20, 21, and 22] investigated the memory problem in generalized thermoelasticity for two temperatures. Kant and Mukhopadhyay [23, 24] studied heat conduction response and evaluated coupled thermoelastic response in axisymmetric problems. Kaur and Singh [25, 26] analysed the nano-beam problem with varying thermal conductivity and examined transverse vibration.

Caputo and Fabrizio differential operator

Following Caputo and Fabrizio [27], the differential operator for an absolutely continuous function F (t) defined as

$$ {}_0^{CF}D^{(\alpha)}F(t)=\frac{1}{1-\alpha}\int_0^t F'(t)\exp\left(-\alpha\frac{(t-\tau)}{1-\alpha}\right)d\tau, \qquad 0\le\alpha\le 1 \tag{1}$$

The above-described Caputo and Fabrizio definition has a nonsingular kernel.

Problem Formulation

Let us consider a generalised thermoelastic problem: an axisymmetric thick circular plate of height 2h defined in the range $0 \le r \le \infty$, $-h \le z \le h$. Further, it is considered that the z-axis, as an axis of symmetry and coordinate system, lies in the middle of the plane between the faces of the top and lower plates. The coordinates of the cylinder are used to express the system of equations under consideration. All the quantities in this problem are independent of coordinate φ because of the assumption that rotation is symmetric about the axis. Thus, displacement vector functions as $\vec{u}=(U,0,W)$..

The following are the motion equations:

$$\mu\nabla^2 U-\frac{\mu}{r^2}U+(\lambda+\mu)\frac{\partial e}{\partial r}-\gamma\frac{\partial T}{\partial r}=\rho\frac{\partial^2 U}{\partial t^2} \tag{2}$$

$$\mu\nabla^2 W+(\lambda+\mu)\frac{\partial e}{\partial z}-\gamma\frac{\partial T}{\partial z}=\rho\frac{\partial^2 W}{\partial t^2} \tag{3}$$

The cubical dilatation e expressed as

$$e=\frac{1}{r}\frac{\partial}{\partial r}(rU)+\frac{\partial W}{\partial z} \tag{4}$$

The equation of heat conduction in absence of thermoelastic diffusion has the form

$$k\nabla^2 T=\left(\frac{\partial}{\partial t}+\tau_0\frac{\partial^{1+\alpha}}{\partial t^{1+\alpha}}\right)(\rho C_E T+\gamma T_0 e) \tag{5}$$

Where the Laplacian operator is as below

$$\nabla^2=\frac{\partial^2}{\partial r^2}+\frac{1}{r}\frac{\partial}{\partial r}+\frac{\partial}{\partial z}$$

where thermal conductivity is denoted by k, τ_0 is a constant denotes as a relaxation time, C_E refers for specific heat at constant strain, T denotes the absolute temperature distribution function, T_0 is the medium temperature such as $(|T-T_0)/T|<<1$ and $\gamma=(3\lambda+2\mu)\alpha_t$ is the material constant.

The other constitutive relations are as follows

$$\sigma_{rr}=2\mu\frac{\partial U}{\partial r}-\gamma(T-T_0)+\lambda e \tag{6}$$

$$\sigma_{zz}=2\mu\frac{\partial W}{\partial z}-\gamma(T-T_0)+\lambda e \tag{7}$$

$$\sigma_{rz}=\mu\left(\frac{\partial U}{\partial z}+\frac{\partial W}{\partial r}\right) \tag{8}$$

where,σ_{ij} denotes the stress functions, U is the radial displacement component and W is the axial displacement component.

The following non-dimensional variable can be added to the system of governing equations to simplify it:

$$r'=d\chi r \qquad z'=d\chi z, \qquad U'=d\chi U, \qquad W'=d\chi W,$$
$$t'=d^2\chi t, \qquad \tau_0'=d^2\chi\tau_0, \qquad \sigma_{ij}'=\frac{\sigma_{ij}}{\mu}, \qquad \theta=\frac{\gamma(T-T_0)}{(\lambda+2\mu)},$$
$$\chi=\frac{\rho c_E}{k}, \qquad d=\sqrt{\frac{\lambda+2\mu}{\rho}}, \qquad \beta^2=\frac{\lambda+2\mu}{\mu}$$

here d denotes the elastic waves propagation speed.

Utilizing the above non-dimensional variables, the equations (2) to (5) rewritten below, where we have conveniently dropped the primes

$$\nabla^2 U-\frac{U}{r^2}+(\beta^2-1)e-\beta^2\frac{\partial\theta}{\partial r}=\beta^2\frac{\partial^2 U}{\partial t^2} \tag{9}$$

$$\nabla^2 W+(\beta^2-1)\frac{\partial e}{\partial z}-\beta^2\frac{\partial\theta}{\partial z}=\beta^2\frac{\partial^2 W}{\partial t^2} \tag{10}$$

$$\nabla^2\theta=\left(\frac{\partial}{\partial t}+\tau_0\frac{\partial^{1+\alpha}}{\partial t^{1+\alpha}}\right)(\theta+\varepsilon e) \tag{11}$$

Also, the constitutive relations (6) to (8) takes the form

$$\sigma_{rr}=2\frac{\partial U}{\partial r}+(\beta^2-2)e-\beta^2\theta \tag{12}$$

$$\sigma_{zz}=2\frac{\partial W}{\partial z}+(\beta^2-2)e-\beta^2\theta \tag{13}$$

$$\sigma_{rz}=\left(\frac{\partial U}{\partial z}+\frac{\partial W}{\partial r}\right) \tag{14}$$

On combining eqns. (12) and (13) and using it in eqn. (4) as

$$\nabla^2 e - \nabla^2 \theta = \frac{\partial^2 e}{\partial t^2} \tag{15}$$

The initial medium is assumed to be quiescent, that is, the problem's beginning conditions are all uniform.

The corresponding boundaries are fixed as

$$\theta\}_{z=-h} = 0 \;;\; \theta\}_{z=h} = f(r,t) \tag{16}$$

$$\sigma_{zz}\}_{z=-h} = 0 \,,\, \sigma_{zz}\}_{z=h} = f(r,t) \tag{17}$$

Solution of the problem

We define the Laplace transform as follows to arrive at a solution to the aforementioned issue in the integral transform domain:

$$L\left[\theta(t)\right] = \bar{\theta}(s) = \int_0^\infty e^{-st}\theta(t)\,dt \tag{18}$$

Also, the Laplace transform of the Caputo and Fabrizio derivatives as in equation (1) is stated as

$$L\left[{}^{CF}_{0}D^{(\alpha)} f(t)\right] = \frac{\partial^\alpha f}{\partial t^\alpha} = \frac{sL[f(t)] - f(0)}{s + \alpha(1-s)} \tag{19}$$

Taking the Laplace transform of equations (9) to (17) consecutively by using equations (18) and (19), we obtain

$$\nabla^2 \bar{U} - \frac{\bar{U}}{r^2} + (\beta^2 - 1)\bar{e} - \beta^2 \frac{\partial \bar{\theta}}{\partial r} = \beta^2 s^2 \bar{U} \tag{20}$$

$$\nabla^2 \bar{W} + (\beta^2 - 1)\frac{\partial \bar{e}}{\partial z} - \beta^2 \frac{\partial \bar{\theta}}{\partial z} = \beta^2 s^2 \bar{W} \tag{21}$$

$$\left[1 + \frac{\tau_0 s}{s + (1-s)\alpha}\right]\bar{\theta} = s\varepsilon\left[1 + \frac{\tau_0 s}{s + (1-s)\alpha}\right]\bar{e} \tag{22}$$

$$(\nabla^2 - s^2)\bar{e} = \nabla^2 \bar{\theta} \tag{23}$$

$$\bar{\sigma}_{rr} = 2\frac{\partial \bar{U}}{\partial r} + (\beta^2 - 2)\bar{e} - \beta^2 \bar{\theta} \tag{24}$$

$$\bar{\sigma}_{zz} = 2\frac{\partial \bar{W}}{\partial z} + (\beta^2 - 2)\bar{e} - \beta^2 \bar{\theta} \tag{25}$$

$$\bar{\sigma}_{rz} = \left(\frac{\partial \bar{U}}{\partial z} + \frac{\partial \bar{W}}{\partial r}\right) \tag{26}$$

Also, conditions (16) and (17) in the transform domain are taken as

$$\bar{\theta}\}_{z=-h} = 0 \;;\; \bar{\theta}\}_{z=h} = \bar{f}(r,s) \tag{27}$$

$$\bar{\sigma}_{zz}\}_{z=-h} = 0 \,,\, \bar{\sigma}_{zz}\}_{z=h} = f(r,s) \tag{28}$$

On removing $\bar{e}$ between the equations (22) and (23), we get

$$\left\{\nabla^4 - \nabla^2\left(s^2 + s\left[1 + \frac{\tau_0 s}{s + (1-s)\alpha}\right](1+\varepsilon)\right) + s^3\left[1 + \frac{\tau_0 s}{s + (1-s)\alpha}\right]\right\}\bar{\theta} = 0 \tag{29}$$

The above eqn. (29) can be written in factorized form as

$$\left\{(\nabla^2 - k_1^2)(\nabla^2 - k_2^2)\right\}\bar{\theta} = 0 \tag{30}$$

where k^2_1 and k^2_2 denotes for the characteristic equation's roots

$$\left\{k^4 - k^2\left(s^2 + s\left[1 + \frac{\tau_0 s}{s + (1-s)\alpha}\right](1+\varepsilon)\right) + s^3\left[1 + \frac{\tau_0 s}{s + (1-s)\alpha}\right]\right\}\bar{\theta} = 0 \tag{31}$$

The complete solution of eqn. (32) can be expressed as,

$$\bar{\theta} = \bar{\theta}_1 + \bar{\theta}_2 \tag{32}$$

Where $\bar{\theta}_i$ denotes the homogeneous equation's solution,

$$(\nabla^2 - k_1^2)\bar{\theta}_i = 0 \quad ; i = 1,2 \tag{33}$$

To find the integral of eqn. (32), we define the Hankel transformation and its inversion with respect to the variable r as follows:

$$\bar{\theta}^*(\eta) = H\left[\bar{\theta}(r)\right] = \int_0^\infty \bar{\theta}(r)\, r\, J_0(\eta r)\,dr \tag{34}$$

where first kind Bessel's function of order zero is denoted by J_0

$$\bar{\theta}(r,z,s) = H^{-1}\left[\bar{\theta}^*(\eta,z,s)\right] = \int_0^\infty \bar{\theta}^*(\eta,z,s)\,\eta\, J_0(\eta r)\,d\eta \tag{35}$$

Applying the transform defined in eqn. (34) to eqn. (33), we get

$$\left\{D^2 - (k_1^2 + \eta^2)\right\}\bar{\theta}_i^* = 0 \quad ; i = 1,2 \;,\; D = \frac{\partial}{\partial z} \tag{36}$$

Equation (36)'s solution is represented as,

$$\bar{\theta}_i^* = A_i(\eta,s)\left(k_i^2 - s^2\right)\cosh\left(q_i z\right) \quad (37)$$

Where $q_i = \sqrt{\eta^2 + k_i^2}$

The entire response in the modified domain can be expressed as

$$\bar{\theta}^*(\eta,z,s) = \sum_{i=1}^{2} A_i(\eta,s)\left(k_i^2 - s^2\right)\cosh\left(q_i z\right) \quad (38)$$

Using (35), the inverse transform of above eqn. (38) becomes,

$$\bar{\theta}(r,z,s) = \int_0^\infty \left\{\sum_{i=1}^{2} A_i(\eta,s)\left(k_i^2 - s^2\right)\cosh\left(q_i z\right)\right\}\eta J_0(\eta r)d\eta \quad (39)$$

Eliminating $\bar{\theta}$ similarly from equations (22) and (23), we obtain

$$\left\{\left(\nabla^2 - k_1^2\right)\left(\nabla^2 - k_2^2\right)\right\}\bar{e} = 0 \quad (40)$$

Using transform defined in (34) to above eqn. (40), we get,

$$\left\{\left(D^2 - q_1^2\right)\left(D^2 - q_2^2\right)\right\}\bar{e}^* = 0 \quad (41)$$

On simplifying eqn. (41) one obtains

$$\bar{e}^*(\eta,z,s) = \sum_{i=1}^{2} A_i(\eta,s)\, k_i^2 \cosh\left(q_i z\right) \quad (42)$$

On taking transform inversion of eqn. (42) by using (35), we get,

$$\bar{e}(\eta,z,s) = \int_0^\infty \left\{\sum_{i=1}^{2} A_i(\eta,s)\, k_i^2 \cosh\left(q_i z\right)\right\}\eta J_0(\eta r)d\eta \quad (43)$$

Similarly applying the integral defined in eqn. (34) to the eqn. (21) and using (38) and (42), we obtain

$$\bar{W}^*(\eta,z,s) = B(\eta,s)\sinh q_3 z + \sum_{i=1}^{2} A_i(\eta,s)\, q_i \sinh\left(q_i z\right) \quad (44)$$

$$q_3 = \sqrt{\eta^2 + \beta^2 s^2}$$

On inverting the Hankel transform of above eqn. we get,

$$\bar{W}(\eta,z,s) = \int_0^\infty \left\{B(\eta,s)\times\sinh q_3 z + \sum_{i=1}^{2} A_i(\eta,s)\times q_i \sinh\left(q_i z\right)\right\}\eta J_0(\eta r)d\eta \quad (45)$$

Next, applying both sides of the equation (4) with the Hankel and Laplace transform theory and utilizing eqns. (41), (43), we get,

$$H\left(\frac{1}{r}\frac{\partial}{\partial r}\left(r\bar{U}\right)\right) = -B(\eta,s)q_3\cosh q_3 z - \eta^2\left[\sum_{i=1}^{2} A_i(\eta,s)\cosh\left(q_i z\right)\right] \quad (46)$$

On inverting the Hankel transform of above eqn. we get,

$$\bar{U} = \int_0^\infty \left\{-B(\eta,s)\times q_3\cosh q_3 z - \eta^2\left[\sum_{i=1}^{2} A_i(\eta,s)\times\cosh\left(q_i z\right)\right]\right\}J_1(\eta r)d\eta \quad (47)$$

On substituting (43), (45) and (47) in (25) and (24) stress tensor components becomes

$$\bar{\sigma}_{zz} = \int_0^\infty \left\{2B(\eta,s)q_3\cosh q_3 z + (\eta^2 + q_3^2)\left[\sum_{i=1}^{2} A_i(\eta,s)\times\cosh\left(q_i z\right)\right]\right\}\eta J_0(\eta r)d\eta \quad (48)$$

$$\bar{\sigma}_{rz} = \int_0^\infty \left\{-(\eta^2 + q_3^2)B(\eta,s)\cosh q_3 z - 2\alpha^2\left[\sum_{i=1}^{2} A_i(\eta,s)\times q_i\sinh\left(q_i z\right)\right]\right\}J_1(\eta r)d\eta \quad (49)$$

The boundary conditions (27) and (28) under Hankel transform, become,

$$\bar{\theta}^*\Big\}_{z=-h} = 0 \;;\; \bar{\theta}^*\Big\}_{z=h} = \bar{f}(\eta,s) \quad (50)$$

$$\bar{\sigma}_{zz}^*\Big\}_{z=-h} = 0 \;,\; \bar{\sigma}_{zz}^*\Big\}_{z=h} = f(\eta,s) \quad (51)$$

The unknown parameters are determined by using the boundary conditions (50) and (51) and the results are as follows:

$$\sum_{i=1}^{2} A_i(\eta,s)\left(k_i^2 - s^2\right)\cosh\left(q_i h\right) = \bar{f}^*(\eta,s) \quad (52)$$

$$\left(\eta^2 + q_3^2\right)\sum_{i=1}^{2} A_i(\eta,s)\cosh\left(q_i h\right) - 2B(\eta,s)q_3\cosh q_3 h = 0 \quad (53)$$

$$2\eta^2\sum_{i=1}^{2} A_i(\eta,s)\, q_i\sinh\left(q_i h\right) + (\eta^2 + q_3^2)B(\eta,s)\cosh q_3 h = 0 \quad (54)$$

Inversion method for double transformation

Because analyzing the analytical inversion of the Laplace transform is difficult, a well-known Gaver-Stehfast algorithm [28–32] is utilized numerically for the inversion process. These parts of the programme are made using MATLAB mathematical software.

Numerical evaluation of results with discussion

In order to perform numerical calculations, copper material properties are considered to have the following physical properties:

$k = 386\,J\,K^{-1}m^{-1}s^{-1}$, $\alpha_t = 1.78\times10^{-5}\,K^{-1}$,
$\mu = 3.86\times10^{10}\,N\,m^{-2}$, $\lambda = 7.76\times10^{10}\,N\,m^{-2}$,
$T_0 = 293\,K$, $\varepsilon = 0.0168\,N\,m\,J^{-1}$,
$\beta^2 = 4$, $a = 1$,

$C_E = 383.1 J\,Kg^{-1}K^{-1}$, $\mu = 3.86\times10^{10} N\,m^{-2}$,
$\rho = 8954\,Kg\,m^{-3}$, $\tau_0 = 0.5s$,
$c_1 = 4.158\times10^{3}\,m\,s^{-1}$, $\psi = 8886.73\,s\,m^{-2}$,
$b = 1$, $\theta_0 = 1$

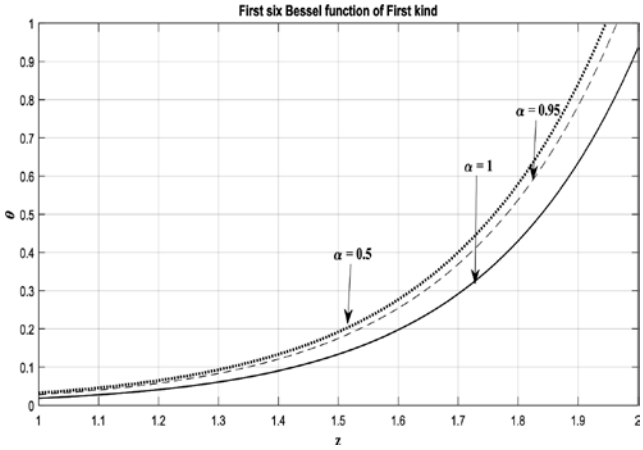

Fig. 1: The temperature pattern for different fractional parameters along thickness

The pattern of temperature distribution is depicted in Fig. 1. along the thickness direction for different fractional parameters. From the plotting, it can be seen that temperature increases when moving from the thick cylindrical body's upper face to its lower face. Also, fractional parameters were found to be inversely proportional to the temperature function, i.e., for small fractional parameters, a large distribution in the temperature function was observed. Overall, a uniform distribution of temperature flow is noted across the thickness direction.

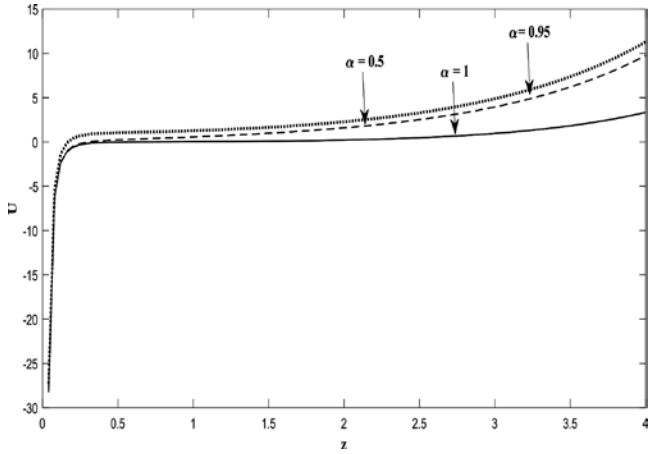

Fig. 2: Radial displacement along thickness for various fractional parameters

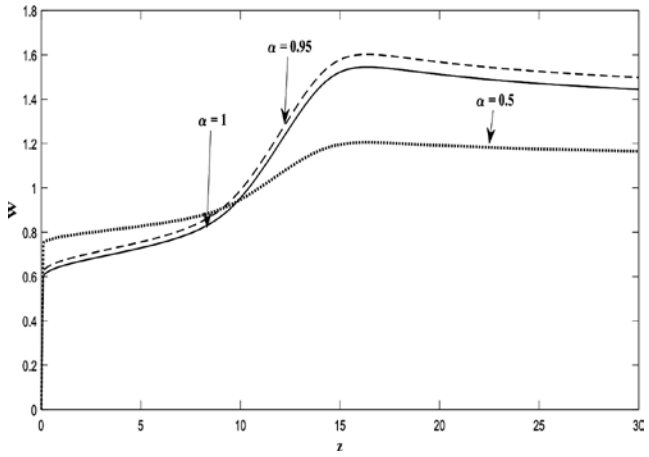

Fig. 3: Axial displacement along thickness for various fractional parameters

Figs. 2 and 3, respectively, show the radial and axial displacement distribution along the thickness direction for different fractional parameters. From the plotting, it can be seen that initially radial displacement increases rapidly in the range $0 \le z \le 0.5$ and becomes smooth afterward, whereas axil displacement fluctuates in $0.5 \le z \le 1$ on moving from the thick cylindrical body's upper face to its lower face. Also, fractional parameters were found to be inversely proportional to the temperature function, i.e., for small fractional parameters, a large distribution in the temperature function was observed. A non-uniform distribution pattern of displacement variation is noted, and a significant discrimination in the curve is obtained for different fractional parameters.

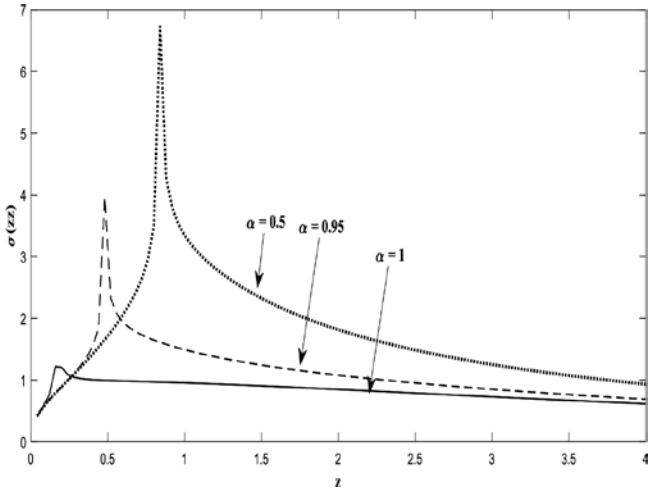

Figure 4: Axial stress pattern for different fractional parameters along thickness

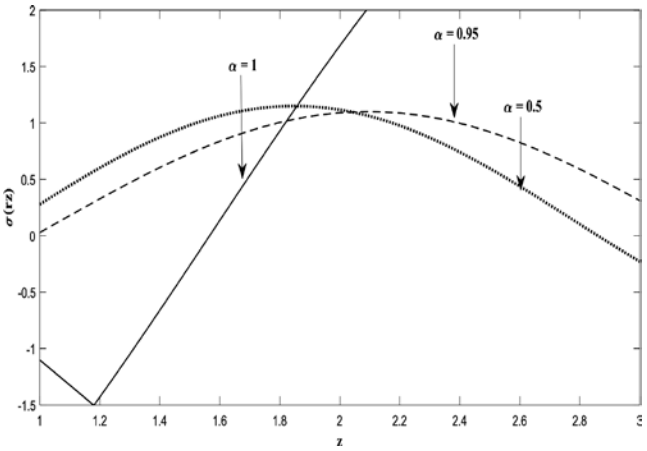

Figure 5: Shear stress pattern for different fractional parameters along thickness

Figs. 4 and 5, respectively, show the axial and shear stress distribution along thickness directions for different fractional parameters. From the plotting, it can be seen that initially, axial stress increases rapidly, near the top surface, where it peaks, and further decreases gradually towards the lower surface. Shear stress distribution follows a non-uniform pattern for different fraction parameters. For small values of fractional parameters, a large distribution of stresses is obtained.

CONCLUSION

The fractional order theory framework is used to resolve the thick circular plate with height 2h under generalized thermo elasticity. The equations that regulate heat conduction with Caputo- Fabrizio fraction derivatives are evaluated analytically by the Laplace and Hankel transform technique. In regard to the Laplace transform's numerical inversion, the Gaver-Stehfast method is adopted. All of the outcomes in terms of temperature and stress are represented graphically for conductivity. A strong distribution effect is noted for various values of fractional parameters. Hence, the above-discussed results may be useful to study conducting materials used for thermoelastic modelling; this describes a new class of relevant materials and is helpful in various structural designs.

REFERENCES

1. Biot M., 1956, Thermoelasticity and irreversible thermodynamics, Journal of Applied Physics 27: 240-253.
2. Lord H., Shulman Y., 1967, A generalized dynamical theory of thermo-elasticity, Journal of the Mechanics and Physics of Solids 15: 299-309.
3. Green A. E., Lindsay K. A., 1972, Thermoelasticity, Journal of Elasticity 2: 1-7.
4. Suhubi E., 1975, Thermoelastic Solids, Academic Press, New York.
5. Dhaliwal R. S., Sherief H., 1980, Generalized thermoelasticity for anisotropic media, Quarterly of Applied Mathematics 33: 1-8.
6. Chandrasekariah D. S., 1986, Thermoelasticity with second sound: a review, Applied Mechanics Review 39: 355-376.
7. Hetnarski R. B., Ignaczak J., 1999, Generalized thermoelasticity, Journal of Thermal Stresses 22: 451-476.
8. H. M. Youssef, Generalized thermoelastic infinite medium with cylindrical cavity subjected to moving heat source, Mechanics Research Communications, vol. 36, pp. 487–496, 2009.
9. H. M. Youssef, State-Space Approach of Two-Temperature Generalized Thermoelastic Medium Subjected to Moving Heat Source and Ramp-Type Heating, Journal of Mechanics of Materials and Structures, vol. 4, No. 9, pp. 1637-1649, 2009.
10. H. M. Youssef, Two-Temperature Generalized Thermoelastic Infinite Medium with Cylindrical Cavity Subjected to Moving Heat Source, J. Archive of Applied Mechanics, vol. 80, 1213–1224, 2010.
11. H. M. Youssef, Generalized thermoelastic infinite medium with spherical cavity subjected to moving heat source, J. Computational Mathematics and Modeling, vol. 21(2), pp. 212-227, 2010.
12. Zenkour, A. M., Nonlocal thermoelasticity theory without energy dissipation for nano- machined beam resonators subjected to various boundary conditions, Microsystem Technologies, 23, 55–65, 2017.
13. Zenkour, A.M., Generalized thermoelasticity theories for axisymmetric hollow cylinders under thermal shock with variable thermal conductivity, Journal of Molecular and Engineering Materials, 6, 1850006, 2018.
14. Zenkour, A.M., Refined micro temperatures multi-phase lags theory for plane wave propagation in thermoelastic medium, Results in Physics, 11, 929–937, 2018.

15. Zenkour, A. M., Refined multi-phase-lags theory for photo thermal waves of a gravitated semiconducting half-space, Composite Structures, 212, 346–364, 2019.

16. Lamba, N. K., Thermosensitive response of a functionally graded cylinder with fractional order derivative, International Journal of Applied Mechanics and Engineering 27. (2022), 107- 124.

17. Lamba, N.K. and Deshmukh, K.C. (2020), "Hygrothermoelastic response of a finite solid circular cylinder", Multidiscipline Modeling in Materials and Structures, Vol. 16 No. 1, pp. 37- 52. https://doi.org/10.1108/MMMS-12-2018-0207

18. N. K. Lamba and K. C. Deshmukh.: Hygrothermoelastic response of a finite hollow circular cylinder, Waves in Random and Complex Media, DOI: 10.1080/17455030 .2022.2030501,(2022)

19. Verma, J., Lamba, N.K. and Deshmukh, K.C. (2022), "Memory impact of hygrothermal effect in a hollow cylinder by theory of uncoupled-coupled heat and moisture", Multidiscipline Modeling in Materials and Structures, Vol. 18 No. 5, pp. 826-844. https://doi.org/10.1108/MMMS-06-2022-0117

20. Ezzat MA, El-Karamany AS, El-Bary AA (2014) Generalized thermo-viscoelasticity with memory-dependent derivatives. Int J Mech Sci 89:470–475. https://doi.org/10.1016/j.ijmecsci. 2014.10.006 22.

21. Ezzat MA, El-Karamany AS, El-Bary AA (2015) A novel magnetothermoelasticity theory with memory-dependent derivative. J Electromagn Waves Appl 29:1018–1031. https://doi.org/10.1080/09205071.2015.1027795 23.

22. Ezzat MA, El-Karamany AS, El-Bary AA (2016) Generalized thermoelasticity with memory-dependent derivatives involving two temperatures. Mech Adv Mater Struct 23:545–553. https://doi. org/10.1080/153 76494.2015.1007189

23. Kant S, Mukhopadhyay S (2017) A detailed comparative study on responses of four heat conduction models for an axisymmetric problem of coupled thermoelastic interactions inside a thick plate. Int J Therm Sci 117:196–211. https://doi.org/10. 1016/j. ijthermalsci.2017.03.018 6.

24. Kant S, Mukhopadhyay S (2019) An investigation on responses of thermoelastic interactions in a generalized thermoelasticity with memory-dependent derivatives inside a thick plate. Math Mech Solids 24:2392–2409. https://doi.org/10.1177/10812 86518755562

25. Kaur I, Singh K (2021) Effect of memory dependent derivative and variable thermal conductivity in cantilever nano-beam with forced transverse vibrations. Forces Mech 5:100043. https://doi. org/10.1016/j. fnmec.2021.100043 17.

26. Kaur I, Singh K (2022) Functionally graded nonlocal thermoelastic nanobeam with memory-dependent derivatives. SN Appl Sci 4:329. https://doi.org/10.1007/s42452-022-05212-8

27. M. Caputo and M. Fabrizio, "A new definition of fractional derivative without singular kernel," Progr. Fract. Differ. Appl., vol. 1, no. 2, pp. 73–85, Feb. 2015. DOI: 10.12785/pfda/010201

28. D. P. Gaver, Observing Stochastic processes and approximate transform inversion," Operations Res., 14, 444-459, 1966.

29. H. Stehfast, Algorithm 368: Numerical inversion of Laplace transforms," Comm. Ass'n. Comp. Mach., 1970, 13, 47-49, 1970.

30. H. Stehfast, Remark on algorithm 368, Numerical inversion of Laplace transforms", Comm. Ass'n. Comp., 13, 624, 1970.

31. J. H. Knight and A. P. Raiche, Transient electromagnetic calculations using the Gaver- Stehfest inverse Laplace transform method. Geophysics, 47(1), pp. 47–50, 1982.

32. W. H. Press , B. P. Flannery, S. A. Teukolsky and W. T. Vetterling, Numerical Recipes, Cambridge University Press, Cambridge, the art of scientific computing ,1986.

Comparative Analysis of G+5 Storey Building with and without Floating Column: A Structural Evaluation

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ABSTRACT

This study focuses on investigating the influence of floating columns on the structural behavior of buildings with intricate designs, particularly those featuring floating columns on multiple floors. Floating columns, which lack a rigid foundation and rely on direct support from beams, are often utilized to accommodate functional needs such as parking areas or reception lobbies. However, they can significantly alter the stiffness and load-carrying capacity of the building, particularly during seismic events. The study compares the performance of a building with and without floating columns when subjected to seismic excitation, examining crucial structural parameters such as horizontal displacement, storey drift, and storey shear. The results indicate that buildings incorporating floating columns are highly susceptible to earthquake-induced damage. Therefore, caution should be exercised when integrating floating columns into building designs within regions prone to seismic activity.

KEYWORDS *: G+5 building, Floating column, Structural analysis, Seismic resistance, Building stability*

INTRODUCTION

Multistory buildings, also known as high-rise buildings, are increasingly becoming popular in urban areas as a solution to the growing need for more space [1]. These buildings are typically characterized by their tall structures and multiple floors, and are designed to accommodate a large number of occupants. They are commonly used for commercial, residential, or mixed-use purposes, and often require specialized engineering and construction techniques to ensure their stability and safety. The design and construction of multistory buildings require careful consideration of various factors such as load-bearing capacity, wind and seismic forces, and building materials to ensure their structural integrity and resilience [2].

During an earthquake, a building undergoes dynamic forces that can cause significant damage or even collapse [3]. The response of a building under earthquake depend on several aspects, such as the building's elevation, weight, foundation type, and the intensity and duration of the earthquake [4]. If a definite storey of a building has fewer columns and walls, it can be more vulnerable to forces acting during an earthquake. The columns and walls provide the building with stability and resistance to lateral forces, such as those generated by seismic waves [5]. In the absence of sufficient columns and walls, the building may experience greater displacement, shear forces, and bending moments, which can lead to structural damage and collapse. To ensure the safety of buildings during earthquakes, building codes and standards have been established to provide guidelines for the construction and design of buildings in seismic zones [6]. These codes and standards require buildings to be designed and constructed to withstand specific seismic forces and to include adequate structural

elements, such as columns and walls, to resist lateral forces [7].

Floating columns are a structural element used in the construction of multistory buildings to enhance their seismic resistance and stability [8]. These columns are designed to transfer the load of the upper floors to the foundation through a compression spring or other devices. The column is suspended above the foundation and does not rest on it, allowing for greater flexibility and reducing the forces acting on the foundation during an earthquake. The use of floating columns has been shown to reduce the amount of structural damage caused by seismic forces during earthquakes [9]. In multistory buildings, the seismic forces acting on the foundation can cause significant damage, leading to the collapse of the structure [10]. The use of floating columns reduces the seismic forces acting on the foundation, which increases the overall stability of the building and prevents collapse. However, the design and construction of floating columns require careful consideration to ensure their effectiveness and safety. Improper design and construction can lead to adverse effects on the building's structural integrity, which can compromise its safety during earthquakes. Additionally, the use of floating columns can increase construction costs and limit the available space on lower floors [11].

The use of floating columns in multistory buildings to improve their seismic performance has been a topic of interest for many researchers. This literature review seeks to offer a comprehensive summary of the research carried out in the field pertaining to the effectiveness of floating columns in improving the seismic resilience of multi-story buildings. Several studies have been conducted to explore this subject and evaluate the impact of floating columns in mitigating seismic forces. In a study by Rai [12], a 10-story building was examined, and the findings demonstrated that the incorporation of floating columns resulted in a significant reduction in lateral displacement and base shear during seismic events. Similarly, Gharebaghi [13] conducted a numerical analysis on a 15-story building, revealing an improvement in its seismic performance due to the utilization of floating columns. The behavior of floating columns under different loading conditions has also been investigated by other researchers. For instance, Mourya et al. [14] conducted an experimental study on a 6-story building, observing that the implementation of floating columns reduced the seismic forces exerted on the foundation. Kanitkar et al. [15] conducted a study on a 5-story building and concluded that floating columns provided enhanced stiffness and strength during earthquakes. Extensive research has been conducted on the design and construction aspects of floating columns as well. Abildinov et al. [16] investigated a 12- story building and emphasized the criticality of proper detailing and reinforcement to ensure the effectiveness of floating columns. Liu et al. [17], in a study on a 9-story building, recommended optimizing the spacing and arrangement of floating columns for optimal performance. Cost-effectiveness studies have also been conducted to evaluate the use of floating columns in multi-story buildings. Tao et al. [18] examined a 7-story building and found that incorporating floating columns resulted in reduced construction and maintenance costs in the long term. Similarly, Coughlin [19] conducted a cost-benefit analysis and concluded that the utilization of floating columns proved to be cost-effective for a 10-story building. However, it is important to consider potential drawbacks and limitations associated with floating columns. Dang et al. [20] identified an increase in differential settlement as a potential concern, which could impact the overall stability of the building. Additionally, the presence of floating columns may introduce complex load transfer mechanisms that require meticulous design and detailing to ensure their effectiveness.

This research study aims to examine and compare the seismic performance of reinforced concrete (RC) buildings with and without floating columns. Specifically, the focus will be on analyzing the response of the buildings when subjected to earthquake loads. The investigation will involve studying the behavior of RC buildings with floating columns positioned inward and at the corners of the structure. The primary objectives of the study include assessing the lateral displacement, storey drift, and storey shear of the buildings using ETABS software. By comparing the performance of the two building types, the research aims to determine the effectiveness of employing floating columns in improving the seismic resilience of multistory buildings. Additionally, the study will explore the behavior of the buildings under varying seismic intensities and loading conditions.

MODELLING OF BUILDING

This research study aims to assess the seismic behavior of a typical G + 5 reinforced concrete (RC) building with dimensions of 15m x 15m in seismic Zone II and IV according to the IS 1893-2016 code. The study involves developing two distinct models of the building: one incorporating floating columns and the other without. The ETABS software, renowned for its application in structural analysis and design, is utilized to create these models. The research evaluates and compares the performance of the building under various seismic intensities and loading scenarios for both models.

Table 1: Details of models 1 and 2

Sr. No.	Case for building	Nomenclature
1	With no floating column	Model 1
2	With floating column	Model 2

Table 2 shows the geometric details of the building including building dimensions, material properties, member properties and the type of load acting over the structure.

Table 2: Geometric details of the building

Building Dimension Proceeding		
a	No. of storeys	6 (G+5)
b	Height of each storey	3.0 m
c	Parking height B1	3.0m
d	Total height of Building	21 m
e	Area of building	843.765 sq. m
f	Zone	II, IV
Material Properties and Code		
a	Concrete	M25
b	Steel	Fe415
c	Concrete design Code	IS 456: 2000
d	Steel design code	IS 800: 2007
Member Properties		
a	Thickness of slab	150 mm
b	Column size	450 X 450mm
c	Beam size	230 X 450 mm
d	Thickness of residential wall	230mm, 115mm
Type of load		
a	Dead load	
b	Live load	
c	Earth quake load	

RESULT AND DISCUSSION

Lateral Displacement

The measurement of a building's lateral displacement resulting from lateral forces is crucial in evaluating its seismic performance. Nonetheless, it has been observed that the inclusion of floating columns can lead to an amplification in the building's lateral displacement. This observation aligns with the results presented in Tables 3 and 4. The augmented lateral displacement may arise from the redistribution of lateral forces triggered by the presence of the floating column.

Table 3: Displacement of building in X and Y direction without floating columns

	Displacement EQX		Displacement EQY	
	Zone II	Zone IV	Zone II	Zone IV
Storey 6	4.26	29.43	4.26	29.43
Storey 5	3.84	26.93	3.84	26.93
Storey 4	3.17	22.93	3.17	22.93
Storey 3	2.32	17.49	2.32	17.49
Storey 2	1.39	10.94	1.39	10.94
Storey 1	0.49	4.122	0.49	4.122
Base	0	0	0	0

Table 4: Displacement of building in X and Y direction with floating columns

	Displacement EQX		Displacement EQY	
	Zone II	Zone IV	Zone II	Zone IV
Storey 6	10.23	32.93	15.16	32.93
Storey 5	9.01	28.49	13.05	28.49
Storey 4	7.65	23.71	10.8	23.71
Storey 3	7.08	18.59	8.42	18.59
Storey 2	4.43	13.21	5.95	13.21
Storey 1	2.63	7.57	3.37	7.57
Base	0	0	0	0

Figures 1 and 2 depict the displacement of a building in both the X and Y directions, considering scenarios

with and without floating columns. These figures unmistakably demonstrate that the incorporation of floating columns can yield a rise in the lateral displacement of the building. This observation aligns with the conclusions drawn in previous studies [21], which have highlighted that the presence of floating columns can induce an increase in lateral displacement due to the redistribution of lateral forces. Nonetheless, it is important to acknowledge that the magnitude of this increase in lateral displacement can vary depending on factors such as the design of the floating columns and the applied load conditions. Consequently, it is crucial to thoroughly assess the impact of floating columns on lateral displacement during the design process of earthquake-resistant structures.

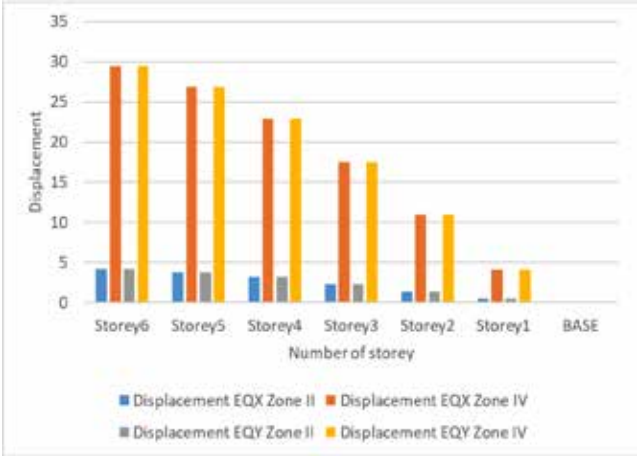

Figure 1: Displacement of building in X and Y direction without floating columns

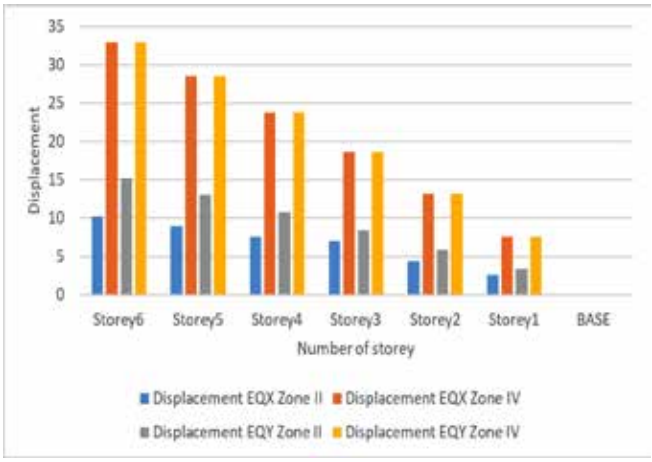

Figure 2: Displacement of building in X and Y direction with floating columns

Storey Drift

When designing buildings to withstand seismic forces, it is crucial to consider the concept of storey drift, which refers to the variation in displacements between different floors. The storey drift is directly influenced by the displacement of each floor. Introducing a floating column into a building causes an increase in the floor's drift, as it leads to a greater displacement of the floor. This phenomenon occurs because the floating column redistributes the lateral forces, resulting in a higher lateral displacement of the entire building. However, it is important to note that as we move towards the upper floors of the building, the floor drift tends to decrease. This is primarily due to the reduced lateral forces acting on the topmost floors. The observations made in Tables 5 and 6 corroborate this finding. Consequently, when designing buildings with floating columns, it is vital to carefully assess the storey drift and implement suitable measures to minimize drift while simultaneously enhancing the structure's seismic resistance.

Table 5: Drift values of building without floating column subjected to earthquake load in the X and Y direction

	Drift in EQX		Drift in EQY	
	Zone II	Zone IV	Zone II	Zone IV
Storey 6	0.000144	0.000823	0.000144	0.000823
Storey 5	0.000222	0.001334	0.000222	0.001334
Storey 4	0.000282	0.001814	0.000282	0.001814
Storey 3	0.000312	0.002184	0.000312	0.002184
Storey 2	0.000296	0.002271	0.000296	0.002271
Storey 1	0.000166	0.001374	0.000166	0.001374
Base	0	0	0	0

Table 6: Drift values of building with floating column subjected to earthquake load in the X and Y direction

	Drift in EQX		Drift in EQY	
	Zone II	Zone IV	Zone II	Zone IV
Storey 6	0.000703	0.001489	0.000405	0.001489
Storey 5	0.00075	0.00159	0.000456	0.00159
Storey 4	0.000797	0.00172	0.000522	0.00172
Storey 3	0.000823	0.00178	0.000554	0.00178
Storey 2	0.00086	0.001883	0.000597	0.001883
Storey 1	0.0011	0.002526	0.000877	0.002526
Base	0	0	0	0

Figures 3 and 4 depict the drift value of a building in both the X and Y directions, comparing scenarios with and without floating columns. The figures clearly demonstrate that the inclusion of floating columns can lead to an augmented drift value in the building, particularly as the displacement of the floors increases. This finding aligns with previous research that has consistently indicated that floating columns can elevate the drift value of a structure due to the redistribution of lateral forces. It should be noted that the magnitude of this increase in drift value may vary depending on factors such as the specific design of the floating columns and the prevailing load conditions. Consequently, it is of utmost importance to meticulously evaluate the impact of floating columns on the drift value during the design phase, aiming to minimize drift while simultaneously enhancing the building's overall resistance to seismic activity.

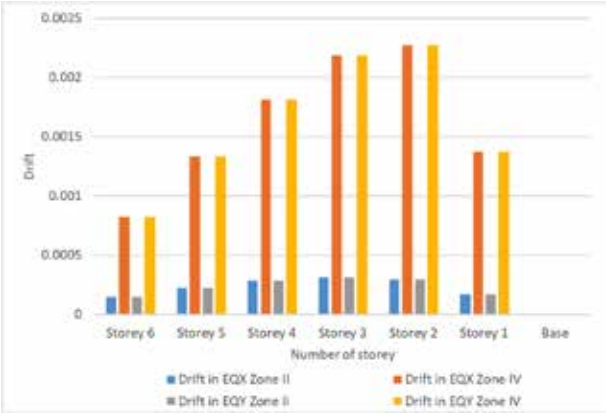

Figure 3: Drift of building without floating column subjected to earthquake load in the X and Y direction

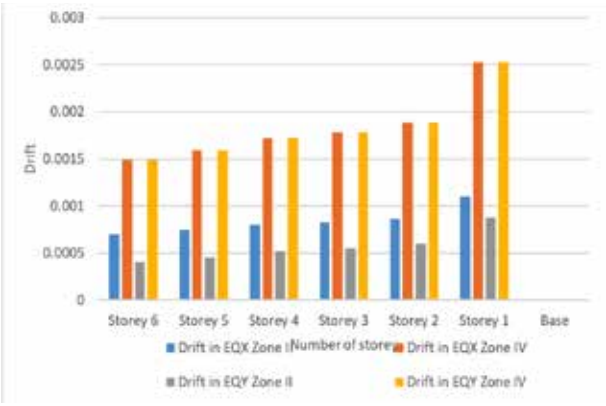

Figure 4: Drift of building with floating column subjected to earthquake load in the X and Y direction

CONCLUSION

In summary, this research study extensively examined the impact of introducing a floating column into a building under lateral loading conditions. The analysis focused on critical parameters such as lateral displacement, storey drift, and the probability of failure for both cases: with and without a floating column. The findings revealed that the building with floating columns exhibited larger lateral displacements in both the X and Y directions, consequently resulting in a heightened probability of failure. Additionally, the presence of a floating column led to significantly increased floor drift in comparison to the normal building. Based on these outcomes, it can be inferred that incorporating floating columns in buildings is not advisable as it poses potential risks to the safety and structural integrity of the structure. Therefore, it is crucial to undertake a thorough evaluation and analysis during the design phase to ensure optimal seismic resistance of the building and minimize the likelihood of failure.

REFERENCES

1. B. Yuen, A. Yeh, S. J. Appold, G. Earl, J. Ting, and L. Kurnianingrum Kwee, "High-rise living in Singapore public housing," Urban Stud., vol. 43, no. 3, pp. 583–600, 2006.
2. V. Žegarac Leskovar and M. Premrov, "A review of architectural and structural design typologies of multi-storey timber buildings in Europe," Forests, vol. 12, no. 6, p. 757, 2021.
3. C. Champion and A. Liel, "The effect of near- fault directivity on building seismic collapse risk," Earthq. Eng. Struct. Dyn., vol. 41, no. 10, pp. 1391–1409, 2012.
4. R. S. E. ABDEL, M. M. Ahmed, and T. M. A. Alazrak, "Evaluation of Soil–foundation-structure Interaction Effects on Seismic Response Demands of Multi-story MRF Buildings on Raft Foundations," 2015.
5. R. S. Mishra, V. Kushwaha, and S. Kumar, "A comparative study of different configuration of shear wall location in soft story building subjected to seismic load," Int. Res. J. Eng. Technol., vol. 2, no. 7, pp. 513–519, 2015.
6. J. Gebelein, M. Barnard, M. Cochran, C. Haselton, R. McLellan, and K. Porter, "Considerations for a framework of resilient structural design for earthquakes," 2017.

7. P. Sharafi, M. Mortazavi, N. Usefi, K. Kildashti, H. Ronagh, and B. Samali, "Lateral force resisting systems in lightweight steel frames: Recent research advances," Thin-Walled Struct., vol. 130, pp. 231–253, 2018.

8. A. P. Mundada and S. G. Sawdatkar, "Comparative seismic analysis of multi storey building with and without floating column," Int. J. Curr. Eng. Technol., vol. 4, no. 5, pp. 3395–3400, 2014.

9. M. Saatcioglu, A. Ghobarah, and I. Nistor, "Performance of structures in Indonesia during the December 2004 great Sumatra earthquake and Indian Ocean tsunami," Earthq. Spectra, vol. 22, no. 3_suppl, pp. 295– 319, 2006.

10. G. Mahajan, "Pathway to net zero energy building," 2017.

11. A. Kareem, T. Kijewski, and Y. Tamura, "Mitigation of motions of tall buildings with specific examples of recent applications," Wind Struct., vol. 2, no. 3, pp. 201–251, 1999.

12. Y. Rai, R. Patel, and D. Bandewar, "Seismic Analysis of High Rise Building with Floating Column in Bracing System."

13. S. A. Gharebaghi, M. Ebad, and N. Fanaie, "Investigating the seismic performance of MRF-CBF dual systems under the effects of staged construction," J. Constr. Steel Res., vol. 207, p. 107956, 2023.

14. A. Maurya and M. R. Eatherton, "Experimental study of the restoring force mechanism in the self-centering beam (SCB)," Front. Struct. Civ. Eng., vol. 10, pp. 272–282, 2016.

15. R. Kanitkar and V. Kanitkar, "Seismic performance of conventional multi-storey buildings with open ground floors for vehicular parking," Indian Concr. J., vol. 78, no. 2, pp. 99–104, 2004.

16. T. Abildinov, A. Bekmurat, A. Irsainova, A. Izimova, and A. Kulchmanov, "DESIGN A MULTI-STORY OFFICE BUILDING IN SAN FRANCISCO, CALIFORNIA USA," 2017.

17. H. Liu, Z. Tang, Y. Chen, and X. Du, "Frequency domain transfer function based multimodal design method for seismic mitigation of building structures," in Structures, 2023, vol. 51, pp. 1539–1552.

18. Z. Tao, Y. Wang, M. Sanayei, J. A. Moore, and C. Zou, "Experimental study of train-induced vibration in over-track buildings in a metro depot," Eng. Struct., vol. 198, p. 109473, 2019.

19. K. J. Coughlin, Steel Structure Response under Fire Conditions Model Based Simulation (MBS). Illinois Institute of Technology, 2019.

20. L. C. Dang, C. C. Dang, and H. Khabbaz, "Modelling of columns and fibre-reinforced load-transfer platform-supported embankments," Proc. Inst. Civ. Eng. Improv., vol. 173, no. 4, pp. 197–215, 2020.

21. A. S. Hokmabadi, B. Fatahi, and B. Samali, "Assessment of soil–pile–structure interaction influencing seismic response of mid-rise buildings sitting on floating pile foundations," Comput. Geotech., vol. 55, pp. 172–186, 2014.

An In-Depth Analysis of Quantum Computing Frameworks: Exploring Prominent Platforms

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ABSTRACT

The ideas, uses, and frameworks of quantum computing are explored in this overview study. Quantum computing utilises the principles of quantum physics to process data by using quantum bits, or qubits, that may exist in several states simultaneously. Due to their immense computing power, quantum computers have the potential to exponentially speed up some types of issues. The article explores a number of applications where quantum computing can have a big impact. These include quantum chemistry, finance, logistics, communications, drug development, weather forecasting, optimisation, machine learning, and scientific research. Quantum computing, which outperforms traditional computers in efficiency and effectiveness, has the potential to change a number of industries by offering answers to complex problems. A brief review of well-known quantum computing frameworks including Qiskit, Cirq, PyQuil, Microsoft Quantum, ProjectQ, Quantum Development Kit, and PennyLane is also included in the study. To create and use quantum algorithms, these frameworks offer tools, programming languages, and simulation capabilities. They enable researchers and developers to explore the possibilities of quantum computing by bridging the gap between quantum hardware and high-level programming

KEYWORDS *: Quantum computing, Applications, Frameworks & Exponential speedup*

INTRODUCTION TO QUANTUM COMPUTING

In contrast to conventional computers, quantum computers have substantially more processing capability, and the area of quantum computing is a young one in computer science and technology. Unlike conventional computers, which utilise bits to encode information as either a 0 or a 1, quantum computers use quantum bits, or qubits, which may simultaneously exist in both 0 and 1 states. Due to this special characteristic, certain computational tasks may be completed by quantum computers exponentially faster than with conventional computers. Quantum computing is built on quantum gates, which are similar to the logic gates used in classical computing. (Avila et al., 2023). Qubits are manipulated by quantum gates, allowing for quantum transformations and operations. Quantum algorithms are more effective than classical algorithms at solving difficult problems by applying a sequence of quantum gates on a collection of qubits. Big numbers can be factored exponentially more quickly with Shor's algorithm than with any other known conventional method, making it one of the most well- known quantum algorithms. (Grurl et al., 2023). This might constitute a danger to the security of widely used encryption techniques, which has important consequences for cryptography and encryption systems.

The idea of quantum entanglement is also introduced by quantum computing. In this situation, two or more qubits are correlated to the point that their states are inextricably connected, regardless of how far apart they are. Quantum computers are able to carry out some calculations and communication tasks more efficiently due to entanglement. Even while quantum computing

has a lot of potential, it is still in its infancy(Carrazza et al., 2023). Significant technological obstacles must be overcome in order to construct and run robust and error-tolerant quantum computers. Physical qubit implementations being studied include topological qubits, superconducting circuits, trapped ions, and photonics. Each has benefits and drawbacks. Cryptography, optimisation, machine learning, and simulations of quantum systems are just a few of the industries that might be completely transformed by quantum computing. It is vital to keep in mind that not all computational activities will benefit from quantum computing, and there are still issues like qubit decoherence and error correction that need to be resolved(Greene-Diniz et al., 2022).

In recent years, large financial expenditures have been made in the research and development of quantum computing by major technical companies, academic institutions, and governments. Academics and developers now have broader access to experimentation and the study of quantum computing's potential thanks to the development of open-source quantum computing frameworks like Qiskit, Cirq, and PyQuil. As the science of quantum computing develops, it has the potential to address issues that are now intractable for conventional computers, resulting in significant advancements in a range of industries and scientific disciplines.(Li et al., 2022).

IMPORTANT CONTENTS OF QUANTUM COMPUTING

A fast-developing topic called quantum computing investigates the possibility of employing quantum physics to carry out calculations. Despite the complexity of the topic, some crucial aspects of quantum computing include:

1. Quantum bits, or qubits, are the elementary building blocks of quantum information. Qubits may exist in a superposition of states, allowing for simultaneous processing and enhanced computational capability, in contrast to traditional bits, which can either represent a 0 or a 1.
2. Quantum Gates: Like conventional logic gates, quantum gates are utilised to control qubits and carry out quantum operations. The Hadamard gate, Pauli gates (X, Y, and Z), and the Controlled-NOT gate are a few examples of quantum gates.
3. Quantum Algorithms: To fully utilise the capabilities of quantum computers, quantum algorithms were created. Famous examples include the Quantum Fourier Transform (QFT), Grover's algorithm for unsorted database searches, and Shor's method for factoring big numbers.
4. Quantum entanglement: This special quality of quantum systems occurs when two or more qubits are coupled to the point that the state of one qubit cannot be represented apart from the other qubits. Entanglement is essential to quantum information processing and enables some quantum algorithms to outperform conventional techniques exponentially.
5. Quantum Error Correction: Environmental perturbations and flaws in the hardware can cause faults in quantum systems. Quantum error correction approaches try to shield quantum data from mistakes and decoherence, enabling accurate calculations.
6. Quantum Superposition and Interference: Quantum superposition is the capacity of qubits to exist in several states at once, whereas interference is the phenomena where quantum states may interact either positively or negatively, resulting in certain results. These characteristics make parallel calculations possible and increase the quantum systems' processing capability.
7. Quantum Teleportation: Quantum teleportation is a technique that allows the transport of quantum information from one location to another using entanglement and traditional transmission. Both quantum networking and communication depend on it..
8. Quantum cryptography: Quantum cryptography takes advantage of the fundamental principles of quantum physics to provide secure communication channels. Quantum key distribution (QKD) protocols, such as BB84 and E91, take advantage of the properties of quantum entanglement to enable secure transfer of encryption keys.
9. Quantum Simulations: Complex quantum systems

that are unsolvable by conventional computers can potentially be simulated by quantum computers. The possibilities for researching chemical processes, material characteristics, optimisation issues, and quantum physics itself are made possible by this capacity.

10. Quantum Hardware: The term "quantum computing hardware" refers to the actual gear used to manage and store qubits. A number of technologies, including as superconducting qubits, trapped ions, topological qubits, and photonics, are being studied to build scalable and error-tolerant quantum computers.

These are only a few of the crucial articles in the quantum computing subject. New ideas and technology will surely materialise as this field of study develops, furthering our knowledge of and potential uses for quantum computing(Yetiş & Karaköse, 2022).

APPLICATION AREA OF QUANTUM COMPUTING

Quantum computing has the potential to change several industries by opening up new computational possibilities that are not achievable with traditional computers. While still in its infancy, applications for quantum computing are being investigated in a number of significant fields(M. Bhatia & Kaur, 2021), such as:

1. Cryptography and Security: Many of the cryptographic techniques now in use to protect sensitive data are susceptible to being broken by quantum computers. They can, however, also allow novel quantum-based cryptography techniques, such as quantum key distribution (QKD), which provides communication channels that are completely secure(Yu et al., 2021).
2. Optimisation and operations research: Quantum computing has the potential to be more effective than conventional computers at resolving optimisation issues. Quantum algorithms might be useful in fields like supply chain optimisation, portfolio optimisation, traffic routing, and scheduling since they can investigate a huge number of options concurrently.
3. Machine learning and artificial intelligence: The goal of quantum machine learning is to use quantum computing to improve conventional machine learning techniques. Pattern recognition, neural network optimisation, and large-scale model training are three operations that quantum computers may be able to speed up. These tasks have potential applications in a variety of industries, including healthcare, banking, and data analysis(Gebauer et al., 2021).
4. Quantum Chemistry and Material Science: Using quantum simulations on quantum computers, it is possible to more precisely simulate and comprehend the behaviour of molecules and materials than is possible with conventional computation. This might lead to improvements in material production, drug discovery, catalyst design, and energy storage.
5. Financial Modelling and Risk Analysis: With the help of quantum computing, complex financial systems may be more precisely modelled. This would improve risk assessment, portfolio optimisation, option pricing, and fraud detection. Monte Carlo simulations may run more quickly with quantum algorithms, producing more reliable financial forecasts(Parthasarathy & Bhowmik, 2021).
6. Supply Chain and Logistics: Quantum computing's optimisation skills may be used to enhance logistics planning, transportation optimisation, and supply chain management. Quantum algorithms can be used to solve complex routing issues, improve
7. Quantum Communications: The use of quantum computing can help secure communication networks. Quantum key distribution (QKD) techniques make use of quantum phenomena to assure the secure exchange of encryption keys. Additionally, quantum networks can offer long-distance secure communication and secure voting systems.
8. therapeutic development and Molecular Modelling: By modelling molecular interactions and forecasting therapeutic efficacy, quantum computers can assist in the development of novel pharmaceuticals. This has the potential to greatly speed up the drug development process, thereby

resulting in more precise and efficient therapies for different ailments(Fyrigos et al., 2021).

9. Weather Prediction and Climate Modelling: Quantum computing's capacity for processing enormous volumes of data and carrying out intricate simulations can improve weather prediction models and climate simulations. This could result in greater comprehension and more accurate forecasts.
10. Scientific Research and Fundamental Physics: Quantum computers can assist in the resolution of challenging issues in fundamental physics, such as modelling the behaviour of quantum systems, comprehending quantum field theories, and looking into the universe's beginnings.

While there is potential for quantum computing in these fields, it is vital to keep in mind that these applications and large-scale quantum computers have not yet been completely realised. Nevertheless, it is anticipated that continued research and development will broaden the possibilities and eventually make quantum computing a reality(Finzgar et al., 2022).

FRAMEWORKS OF QUANTUM COMPUTING

Software platforms or libraries known as quantum computing frameworks offer tools, programming languages, and abstractions to make it easier to create and run quantum algorithms on quantum computers or simulators. These frameworks(Mathews et al., 2022) aid in bridging the gap between high-level algorithms and the underlying quantum hardware. These well-known quantum computing frameworks are described below with Table 1.

Table 1: Frameworks of quantum computing

S no	Framework	Year of Inception	Owned By	Features
1	Qiskit	2017	IBM Quantum	Comprehensive tools, Qiskit Terra, Aer, Ignis, Aqua
2	Cirq	2018	Google	Low-level operations, Python library, gate-based simulations
3	PyQuil	2017	Rigetti Computing	Python library, Quil language, access to Rigetti's hardware
4	Microsoft Quantum	2017	Microsoft	Q# programming language, simulation, Azure Quantum integration
5	ProjectQ	2016	Independent	Circuit compilation, optimization, Python library
6	Quantum Development Kit	2019	IonQ	QUIL programming language, trapped- ion quantum computers
7	Penny Lane	2018	Xanadu	Integration with machine learning, differentiable programming

1. Qiskit: IBM Quantum created the open-source Qiskit framework. Qiskit Terra, Qiskit Aer, Qiskit Ignis, and Qiskit Aqua are just a few of the high-level quantum programming languages that are available. Users may create quantum circuits using Qiskit, simulate them on conventional computers, and then execute them on IBM's quantum hardware(Carfora & Marzuoli, 2017).
2. Cirq: Cirq is an open-source framework created by Google that offers tools for designing, modifying, and improving quantum circuits. With a Python library for creating quantum algorithms, it focuses on low-level operations. Cirq supports both the usage of gate operations for quantum simulations as well as circuit-based quantum computing(Y. H. Lee et al., 2016).
3. PyQuil: Rigetti Computing created PyQuil, a framework for quantum programming. It provides a Python library that facilitates the development and execution of quantum programmes written in the quantum instruction language Quil developed by Rigetti. For executing quantum programmes, PyQuil offers access to the quantum processors and simulators from Rigetti(Clarke et al., 2017).

4. Microsoft Quantum Development Kit: A software framework that offers tools, libraries, and languages for creating quantum algorithms is known as Microsoft Quantum Development Kit. It consists of the Q# programming language, which was created especially for quantum computing. The kit enables users to run quantum programmes on Microsoft's Azure Quantum's quantum hardware after simulating them on conventional computers(Y. Lee et al., 2020).

5. ProjectQ: ProjectQ is an open-source framework with a concentration on the compilation and optimisation of quantum circuits. It offers a Python library for writing quantum algorithms and enables execution on a variety of backends, including simulators and actual quantum devices, as well as simulation on conventional computers(JavadiAbhari et al., 2014).

6. IonQ's Quantum Development Kit (QDK) For IonQ's trapped-ion quantum computers, the Quantum Development Kit is a software development kit that makes it easier to create quantum programmes. The QUIL programming language is used to create and simulate quantum circuits utilising libraries and other tools(Steiger et al., 2018).

7. PennyLane: Xanadu created the PennyLane quantum machine learning framework. It combines machine learning libraries with quantum computing, enabling users to programme differentiable quantum circuits and carry out hybrid classical-quantum calculations. IBM Quantum and Google Cirq are only two of the quantum computing systems that PennyLane supports(A. Bhatia et al., 2020).

These frameworks offer a variety of programming languages, abstraction levels, and features designed for certain hardware systems(Hasan et al., 2022). They provide a variety of functions, including as simulation, circuit design, execution on quantum devices, and integration with traditional computers. The framework that best satisfies a researcher's or developer's demands and the particular quantum computing platform they are using can be chosen(Hua et al., 2021).

CONCLUSION

In conclusion, quantum computing represents a revolutionary advancement in the field of computation, providing previously unheard-of power and skills that go well beyond the capabilities of conventional computers. Quantum computing has the potential to revolutionise several industries, from encryption and optimisation to machine learning and scientific research, by utilising the ideas of quantum physics. Researchers and developers have access to strong tools and programming languages to fully use the potential of quantum algorithms thanks to the exploration of many quantum computing frameworks, including Qiskit, Cirq, PyQuil, and others. These frameworks enable the creation and execution of quantum programmes by bridging the gap between quantum hardware and high-level programming. The use cases for quantum computing are also many and varied. Quantum computers' exponential speedup and problem-solving ability may be used to advance a variety of industries, including banking, logistics, drug development, weather forecasting, and basic physics. Quantum computing has the ability to change how we approach scientific problems and corporate operations by solving complicated problems more effectively.

Despite the fact that quantum computing is still in its early phases, tremendous progress has been achieved, and government, academic, and commercial funding are fueling new developments in hardware, error-correction techniques, and algorithm development. An climate of innovation and information sharing is being fostered through collaborative efforts on a global scale.

Future applications of quantum computing are obvious. Quantum computers will become a reality when the technology develops and problems like qubit stability, error correction, and scalability are solved. With each milestone attained, we get closer to realising quantum computing's full potential and opening the door to a new age of computing.

REFERENCES

1. Avila, A., Santos, H., Cruz, A., Xavier-de-Souza, S., Lucca, G., Moura, B., Yamin, A., & Reiser, R. (2023). HybriD-GM: A Framework for Quantum Computing Simulation Targeted to Hybrid Parallel Architectures. Entropy, 25(3). https://doi.org/10.3390/e25030503

2. Bhatia, A., Bibhu, V., Lohani, B. P., & Kushwaha, P. K. (2020). An Application Framework for Quantum Computing using Artificial intelligence Techniques. 264–269. https://doi.org/10.1109/INBUSH46973.2020.9392164

3. Bhatia, M., & Kaur, A. (2021). Quantum computing inspired framework of student performance assessment in smart classroom. Transactions on Emerging Telecommunications Technologies, 32(9). https://doi.org/10.1002/ett.4094

3. Carfora, M., & Marzuoli, A. (2017). Combinatorial framework for topological quantum computing. In Lecture Notes in Physics (Vol. 942, pp. 307–345). Springer Verlag. https://doi.org/10.1007/978-3-319-67937-2_7

4. Carrazza, S., Efthymiou, S., Lazzarin, M., & Pasquale, A. (2023). An open-source modular framework for quantum computing. 2438(1). https://doi.org/10.1088/1742- 6596/2438/1/012148

5. Clarke, J. S., Thomas, N., Roberts, J., Pilliarisetty, R., Yoscovits, Z., Caudillo, R., George, H., Singh, K. J., Michalak, D., Amin, P., Mei, A., Bruno, A., Poletto, S., Boter, J., Droulers, G., Kalhor, N., Samkharadze, N., Dehollain, J. P., Yeoh, L., … Vandersypen,

6. L. M. K. (2017). Quantum computing within the framework of advanced semiconductor manufacturing. 13.1.1-13.1.3. https://doi.org/10.1109/IEDM.2016.7838406

7. Finzgar, J. R., Ross, P., Holscher, L., Klepsch, J., & Luckow, A. (2022). QUARK: A Framework for Quantum Computing Application Benchmarking. 226–237. https://doi.org/10.1109/QCE53715.2022.00042

8. Fyrigos, I.-A., Chatzinikolaou, T. P., Ntinas, V., Vasileiadis, N., Dimitrakis, P., Karafyllidis, I., & Sirakoulis, G. C. (2021). Memristor crossbar design framework for quantum computing. 2021-May. https://doi.org/10.1109/ISCAS51556.2021.9401581

9. Gebauer, R., Karcher, N., Hurst, J., Weber, M., & Sander, O. (2021). Taskrunner: A Flexible Framework Optimized for Low Latency Quantum Computing Experiments (Q. G., X. J.,

10. Z. D., M. V., R. M. F., & S. R. (eds.); Vols. 2021-September, pp. 123–128). IEEE Computer Society. https://doi.org/10.1109/SOCC52499.2021.9739306

11. Greene-Diniz, G., Manrique, D. Z., Sennane, W., Magnin, Y., Shishenina, E., Cordier, P., Llewellyn, P., Krompiec, M., Rančić, M. J., & Muñoz Ramo, D. (2022). Modelling carbon capture on metal-organic frameworks with quantum computing. EPJ Quantum Technology, 9(1). https://doi.org/10.1140/epjqt/s40507-022-00155-w

12. Grurl, T., Pichler, C., Fub, J., & Wille, R. (2023). Automatic Implementation and Evaluation of Error-Correcting Codes for Quantum Computing: An Open-Source Framework for Quantum Error Correction. 2023-January, 301–306. https://doi.org/10.1109/VLSID57277.2023.00068

13. Hasan, T., Ahmad, F., Rizwan, M., Alshammari, N., Alanazi, S. A., Hussain, I., & Naseem, S. (2022). Edge Caching in Fog-Based Sensor Networks through Deep Learning- Associated Quantum Computing Framework. Computational Intelligence and Neuroscience, 2022. https://doi.org/10.1155/2022/6138434

14. Hua, F., Chen, Y., Jin, Y., Zhang, C., Hayes, A., Zhang, Y., & Zhang, E. Z. (2021). AutoBraid: A framework for enabling efficient surface code communication in quantum computing. 925–936. https://doi.org/10.1145/3466752.3480072

15. JavadiAbhari, A., Patil, S., Kudrow, D., Heckey, J., Lvov, A., Chong, F. T., & Martonosi, M. (2014). Scaffcc: A framework for compilation and analysis of quantum computing programs. https://doi.org/10.1145/2597917.2597939

16. Lee, Y., Agarwal, T., & Luisier, M. (2020). Ab initio modeling framework for Majorana transport in 2D materials: Towards topological quantum computing. 2020-December, 30.3.1-30.3.4. https://doi.org/10.1109/IEDM13553.2020.9371923

17. Lee, Y. H., Khalil-Hani, M., & Marsono, M. N. (2016). An FPGA-Based Quantum Computing Emulation Framework Based on Serial-Parallel Architecture. International Journal of Reconfigurable Computing, 2016. https://doi.org/10.1155/2016/5718124

18. Li, N., Yan, F., & Hirota, K. (2022). Quantum data visualization: A quantum computing framework for enhancing visual analysis of data. Physica A: Statistical Mechanics and Its Applications, 599. https://doi.org/10.1016/j.physa.2022.127476

19. Mathews, M., Yin, X., Baumgartner, A., Esslinger, T., & Akin, A. (2022). A Control and Testing Framework for a Digital Micromirror Device in Neutral Atom Quantum Computing and Simulation Platforms. 724–726.https://doi.org/10.1109/QCE53715.2022.00098

20. Parthasarathy, R., & Bhowmik, R. T. (2021). Quantum Optical Convolutional Neural Network: A Novel Image Recognition Framework for Quantum Computing. IEEE Access, 9, 103337–103346. https://doi.org/10.1109/ACCESS.2021.3098775

21. Steiger, D. S., Häner, T., & Troyer, M. (2018). ProjectQ: An open source software framework for quantum computing. Quantum, 2. https://doi.org/10.22331/q-2018-01-31- 49

22. Yetiş, H., & Karaköse, M. (2022). A New Framework Containing Convolution and Pooling Circuits for Image Processing and Deep Learning Applications with Quantum Computing Implementation. Traitement Du Signal, 39(2), 501–512. https://doi.org/10.18280/ts.390212

23. Yu, Y., Qiu, D., & Yan, R. (2021). An efficient framework for sentence similarity inspired by quantum computing (G. Z., L. X., O. S.G., C. L., M. B.F., & W. X. (eds.); pp. 157–163). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ICKG52313.2021.00030

Analysis of Image Captioning-A Deep Learning and Machine Learning Approach

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ABSTRACT

Image captioning in research becoming a most popular and interesting technology in recent years .If we assign proper name or description to the image then it is termed as image captioning. Captioning to images it's necessary to generate meaningful and related words, statements for the particular image. Image captioning means not only to identify the proper objects and assigning captions to that image but also requires to builds logically correct naming i.e. correct in the order of syntax and semantics. This automatic captioning to the image natural language processing and computer vision based on various aspects of artificial intelligence comes under industry 4.0 and 5.0 frames an important role. Like, In this era most research on image captioning making use of deep-learning techniques like Encoder-Decoder Model with convolution neural network (CNN), machine learning w.r.t. computerized vision. We would like to represent a comprehensive assessment of current machine learning and also explain the reason for choosing this tool for research.

KEYWORDS *: Image captioning, CNN, Deep-Learning, Machine Learning*

INTRODUCTION

Image captioning in the field of research becoming a very popular and interesting technology in recent years. We can see number of images uploaded on social sites by people every day. Also we know we go through various articles, notes, videos, news papers… etc. which includes many images .Some of the images are titled by human being or some or not. In such case there can be variations in captioning in form of syntax, semantic errors because statements, views and vocabulary of individuals can vary accordingly.

If some pictures don't have captions, people can understand most of them anonymously, bu t sometimes they don't. However, if people want automatic signatures from machines, mac hines need to interpret/ convert some signatures. For this reason researchers work on various new technology for the analysis and implementation of image captioning process. Various techniques like Content-Based Image Retrieval (CBIR), Neural Network, convolution neural network, YOLOv4 model, MS coco model, LSTM model, Encoder- Decoder model, supervised technique, dense technique…etc. are used by various researchers with Deep Learning and machine learning .Image captioning having many benefits but the main aim behind this technique is to generate captions to the images / data provided by the humans. This helps to automatic generation of text or captioned label without the users or human role. Work effectively for blind people or those with limited vision can readily interpret the images. One can quickly and easily organize or arrange those files by creating captions for many photographs contained in the same file. This method is helpful for web development as well because it generates a specified image caption very quickly.

Hence, it can be applied in every sectors for example, social sites like Instagram, Facebook, Twitter. Health an educational sectors and sites related to that like biomedicine, business, the military, education, online searching, and digital libraries. The auto generated descriptions for images like kids are playing, cat is sleeping will creates interest in kids also to study

effectively with images an which helps them to understand concepts more easily with visual images. Now, in next section some description is given regarding literature and methods applied for image captioning by various researchers.

DETAILED REVIEW OF DIFFERENT IMAGE CAPTIONING METHODS

Because it is practical and suitable for real-time captioning to images, Image captioning methods have developed in each sector like education, medical, security, military...etc. Various algorithm and methods have evaluated for image captioning techniques under different prospective. The survey of related work is :

Research from Subhash Chand Gupta et.al [1]. In that work authors focus we can generate description/caption for images in short as an output for the given inserted image. Authors work and generated the method for captioning the image using Deep Learning and Natural Language Processing, this work basically implemented with the vision for assisting people with visual impairments, and again be rejected by many websites with the intention of automating the development of captions, which once again minimizes the need for human captioning. In this according to input image to make easier communication with machines Natural Language Processing (NLP) along with before sending the words to the RNN, NLP techniques like tokenization, stemming, and Word-Lemmatize are applied to the words. As a result, it became simple to retrieve and generated captions are also easy to understand. The steps which followed for this entire simulation and experiment are:-

i) Object identification: Object identification for the image through the CNN. Then, the application of RNN and Long Short -Term Memory (LSTM) helped to assign a meaningful description for images.

ii) Use of Flickr Dataset

iii) Model Training :- Trained model created by the combination of CNN and RNN

iv) Epoch:- Epoch is a shorthand for “number of counts.”. The improvement of model based on the number of epochs/counts, here stated that if more number of counts, then model became more improved.

MD. ZAKIR HOSSAIN et.al [2] this was also survey paper with great ease. indicates that Deep learning-based methods can deal with the difficulties and complexity of image captioning. The author’s goal in writing this survey study was to provide an in-depth analysis of the current deep learning-based picture captioning methods. In order to assess the effectiveness, strengths, and limitations of the strategies, the author covered their theoretical roots.

Oriol Vinyals,et.al [3] In the aforementioned study, the author looks into this issue and makes the argument that image captioning is a well-known branch of artificial intelligence (AI) research that deals with comprehending images and providing a verbal description for them. Understanding an image requires the ability for the identity of objects. While captioning an image it also needed to understand the details such as location, object properties and their interactions for proper image dimensions and clarity. And for proper logiccaptioned statements required both syntactic as well as semantic understanding of the language. In this research, the author introduced a deep recurrent architecture-based generative model that incorporated recent advances in computer vision and machine translation and could be used to produce intelligible phrases that describe an image.

Timo Ojala, et.al [4], In this study, the author proposed a conceptually straightforward and computationally straightforward method that is robust to variations in grey scale and that effectively discriminates a wide variety of rotating textures. Traditional machine learning is discussed in length in this article. Because this method uses hand-crafted features like Local Binary Patterns (LBP), the author explains why these features are important and how they operate.

David G Lowe [5], this paper used identification of key points for the object recognition. The strategy we’ve outlined makes use of least-squares pose determination,The development of distinctive invariant key points is the main focus of thisresearch, as already noted. In the aforementioned [5] paper, object recognition was carried out by first individually comparing each key point to the database of keypoints collected from training photos. Many of those early matches, according to the author, may not be accurate

because of ambiguous traits or features that result from background clutter. Consequently focus on Scale-Invariant Feature Transform (SIFT) for study of image captioning, Navneet Dalal and Bill Triggs. [6], methods and technology corresponding to it is common practise to employ the Histogram of Oriented Gradients (HOG) and a combination of these properties. These methods extract features from inputs that are provided.

Bernhard E Boser et.al,[7] include the concept of Support Vector Machines (SVM) and also explain its classification with other machines/methods in order to classify an object.

Vani M1, Priya S2 [8],In this paper author produced caption to input image in English. In This image caption generator had been developed using a CNN-RNN model. This model was totally depends on the data, so, it could not predict the words that was out of its vocabulary. This dataset added and explained by author contained near about 8000 images. But author said that higher accuracy of model output they need to train the model on larger than 100,000 images datasets so that better accuracy models could be developed.

C. Elamri and T. Planque, [9], According to the author, automatically describing an image's contents was a difficult undertaking, but it was crucial for assisting those who are blind. Modern smart phones have the ability to capture pictures, which can assist those who are vision challenged in capturing the environment. Here, captions can be created using photographs as input that are loud enough for visually impaired people to hear and understand better what is going on around them. In this instance, Christopher Elamri extracts features from a picture using a CNN model. Then, using an RNN or LSTM model, these attributes are used to create an image description that uses grammatically sound English phrases to describe the scene. Create a description of the image in English that is properly punctuated.

Imad Afyouni[10],In this research [10] work implementation done for generating image caption in Arabic in Arabic language using machine learning and data analysis. for arabic caption to work input performed with the help of three different models . The COCO and Flickr30k datasets are used to develop and train all three models. After testing, a subset of the COCO dataset is built in Arabic. One or more observed items can be handled by the first model, which is an object-based captioned. The third model is based solely on a soft attention mechanism, compared to the second model, that employs both an object detector and attention-based captioning. The model has been evaluated using multilingual semantic statements to generate the accuracy.

Ayush Kumar Poddar et al.[11] In this image captioning with machine learning and deep learning process performed to provide caption to given image in Hindi.

Shuang Bai et al.[12] The author of this research provided a survey on image captioning. The main focus was on neural network-based techniques, which produce cutting-edge outcomes. Additionally, the author discussed potential areas for future research in automatic image captioning.

Duy-Kien Nguyen et al.[13] In this paper also author mentioned that vision and language have made significant progress, in various field one of them essential is image captioning.

William Fedus et al.[14] In this paper research basically based on conditional GAN models in the context of natural language.Author introduced a text generation model which trained on in-filling (MaskGAN). The MaskGAN algorithm directly achieved this through GAN-training and this improved the generated samples as assessed by human evaluators.

William Fedus et al.[15] , in this paper author first examined the importance of CNN- LSTM framework, Then it worked to generate knowledge-base queries which reflect the content of the question and the image, in order to extract more specifically related information. In this author created a baseline for implementing results by connecting CNN to an LSTM. The CNN is a pre-trained (on ImageNet) VggNet model from which they extract the coefficients. Author also implemented a baseline model VggNet+ftLSTM, and also make a use of COCO dataset.

From this listed research papers and other we have studied the role of CNN (convolutional neural network), DCNN (dynamic convolutional neural network), LSTM (Long Short Term Memory), NLP (Natural Language Processing), various datasets like Flickr Dataset, various

models like COCO model. From this survey we also able to examine that how machine learning and deep learning is essential and we can work further for more improvements and to reduced laggings in output with the techniques machine learning and deep learning.

The brief summary of some literatures related to image captioning is given in a following table ,in the form of reference number of paper for which detailed information we can easily access from the column of contents:-

Table 1. : - Brief analysis of Some Analyzed Research Papers

Sr. No.	Reference No.	Contents/ Examined Survey :- The Concept/Algorithm/Model Used in given reference.
1	1	Deep Learning and Natural Language Processing Concept
2	2	Concept of various datasets and deep learning based automatic image captioning techniques.
3	3	Deep recurrent architecture model.
4	4	Concept of traditional Local Binary Patterns (LBP)
5	5	Concept of Scale-Invariant Feature Transform (SIFT)
6	6	Concept of Histogram of Oriented Gradients (HOG)
7	7	Concept and working of of Support Vector Machines (SVM)
8	8	Details and working of CNN-RNN model
9	9	Details and working of RNN and LSTM model
10	10	Details and working of COCO and Flickr30k dastaets
11	11	Details of multi-layered CNN-LSTM neural network model
12	14	Study of MaskGAN algorithm
13	15	Details and working of CNN,LSTM,COCO model

PARAMETERS FOR THE CLASSIFICATION OF DEEP LEARNING

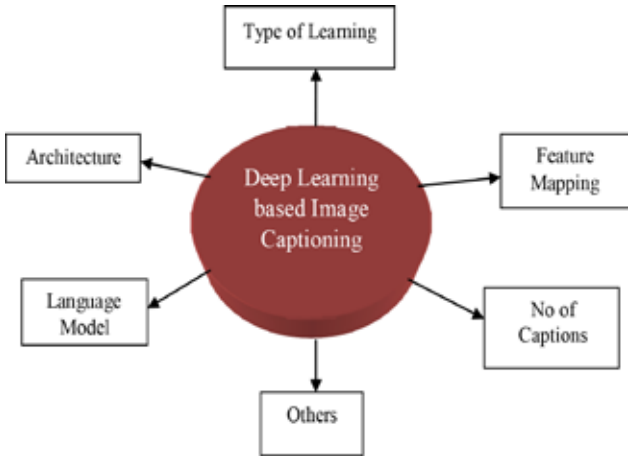

Fig. 1. Parameters for the Classification of Deep Learning

Several of the parameters used to classify deep learning using various criteria are shown in the diagram, along with an explanation of how they apply to deep learning-based picture captioning:

Type of learning

Number of learning methodology is available but in deep learning mainly go through the learning method as :

Supervised- learning	Unsupervised- learning
Training data for supervised learning includes the expectedoutput known as labels or captions.	Unsupervised learning includes unlabeled data.

Feature Mapping

In Image captioning features to Map objects are:

Visual space	Multimodal Space
Visual space is space by an observer subjective to the counterpart of physical objects.	Multi-model space/ database unify multiple database systems into one.

3) Architecture:-

For Architecture Encoder-Decoder techniques and

Compositional Model prefer mostly in deep learning .

Language Models-

Various Language Models for caption implementation according to images are available but in survey it is found that many researchers prefer LSTM model for image captioning with deep learning.

Number of captions-

Here also, various captioning methods are available but in survey it is found that researchers prefer dense captioning method for image captioning with deep learning.

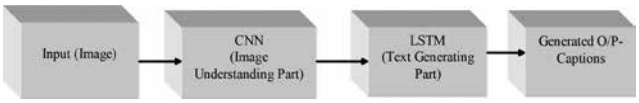

Fig. 2. An Encoder-Decoder architecture-based block diagram for image captioning

DATASETS

In this survey we have studied a number of datasets that are made up of English-language descriptions and photos. [1,3]

Dataset name	size		
	train	Valid	test
Pascal VOC 2008 [6]	-	-	1000
Flickr8k [26]	6000	1000	1000
Flickr30k [33]	28000	1000	1000
MSCOCO [20]	82783	40504	40775
SBU [24]	1M	-	-

In this way we have also studied various datasets and want to work further with one of the dataset mostly with Flickr advance dataset.

CONCLUSION

In light of the extensive discussion of the many Image captioning methods, in this study, we examine deep learning and machine learning based approaches along CNN,LSTM model for image captioning. We have given a comparison, classification, some diagrammatical and tabular details for image captioning techniques; we have also studied and describe different datasets with their advantages and weakness. From this study we come to know that, Deep-Learning an machine learning we can used with CNN (Convolutional neural networks), or LSTM layers to encode and decode captions properly and hence, the process of generating any new papers, notes, website becomes more which automatically generate the caption using image captioning generating method. Our primary focus is on techniques based on neural networks. We presented various image captioning method and their comparisons, from this we find we can go through this image captioning method using machine and deep learning because, image captioning method becoming more and more popular as it saves the time to of captioning the image and also provide relevant vocabulary which is syntax an symmetrically correct. We also think to study further on Flickr dataset with Deep learning and machine learning technique for progress in output generation in image captioning.

REFERENCES

1. Subhash Chand Gupt et al., "Generating Image Captions using Deep Learning and Natural Language Processing", in 9th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO) Amity University, Noida, India. Sep 3-4, 2021

2. MD. ZAKIR HOSSAIN, et al, "A Comprehensive Survey of Deep Learning for Image Captioning. ACM Comput. Surv. 0, 0, Article 0 (October 2018), "

3. Oriol Vinyals, Alexander Toshev, Samy Bengio, and Dumitru Erhan. 2017. Show and tell: Lessons learned from the 2015 mscoco image captioning challenge. IEEE transactions on pattern analysis and machine intelligence 39, 4 (2017), 652–663.

4. Timo Ojala, Matti PietikÃď inen, and Topi MÃď enpÃď Ãď. 2000. Gray scale and rotation invariant texture classification with local binary patterns. In European Conference on Computer Vision. Springer, 404–420.

5. David G Lowe. 2004. Distinctive image features from scale-invariant keypoints. International journal of computer vision 60, 2 (2004), 91–110.

6. Navneet Dalal and Bill Triggs. 2005. Histograms of oriented gradients for human detection. In Computer Vision and Pattern Recognition, 2005. CVPR 2005.

IEEE Computer Society Conference on, Vol. 1. IEEE, 886–893.

7. Bernhard E Boser, Isabelle M Guyon, and Vladimir N Vapnik. 1992. A training algorithm for optimal margin classifiers. In Proceedings of the fifth annual workshop on Computational learning theory. ACM, 144–152

8. Vani M1 , Priya S2 International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 10 Issue XI Nov 2022

9. C. Elamri and T. Planque, "Automated Neural Image Caption Generator for Visually Impaired People,"California, 2016.

10. Imad Afyouni, Imtinan Azhara, Ashraf Elnagara," 5th International Conference on AI in Computational_ Linguistics. 10.1016/j.procs.2021.05.108"

11. Ayush Kumar Poddar ,Dr.Rajneesh Rani. "International Conference on Machine Learning and Data Engineering Procedia Computer Science 218 (2023) 686–696"

12. Shuing Bai "A Survey on Automatic Image Caption Generation" in ResearchGate Article in Neuro computing · May 2018

13. Nguyen, D. K., & Okatani, T. (2019). "Multi-task learning of hierarchical vision-language representation", IEEE Conference on Computer Vision and Pattern Recognition (pp. 10492-10501).

14. William Fedus, Ian Good fellow, and Andrew M Dai. 2018. Maskgan: Better text generation via filling in the _. arXiv preprint arXiv:1801.07736.

15. Qi Wu, Chunhua Shen, Peng Wang, Anthony Dick, and Anton van den Hengel. 2018. Image captioning and visual question answering based on attributes and external knowledge. IEEE transactions on pattern analysis and machine intelligence 40, 6, 1367–1381.

16. Rennie, S. J., Marcheret, E., Mroueh, Y., Ross, J., & Goel, V. (2017). "Self-critical sequence training for image captioning", IEEE Conference on Computer Vision and Pattern Recognition (pp. 7008- 7024).

17. P. Das, A. Ghosh and R. Majumdar, "Determining Attention Mechanism for Visual Sentiment Analysis of an Image using SVM Classifier in Deep learning based Architecture," 2020 8th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO), 2020, pp. 339-343, doi: 10.1109/ICRITO48877.2020.9197899.

18. Xiao, X., Wang, L., Ding, K., Xiang, S., Pan, C. (2019) "Deep hierarchical encoder–decoder network for image captioning" IEEE Transactions on Multimedia 21.11 : 2942-2956.

19. Vinyals, O., Toshev, A., Bengio, S., Erhan, D. (2015) "Show and tell: A neural image caption generator" Proceedings of the IEEE conference on computer vision and pattern recognition.

20. M. Rohrbach, W. Qiu, I. Titov, S. Thater, M. Pinkal, and B. Schiele, "Translating video content to natural language descriptions," in Proc. IEEE Int. Conf. Comp. Vis., 2013.

21. R. Socher, A. Karpathy, Q. V. Le, C. D. Manning, and A. Y. Ng, "Grounded compositional semantics for finding and describing images with sentences," Proc. Conf. Association for Computational Linguistics, 2014.

22. C. Gan, T. Yang, B. Gong, Learning attributes equals multi-source domain generalization, in: IEEE Conference on Computer Vision and Pattern Recognition, Miami, FL, USA, 2016, pp. 87–97.

23. Y.-W. Chao, Z. Wang, R. Mihalcea, J. Deng, Mining semantic affordances of visual object categories, in: IEEE Conference on Computer Vision and Pattern Recognition, Boston, MA, USA, 2015, pp. 4259– 4267

24.] L. Bourdev, J. Malik, S. Maji, Action recognition from a distributed representation of pose and appearance, in: IEEE Conference on Computer Vision and Pattern Recognition, Providence, RI, 2011, pp. 3177–3184

25. A. Graves. Generating sequences with recurrent neural networks. arXiv:1308.0850, 2013.

26. B. Z. Yao, X. Yang, L. Lin, M. W. Lee, and S.-C. Zhu. I2t: Image parsing to text description. Proceedings of the IEEE, 98(8), 2010

27. O. Russakovsky, J. Deng, H. Su, J. Krause, S. Satheesh, S. Ma, Z. Huang, A. Karpathy, A. Khosla, M. Bernstein, A. C. Berg, and L. Fei-Fei. ImageNet Large Scale Visual Recognition Challenge, 2014

28. Qi Wu, Chunhua Shen, Peng Wang, Anthony Dick, and Anton van den Hengel. 2018. Image captioning

and visual question answering based on attributes and external knowledge. IEEE transactions on pattern analysis and machine intelligence 40, 6, 1367–1381.

29. Arof H and Deravi F (1998) Circular neighbourhood and 1-D DFT features for texture classification and segmentation. IEE Proceedings - Vision, Image and Signal Processing 145:167-172.

30. Cohen FS, Fan Z and Patel MA (1991) Classification of rotated and scaled texture images using Gaussian Markov Random Field models. IEEE Transactions on Pattern Analysis and Machine Intelligence 13:192- 202

31. Ojala T, Mäenpää T, Pietikäinen M, Kyllönen J, Viertola J and Huovinen S (2001) Outex - A new framework for empirical evaluation of texture analysis algorithms, submitted.

32. P. Kuznetsova, V. Ordonez, T. Berg, and Y. Choi. Treetalk:Composition and compression of trees for image descrip- tions. ACL, 2(10), 2014.

33. Chen, X., & Zitnick, C. L. (2014). "Learning a recurrent visual representation for image caption generation", . arXiv preprint arXiv:1411.5654.

An Improved Harmony Inspired and Simulated Annealing Load Balancing Approach for Dynamic Tasks Allocation in Cloud Computing Environment

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ABSTRACT

In a cloud computing (CC) environment, tasks are assigned to virtual machines (VMs) with varying durations, start times, and execution times. Consequently, balancing these loads across VM is crucial. Load balancing (LB) must be performed so that almost all VMs are balanced to maximize the system's usage of its capability and performance. This paper proposes a new LB approach based on two optimization algorithms to overcome the issue of LB at VMs. This approach combines an improved harmony- inspired algorithm, and a simulated annealing algorithm for dynamic task allocation called the Dynamic improved HISA load balancing approach. In the Harmony-inspired algorithm, HMCR calculation is improved using a linear decreasing strategy to update HMCR and PAR values by dynamic change strategy. Then probability is checked and considered as a threshold to evaluate the best fitness of the new Harmony and choose either an improved Harmony-inspired algorithm or simulated annealing to allocate tasks for available cloud resources. The simulations have been simulated in the CloudSim simulator by taking two cases in which 3 or 5 VMs and 10 to 50 cloudlets have been considered. Both cases have been tested five times in a running environment but displayed only the best performance outcomes. These experimented outcomes of test cases tell us that the proposed dynamic improved HISA-LB approach achieved better outcomes by min makespan or increased resource utilization with throughput over the existing LBMPSO approach.

KEYWORDS *: Cloud computing, Load balancing, Task scheduling, Dynamic task allocation, Improved harmony search, Simulated annealing*

INTRODUCTION

CLOUD computing is a large-scale distributed computing model that is abstracted, virtualized, or dynamic and therefore depends on the operator's economic size. The primary element of CC is controlled computing power, storage, platforms, and services made available to external users on demand via the Internet. CC is a new computer architecture aiming to relieve users of the burden of managing hardware, software, and data resources by offloading them to cloud service providers[1]. Clouds provide many resources, such as high-performance computing systems, data centers, storage, and software applications. It also manages these resources because users may access them from wherever and without experiencing performance issues. Cloud computing delivers more abstract resources and services, which may be separated into three levels: software as a service, platform as a service, and infrastructure as which service [2].

Cloud service providers rely heavily on resource allocation methods such as load balancing to achieve the goal of effective resource management. The load balancing method in cloud computing systems entails reorganizing task distribution across other nodes in a cloud computing platform. The load balancing technique includes continuously identifying overloaded and lightly loaded cloud computers and migrating a workload from overburdened machines to lighter-loaded cloud servers. It contributes to optimal cloud resource usage by preventing virtual machine instances from becoming

overcrowded, underloaded, or inactive[3]. Numerous load-balancing algorithms have been presented in the literature, and most of them are already widely used in different public and private CC platforms [4].

In a cloud context, task scheduling is an NP-hard combinatorial optimization issue because the no. of tasks is always growing and the duration of each work is subject to rapid change. The mappings between tasks as well as resources are challenging to develop. As a result, we need a competent TS strategy that can better handle the work and address the NP-hard problem[5] [6]. Numerous scholars have concentrated on heuristic, meta-heuristic, and other hybrid scheduling algorithms to address this problem. Swarm intelligence techniques are now being employed to solve these types of difficulties. Kennedy and Eberhart presented PSO as the most prominent swarm intelligence optimization technique [7]. In [8], a modified PSO algorithm known as LBMPSO was presented to handle the difficulties of LB and TS. The LBMPSO TS approach is predicated on the PSO algorithm, which employs a FF (fitness function) to determine the optimal particle arrangement. FF computes each VM's execution times, and returns increased execution time as the PSO particle's fitness value (F). However, when the issue becomes larger, the conventional MPSO method is no longer a viable solution in all cases.

To resolve these issues for all scenarios, a new dynamic, optimized load balancing approach is proposed by combining the improved HSA and SAA in a cloud computing environment for dynamically task allocation for efficient resource utilization and minimizing the makespan.

The main contributions of this study work are as occurs:

1) To deal with TS and load balancing issues at different VMs and cloudlets.

2) To design a new dynamic improved HISA load balancing approach utilizing two optimization algorithms for improvising the harmony memory.

3) The Improved HISA-LB approach is optimized by updating HMCR, PAR and Fret width by dynamic allocation of tasks in task scheduling.

4) It provides dynamic task allocation to balance the load in two cases.

5) The proposed approach is compared with the existing LBMPSO algorithm using different performance indicators to minimize makespan and improve resource utilization.

The remainder of the paper is organized as follows. The next section II highlights research on different existing cloud LB strategies. A new dynamic and efficient LB approach is obtainable in section III. Test outcomes by experimenting in a cloud- running environment are discussed in section IV. At last, conclude the entire research work with some future recommendations in section V.

RELATED WORK

The ICT industry has been pushed toward cloud computing by the spectacular advantages of virtualization and cloud technology. Many businesses that facilitate services via information and communication technologies have embraced CC or begun transferring services to cloud infrastructure. There has been an important rise in the difficulty of resource management and LB for both cloud service providers and their customers as a consequence of the popularity of cloud-based infrastructure. Researchers have proposed several load-balancing strategies to make the most of the cloud's available resources. In this article[9], researchers offer a unique load-balancing approach that illustrates work shifting from a heavily loaded virtual machine (VM) to a less busy one in a cloud-based. This study presents an effort to assist cloud stakeholders in resolving the issue of uneven resource consumption.

Virtual machine (VM) load balancing is a crucial component of cloud TS. The current study of [10] suggested a hybrid optimization technique called MMHHO for dynamic LB. The hybrid method suggested in current research optimizes system performance by increasing VM throughput, distributing workload evenly among VMs, and maintaining priority parity by varying task wait times. Created on simulation outcomes, it is clear that the proposed MMHHO load balancing technique is superior to alternatives.

In this paper, [11] cloud computing's essential role in scheduling tasks and allocating resources led researchers

to develop a new HYBRID bio-inspired algorithm. Several cloud-based systems rely on tried-and-true scheduling techniques like RR, FCFS, ACO, etc. Since the cloud gets work from clients at a high pace, effective resource allocation is essential. In this work, researchers present a HYBRID Bio-Inspired algorithm (Modified PSO + Modified Collaborative Swarm Optimization) to distribute and manage resources (CPU as well as Memory) according to the needs of the jobs running on the virtual machines. The investigational findings show that our suggested HYBRID algorithm is superior to its peer research and benchmark methodologies in making the most of the cloud's available resources, ensuring the system's uptime, & decreasing average response time.

In this paper, [8] suggested an LB method that uses modified PSO task scheduling (LBMPSO) to allocate cloud resources to tasks to reduce time and optimize resource use. To do this, the data center's tasks and resources must have accurate and up-to- date information about one another. To test the suggested scheduling technique, researchers used the CloudSim simulator. The simulation findings show that the suggested scheduling technique outperforms advanced methods in decreasing makespan and increasing resource usage.

Large amounts of diverse data exist on the cloud, necessitating intensive computations before they can be accessed. To address these issues, M. Junaid et al. [12] developed a method for LB using a hybrid of CSO and SVM they call DFTF. Firstly, the proposed approach employs one or more SVM classifiers to categorise data in cloud from multiple sources into different kinds, such as text, pictures, video, and audio. After that, information is sent into a modified version of the LB algorithm CSO, which is responsible for fairly distributing the workload between VMs. Throughput was increased by 7%, response time by 8.2%, migration time by 13%, energy consumption by 8.5%, optimization time by 9.7%, overhead time by 6.2%, SLA violation by 8.9%, and average execution time by 9%, according to simulation findings compared to previous methodologies. These outcomes were superior to those achieved by several baselines employed in this study (including CBSMKC, FSALB, PSO- BOOST, IACSO-SVM, CSO-DA, and GA-ACO).

In the research article of [13], The novel FIMPSO algorithm is presented as a combination of the firefly algorithm and the Improved Multi-Objective PSO (IMPSO) method for LB. The Firefly (FF) algorithm is used to narrow search space and the IMPSO method zeros in on the best possible answer. The suggested FIMPSO algorithm improved upon key indicators, including appropriate resource utilization and task response times, and it also managed to successfully average load for making. According to the simulation results, the suggested FIMPSO model outperformed the competing approaches.

To ensure QoS & user experience, MEC services are integrated and delivered closer to the edge of the user. This research aimed to minimize processing time and service cost in MEC networks by offloading workloads from MD to ES. The primary takeaway from the research is the feasibility of scheduling delivery of offloaded activities to ES VMs to optimize for computing time, cost of service, wastage over capabilities of ES, as well as max associativity (AE, X) of a task with an ES while yet preserving MD mobility. [14] provided a method for dynamically scheduling tasks and balancing load that uses an APSO method in conjunction with dynamic programming as a multi-objective optimization tool. Simulation experiments were used to evaluate the suggested technique against the industry-standard PSO, APSO, and PSO-GA algorithms. Compared to PSO-GA, the suggested technique improved performance by decreasing task makespan by 30% and enhancing resource usage by 29%. Furthermore, the suggested technique was linked to increases in fitness function value and reductions in service cost or waiting time relative to other methods.

Because of the high volume of incoming tasks in the cloud, LB is a critical concern. An intelligent choice is made by the data center controller or an agent to complete a large number of tasks in a short amount of time or quickly. In this work, [15] introduced a powerful scheduling technique, DRLPPSO, for balancing loads and their parameters using deep reinforcement learning and parallel particle swarm optimization. Our experiments show that particularly in comparison to MPSO, A3C, and Deep DQN methods, our suggested scheduling algorithm tends to increase the reward by 15.7%, 12%, and 13.1% for a task set of 2000, as well as enhances the reward by 17.5%, 12.6%, or 15.3% for a task set of 4000.

Despite substantial infrastructural advances, cloud computing still faces several load-balancing difficulties. Several strategies for improving load balancing effectiveness have been suggested in the literature. According to recent research, LB strategies based on metaheuristics give superior solutions for optimal resource scheduling and allocation in the cloud. Nevertheless, most present techniques focus on a few QoS indicators while ignoring several crucial aspects. The performance efficiency of these technologies is increased further by combining them with optimization methods.

RESEARCH METHODOLOGY

This section proposes a novel load-balancing approach based on an improved harmony-inspired and simulated annealing algorithm for dynamic task allocation named dynamic improved HISA-LB to solve the TS and LB problems discussed below.

Statement of the Problem

Develop an algorithm for scheduling tasks which, in addition to satisfying the user's criteria, produces a high resource use effectiveness. The existing methods for task scheduling in Cloud merely map tasks to VMs without considering the LB of the host computers. This may be done to prevent the overhead required, seeing as how satisfying users' needs is a higher priority than breaking the SLA. In previous work [8], A PSO algorithm with certain modifications, given the name LBMPSO, was employed to find a solution to the issue of LB and job scheduling. The LBMPSO TS approach was founded on the PSO algorithm, which relied on a fitness function to determine each particle's optimal configuration. FF was responsible for determining the execution times of each VM and returning the execution time considered the most elevated fitness value (F) of every PSO particle. However, inefficient utilization of resources can result in significant loss of power resources and financial loss for cloud service providers. This is because it was experiencing some convergence local optima problems, which caused it to not utilize the task allocation in a manner that was as efficient as possible to minimize execution time.

Therefore, our solution is to create a task scheduling algorithm that also considers the hosts' load. This will allow us to avoid overloading the hosts, which will allow us to meet the user's time requirements (thus adhering to SLA as well as improving QoS), as well as identify underloaded hosts, which will prevent the unneeded consumption of energy as well as increase the throughput.

Proposed Methodology: HISA-LB Model

Virtualization technology is utilized in the Cloud to manage resources efficiently. This project seeks to address the issue of dynamic, reliable task scheduling and resource utilization in a virtualized data center by mapping user request (tasks) to virtual machines and virtual machines to hosts, accompanied by addressing imbalances in host loads for efficient resource utilization.

A detailed proposed methodology is described in this section that is based on two optimization techniques. An improved dynamic harmony-inspired search algorithm and simulated annealing are used as these two techniques for load balancing by allocating tasks dynamically. The harmony-inspired algorithm is improved by updating the HMCR, PAR and Fret width calculation process. This approach is termed the Dynamic improved HISA load balancing approach that mainly focuses on efficient resource allocation that causes resource utilization to be increased, and makespan can be decreased. This approach calculates a minimum makespan as a FF to estimate the ideal arrangement of every Harmony and fret width. Fig. 1 depicts the proposed method's flowchart for its significance in allocating tasks and resources.

Improved Harmony Inspired Algorithm for Dynamic Task Allocation

Harmony is a possible solution in the HSA, where each decision variable of the solution corresponds to a note. HS features a harmonic memory (HM) that stores a predefined number of harmonies (N). Assume the aim is to minimize/maximize a fitness function (f) under the influence of d choice factors. The following is the definition of this optimization process:

$$Min\ (or\ Max) f = (x_1, x_2, .. x_d) \quad (1)$$

wherein f is the fitness function and x_i I = 1,2,...,d) denotes the decision variable I and d denote the issue dimension.

For this research, the fitness function is calculated by eq. (2)

$$Fit = T_{wait} + Makspan + RU \quad (2)$$

Where Fit= fitness function of Dynamic improved HISA-LB

T_{wait} = waiting time. Now is the time to wait for work to be assigned to a separate VM.

RU = Resource utilization

The specifics of each stage are described in the following format[16]:

Step 1. Initialization of HM

At the outset of HS, N harmonies are generated in the metric space and stored in HM. It is possible to provide Harmony I using a vector: Harmony I = [xi,1xi,2... xi,d]. Eq. (2) may be utilized to set up HM.

$$x_{i,j}^{0} = x_j^{min} + Rand(x_j^{max} - x_j^{min}) \quad (3)$$

here x_j^{max} & x_j^{min} The maximum and minimum values for choice variables j and rand are uniformly distributed random integers among 0 or 1.

Step 2: Improvisation of an HM

The next step is to improvise a new harmony, $x_i^{new} = [x_1^{new}, x_2^{new}, \ldots, x_d^{new}]$. The HS algorithm's most notable characteristic is that, unlike the other algorithms, it creates a new harmonic by using all of the existing harmonies. The technique outlined below must be used to generate the decision variable j. This process is repeated with each of the choice factors until a new harmony is found.

$$x_i^{new} = \begin{cases} x_i^j & j \in (1, 2, \ldots, HM), Rand < HM\_CR \\ x_i \in X_i, & else \end{cases} \quad (4)$$

The pitch of each component acquired by taking the Memory into account is evaluated to determine whether it has to be altered.

The PAR parameter controls the rate of pitch adjustment. The following equation may be used to explain the pitch-adjustment process:

$$x_i^{new} = \begin{cases} x_i^j \pm Rand * F_W, & Rand < P\_A\_R\_ \\ x_i^{new}, & else \end{cases} \quad (5)$$

wherein Rand is a random no. Uniformly distributed among 0 as well as 1.

1) HMCR

HMCR ∈[0, 1] specifies whether a decision variable's value is to be selected from HM. This study employs a linear reducing technique to update HMCR to ensure that algorithms can rapidly identify local optimums in early operation while ensuring that resolutions reached in later operations are different [12]:

$$HM\_CR(t) = HM\_CR_{max} - \frac{(HM\_CR_{max} - HM\_CR_{min}) * t}{T_{max}} \quad (6)$$

where t is the current iteration number; To determine a maximum number of repetitions, we use the parameter Tmax. The maximal harmony memory consideration rate (HMCRmax) and thus the lowest HMCR (HMCRmin).

2) Pitch Adjustment Rate

Local search in HS is determined in part by the PAR. Using the right PAR may prevent the search from being stuck in a local optimum. In general, a lower PAR is helpful in the early search stage for finding the local optimum solution, whereas a bigger PAR is good for bypassing that solution and moving on to the next. The method presented in this research incorporates a dynamic change approach for PAR, and the corresponding mathematical formula for PAR is:

$$P\_A\_R(t) = \frac{(P\_A\_R_{max} - P\_A\_R_{min})}{\frac{\pi}{2}} * \arctan t + P\_A\_R_{min} \quad (7)$$

wherein P_A_R(t) is the rate at which the pitch is adjusted for the t-the generation, $P\_A\_R_{max}$ is the rate at which the harmony memory is considered at its maximum, as well as $P\_A\_R_{min}$ is the rate at which it is considered at its lowest.

3) Fret Width

If used correctly, the proper Fret Width (F_W) can effectively change the pace at which an algorithm converges to the optimum solution. The value of F_W goes from being huge to quite little throughout this work. The value of F_W will vary dynamically depending on the generation number, as seen in the following:

$$F\_W(t) = F\_W_{max} - \frac{(F\_W_{max} - F\_W_{min}) * t}{T_{max}} \quad (8)$$

where F_W(t) is the pitch fret width for the t-the generation, F_W_{max}, as well as F_W_{min}, are the maximal and minimal harmony memory processing rate, correspondingly.

Step 4: Harmony Memory Update

If, after assessing the fitness function, the newer harmony vector is determined to be superior to the worst vector, the newer vector will take the place of the worst vector.

Step 5: Termination condition check

In the instance that the maximal number of iterations has been exceeded, the Dynamic Improved HS Algorithm is terminated. In such a case, steps three and four are performed repeatedly.

The optimization steps for the improved HS algorithm are concise in following Algorithm 1.

Algorithm 1: Improved HSA

Method:

Step 1. Initialize HSA parameters.
Step 2. Initialize maximal no. of iterations *T*max; the harmony memory size (HMS), maximal & minimal HM considering rate, HM_CRmax &HM_CRmin; maximal and minimal pitch adjusting rate, P_A_Rmax and P_A_Rmin; maximal and minimal fret width, F_Wmax or F_Wmin.
Step 3. Initialize harmony memory (HM).
Step 4. Establish novel Harmony based on HM. Utilize equations (2), (3), (4), (5), as well as (6) to create a novel harmony.
Step 5. Increase HM. Employ (1) to assess the suitability of the new Harmony. If novel Harmony is superior to the least favorable harmonic in HM, the least favourable Harmony is removed from HM and novel Harmony is added.
Step 6. Evaluate the termination condition. Improved HS will end if no. of iterations exceeds maximal no. of iterations Tmax. Otherwise, proceed to Step 4.
Step 7. **Return** The best-optimized solution in the harmony memory for dynamic task allocation

2. Simulated Annealing

In the procedure of finding an optimal solution, SA recognizes not only an optimization solution but as well as an inferior solution with such random acceptance criterion, as well as the probability of accepting worse alternatives tends to be zero, having caused the method to potentially jump out of the local region of solutions as well as find the optimal global solution. The algorithm's convergence could be maintained. This work implements SA in the otherwise clause if probabilities are less than or equivalent to HMCR, enhancing the memory capacity of HI algorithms. The procedure of SA is as follows:

Step1: Initial value x_0 is produced.

Step2: A novel reasonable solution x_1 is produced under temperature tmp_k, x_1 is in neighborhood solution of x_0

Step3: Estimate the variance Δ Fit=Fit(x_1)−Fit(x_0) of fitness function Fit(x_0) and Fit(x_1); Step4: Receiving novel solution by min {1, exp¿ of probability, that random [0,1] is random no. among 0 or 1. If the solution reaches the balance status of temperature tmp_k, turn to (5), or turn to (2);

Step5: Temperature may be decreased in a certain way. Temperature drop function may be distinct as $tmp_{k+1} = \alpha\ tmp_k$, $\alpha = 0.9$.

The procedure of SA is given below in algorithm2:

Algorithm2: Simulated Annealing

Procedure:

1. Randomly initialize a processing unit set and the control parameter to a very large positive value.
2. Repeat until the control parameter value reaches the minimum:
   a) Generate a random set of processing units and calculate ΔFit using the:
   $$\Delta Fit = Fit(x_1) - Fit(x_0) \quad (9)$$
   b) Select the new set of a processing unit with probability Pij calculated using:
   $$P_{ij}(Fit) = min\{1, \exp(-(Fit(x_1) - Fit(x_0))/Fit)\} \quad (10)$$
   c) Repeat until the inner loop break condition is met.
   d) Decrease the temperature by a certain rate.
   e) Goto steps two loops.
3. End

The proposed dynamic improved HISA load balancing approach is described in detail with pseudocode in Algorithm 3, and the flowchart for this model can be seen in Figure 3.

Algorithm3. Dynamic Improved HISA Load Balancing Approach

Pseudocode:

1. Begin
2. Generate the harmony memory
3. Initialization of all parameters, tmp (temperature), Num (t) = 0, T_{max}= 5000
4. Calculate all parameters values
5. Evaluate the fitness function by the formula

$$Fit = T_{wait} + Makspan + RU$$

6. Place BestX (the best solution in Harmony Memory (HM)) into δ
7. BstSol = BstSASol = δ
8. For p = (1 to t) do
9. Update the HMCR by the given formula

$$HM\_CR\ (t) = HM\_CR_{max} - \frac{(HM\_CR_{max} - HM\_CR_{min}) * t}{T_{max}}$$

10. If (random (0,1) ≤ HM_CR) Then
11. Select 2 vectors solution symbolized as υ1 & υ2 at random from Harmony memory
12. Update PAR by dynamic change strategy by the given formula

$$P\_A\_R(t) = \frac{(P\_A\_R_{max} - P\_A\_R_{min})}{\frac{\pi}{2}} * \arctan t + P\_A\_R_{min}$$

13. F_W changes dynamically with the number of iterations by the given formula

$$F\_W(t) = F\_W_{max} - \frac{(F\_W_{max} - F\_W_{min}) * t}{T_{max}}$$

14. If (random (0,1) ≤ P_A_R) Then
15. υ = put on a PMX crossover to υ1 and υ2
16. newX = the best neighbor amongst some of the neighbors created by υ
17. If (SumFit(newX) < SumFit(worstX)) Then
18. Swap worstX by newX **//Modifying the HM**
19. End of If
20. End of If
21. End of If
22. Else
23. δ' = the best neighbor among the generated neighbors of δ
24. ΔFit = SumFit(δ') – SumFit(δ)
25. probability = Random (0,1)
26. If ((ΔFit ≤ 0) or (probability < $e^{-\Delta Fit/tmp}$)) Then
27. $\delta = \delta'$, newX = δ'
28. If (SumFit(newX) < SumFit(worstX)) Then
29. Swap the worstX by newX **// Modifying the HM**
30. End of If
31. If (SumFit(δ) < SumFit(BstSASol)) Then
32. BstSASol = δ
33. End of If
34. End of If
35. tmp = Modify (tmp)
36. End of Else
37. If (SumFit(BestX) < SumFit(BstSol))
38. BstSol = BestX, t = 0
39. End of If
40. If (SumFit(BstSASol) - SumFit(BstSol) ≥ T_{max})
41. δ = BstSol
42. End of If
43. End of For
44. Get the result BstSol together with its fitness function value
45. Stop.

Output: Dynamic task allocation

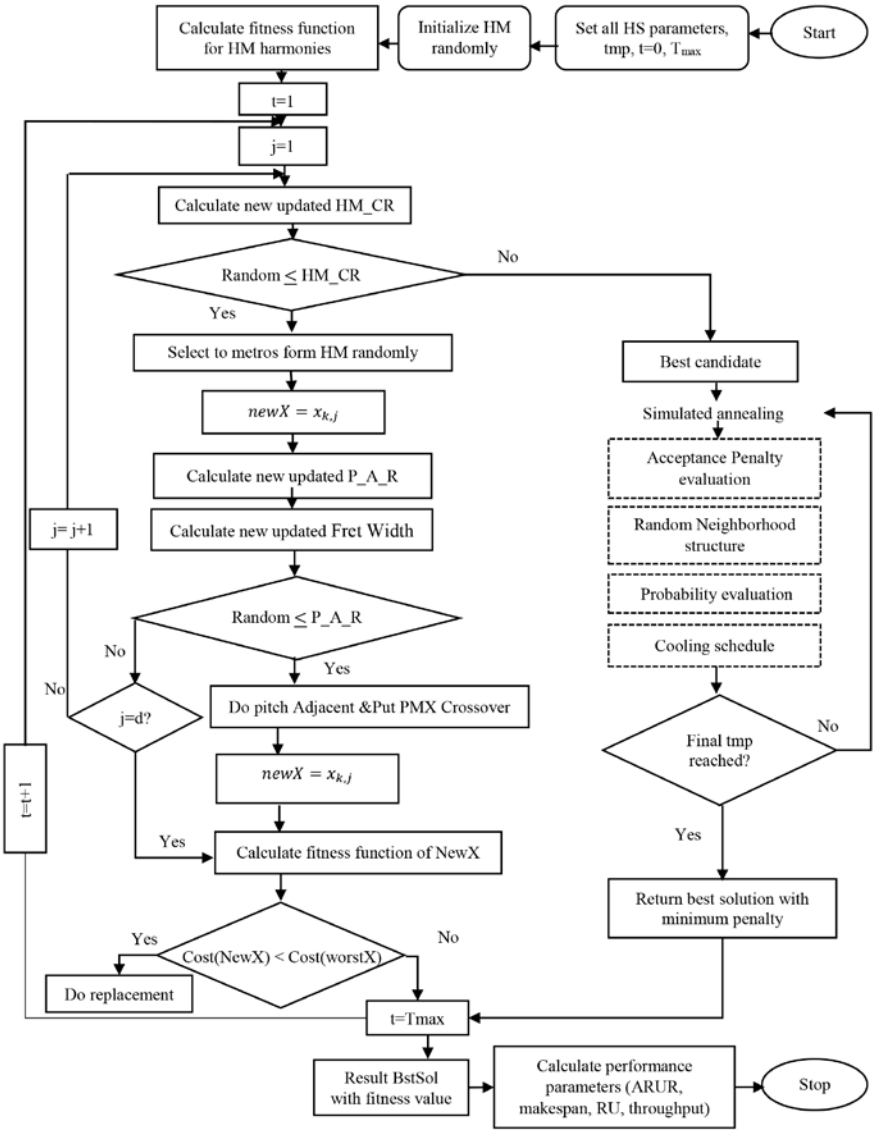


Fig. 1. Flowchart of proposed Dynamic improved HISA load balancing approach

RESULTS AND DISCUSSION

The proposed Dynamic HISA load balancing algorithm is simulated using the CloudSim tool and executed on Eclipse Java Programming Environment. There are several parameters to appraise the proposed algorithm's performance, which are helpful in performing a comparison with other existing techniques. The experimental setting and parameters details are given below.

A. Experiment Setting

No experiments have been conducted to obtain desired results in cloud scenarios. For the setup of the experimental scenarios in the cloud, there is a need for some parameters that are defined in table 1. Such parameters are related to the required cloudsim setting, HSA and SAA. There are two scenarios in a testing environment

- 3 VMs and 10 to 50 cloudlets
- 5 VMs and 10 to 50 cloudlets

Table 1. Parameters properties detail

Setting	Parameters	Value
Software	Operating system	Windows 10 (64-bits)
	RAM	12 GB
Cloud parameters	Simulation Tool	CloudSim
	Cloudlets (Tasks) range	10-50
	Cloudlet Length	1000-6000
	Cloud File Size	300
	Virtual machine range	3-5
	Memory	256-512 GB
	CPU	1-5
	Bandwidth	1000
	Virtual Machine Monitor	XEN
	Processing speed	250-300 MIPS
Harmony Search Algorithm parameters	Harmony Memory Size	20
	Number of New Harmonics	30
	Maximum Harmony Memory Consideration Rate (HM_CR_Max)	0.95f
	Minimum Harmony Memory Consideration Rate (HM_CR_Min)	0.6f
	Maximum Pitch Adjustment Rate (P_A_R_Max)	0.99f
	Minimum Pitch Adjustment Rate (P_A_R_Min)	0.01f
	Maximum Fret Width (F_W_Max)	1.0f
	Minimum Fret Width (F_W_Min)	0.001f
	Number of iterations (T_{max})	5000
Simulated Algorithm parameters	cooling rate (α)	0.9
	initial temperature (t_0)	1000

B. Key Performance Indicators

Key Performance Indicator compares particular KPIs of conventional IT with CC solutions to promote CC adoption. These are cost, time, quality, and profitability measures related to Cloud Computing features. The performance results of the model measure these indicators.

Makespan: Makespan is the time difference between the beginning and end of a series of tasks or activities. It is also defined as the completion time of the last job to leave the system calculated in the eq. (8).

$$\text{Makespan}=\text{Last Finish Time}=FT_n \quad (8)$$

Where, FT_n is the finish time of the last task. Maximum makespan is same as makespan last completion time.

$$\text{Makespan}_{max} = \text{Max}\{FT_1, FT_2, FT_3 \ldots FT_n\} \quad (8)$$

$$\text{Makespan}_{min} = \text{Min}\{FT_1, FT_2, FT_3 \ldots FT_n\} \quad (8)$$

Average Execution Time: The execution time, also

known as CPU time, is the entire quantity of time that the procedure runs; this time is normally independent of the initiation time but frequently relies on the input data. The execution time is the difference between the end and start times. Subtract the start time from the finish time to determine the execution time.

ET = End time−Start time (8)

The expected execution time (EET) or average execution time of task T_i, where i = {1, 2,.....x) execute on virtual machine VMj, where j = {1,2,…,y} may be signify as an Equation. (2).

$$EET_{i,j} = \sum_{i=1}^{x} T_i * \sum_{j=1}^{y} VM_{sr} \quad (8)$$

Throughput: Throughput is the efficiency at which a computer service or device accomplishes tasks over a certain period. Adequate throughput is required to ensure that all applications execute efficiently. The formula is:

Througput = (number of incoming requests)/(total time) (9)

Resource Utilization:

Resource utilisation is a key aspect of saving energy in data centers. The total execution time of all tasks multiplied by the greatest execution time or makespan is used to evaluate resource utilisation.

RU = (execution $time_i$/makespan) (10)

Average Resource Utilization Ratio: Eq. (10) shows the average utilisation.

$$ARUR = \frac{\sum_{j=1}^{m} RU}{m} * 100 \quad (11)$$

where 'm' number of resources.

Resource Utilization is defined as the percentage of resources consumed by the incoming workload. In other words, it shoes

C. Results

In this section, several results were obtained after experimentations into two cloud cases by the proposed Dynamic improved HISA load balancing approach. All these results are displayed in screenshots, tabular and graphical forms on 3VMs and 5VMs 10 to 50 cloudlets.

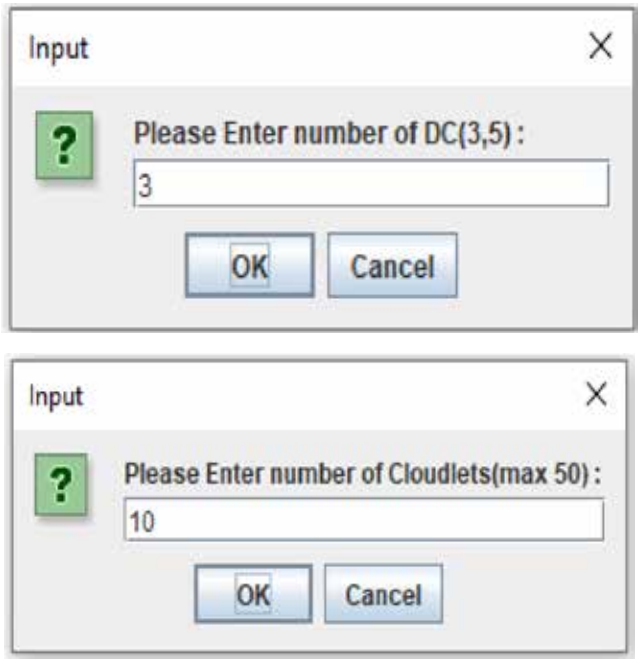


Fig. 2. GUI for entering Number of (a) Datacenter (b) Cloudlets

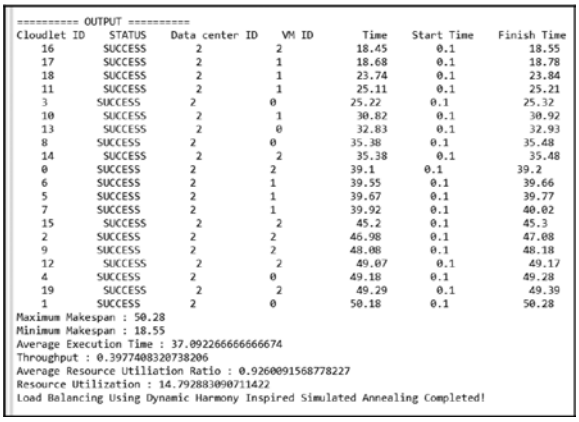
Figure 2 shows the GUI for entering a number of the Virtual machine at a data center and the cloudlets after selecting VMs.

From here, the user can choose either 3 or 5 VM and cloudlets between 10 (minimum) to 50 (maximum) for any scenarios to test the approach.

1) Case1: 3 Virtual Machines 10 to 50 cloudlets

```
========== OUTPUT ==========
Cloudlet ID    STATUS    Data center ID    VM ID    Time    Start Time    Finish Time
    8          SUCCESS        2            2       6.7       0.1           6.8
    3          SUCCESS        2            0      11.75      0.1          11.85
    1          SUCCESS        2            2      16.68      0.1          16.78
    2          SUCCESS        2            1      18.66      0.1          18.76
    4          SUCCESS        2            1      20.34      0.1          20.44
    9          SUCCESS        2            2      20.55      0.1          20.65
    7          SUCCESS        2            2      23.72      0.1          23.82
    0          SUCCESS        2            2      25.83      0.1          25.93
    5          SUCCESS        2            1      28.59      0.1          28.69
    6          SUCCESS        2            1      28.77      0.1          28.87
Maximum Makespan : 28.87
Minimum Makespan : 6.8
Average Execution Time : 20.158533333333333
Throughput : 0.34636432909229453
Average Resource Utiliation Ratio : 0.7694906904965326
Resource Utilization : 7.0168333063938855
Load Balancing Using Dynamic Harmony Inspired Simulated Annealing Completed!
```

Fig. 3. 10 cloudlets at 3 VMs

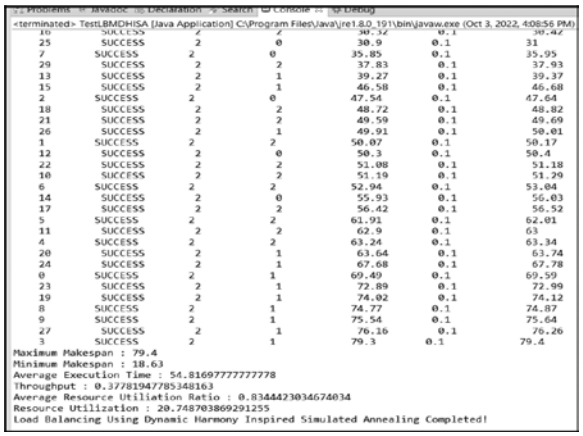


```
========== OUTPUT ==========
Cloudlet ID    STATUS    Data center ID    VM ID    Time    Start Time    Finish Time
    16         SUCCESS          2           2      18.45       0.1          18.55
    17         SUCCESS          2           1      18.68       0.1          18.78
    18         SUCCESS          2           1      23.74       0.1          23.84
    11         SUCCESS          2           1      25.11       0.1          25.21
     3         SUCCESS          2           0      25.22       0.1          25.32
    10         SUCCESS          2           1      30.82       0.1          30.92
    13         SUCCESS          2           0      32.83       0.1          32.93
     8         SUCCESS          2           0      35.38       0.1          35.48
    14         SUCCESS          2           2      35.38       0.1          35.48
     0         SUCCESS          2           2       39.1       0.1          39.2
     6         SUCCESS          2           1      39.55       0.1          39.66
     5         SUCCESS          2           1      39.67       0.1          39.77
     7         SUCCESS          2           1      39.92       0.1          40.02
    15         SUCCESS          2           2       45.2       0.1          45.3
     2         SUCCESS          2           2      46.98       0.1          47.08
     9         SUCCESS          2           2      48.08       0.1          48.18
    12         SUCCESS          2           2      49.07       0.1          49.17
     4         SUCCESS          2           0      49.18       0.1          49.28
    19         SUCCESS          2           2      49.29       0.1          49.39
     1         SUCCESS          2           0      50.18       0.1          50.28
Maximum Makespan : 50.28
Minimum Makespan : 18.55
Average Execution Time : 37.092266666666674
Throughput : 0.3977408320738206
Average Resource Utiliation Ratio : 0.9260091568778227
Resource Utilization : 14.792883090711422
Load Balancing Using Dynamic Harmony Inspired Simulated Annealing Completed!
```

Fig. 4. 20 cloudlets at 3 VMs

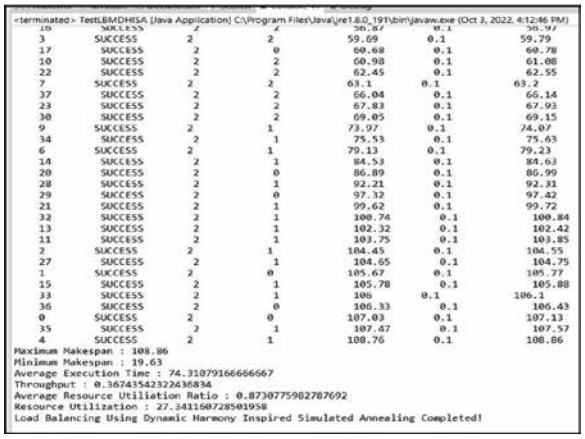
Figure 3 depicts the outcome for case-1 with three virtual machines and ten cloudlets. This cloudlets ID displays the status, data center ID, virtual machines ID, time, start time, and end (or finish) time, with Cloudlets ID 6 having the longest finish time of 28.87 seconds and Cloudlets ID 8 having the shortest finish time of 6.8 seconds. Five tests during this case resulted in a maximum makespan of 28.87 seconds. The average resource usage ratio is 0.769, and the maximum throughput is 0.346.

Figure 4 depicts the outcome for case-1 with three virtual machines and twenty cloudlets. In this, cloudlets ID 1 has the longest finish time of 50.28 seconds, and Cloudlets ID 16 has the shortest finish time of 18.55 seconds. Five tests during this case resulted in a maximum makespan of 50.28 seconds which is the minimum in all five tests. The highest Resource Utilization is 14.79, ARUR is 0.926, and the maximum throughput is 0.397.



```
<terminated> TestLBMDHISA [Java Application] C:\Program Files\Java\jre1.8.0_191\bin\javaw.exe (Oct 3, 2022, 4:08:56 PM)
    25         SUCCESS          2           0       30.9       0.1          31
     7         SUCCESS          2           0      35.85       0.1        35.95
    29         SUCCESS          2           2      37.83       0.1        37.93
    13         SUCCESS          2           1      39.27       0.1        39.37
    15         SUCCESS          2           1      46.58       0.1        46.68
     2         SUCCESS          2           0      47.54       0.1        47.64
    18         SUCCESS          2           2      48.72       0.1        48.82
    21         SUCCESS          2           2      49.59       0.1        49.69
    26         SUCCESS          2           1      49.91       0.1        50.01
     1         SUCCESS          2           2      50.07       0.1        50.17
    12         SUCCESS          2           0       50.3       0.1        50.4
    22         SUCCESS          2           2      51.08       0.1        51.18
    10         SUCCESS          2           2      51.19       0.1        51.29
     6         SUCCESS          2           2      52.94       0.1        53.04
    14         SUCCESS          2           0      55.93       0.1        56.03
    17         SUCCESS          2           2      56.42       0.1        56.52
     5         SUCCESS          2           2      61.91       0.1        62.01
    11         SUCCESS          2           2       62.9       0.1          63
     4         SUCCESS          2           2      63.24       0.1        63.34
    20         SUCCESS          2           1      63.64       0.1        63.74
    24         SUCCESS          2           1      67.68       0.1        67.78
     0         SUCCESS          2           1      69.49       0.1        69.59
    23         SUCCESS          2           1      72.89       0.1        72.99
    19         SUCCESS          2           1      74.02       0.1        74.12
     8         SUCCESS          2           1      74.77       0.1        74.87
     9         SUCCESS          2           1      75.54       0.1        75.64
    27         SUCCESS          2           1      76.16       0.1        76.26
     3         SUCCESS          2           1       79.3       0.1        79.4
Maximum Makespan : 79.4
Minimum Makespan : 18.63
Average Execution Time : 54.816977777777778
Throughput : 0.37781947785348163
Average Resource Utiliation Ratio : 0.8344423034674034
Resource Utilization : 20.748703869291255
Load Balancing Using Dynamic Harmony Inspired Simulated Annealing Completed!
```

Fig. 5. 30 cloudlets at 3 VMs

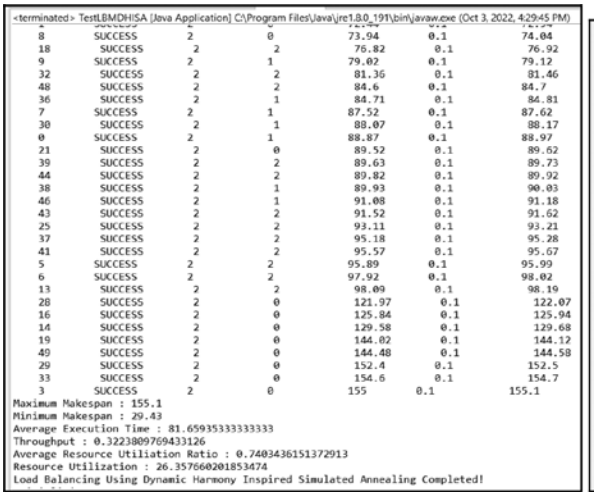


```
<terminated> TestLBMDHISA [Java Application] C:\Program Files\Java\jre1.8.0_191\bin\javaw.exe (Oct 3, 2022, 4:12:46 PM)
     3         SUCCESS          2           2      59.69       0.1          59.79
    17         SUCCESS          2           0      60.68       0.1          60.78
    10         SUCCESS          2           2      60.98       0.1          61.08
    22         SUCCESS          2           2      62.45       0.1          62.55
     7         SUCCESS          2           2       63.1       0.1          63.2
    37         SUCCESS          2           2      66.04       0.1          66.14
    23         SUCCESS          2           2      67.83       0.1          67.93
    30         SUCCESS          2           2      69.05       0.1          69.15
     9         SUCCESS          2           1      73.97       0.1          74.07
    34         SUCCESS          2           1      75.53       0.1          75.63
     6         SUCCESS          2           1      79.13       0.1          79.23
    14         SUCCESS          2           1      84.53       0.1          84.63
    20         SUCCESS          2           0      86.89       0.1          86.99
    28         SUCCESS          2           1      92.21       0.1          92.31
    29         SUCCESS          2           0      97.32       0.1          97.42
    21         SUCCESS          2           1      99.62       0.1          99.72
    32         SUCCESS          2           1     100.74       0.1         100.84
    13         SUCCESS          2           1     102.32       0.1         102.42
    11         SUCCESS          2           1     103.75       0.1         103.85
     2         SUCCESS          2           1     104.45       0.1         104.55
    27         SUCCESS          2           1     104.65       0.1         104.75
     1         SUCCESS          2           0     105.67       0.1         105.77
    15         SUCCESS          2           1     105.78       0.1         105.88
    33         SUCCESS          2           1        106       0.1         106.1
    36         SUCCESS          2           0     106.33       0.1         106.43
     0         SUCCESS          2           0     107.03       0.1         107.13
    35         SUCCESS          2           1     107.47       0.1         107.57
     4         SUCCESS          2           1     108.76       0.1         108.86
Maximum Makespan : 108.86
Minimum Makespan : 19.63
Average Execution Time : 74.31079166666667
Throughput : 0.3674354232436834
Average Resource Utiliation Ratio : 0.8730775982787692
Resource Utilization : 27.341160728501958
Load Balancing Using Dynamic Harmony Inspired Simulated Annealing Completed!
```

Fig. 6. 40 cloudlets at 3 VMs

Figure 5 depicts the outcome for case-1 with three virtual machines and thirty cloudlets; in this, cloudlets. ID 3 has the longest finish time of 79.4 seconds. Five tests during this case resulted in a maximum makespan of 79.4 seconds, the minimum in all five tests, whereas the minimum makespan is 18.63 seconds. The highest Resource Utilization is 20.748, ARUR is 0.83, and the maximum throughput is 0.377.

Figure 6 depicts the outcome for case-1 with three virtual machines and forty cloudlets. Cloudlet ID 4 has the longest completion time, in this case, clocking in at 108.86 seconds. However, the start time for every cloudlet is 0.1 seconds. Five tests, in this case, resulted in a maximum makespan of 108.86 seconds and a minimum makespan of 19.63 seconds. The maximum resource utilization is 27.34, and the maximum throughput is 0.367.



```
<terminated> TestLBMDHISA [Java Application] C:\Program Files\Java\jre1.8.0_191\bin\javaw.exe (Oct 3, 2022, 4:29:45 PM)
     8         SUCCESS          2           0      73.94       0.1          74.04
    18         SUCCESS          2           2      76.82       0.1          76.92
     9         SUCCESS          2           1      79.02       0.1          79.12
    32         SUCCESS          2           2      81.36       0.1          81.46
    48         SUCCESS          2           2       84.6       0.1          84.7
    36         SUCCESS          2           1      84.71       0.1          84.81
     7         SUCCESS          2           1      87.52       0.1          87.62
    30         SUCCESS          2           1      88.07       0.1          88.17
     0         SUCCESS          2           1      88.87       0.1          88.97
    21         SUCCESS          2           0      89.52       0.1          89.62
    39         SUCCESS          2           2      89.63       0.1          89.73
    44         SUCCESS          2           2      89.82       0.1          89.92
    38         SUCCESS          2           1      89.93       0.1          90.03
    46         SUCCESS          2           1      91.08       0.1          91.18
    43         SUCCESS          2           2      91.52       0.1          91.62
    25         SUCCESS          2           2      93.11       0.1          93.21
    37         SUCCESS          2           2      95.18       0.1          95.28
    41         SUCCESS          2           2      95.57       0.1          95.67
     5         SUCCESS          2           2      95.89       0.1          95.99
     6         SUCCESS          2           2      97.92       0.1          98.02
    13         SUCCESS          2           2      98.09       0.1          98.19
    28         SUCCESS          2           0     121.97       0.1         122.07
    16         SUCCESS          2           0     125.84       0.1         125.94
    14         SUCCESS          2           0     129.58       0.1         129.68
    19         SUCCESS          2           0     144.02       0.1         144.12
    49         SUCCESS          2           0     144.48       0.1         144.58
    29         SUCCESS          2           0      152.4       0.1          152.5
    33         SUCCESS          2           0      154.6       0.1          154.7
     3         SUCCESS          2           0        155       0.1          155.1
Maximum Makespan : 155.1
Minimum Makespan : 29.43
Average Execution Time : 81.65935333333333
Throughput : 0.32238097694331126
Average Resource Utiliation Ratio : 0.7403436151372913
Resource Utilization : 26.357660201853474
Load Balancing Using Dynamic Harmony Inspired Simulated Annealing Completed!
```

Fig. 7. 50 cloudlets at 3 VMs

```
========== OUTPUT ==========
Cloudlet ID    STATUS    Data center ID    VM ID    Time    Start Time    Finish Time
     7         SUCCESS         2            3      5.66       0.1          5.76
     0         SUCCESS         2            3      12.13      0.1          12.23
     8         SUCCESS         2            4      12.9       0.1          13
     4         SUCCESS         2            3      15.04      0.1          15.14
     6         SUCCESS         2            3      15.15      0.1          15.25
     1         SUCCESS         2            3      17.92      0.1          18.02
     3         SUCCESS         2            4      20.66      0.1          20.76
     9         SUCCESS         2            2      21.12      0.1          21.22
     2         SUCCESS         2            2      22.02      0.1          22.12
     5         SUCCESS         2            4      22.14      0.1          22.24
Maximum Makespan : 22.24
Minimum Makespan : 5.76
Average Execution Time : 16.471966666666667
Throughput : 0.4496537665997183
Average Resource Utiliation Ratio : 0.5609340807578165
Resource Utilization : 7.451647231631644
Load Balancing Using Dynamic Harmony Inspired Simulated Annealing Completed!
```

Fig. 8. 10 cloudlets at 5 VMs

Figure 7 depicts the outcome for case-1 with three virtual machines and fifty cloudlets. In this case, cloudlet ID 38 is successful at Datacenter ID 2 with no VM allocation and took 155.1seconds to complete. Cloudlet ID 3 has a start time of 0.1 seconds. It obtained a 155.1seconds maximum makespan from five tests for three virtual machines and fifty cloudlets. The maximum resource usage is 26.357, ARUR is 0.74, and the maximum throughput is 0.322.

2) Case 2: 5 Virtual Machines 10 to 50 cloudlet

```
========== OUTPUT ==========
Cloudlet ID    STATUS    Data center ID    VM ID    Time    Start Time    Finish Time
    15         SUCCESS         2            2      5.49       0.1          5.59
    13         SUCCESS         2            3      6.86       0.1          6.96
    19         SUCCESS         2            2      7.29       0.1          7.39
    18         SUCCESS         2            4      7.47       0.1          7.57
     9         SUCCESS         2            2      9.1        0.1          9.2
     4         SUCCESS         2            3      10.11      0.1          10.21
     5         SUCCESS         2            4      10.22      0.1          10.32
    11         SUCCESS         2            3      11.15      0.1          11.25
     6         SUCCESS         2            4      14.11      0.1          14.21
    12         SUCCESS         2            3      15.34      0.1          15.44
     1         SUCCESS         2            4      17.75      0.1          17.85
     0         SUCCESS         2            3      19.65      0.1          19.75
     7         SUCCESS         2            3      20.2       0.1          20.3
    14         SUCCESS         2            3      22.1       0.1          22.2
    10         SUCCESS         2            3      22.98      0.1          23.08
     2         SUCCESS         2            2      23.37      0.1          23.47
    17         SUCCESS         2            4      24.6       0.1          24.7
    16         SUCCESS         2            4      24.96      0.1          25.06
     8         SUCCESS         2            4      26.48      0.1          26.58
     3         SUCCESS         2            4      26.94      0.1          27.04
Maximum Makespan : 27.04
Minimum Makespan : 5.59
Average Execution Time : 16.308441666666667
Throughput : 0.739655912069705
Average Resource Utiliation Ratio : 0.5442851718713788
Resource Utilization : 12.136600886600885
Load Balancing Using Dynamic Harmony Inspired Simulated Annealing Completed!
```

Fig. 9. 20 cloudlets at 5 VMs

```
<terminated> TestLBMDHISA [Java Application] C:\Program Files\Java\jre1.8.0_191\bin\javaw.exe (Oct 3, 2022, 3:19:41 PM)
     6         SUCCESS         2            4      13.1       0.1          13.2
    28         SUCCESS         2            2      14.69      0.1          14.79
    10         SUCCESS         2            2      17.18      0.1          17.28
    23         SUCCESS         2            4      19.21      0.1          19.31
    24         SUCCESS         2            3      20.26      0.1          20.36
     3         SUCCESS         2            4      23.31      0.1          23.41
     9         SUCCESS         2            2      24.26      0.1          24.36
     8         SUCCESS         2            4      24.61      0.1          24.71
     1         SUCCESS         2            4      25.13      0.1          25.23
    16         SUCCESS         2            3      25.96      0.1          26.06
    29         SUCCESS         2            4      26.07      0.1          26.17
    27         SUCCESS         2            3      26.63      0.1          26.73
    21         SUCCESS         2            4      26.74      0.1          26.84
    18         SUCCESS         2            2      27.61      0.1          27.71
    26         SUCCESS         2            2      28.73      0.1          28.83
     7         SUCCESS         2            3      28.88      0.1          28.98
    12         SUCCESS         2            2      30.83      0.1          30.93
     5         SUCCESS         2            4      31.31      0.1          31.41
    15         SUCCESS         2            3      31.99      0.1          32.09
    22         SUCCESS         2            3      32.54      0.1          32.64
    14         SUCCESS         2            2      33.06      0.1          33.16
     4         SUCCESS         2            3      33.21      0.1          33.31
    17         SUCCESS         2            3      33.32      0.1          33.42
    11         SUCCESS         2            4      33.69      0.1          33.79
    20         SUCCESS         2            4      35.06      0.1          35.16
     0         SUCCESS         2            4      35.33      0.1          35.43
    25         SUCCESS         2            3      35.85      0.1          35.95
     2         SUCCESS         2            2      37.1       0.1          37.2
    19         SUCCESS         2            3      37.28      0.1          37.38
Maximum Makespan : 37.38
Minimum Makespan : 12.12
Average Execution Time : 27.498222222222232
Throughput : 0.8024823453884012
Average Resource Utiliation Ratio : 0.5885262857550466
Resource Utilization : 22.14708609743919
Load Balancing Using Dynamic Harmony Inspired Simulated Annealing Completed!
```

Fig. 10. 30 cloudlets at 5 VMs

Figures 8 to 12 illustrate the outcome for case 2 with Five Virtual machines with up to 50 cloudlets, similar to case 1. These cloudlet ID are included as per their state and finish time, wherever cloudlet IDs are sorted as per minimum finish time and maximum makespan in seconds. In this case, five independent tests were conducted on every case, with just the shortest maximum makespan findings in case 2. As a result of the presented Dynamic Improved HISA load balancing approach, certain performance indicators such as maximum resource utilization, ARUR, minimum makespan, and throughput have been included.

```
<terminated> TestLBMDHISA [Java Application] C:\Program Files\Java\jre1.8.0_191\bin\javaw.exe (Oct 3, 2022, 3:15:57 PM)
    31         SUCCESS         2            2      28.48      0.1          28.58
    22         SUCCESS         2            4      29.34      0.1          29.44
    11         SUCCESS         2            4      30.51      0.1          30.61
    13         SUCCESS         2            4      32.37      0.1          32.47
     0         SUCCESS         2            4      33.94      0.1          34.04
    25         SUCCESS         2            2      35.55      0.1          35.65
     9         SUCCESS         2            3      35.92      0.1          36.02
     4         SUCCESS         2            2      36.16      0.1          36.26
     7         SUCCESS         2            3      38.41      0.1          38.51
    12         SUCCESS         2            3      44.04      0.1          44.14
    21         SUCCESS         2            3      44.15      0.1          44.25
    15         SUCCESS         2            2      44.3       0.1          44.4
    38         SUCCESS         2            3      44.41      0.1          44.51
    30         SUCCESS         2            3      46.34      0.1          46.44
    28         SUCCESS         2            2      47.62      0.1          47.72
     5         SUCCESS         2            3      47.73      0.1          47.83
    24         SUCCESS         2            2      48.49      0.1          48.59
    14         SUCCESS         2            3      48.67      0.1          48.77
    29         SUCCESS         2            3      48.78      0.1          48.88
    18         SUCCESS         2            2      49.04      0.1          49.14
    33         SUCCESS         2            2      50.29      0.1          50.39
    34         SUCCESS         2            3      53.73      0.1          53.83
    17         SUCCESS         2            3      54.82      0.1          54.92
     1         SUCCESS         2            3      55.92      0.1          56.02
    16         SUCCESS         2            3      56.25      0.1          56.35
     2         SUCCESS         2            3      56.73      0.1          56.83
    32         SUCCESS         2            3      57.73      0.1          57.83
    35         SUCCESS         2            3      58.01      0.1          58.11
     6         SUCCESS         2            3      60.2       0.1          60.3
Maximum Makespan : 60.3
Minimum Makespan : 11.97
Average Execution Time : 38.50565416666666
Throughput : 0.6634030920112447
Average Resource Utiliation Ratio : 0.4800644606671072
Resource Utilization : 25.61111034328346
Load Balancing Using Dynamic Harmony Inspired Simulated Annealing Completed!
```

Fig. 11. 40 cloudlets at 5 VMs

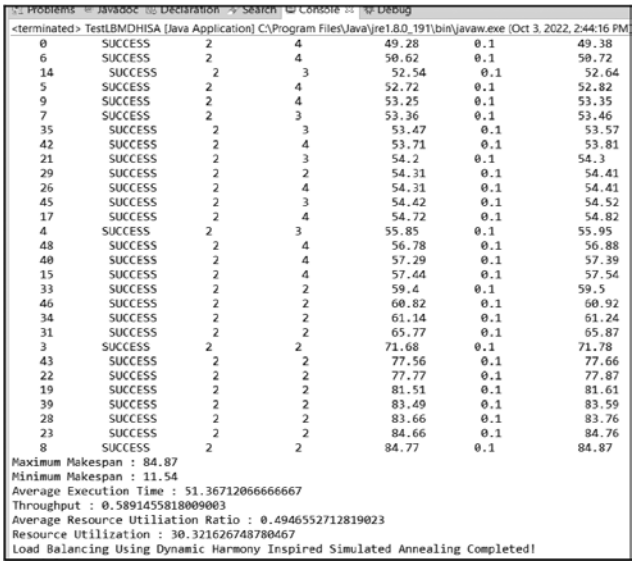


Fig. 12. 50 cloudlets at 5 VMs

Table 2 displays the various test outcomes of two cases in a cloud computing operating context. It computed the findings on various cloudlets sizes from 10 to 50 using dynamic performance such as minimum and maximum makespan, average execution time, throughput, resources use, and ARUR. Table 2 shows that initially, the makespan is minimum at ten cloudlets, which is 28.87 seconds for 3 VMs in the first case. Makespan increases as the number of cloudlets or tasks increases and the highest makespan at 50 cloudlets are 155.1 seconds. Similarly, the makespan and avg. Execution time results increase from 10 to 50 cloudlets for 5 VMs in the second case, but case 2 makespan is less than case 1. This table shows that the throughput value is highest at 20 cloudlets only among all cloudlets sizes, achieving 40% throughput in the first case. But when looking for 5 VMs in case 2, it achieved a higher throughput rate compared to case1 and maximum throughput achieved at 30 cloudlets size by achieving 80 % throughput. Also, it may be seen that Resource utilization is enhanced as no. of cloudlets increases. Therefore, the highest resource utilization value is 27.34 at 40 cloudlets in case 1. Similarly, resource utilization is increased per increment in cloudlets size for 5 VMs in the second case, and its Resource utilization is higher than in the first case, meaning cloudlets efficiently utilize their available resources by properly allocating tasks and achieving the highest Resource utilization of 30.32 at 50 cloudlets.

Table 2. Tests run for the proposed Dynamic Improved HISA-LB approach

Cases	Cloudlets size	Maximum Makespan	Minimum Makespan	Average Execution Time	Throughput	RU	ARUR
Case-1	10	28.87	6.8	20.16	0.35	7.02	0.77
	20	50.28	18.55	37.09	0.40	14.79	0.93
	30	79.4	18.63	54.82	0.38	20.75	0.83
	40	108.86	19.63	74.31	0.37	27.34	0.87
	50	155.1	29.43	81.66	0.32	26.36	0.74
Case-2	10	22.24	5.76	16.47	0.45	7.45	0.56
	20	27.04	5.59	16.31	0.74	12.14	0.54
	30	37.38	12.12	27.49	0.80	22.15	0.59
	40	60.3	11.97	38.51	0.66	25.61	0.48
	50	84.87	11.54	51.37	0.59	30.32	0.49

Table 3. Comparison of two approaches for different Tests in both Cases

Cases	Approaches	Runs	Maximum Makespan	Minimum Makespan	Average Execution Time	Throughput	RU	ARUR
Case-1	Dynamic Improved HISA-LB	Test 1	28.87	6.8	20.16	0.35	7.02	0.77
		Test 2	50.28	18.55	37.09	0.40	14.79	0.93
		Test 3	79.4	18.63	54.82	0.38	20.75	0.83
		Test 4	108.86	19.63	74.31	0.37	27.34	0.87
		Test 5	155.1	29.43	81.66	0.32	26.36	0.74
	LBMPSO	Test 1	54.1	4.27	24.04	0.185	4.46	0.604
		Test 2	107.8	13.38	49.22	0.186	9.15	0.565
		Test 3	155.26	13.81	69.16	0.193	13.38	0.553
		Test 4	208.63	23.54	92.18	0.192	17.69	0.539
		Test 5	246.82	24.47	102.41	0.203	20.77	0.541
Case-2	Dynamic Improved HISA-LB	Test 1	22.24	5.76	16.47	0.45	7.45	0.56
		Test 2	27.04	5.59	16.31	0.74	12.14	0.54
		Test 3	37.38	12.12	27.49	0.80	22.15	0.59
		Test 4	60.3	11.97	38.51	0.66	25.61	0.48
		Test 5	84.87	11.54	51.37	0.59	30.32	0.49
	LBMPSO	Test 1	27.4	4.44	14.03	0.365	5.16	0.702
		Test 2	100.1	4.93	37.21	0.199	7.46	0.328
		Test 3	92.1	4.95	29.58	0.326	9.67	0.431
		Test 4	128.83	6.74	40.56	0.310	12.63	0.404
		Test 5	130.23	8.83	45.69	0.384	17.58	0.456

Table 3 displays the top five testing outcomes for both the new dynamic improved HISA-load balancing approach and the conventional LBMPSO approach in the cloud operating environment for Cases 1 and 2. It compares the outcomes of tests conducted on varying cloudlet sizes of 10 to 50 regarding minimum and maximum makespan, average execution time, throughput, average resource use, and resource utilization for both cases. On varied cloudlet sizes, the new dynamic improved HISA-LB outperformed the LBMPSO technique in terms of performance indicators.

Figure 19 depicts the comparative line graph between the proposed dynamic improved HISA-LB approach and the existing LBMPSO approach for 3 VMs and 5 VMs at 10 to 50 tasks in both cases, respectively. The comparison is made to compare makespan and execution time in both approaches for two cases. The makespan comparison is for minimum and maximum makespan values measured in seconds. This comparison graph shows that the maximum makespan is less significant as the number of tasks increases compared to the existing approach in case 1. Still, difference was less in case 2.

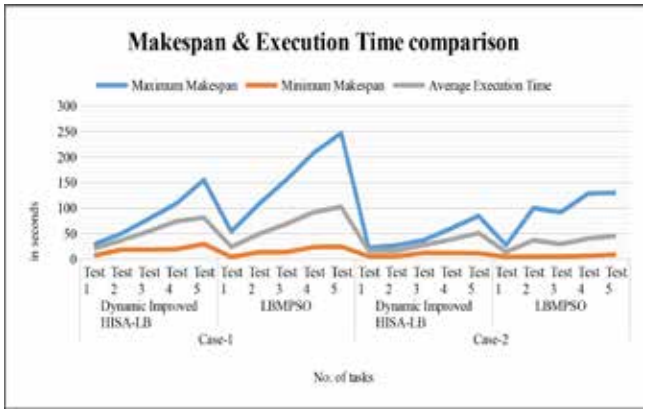


Fig. 13. Comparison line graph of Makespan and execution time obtained for both cases

Similarly, when looking at minimum makespan, it was also minimized in minimum makespan using the proposed approach. The makespan was very high at test 5 with 50 cloudlets but lowest at test 1 with ten cloudlets in both cases. Also, an average execution time was minimized initially, but when the number of tasks increases (or tests), it goes high at test 5 by the proposed LB approach in both cases.

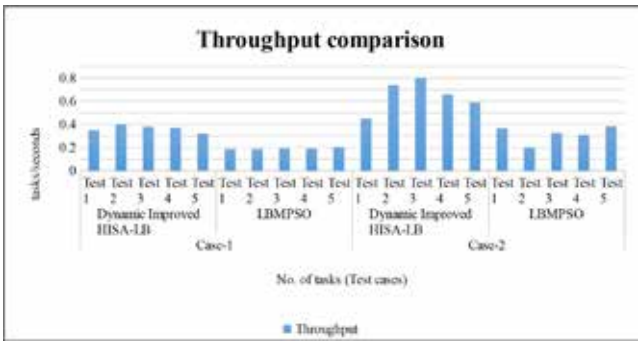


Fig. 14. Comparison bar graph of throughput obtained for both cases

Figure 14 depicts the comparative throughput graph for both cases, including the proposed Dynamic improved HISA-LB and existing LBMPSO approaches. This bar graph comparison shows that throughput has several variations as the number of tasks increases in each case. Here a total of 5 tests have been experimented with, and the highest throughput is 0.40 at 20 cloudlets by the proposed Dynamic improved HISA-LB approach in case-1. In contrast, the existing LBMPSO approach achieved throughput between 0.18 to 0.20 for all five tests that were minimal compared to the proposed approach. Similarly, the proposed dynamic improved HISA-LB approach achieved the highest throughput at test 3 (cloudlets 30) in case 2 than the existing LBMPSO approach.

Figure 15 depicts the resource utilization and ARUR in cases 1 and 2 between the proposed Dynamic improved HISA-LB approach and the existing LBMPSO approach. From this comparison, we can compare that the proposed approach achieved higher resource utilization than the existing LBMPSO approach. Based on this discovery, it has been shown via analysis that a rise in the number of tasks results in a rise in resource use for both methodologies. Nevertheless, when employing the old LBMPSO technique, the resource consumption will rise no matter the number of virtual machines used since it will always be related to the number of processes. But the proposed approach achieved high resource utilization and ARUR compared to the existing approach at test 4 (cloudlets 40) in case 1 and 5 (cloudlets 50) in case 2.

Fig. 15. Comparison bar graph of resource utilization and ARUR obtained for both cases

CONCLUSION

CC is a broad concept that enables consumers and corporations to obtain services depending on their needs. Among the model's services are storage, deployment platforms, and simple access to web services. LB is a common issue in the cloud that makes it challenging to maintain application speeds consistent with QoS measurements and SLA necessary documentation by cloud providers to businesses. Cloud companies struggle to share server burdens evenly. Employing the resources of virtual machines (VMs) effectively should optimize and assure high user satisfaction for an effective load-balancing strategy. This study presents a new load balancing technique called dynamic improved HISA-LB, premised on improved HIA and SA optimization methods in a static, dynamic, and nature-inspired cloud infrastructure to address the data center Response Time as well as overall performance. Changing HMCR, PAR, and fret width enhanced the harmonic-inspired algorithm's improvisation in the harmony memory phase. Several tests using the CloudSim simulator and various performance metrics have been conducted. The results of this research indicate that the dynamic improved HISA-LB technique minimizes the maximal and minimal makespan time by reducing the average execution time compared to the LBMPSO strategy. Besides, resource utilization and throughput were

higher than the LBMPSO technique in both cases. This way, the load is balanced by dynamic task allocation at 3 or 5 virtual machines.

The algorithm may, at some point in the not-too-distant future, be adapted for use on a supercomputer. The scheduling may be done online with the help of preemption, which results in improved utilization and increases revenues. The model that is now being proposed may be enhanced with the inclusion of a variety of price structures that correspond to the various working hours, such as the "peak time".

REFERENCES

1. B. Hayes, "Cloud Computing," Commun. ACM, vol. 51, no. 7, pp. 9–11, Jul. 2008, doi: 10.1145/1364782.1364786.
2. G. Gan, T. Huang, and S. Gao, "Genetic simulated annealing algorithm for task scheduling based on cloud computing environment," in 2010 International Conference on Intelligent Computing and Integrated Systems, 2010, pp. 60–63. doi: 10.1109/ICISS.2010.5655013.
3. S. K. Mishra, B. Sahoo, and P. P. Parida, "Load balancing in cloud computing: A big picture," J. King Saud Univ. - Comput. Inf. Sci., vol. 32, no. 2, pp. 149–158, 2020, doi: https://doi.org/10.1016/j.jksuci.2018.01.003.
4. N. A. Joshi, "Technique for Balanced Load Balancing in Cloud Computing Environment," Int. J. Adv. Comput. Sci. Appl., vol. 13, no. 3, pp. 110–118, 2022, doi: 10.14569/IJACSA.2022.0130316.
5. T. Prem Jacob and K. Pradeep, "A Multi-objective Optimal Task Scheduling in Cloud Environment Using Cuckoo Particle Swarm Optimization," Wirel. Pers. Commun., vol. 109, no. 1, pp. 315–331, 2019, doi: 10.1007/s11277-019-06566-w.
6. M. Agarwal and G. M. S. Srivastava, "A PSO Algorithm-Based Task Scheduling in Cloud Computing," in Soft Computing: Theories and Applications, 2019, pp. 295–301.
7. J. Kennedy and R. Eberhart, "Particle swarm optimization," in Proceedings of ICNN'95 - International Conference on Neural Networks, 1995, vol. 4, pp. 1942–1948 vol.4. doi: 10.1109/ICNN.1995.488968.
8. A. Pradhan and S. K. Bisoy, "A novel load balancing technique for cloud computing platform based on PSO," J. King Saud Univ. - Comput. Inf. Sci., 2020, doi: 10.1016/j.jksuci.2020.10.016.
9. N. Joshi, K. Kotecha, D. B. Choksi, and S. Pandya, "Implementation of Novel Load Balancing Technique in Cloud Computing Environmen," in 2018 International Conference on Computer Communication and Informatics, ICCCI 2018, 2018, pp. 1–5. doi: 10.1109/ICCCI.2018.8441212.
10. M. Haris and S. Zubair, "Mantaray modified multi-objective Harris hawk optimization algorithm expedites optimal load balancing in cloud computing," J. King Saud Univ. - Comput. Inf. Sci., 2022, doi: 10.1016/j.jksuci.2021.12.003.
11. S. G. Domanal, R. M. R. Guddeti, and R. Buyya, "A Hybrid Bio-Inspired Algorithm for Scheduling and Resource Management in Cloud Environment," IEEE Trans. Serv. Comput., vol. 13, no. 1, pp. 3–15, 2020, doi: 10.1109/TSC.2017.2679738.
12. M. Junaid et al., "Modeling an Optimized Approach for Load Balancing in Cloud," IEEE Access, vol. 8, pp. 173208–173226, 2020, doi: 10.1109/ACCESS.2020.3024113.
13. A. F. S. Devaraj, M. Elhoseny, S. Dhanasekaran, E. L. Lydia, and K. Shankar, "Hybridization of firefly and Improved Multi-Objective Particle Swarm Optimization algorithm for energy efficient load balancing in Cloud Computing environments," J. Parallel Distrib. Comput., vol. 142, pp. 36–45, 2020, doi: https://doi.org/10.1016/j.jpdc.2020.03.022.
14. T. Alfakih, M. M. Hassan, and M. Al-Razgan, "Multi-Objective Accelerated Particle Swarm Optimization With Dynamic Programing Technique for Resource Allocation in Mobile Edge Computing," IEEE Access, vol. 9, pp. 167503–167520, 2021, doi: 10.1109/ACCESS.2021.3134941.
15. A. Pradhan, S. K. Bisoy, S. Kautish, M. B. Jasser, and A. W. Mohamed, "Intelligent Decision-Making of Load Balancing Using Deep Reinforcement Learning and Parallel PSO in Cloud Environment," IEEE Access, vol. 10, pp. 76939–76952, 2022, doi: 10.1109/ACCESS.2022.3192628.

[16] W. Sun and X. Chang, "An Improved Harmony Search Algorithm for Power Distribution Network Planning," J. Electr. Comput. Eng., vol. 2015, p. 753712, 2015, doi: 10.1155/2015/753712.

A Review on Image Forgery Detection using Machine Learning and Deep Learning Techniques

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ABSTRACT

The advent of digital image manipulation software has made it easier to create forged images, which can be used to deceive or mislead people. This has led to an increasing need for effective image forgery detection techniques. In this research work, we aim to develop a robust and efficient image forgery detection system using machine learning (ML) and deep learning (DL) techniques. We begin by collecting a diverse dataset of forged images, consisting of various types of forgeries, such as copy-move, splicing, and inpainting. We then use this dataset to train and test several ML and DL algorithms, including convolutional neural networks (CNNs), support vector machines (SVMs), and random forests (RFs), to compare their performance in detecting different types of forgeries.

KEYWORDS *: Machine learning, Deep learning.*

INTRODUCTION

Image forgery detection is an important task in the field of digital forensics, aiming to identify manipulated or tampered images. With the rise of sophisticated image editing software, it has become increasingly challenging to detect such forgeries using traditional methods. As a result, researchers have turned to machine learning and deep learning techniques to develop more robust and accurate solutions. Machine learning and deep learning techniques leverage the power of artificial intelligence to automatically learn patterns and features from large datasets. These methods have shown great potential in various domains, including image analysis and computer vision. By applying these techniques to image forgery detection, researchers have made significant advancements in detecting various types of image manipulations. One of the fundamental approaches in image forgery detection is based on analyzing image inconsistencies, such as abrupt changes in lighting, texture, or noise patterns. Machine learning algorithms can be trained to recognize these inconsistencies by learning from a large dataset of authentic and manipulated images. These algorithms can extract meaningful features from the images and use them to classify whether an image is genuine or forged. Deep learning techniques, particularly convolutional neural networks (CNNs), have emerged as powerful tools in image forgery detection. CNNs are designed to mimic the human visual system by learning hierarchical representations of images. They can automatically learn complex features and spatial relationships, enabling them to effectively detect forgery artifacts in images. Several specific techniques have been developed using machine learning and deep learning for different types of image forgery detection. Some of these include copy-move forgery detection, where a region of an image is copied and pasted onto another location, and splicing forgery detection, where parts of different images are combined to create a new image. Other techniques focus on detecting image retouching, object removal, or image tampering in the frequency or spatial domains.

The success of machine learning and deep learning-based image forgery detection heavily relies on the availability of large and diverse training datasets. These datasets should include authentic images along with a wide range of manipulated images to ensure the algorithms can learn the subtle differences between them. Researchers continuously work on collecting and

curating such datasets to improve the performance of their models.

Background and Motivation

In today's digital age, the manipulation and tampering of images have become widespread, posing significant challenges in various domains, including journalism, law enforcement, and digital forensics. With the advent of powerful image editing software and the ease of sharing images on digital platforms, it has become increasingly difficult to distinguish between genuine and manipulated images. This has created a pressing need for effective image forgery detection techniques. Traditional methods of image forgery detection, such as manual inspection and pixel-level analysis, have proven to be time consuming, subjective, and limited in their ability to detect sophisticated forgeries. This has prompted researchers to explore the potential of machine learning and deep learning techniques, which can automatically learn patterns and features from large datasets, to address this issue. Machine learning techniques provide a systematic approach to analyze and classify images based on extracted features. By training models on a diverse dataset of authentic and manipulated images, these techniques can learn the intricate differences between them. With the ability to automatically extract relevant features, machine learning algorithms can detect inconsistencies in lighting, texture, noise patterns, and other characteristics that indicate image forgery.

Deep learning, a subset of machine learning, has gained significant attention in recent years due to its remarkable performance in image analysis tasks. Convolutional Neural Networks (CNNs), in particular, have proven to be highly effective in capturing complex spatial relationships and features from images. The hierarchical architecture of CNNs enables them to learn progressively more abstract representations, making them well suited for detecting image forgery artifacts that may be subtle and challenging to identify with traditional methods.

Image forgery techniques

Image forgery techniques involve manipulating or altering digital images to deceive viewers or convey false information. Here are some common image forgery techniques and corresponding detection methods:

1. Copy-Move Forgery Detection:

Copy-move forgery involves copying a portion of an image and pasting it onto another area, often to conceal or duplicate objects. Detection methods for this technique include:

- Block-based methods: Analyzing the image in small overlapping blocks to identify duplicated regions with similar patterns.
- Keypoint-based methods: Extracting keypoints from the image and comparing their descriptors to identify similar regions.
- Tampering consistency check: Examining inconsistencies in the image's statistical properties (e.g., noise distribution) to identify forged regions.

2. Splicing Forgery Detection:

Splicing forgery refers to combining two or more separate images to create a single composite image. Detection methods for this technique include:

- Forgery detection based on sensor pattern noise: Analyzing the unique noise patterns introduced by camera sensors to identify inconsistencies between different regions.
- Illumination inconsistency analysis: Examining variations in lighting conditions or shadows to detect spliced regions.
- Color-based analysis: Comparing color histograms or examining abrupt changes in color properties to identify spliced areas.

3. Image Retouching Forgery Detection:

Image retouching forgery involves manipulating an image to remove or modify specific objects or features. Detection methods for this technique include:

- Blur inconsistency analysis: Examining inconsistencies in blur levels across different regions of the image to identify retouched areas.
- Edge-based analysis: Detecting abrupt changes or inconsistencies in edge structures that may indicate retouching.

- Noise analysis: Analyzing statistical properties of noise or artifacts introduced during retouching to identify manipulated regions.

4. Frequency Domain Tampering Detection:

Frequency domain tampering involves altering the image by modifying its frequency content using techniques like Fourier transform. Detection methods for this technique include:

- High-pass filter analysis: Examining high-frequency components of the image to detect inconsistencies or artifacts introduced by tampering.
- Phase correlation: Comparing the phase information of different frequency components to identify tampered regions.
- Discrete Cosine Transform (DCT) analysis: Analyzing the DCT coefficients to detect inconsistencies or modifications introduced by tampering.

5. Spatial Domain Tampering Detection:

Spatial domain tampering involves directly modifying the pixel values or spatial characteristics of the image. Detection methods for this technique include:

- Error level analysis: Comparing the compression artifacts or inconsistencies in error levels across different regions to identify tampered areas.
- Histogram analysis: Analyzing histograms or pixel value distributions to detect anomalies or modifications.
- Noise inconsistency analysis: Examining variations in noise patterns or statistical properties within the image to identify tampered regions.

These are just some examples of forgery detection methods for various image manipulation techniques. It's important to note that detection accuracy can vary based on the sophistication of the forgery and the available resources.

LITERATURE SURVEY

This survey paper provides an extensive review of deep learning-based image forgery detection techniques. It discusses various deep learning architectures, datasets, and evaluation metrics used in the field. The paper also highlights challenges and future directions for research in this area.[1]

This paper proposes a deep convolutional neural network (CNN) for detecting image splicing forgeries. The network is trained to extract discriminative features from spliced images and achieve high detection accuracy. Experimental results demonstrate the effectiveness of the proposed approach.[2]

This paper presents a method for localizing image forgery through the analysis of Color Filter Array (CFA) artifacts. By analyzing the inconsistencies in the CFA patterns, the proposed method can identify regions that have undergone manipulation. Experimental results demonstrate the effectiveness of the approach in localizing forged regions.[3]

This paper proposes a multi-task learning framework for simultaneously detecting and localizing image forgeries. The network is trained to perform two tasks: classification of authentic/forged patches and regression of forgery localization maps. The results show improved performance in both forgery detection and localization compared to single-task approaches.[4]

This paper introduces a multi-scale convolutional neural network (CNN) for image splicing detection. The network processes the input image at multiple scales to capture both local and global information. Experimental results demonstrate the effectiveness of the proposed method in detecting image splicing forgeries.[5]

This paper presents an approach for localizing image splicing forgeries based on block-grained analysis of JPEG artifacts. The proposed method exploits inconsistencies in the JPEG compression artifacts caused by splicing to identify the manipulated regions. Experimental results show the effectiveness of the approach in accurately localizing spliced regions.[6]

CONCLUSION

The conclusion summarizes the key findings of the survey paper. It highlights the advancements made in image forgery detection using machine learning and deep learning techniques and emphasizes the importance of further research to address existing challenges and improve the overall performance of forgery detection systems.

FUTURE SCOPE

The future scope for as image forgery techniques evolve, so do adversarial attacks aimed at deceiving forgery detection algorithms. Future research should focus on developing forgery detection models that are robust against adversarial attacks. Techniques such as adversarial training, defensive distillation, and robust optimization can be explored to enhance the resilience of the models and ensure their reliability in real-world scenarios.

REFERENCES

1. "Deep Learning-Based Image Forgery Detection: A Survey"Authors: A. A. Khalid, M. T. Riaz, S. D. Khan, et al. Published in: IEEE Access, 2018
2. "Deep Convolutional Neural Network for Image Splicing Forgery Detection" Authors: N. Wang, X. Zhao, X. Lin, et al. Published in: 2017 IEEE International Conference on Image Processing (ICIP)
3. "Image Forgery Localization via Fine-Grained Analysis of CFA Artifacts" Authors: H. Liu, R. Li, S. S. Gao, et al.Published in: IEEE Transactions on Information Forensics and Security, 2018
4. Title: "Multi-Task Learning for Image Forgery Detection and Localization" Authors: D. Cozzolino, G. Poggi, and L. Verdoliva Published in: 2017 IEEE Conference on Computer Vision and Pattern Recognition Workshops (CVPRW)
5. Title: "Image Splicing Detection Using Multi-Scale Convolutional Neural Networks"Authors: J. Wang, Y. Zhang, S. Chang, et al. Published in: 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)
6. Title: "Image Splicing Localization via Block-Grained Analysis of JPEG Artifacts" Authors: H. Liu, R. Li, S. S. Gao, et al. Published in: IEEE Transactions on Information Forensics and Security, 2019
7. Ali SS, Ganapathi II, Vu N-S, Ali SD, Saxena N, Werghi N. Image Forgery Detection Using Deep Learning by Recompressing Images. Electronics. 2022; 11(3):403.
8. H. Wu, J. Zhou, J. Tian and J. Liu, "Robust Image Forgery Detection over Online Social Network Shared Images," 2022 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), New Orleans, LA, USA, 2022, pp. 13430-13439
9. H. Wu, J. Zhou, J. Tian, J. Liu and Y. Qiao, "Robust Image Forgery Detection Against Transmission Over Online Social Networks," in IEEE Transactions on Information Forensics and Security, vol. 17, pp. 443-456, 2022
10. M. Ali Qureshi and M. Deriche, "A review on copy move image forgery detection techniques," 2014 IEEE 11th International Multi-Conference on Systems, Signals & Devices (SSD14), Barcelona, 2014, pp. 1-5, doi: 10.1109/SSD.2014.6808907.
11. S. Pradhan, U. Chauhan and S. Chauhan, "A Review on Digital Image Forgery Detection," 2022 2ndInternational Conference on Innovative Practices in Technology and Management (ICIPTM), Gautam Buddha Nagar, India, 2022, pp. 697-702, doi: 10.1109/ICIPTM54933.2022.9754125.
12. B. Singh and D. K. Sharma, "Image Forgery over Social Media Platforms - A Deep Learning Approach for its Detection and Localization," 2021 8th International Conference on Computing for Sustainable Global Development (INDIACom), New Delhi, India, 2021, pp. 705-709.
13. B. Singh and D. K. Sharma, "Image Forgery over Social Media Platforms - A Deep Learning Approach for it Detection and Localization," 2021 8th International Conference on Computing for Sustainable Global Development (INDIACom), New Delhi, India, 2021, pp. 705-709.
14. Habibi, Muhammad and Hamid Hassanpour. "Splicing Image Forgery Detection and Localization Based on Color Edge Inconsistency using Statistical Dispersion Measures."International Journal of Engineering 34 (2021): 443-451.
15. M. Aloraini, M. Sharifzadeh and D. Schonfeld, "Sequential and Patch Analyses for Object Removal Video Forgery Detection and Localization," in IEEE Transactions on Circuits and Systems for Video Technology, vol. 31, no. 3, pp. 917-930, March 2021, doi: 10.1109/TCSVT.2020.2993004.
16. B. Singh and D. K. Sharma, "Image Forgery over Social Media Platforms - A Deep Learning Approach for its Detection and Localization," 2021 8th International Conference on Computing for Sustainable Global Development (INDIACom), New Delhi, India, 2021, pp. 705-709

Amalgamation of Internet of Vehicles (IoV) with Metaverse (MetaIoV)

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ABSTRACT

Internet of Vehicles (IoV) is a network of connected vehicles that enables real-time data exchange and communication, while Metaverse is a virtual world that enables users to interact with each other and with virtual objects in a shared environment. The integration of IoV with Metraverse has the potential to revolutionize the automotive industry and create new opportunities for innovation and collaboration.

This paper provides a comprehensive overview of the metaverse and Internet of Vehicles (IoV), alongside it explores the integrative possibilities and challenges in amalgamation of IoV with Metaverse. It also delves into the future possible attacks on MetaIoV.

KEYWORDS *: Internet of vehicles (IoV), Metaverse, MetaIoV issues, MetaIoV attacks, Security*

INTRODUCTION

Any sufficiently advanced technology is indistinguishable from magic. is the third of Arthur C Clarke's famous three laws which really makes sense in the concept of Metaverse with IoV. It seems like magic to imagine that a car sense some fault in tyre and informs a mechanic to look into its parts and system through Metaverse and gets the report of the analysis, then stops on its own and talks to a garage mechanic to change the tyre meanwhile you are discussing a business deal with a 3D Avatar of someone sitting next to you talking to you like you are present at that place and the car informs that the new tyre is fixed and it is ready to move to the destination. Isn't it fascinating? Just like bumblebee of the movie Transformers. Its all possible with IoV's amalgamation with Metaverse.

The metaverse encompasses a virtual environment that enables real-time interaction among individuals and digital objects. It combines the immersive experience of virtual reality with the connectivity and data exchange facilitated by the Internet of Things. This convergence of technologies is seen as the evolution of the internet, offering a shared, persistent, 3D virtual space where users can experience life in unique ways not possible in the physical world. The metaverse is powered by Web3 technologies such as VR, AR, NFTs, and blockchain, and it is influencing advancements in various industries, including automotive.

In the realm of transportation, enhancing convenience, safety, and user experience is paramount. The Internet of Vehicles (IoV) has emerged as a solution by leveraging historical knowledge and human experiences to optimize performance. The IoV integrates internet connectivity and communication technologies into vehicles, enabling seamless communication and interaction between them. This connectivity empowers vehicles to exchange data and information, leading to improved transportation experiences and capabilities.

The integration of the Metaverse (a virtual reality-based digital universe) and the Internet of Vehicles (IoV, a network of connected vehicles) opens up numerous possibilities for innovative experiences and applications. Here are a few potential examples of how this integration could shape the way we interact with transportation and virtual environments:

Virtual Test Drives: Instead of physically visiting a car dealership, potential buyers could experience virtual

test drives from the comfort of their homes. They could explore virtual showrooms, customize their vehicle options, and take simulated test drives in a realistic virtual environment, all within the Metaverse.

Real-time Traffic Data: IoV technology enables vehicles to communicate with each other and share real-time traffic information. This data could be visualized within the Metaverse, creating an immersive experience where users can view live traffic conditions, plan routes, and receive navigation assistance based on real-time data.

Augmented Reality Navigation: Through the integration of IoV and the Metaverse, augmented reality (AR) could be used to enhance navigation. Drivers could wear AR glasses or use smartphone apps to overlay virtual navigation markers, street names, and directions onto the real-world view, making it easier to navigate unfamiliar areas.

Virtual Carpooling and Ride-Sharing: Within the Metaverse, users could engage in virtual carpooling and ride-sharing experiences. They could join virtual communities where they share rides, split costs, and interact with other users as they travel together in a simulated vehicle environment, blurring the line between virtual and physical transportation.

Virtual Car Maintenance and Repairs: With the integration of IoV and the Metaverse, vehicle owners could access virtual workshops and tutorials for maintenance and repairs. They could virtually inspect their vehicles, receive step-by-step instructions, and even collaborate with virtual mechanics or technicians to solve issues.

Virtual Traffic Simulations: Traffic planning and simulations could be conducted within the Metaverse, utilizing real-time data from IoV systems. City planners and transportation authorities could model different traffic scenarios, test infrastructure improvements, and evaluate the impact of new policies before implementing them in the real world.

Virtual Tourism and Travel Experiences: The integration of the Metaverse and IoV could revolutionize the travel industry. Users could embark on virtual tours of different destinations, exploring realistic virtual environments and interacting with simulated attractions. They could even "drive" through virtual replicas of famous scenic routes, offering a unique travel experience without leaving their homes.

Collaborative Design: The integration of IoV and Metaverse could enable collaborative design, where designers and engineers can work together in a virtual environment to design and test new vehicles and technologies. This could be useful for reducing development time and costs, improving collaboration, and accelerating innovation.

User engagement: The integration of IoV and Metaverse could enable new ways to engage with users, such as through virtual showrooms, interactive product demonstrations, and other immersive experiences. This could be useful for marketing, customer engagement, and other applications where user experience is important.

Smart Traffic Management: The integration of IoV and Metaverse can enable smart traffic management, where real-time traffic data is collected from IoV sensors and used to optimize traffic flow in a virtual environment. This can be useful for reducing congestion, improving safety, and enhancing the overall driving experience. For example, traffic lights in a virtual city can be controlled based on real-time traffic data from IoV sensors, resulting in smoother traffic flow and reduced wait times for drivers.

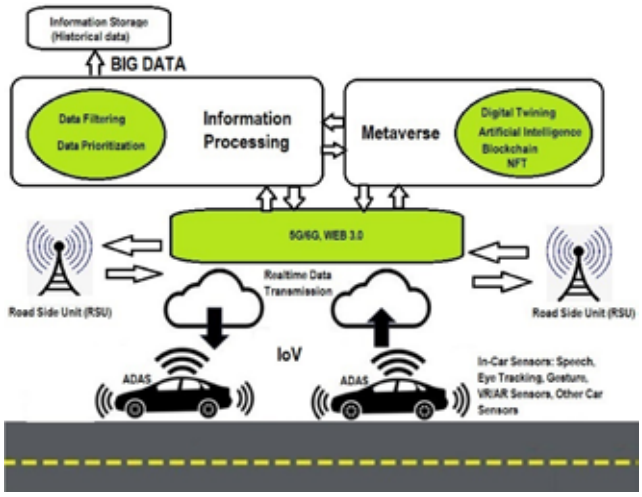

Figure 1. Working of MetaIoV

In Figure 1, the IoV data and Metaverse are connected through an integration layer that allows them to

exchange information and interact with each other. The integration layer could be implemented using APIs, middleware, or other technologies that enable communication between the two systems.

The IoV data could include information about vehicles, such as their location, speed, and status, while the Metaverse could provide a virtual environment where users can interact with each other and with virtual objects. The User App could be a mobile or web application that allows users to access both the IoV data and the Metaverse from a single interface.

The integration between the IoV and Metaverse could enable new use cases and applications. For example, a user could use the User App to enter the Metaverse and interact with virtual vehicles that are based on real-world IoV data. Alternatively, a user could use the User App to monitor the status of their real-world vehicle while also interacting with other users in the Metaverse.

Overall, the integration of IoV and Metaverse could create new opportunities for innovation and collaboration in the automotive and technology industries.

LITERATURE REVIEW

The term "Metaverse" gained significant popularity after Facebook rebranded itself as Meta in October 2021 and committed to investing over $10 billion in the concept. Not only Meta, but other major tech companies such as Google, Microsoft, Nvidia, and Qualcomm are also making substantial investments in the Metaverse. McKinsey & Company has optimistically projected that the Metaverse economy could reach a value of $5 trillion by 2030, with e-commerce serving as the primary driving force and gaming, entertainment, education, and marketing emerging as crucial sectors within the Metaverse ecosystem [1].

In the present day, the term "Metaverse" is utilized by various companies to describe a wide array of enhanced online environments. These can range from popular online video games like Fortnite to emerging virtual workplaces such as Microsoft's Mesh or Meta's Horizon Workrooms, as well as virtual dressing rooms and virtual operating rooms. Instead of being confined to a single shared virtual space, the current rendition of the Metaverse is taking the form of a multiverse, consisting of multiple interconnected metaverses that have limited interoperability due to competition between companies vying for prominence [1].

Preceding the acquisition, Nike strategically filed seven trademark applications to facilitate the creation and commercialization of virtual sneakers and apparel. In a noteworthy collaboration, Nike joined forces with Roblox to establish "Nikeland," an immersive digital world offering a unique interactive experience for avid Nike followers. Within this virtual realm, enthusiasts can engage in captivating games, forge connections with like-minded individuals, and adorn their avatars with an extensive range of meticulously designed virtual Nike apparel [2].

Hyundai has introduced an innovative concept known as 'Metamobility,' aiming to spearhead a seamless integration between smart devices and the metaverse. This visionary approach seeks to extend the boundaries of mobility into the realm of virtual reality (VR), enabling individuals to transcend the constraints of physical movement within the constraints of time and space. Hyundai Motor envisions a future where robots serve as a conduit between the real world and virtual spaces, empowering users to effect changes within the metaverse that seamlessly manifest in their physical reality. By bridging these two realms, Hyundai is poised to revolutionize the way we interact with and shape our virtual and physical environments [3].

In the context of automotive applications, a thought-provoking perspective on the utilization of the metaverse revolves around the concept of Operational Design Domain (ODD). The ODD delineates specific conditions and geographic areas in which automated vehicles are authorized to operate. By virtually mapping out these designated domains well in advance, the groundwork can be laid for seamless integration of the metaverse with autonomous driving. While it may take some time before drivers fully immerse themselves in the metaverse experience, passengers could potentially engage with the metaverse during their journeys even before highly automated driving systems become widespread and readily accessible [4].

The automotive industry has discovered an alternative application of the metaverse that extends beyond the confines of the vehicle itself. BMW's implementation of the Omniverse serves as an illustrative example of

how manufacturers are harnessing the power of the metaverse to establish a virtual environment dedicated to the production of cars, rather than solely focusing on the driver's experience. This innovative approach empowers original equipment manufacturers (OEMs) to visualize their production lines and implement efficiency enhancements or design modifications. By simulating various scenarios within the Omniverse, engineers can thoroughly evaluate and refine concepts before implementing them in the physical realm, thereby streamlining the production process and driving continuous improvement [5].

In the city of Chennai, a pioneering company has successfully developed and implemented a cutting-edge virtual reality system aimed at providing medical students with invaluable hands-on experience in diverse medical procedures, all without direct interaction with patients. By leveraging this advanced technology, students are afforded the opportunity to engage in realistic simulations that closely emulate real-world scenarios, enabling them to enhance their skills and proficiency before venturing into actual clinical practice. This innovative solution serves as a transformative tool in medical education, bridging the gap between theoretical knowledge and practical application while prioritizing patient safety and fostering a well-rounded learning experience [6].

NVIDIA Drive Map is working on "Earth-scale digital twin" [7]. To connect Metaverse to Internet of Vehicles we will have to map every component of real world with its Digital Twin. In future, every brand / product will provide a unique ID to connect the devices to the Metaverse. For example, if I purchase a handbag or a watch in real world it will be available with my avatar in the Metaverse. Now, for older objects, companies may provide certain scanning devices which will take parameters and attributes of the physical product and provide one unique Digital ID to include that product to the Metaverse.

In today's scenario the connected cars have the Unique ID as they are connected to internet, hence they can easily be mapped to Metaverse and other older cars need to be connected to the net and provided with Unique ID to have a digital twin in the Metaverse.

METAVERSE AND IOV ENABLERS

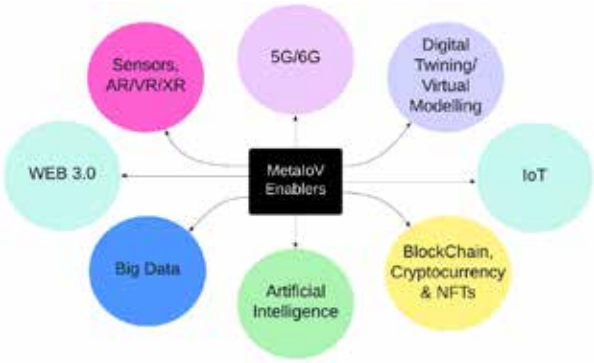

Figure 2. Metaverse and IoV Enablers

Digital twin avatars: The foundation of MetaIoV lies in the concept of Digital Twining, which goes beyond existing on computer screens to encompass AI-powered holograms or holographic images capable of performing assigned tasks. This transformative technology enables individuals, such as CEOs, to activate AI-powered holograms of themselves, facilitating simultaneous engagement with multiple stakeholder groups.

Professor Mehrabian's research emphasizes three crucial elements for effective face-to-face communication of emotions and attitudes: nonverbal behavior (e.g., facial expressions), tone of voice, and the literal meaning of spoken words. These elements play a pivotal role in conveying liking or disliking towards others. Incorporating facial expression identification [8] into the creation of digital twins becomes essential in accurately reflecting emotions and enabling effective communication within the Metaverse. By leveraging these advancements, people can interact and communicate seamlessly within this virtual realm.

AR (Augmented Reality),VR (Virtual Reality), XR (Extended Reality): Extended reality (XR) technology, encompassing augmented reality (AR) and virtual reality (VR), plays a crucial role in the realization of the metaverse [9]. AR enhances the physical environment by overlaying digital information, providing users with an enriched real- world experience. VR, on the other hand, immerses users in a simulated 3D environment, replicating reality through headsets that occupy their field of vision. Haptic technologies, such as gloves and vests, further enhance the immersive nature of VR interactions.

AR, although less immersive than VR, allows users to interact with their physical surroundings while incorporating digital overlays. Examples of AR include popular games like Pokémon Go and consumer products like Google Glass and heads-up displays in car windshields.

The integration of AR and VR technologies is pivotal in the development of the metaverse, a digital space enabling users to engage with one another and the virtual environment in ways resembling real-world experiences. These technologies offer unique capabilities to create immersive and interactive encounters within the metaverse, revolutionizing various aspects of interaction, learning, entertainment, and collaboration.

Non-fungible tokens (NFTs) have emerged as a pivotal element driving the utility and appeal of the metaverse. These unique digital assets leverage blockchain technology, similar to cryptocurrencies, to provide secure ownership records. Unlike traditional currencies, NFTs represent various forms of digital content, including artwork, music, and virtual properties. Owning an NFT grants individuals a digital deed or proof of ownership, enabling them to participate in the buying and selling of these assets within the metaverse, thus enhancing its immersive and dynamic nature [10].

Blockchain technology assumes a critical dual role within the metaverse, showcasing its indispensability. Firstly, it serves as a decentralized data repository, empowering users to securely store their information across the metaverse. This ensures data integrity and availability regardless of the virtual location. Secondly, blockchain facilitates the establishment of a comprehensive economic framework that links the virtual realm of the metaverse with the physical world. Notably, non-fungible tokens (NFTs) exemplify this integration by enabling virtual assets to attain tangible value, allowing users to trade virtual

items with the same fluidity as real-world transactions. Thus, blockchain acts as a vital bridge between the metaverse and reality, fostering seamless connectivity and enabling a dynamic virtual economy [11].

Upcoming 6G wireless systems hold the potential to deliver advanced computing, sensing, localization, and communication capabilities, fostering accelerated transmission speeds that are vital for the metaverse. This technological evolution enables participants to engage in immersive experiences within various domains such as gaming, education, entertainment, engineering, and more, all with minimal latency. The enhanced resources provided by 6G wireless systems pave the way for seamless and immersive interactions within the metaverse, ensuring an enriched user experience [12] [13].

The Internet of Things (IoT) has emerged as a critical component in the context of the Metaverse, facilitating immersive and cyber-virtual experiences within mixed reality environments. By harnessing the power of IoT, the Metaverse can seamlessly integrate real-time data from the physical world into the digital realm, enabling users to interact with a rich and dynamic virtual environment. The IoT serves as a bridge between the experiential interface of users and the AR/VR-driven virtual world, enhancing the overall engagement and interactivity within the Metaverse [14].

Big Data: The advancement of automotive telematics has led to the integration of modern vehicles with heterogeneous radio access technologies, enabling them to seamlessly communicate and exchange vast amounts of information with their surrounding environment. This increased connectivity and data exchange give rise to massive datasets that require sophisticated handling and analysis, which can be effectively accomplished through the utilization of Big Data technology [15].

Artificial Intelligence (AI) encompasses the computational capabilities of machines to engage in higher-level logical processes, such as problem-solving, inference, generalization, and learning from past experiences. In the context of the Metaverse, AI plays a pivotal role, demanding rapid and sophisticated processing power to support its various applications and functionalities [16].

Web 3.0 represents the evolution of the internet into a Semantic Web, characterized by its intelligent, self-sustaining nature and open architecture. With the integration of AI and machine learning, Web 3.0 acts as a “global brain,” capable of conceptually and contextually interpreting content [17]. This

transformative technology holds immense potential for the convergence of the Internet of Vehicles (IoV) and the Metaverse, offering unprecedented levels of competence and capability.

REQUIREMENTS FOR METAVERSE AND IOV INTEGRATION

The integration of IoV and Metaverse could be technically complex, requiring the development of new APIs, middleware, and other integration technologies.

API development: To integrate IoV and Metaverse, new APIs may need to be developed to enable communication between the two systems. These APIs would need to be designed to handle the specific data formats and protocols used by each system, and would need to be secure and reliable to ensure the integrity of the data being exchanged.

Middleware Development: Middleware may be required to facilitate the integration of IoV and Metaverse. This could include message brokers, data transformation tools, and other middleware components that enable data to be exchanged between the two systems.

Data Integration: The integration of IoV and Metaverse would require the integration of different types of data, such as vehicle data, user data, and virtual environment data. This could be challenging due to differences in data formats, data structures, and data quality.

Performance Optimization: The integration of IoV and Metaverse could impact the performance of both systems, as data is exchanged and processed between them. This could require performance optimization techniques, such as caching, load balancing, and other optimization strategies to ensure that the integration does not impact the user experience.

Testing and Debugging: The integration of IoV and Metaverse would require extensive testing and debugging to ensure that the integration works as expected and does not introduce new bugs or errors into either system. This could be challenging due to the complexity of the integration and the need to test across multiple platforms and environments.

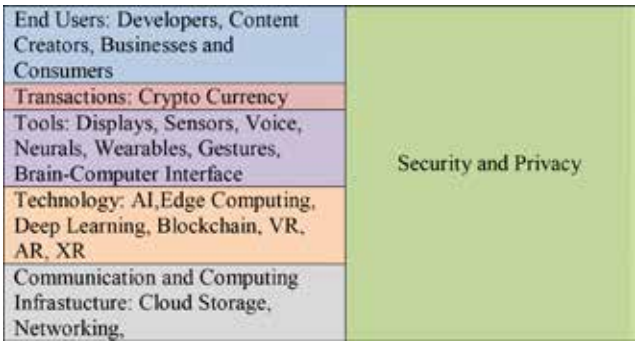

Figure 3. Tools, technology and infrastructure for MetaIoV

PROBLEMS RELATED TO METAIOV AND THEIR PROBABLE SOLUTIONS

Gadget / tool weight (Heavy to use gadgets or devices)

Various companies are actively developing innovative tools aimed at replacing smartphones as the primary interface for accessing the future metaverse. One notable example is Apple's VR/AR headset, known as Vision Pro, which introduces a feature called EyeSight. This feature allows the wearer's eyes to be visible to others, creating a more natural and immersive interaction. Additionally, Vision Pro enables users to experience immersive video content that replicates the feeling of physically being present in a specific location. Another notable functionality is the integration of FaceTime, where the Vision Pro headset scans the user's face and generates a realistic model that accurately represents their movements and expressions during FaceTime calls [18].

In addition to smartphone alternatives, the emergence of Brain-Computer Interface (BCI) technology offers an intriguing solution to reduce reliance on cumbersome devices. BCI systems detect and interpret brain signals, translating them into actionable commands that can be transmitted to actuation devices for executing desired actions. When integrated with automobiles, BCI has the potential to enable individuals to control vehicles directly using their thoughts, bypassing the need for physical input devices [19].

Heavy Computing Power

To effectively utilize the Internet of Vehicles (IoV) data within the Metaverse, substantial computational

resources are essential. Intel has highlighted a significant challenge in realizing ambitious metaverse goals, emphasizing the inadequate processing power currently available. The Metaverse demands a substantial 1,000-fold increase in computing capacity beyond the existing collective capability, underscoring the need for substantial advancements [20]. This is especially critical when considering the integration of IoV with the Metaverse.

Addressing the demanding computational requirements in both the Metaverse and IoV necessitates a collaborative approach involving multiple stakeholders. Technology companies, infrastructure providers, and policymakers must join forces to tackle this challenge. Furthermore, progress in artificial intelligence, virtual reality, and network infrastructure will be pivotal in shaping the future of computing power within the Metaverse.

Data Hacking, Integrity

In the amalgamation of the Metaverse and IoV, data hacking refers to unauthorized access, manipulation, or theft of data within virtual environments and connected vehicles. It involves exploiting vulnerabilities in the systems, networks, or applications to gain unauthorized access to sensitive information or control over virtual assets and vehicles. Data hacking poses risks such as privacy breaches, identity theft, financial fraud, and compromised safety.[22]

Data integrity, in the context of Metaverse and IoV amalgamation, refers to the trustworthiness and accuracy of data within virtual environments and connected vehicles. Maintaining data integrity ensures that information is not tampered with or modified maliciously, preserving the reliability and consistency of the data. Breaches in data integrity can lead to altered information, misleading virtual experiences, compromised safety measures, and potential accidents. [22].

It is required to implement strong encryption, secure authentication mechanisms, and access controls to protect data from unauthorized access. Regular security audits, vulnerability assessments, and penetration testing can help identify and address potential vulnerabilities. Another way is to Utilize secure communication protocols, such as Transport Layer Security (TLS), multi-factor authentication to ensure the confidentiality and integrity of data.

Cyber-Syndrome (Internet Addiction Disorder or Problematic Internet Use) Cyber-Syndrome, a multifaceted condition, arises from the excessive and prolonged use of the Internet, impacting individuals physically, socially, and mentally [21]. Moreover, research highlights the potential negative societal implications of Second Life users, attributed to its addictive nature [24]. It is crucial to address the needs of individuals with physical disabilities, such as deafness or blindness, by developing inclusive technologies that ensure accessibility and equal participation [25]. Recognizing these challenges, it becomes imperative to promote responsible Internet usage, foster digital well-being, and strive for universal accessibility in the Metaverse and IoV amalgamation.

It is required to Increase awareness about the potential risks and consequences of excessive internet use. Therapy, counseling, or support groups can assist in addressing underlying issues, improving coping mechanisms, and developing healthier habits. Similarly, encourage periodic digital detoxes or internet breaks to reset and recharge. This involves taking a break from electronic devices and engaging in offline activities such as exercise, hobbies, spending time with loved ones, and practicing mindfulness.

Hyper Spatiotemporality

It refers to a unique characteristic of the Metaverse, distinguishing it from the physical world. Unlike our reality, which is bound by spatial limitations and irreversible time, the Metaverse transcends these constraints. Through the convergence of various technologies, it enables users to navigate across different points in time, accessing past events and even envisioning future scenarios. This extraordinary feature of the Metaverse is made possible by leveraging advanced tools and techniques, granting individuals unprecedented freedom to traverse temporal dimensions within this immersive digital realm [23].

Standardization can help align spatial and temporal representations, ensuring consistent experiences across different virtual environments and connected vehicles. Another solution can be accurately aligning virtual

representations with real-world data, such as geolocation and time stamps, to ensure seamless integration and avoid conflicts or discrepancies.

Poor sensor/actuator performance

In tackling this challenge, researchers [23] have suggested the application of Nanotechnology as a promising avenue for improving the capabilities of sensors and actuators in the Metaverse context. By leveraging nanomaterials such as graphene and nanowires, it becomes possible to achieve higher levels of sensitivity, selectivity, faster response times, and increased durability. This technological advancement opens up new possibilities for enhancing sensing and communication capabilities within the Metaverse realm.

Intrusive and extensive data collection

The convergence of the Metaverse and IoV raises concerns about intrusive data collection. Solutions involve implementing data minimization practices, anonymizing collected data, and employing strong security measures to protect user privacy while still enabling personalized experiences.

Challenges in Data Rights and Ownership in the Metaverse and IoV Context

Data ownership and user rights in the Metaverse and IoV require clear policies. Solutions include establishing transparent data ownership frameworks, ensuring informed user consent, and promoting fair data practices to empower individuals with control over their data.

Impossible loops possibility in Metaverse

Addressing the possibility of impossible loops in the Metaverse requires careful design and implementation. Solutions involve developing robust systems and algorithms that prevent paradoxical or infinite loops while maintaining the flexibility and creativity of the virtual environment, ensuring stability and coherent user experiences.

TYPES OF POSSIBLE ATTACKS ON METAIOV

Type of Possible Attacks	Risk Factor					Description	Severity
	Confidentiality	Integrity	Availability	Authenticity	Non-Repudiation		
Virtual Data Breach	High	High	High	Medium	Medium	Unsanctioned access and disclosure of sensitive personal data from the Metaverse and IoV, compromising privacy and leading to potential identity theft and fraud.	High
Manipulation of Virtual Traffic	Medium	High	High	High	Medium	Deliberate tampering with virtual traffic systems, causing chaos, traffic congestion, and potential accidents within the IoV and virtual environments of the Metaverse.	Medium
Virtual Identity Spoofing	High	High	High	High	High	Creation and use of counterfeit virtual identities to deceive individuals, commit fraud, gain unauthorized access to sensitive systems, and manipulate the IoV and Metaverse interactionsf or malicious purposes.	High

Metaverse Malware Outbreak	Medium	High	High	Medium	Medium	Widespread dissemination of malware within the Metaverse, affecting connected devices, compromising user data, and disrupting virtual experiences and interactions with the IoV.	Medium
Virtual Surveillance Exploitation	Medium	Medium	High	High	Medium	Unauthorized monitoring and gathering of sensitive information from virtual environments, compromising user privacy and potentially enabling targeted attacks within the Metaverse and IoV.	Medium
IoV Manipulation	High	High	High	High	High	Exploitation of vulnerabilities in the IoV infrastructure, allowing unauthorized control or manipulation of connected vehicles, leading to accidents, traffic disruptions, and potentially physical harm.	High
Virtual Financial Fraud	High	High	High	High	High	Engaging in fraudulent activities within the Metaverse's virtual economy and financial systems, leading to significant monetary losses, disruption of economic stability, and erosion of user trust in virtual transactions.	High
Deepfake Attacks	Medium	Medium	High	High	Medium	Creation and dissemination of highly convincing deepfake content within the Metaverse and IoV, causing reputational damage, misinformation, and potential social and political unrest.	Medium

CONCLUSION

The Metaverse can be seamlessly integrated with the Internet of Vehicles (IoV) through the utilization of the concept of digital twinning, creating virtual counterparts of vehicles and their associated systems, which can then be connected to the Metaverse. This allows for the gathering of data from the physical vehicles, enabling the Metaverse to perform in- depth analysis and prediction of performance outcomes and potential issues. Furthermore, the Metaverse can also be leveraged as a virtual testing ground for simulating the behaviour of vehicles in various scenarios. Additionally, the integration with IoV platforms allows for seamless communication, navigation, and real-time data exchange between the vehicles and the Metaverse, further enhancing the overall experience.

The integration of these technologies presents both challenges and opportunities, and further research and development are necessary to fully exploit their potential. In future, researchers can combine different models to generate high security, low complexity, and high energy efficiency methods, that can be used for real-time deployments for integrating Metaverse with IoV.

REFERENCES

1. https://www.techtarget.com/whatis/feature/The-metaverse-explained-Everything-you- need-to-know

2. https://www.cnbc.com/2021/11/18/nike-teams-up-with-roblox-to-create-a-virtual- world-called-nikeland-.html

3. https://www.hyundai.com/worldwide/en/company/newsroom/hyundai-motor-shares-vision-of-new-metamobility-concept%252C-%25E2%2580%2598expanding-human-reach%25E2%2580%2599-through-robotics-%2526-metaverse-at-ces-2022- 0000016777

4. https://www.sae.org/news/2019/11/odds-for-av-testing

5. https://venturebeat.com/ai/bmw-uses-nvidias-omniverse-to-build-state-of-the-art- factories/

6. https://economictimes.indiatimes.com/small-biz/entrepreneurship/how-a-chennai-firm- is-training-indias-future-doctors-through-virtual-reality/articleshow/100318803.cms

7. https://www.slashgear.com/806714/nvidia-is-mapping-earths-digital-twin-and-your- car-could-help/

8. S. A. H. Shaikh and D. Jadhav, "Human Face Detection and Facial Expression Identification," 2018 Second International Conference on Computing Methodologies and Communication (ICCMC), Erode, India, 2018, pp. 956-962, doi: 10.1109/ICCMC.2018.8487651.

9. Koutitas G., Smith S., Lawrence G., "Performance evaluation of AR/VR training technologies for EMS first responders", Virtual Real., 25 (1) (2021), pp. 83-94.

10. T. M. Fernández-Caramés and P. Fraga-Lamas, Eds., Blockchain Potential in AI. IntechOpen, 2022. doi: 10.5772/intechopen.91580.

11. Jeon, Hyun-joo & Youn, Ho-chang & Ko, Sang-mi & Kim, Tae-heon. (2021). "Blockchain and AI Meet in the Metaverse". 10.5772/intechopen.99114.

12. Muhammad Zawish, Fayaz Ali Dharejo, Sunder Ali Khowaja, Kapal Dev, Steven Davy, Nawab Muhammad Faseeh Qureshi, Paolo Bellavista," AI and 6G into the Metaverse: Fundamentals, Challenges and Future Research Trends", arXiv:2208.10921v2, https://doi.org/10.48550/arXiv.2208.10921

13. Tang F., Chen X., Zhao M., Kato N. "The roadmap of communication and networking in 6G for the metaverse" IEEE Wirel. Commun. (2022).

14. Li, Kai & Cui, Yingping & Li, Weicai & Lv, Tiejun & Yuan, Xin & Li, Shenghong & Ni, Wei & Simsek, Meryem & Dressler, Falko. (2022). When Internet of Things meets Metaverse: Convergence of Physical and Cyber Worlds.

15. Wenchao Xu, Haibo Zhou, Nan Cheng, Feng Lyu, Weisen Shi, Jiayin Chen and Xuemin (Sherman) Shen, "Internet of Vehicles in Big Data Era," IEEE/CAA J. Autom. Sinica, vol. 5, no. 1, pp. 19-35, Jan. 2018. doi: 10.1109/JAS.2017.7510736.

16. Güven, İlkim & Balli, Osman. (2022). Empowering Metaverse Through Artificial Intelligence.

17. Rudman, Riaan & Bruwer, Rikus. (2016). Defining Web 3.0: Opportunities and challenges. The Electronic Library. 34. 132-154. 10.1108/EL-08-2014-0140.

18. https://www.apple.com/in/newsroom/2023/06/introducing-apple-vision-pro/

19. Xiang Zhang, Lina Yao, Shuai Zhang, Salil Kanhere, Michael Sheng, and Yunhao Liu, "Internet of Things Meets Brain-Computer Interface: A Unified Deep Learning Framework for Enabling Human-Thing Cognitive Interactivity", JOURNAL OF LATEX CLASS FILES, VOL. 14, NO. 8, AUGUST 2015.

20. https://www.theverge.com/2021/12/15/22836401/intel-metaverse-computing- capability-cpu-gpu-algorithms.

21. Ning H, Dhelim S, Bouras M A, et al. Cyber-syndrome and its formation, classification, recovery and prevention[J]. IEEE Access, 2018, 6: 35501-35511.

22. Jeon, Hyun-joo & Youn, Ho-chang & Ko, Sang-mi & Kim, Tae-heon. (2021)., "Blockchain and AI Meet in the Metaverse", 10.5772/intechopen.99114.

23. Kumar H, Kuča K, Bhatia SK, Saini K, Kaushal A, Verma R, Bhalla TC, Kumar D., "Applications of Nanotechnology in Sensor-Based Detection of Foodborne Pathogens. Sensors (Basel)". 2020 Apr 1;20(7):1966. doi: 10.3390/s20071966. PMID: 32244581; PMCID: PMC7181077.

24. Kaplan, Andreas (November 2, 2021). "Facebook's Metaverse: A nightmare turning into reality?". ESCP. Retrieved March 10, 2022.

25. Allam, Zaheer; Sharifi, Ayyoob; Bibri, Simon Elias; Jones, David Sydney; Krogstie, John (July 8, 2022). "The Metaverse as a Virtual Form of Smart Cities: Opportunities and Challenges for Environmental, Economic, and Social Sustainability in Urban Futures". Smart Cities. 5 (3): 771–801. doi:10.3390/smartcities5030040. ISSN 2624-6511.

Wireless Power Transmission: A Comprehensive Review

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ABSTRACT

Wireless power transmission has emerged as a promising technology that caters to the evolving demands of science and technology. Its potential applications span across various fields, including electronics, medical devices, and industrial settings, making it a subject of extensive research worldwide. This comprehensive review paper examines the historical development and classification of wireless power transmission, highlighting its diverse application areas. A comparative analysis of different wireless power transmission methods is presented. By synthesizing existing knowledge, this review sheds light on the advancements, challenges, and future directions in the domain of wireless power transmission, offering valuable insights for researchers and practitioners alike.

KEYWORDS *: Wireless power transmission, Application, Advantages, Disadvantages, Technologies, Efficiency*

INTRODUCTION

Power Transfer has been used in the conventional form of wires which usually have the problems such as loose connections, overlapping of wires, exposure of wires etc. These result in loss of current which also may be harmful if comes in contact. Additionally, these wires cannot be laid down to transmit signals in areas of high altitude or deep-sea beds. Thus, there is an apt need for a new power transmission source that can overcome the loose ends of conventional wiring. This is found in Wireless Power Transmission (WPT). WPT plays an enormous role in transmitting power from one point to another through the vacuum medium or atmosphere but without the use of cables or any other material. WPT is in use in consumer electronic goods as well as being increasingly developed for the automotive industry to charge Electric Vehicle batteries. Wireless electricity Transfer (WPT) has the potential to totally transform the way electricity is transmitted, leading to a paradigm change. Wireless Power Transfer is a groundbreaking method for moving huge amounts of energy from one place to another in the environment without using traditional wires or any other material [2]. From being only theoretical ideas to being a standard function on manufactured goods, particularly mobile phones and portable smart gadgets, wireless charging has advanced [3]. New Generation mobile devices were introduced in 2014 by tech giants, like Huawei and Samsung. These appliances are equipped with wireless charging capabilities. Several Tech Industries, including Qualcomm, Evatran, WiTricity, and others, have already created alternatives that can transfer power via an acceptable gap of 150 to 300 mm.

RECENT TRENDS

Various technologies have evolved in the area of activities of energy transmission. The use of wireless energy transfer technology started in 1888 and the technologies have been evolved since 1888. In end of 19 century inspired by Maxwell's theory,Heinrich Hertz showed convincing proofs by using his spark-gap radio transmitter. In 1964, William C. Brown, a microwave electronics expert, created a "Helicopter model" which was capable of receiving and using microwave signals as direct current through an antenna array. Its only drawback is that it can only transmit signals for a distance of a few meters.

Another successful attempt in making a wireless power transmitter was made by NASA in 1975. This

transmitter was capable of transmitting signals of a power of few kW over a range of 1.5 km. The signal was transmitted with a total efficiency of 82%. Its only drawback is that it needs a receiver antenna of area 24 m^2 and a reflector antenna of 28 m diameter to generate the signal. In 2011, the evolution of wireless power transmission took a drastic change with the invention of wireless chargers for handsets. Wireless chargers have a power transmitting efficiency of up to 70%. Samsung was one of the first companies to incorporate wireless charging in their phones. A better example is Xiaomi's mi air charger which can charge phones at a maximum distance of 7 meters.

Fig. 1. Evolution of wireless power transmission technologies

Fig. 2. Wireless power transmitter by NASA

One of the most successful WPT devices was developed by a group of researchers led by Christopher Rodenbeck in the SCOPE-M Project guided by the US government Navy. In 2022, "SCOPE-M Project" was established by the pentagon in order to supply electricity to the military bases. Utilizing a microwave beam having a frequency of a few GHz, the SCOPE-M project performed successfully. The researchers set up a sender to transmit signals at Maryland and the receiver was set up at Massachusetts. It used a square rectenna to convert an x-band microwave beam to 1 kW of DC power at a range of 1 km. It worked with a total efficiency of 60% by beaming 1.6 kW over a target at 1km distance. The frequency of 10- GHz was selected as it can be beamed successfully with minimum losses in extreme weather conditions, also it was harmless for animals and birds in the region. It was the most significant microwave energy beaming demonstration that has occurred in nearly 50 years. This tech is touted as the future of wireless energy transfer and it can also be used for sending Microwave Power Beams from Space to Earth.

Fig. 3. Xiaomi's mi air charger

Qi (which transcends from a Chinese word simply meaning energy) is one of the very first standards developed by the Wireless energy Consortium, primarily used for short-range charging in smartphones, smartwatches, and devices of low power consumption. Qi technology charges devices by simply placing them on a compatible charging pad or mat.

Qi's standard is based on the fundamentals of Electromagnetic Induction which requires the charging pad (transmitter) and the device(receiver) to remain in proximity. Qi became very famous once it got introduced in the markets in 2010. Companies that started utilizing this standard for commercial purposes were Samsung, LG, Philips, Toyota, Microsoft, and Sony. Qi has few drawbacks which include heating of metal, alignment of positions of coils. It can charge only one device at a given time etc. Over time Qi became the most used

and prime standard for wireless charging in consumer electronics. However, there are several restrictions with Qi technology and potential solutions are also worked out. The capacity of this technology ranges from 5 to 15 W, which makes it suitable for charging small devices like smartphones with ease. However, modifications have to be made to increment its power from base 30 W to limit 60 W which will make it available for larger devices (like laptops) to use. The limitations which resist Qi to reach its full potential are heating, temperature effect on energy transmission, and the need of aligning the transmitter and receiver. In traditional wireless charging systems, alignment between both the coils is crucial for efficient power transfer. If the positions of both the coils are mismatched the charging efficiency may decrease, resulting in loss of power transfer or slow charging altogether. To avoid any energy losses users need to align their devices precisely with charging pads.

Rezence developed by Alliance for Wireless Power (A4WP) in 2012 works on the principle of magnetic resonance. It can charge multiple devices at a given time, over longer distances, and provide higher power levels, making it appropriate for charging devices with high power consumption such as laptops and tabs. A device based on Rezence technology is enough to power up eight devices mid-range distance. Rezence technology along with magnetic resonance uses Bluetooth facilities to know crucial information like power requirements, charging status, and safety protocols which provides users with extra convenience. The A4WP's Rezence technology is for larger devices whereas Qi is popularly known and used for charging smaller devices over short-range distances. Rezence technology is trusted by automobile companies like BMW enabling wireless charging in their car models, IT service companies like Fujitsu, tech companies like Dell, and electric and electronic appliance companies like Panasonic.

Another industry consortium was Power Matters Alliance, founded in 2012, which also utilized magnetic inductive charging technology, similar to Qi. PMA worked in favour of promoting WPT within the automobile sector and popular industrial sites. Despite being in top-notch competition with Qi, PMA gained customers from major companies like Duracell, AT&T, Starbucks, and General Motors. Later on, in mid-2010s, Power Matters Alliance and Alliance 4 Wireless Power integrated to form the Air Fuel Alliance standard.

CLASSIFICATION OF WIRELESS ENERGY TRANSFER

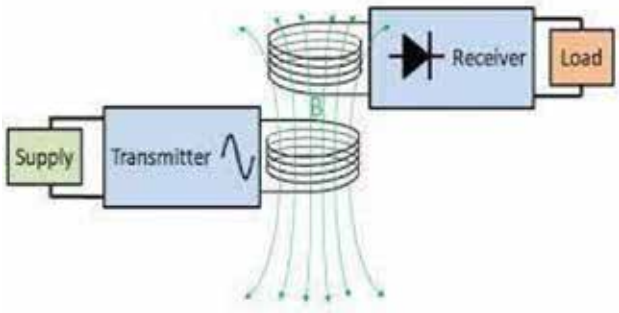

Fig. 4. Conventional wireless energy transfer

The conventional method of wireless power transmission is illustrated in Fig. 4. The modern methodology of transmitting energy without conventional use of wires has been named as Wireless energy transmission. Without the use of towers and transmission lines, a wireless transmission transmits electricity from the power plant to the user. Using induction coils, electrical energy is transported wirelessly (WPT) over an air gap from a power source to an electrical load. These coils create an electromagnetic field that transmits energy with complete galvanic separation from a charging power house station to the portable device. At the receiver end the energy from the electromagnetic field is changed to energy for use. The two types of Wireless Energy Transfer systems are far-field and near-field WPT systems, respectively, as determined by the energy transfer mechanism [1].

Far-Field Wireless Energy Transfer

Far-field wireless energy transfer is based on electromagnetic radiation This technique uses radio wave and electromagnetic wave transfer at a particular frequency to transfer energy as radiation. Waves in this technique are used as medium of transfer. It has two examples which are microwave energy wireless transfer and laser energy wireless transfer.

Microwave Energy Wireless Transfer

Microwave energy transmission is one of the ways

to transmit energy far apart. Based on the techniques used for sending this energy it has a number of uses. In the technique which involves coinciding transmission and reception satellite for enhancing the energy send to the acceptor assures us high energy Transfer. This technique also involves magnetron for conversion of Ac to dc and then to microwave energy and again at acceptor end this magnetron converts the microwave energy to DC and then to Ac for use .This technique is efficient in conversion of energy .The another technique which is used for energy transmission between spacecraft and Solar satellite involves components like Dc-Rf converter, rectifier, low pass filter initiates at central power station where DC power is converted to transmissible waves of certain frequency and are propagated in the space through transmitter then acceptor device accepts those frequencies and low pass filter cut-offs down some frequencies and then through rectifier and DC filter energy gets changed to electrical energy.

It is observed that this technique is only applicable in space because microwave has bad effects on environment of earth, these waves interfere the communication gadgets .The aeronautical industry use a technique for supply to the drone ships which are without a crew .This technique uses microwave gadgets capable of sending signals as waves containing electrical energy through a specialized transmitter and at the acceptor end the this wave containing electrical energy is given to the load .This technique ensures us with high transmission power and it does not get affected by different weather conditions at the location of supply far apart. It is observed that all the techniques are not that much efficient and are highly prized due to extensive use of acceptors.

Laser Energy Wireless transfer

The technique used in LPT is based on propagation of concentrated unidirectional beam which is near infrared in nature and this beam is received by an acceptor situated at the location far away from the transmitter used for sending the beam. At the acceptor end there are specialized solar energy-based cells which convert this unidirectional beam to electrical energy. At the transmitter end a complex convergence system is used to concentrate that beam and to send in the direction of the acceptor. Some specialized tracking devices are also needed at the acceptor end. An Acceptor which is familiar with properties of light beams converts the energy content of the light beam to electrical energy. Due to this it is helpful in charging the source of the device containing the receiver. The main components at the acceptor is the high performing rectifier which makes the current stable and amplified. This rectifier equipped model has low efficiency because it causes power loss. It is observed that there are problems with this technique of transmission. The proper set up of specialized Tracking devices are needed to detect the beam which makes it very complex while setting up it for the process of transmission. The beam is also vulnerable to bad weather conditions like heavy rainfall, mist and highly concentrated beam is also harmful for human kind. It is more efficient than microwave energy wireless transfer because of better contact between transmitter and acceptor than contact between transmitter and acceptor in the microwave energy transfer. It is assuring higher power transmission than microwave energy transfer to the location of the acceptor which is far apart. In the future there is a chance of using LPT devices for illumination of light on satellites revolving close to Earth during the time of solar eclipse, lunar eclipse. There is also a chance of launching this LPT device in the commercial market when these devices will be successful.

Near -Field Wireless Energy Transfer

Near-Field wireless Energy Transfer is a concept of energy transfer which involves several techniques for transferring radiant energy through magnetic fields and the basis of this energy transfer is integrated working of two coils under the influence of magnetic field. Magnetic field has higher attenuation than electric field that is why it is used in short range. It is safer for transmission of the energy or over short range as it is non radiative. The principle of near field wireless power transmission is based on the principle of a transformer. It has two coils, primary and secondary. Source of voltage which is alternating in nature is joined to first coil then by the phenomena of electromagnetic induction results in the generation of force which is electromotive. This force is generated in the secondary coil, which results in flow of changes in the second coil. The current source

(I), amplitude (A) and frequency (f) is connected in the primary coil and N1 is the number of turns or windings in coils. As per the statements of Faraday's law, Electromotive Force will be generated in the second coil, then flow of charge is induced in the second coil. $\varepsilon = -N.S.\ dB/dt$. In magnetic field induction is normal to the surface through which the magnetic flux is passing $\varphi = B \cdot$ Negligible all the loss, the efficiency voltage on output in the secondary coil is

$$Urmsn = k\,\pi\,\sqrt{2} \cdot f \cdot Nn \cdot Bm \cdot S$$

where K=coupling coefficient=Amplitudes of magnetic flux density.

Near field WPT is classified in two types i.e., Inductive Energy transfer and Capacitive Energy transfer. It is based on laws of ampere and Faraday.

Inductive Energy transfer

Inductive Energy transfer is further differentiated into two types i.e.,

1. Inductive conjugated wireless power transfer and
2. Magnetically conjugated resonance wireless power transfer.

This system has two components, one is sender and another acceptor. At the sender's end there is a rectifier of ac|dc nature which changes AC to DC or DC to AC. The acceptor circuit receiving coil which has an ac/dc inverter used to change DC to AC and regulator is used to stabilize the voltage at output. There are factors which affect IPT coupling coefficient. Coupling coefficient is inversely proportional to distance between the sender and receiver.

Inductive coupled wireless energy transfer

Frequently used technique for wireless power transfer. This technology uses the magnetic field for transmission of energy. Transmitter and receiver coil are coupled together at short distances. This technology functions at frequency at kilohertz and maximum distance is 40mm. If the distance between the coil is increased from 2 cm to for 10 cm, the coupling coefficient is decreased from 60% to 10% efficiency of energy transfer drops by 40%. Coupling coefficient and efficiency of energy transfer is upgraded by shape and size of coil and position of transmitter and receiver. The advantage of this system is that very simple technology is used. Its work on low frequency is safer for the human being as it is non radiative. It is ideal in case of a shortly separated energy transfer. The major disadvantage is that the coupling coefficient for long distance is very low.

Magnetic conjugated resonance wireless power transfer

The basis of Magnetic conjugated resonance wireless energy transfer is similar to IWPT. Frequency of the operation of this technology is in the range between a few kilowatts to ten megahertz. Energy transmission range is about several meters Range of power transmission is not affected by the surrounding conditions. It used magnetic resonant coil instead of coil with winding. The paper states that efficiency of energy transmission depends upon the structure and of the coil arranged and medium. Paper shows the three different arrangements of a rectangular coil. Coil has dimensions of 498x10.4x20.2 mm and turns contain 12 curves, self-inductance is 212 μH. Rectangular coil is placed in three different ways: the first coin is placed horizontal at distance d; second one is slightly vertical to the original position and third one is placed at a slightly inclined angle. As we know, the coupling coefficient between the two coils decreases with increasing distance. The value of coupling coefficient decreases in the case of vertical and horizontal engagement of the coils. Changing the upright distance from 1.5 cm to 16 cm changes one third of the coupling coefficient than the original one. Horizontal distance of the coil is 200 mm, reducing the couplings coefficient by 50%. The coupling coefficient of the incline rectangular coil is changed from the initial one. Its value has increased by 6%. The shape of a coil also affects the wireless power transmission considering the oval, square and pentagonal shape of a coil is taken for the transmission and receiver coin. Surface area of a coil is about 110 -120 mm^2 both the coins have similar number of windings;15 turns for oval shape and 14 turns for pentagonal and square shape. It is observed that the minimal value of electrical transfer efficiency was generated in elongated circle shape coil highest value software in a pentagonal shape. Coupling coefficient of pentagonal shape coil has increased after 30%.

Capacitive Energy Transfer

Capacitive Energy Transfer works on ordinary

transformers instead of using magnetic field for transmission it uses electric field. It has two metal or conductive material plates for transmission and receiver. Ac voltage is applied to transmission, energy is transferred through electrostatic induction. This technology is cheaper than other wireless power transmission in short range and it's portable than Inductive power transfer. The major drawback about this technology is it only works in very short range.

Comparative Analysis

Far field wireless power transfer is being compared between two of its subclasses being: - microwave power transmission and laser power transmission.

Table 1. Comparative Study of Factors of Far Field Energy Transfer

Parameters	Microwave Energy Wireless Transfer	Laser Energy Wireless Transfer
Efficiency	Less Efficient	More efficient
Working Principle	Based on Electromagnetic Radiation	Using Uni-directional beam for Power Supply
Effect of Weather Condition	Less vulnerable to different whether condition	More vulnerable to different weather conditions
Effect of Atmospheric Absorption	Less effect of Atmospheric Absorption	More effect of atmospheric absorption
Specialized Gadgets	No Specialized gadgets used	Complex Optics system for directing beam and specialized mechanisms for tracking
Applications	To supply power between satellites and spacecrafts	LPT is used to illuminate satellites closer to Earth

Near Field Wireless Power Transfer is being Compared between three of its Subclasses being: - MCR WTP, IWTP, CTP

Table 2. Comparison of different factors various Inductive power transfer techniques

Types of Inductive Energy Transfer Techniques			
Factors	Magnetically Conjugated Resonance	Inductive	Capacitive
Frequency of Operation	More than others	Moderate	Moderate
Loss in Hysteresis	Nil	Few	Few
Loss of Eddy Current	More than others	Moderate	Least
Coefficient Of Coupling	less than 0.25	More than 0.5	Almost Equal to 1
Effectiveness in operation	Moderate	High	Moderate
Distance between Transmitter and Receiver	Moderate	Moderate	Least

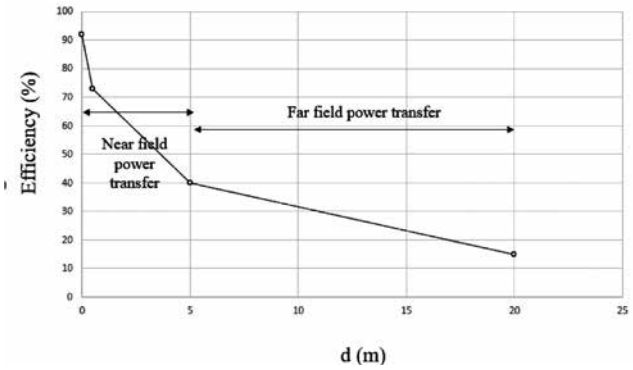

Fig. 5. Efficiency of near field and far field energy transfer with distance

The energy-transfer efficiency declines with expanding distance, as shown in Figure 5. As can be observed, the IWPT technology provides an efficiency that is maximum in the short- distance range (between 68% and 95%). A change in energy transfer technology is necessary to increase the distance between the sender and receiver, which reduces energy efficiency to 45–65%. The far-field energy transfer technique yields the lowest energy-transfer efficiency values, and these values are significantly influenced by other factors, such as the weather, the design of the transmitter and receiver, the type of materials used to construct the system's various components, etc.

The method that employs the electric flux to transfer electrical energy has the highest coupling coefficient value, as displayed in Table 2, but the distance at which this energy can be sent is also the shortest. The method that transfers power using resonance frequency, on the other hand, has a poorer transmission efficiency than the Inductive Energy transfer while having the maximum operational frequency values and no hysteresis losses. Additionally, with the MCR WPT technology, the considerable losses caused because of the rising eddy currents lower the value of the evaluated efficiency. Magnetically Conjugated Resonance could function at a least signal frequency value, but it reduces the system's efficiency and lowers its Q factor. The frequency range where a high efficiency can be attained has an ideal value range of 5 to 20 MHz.

Wireless Energy Transfer Applications

WPT has found numerous applications in various commercial as well as non-profit industries offering added

convenience and comfort to users. The applications of Principles of Wireless Power Transmission in the field of Electric vehicles bring a radical change in transportation and commuting facilities avoiding the exhaustion of fossil fuels and saving them for future generations. Wireless charging pads embedded in parking spaces or roads, allow EVs to charge while being parked or even while driving. This technology can greatly enhance the driving and charging experience of electric vehicles and increase the adoption of the same in the future. Wireless charging facilities in medical devices such as neurotransmitters and pacemakers lessen the risk of deteriorating health conditions of patients by ruling out the factor of replacing batteries within the device. WPT can be used to supply electricity in inaccessible and remote areas where the development of substations is difficult. Microwave or laser-based systems transmit power over long distances without the need for physical cables. The power can be received and converted into usable electricity in the remote area. This process can positively reduce the need for wires and substations and is useful to power electric devices where interconnecting wires are troublesome. WPT has revolutionized the whole concept of traditional charging by enabling wireless charging in various devices ranging from low to high power consumption like smartphones, watches, laptops, and tabs. Haier Group, in 2010 launched the world's first series of "tailless TV" without the use of power, signal, and network lines. Along with-it wireless technology proves to be a boon for fields like industrial automation, robotics, unmanned aerial vehicles (UAV), wireless sensor network (WSN), the Internet of Things (IoT) wearable technology, and smart home systems.

Advantages of Wireless Energy Transfer

High power up to several kW can be transferred using certain WPT technologies. It is viable to achieve higher efficiency, around 90%, in certain wireless power transfer technologies. These wireless power transfer technologies are designed to transfer power without generating eddy currents. Some wireless power transfer technologies are suitable for charging mobile phones and other small devices and utilize metal plates as the transmitter and receiver, which can help reduce costs. These technologies provide good galvanic isolation, ensuring electrical separation between the power source and the receiving device. Wireless power transfer technologies can also be applied to various devices, ranging from small devices like phones to large applications such as electric vehicles.

Drawbacks of Wireless Energy Transfer

Wireless energy transfer has moderate efficiency in the short range of 70-80%. While transferring energy from one location to another, the range varies from centimeters to meters. It has low efficiency, less than 10% or 20%. These energy power transfers have short transmission distances, usually up to a maximum of 100 mm and have significant losses in eddy current that restrict the application area. Wireless energy transfer has complex implementations required for certain wireless power transfer technologies.

CONCLUSION

The chosen researchers have created and tested numerous compensation approaches based on the data reviewed in the above study to enhance the functioning of wireless energy transfer systems utilizing a variety of optimization methodologies. Despite the extensive research in this field, Wireless Energy Transfer has yet to reach its maximum potential in the context of transferring energy, dimension/proportion of coil, frequency and distance. This is due to the fact that the latest-designed transmitter and receiver coils are gigantic enough to accommodate them in commercial devices. Additionally, the coils are not mobile as they will occupy a massive surface within the working area. To overcome the shortcomings, Wireless Energy Transfer needs to be studied and applied in more depth as this technology will be a driving force in the coming decades.

REFERENCES

1. M. A. Houran, X. Yang, and W. Chen, "Magnetically Coupled Resonance WPT: Review of Compensation Topologies, Resonator Structures with Misalignment, and EMI Diagnostics" , MDPI Journal, 2018.
2. A. M. Jawad, R. Nordin, and S. K. Gharghan, "Opportunities and Challenges for Near-Field Wireless Power Transfer: A Review", MDPI Journal, 2017, pp. 1–28.
3. B. Zhu, J. Li, W. Hu, and X. Gao, "Review of Magnetic Coupling Resonance Wireless Energy Transmission",

International Journal of u- and e- Service, Science and Technology vol. 8, no. 3, pp. 257–272, 2015.

4. K. Arai, "Wireless power transfer solution for 'Things' in the internet of Things", proceedings of the Future Technologies Conference (FTC), vol. 1. 2018.
5. M. Shidujaman, H. Samani, and M. Arif, "Wireless power transmission trends," 2014 Int. Conf. Informatics, Electron. Vision, ICIEV 2014, 2014.
6. R. Zhang, "Communications and Signals Design for Wireless Power Transmission," cs.IT, 2016.
7. H. Hong, D. Yang, and S. Won, "The Analysis for Selecting Compensating Capacitances of Two- Coil Resonant Wireless Power Transfer System," Proc. - 1st IEEE Int. Conf. Energy Internet, ICEI 2017, pp. 220–225, 2017.
8. Y. Zhang, Z. Yan, Z. Liang, S. Li, and C. Mi, "An LCL-N Compensated Strongly-Coupled Wireless Power Transfer System for High-Power Applications," 2019 IEEE Appl. Power Electron. Conf. Expo., pp. 3088–3091, 2019.
9. P. S. Patil and S. K. Padaganur, "Challenging Issues In Wire Less Power Transmission Methods A Survey," International Journal of Scientific and Technology Research vol. 7, no. 8, pp. 136– 139, 2018.
10. A. Massa, G. Oliveri, F. Viani, and P. Rocca, "Array designs for long-distance wireless power transmission: State-of-the-art and innovative solutions," Proc. IEEE, vol. 101, no. 6, pp. 1464– 1481, 2013.
11. X. Lu, P. Wang, D. Niyato, D. I. Kim, Z. Han, and C. Engineering, "Wireless Charging Technologies: Fundamentals, Standards, and Network Applications," EEE Communications Surveys and Tutorials, 2016, pp. 1–40.
12. A. Arshad, S. Khan, A. H. M. Zahirul Alam, and R. Tasnim, "Investigation of inductive coupling approach for non-contact bidirectional transfer of power and signal," 2012 Int. Conf. Comput. Commun. Eng. ICCCE 2012, no. July, pp. 570–573, 2012.
13. V. Shevchenko and S. Member, "Compensation Topologies in IPT Systems: Standards, Requirements, Classification, Analysis, Comparison and Application," IEEE Access, pp. 120559– 120580, 2019.
14. Y. Luo, Y. Yang, S. Chen, and X. Wen, "Power Waves-based Analysis of Magnetically Coupled Resonant Wireless Power Transfer", IEEE Accss, pp. 878–882, 2017.
15. X. Chen and X. Gong, "Modeling of wireless power system with giant magnetostrictive material load under multi-field coupling," Conf. Proc. - IEEE Appl. Power Electron. Conf. Expo. - APEC, no. Mci, pp. 3100–3105, 2017.
16. P. Bakolia, "Wireless Power Transmission – The Future of Power Transmission System. By", Journal of Advanced Computing and Communication Technologies, no. 5, pp. 48–54, 2017.
17. T. S. C. Rao, "Categories, Standards and Recent Trends in Wireless Power Transfer: A Survey" Indian Journal of Science and Technology, vol. 9, no. May 2016.
18. S. H S, "Wireless Charging Techniques – A Survey," Int. J. Res. Appl. Sci. Eng. Technol., vol. V, no. III, pp. 480–484, 2017.
19. W. Is and W. Power, "Introduction to Wireless Power Transfer: Benefits, Markets, and What is your opinion?", Mendeley, pp. 1–2, 2019.
20. S. Li, W. Li, S. Member, J. Deng, and S. Member, "A Double-Sided LCC Compensation Network and Its Tuning Method for Wireless Power Transfer", IEEE Transactions on Vehicular Technology vol. 64, no. 6, pp. 2261–2273, 2015.
21. C. Park et al., "Innovative 5m-off-distance Inductive Power Transfer Systems with Optimally Shaped Dipole Coils," IEEE Transactions on Power Electronics, vol. 8993, no. c, 2014.
22. C. Saha et al., "Wireless power transfer using relay resonators Wireless power transfer using relay resonators," AIP Conference Proceedings, vol. 263902, 2018.
23. S. Ansari, A. Das, and A. Bhattacharya, "Two-Coil System with class-E Resonant High- Frequency Inverter" IEEE International Conference on Signal Processing and Integrated Networks pp. 269–273, 2019.
24. S. Lee, K. Yi, and M. Kim, "Distance Using a GaN-Based Full-Bridge Inverter" MDPI Journal, 2019.
25. Nandankar, P., Thaker R., Mughal, S.N., Saidireddy M., Linda, A., Kostka J.E., Nag, M.A., "An IoT based healthcare data analytics using fog and cloud computing," Turkish Journal of Physiotherapy and Rehabilitation, (2021), 3, 32.
26. Nandankar, P., Dasarwar, A., Kachare, G., "Comparison of improved converter topologies for high voltage gain," International Conference on Communication

Information and Computing Technology (ICCICT), (2018), DOI: https://doi.org/10.1109/ICCICT.2018.8325893

27. Nandankar, P.V.; Rothe, J., "Highly efficient discontinuous mode interleaved DC-DC converter," International Conference on Electrical, Electronics, and Optimization Techniques, Chennai, India, 3–5 March 2016; pp. 476–481.

28. P. V. Nandankar, P. P. Bedekar, et P. V. Dhawas, « Efficient DC-DC converter with optimized switching control: A comprehensive review », Sustainable Energy Technologies and Assessments, vol. 48, p. 101670, déc. 2021, doi: 10.1016/j.seta.2021.101670.

29. Nandankar, P.V., Bedekar, P.P., Dhawas, P.K.V.: Variable switching frequency control for efficient DC/DC converter. Material Today: Proceedings (2021).

30. X. Zhang, X. Zhang, C. Zhang, S. Yao, H. Qi, and Y. Xu, "Optimal design and analysis of wireless power transfer system with converter circuit", EURASIP Journal on Wireless Communications and Networking pp. 1–6, 2017.

Power Factor Improvement Methods for Energy Efficient Usage in Industries

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ABSTRACT

This paper discusses the importance of improving power factor for efficient electrical power usage and extended electrical equipment lifespan. The implemented action plan is presented as an example, showcasing the reduction in penalties for consumer consumption. This article discusses the importance of improving power factor in electrical power usage, as well as the methods that can be used to achieve this. It presents data on energy consumption, power factor, and the difference between kWH and kVAH for a period of fifteen months. The article also describes an action plan that was implemented to improve the power factor, resulting in reduced penalties for consumers and increased energy savings. The conclusion emphasizes the significance of improving power factor for efficient energy usage, reduced costs, and extended equipment lifespan, and highlights several methods for achieving this goal. The research concludes by highlighting the various methods available to improve power factor, including installing power factor correction capacitors and upgrading electrical equipment.

KEYWORDS: *APFC panel, Photovoltaic, Faults*

INTRODUCTION

Energy efficient technology, which involves improving the power factor, is widely practiced in the industrial and commercial sectors to maintain power quality and increase energy savings monthly [1]. A reduction in the difference between kWH and kVAH results in greater energy efficiency. The identification gap in the last 6 months, with a rapid decrease in the power factor and an increase in the difference between kWH and kVAH, has resulted in penalties being paid by consumers. Improving power factor is important for ensuring efficient electrical power usage and reducing energy costs [2]. Power factor is the ratio of active power to apparent power in an AC circuit, and it reflects how effectively electrical power is being used [3]. A low power factor indicates that a portion of the electrical power being supplied is not being utilized effectively and is being wasted. There are several reasons why a low power factor may occur in an electrical system. One common reason is the presence of inductive loads, such as electric motors, which consume reactive power. Reactive power is the power that is required to establish and maintain a magnetic field in inductive devices. Other reasons for a low power factor may include undersized electrical equipment, long transmission lines, and harmonics [4]. To improve the power factor and make the system healthy,the following actions can be taken: [5], [6].

1) Conduct a Power Factor Correction Study: A power factor correction study can be conducted to determine the cause of low power factor to analyses the system and identify the causes of low power factor.
2) Install Power Factor Correction Equipment: Based on the findings of the power factor correction study, the installation of power factor correction equipment may be recommended.
3) Perform Preventive Maintenance: Regular maintenance of electrical equipment such as transformers, motors, and switch gear can help to maintain a healthy power factor. Maintenance

should be carried out at regular intervals to prevent equipment failure and ensure the equipment is operating efficiently.

4) Use Energy Efficient Equipment: Replacing old equipment with new, energy-efficient equipment can help to improve power factor. Newer equipment is designed to operate more efficiently and often has a higher power factor.

By taking these actions, it is possible to increase the power factor and make the system healthy. This can result in energy savings, reduced penalties, and improved power quality.

EXPERIMENTAL METHODOLOGY

The given Table I provides a monthly analysis of energy consumption, power factor, and the difference between the energy consumed in kWH and kVAH for 11 months from January 2022 to November 2022. The power factor ranges from 0.982 to 0.998, indicating that there is a scope for improvement in power factor to achieve greater efficiency. The energy consumption varies between 545688 kWH in July to 911524 kWH in February, with an average consumption of around 766385 kWHper month. The difference between kWH and kVAH ranges from 1827 in February to 8144 in September, with an average difference of around 4715 kWH per month. The monthly analysis can help to identify the areas where power factor correction can be applied to improve the efficiency of the system. There are several ways to improve power factor, including: [3].

1. Installing power factor correction capacitors: Capacitors are used to offset the inductive loads in the electrical system, thereby improving power factor.
2. Upgrading electrical equipment: Upgrading electrical equipment such as motors, transformers, and generators can improve power factor.
3. Reducing electrical load: Reducing the electrical load on the system by turning off unnecessary equipment or using more efficient equipment can improve power factor.

Table II shows scenario of Automatic Power Factor Corrector (APFC) bank. Following are the actions to be taken.

1) To take all feeders data in (Amps): The first step in improving power factor is to collect data on the current and voltage of all feeders. This data will help in calculating the apparent power (VA) and the real power (W) of the system. By measuring the current in amperes (A), we can determine how much power is being used by each feeder [7].

Table I: Monthly KWH and KVAH Difference

Sr. No	Month	Energy Consumed in kwh	Energy consumed in	Power factor	Difference (KWH-KVAH)
1	Jan-22	608301	612788	0.993	4487
2	Feb-22	911524	913351	0.998	1827
3	Mar-22	781833	784973	0.996	3140
4	Apr-22	892604	897089	0.995	4485
5	May-22	866583	872082	0.994	5499
6	Jun-22	892604	897089	0.995	4485
7	Jul-22	545688	555633	0.982	9945
8	Aug-22	794426	800026	0.993	5600
9	Sep-22	788129	796273	0.990	8144
10	Oct-22	712263	719884	0.989	7621
11	Nov-22	655357	663317	0.988	7960

2) Identify the causes of pf reduction: Once the current data is collected, the next step is to identify the causes of power factor reduction. Some common causes of power factor reduction are: - Inductive loads: Inductive loads, such as electric motors and transformers, consume reactive power and reduce the power factor of the system.

3) Identify the reason for the cause: After identifying the cause of power factor reduction, the next step is to determine the reason for the cause. For example, if inductive loads are causing the power factor reduction, it is important to identify which specific equipment or feeders are responsible for the inductive load. If harmonic distortion is causing the reduction,it is important to determine which equipment or devices are generating the harmonics [8]

4) Action to increase the pf and make system healthy: Once the causes of power factor reduction are identified and the reasons for the cause are determined, appropriate actions can be taken to increase the power factor and make the system healthy. Some common actions include: Installing capacitors: It helps system to improve power factor by supplying reactive power to offset the reactive power consumed by inductive loads. Installing capacitor bank of low current carrying capacity to avoid manual operating operations. Conducting regular maintenance: Regular maintenance of equipment can ensure that they are operating at maximum efficiency, reducing the amount of reactive power consumed and improving the power factor [9].

Table II provides status and readings of different capacitor panels in various locations. Here's an explanation of the columns:

1) Panel Name: Name or label of the capacitor panel.

2) Location: The location or place where the capacitor panel is installed (e.g., Lab 1, Office 2, Dept 3, etc.).

3) Feeder no.: Feeder number associated with the capacitor panel.

4) Capacity (kVAR): The rated capacity of the capacitor panel in kilovolt-ampere reactive (kVAR).

5) Rated Current: The rated current for the capacitor panel.

6) Actual Current: The actual current flowing through the capacitor panel.

7) Status (R/Y/B): The status of the capacitor panel in terms of the three phases - R (Red), Y (Yellow), B (Blue).

Table II informs about the status and current readings for each feeder within the capacitor panels in different locations. It also includes notes on any faults or issues identified with the panels or associated components. Fig.1 shows detailed single line diagram for different loads connected to capacitor banks.

Faults and Reasons for Power Factor Reduction: [10]

1) Current increase than rated current-Efficiency of capacitor bank decreased. A low impedance failure and broken connector can cause such cause. Generally, capacitors get overloaded due to order of 5th and above harmonies, which reduces life of capacitor bank. Majorly Variable Frequency Drives generate harmonics.

2) Lower Current Rating-Capacitor Bank efficiency. Dielectric fails within the capacitor.

3) Contactor/Reactor Failure-Over current causing overheating, fluctuations in voltage, voltage instability, aging, temperature rise.

4) Current rating zero-Reactors are not available.

5) Faulty Controller-Over voltage, Instability of voltage, voltage fluctuation, and controller setting-set incorrect.

6) Faulty Reactor-Harmonies due to nonlinear loads, ferro resonance effect.

Table II: Part I-APFC Bank Status

Sr. no	Panel Name	Location	Feeder no.	Capacity (KVAR)	Rated Current	Actual Current			Status
						R	Y	B	
1	Capacitor Panel 1	Lab 1	2F1	100	147	160	0	158	Reactor Faulty
			3F1	100		159	161	160	Increase in current
			3F2	50	74	82	83	82	Increase in current
			3F3	50		79	80	80	Increase in current
			4F1	50		79	80	81	Increase in current
			4F2	50		80	81	80	Increase in current
			4F3	50		79	80	80	Increase in current
			4F4	50		79	81	80	Increase in current
			5F1	25	36	35	36	35	Normally Working
			5F2	25		36	35	35	Normally Working
			5F3	25		34	34	35	Normally Working
2	Capacitor Panel 2	Lab 2	2F1	100	147	0	0	0	Reactor not Available
			3F1	100		0	0	0	Reactor not Available
			3F2	25	74	0	0	0	Reactor not Available
			3F3	25		0	0	0	Reactor not Available
			4F1	50		79	80	81	Increase in current
			4F2	50		78	80	80	Increase in current
			4F3	50		80	81	80	Increase in current
			4F4	25		0	0	0	Reactor not Available
			5F1	25	36	35	35	35	Normally Working
			5F2	25		34	35	35	Normally Working
			5F3	25		34	35	35	Normally Working
3	Capacitor Panel 3	Lab 3	2F1	100	147	155	156	156	Increase in current
			3F1	100		155	155	156	
			3F2	50	74	77	77	78	Increase in current
			3F3	50		76	77	76	Increase in current
			4F1	50		78	79	78	Increase in current
			4F2	50		78	78	79	Increase in current
			4F3	50		77	78	77	Increase in current
			4F4	50		79	80	80	Increase in current
			5F1	25	36	33	34	34	Normally Working
			5F2	25		33	34	33	Normally Working
			5F3	25		34	34	34	Normally Working
4	Capacitor Panel 4	Lab 4	5F1	25	36	35	36	36	Normally Working
			5F2	25		36	35	35	Normally Working
			5F3	25		35	35	35	Normally Working
			5F4	25		36	36	35	Normally Working

Sr. no	Panel Name	Location	Feeder no.	Capacity (KVAR)	Rated Current	Actual Current			Status
						R	Y	B	
5	Capacitor Panel 5	Office 1	6F1	25	36	38	37	38	Increase in current
			6F2	25		39	38	38	Increase in current
			6F3	25		38	39	38	Increase in current
			6F4	25		37	38	38	Increase in current
6	Capacitor Panel 6	Office 2	5F1	25	36	39	39	38	Increase in current
			5F2	25		37	39	38	Increase in current
			5F3	25		38	38	38	Increase in current
			5F4	25		39	39	39	Increase in current
			5F5	25		38	39	39	Increase in current
7	Capacitor Panel 7	Office 3	5F1	25	36	40	31	31	Increase in current
			5F2	25		41	32	41	Increase in current
			5F3	25		42	38	42	Increase in current
			5F4	25		41	39	42	Increase in current
			5F5	25		41	39	42	Increase in current
8	Capacitor Panel 8	Office 4	4F3	25	36	39	40	39	Increase in current
			4F4	25		40	40	40	Increase in current
			4F5	25		40	40	39	Increase in current
			4F6	10	14.5	13	13	13	Normally Working
9	Capacitor Panel 9	Office 5	6F1	25	36	39	39	39	Increase in current
			6F2	25		39	39	39	Increase in current
			6F3	25		39	39	40	Increase in current
			6F4	25		39	39	39	Increase in current
10	Capacitor Panel 10	Office 6	5F1	25	36	0	34	34	Contactor/reactor faulty
			5F2	25		29	29	38	Normally Working
			5F3	25		0	34	33	Contactor/reactor faulty
			5F4	25		39	39	34	Normally Working
			5F5	25		0	34	31	Contactor/reactor faulty
11	Capacitor Panel 11	Office 7	2F1	25	36	31	40	39	Increase in current
			2F2	25		38	39	39	Increase in current
			2F3	25		0	0	0	Spare
			2F4	25		39	40	39	Increase in current
			2F5	25		0	32	33	Contactor/reactor faulty
			2F6	25		0	0	0	Spare
12	Capacitor Panel 12	Office 8	5F3	25	36	39	39	38	Increase in current
			5F4	25		40	42	41	Increase in current
			5F5	10	14.5	13	13	13	Normally Working
			5F6	25	36	39	39	38	Increase in current

Sr. no	Panel Name	Location	Feeder no.	Capacity (KVAR)	Rated Current	Actual Current			Status
						R	Y	B	
13	Capacitor Panel 13	Dept 1	5F1	25	36	9.2	35.1	38	low current in one phase
			5F2	25		42	42	42	Increase in current
			5F3	25		9.3	4.3	5.4	Decrease in current
			5F4	25		41	41	42	Increase in current
			5F5	25		42	42	42	Increase in current
			5F6	25		41	42	34.9	Increase in current
14	Capacitor Panel 14	Dept 2	6F1	25	36	36	38	37	Normally Working
			6F2	25		3.9	2.5	4.6	decrease in current
			6F3	25		0	0	0	MCCB Tripped
			6F4	25		35	37	36	Normally Working
			6F5	25		35	37	36	Normally Working
			6F6	25					Spare
15	Capacitor Panel 15	Dept 3	2F1	50	74	71	72	72	Normally Working
			2F2	50		0	0	0	Controller faulty, manually operated
			2F3	50		0	0	0	
			2F4	50		72	73	72	Normally Working
			3F1	50		71	71	71	Normally Working
			3F2	50		72	72	72	Normally Working
			4F1	100	147	144	146	146	Normally Working
16	Capacitor Panel 16	Dept 4	2F1	50	74	72	72	71	Normally Working
			2F2	25		0	0	0	Controller faulty, manually operated
			2F3	25		0	0	0	
			2F4	50		73	72	71	Normally Working
			3F1	50		71	72	72	Normally Working
			3F2	50		72	72	74	Normally Working
			4F1	100	147	145	147	147	Normally Working
			Total kVAR	3670					

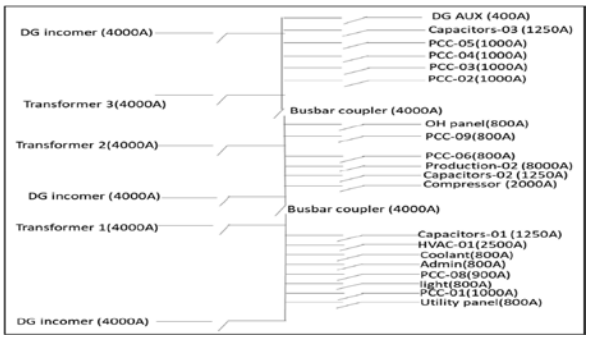

Fig. 1. Single Line Diagram

7) MCCB trips-Overloading, short circuits.

8) One of the phases current values is zero-Faulty contactor/Reactors. Over current causing overheating, fluctuations in voltage, voltage instability, aging, Temperature rise.

Photovoltaic System Connected to Grid Impacts on Reduction of Power Factor

Photovoltaic system only generates and injects active power by default and no reactive power. As generation of solar increases, the active power consumption from grid decreases, while the reactive power is constant. The power factor of a system with PV generation can decrease as the generation of solar increases, due to the increase in the difference between kW and kVA values [11].

Table III shows Impact on power factor with solar generation. The impact of solar generation on power factor is shown in the table, indicating as solar generation increases in the afternoon, it decreases the power factor. Active power consumed by the load, while apparent power is the total power consumption including both active and reactive power. In a grid system, both active and reactive power are delivered to the load. Reactive power is required to maintain the voltage level in the system and to support the operation of inductive loads, such as motors and transformers. However, a PV system does not inject reactive power into the system by default, and as a result, the reactive power delivered to the load remains constant, while the active power consumed from the grid decreases as the generation of solar increases. As a result, the apparent power consumed by the load decreases, while the active power remains the same. This leads to an increase in the difference between kW and kVA values, which in turn reduces the power factor of the system. This decrease in power factor can lead to several issues, such as increased losses in the system, reduced voltage stability, and increased penalties for low power factor. To overcome this, PV systems can be equipped with reactive power compensation equipment, such as capacitors or reactive power inverters, which can inject reactive power into the system and improve the power factor. Additionally, the PV system can be designed to operate in such a way that it injects both active and reactive power into the system, which can further improve the power factor and reduce the impact of the difference between kW and kVA values [12].

Table III: Impact on Power Factor with Solar Generation

Source Parameter							Source Parameter				
Sr.no	**Time**	**Solar Power (KW)**	**Load (KW)**	**Solar delive-red Load %**	**Load (KVA)**	**differ-ence (KW-KVAR)**	**Source Type**	**KW**	**Grid delivered load %**	**KVAR**	**PF**
12	17:00:32	22.93	1237	2	1245	8.7	Grid	1214	98	140.61	0.99
11	16:00:32	74.44	1085	7	1102	16.5	Grid	1011	93	175.18	0.98
10	15:00:34	119.72	1047	11	1066	19.2	Grid	927	89	-179.4	0.98
9	14:00:33	127.2	805	16	821	16.4	Grid	677	84	135.93	0.96
8	13:00:31	126.6	840	15	856.3	16.3	Grid	713	85	141.38	0.96
7	12:00:31	123.88	794	16	813.5	19.5	Grid	670	84	-149.9	0.97
6	11:00:30	127.31	883	14	906	22.7	Grid	756	86	173.29	0.97
5	10:00:34	125.78	1009	12	1023	14.3	Grid	883	88	-148.5	0.98
4	09:00:32	97.78	945	10	960.9	15.4	Grid	848	90	154.87	0.98
3	08:00:34	42.1	1003	4	1016	13.2	Grid	961	96	-155.2	0.99
2	07:00:33	3.07	1160	0	1168	8.2	Grid	1157	100	45.23	0.99
1	06:00:04	0	1052	0	1065	12.8	Grid	1052	100	160.78	0.99

Weekly-off days Action Plan

In industrial and commercial settings, the loads are typically not purely inductive, which means that the power factor is not unity. This can lead to several issues, including increased losses, reduced efficiency, and higher energy bills. Capacitor banks are commonly used to supply the required reactive power to the system. During normal operation, the capacitor banks operate automatically to maintain the power factor at a desirable level. However, during off days or periods of low current/minimum load, the capacitor banks may not operate automatically. To address this issue, it is necessary to install low kVAR capacitor banks that can operate at low current levels. For example, a minimum current of 20 amperes is required for a 25 kVAR bank. To ensure that the capacitor banks operate efficiently and effectively, it is important to develop an action plan that outlines the appropriate switching on and off the banks based on the load current. This can be done manually by monitoring the load current and switching the banks on or off as required to maintain the power factor at a desirable level. Capacitor banks arean effective means of compensating for reactive power absorbed by inductive loads and improving the power factor of the system. However, to ensure efficient operation, it is important to install low kVAR banks that can operate at low current levels and develop an action plan for switching the banks on and off based on the load current.

RESULT

To achieve a power factor of 0.999, it is necessary to have capacitor banks for each feeder panel as well as a centralized system. This can be further supported by an integrated solar system to maintain the power factor efficiently.

Table I V shows improvement in monthly kWH & kVAH. I n October and November, power factor was at 0.989 and 0.988 respectively, with a kWH and kVAH difference of 7621 and 7960 respectively. An action plan was put in place to address the issue, by changing the reactors and contactors, the power factor was improved and reached 0.998 with a kWH and kVAH difference of only 1461.This improvement in power factor is significant reduction difference between kWH and kVAH. The reduction in the difference between kWH and kVAH ultimately leads to energy-efficient technology. The execution of the action plan has resulted in an improved power factor, thereby reducing penalties for consumers, and contributing to maintaining power quality while increasing energy savings on monthly consumption.

Table IV: Monthly kWH and kVAH Difference Improvement

Sr. No	Month	Energy Consumed in KWH	Energy consumed in KVAH	Power factor	Difference (KWH-KVAH)
1	Jan-22	608301	612788	0.993	4487
2	Feb-22	911524	913351	0.998	1827
3	Mar-22	781833	784973	0.996	3140
4	Apr-22	892604	897089	0.995	4485
5	May-22	866583	872082	0.994	5499
6	Jun-22	892604	897089	0.995	4485
7	Jul-22	545688	555633	0.982	9945
8	Aug-22	794426	800026	0.993	5600
9	Sep-22	788129	796273	0.990	8144
10	Oct-22	712263	719884	0.989	7621
11	Nov-22	655357	663317	0.988	7960
12	Dec-22	692483	697906	0.992	5423
13	Jan-23	663989	665957	0.997	1968
14	Feb-23	531222	533757	0.996	2535
15	Mar-23	829253	830713	0.998	1461

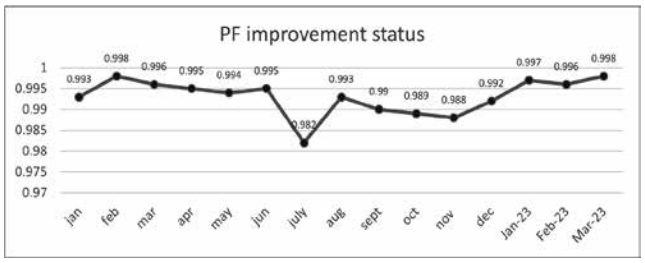

Fig. 2. Monthly representation status of power factor improvement

Fig 2 illustrates the monthly improvements in the power factor. Starting from August 2022, there was a consistent decline in the power factor, reaching its lowest point of 0.988 in November 2022. However, the power factor action plan was implemented in December, leading to noticeable improvements. From month of December onwards, there was a steady increase in the power factor, ultimately reaching 0.998 in March 2023.

CONCLUSION

Improving power factor is crucial for efficient electrical power usage, reduced energy costs, and extended electrical equipment lifespan. When the power factor is low, it results in an inefficient use of electrical power, leading to higher energy consumption and increased utility bills. Additionally, a low power factor puts a strain on electrical equipment, reducing its lifespan and increasing the risk of breakdowns and maintenance costs. One effective approach is to install power factor correction capacitors. These capacitors help offset the reactive power in the electrical system, bringing the power factor closer to unity (1.0). By compensating for reactive power, power factor correction capacitors reduce the overall power demand and improve the efficiency of the system. Another method to improve power factor is upgrading electrical equipment. Older equipment tends to have lower power factors, so replacing or retrofitting them with more energy-efficient models can significantly improve power factor and energy efficiency. Upgraded equipment is designed to operate more efficiently and maintain a higher power factor, resulting in reduced energy consumption and cost savings over time. By implementing energy conservation measures, optimizing electrical system design, and eliminating unnecessary or inefficient equipment, the overall power demand can be reduced. Installing power factor correction capacitors, upgrading equipment, and reducing the electrical load are effective methods to achieve a higher power factor, By implementing these measures, industries and organizations can optimize their energy usage, reduce operational costs, and enhance the overall reliability and performance of their electrical systems.

REFERENCES

1. R. S. Biswas and S. Mal, “Automatic power factor improvement using microcontroller,” in 2015 International Conference and Workshop on Computing and Communication (IEMCON). IEEE, 2015, pp. 1–6.
2. O. Garcia, J. Cobos, R. Prieto, P. Alou, and J. Uceda, “Power factor correction: A survey,” in 2001 IEEE 32nd annual power electronics specialists conference (IEEE Cat. No. 01CH37230), vol. 1. IEEE, 2001, pp. 8–13.
3. M. N. Zaidi and A. Ali, “Power factor improvement using automatic power factor compensation (apfc) device for medical industries in malaysia,” in MATEC Web of Conferences, vol. 150. EDP Sciences, 2018, p. 01004.
4. L. Xu, W. Wu, and W. Zhao, “Airgap magnetic field harmonic synergetic optimization approach for power factor improvement of pm vernier machines,” IEEE Transactions on Industrial Electronics, vol. 69, no. 12, pp. 12 281–12 291, 2021.
5. S. R. McCormick, K. Hur, S. Santoso, A. Maitra, and A. Sundaram, “Capacitor bank predictive maintenance and problem identification using conventional power quality monitoring systems,” in IEEE Power Engineering Society General Meeting, 2004. IEEE, 2004, pp. 1846–1850.
6. R. Se´vigny, S. Me´ nard, C. Rajotte, and M. McVey, “Capacitor measurement in the substation environment: A new approach,” in 2000 IEEE ESMO-2000 IEEE 9th International Conference on Transmission and Distribution Construction, Operation and Live-Line Maintenance Proceedings. ESMO 2000 Proceedings. Global ESMO 2000. The Pow. IEEE, 2000, pp. 299–305.
7. A. K. Tiwari, D. Sharma, and V. K. Sharma, “Automatic power factor correction using capacitive bank,” Journal of Engineering Research and Applications, vol. 4, no. 2, pp. 393–395, 2014.

8. Y.-K. Chen, T.-J. Liang, and W.-C. Wu, "Design and implementation of a photovoltaic grid-connected micro-inverter with power factor correction technology," in 2015 9th International Conference on Power Electronics and ECCE Asia (ICPE-ECCE Asia). IEEE, 2015, pp. 294–300.

9. J. W. Kolar and T. Friedli, "The essence of three-phase pfc rectifier systems—part i," IEEE Transactions on Power electronics, vol. 28, no. 1, pp. 176–198, 2012.

10. S. A. Qureshi and N. Aslam, "Efficient power factor improvement technique and energy conservation of power system."

11. P. D. Larasati, S. Handoko et al., "Analysis of the effect of installing capacitor bank in the photovoltaic on–grid 122 kwp for power factor correction," in 2020 7th International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE). IEEE, 2020, pp. 207–212.

12. T. W. Ngwe, S. Winn, and S. M. Myint, "Design and control of automatic power factor correction apfc for power factor improvement in oakshippin primary substation," 2018.

Energy Management with Hybrid Energy Sources for Electric Vehicles: A Review

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ABSTRACT

The increasing demand for environmentally friendly energy and the reduction of emissions have compelled car manufacturers to explore cleaner modes of transportation. The market share of electric vehicles is growing rapidly each year and is expected to continue this upward trend. This paper aims to investigate the energy management systems strategies and various HESS typologies configurations used in existing literature. Inclusive a range of approaches aimed at minimizing costs, weight, and energy consumption, while simultaneously maximizing the range and reliability of electric vehicles. The paper explores the existing requirements for the widespread acceptance of electric vehicles and provides a brief summary of hybrid energy storage consisting of battery, fuel cell, super capacitor and flywheel. By doing so, the lifespan of the battery can be extended, and overall efficiency and cost can be optimized. Challenges are also discussed.

KEYWORDS *: Hybrid energy storage system, Energy management, Electric vehicle, Regenerative braking*

INTRODUCTION

Electric vehicles (EV) have achieved significant popularity as alternative to internal combustion engine (ICE) vehicles. Currently, fossil fuels acquired the transportation sector with a 94% share, whereas electricity, bio-fuel, and natural gas represent only 1%, 2%, and 3%. Within the transportation sector, alternative technologies such as Plug-in Hybrid Vehicles (PHEV), Fuel Cell Vehicles (FCV) and Pure Electric Vehicles (PEV) are available, offering efficient performance and power output [1]. Electric vehicles are four times more efficient than ICE Vehicles [2]. The number of electric cars on the road in 2022 crossed over 26 million marking a 60% increase compared to 2021 and more than a five times growth from 2018 [3].Huge adoption of electric vehicles (EV) benefits the environment but storage system performance and efficiency need improvement[5].These problems affects a limited battery lifespan, expensive costs,more charging time, susceptibility to temperature variations, and the necessity for monitoring and maintaining equal charge distribution in battery cells using a complex energy management system (EMS)[6],[8]. These challenges are faced by the increasing power consumption and charging demands that occur during intense driving scenarios, such as acceleration, uphill travel, and regenerative braking [4].

Electric vehicles (EV) necessitate a capable EMS to effectively address challenges associated with the hybridization of energy sources [31][35]. These energy sources can take various forms, such as combining high-energy density batteries and fuel cell [FC] with high-power density Super capacitor (SC) and flywheel (FW)[12],[47][50]. To overcome this, researchers are studying a hybrid energy storage system (HESS) that combines batteries and Super capacitor [26-39]. HESS offers advantages such as lower costs and weight, improved EV efficiency, and longer lifespan due to a more balanced and precise system [8], [16], [17]. To optimize energy capture during regenerative braking [7].an effective energy management system (EMS) is crucial [13]. Studies indicate that implementing regenerative braking can result in an 8-25% increase in the driving range of electric vehicles [9][11]. The EMS can effectively manage the distribution of power consumption across various sources of the vehicle's

energy storage system, taking into account factors such as the vehicle's performance, battery life, and available kinetic energy [14]. A combination of battery, Super capacitor, fuel cell, and flywheel is commonly employed in literature to address peak power demands and absorb regenerative braking energy quickly [26-51]. This approaches extends battery life cycle and enhances the electric vehicle's range on a single charge.

This paper organized as, firstly in section II discuss Necessity of Hybrid Energy Storage Systems for EV, section III describe necessity and various energy management strategies used in electric vehicle with HESS, section IV give Comparative study of different Typologies of Hybrid Energy Storage System lastly section V discuss Challenges faced in hybrid energy storage system when integrated together in EV Application.

NECESSITY OF HYBRID ENERGY STORAGE SYSTEMS

In order to improve the lifespan of an ESS minimize quick discharge, boost energy availability, and optimize system efficiency, it is a widely adopted approach to connect multiple energy storage units in parallel or series setups. Several important parameters need to be taken into account while evaluating HESS. These include specific power and energy, energy and power density, lifetime, cost and various additional considerations [11].The combination of batteries with Super capacitors (SC) offer several advantages. These involve minimizing peak power demands, improving the driving range, mitigating battery degradation, and extending entire lifespan and State of Health (SOH) [12].This specific pairing proves highly suitable for Electric Vehicle (EV) applications, mostly due to its exceptional power density with energy density capabilities. Moreover, the integration of batteries with SC enables effective energy storage during braking, allowing seamless energy transfer within the structure [13].The presence of SC also contributes to sustaining the dynamic load profile of the vehicle and improve the achievable driving range. Therefore, the battery-super capacitor combination serves as an effective solution for long-term energy management and dynamic power control in EV [14].

Fuel cell electric vehicles (FCEV) provide zero emissions, low operational noise, and significant power efficiency [41]. However, challenges such as manufacturing costs, fuel production and distribution, limited power demand action, and the lack of bidirectional electric power flow have affected their commercial growth [6]. On the plus side, FCEV benefit from fast refueling compared with battery charging, but they are unable to recover regeneration energy [15],[40]. Combining high-power and high- energy storage unit in a hybrid configuration gives distinct advantages for electric vehicle applications. High-power storage system have a fast response rate, while high-energy storage device have a slower response rate. This supplementary characteristic enables optimal power with density, longer life cycles, and improved overall efficiency [16]. To overcome the challenges mentioned, a common method is to enhance vehicle performance by combining energy storage devices such as batteries, super capacitors, fuel cells, and flywheels with hybridization indifferent arrangements.

ENERGY MANAGEMENT SYSTEM FOR EV WITH HESS

Necessity of EMS

The Energy Management System in electric vehicles is an Electronic Control Unit (ECU) which optimizes energy utilization. It depends on sensor inputs, battery and super capacitor data, internal structure, and driver instructions to determine power demands [17]. A centralized control system is necessary for managing modules and functionalities effectively. Vast research focuses on enhancing EMS due to its complicated nature and diverse potential capabilities [10]. To meet the demands, the EMS must be adaptable and flexible, allowing it to adjust according to the driving cycle and the state of the storage system [39]. Figure 1 shows the fundamental block diagram of EMS, where input and reference signals from the vehicle system create control signals. These signals are then directed to the suitable converters, ensuring the electric vehicle fulfills its power demands across various operations. EV use diverse regenerative braking control strategies to improve energy capture [18]. The effectiveness of EMS depends on the algorithm designed based on control strategies and driving situations.

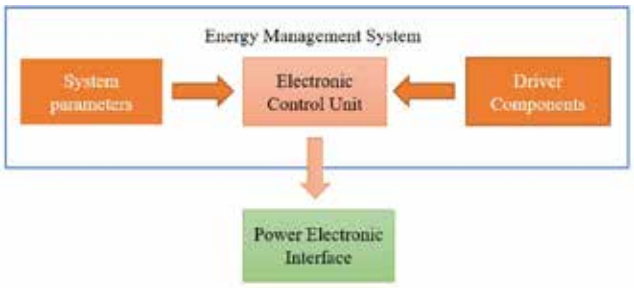

Fig. 1. Fundamental Block Diagram of EMS

The main function of EMS is to efficiently manage power distribution between battery, super capacitor, fuel cell, and flywheel hybrid system. Control strategies determine the timing and amount of power taken from various energy storage devices based on driving scenarios. During regenerative braking, EMS effectively chooses the energy storage device for recharging. EMS in combined Energy Storage Systems achieves several objectives, including meeting load Demand, sustaining battery voltage and State of Charge (SOC), improving system efficiency, and extending battery lifetime [10-16].

Classification of Energy Management Systems

The current literature presents different approaches for applying Energy Management system (EM) in Hybrid Energy Storage Systems in Electric Vehicles. Their approaches can be broadly classified as shown in Fig.2.

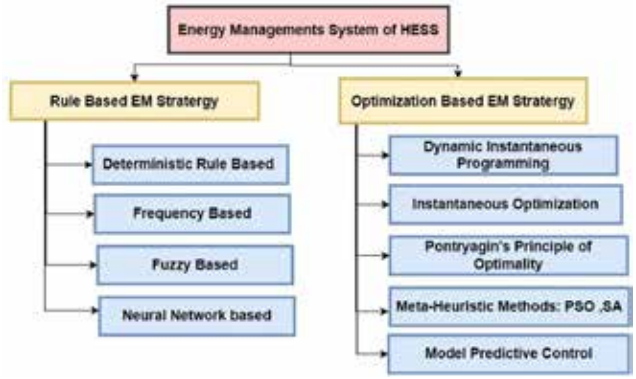

Fig. 2. Classification of EMS

Rule-based Strategies

Rule-based control techniques are structured method to designing control systems for vehicle drive cycles. They depends on empirical data, heuristics, and human information to establish deterministic design rules. These principles are implemented using either lookup tables or conditional actions in the form of if-then laws. Rule-based EMS (Energy Management System) strategies can be classified into the following types:

Deterministic rule-based control strategy

Deterministic rule-based control strategy is used for power sharing in hybrid energy storage systems (HESS) . State-based logic control algorithms offer a feasible solution for multi-source energy management in small electric vehicles. This strategy determines power requirements in advance and designs rule-based strategies depends on reference values. The rules involve storing regenerative braking energy in specific ESS, and power delivery based on power requirements [17]. The effectiveness of this technique depends on the choosing of charge/discharge characteristics, size, state, and power managing capacity of the HESS.

Frequency-based control strategy

The frequency-based control strategy regulates system behavior by considering frequency nature. In the power-split strategy, the high-frequency part of load power is directed to the super capacitor or flywheel, while the renaming power is supplied to the battery or fuel cell. This method allows for effective power requirement control using different frequency signals, transforming to the state of charge and load current direction [18]. But this strategy has limitations in managing more than two energy sources.

Fuzzy logic based control strategy

Fuzzy logic control (FLC) is an adaptive algorithmic strategy that utilizes fuzzy set theory and rules to effectively handle hybrid energy storage systems (HESSs) in different operational situations. Unlike rule-based control strategies, FLC does not require specific mathematical models and instead relies on the designer's knowledge of the system, offering adaptability and durability [19]. In HESS, FLC is employed to control the state of charge (SOC) of the super capacitor, ensuring stability, and allowing efficient peak power delivery and regenerative energy storage. It is particularly valuable when an exact plant model is unavailable.

Neural network-based control strategy

Neural networks, which simulate human brain

thinking, are utilized in control techniques for bidirectional converters and energy management in hybrid energy storage units. These strategies offer advantage such as faster computations, reduced data storage requirements, and enhanced transient reaction. Compared to traditional PI controllers, neural network controllers address limitations associated to adjusting to reference modifications [20].This neural network-based strategy optimizes energy utilization, enhances system performance, and leads to increased range, longer battery life, and improved overall efficiency in electric vehicles.

Optimization based Strategies

Optimization-based control involve involves use of either soft computing techniques or optimal control theory. The control problems can be solved by EM without the need for any previous knowledge. There are different types of optimization based Strategies as shown in Fig. 2.

Model predictive control

This control strategy predicts future inputs based on data and optimization. It used in electric vehicles to address energy management issues when used with HESS. Future values can be forecast by comparing model and process outputs. An optimization problem is used to calculate set points and correct feedback errors [21]. Prediction accuracy and control plan optimization are key factors in the effectiveness of MPC, for this strategy large memory may be required for complex calculations.

Dynamic Programming

Dynamic programming (DP) is a mathematical method using system models to find the appropriate control approach. It needs a numerical model, compared to rule-based techniques. Based on the model and specific situations, DP optimizes power distribution. For systems with numerous inputs and outputs, however, it could be computational burden [22]. For DP to predict power demand in hybrid energy storage systems, accurate topography data is also required. It can optimize power converter size, impacting battery cost and degradation of a battery in electric vehicles.

Instantaneous Optimization

In hybrid energy storage systems (HESS), exact driving cycle data is necessary for predicting power demand for energy management (EM). But due to a number of reasons, collecting exact data is tough. The power split between HESS is immediately optimized using a method known as instantaneous optimization to operate this. The super capacitor state of charge (SOC) is adjusted using a simple process dependent on vehicle speed (Vs.), providing effective energy use. The SC works at a high SOC to satisfy peak power demands during acceleration while (Vs.) is low. Voltage is continuously monitored and updated in real time when vehicle is running. Benefit of this strategy is it does not depend on vehicle predicted power demand in future [23].

Pontryagin's principle

This technique find the ideal control for a system that changes between states while taking limitations into account. It evaluates the system as a Hamiltonian system and develops the best control using Hamiltonian Equations of State Space (HESS). The aim of this strategy for an electric vehicle (EV) is to minimize the battery RMS current while meeting the Hamiltonian requirements. Three concepts must be stated for the purpose to tackle this problem: The system's dynamical model, the cost function, which is the battery RMS current, and the constraints, which shows controlling the SC voltage and the converter output current [24].

Meta-Heuristic-based EM strategies

PSO is a Meta-Heuristic-based algorithm is an optimization strategy called Particle Swarm Optimization (PSO) is developed as an outcome of analyses of bird flocks. In PSO, a swarm (group) of particles that tend towards the ideal solution is used as a representation of the search space. Form the algorithm work in three steps are Initialization,exploration, and evaluation. PSO is a continuous process that finds the optimal possible solution with little time and effort required. As a result, it is used for real-time applications including energy management for electric vehicles (EV) driven by hybrid energy storage systems. Its benefits include Short computation time, easy implementation, best optimal solution found In order to implement in real time with a big memory, a high-speed controller is necessary[25].

TYPOLOGIES OF HYBRID ENERGY STORAGE SYSTEM

A Hybrid Energy Storage System consists different types of energy storage devices with different characteristics. In a normal setup the battery is directly connected in series to the inverter and drive train which is a simpler configuration. However, in a hybrid system combining the battery and SC to the DC link requires the use of DC/DC converters, which work in buck and boost modes and necessitate switching control for power control. This control action depends on system data and road conditions. The configuration of the battery, SC, fuel cell, flywheel, and DC/DC converter connection to the DC link determines the types of the ESS combination, as shown in Fig.3.

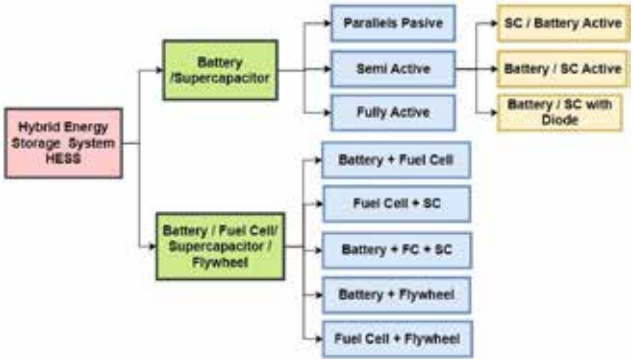

Fig. 3. Classification of HESS

Battery – Super capacitor Hybrid

Passive Parallel hybrid

This configuration Fig. 4 offers the advantage of removing the need for an additional DC-DC converter and stabilizes the DC link voltage by incorporating a battery. This results in minimized fluctuations in the DC-link voltage. The existence of the battery pack ensures a constant voltage for the super capacitor, allowing for selecting the super capacitor's size to meet the specific need of the low-pass filter [26]. By combining the converter and battery, SC in in parallel, this configuration avoid current surges and voltage drops. It also maintain the system's terminal voltage with the battery's discharge characteristics therefore limiting the SC voltage [27]. Also when the stored energy in the SC is released to the load. The super capacitor suffer a rapid decline in voltage, placing an extra burden on the battery,which has to manage both the super capacitor and the load. While this topology is lightweight, straightforward, and cost-effective, it has drawbacks in terms of performance [28].

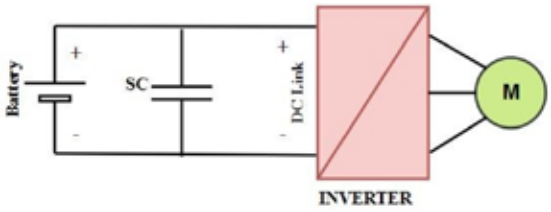

Fig. 4. Passive Parallel hybrid

Semi-active hybrid

The previous configuration goes from inconsistent current and excessive ripple, mainly caused by exposure to unpredictable drive cycles, resulting in battery degradation. To overcome these issue and improve accuracy, a DC/DC Power converter is placed across the battery and super capacitor [30].

Battery with Super capacitor Active

In this particular topology shown in Fig.5, a bidirectional DC/DC converter is positioned across the SC bank and battery pack, enabling the battery pack to have a lower voltage. This minimize weight and costs [30]. The SC functions as a low-pass filter, enabling the utilization of the entire voltage range without direct clamping across the SC and battery. During regenerative mode, energy is stored back into the SC resulting in improved efficiency [31]. Additionally, the SC bank used in this system has a lower equivalent series resistance (ESR) in comparison to the battery bank. Allowing it to efficiently absorb the maximum of current spikes [29] [31]. The DC-DC converter allows effective control of the charge and discharge rates of both the SC and battery banks, thereby augmenting system efficiency and increased battery lifespan. The primary challenge lies in controlling the power converter within this specific topology [31].

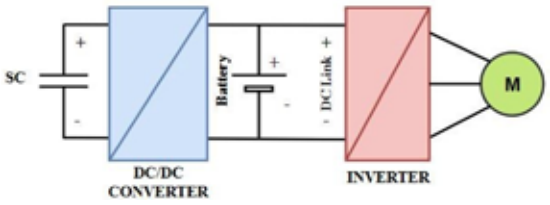

Fig. 5. Battery with super capacitor active

Super capacitor with Battery active

In a different semi-active topology Fig.6, the DC/DC converter is connected to the battery, giving the option to disconnect the battery from the DC link for a smaller pack [30]. This configuration enables for control of a wide range of super capacitor (SC) voltage deviations through the DC-DC converter, while providing a consistent DC link voltage by directly connecting the battery to the DC link [34]. However, it's important to know that in cases of sudden power spikes, the battery might struggle to meet immediate power requirements, making the direct connection of the SC to the DC link beneficial for efficient handling of power fluctuations [29]. The disadvantage is the need for a larger DC/DC converter with a higher current rating, leading in a larger converter size compared to the battery-SC active configuration.

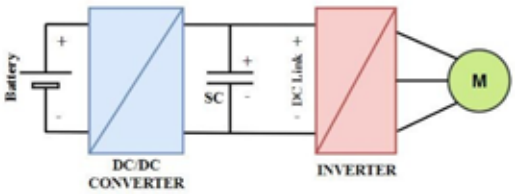

Fig. 6. Super capacitor with Battery active

Battery- Super capacitor Topology with diode

Fig.7 shows a modern semi-active arrangement with a battery/SC arrangement and a bypass diode for direct power flow from the battery to the DC link. The SC charges using the battery when its voltage is low, reducing the power rating demand of the DC-DC converter correlated to an active battery/SC setup [33]. However, this arrangement has limitations, such as SC limitations by battery voltage and fluctuating DC-link voltage, depends on SC voltage dropping below the battery voltage for system stability through acceleration [35]. To mitigate these challenges, a unidirectional converter replaces the bidirectional converter in Figure 7, enhancing system efficiency, decrease converter cost, simplifying the control system, and enabling simple operation and control of the converter [28]. A switch is also connected to prevent direct battery charging, achieving effective energy management through preset rules and selective use of the bidirectional DC-DC converter in buck and boost mode [36].

Fully Active Hybrid

This hybrid topology uses two bidirectional DC-DC converters to individually regulate the SC and battery as seen in Figure 8, addressing DC link voltage differences [37]. Parallel connection of these converters stabilizes the DC link voltage, eliminating voltage balancing problem. The SC and battery work at lower voltages than the DC-bus,

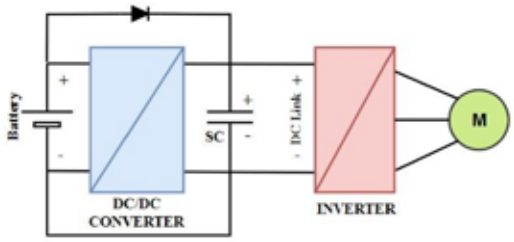

Fig. 7. Battery - Super capacitor Topology with Diode

Maximizing SC utilization and accepting wider voltage variations [38]. This configuration provide autonomous regulate of the Energy Storage System (ESS) with independent power transfer from the SC and battery, resulting in a smaller and cost-effective ESS with steady DC link voltage and optimized SC voltage limits [39]. However, it requires full-size converters, adding difficulty and costs compared with other topologies.

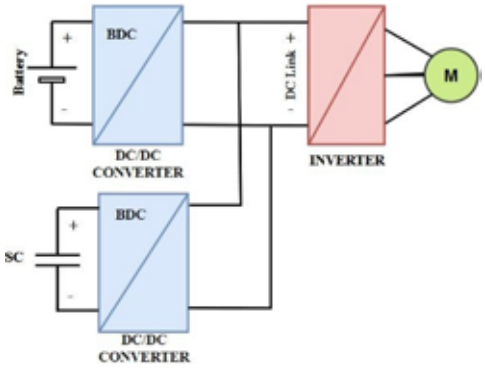

Fig. 8. Fully Active Hybrid

Battery- Super capacitor- Fuel Cell- Flywheel Hybrid Topologies

Fuel cell+ Battery hybrid

Fuel cell battery topology shown in Fig.9 commonly used provides benefits of regenerative braking, energy capturing, and high- speed acceleration. Fuel cell work as the primary storage unit, while the battery helps high

acceleration and regenerative braking [41]. Battery and fuel cell were connected to the DC link via bidirectional (BDC) and unidirectional (UDC) DC/DC converters. To improve fuel cell (FC) efficiency, the hybridization procedure includes an initial battery startup, avoiding low-efficiency operation and providing high current for electric motor initiation [42]. Battery propels the vehicle, while the fuel cell maintains consistent power output according to need. Excess power charges the battery,considering its state. This hybrid approach improve acceleration, regenerative braking storage efficiency, range, refueling time, and increase battery and fuel cell lifespan.

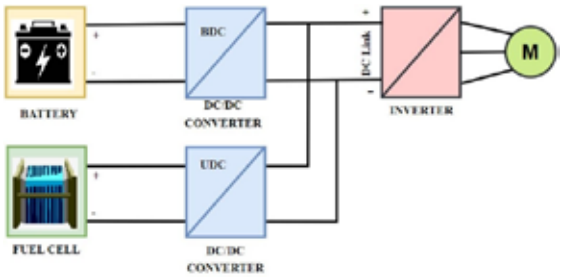

Fig. 9. Fuel cell + Battery Hybrid

Fuel cell + Super capacitor Hybrid

The super capacitor supports the fuel cell in managing sudden power demand spikes throughout transients, improving efficiency in situations with continuous start and stop cycles, as shown in Fig.10 [43]. An efficient DC-DC converter placed between the super capacitor and the DC link, along with a direct parallel connection of the fuel cell unit, optimizes fuel consumption [44]. In a charge maintaining hybrid system, the greater specific energy of the battery may not be beneficial as the vehicle's range depends on the hydrogen tank capacity. Relying solely on the energy stored in the super capacitor throughout the fuel cell start-up stage is insufficient to sustain the vehicle load [45].

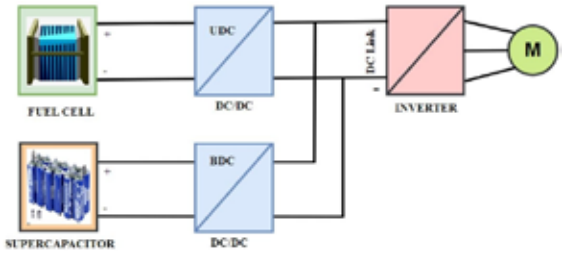

Fig. 10. Fuel cell + Supercapacitor Hybrid

Fuel cell - Battery – Super capacitor Hybrid

Figure.11 shows a configuration that combines FC + battery + SC systems, gives uninterrupted energy supply and improved fuel cell performance throughout transients [46]. This arrangement enhances the dynamic response of the FC system, sustaining a high state of charge (SOC) in the super capacitor bank for better acceleration and enabling energy storage in regenerative braking, thereby extending the vehicle's range[15]. This arrangement provide superior power transfer efficiency compared to previous typologies, but it add complexity in structure and control strategies with the combining of three DC/DC converters [47]. The control principle aims to minimize load on the FC and battery by reducing quick power transitions. However, the combination of three energy storage units' increases costs, and the complex nature requires a complicated energy management strategy for optimal operation. .Solely depending on the energy stored in the SC and the fuel cell start-up phase is sufficient to sustain the vehicle load [44]. Therefore, a practical solution involves hybridizing the FC, Battery, and SC gives a more feasible approach.

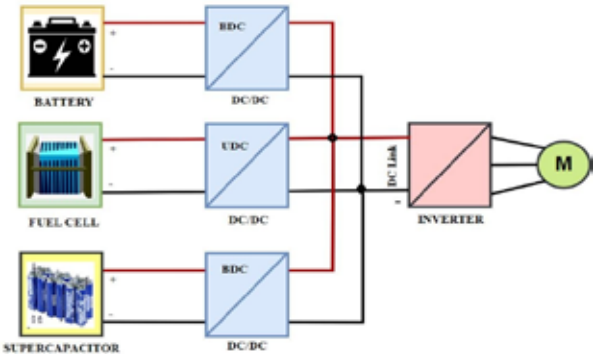

Fig. 11. Fuel cell - Battery – Super capacitor Hybrid

Fuel cell - Fly wheel Hybrid

In this arrangement shown in Fig.12, the fuel cell (FC) acts as the main energy source, and a flywheel is employed as a replacement to batteries for energy storage. The lifespan of fuel cells used in vehicles is shorter than in stationary applications, mainly due to the effects of dynamic load cycling, startup/shut down operations, and freeze/warm operations on fuel cell performance [48]. To tackle these challenges, combining fuel cells with other energy storage devices

is necessary. Flywheel delivering power during high-energy need in the electromagnetic (EM) system [49]. this arrangement is used in for city bus use flywheel and fuel cell. Flywheels gives several advantages, combining fast Charging, high efficiency, regenerative braking energy storage, and superior power ratings compared to batteries. They are also nature friendly, work effectively in various temperatures, offer high energy storage capacity, and has more lifetime.

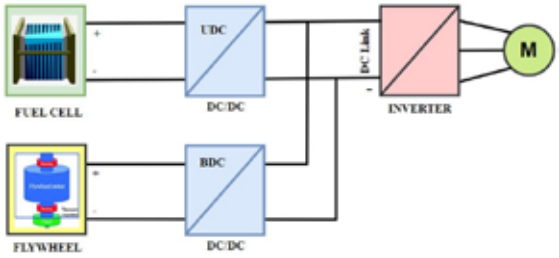

Fig. 12. Fuel cell - Fly wheel Hybrid

Battery – Flywheel Hybrid

The arrangement shown in Fig.13 aims to optimize system performance and efficiency. Batteries have limitations in power output and handling high current rates, which are overcome by adding a flywheel into the system. This topology proves beneficial in automotive applications, The Jaguar XF (since 2011) and the Volvo S60 have implemented mechanical flywheel systems, while the Audi R18 e-tron quatrain, a race car model, has used an electric flywheel configuration [50]. Applying this topology, along with a neural network-based energy management strategy, results in a significant enhancement in energy recovery by 1.17 times compared to a single battery system. The maximum charging current required by the battery decreases significantly by 42.27% [51]. The integration of a battery-FW topology may introduce additional complexity and cost.

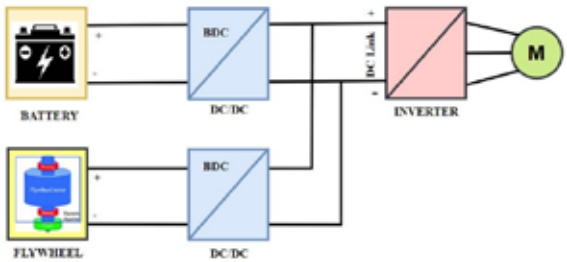

Fig. 13. Battery – Flywheel Hybrid

CHALLENGES OF HESS IN EV APPLICATION

HEV combine energy storage systems for high efficiency and performance, but they face various challenge. following are the some challenges faced by electric vehicle when integrated with HESS

Integration Complexity

Integrating multiple energy storage systems in hybrid energy storage electric vehicles (HEV) is a complex task. Different types of storage devices, such as batteries, super capacitors, fuel cells, and flywheels, need careful management of their unique characteristics and working principles. Complex control algorithms are needed to dynamically distribute power depending on driving conditions and energy demand. Efficient power management methods are important for optimizing energy utilization. Effective communication and interconnection between components ensure seamless integration. Improved diagnostic and monitoring systems are necessary for maintaining the health of energy storage systems. For future developments need more research work on these challenges with new technologies.

Control and Optimization

In hybrid energy storage electric vehicles, control and optimization challenges include efficiently managing energy flow between storage systems and the power-train. It regulates electric motor for optimal fuel efficiency and electric drive-train and Storage System ordination balance. Optimization algorithms need work in real time and fast for scenario of vehicle on road without malfunction. Ongoing research need to focuses on enhancing control and optimization techniques for improved HEV performance and efficiency.

Cost

Developing hybrid energy storage system for electric vehicles faces significant cost-related challenges. The integration of multiple energy storage systems increases expenses, driven by complex technologies and materials. Increasing production to meet demand is difficult, preventing cost reduction. Charging/refueling infrastructure establishment and maintenance bring to ownership costs. Due to additional power

electronic converters and storage units cost increases. Overcoming these challenges requires advancements in manufacturing, materials, R&D, and infrastructure. Economies of scale and technological advancements are expected to lower upfront costs for HEV technology. Government incentives and subsidies can help mitigate costs and promote wider adoption of electric vehicles.

Sizing

In hybrid energy storage systems sizing the energy storage devices is important for overall vehicle performance. Battery sizing involves balancing energy and power density, optimizing size, weight and ensuring safety and thermal management. Fuel cell sizing requires balancing power output and weight, addressing hydrogen storage challenges and ensuring hydrogen refueling infrastructure availability. Super capacitor sizing include achieving desired energy density and managing size and weight. Flywheel sizing need managing size and weight while meeting power and energy requirements, along with complicated control systems for stability and safety. Sizing challenges impact performance, energy density, and cost, weight, and infrastructure considerations in hybrid energy storage systems.

Packaging and Weight

Packaging and weight add significant challenges in hybrid energy storage electric vehicle development. Effectively fitting multiple energy storage systems within limited space requires careful packaging and design modifications. The additional weight impacts vehicle efficiency, handling, and performance, requiring adjustments to suspension, braking, and structural components. Achieving the right balance between energy storage, space, and weight is challenging. Innovative approaches are needed to meet performance and efficiency goals while ensuring customer safety and comfort.

Safety

As fuel cell is introduced in HESS, which use highly explosive Hydrogen. Fuel cell is better for stationary application but not in case of electric vehicle there is risk of storing hydrogen with electrical devices. Storing hydrogen in electric vehicle in small size and ensure safety is big challenge.

CONCLUSION

The limitations and drawbacks faced by electric vehicle energy storage which is battery is solved by hybridization of energy storage system. HESS system combine high power (SC and FW) and high energy (battery and FC) devices. HESS purpose is to store regenerative braking energy, maintain voltage level, fast charging and extended range without degrading the battery and fuel cell life during intense driving scenarios.

HESS need an effective control to various operations which is done by EMS effectively as a result HESS based EV has improved performance and extended range in single charge without degrading ESS life. For high performance and efficiency of HESS need an effective EMS which require a sophisticated control strategy which decide power flow from ESS to power-train efficiently in real time.

During the hybridization of ESS it face challenges which are integration complexity, high cost, and sizing and safety issue when different energy storage technologies are combined. Along with these challenges HESS provide an attractive benefits which are flexibility of charging or fueling, short charging time using fuel cell, SC, FW technologies by adding fuel cell it has fast refueling and long range. At the end by choosing optimal sizing and energy management strategy cost can be satisfactory down and HESS vehicle performance is enhanced by overcoming challenges faced in single energy storage electric vehicle.

References

[1] M. K. Hasan, M. Mahmud, A. K. M. Ahasan Habib, S. M. A. Motakabber, and S. Islam, “Review of electric vehicle energy storage and management system: Standards, issues, and challenges,” J. Energy Storage, vol. 41, Sep. 2021, doi: 10.1016/j.est.2021.102940.

[2] W. Saikong and T. Kulworawanichpong, “Comparative Study of Energy Consumption for Electric Vehicles with Various On-board Energy Storage Systems,” in Energy Procedia, Elsevier Ltd, 2017, pp. 81–86. doi: 10.1016/j.egypro.2017.10.060.

[3] IEA. (2023). Global EV Outlook 2023 – Analysis. [online] Available at https://www.iea.org/reports/global-ev-outlook-2023

[4] N. M. Jamadar, A. Bhagat, S. Gaikwad, V. Honmane,

and P. Patil, "Reliability assessment of supercapacitor for electric vehicle withhybrid energy storage," Life Cycle Reliab. Saf. Eng., vol. 11, no. 1, pp. 49–59, Mar. 2022, doi: 10.1007/s41872-022-00184-5.

[5] T. Yong and C. Park, "A qualitative comparative analysis on factors affecting the deployment of electric vehicles," in Energy Procedia,Elsevier Ltd, 2017, pp. 497–503. doi: 10.1016/j.egypro.2017.09.066.

[6] Hannan, Mahammad A., F. A. Azidin, and Azah Mohamed. "Hybrid electric vehicles and their challenges: A review." Renewable andSustainable Energy Reviews 29 (2014): 135-150.

[7] A. Joseph Godfrey and V. Sankaranarayanan, "A new electric braking system with energy regeneration for a BLDC motor driven electric vehicle," Eng. Sci. Technol. an Int. J., vol. 21, no. 4, pp. 704–713, Aug. 2018, doi: 10.1016/j.jestch.2018.05.003.

[8] Z. Fu, Z. Li, P. Si, and F. Tao, "A hierarchical energy management strategy for fuel cell/battery/supercapacitor hybrid electric vehicles," Int. J. Hydrogen Energy, vol. 44, no. 39, pp. 22146–22159, Aug. 2019, doi: 10.1016/j.ijhydene.2019.06.158.

[9] I. Shchur, I. Bilyakovskyy, and V. Turkovskyi, "Improvement of switched structure semi-active battery/supercapacitor hybrid energy storage system for electric vehicles," IET Electr. Syst. Transp., vol. 11, no. 3, pp. 241–255, Sep. 2021, doi: 10.1049/els2.12017.

[10] R. S. Sankarkumar and R. Natarajan, "Energy management techniques and topologies suitable for hybrid energy storage system powered electric vehicles: An overview," International Transactions on Electrical Energy Systems, vol. 31, no. 4. John Wiley and Sons Ltd, Apr. 01, 2021. doi: 10.1002/2050-7038.12819.

[11] L. Kouchachvili, W. Yaïci, and E. Entchev, "Hybrid battery/supercapacitor energy storage system for the electric vehicles," Journal of Power Sources, vol. 374. Elsevier B.V., pp. 237–248, Jan. 15, 2018. doi: 10.1016/j.jpowsour.2017.11.040.

[12] K. Itani, A. De Bernardinis, Z. Khatir, and A. Jammal, "Comparative analysis of two hybrid energy storage systems used in a two front wheel driven electric vehicle during extreme start-up and regenerative braking operations," Energy Convers. Manag., vol. 144, pp. 69–87, 2017, doi: 10.1016/j.enconman.2017.04.036.

[13] P. Thounthong, S. Raël, and B. Davat, "Energy management of fuel cell/battery/supercapacitor hybrid power source for vehicle applications," J. Power Sources, vol. 193, no. 1, pp. 376–385, Aug. 2009, doi: 10.1016/j.jpowsour.2008.12.120.

[14] C. Capasso, D. Lauria, and O. Veneri, "Experimental evaluation of model-based control strategies of sodium-nickel chloride battery plus supercapacitor hybrid storage systems for urban electric vehicles," Appl. Energy, vol. 228, pp. 2478 –2489, Oct. 2018, doi: 10.1016/j.apenergy.2018.05.049.

[15] J. E. Valdez-Resendiz, J. C. Rosas-Caro, J. C. Mayo-Maldonado, A. Claudio-Sanchez, O. Ruiz-Martinez, and V. M. Sanchez, "Improvement of ultracapacitors-energy usage in fuel cell based hybrid electric vehicle," Int. J. Hydrogen Energy, vol. 45, no. 26, pp. 13746–13756, May 2020, doi: 10.1016/j.ijhydene.2019.12.201. 37 and 15 same

[16] R. Hemmati and H. Saboori, "Emergence of hybrid energy storage systems in renewable energy and transport applications – A review," Renewable and Sustainable Energy Reviews, vol. 65. Elsevier Ltd, pp. 11–23, Nov. 01, 2016. doi: 10.1016/j.rser.2016.06.029.

[17] Carter R, Cruden A, Hall PJ. Optimizing for efficiency or battery life in a battery/supercapacitor electric vehicle. IEEE Trans Veh Technol. 2012;61(4):1526-1533.

[18] Sun L, Feng K, Chapman C, Zhang N. An adaptive power-Split strategy for battery–Supercapacitor powertrain—design, simulation, and experiment. IEEE Trans Power Electron. 2017;32(12):9364-9375.

[19] Talla J, Streit L, Peroutka Z, Drabek P. Position-based TS fuzzy power management for tram with energy storage system. IEEE Trans Ind Electron. 2015;62(5):3061-3071.

[20] Nguyen BH, Trovao JP, German R, Bouscayrol A. An Optimal Control-Based Strategy for Energy Management of Electric Vehicles Using Battery/Supercapacitor. In 2017 IEEE Vehicle Power and Propulsion Conference (VPPC) 2017 Dec 11 (pp. 1-6). IEEE.

[21] Gomozov O, Trov ao JP, Kestelyn X, Dubois MR. Adaptive energy management system based on a real-time model predictive control with nonuniform sampling time for multiple energy storage electric vehicle. IEEE Trans Veh Technol. 2017;66(7):5520-5530.

[22] Choi ME, Lee JS, Seo SW. Real-time optimization for power management systems of a battery/supercapacitor hybrid energy storage system in electric vehicles. IEEE Trans Veh Technol. 2014;63(8):3600-3611.

[23] Wieczorek M, Lewandowski M. A mathematical representation of an energy management strategy for hybrid energy storage system in electric vehicle and real time optimization using a genetic algorithm. Appl Energy. 2017;192:222-233.

[24] Nguyen BH, Trovao JP, German R, Bouscayrol A. An Optimal Control-Based Strategy for Energy Management of Electric Vehicles Using Battery/ Supercapacitor. In 2017 IEEE Vehicle Power and Propulsion Conference (VPPC) 2017 Dec 11 (pp. 1-6). IEEE.

[25] Pillai DS, Rajasekar N. Metaheuristic algorithms for PV parameter identification: a comprehensive review with an application to threshold setting for fault detection in PV systems. Renew Sust Energ Rev. 2018;82:3503-3525.

[26] Ostadi, A., M. Kazerani, and Shih-Ken Chen. "Hybrid Energy Storage System (HESS) in vehicular applications: A review on interfacing battery and ultra-capacitor units." In 2013 IEEE Transportation Electrification Conference and Expo (ITEC), pp. 1-7. IEEE, 2013.

[27] L. Gao, R. A. Dougal, and S. Liu, "Power enhancement of an actively controlled battery/ultracapacitor hybrid," IEEE Trans. Power Electron., vol. 20, no. 1, pp. 236–243, Jan. 2005, doi: 10.1109/TPEL.2004.839784.

[28] Nielson G, Emadi A. Hybrid energy storage systems for high-performance hybrid electric vehicles. In 2011 IEEE Vehicle Power and Propulsion Conference 2011 Sep 6 (pp. 1-6). IEEE. https://ieeexplore.ieee.org/abstract/document/6573471

[29] Kuperman A, Aharon I, Malki S, Kara A. Design of a Semiactive Battery-Ultracapacitor Hybrid Energy Source. IEEE Transactionson Power Electronics. 2013;28(2):806-815. http://dx.doi.org/10.1109/tpel.2012.2203361.

[30] Cao J, Emadi A. A new battery/ultracapacitor hybrid energy storage system for electric, hybrid, and plug-in hybrid electric vehicles. IEEE Trans Power Electron. 2012;27(1):122-132.

[31] Girard HL, Wang H, d'Entremont AL, Pilon L. Enhancing faradaic charge storage contribution in hybrid pseudocapacitors. Electrochim Acta. 2015;182:639-651

[32] Chemali E, McCurlie L, Howey B, et al. Minimizing battery wear in a hybrid energy storage system using a linear quadratic regulator. Paper presebted at: Industrial Electronics Society, IECON 2015-41st Annual Conference of the IEEE November 9, 2015 (pp. 003265– 003270). IEEE.

[33] Zhuge K, Kazerani M. Development of a hybrid energy storage system (HESS) for electric and hybrid electric vehicles. In 2014 IEEE Transportation Electrification Conference and Expo (ITEC) 2014 Jun 15 (pp. 1-5). IEEE.

[34] Miller JM, Deshpande U, Dougherty TJ, Bohn T. Power electronic enabled active hybrid energy storage system and its economic viability. In 2009 Twenty-Fourth Annual IEEE Applied Power Electronics Conference and Exposition 2009 Feb 15 (pp. 190-198). IEEE.

[35] Lukic SM, Cao J, Bansal RC, Rodriguez F, Emadi A. Energy storage systems for automotive applications. IEEE Trans Ind Electron. 2008; 55(6):2258-2267.

[36] Wang B, Xu J, Cao B, Ning B. Adaptive mode switch strategy based on simulated annealing optimization of a multi-mode hybrid energy storage system for electric vehicles. Appl Energy. 2017;194:596-608.

[37] Wang B, Xu J, Cao B, Zhou X. A novel multimode hybrid energy storage system and its energy management strategy for elect ric vehicles. J Power Sources. 2015;281:432-443.

[38] Di Napoli A, Crescimbini F, Capponi FG, Solero L. Control strategy for multiple input DC-DC power converters devoted to hybrid vehicle propulsion systems. InIndustrial electronics, 2002. isie 2002. proceedings of the 2002 ieee international symposium on 2002 Jul 8 (Vol. 3, pp. 1036-1041). IEEE.

[39] Hannan MA, Azidin FA, Mohamed A. Multi-sources model and control algorithm of an energy management system for light electric vehicles. Energy Convers Manag. 2012;62:123-130.

[40] Muthukumar, M., N. Rengarajan, B. Velliyangiri, M. A. Omprakas, C. B. Rohit, and U. Kartheek Raja. "The development of fuel cell electric vehicles–A review." Materials Today: Proceedings 45 (2021): 1181-1187.

[41] Tang, Yong, Wei Yuan, Minqiang Pan, and Zhenping Wan. "Experimental investigation on the dynamic performance of a hybrid PEM fuel cell/battery system for lightweight electric vehicle application." Applied Energy 88, no. 1 (2011): 68-76.

[42] Ettihir, K., Loïc Boulon, and K. Agbossou. "Optimization-based energy management strategy for a fuel cell/battery hybrid power system." Applied Energy 163 (2016): 142-153.

[43] Wei, Qing Sheng, Xia Zhang, Byeong-Heon Kim, and Byeong Soo Oh. "Experimental investigation of supercapacitor based regenerative energy storage for a fuel cell vehicle equipped with an alternator." International Journal of Hydrogen Energy 47, no. 3 (2022): 1954-1964.

[44] Van Mierlo, Joeri, Yonghua Cheng, Jean-Marc Timmermans, and Peter Van den Bossche. "Comparison of fuel cell hybrid propulsion topologies with super-capacitor." In 2006 12th International Power Electronics and Motion Control Conference, pp. 501-505. IEEE, 2006.

[45] Gao, Wenzhong. "Performance comparison of a fuel cell-battery hybrid powertrain and a fuel cell-ultracapacitor hybrid powertrain." IEEE Transactions on vehicular technology 54, no. 3 (2005): 846-855.

[46] İnci, Mustafa, Mehmet Büyük, Mehmet Hakan Demir, and Göktürk İlbey. "A review and research on fuel cell electric vehicles: Topologies, power electronic converters, energy management methods, technical challenges, marketing and future aspects." Renewable and Sustainable Energy Reviews 137 (2021): 110648.

[47] Thounthong, Phatiphat, Stephane Rael, and Bernard Davat. "Energy management of fuel cell/battery/supercapacitor hybrid power source for vehicle applications." Journal of power sources 193, no. 1 (2009): 376-385.

[48] Huang, Chung-Neng, and Yui-Sung Chen. "Design of magnetic flywheel control for performance improvement of fuel cells used in vehicles." Energy 118 (2017): 840-852.

[49] D'Ovidio, G., C. Masciovecchio, and N. Rotondale. "City bus powered by hydrogen fuel cell and flywheel energy storage system." In 2014 IEEE International Electric Vehicle Conference (IEVC), pp. 1-5. IEEE, 2014.

[50] Hedlund, Magnus, Johan Lundin, Juan De Santiago, Johan Abrahamsson, and Hans Bernhoff. "Flywheel energy storage for automotiveapplications." Energies 8, no. 10 (2015): 10636-10663.

[51] Wang, Wei, Yan Li, Man Shi, and Yuling Song. "Optimization and control of battery-flywheel compound energy storage system duringan electric vehicle braking." Energy 226 (2021): 120404.

Study of Fault Current Behaviour in Conventional and Hybrid Mode of Distribution System

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ABSTRACT

In this research paper a hybrid distribution system is model by using MATLAB. The system fault current behaviour is studied for over current protection using over current relay. In this research first the distribution systems performance is studied by considering conventional way of power flow and fault currents behaviour is monitor for both symmetrical and unsymmetrical faults. The same system is now modified as hybrid distribution system by adding distribution generator in the system and again the behaviour of system for symmetrical and unsymmetrical faults are monitor and observed for over current. The aim of power system protection is to insure reliable and stable operation of the power system. This can be ensuring with proper selection and operation of protective devices specially circuit breaker. The study shows that due to hybrid mode of operation the relay settings needs to tune once again as compared to conventional mode of operation. This study will help the system operator to set the relay according to conventional as well as hybrid mode of power flow.

KEYWORDS *: Conventional and hybrid distribution system, Over current relay, MATLAB simulation*

INTRODUCTION

Power system mainly classified in to three categories generation, transmission and distribution. Nowadays it has become very important and necessary to operate distribution system at its maximum capacity. Power system is operated at conventional mode as well as bidirectional mode. In this work, a conventional system is simulated for different fault conditions and result are observed. The setting of relay is monitored. In second phase for same conventional system a distributed generator is connected and again fault scenario is observed. [1]

In conventional mode of operation power system power flow in generation to load that is one direction. Here in the distribution network we have to consider load which will be fed from the conventional generator [2].

The same system is considered for hybrid case however at the receiving end wind power generator has been added so now the power flow from by both direction the load is fed by the generator as well as the wind generator [3]. We can check the magnitude of current in different types of fault [4]. The same system has been configurated in the MATLAB environment. We can simulate hybrid distribution network of power system by using MATLAB simulation. Study the hybrid distribution network during different fault condition and observed operation of relay during fault condition. Over current relay is used for protection purpose [2] [5] [6]. By using MATLAB simulation, the analysis of distribution line fault can be easily carried out.

FAULTS AND CLASSIFICATION

Fault is an abnormal condition of the system that involves the electrical power failure in system. In fault condition magnitude of current is changes. [7] Power system faults mainly categories a

Unsymmetrical Faults

It doesn't affect all system equally. In condition of pre fault system will be balanced and in post fault system will be unbalanced. In three phase power system current differing in magnitude and phases. These faults are involving in two phases i.e. Line to Line, Line to Ground, Double line to Ground. [2]

Symmetrical faults

It equally affects all phases. In condition of pre fault and post fault system will be balanced. These faults are involving in three phases i.e. Three-line Fault, Three line to Ground Fault. [2]

METHODOLOGY

In this research work simulation technique is used to find the behaviour of fault current. [8] First using the conventional system how the fault current behaves at point of common coupling by taking the readings of over current relay. And measure the magnitude of fault current by using the over current relay. In second case we have consider the same system however in this system the distributed generator in the form of wind is connected to the distribution network because of this configuration the system is behave as a hybrid. The conventional power flow in wind direction and the distributed generation in another direction through the simulation. [9] We have identified the magnitude again the fault created in the same way as did in conventional way and readings has been taken at the point of common coupling to the behaviour of over current relay.

MODELING AND SIMULATION

Conventional System

Fig 1 shows the conventional power system. [8] In this conventional mode of system we have to consider thermal generator with capacity 2 MW the line is of 100 km and the load of 20 kW is connected at the receiving end over current protection the scheme is implemented. Scope has been used to check the three-phase voltage and current magnitude.

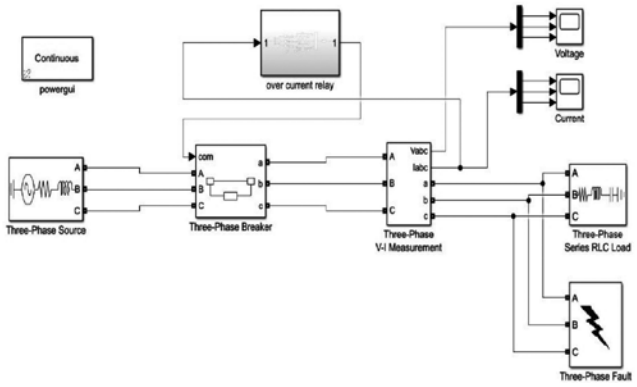


Figure 1. Conventional System

Hybrid System

The Hybrid Power system is shown in Fig 2. considered for hybrid case at the receiving end wind power generator with 1.5 MW capacity has been added so now the power flow from by both direction the load is fed by the generator as well as the wind generator.

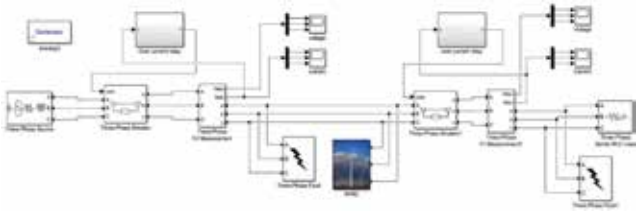


Figure 2. Hybrid System

A hybrid energy system typically combines two or more energy sources in order to increase system efficiency and improve supply energy balance. It has higher system reliability because of a typical hybrid energy system includes two or more renewable energy technologies, that is wind and solar panels [3] [10].

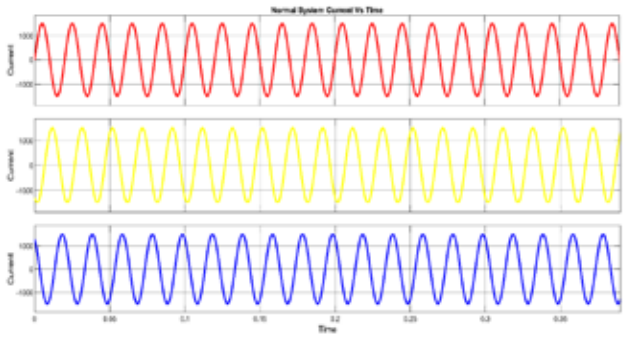
Hybrid power system generate a power from wind as well as three phase source which is store in battery. There are different types of components are used like three phase source, circuit breakers, step up transformer and step-down transformer, over current relay, Transmission line, load and main component is Wind Turbine Generator. Hybrid power system ensure continuous and reliable power production.

SIMULATION RESULTS

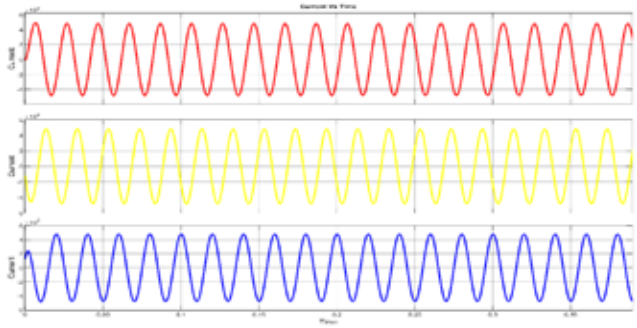
A. Normal Case (Without Fault)

In normal case there is no systemic failure occurs that is system is in healthy condition. Fig 3a and Fig 3b shows current waveform of with no fault occurs in conventional system and hybrid system. In normal condition the power is generated by generator which is acting as a source by load capacity 20 KW and generator capacity 2 MW.

In hybrid mode power is generated by generator as well as wind power generator with 1.5 MW capacity system is in balance mode. In normal case there is no fault then magnitude of current in conventional system is 1.493 kA and in hybrid system 3.772 mA.



(a) Conventional System



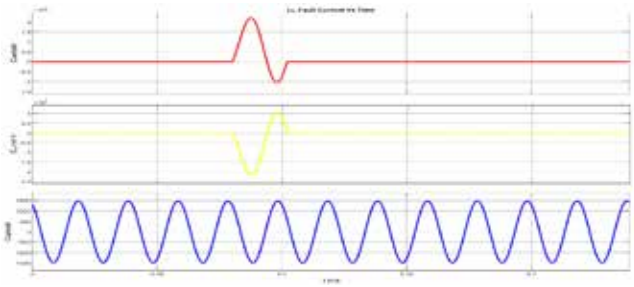
(b) Hybrid System

Figure 3. Current vs Time Without Fault waveform

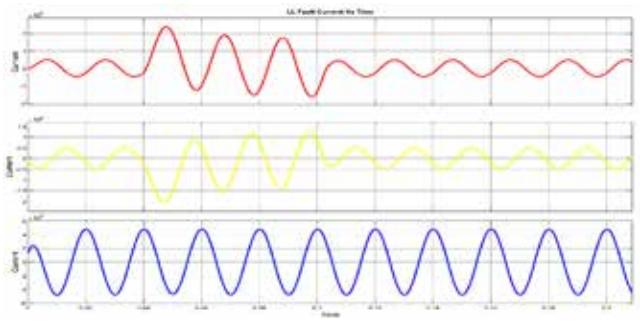
B. Line to Line Fault (L-L Fault)

In double line fault two lines comes in contact with each other along with each other. LL faults occur between two phases and another one phase is in healthy condition. At that time magnitude of current in conventional system is 2.201 mA and in hybrid system is 2.327 mA.

Fault is created between 0.08 to 0.1 sec then relay will be operated in 0.09 sec and send the signal to the CB and fault must be cleared as quickly as possible. Fig 4a and Fig 4b represents current waveform of LL fault occurs in conventional and hybrid system.



(a) Conventional System



(b) Hybrid System

Figure 4. LL Fault Current vs Time waveform

C. Single Line to Ground Fault (L-G Fault)

In single line fault one conductor contacts the neutral conductor or contacts the ground. LG faults occurs in one phase to the ground and another two phases are in healthy condition.

Then magnitude of fault current in conventional system is 2.269 mA and in hybrid system is 2.571 mA. Fault is created between 0.08 to 0.1 sec then relay will be operated at 0.09 sec. Fig 5 and Fig 6 display current waveform of LG fault occurs in conventional and hybrid system.

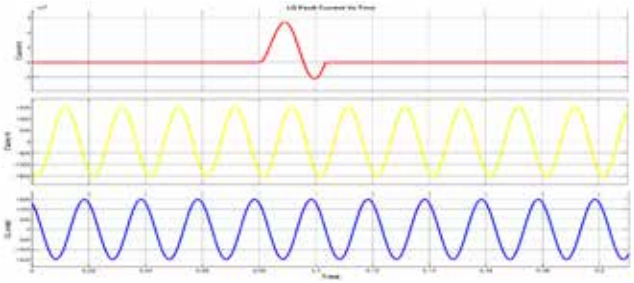


Figure 5. LG Fault Current vs Time waveform in conventional system

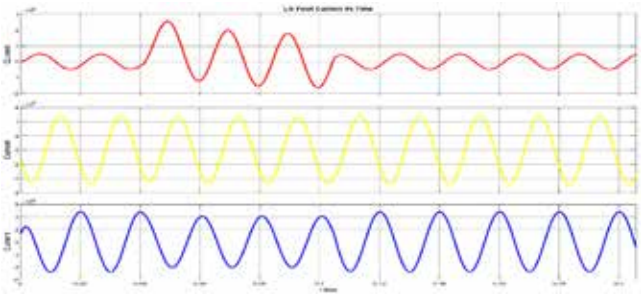


Figure 6. LG Fault Current vs Time waveform in hybrid system

Double Line to Ground Fault (L-L-G Fault)

For two lines to the ground fault 2 conductors are short circuited. Faults occur between two phases to ground and another one phase is in healthy condition. At that time magnitude of current in conventional system is 2.578 mA and in hybrid system is 2.704 mA. Fault is created between 0.08 to 0.1 sec then relay will be operated at 0.09 sec. Fig 7 and Fig 8 shows current waveform of LLG fault occurs in conventional and hybrid system.

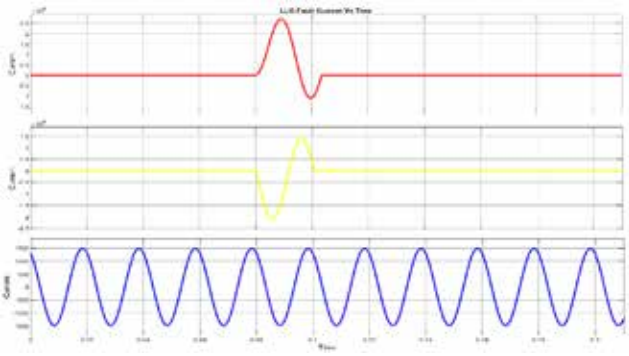


Figure 7. LLG Fault Current vs Time waveform in conventional system

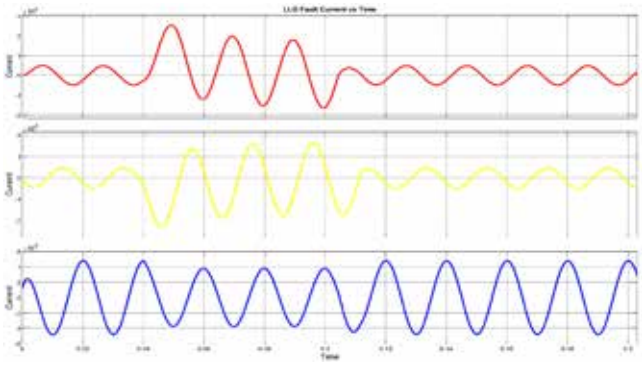


Figure 8. LLG Fault Current vs Time waveform in hybrid system

E. Three Phase Fault (L-L-L Fault)

Fault in 3 phases all the 3 lines or phases short circuits occur. 3 phase fault three phase short circuited such types of faults are balanced. The magnitude of current in conventional system is 2.577 mA and in hybrid system is 2.705 mA. Fault is created between 0.08 to 0.1 sec then relay will be operated at 0.09 sec. Fig 9 and Fig 10 represents current waveform of LLL fault occurs in conventional and hybrid system.

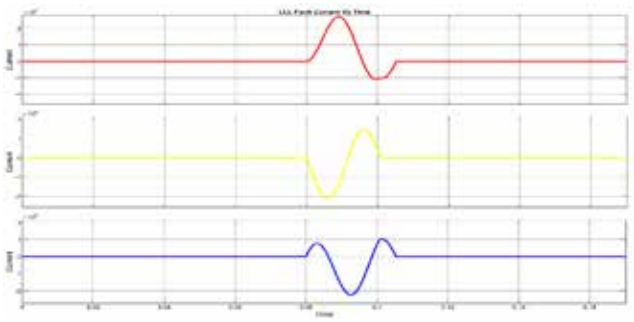


Figure 9. LLL Fault Current vs Time waveform in conventional system

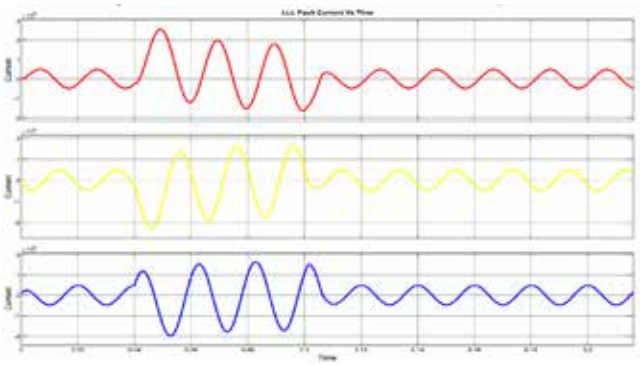


Figure 10. LLL Fault Current vs Time waveform in hybrid system

F. Three Phase to Ground Fault (L-L-L-G Fault)

Fault in 3 phases all the 3 lines or phases short circuits occur. 3 phase fault three phase short circuited such types of faults are balanced. The magnitude of current in conventional system is 2.567 mA and in hybrid system is 2.702 mA. Fault is created between 0.08 to 0.1 sec then relay will be operated at 0.09 sec. Fig 11 and Fig 12 shows current waveform of LLLG fault occurs in conventional and hybrid system

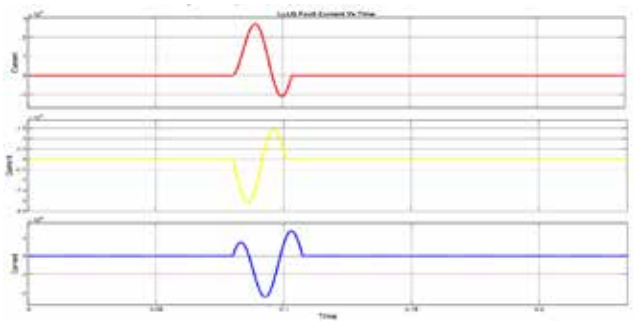


Figure 11. LLLG Fault Current vs Time waveform in conventional system

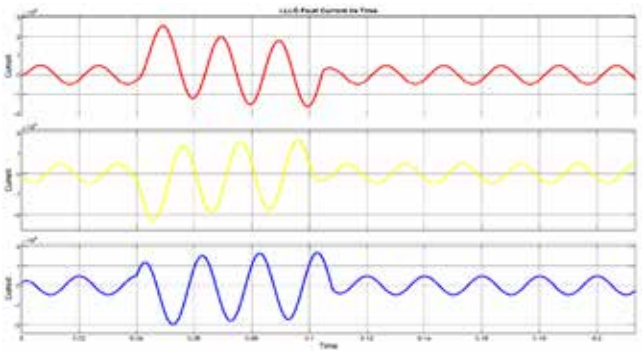


Figure 12. LLLG Fault Current vs Time waveform in hybrid system

CONCLUSIONS

In this work a conventional system and hybrid system is simulated in MATLAB. The different types of symmetrical and unsymmetrical faults are created to check the magnitude of fault current and it is observed that for all fault the magnitude of fault current is more in hybrid system which required to tune the existing over current relay setting.

REFERENCES

1. M. R. Jegarluei, P. Aristidou, and S. Azizi, "Wide-area backup protection against asymmetrical faults in the presence of renewable energy sources," International Journal of Electrical Power & Energy Systems, vol. 144, p. 108528, 2023.
2. M. A. Ibrahim, W. K. Ibrahim, and A. N. Hamoodi, "Design and implementation of overcurrent relay to protect the transmission line," International Journal of Engineering Research and Technology, vol. 13, no. 11, pp. 3783–3789, 2020.
3. V. Gevorgian, M. Singh, and E. Muljadi, "Symmetrical and unsymmetrical fault currents of a wind power plant," in 2012 IEEE Power and Energy Society General Meeting. IEEE, 2012, pp. 1–8.
4. C. H. R. N. B. M. Apoorva.G.M, Rekha K.V, "Three phase fault analysis using simpower system," vol. 1, pp. 412–414, 2016.
5. M. D. Devdhariya, V. R. Adroja, K. M. Rafaliya, and M. M. Desai, "Power system protection with relay co-ordination," Int. J. Eng. Dev. Res, vol. 5, pp. 101–105, 2017.
6. K. Anupreyaa and T. S. Karthiga, "Relay coordination for distribution system," in 2016 Second International Conference on Science Technology Engineering and Management (ICONSTEM). IEEE, 2016, pp. 337–341.
7. N. K. Dr. Shakuntla Boora, Mohit Yadav, "Matlab simulation based study of various types of faults occurring in the transmission lines," International Journal of Engineering Research and Technology (IJERT), vol. 8, no. 12, 2019.
8. C. V. Tharani, M. Nandhini, R. Sundar, and K. Nithiyananthan, "Matlab based simulations model for three phases power system network," International Journal for Research in Applied Science & Engineering Technology (IJRASET), vol. 4, no. 11, 2016.
9. B. C. T. Aaron Don M. Africa, Benjamin Emmanuel Uy, "A simulink model for transmission line fault detection," International Journal of Emerging Trends in Engineering Research.
10. B. P. Prakash Kumar Hota, Babita Panda, "Fault analysis of grid connected photovoltaic system," American Journal of Electrical Power and Energy Systems, vol. 5, no. 4, pp. 35–44, 2016.

Analysis of SRM and BLDC Drive System for Regenerative Braking

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ABSTRACT

Falls among elderly people provide considerable health hazards, frequently cause severe injuries, and lower quality of life. The design and development of an Internet of Things (IoT) gadget for detecting falls in older people are discussed in this research article. The suggested device tracks the wearer's movement patterns using a mix of accelerometer and gyroscope sensors. Real-time sensor data analysis and accurate fall event classification are done using a machine learning system. The wearable, inconspicuous, and user-friendly design of the device ensures a high level of acceptance and adoption among older users. With a high detection accuracy rate of 95% and a low false-positive rate. The suggested IoT device is quite robust.

KEYWORDS *: BLDC brushless DC, EV electric Vehicle, SRM switch reluctance motor drive, SOC state of charge, PWM pulse width modulation*

INTRODUCTION

The increasing demand for electric vehicles (EVs) as a sustainable mode of transportation has led to extensive research on efficient and effective drive systems. Regenerative braking, which harnesses and converts kinetic energy into electrical energy during braking, is a crucial feature in electric vehicle drive systems. It offers numerous advantages, including reduced reliance on external power sources, improved energy efficiency, and decreased emissions. To achieve optimal regenerative braking performance, the selection of an appropriate drive system is of utmost importance. Regenerative braking is a technique that captures and converts kinetic energy from a vehicle's wheels into electrical energy during braking[1-3]. Regenerative braking increases driving range by 16.25% [4]This energy is stored in batteries for later use. Lenz's law states that the generated back electromotive force (emf) opposes the vehicle's motion. When braking, the motor functions as a generator, reducing the magnetic field strength and slowing down the vehicle. The torque acts in the opposite direction of wheel rotation. Regenerative braking offers several benefits, including reduced reliance on fuel, improved fuel efficiency, and decreased emissions. It is especially effective in urban areas with frequent stop-and-go traffic. Both BLDC motors and SRMs are capable of regenerative braking, enabling the conversion of mechanical energy back into electrical energy[5-8]. Utilizing regenerative braking of an electric vehicle the driving efficiency of electric vehicles[9]. However, implementation of such schemes along with battery charging circuits would require additional circuits which in turn increases the complexity[10]. Compared to conventional braking systems, regenerative braking allows for shorter braking durations and faster deceleration of the vehicle. In this paper, Brushless DC (BLDC) motors and Switched Reluctance Motors (SRMs) drive system is simulated using matlab simulink[11].

In this study, a comparative study of SRM and BLDC drive systems for regenerative braking will be conducted. The analysis will include the design and simulation of the drive systems using MATLAB/Simulink[12]. The performance parameters, such as stator current, state of charge (SoC) of the battery, actual speed, and torque, will be evaluated and compared for both SRM and BLDC motors during regenerative braking scenarios[13]. By conducting this analysis, we aim to gain insight into the advantages and limitations of SRM and BLDC drive systems for regenerative braking. The

findings of this research will help to the understanding and selection of the most suitable motor technology for efficient and effective regenerative braking in electric vehicle applications[14].

MACHINES EMPLOYED FOR REGENERATION

Brushless DC Motor Drive

The converter circuit is depicted in Figure.1 above utilizing MOSFET switches. The RLE load is made up of the motor stator winding resistance, inductance, and back emf. BLDC motors are widely utilized in electric vehicles due to their high efficiency, compact size, and precise control capabilities [16]. During regenerative braking, the BLDC motor operates as a generator, converting the mechanical energy of the vehicle's motion into electrical energy [17].

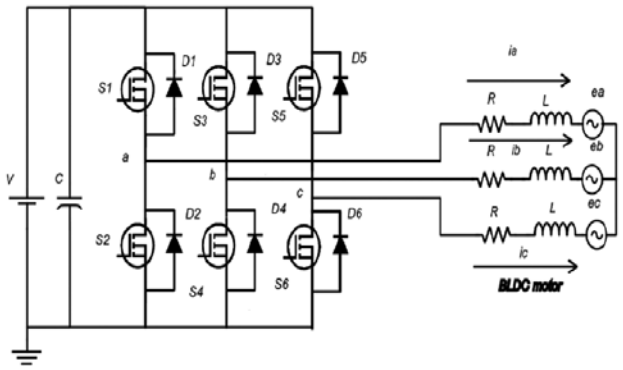

Figure 1. BLDC motor drive

In Figure.1 a three-phase bridge inverter used to convert DC power into AC voltage to drive a Brushless DC (BLDC) motor[4]. The inverter consists of six power switches controlled by pulse width modulation (PWM) signals. BLDC motors utilize permanent magnets in the rotor, eliminating the need for excitation current and increasing overall efficiency. However, BLDC motors are prone to iron losses, which can be reduced through case cooling. The cost of magnets is relatively high, and employing field weakening techniques to extend the motor's speed range can decrease efficiency at high speeds. BLDC motors have specific torque-speed curves with regions of constant torque, constant power, and high-speed operation. As the speed approaches the rated motor speed, the torque decreases while maintaining constant power output[8].

SRM Motor Drive

SRMs are a promising motor technology for electric vehicle applications, known for their robustness, simplicity, and cost- effectiveness The generated electrical energy is fed back into the vehicle's battery for storage and subsequent use, contributing to the overall energy efficiency of the system. The regenerative braking feature of SRMs helps in reducing energy consumption and increasing the driving range of electric vehicles[19]

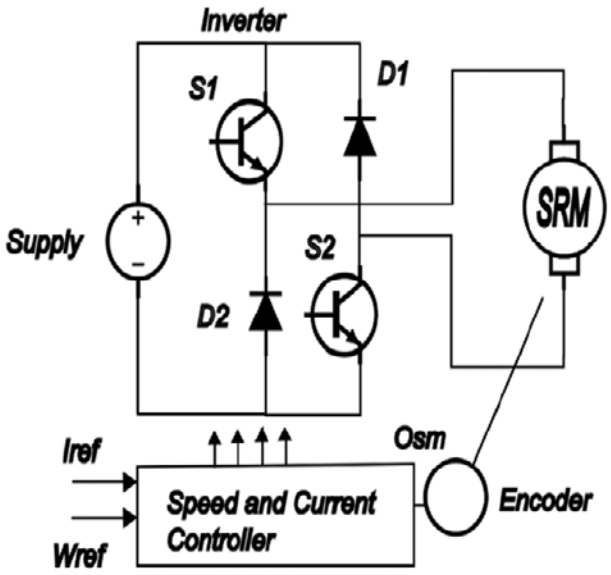

Figure 2. SRM motor drive

The SRM consists of a salient-pole rotor and stator windings, with the rotor aligning with the energized stator pole[9]. The angular position of the rotor is determined by an electronic position sensor, and the stator windings are switched to maintain rotation. The SRM is robust, functions well in hot and vibrating environments, and produces torque regardless of phase current polarity. It has a simple construction with concentrated stator windings and no rotor windings, resulting in improved power density and efficiency. However, controlling SRMs can be challenging due to their nonlinear characteristics. The SRM drive system includes a power supply, driver circuit, position sensor, current controller, and speed controller. In Figure 2, a proportional-integral (PI) controller is used to control the output speed, and a hysteresis current controller ensures safe operating limits for motor current. [20].

DESIGN AND SIMULATIONS OF DRIVES FOR REGENERATIVE BRAKING

Design of BLDC and SRM

Brushless DC Motor

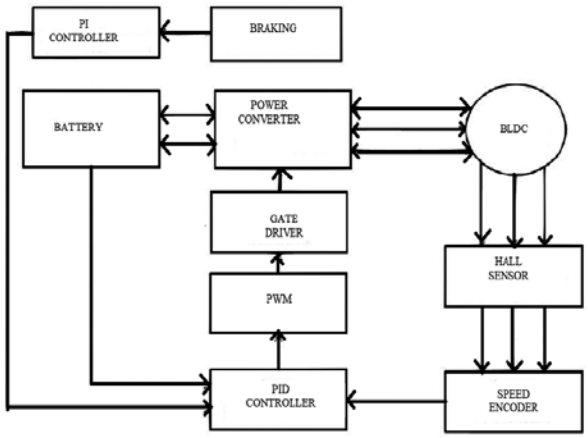

Figure 3 BLDC Block Diagram

In Figure 3 the Block diagram includes:

- Power Supply: Provides the input voltage to the motor drive system.
- Motor Controller: The central control unit consists of a microcontroller/processor, commutation logic, PWM generator, current sensing, and speed/position sensing.
- Power Stage: Responsible for delivering power to the motor, comprising power switches (MOSFETs or IGBTs) and gate drivers.
- BLDC Motor: The actual motor itself with a rotor containing permanent magnets and a stator with three-phase windings.

The motor controller processes commands and feedback signals generates control signals, and determines the switching sequence for the motor windings. The PWM generator generates PWM signals to control the power switches. Current sensing circuitry monitors motor current for precise control. Speed/position sensing components detect rotor position or speed for accurate motor control. The power switches and gate drivers control the current flow through the motor windings. The energized windings in the correct sequence generate torque and drive the mechanical load.

Switched Reluctance Motor

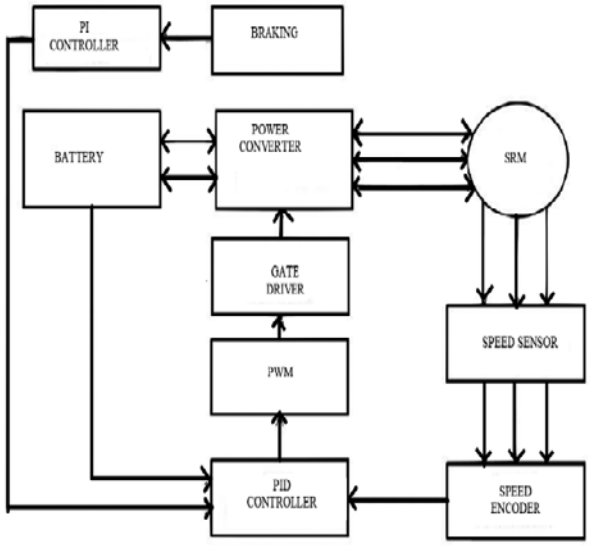

Figure 4 SRM block diagram

In Figure 4 the block diagram includes:

- Input Power Supply: Provides the input voltage to the SRM drive system, typically a DC power supply or an AC grid converted to DC using a rectifier.
- Converter Circuit: Converts the input power to the required form for driving the SRM, with sub-blocks such as a rectifier to convert AC to DC and a DC-DC converter to regulate the voltage if necessary.
- Digital Controller: The central control unit of the SRM drive system, consisting of a microcontroller/processor, position and speed sensors, current sensing, and a PWM generator.
- Power Stage: Controls the current flow through the SRM windings and includes power switches driven by PWM signals and gate drivers that amplify and drive the power switches.

The digital controller processes feedback signals, calculates control signals, and generates PWM signals for the power switches. Position and speed sensors provide feedback for precise control. Current sensing monitors the SRM windings' current, and the PWM generator converts digital control signals into analog PWM signals. The power stage consists of power switches and gate drivers to control the current flow through the windings.

Simulations of BLDC and SRM

BLDC Simulation

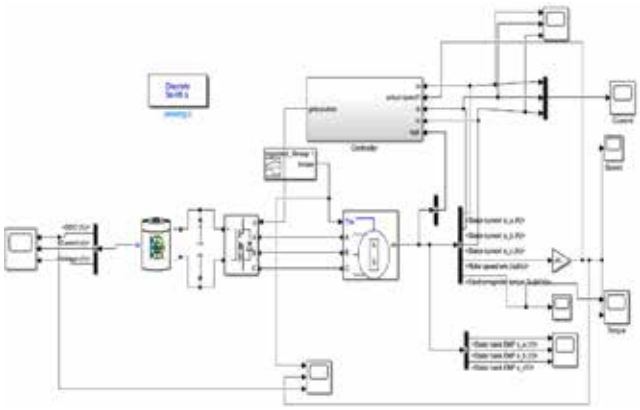

Figure 5. Simulation of BLDC drive system

This simulation is designed based on the block diagram in Figure. 3, DC voltage source, an inverter, a three-phase bridge, a motor model, and a control algorithm are added and interconnected in above Figure 5. Open Simulink and create a new model. Add necessary blocks for the BLDC motor simulation, including a DC voltage source, an inverter, a three-phase bridge, a motor model, and a control algorithm. Connect the DC voltage source to the inverter, converting DC voltage into a three-phase AC voltage. Connect the output of the inverter to the three-phase bridge, controlling the current flow in the motor windings. Connect the three-phase bridge to the BLDC motor model, representing the electrical and mechanical characteristics of the motor. Implement a control algorithm with speed and current control loops, connecting it to the three-phase bridge and the motor model. Modify the control algorithm to enable regenerative braking by detecting braking conditions and generating appropriate signals to reverse the current flow in the motor windings. Run the simulation to observe the behavior of the BLDC motor with regenerative braking. Analyze performance parameters such as motor speed, torque, current, and energy regeneration.

SRM simulation

This simulation is based on the block diagram in Figure 4, In the above simulation in Figure 6 controller block consists of a speed and torque controller block. Open Simulink and create a new model. Add necessary blocks for simulating the SRM, including a power supply, a position sensor, a hysteresis current controller, a pulse generator, and a switch block. Connect the power supply block to the position sensor, which provides feedback on the rotor position. Connect the position sensor output to the hysteresis current controller, which limits the motor current within desired reference values. Connect the hysteresis current controller output to the pulse generator, generating switching signals based on the rotor position. Connect the pulse generator output to the switch block, controlling the energization of the stator windings. Add a control algorithm block for speed control and braking detection logic. Connect the control algorithm block to the switch block, calculating required switching signals based on desired speed and braking conditions. Modify the control algorithm to enable regenerative braking by detecting braking conditions and generating signals to reverse the current flow in the motor windings. Run the simulation to observe the behavior of the SRM with regenerative braking. Analyze performance parameters such as motor speed, torque, current, and energy regeneration.

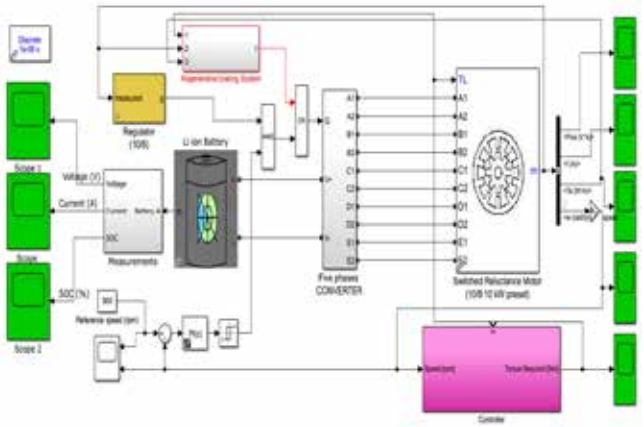

Figure 6. Simulation of SRM drive system

RESULTS

Results for BLDC

Motor Currents

Here the simulations are performed on the MATLAB platform, the duration of the simulation was taken as 2.5 seconds and the initial state of charge is set to 60%.

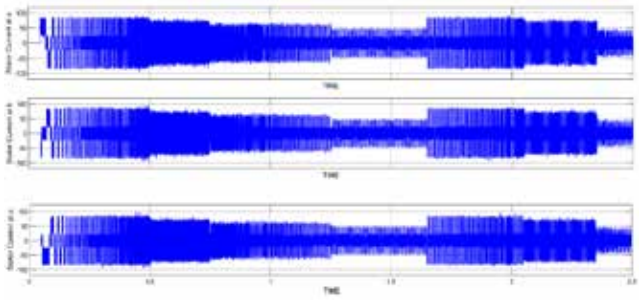

Figure 7. Stator Current vs Time of BLDC

Initially, the stator current is in the normal operating range during motoring operation as seen Figure 7. When regenerative braking is activated, the current starts to decrease gradually from its steady-state value. As the motor transitions from motoring to regenerative braking, the stator current goes through a zero-crossing point and starts to reverse direction. This reversal indicates the change in energy flow from mechanical to electrical, as the motor now acts as a generator.

SOC% for BLDC

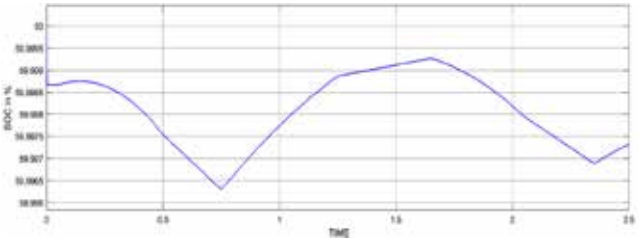

Figure 8. SOC of BLDC

When the BLDC motor operates and consumes electrical energy from the battery, the SoC vs. time graph in Figure 8, reflects a discharging phase., the SoC value increases gradually as the battery receives electrical energy from regenerative braking.

Actual Speed of BLDC

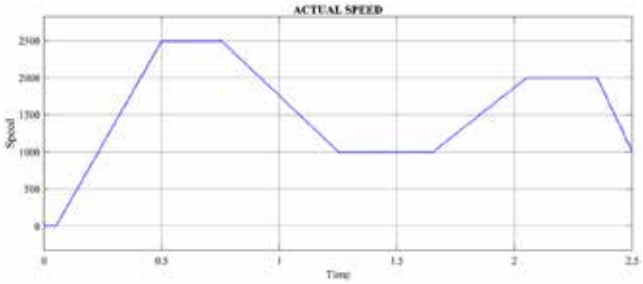

Figure 9. Actual and vs Time of BLDC

The actual speed in Figure 9, refers to the measured or observed speed of the BLDC motor at any given time. The actual speed vs. time graph shows the actual rotational speed of the motor during its operation. The actual speed can be obtained using sensors such as encoders or Hall effect sensors that provide feedback on the motor's rotational position and speed.

Torque of BLDC

As the motor accelerates and gains speed, the torque value may rapidly increase. During braking, the torque vs. time graph in Figure. 10, shows a decrease in torque as the motor slows down or applies a braking force. The rate of deceleration and the magnitude of the negative torque is due to the braking.

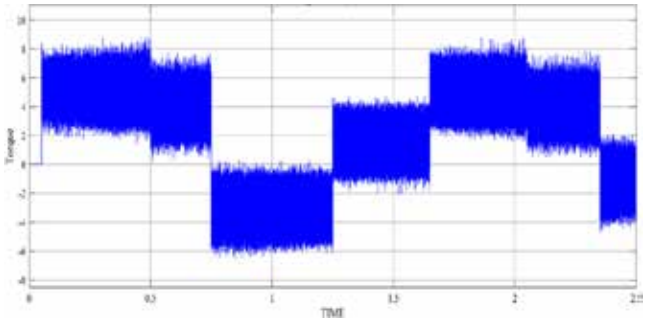

Figure 10. Torque vs Time of BLDC

Results for SRM

Motor Currents

During motor startup, there is a surge or peak in the stator current as seen in Figure 11, higher than the steady-state current. This surge helps overcome inertia and initiate rotation from a standstill. The stator current eventually reaches a peak value during the braking phase, which represents the maximum amount of electrical energy being regenerated.

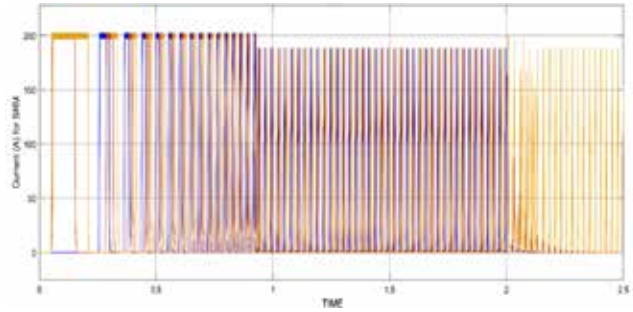

Figure 11. Current vs time of SRM

SOC% for SRM

During regenerative braking, the power flow in the motor reverses direction. Instead of consuming electrical power from the power supply, the motor acts as a generator and produces electrical power. The SOC of the battery during regenerative braking increases as the motor decelerates as seen in Figure 12. The higher the deceleration rate, the higher the SOC of battery.

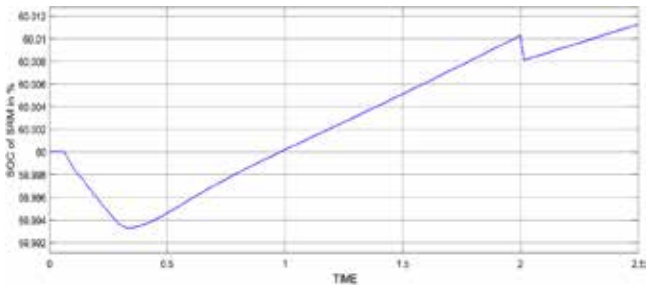

Figure 12. SOC% vs Time of SRM

Actual Speed of SRM

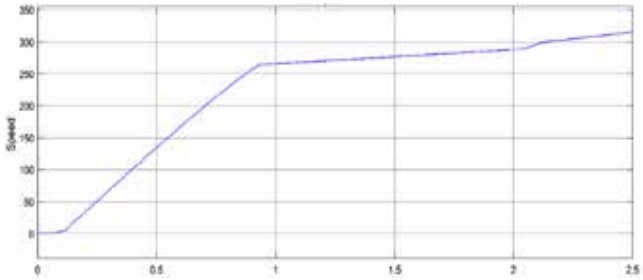

Figure 13. Actual Speed vs Time of SRM

The actual speed of the SRM may increase from zero as the motor accelerates. The rate of acceleration depends on factors such as the motor's design, applied voltage or current, and the load conditions. Once the motor reaches its operating speed, the actual speed vs. time graph in Figure 13, stabilizes into a relatively constant speed.

Torque of SRM

At the beginning of the graph in Figure 14, during the startup phase, the torque value is typically high. The motor requires higher torque to overcome the inertia and initiate rotation from a standstill. The torque may exhibit a rapid increase during this phase as the motor accelerates and gains speed. Once the motor reaches its operating speed, the torque vs. time graph stabilizes into a relatively constant torque output.

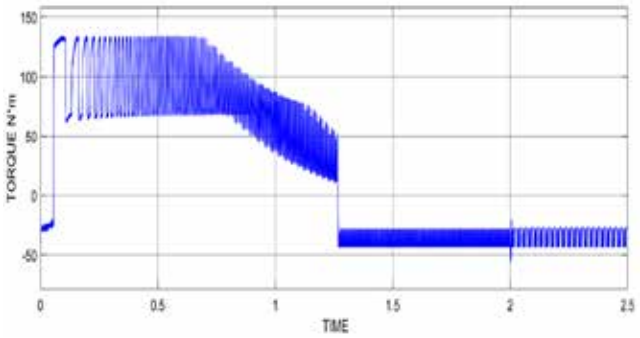

Figure 14. Torque vs time graph of SRM

When considering the State of Charge (SoC) in the context of motor selection, it is important to note that the SoC typically pertains to the battery or energy storage system rather than the motor itself. Both BLDC (Brushless DC) and SRM (Switched Reluctance Motor) can be used with batteries, and their performance may depend on the SoC of the battery. However, the SoC is not a defining factor in determining whether BLDC is better than SRM or vice versa.

Smooth Torque Output: BLDC motors provide smooth torque output due to the presence of permanent magnets and the utilization of electronic commutation. This results in reduced torque ripple and improved overall system performance. High Torque Density: BLDC motors have a higher torque density compared to SRMs. They can provide higher torque output for a given motor size, which is beneficial for applications that require high torque in a compact form factor.

Precise Speed and Torque Control: BLDC motors offer precise control over speed and torque through advanced motor control algorithms. The use of position sensors (such as encoders or Hall effect sensors) allows accurate feedback for closed-loop control, enabling precise torque control and better performance in dynamic applications.

Higher Torque-to-Inertia Ratio: SRMs typically have a higher torque-to-inertia ratio compared to BLDC motors. This means that for a given rotor inertia, SRMs can deliver higher torque output, which is beneficial in applications that require rapid acceleration and deceleration. It's important to note that SRMs also have some limitations, such as higher torque ripple.

CONCLUSION

Both BLDC motors and SRMs have their advantages and limitations. BLDC motors offer smooth torque output, high torque density, and precise speed and torque control. They are suitable for applications that require high torque in a compact form factor and demand precise control over motor performance. On the other hand, SRMs have a higher torque-to-inertia ratio, which allows for rapid acceleration and deceleration. They are robust, function well in harsh environments, and have improved power density and efficiency. However, SRMs can be challenging to control due to their nonlinear characteristics and exhibit higher torque ripple. Hence according to the study BLDC drive system should be preferred for regenerative braking applications.

REFERENCES

1. S. S. Bhurse and A. A. Bhole, "A review of regenerative braking in electric vehicles", 2018 International Conference on Computation of Power, Energy, Information and Communication (ICCPEIC), pp.363-367, March 2018.
2. O. C. Kivanc, O. Ustun, G. Tosun, and R. N. Tuncay, "On regenerative braking capability of BLDC motor", 42nd Annual
3. Kuo- Kai Shyu, Hong-Lin Jhou, Ming-Ji Yang, Bin-Yen Ma, "A Cost- Effective Method of Electric Brake with Energy Regeneration for Electric Vehicles", IEEE Transactions on Industrial Electronics, Vol.56,
4. Conference of the IEEE Industrial Electronics Society (IECON), pp. 1710-1715, 2016.
5. X. Jiaqun and C. Haotian, "Regenerative brake of brushless DC motor for light electric vehicle", 18th International Conference on Electrical Machines and Systems (ICEMS) Thailand, pp.1423-1428, Oct 2015.
6. M. R. Hazari, E. Jahan, M. E. Siraj, M. T. I. Khan and A. M. Saleque, "Design of a Brushless DC (BLDC) motor controller," 2014 International Conference on Electrical Engineering and Information & Communication Technology, Dhaka, Bangladesh, 2014, pp. 1-6, doi: 10.1109/ICEEICT.2014.6919048.
7. O. C. Kivanc, O. Ustun, G. Tosun and R. N. Tuncay, "On regenerative braking capability of BLDC motor," IECON 2016 - 42nd Annual Conference of the IEEE Industrial Electronics Society, Florence, Italy, 2016, pp. 1710-1715, doi: 10.1109/IECON.2016.7793608.
8. R. Abdel-Fadil and L. Számel, "State of the Art of Switched Reluctance Motor Drives and Control Techniques," 2018 Twentieth International Middle East Power Systems Conference (MEPCON), Cairo, Egypt, 2018, pp. 779-784, doi: 10.1109/MEPCON.2018.8635219.
9. J. -W. Ahn and G. F. Lukman, "Switched reluctance motor: Research trends and overview," in CES Transactions on Electrical Machines and Systems, vol. 2, no. 4, pp. 339-347, Dec. 2018, doi: 10.30941/CESTEMS.2018.00043.
10. Amritha Anand , Nandan.G , Najma.Habeeb, A Novel Method of Energy Regeneration in Electric.
11. Chih-Chiang Hua, Shih-Jyun Kao, Yi-Hsiung Fang,"Design and Implementation of a Regenerative Braking System for Electric Bicycles with a DSP Controller", 2013 1st International Future Energy Electronics Conference (IFEEC),pp.641-645,2016
12. W. Dixon and M. E. Ortlizar, "Ultracapacitors + DC-DC Converters in Regenerative Braking System," IEEE Aerosp. Electron. Syst. Mag., vol. 17, no. 8, pp. 16-21, Aug. 2002.
13. J. C. R. J. M. R. F. Z. P. A. Valderrabano, "A DC -DC multilevel boost converter," no. August 2008, pp. 129-137, 2009
14. Nian, X., Peng, F., Zhang, H. (2014). Regenerative braking system of electric vehicle driven by brushless DC motor. IEEE Transactions on Industrial Electronics, 61(10), 5798-5808
15. Joseph Godfrey and V. Sankaranarayanan, An Electric Braking Scheme for a BLDC Motor Driven Electric Vehicle, Power Research - A Journal of CPRI, vol. 16, no. 2, p. 173, Dec. 2020.
16. Chau, K.T., Chan, C.C. (2007). Modern Electric Vehicle Technology. Oxford University Press.
17. Miller, T.J.E. (2012). Brushless Permanent-Magnet and Reluctance Motor Drives. Oxford University Press.
18. Pillay, P., Krishnan, R. (2018). Modeling, Simulation and Analysis of Permanent Magnet Motor Drives. Wiley.
19. Regenerative Braking Control of Electric Vehicle using Brushless DC Motor Authors: R. Velmathi, S. Parthiban, and S. Prakash
20. A Study on Regenerative Braking Control of Switched Reluctance Motor Authors: J. H. Lee, K. B. Lee, and M. S. Kim

Hardware Implementation of Perturb and Observe MPPT Algorithm for Enhancement of Power Generation Capacity of Solar PV System

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ABSTRACT

A solar PV system's MPPT algorithm is crucial because it maximizes power generation by keeping the solar panel's operating point at its Maximum Power Point (MPP). Due to its ease of use and efficiency in tracking the MPP under changing weather circumstances, the Perturb & Observe (P&O) MPPT method has been used in a great amount. This paper presents a hardware implementation of the algorithm to improve the power generation capacity of a 10 watts solar PV panel system. The system's MOSFET based DC-DC converter's design and fabrication is also used in this part. The converter is made for small-scale solar PV systems due to its high efficiency and cheap operating cost. The system is an adaptable and simple to replicate solution that can be employed in a variety of applications with the help of the Arduino platform and MOSFET based DC-DC converter.

KEYWORDS *: Arduino, MOSFET base DC-DC converter, MPPT, Perturb and Observe algorithm*

INTRODUCTION

As a feasible replacement for conventional fossil fuels, solar energy is becoming more and more popular. It is a renewable and sustainable energy source. Small-scale solar PV systems which are used to power the remote and off-grid sites like cabins, boats and RV's as one of the most widespread solar energy applications. However the factors like weather and shade have an impact on how much power solar systems can generate [1]. To modify the duty cycle based on the observed voltage, the suggested system will incorporate a voltage sensor, an Arduino Uno board and a MOSFET based DC-DC converter. The system will be put to the test in various weather scenarios to determine how well it tracks the MPP and increases the solar PV system's ability to generate power.

The issues include the minimal power generation capacity of small scale solar PV systems due to the elements including weather, shade and temperature changes. The operating point of the solar panel cannot be maintained at its MPP by conventional fixed voltage methods used in small-scale solar PV systems because they do not take these parameters into consideration. As a result, the capacity and efficiency of power generation are decreased.

The main objectives of this work are as follows:

- To design and implement a hardware system based on the Perturb and Observe (P&O) Maximum Power Point Tracking (MPPT) algorithm using the Arduino platform.
- To enhance the power generation capacity of a small-scale solar PV system by maintaining the operating point of the solar panel at its maximum power point (MPP) under varying weather conditions.
- To provide a cost-effective and efficient solution for enhancing the power generation capacity of small-scale solar PV systems.

PROPOSED METHODOLOGY

A popular algorithm for photovoltaic application is the Perturb & Observe (P&O). The P&O algorithm's fundamental premise is to alter the PV panel's operating point and track any resulting change in power output. The algorithm may track the MPP of the panel by gradually shifting the operating point in the direction of maximum power. These are the primary parts of this system:

- Solar panels: An energy source that transforms solar energy into electrical energy.
- DC-DC converter: It's a device which transforms solar panel output into a voltage level that is appropriate for the load or battery.
- MPPT control unit: A computer algorithm that continuously modifies the DC-DC converter's duty cycle in order to determine the maximum power point. The Arduino processor then feeds the algorithm to the trigger circuit.
- Load/Battery: The appliance that uses or stores the electricity produced by the solar panel.

The perturb and observe algorithm operates by varying the duty cycle of the DC-DC converter to track changes in the solar panel's output power. After that, the algorithm modifies the duty cycle so that the output power grows until it reaches the maximum power point.

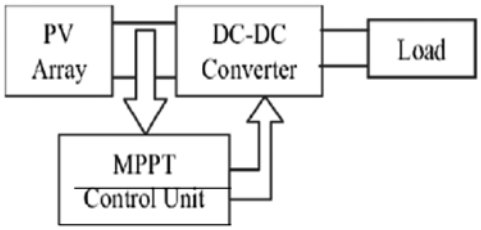

Fig 1: Proposed system block diagram

Overall, the proposed methodology may help for maximising a solar panel system's energy output and enhancing system efficiency. The power converter that connects the PV panel to the load is often controlled by a microcontroller or a Digital Signal Processor (DSP) in the hardware implementation of the P&O MPPT algorithm. The flowchart of the proposed system is presented in Fig 2. The P&O MPPT algorithm is put into practice using the following steps:

Sensing: The PV panel's voltage and current must first to be realised. A voltage sensor and a current sensor can be used for this purpose.

Perturbation: The next step is to alter the power converter's duty cycle in order to disturb the PV panel's operational point. Small adjustments are made to the duty cycle. After each adjustment, the panel's power output is measured.

Power calculation: The voltage and current sensed in step 1 are used to determine the panel's power output.

Comparison: To determine the changes in the direction, the power output is compared to the preceding value. The duty cycle is further raised in the same way if the power output has risen.

Convergence: Until the power output achieves a maximum value, the algorithm keeps changing the operating point of the panel. The algorithm converges to that point once the MPP is attained and maintains the duty cycle at that value.

Load control: The power converter and the power flowing from the PV panel to the load are both controlled by the duty cycle.

Fig 2: Flowchart of P&O MPPT

The proposed system has been simulated using Proteus software and PVSOL software.

Simulink model: The P&O MPPT consists a solar panel based on the MPPT algorithm implemented using the Arduino Uno, an N-channel MOSFET, an NPN transistor and a Schottky diode. The Arduino Uno will be used to measure the solar panel voltage and current, control the MOSFET and transistor and execute the MPPT algorithm. The N-channel MOSFET will act as a power switch to control the connection between the solar panel and the load. The NPN transistor will act as a driver to control the MOSFET's gate voltage. The Schottky diode will be connected in parallel with the load to prevent reverse current flow. The circuit diagram is shown in Fig 3.

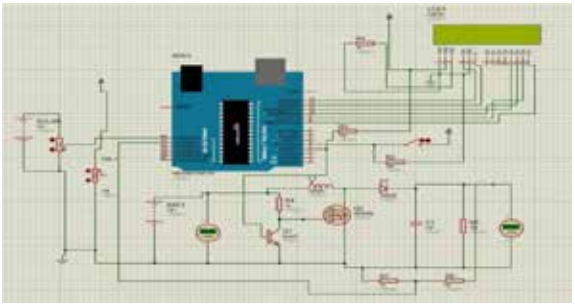

Fig 3: Circuit diagram of proteus simulation of MPPT

The Arduino plays the main role of controlling the DC-DC booster here. The Arduino algorithm is designed in such a way that when the value of input voltage goes below the certain sets of value then it activate its output pin. Hence the voltage value has been increase at the point of MPPT. The complete circuit diagram of the system is shown in fig 4 and its hardware design is observable in Fig 5.

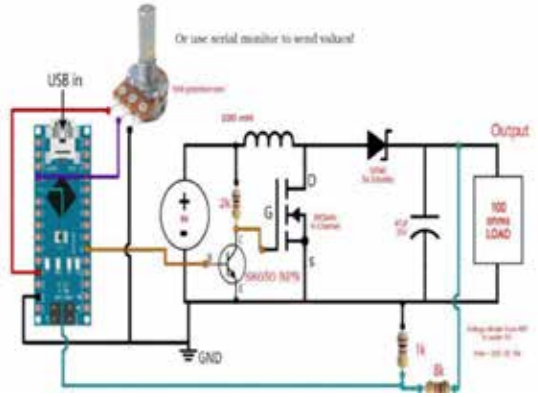

Fig 4: Circuit diagram of P&O MPPT

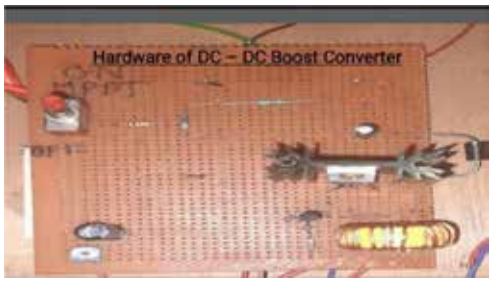

Fig 5: Hardware implementation of P&O MPPT

The system as shown in Fig 6 has been tested under various conditions to ensure it responds well for changing solar panel characteristics.

Fig 6: Testing of P&O MPPT with different tilt angle and weather conditions

The solar panel output using P&O MPPT with different tilt angle was analyzed. The main concern has been there around the voltage and current received as output of MPPT. The output results are noted in the Table 1.

Table 1: Output voltage and current at various tilt angles

Sr. no.	Tilt angle (In degree)	PV Cell Voltage (In volts)	PV Cell Current (In ampere)
1.	20	19.85	0.140
2.	21	19.63	0.137
3.	22	19.62	0.136
4.	23	19.60	0.135
5.	24	19.59	0.132
6.	25	19.57	0.130
7.	26	19.55	0.129
8.	27	19.54	0.128
9.	28	19.53	0.127
10.	29	19.52	0.126
11.	30	19.51	0.125

To analyze the performance of MPPT, tests were conducted with different solar panel conditions such as with shading with dust and with water. The output

results are listed in Table 2 and the observations of the same are as follows:

- Output voltage of solar panel with dust: [19.54 V] and solar panel with water: [19.93 V].

Table 2: Output voltage under solar panel shading condition

Sr. no.	Tilt angle (In degree)	PV Cell Voltage (In volts)	PV Cell Current (In ampere)
1.	20	19.85	0.140
2.	21	19.63	0.137
3.	22	19.62	0.136
4.	23	19.60	0.135
5.	24	19.59	0.132
6.	25	19.57	0.130
7.	26	19.55	0.129
8.	27	19.54	0.128
9.	28	19.53	0.127
10.	29	19.52	0.126
11.	30	19.51	0.125

Tests conducted on P&O MPPT results shows that when we place solar panel according to the latitude of the place where it is to be installed, the maximum output will be achieved. The Fig 6 shows the V-I characteristics of PV panel with varying tilt angle of panel.

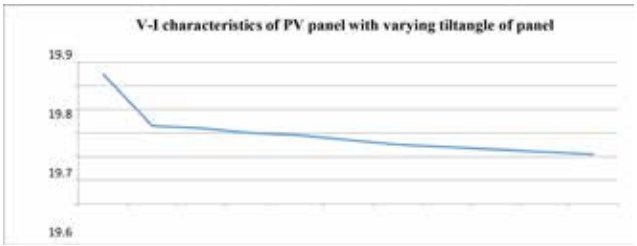

Fig 7: V-I characteristics of PV panel with varying tilt angle of panel

CONCLUSION

Based on the hardware implementation of Perturb and Observe (P&O) MPPT algorithm for enhancement of power generation capacity of a 10-watt solar PV panel, the following conclusions are drawn:

- The P&O algorithm tracks the MPP of a solar PV panel.
- The hardware implementation of the P&O algorithm is relatively easy and inexpensive.
- The performance of this algorithm is highly dependent on the step size used for perturbing the solar panel's operating point. A small step size can improve accuracy but also increase the time taken to converge to the maximum power point while a large step size can decrease convergence time but also reduces the accuracy.
- The P&O algorithm can experience some issues such as oscillations around the maximum power point and convergence to a local maximum rather than the global maximum.
- Based on the experimental results, it is noted that when the tilt angle of solar panel is equal to latitude then the output voltage of PV module is maximum as compared to other tilt positions of PV panel.

REFERENCES

1. Y. Xu, X. Huang, H. Tang, and X. Tang, "A Fast Perturb and Observe MPPT Method for PV Systems Under Fast-Varying Weather Conditions," IEEE Transactions on Industrial Electronics, vol. 67, no. 3, pp. 2109-2121, Mar. 2020.
2. Y. Liu, Y. Chen, Z. Liu, Y. Song, and Q. Li, "Hardware Design and Experimental Study of MPPT Algorithm Based on Adjustable Step Size for PV System," IEEE Transactions on Power Electronics, vol. 35, no. 7, pp. 7623-7632, Jul. 2020.
3. H. Guo, H. Liu, and Z. Liang, "A Non-Iterative Perturb and Observe MPPT Technique for Photovoltaic Systems," IEEE Transactions on Industrial Electronics, vol. 65, no. 5,pp. 4245-4255, May 2018.
4. H. Guo, H. Liu, Z. Liang, and W. Gao, "An Improved Perturb and Observe MPPT Method for PV Systems," IEEE Transactions on Power Electronics, vol. 32, no. 3, pp.2020-2030, Mar. 2017.
5. P. K. Hota, A. K. Sahoo, B. Subudhi, and K. K. Mahapatra, "An Improved P&O MPPTScheme for Solar PV System," IEEE Transactions on Industrial Electronics, vol. 62,no. 4, pp. 2402-2410, Apr. 2015.
6. T. Esram and P. L. Chapman, "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques," IEEE Transactions on Energy Conversion, vol. 22, no. 2, pp. 439-449, Jun. 2007.
7. S. P. A. Kumar, P. Suresh, and T. N. Veziroğlu, "A New MPPT Design Method for PV Systems," IEEE Transactions on Sustainable Energy, vol. 8, no. 4, pp. 1453-1460, Oct.2017

Design and Development of Prototype Model of Solar Drying System for Food Commodities

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ABSTRACT

The preservation of food commodities is a critical issue for both developed and developing countries as food losses and waste contribute to food insecurity, economic losses and environmental degradation. Solar drying is a process of dehydrating food commodities using solar energy. In this system, Peltier module is used which is a thermoelectric device that converts electrical energy into thermal energy and vice versa. The benefits of using a solar drying system for food commodities are numerous. Solar drying systems are sustainable and environmentally friendly as they use renewable energy sources and reduce greenhouse gas emissions. They are also cost-effective and accessible as they can be used by small-scale farmers and producers in areas with limited access to electricity. Additionally, solar drying systems help to reduce food waste and post-harvest losses which can contribute to food insecurity.

KEYWORDS *: Food preservation, Peltier module, Prototype model, Solar drying system*

INTRODUCTION

The method used mostly for the preservation of food when there is a combination of heat from the sun with wind is known as drying. It's the oldest method of agricultural materials with the help of solar energy. This work presents the design, construction and performance of a solar dryer for food preservation. The exhaust fan's output i.e., the heated air is circulated in the room. Simultaneously, the room takes the solar energy form the glass alignment. The observation in the inner cabin's temperature is more than the room temperature at the most time of the day light. Dryer ensuring the good quality of the dried materials with a rapid manner.

The main objectives of this work are as follows:

1. Develop sustainable and cost-effective methods for preserving food.
2. Explore the benefits of solar drying systems for food commodities.
3. Identify the best practices and technologies for solar drying and evaluate their effectiveness in preserving food.
4. Share knowledge with farmers, food processors and policy makers to promote the adoption of solar drying systems.
5. Improve food security by reducing food waste and increasing the availability of nutritious food.
6. Contribute to sustainable development by using a natural and environmentally friendly method that does not require the use of fossil fuels.
7. Increase awareness of the importance of food preservation and the potential of solar drying systems to improve food security.

PROPOSED METHODOLOGY

The description of the flowchart as shown in Fig 2:

1. Construct a drying chamber using acrylic sheets: Build a chamber using acrylic sheets to create an enclosed space for drying food.
2. Install a Peltier module: Place a Peltier module between the solar panel and the drying chamber. This module helps control the temperature inside the chamber.

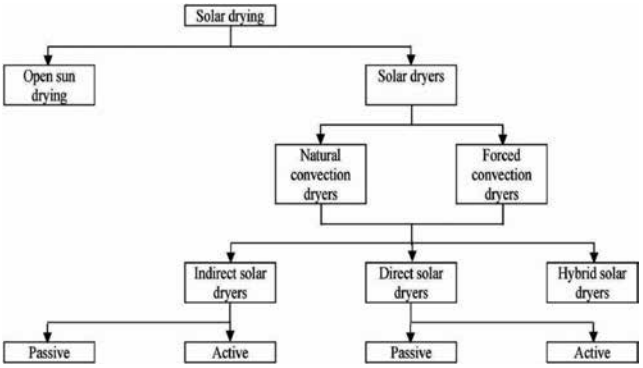

Fig 1: Classification of Solar Drying System

3. Wash and prepare the food commodities: Clean and slice the food items you required to dry. Prepare them by ensuring they are properly sliced for efficient drying.

4. Arrange the food commodities on drying trays: Place the sliced food on drying trays and make sure there is enough space between them for airflow.

5. Place the trays in the drying chamber: Put the drying trays inside the chamber, ensuring they are evenly spaced for proper air circulation.

6. Connect the Peltier module to the solar panel: Wire the Peltier module to the solar panel so that it can draw power from it. This connection allows the module to work.

7. Monitor temperature: Use monitoring equipment to keep an eye on the temperature levels inside the drying chamber. This helps ensure optimal drying conditions.

Purpose of this Method

The use of this method for solar drying offers several advantages over other methods which make it a preferred choice in certain applications. Here are some reasons, why Peltier modules are used in solar drying systems:

- Energy efficiency and precise temperature control.
- Compact and portable.
- Flexibility, adaptability and environment friendliness.

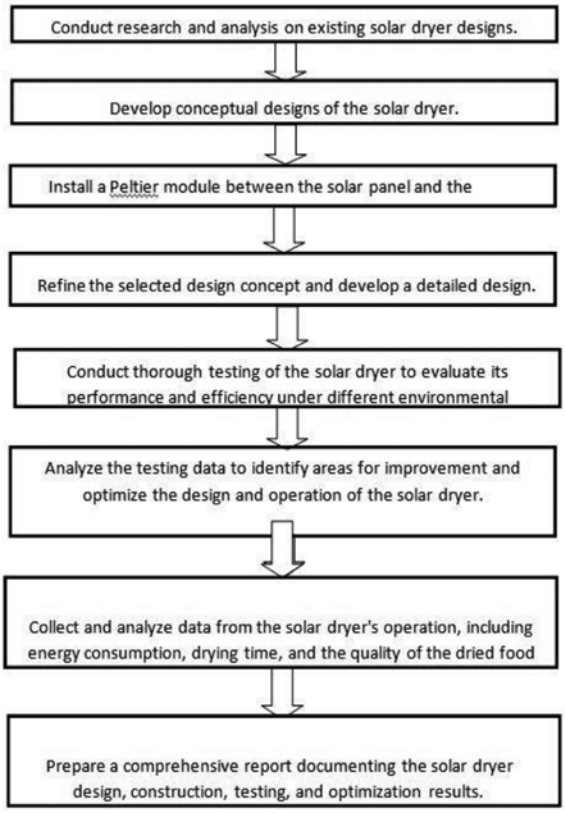

Fig 2: The flowchart for the proposed methodology adopted

MODELING AND ANALYSIS

A solar drying system utilizing a Peltier module works by harnessing solar energy through solar panels which generate electricity. The electricity is used to power the Peltier module, a device that transfers heat from one side to the other when an electric current is applied. The module consists of a hot side and a cold side. The hot side absorbs heat from the air inside the drying chamber while the cold side releases heat, cooling the air. A heat sink and fan help dissipate the absorbed heat efficiently. The drying chamber is insulated to minimize heat loss and holds the items to be dried. Air circulation is facilitated by fans or blower by ensuring uniform drying. A control system regulates temperature and humidity inside the chamber adjusting the power supplied to the Peltier module accordingly. Regular maintenance and monitoring are important for optimal system performance. The complete setup of solar dryer prototype model is shown in Fig 3.

Fig 3: Prototype Model

RESULTS AND DISCUSSION

In this case, few samples of neem leaves are taken and processed through the proposed system. The formula used to calculate the moisture content is:

$$\% \text{ Moisture content} = \frac{(\text{Inital weight} - \text{Final weight})}{\text{Initial weight}} * 100$$

Details of moisture removed during drying (in the month of march - april) both Inside and the Outside chamber are as shown below in Table 1.

Table1: Details of Moisture Analysis

Sr. no	Time	Inside chamber			Outside Chamber	
		Temperature °C	Weight gm	Moisture removed	Weight gm	Moisture removed
1.	10 am	31	25	0%	25	0%
2.	11 am	35	23	8%	24	4%
3.	12 am	39	20	20%	22	12%
4.	1 pm	43	17	32%	20	20%
5.	2 pm	47	15	40%	18	28%
6.	3 pm	51	9	64%	15	40%

From the Table1, in outside the chamber, its noted that the moisture is removed from 0% to 40% while inside the chamber moisture removed is 64%, keeping them for 6hrs in both the cases. From this analysis, its found that this solar dryer is more efficient than the open drying system. The physical appearance of neem leaves before and after placing inside the chamber is shown in Fig 4 and Fig 5. The drying rate is displayed in Fig 6.

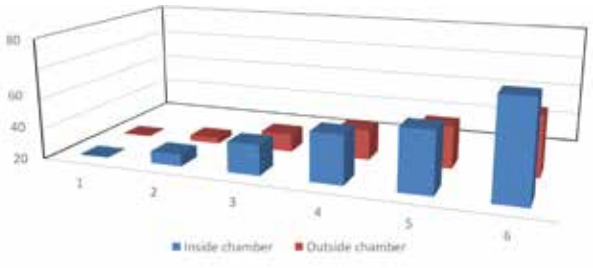

Fig 6: Graphical Representation of Dry

Fig 4: Neem leaves before dry

Fig 5: Neem leaves after dry

CONCLUSION

The solar drying system using Peltier module is a promising technology for preserving food commodities. The system is energy-efficient, environmentally friendly and capable of producing high quality dried food products. The use of renewable energy sources such as solar panels and the integration of Peltier modules preservation particularly in areas with limited access to electricity.

Overall, the solar drying system using Peltier module has great potential for the future of food preservation. With continued research and development, it could

become a widely adopted technology for preserving food commodities.

REFERENCES

1. Ankit Kumar, Kamred Udham Singh, Mukesh Kumar Singh, Alok Kumar Singh Kushwaha, Abhishek Kumar and Shambhu Mahato "Design and Fabrication of Solar Dryer System for Food Preservation of Vegetables or Fruit" in Journal of Food Quality , 2022.
2. Jaivindra Singh, Mayur Pratap Singh, Modassir Akhtar, Akhil Khajuria "Design and Performance Analysis of an Indirect Type Solar Dryer" in International Journal of Advanced Research in Science, Communication and Technology (IJARSCT), Vol. 2, Issue 7, May 2022.
3. Patchimaporn Udomkun, Sebastian Romuli, Steffen Schock, Busarakorn Mahayothee, Murat Sartas, Tesfamicheal Wossen, Emmanuel Njukwe, Bernard Vanlauwe, Joachim Müller "Review of solar dryers for agricultural products in Asia and Africa: An innovation landscape approach" in The Journal of Environmental Management, 268, p. 110730, 2020
4. Atul H Patel, S A Shah, Hitesh Bhargav, "Review on Solar Dryer for Grains, Vegetables and Fruits" in International Journal of Engineering Research & Technology (IJERT), Vol. 2 Issue 1, January- 2013
5. Kumar, R., Dhiman, S., Sharma, R.K., Singh, S.P. "Development of Peltier module-based indirect solar dryer for drying food products: An overview. Drying Technology", 2020.
6. Anupam Tiwar, "A Review on Solar Drying of Agricultural Produce," Journal of Food Processing & Technology, Volume 7, Issue 9.
7. J. O'Donoghue and R. J. Fuller, "Experience with the Australian version of the Hohenheim solar tunnel dryer" in Proceedings of the 37th Annual Conference of the Australian and New Zealand Solar Energy Society (Solar '99), Victoria, Australia, 1999.
8. N. Chiewchan, A. Mujumdar, and S. Devahastin, "Application of Drying Technology to Control Aflatoxins in Foods and Feeds: A Review" Drying Technology, Vol. 33, no. 14, pp. 1700–1707, Jul. 2015.
9. Abdul Jabbar N. Khalifa, Amer M. Al-Dabagh and W. M. Al-Mehemdi "An Experimental Study of Vegetable Solar Drying Systems with and without Auxiliary Heat" International Scholarly Research Network (ISRN) Renewable Energy, 2012.

Development of Human Machine Interface Android App for Monitoring and Control of Induction Motor

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ABSTRACT

The AC induction motor is the most popular motor used in consumer and industrial applications which is represented as the muscle behind the industrial revolution. In this paper, the switching ON & OFF the induction motor is controlled and the monitoring will be done by the Android app. Android application is used here as a transmitter and remote control to do switching ON and OFF the motor with the help of a WIFI module i.e., NODE MCU. The main objective of this work is to reduce the human time to do the similar job which can also be controlled by an HMI wirelessly. In industries, there is the absence of a direct human machine interface and so the machine's switching mechanism has to be done manually through a control panel which can be eliminated by this work. With a microcontroller interfaced with a Wi-Fi module, the data shall be sent over the internet. The data is logged in the cloud platform that can be assessed using mobile phones, tablets, laptops, etc. The data logged can be further analyzed for load flow studies, load forecasting and load management which further enhancing the electrical power system stability & control. It's implemented to monitor the electrical parameters at every instant in the mobile devices. This will be helpful for accuracy, fast work, less time consuming, storage of data, etc. Data collection, storage, analysis and early alert system are important for the efficient controlling and monitoring ofa power system.

KEYWORDS *: Android application, Cloud platform, IOT, NodeMCU, Parameter monitoring, Relay*

INTRODUCTION

Induction motors are widely used in industrial applications due to their simplicity, low cost and high reliability. However, traditional methods of controlling induction motors often require the manual adjustment of switches or knobs which can be time consuming and prone to human error.

The development of a human machine interface Android app for controlling an induction motor is necessary to address the complexities and limited accessibility of current methods. The objective is to develop an app that provides a simple and intuitive interface for controlling an induction motor, using a user-friendly design and appropriate programming languages and frameworks. The expected outcome of this work is an Android app that improves the efficiency of induction motor control and enables wider access to this technology.

The main objective of this work is as follows:

- To improve the efficiency of industrial processes by reducing the time and effort required to control the motor.
- To reduce the risk of human error which can lead to safety hazards and equipment damage.
- To enable remote control & monitoring of multiple induction motors which can be useful in situations where physical access to the motor is limited.

PROPOSED METHODOLOGY

This section is majorly focuses on the controlling and monitoring of the induction motor using the IoT which will be controlled by an Android Application.

Monitoring of the System

- For monitoring purposes, PZEM-004T has been used. It utilizes the current principle of the transformer which converts the currentinto the voltage and further uses the inbuilt logic to calculate the current, voltage, power factor, frequency and active power of the system (load connected in the system).
- A 100 A CT is required with this PZEM -004T. It is connected with the NodeMCU (ESP8266) for receiving and sending datato the NodeMCU.
- Further, the NodeMCU sends the data to the Google based cloud server i.e. google firebase and the same data is reflected in the mobile application. The circuit diagram and pin details of the PZEM-004T with the system are shown in the Fig 1. Flowchart has been shown in Fig 2.

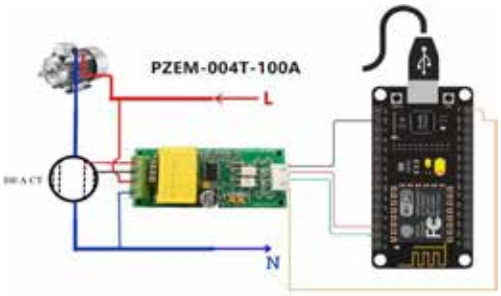

Fig 1: Circuit diagram for monitoring purpose

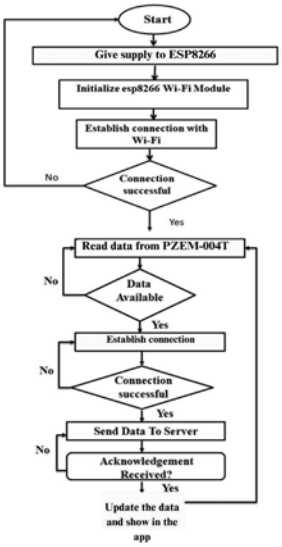

Fig 2: Flowchart of the electrical parameter monitor through cloud

Controlling of the System

- There is a use of NodeMCU ESP8266 (Wi-Fi Module), relay channel (5V DC-230VAC) for controlling the Induction motor.
- The Relay channel is connected with the NO and NC switches for controlling of the motor.
- The command from the NodeMCU is given to the relay channel 5V side as the relay channel receives the signal in DC form only.
- This 5V DC signal which is received on the relay channel end depends on the command received by the ESP8266. The command is given to the NodeMCU from the google firebase.
- A Mobile based application is used to send the command which is stored in the Google Firebase at a particular private database. Depending on the updates in the database, the signal (command) is received at the NodeMCU end which further transfers to the 5V DC side of the relay channel for the further operation of the relay. The circuit diagram and pin details are shown in the Fig 3 respectively. The flowchart of this part is shown in Fig 4.

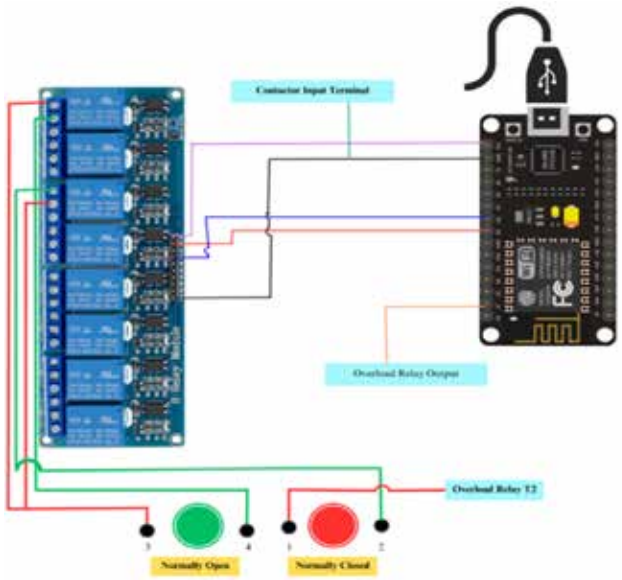

Fig 3: Circuit diagram for switching purpose

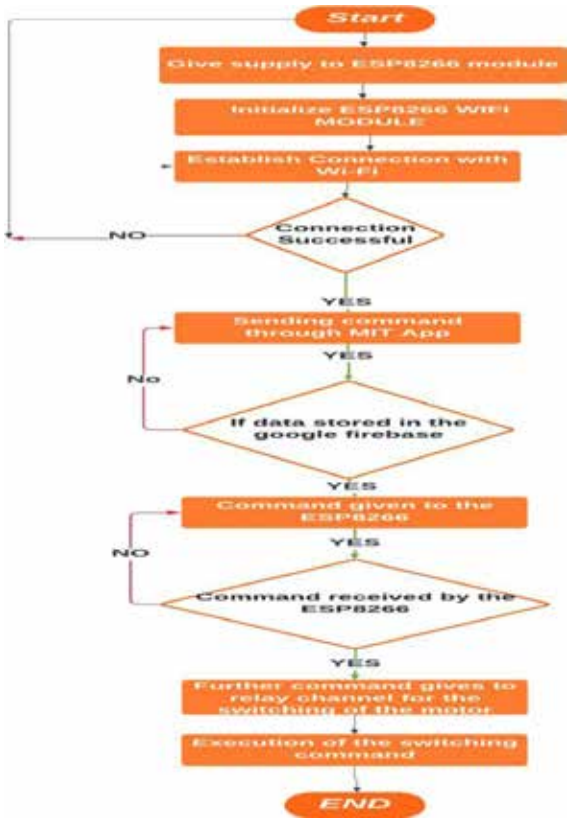

Fig 4: Flowchart of the switching purpose

PROPOSED SYSTEM

- This project includes the use of the Internet of Things which allows the user to control and monitor the multiple numbers of the motor using a single mobile-based Android application.
- The whole project is based on industrial automation and the automation purpose to send/receive the data to the Google Firebase with the help of Wi-Fi module.
- Micro-controller is connected to a Wi-Fi module and internet connection.
- This electrical parameter of the load is monitored by PZEM -004T which is connected to theIOT devices for further processing.
- This system is affordable and suitable for the industrial sector.
- The block diagram of the proposed system is shown is shown in Fig 5.

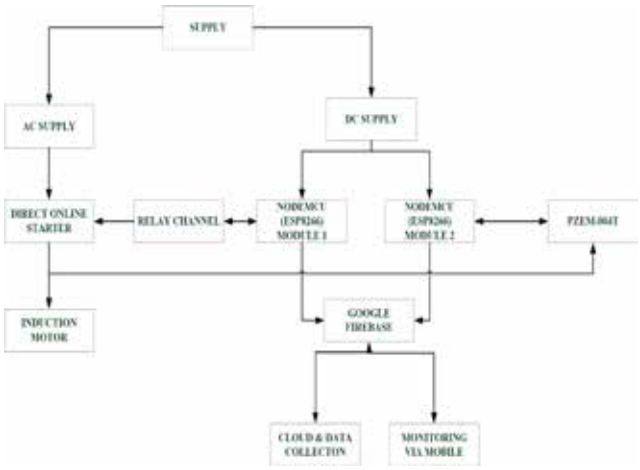

Fig 5: Block diagram of the prototype

Advantages

- It is Low cost and a simple circuit.
- It is a compact product with very less components.
- It is reliable and highly efficient.
- Low Energy consumption , reduced physical effort and maintainance.

Applications

- Use for Industrial automation , agricultural application, load forecasting.
- Use in industries like coal fields, petrol refining, etc.

RESULT

The HMI android app has been successfully tested on a motor. The final view of the app is shown in Fig 6. The app provided a user-friendly interface for controlling and monitoring the motor which makes easy for users to operateand manage the motor. It is capable to control the motor by performing 'ON' & 'OFF' the motor. It can control multiple motors using a single mobile application. This is also monitor the parameters like voltage, current, power factor, frequency and active power. The tests that are conducted during this work include tests like load tests, usability tests, performance tests, etc. The application is suitable for a wide range of android mobiles. The no-load test that is performed on the 0.25 HP motor. The results obtained are listed on Table 1.

Table 1: Monitoring results of the 0.25 HP Single Phase Induction Motor on No-Load

Voltage (V)	Current (A)	Power Factor	Frequency (Hz)	Active Power (W)	Time (sec)
239	0.036	0.5	50	0.4	8.9
240.6001	0.036	0.5	50	0.4	4.7
239.7	0.036	0.5	50	0.4	2.5
240.6001	0.036	0.5	50.1	0.4	4.2
241.2	0.036	0.5	50.1	0.4	7.6
241.3	0.036	0.5	50	0.4	4.5
241.1001	0.036	0.5	50	0.4	3.8
241.2	0.036	0.5	49.8	0.4	3.9
241.8	0.036	0.5	50	0.4	3.5
241.5	0.036	0.5	50.1	0.4	3.6

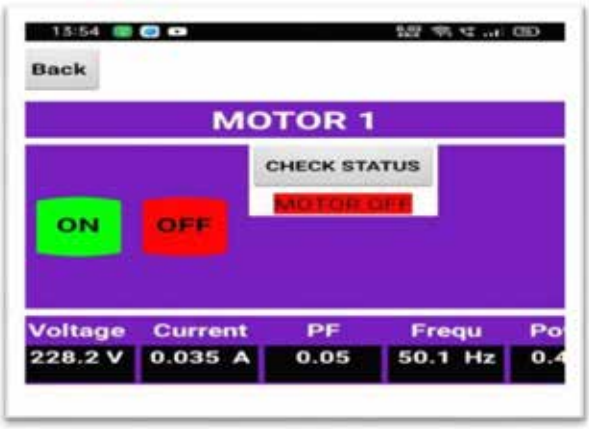

Fig 6: Real-time controlling and monitoring in MIT App

CONCLUSIONS

Human Machine Interface is provided to control the Induction motors through the mobile application and shall ease the human effort for the operators. The controlling of 'ON' & 'OFF' operation of the induction motor is done through an Android app via smartphone. The developed Androidapplication is used to control the motor through the Internet of Things (IoT) using the cloud (Google Firebase) for automation. The development of the HMI android app for controlling and monitoring motors is an important application in the field of automation and the industrial Internet of Things.

REFERENCES

1. Mehmet Şen, Basri Kul, "IoT-Based Wireless Induction Motor Monitoring", In proc. IEEE 2017 XXVI International Scientific Conference "Electronics" (ET)-Sozopol, pg 1–5.
2. Gowsalyaa.V, Sabari.R, Sivaranjani.C, Venkatesh.R.J, "IoT-based Monitoring of Induction Motor Performance", International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395-0056, p-ISSN: 2395-0072, Volume: 07 Issue: 03.
3. Gopika B, Dr. Sabu George. IoT, "Based Smart Energy Management System using Pzem- 004t Sensor & Node MCU", International Journal of Engineering Research & Technology (IJERT).
4. G. Mamatha, A. H. Thejaswi, "Induction Motor Condition Monitoring and Controlling Based on IoT", International Journal of Research in Engineering, Science and Management, Volume 4, Issue 9, September 2021.
5. Mikho Mikhov, Nikolay Stoyanov, Georgi Stanchev, Zdravko Doichev, "An application of wireless standards for remote monitoring of electric drive systems", International Journal of Engineering Research and Development, Volume2, Issue 12, August 2012.
6. Muzahidul Islam, Md Tarek Hossein, Md. Ilias Rahman, Md. Mohtasim Billah, Mohammad Al Mahfuz, Mohammad Hasibul Hasan Hasib, "Android Based Home Automation Using AVR Microcontroller Through Wireless Communication", In proc. IEEE 2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT) - Dhaka, Bangladesh, 2019.
7. MIT App Inventor (https://appinventor.mit.edu/)

Development of Laboratory Prototype for Soft Starting of Induction Motor

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ABSTRACT

The induction motor is widely used in various industrial applications due to its simplicity, robustness and cost-effectiveness. However, the abrupt starting current of an induction motor can cause mechanical stress, voltage dips and disturbances in the electrical network. To mitigate these issues, soft starting techniques have been developed to gradually increase the motor voltage during startup thereby reducing the inrush current and enhancing motor performance. This work proposes development of a laboratory prototype for soft starting of an induction motor using Arduino Uno and BTA16 triac. The control algorithm programmed in the microcontroller ensures a gradual increase in motor voltage thereby reducing the inrush current and minimizing mechanical stress on the motor. Current waveforms, voltage waveforms and startup time are analyzed using PROTEUS software. Experimental testing results demonstrate that the developed prototype effectively achieves soft starting characteristics, resulting in smoother motor operation and reduced electrical disturbances.

KEYWORDS *: Arduino uno, BTA16 triac, Induction motor, Soft starter*

INTRODUCTION

Induction motors play a crucial role in various industries. However, the starting an induction motor directly across the line can lead to several issues such as high inrush current, voltage dips, mechanical stress and decreased motor lifespan. In an industry where several low rating induction motors are connected (less than 5 HP) then if all induction motors are switched on simultaneously the resultant high current can cause voltage sags affecting other equipment connected to the same electrical network. This condition compromises the overall power quality. To overcome these issues, there is a need for a suitable soft starter solution for induction motors. The development of a soft starter specifically tailored for small induction motors presents unique challenges. Factors such as cost-effectiveness, compactness, ease of installation and compatibility with various load types must be considered in the design and implementation process.

Purpose of Study

- A soft starter can eliminate problem of high starting current by gradually increasing the voltage providing a controlled ramp-up to full speed.
- It controls starting torque and reduces mechanical shocks to the motor.
- It is useful extending the life of motor and reduces motor heating. So, a soft starter provides
- a gentle acceleration up to full speed. The function of the work has been shown in the Fig 1.

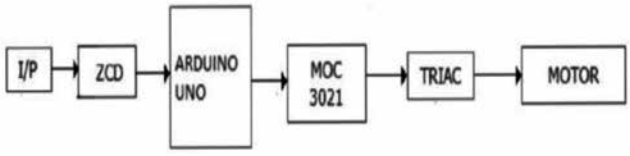
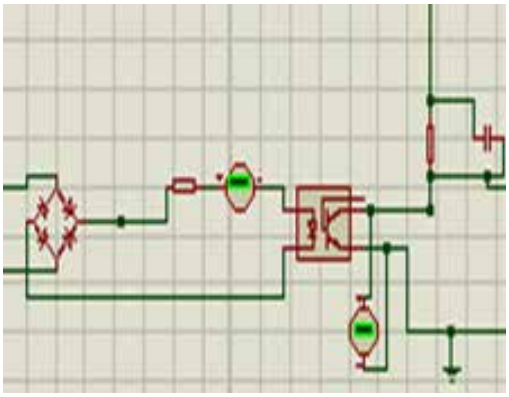
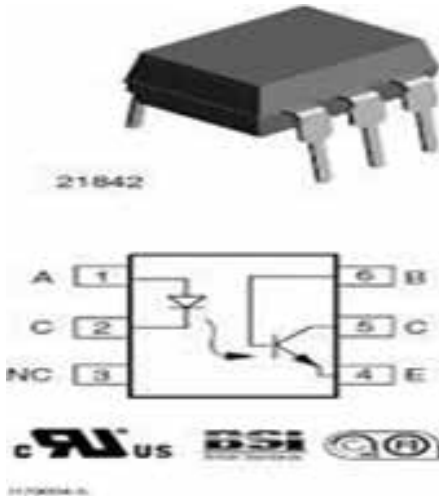
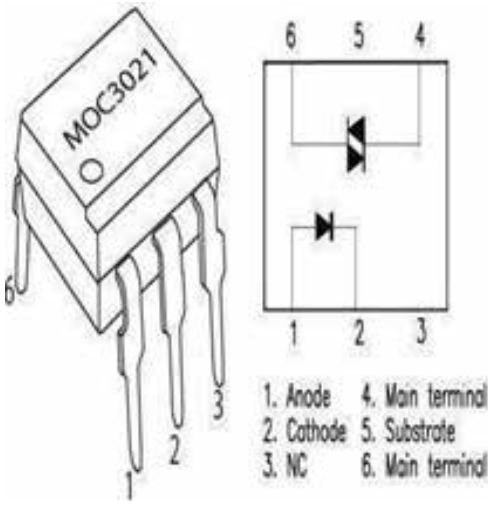


Fig 1: Proposed block diagram

In Table 1, the specification of the components required for making the prototype.

Table 1: Overview of the components

SR. NO.	Name of Components	Diagram	Description
1	ZCD		A zero crossing detector circuit is used to detect the moment when the AC voltage signal crosses zero. It is typically implemented using a simple circuit composed of optocoupler that detects the zero- crossing point of the AC voltage signal.
2	4N25 (OPTOCOUPL ER)		The 4N25 optocoupler is a device that is commonly used to provide isolation between the control circuitry and the high voltage circuitry that is used to control the motor, protecting the control circuitry from damage and increasing the safety of the system.
3	MOC3021 (OPTOCOUPL ER)		The MOC3021 optocoupler is a device that is used to provide isolation between two circuits i.e. controller circuit and triac circuit.

The process of this project has been shown in the Fig 2.

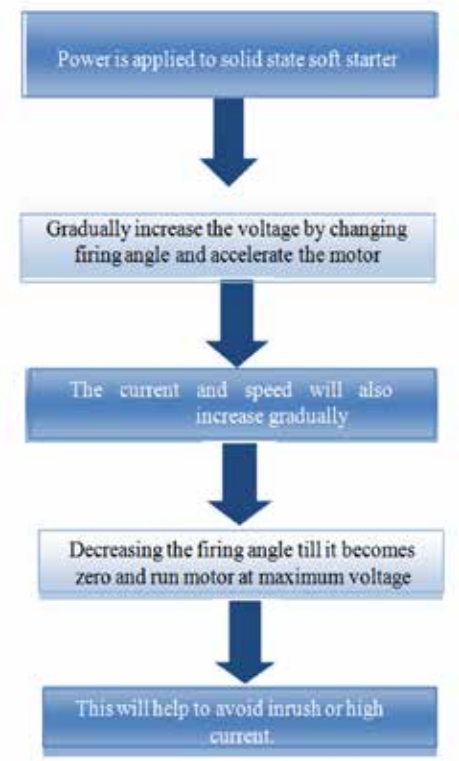


Fig 2: Flowchart of working of solid state soft starter

HARDWARE IMPLEMENTATION

Manual firing angle control: In Fig 3, when analyzing motor current with a soft starter, the inrush current is significantly reduced which leads to a smoother and more controlled starting process. This can help to increase the life of the motor and other electrical components in the system.

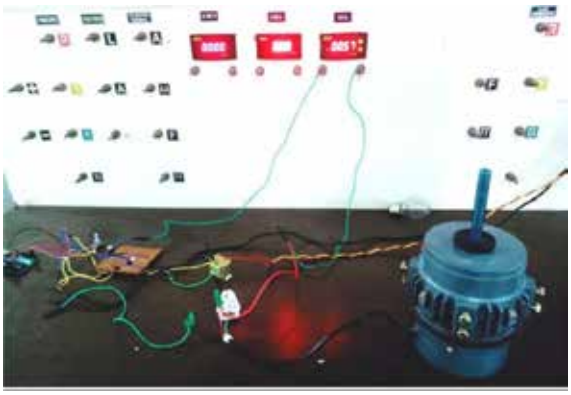


Fig 3: Hardware test of single phase manual firing angle controller on motor

Automatic firing angle control: After successful testing of manual firing angle controller on resistive and inductive load, the hardware implementation of automatic soft starter prototype has been carried out as shown in Fig 4. The firing angle is controlled automatically without using potentiometer and it is done by the program. This initializes the motor and zero crossing pins attach the interrupt and enter a loop that waits for a zero crossing event. The output of Arduino is given in the Fig 5. When a zero crossing is detected, the program sets the motor speed based on the soft start duration and then gradually increases it until it reaches the maximum speed.

Fig 4: Hardware test of single phase automatic soft starter prototype

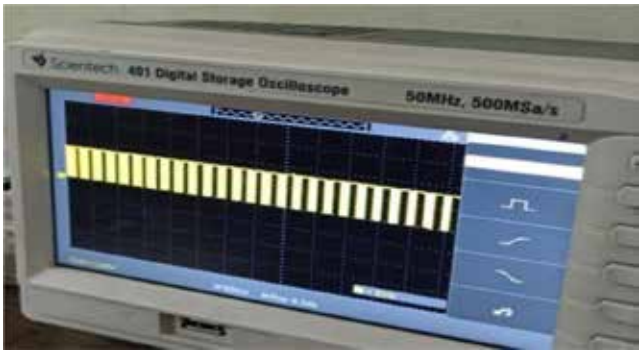


Fig 5: Gate pulse generated at output pin of Arduino

RESULTS AND DISCUSSION

Simulink model: The prototype of a soft starter for manual firing angle control with resistive load and their characteristics is implemented in PROTEUS Simulink first. The reason for using PROTEUS simulation is to operate multiple simulations in the Simulink atmosphere and it has dedicated various tools for modeling simulation without directly performing on

hardware. The Fig 6 shows the PROTEUS Simulink model of a soft starter in a 3 phase induction motor.

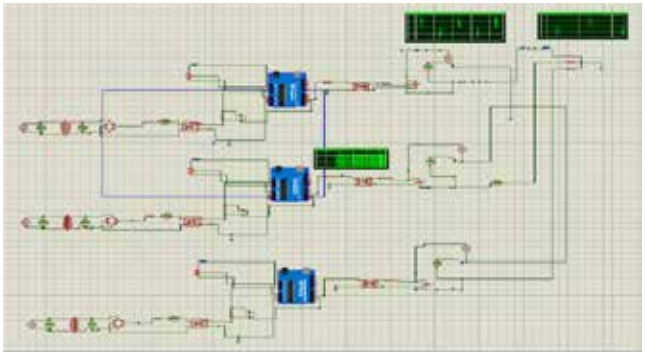


Fig 6: Circuit diagram of proteus simulation soft starter prototype with resistive load

Basically the main aim of this work is to slowly increase the starting current. For the implementation of soft starting rather than going directly on hardware, the status of current on resistive load. For that in the above circuit diagram, potentiometer is used for manual firing angle control. According to position of potentiometer, firing angle of triac as well as how much current should flow through the load is decided. If position of potentiometer is at 50% then the 50% output voltage and current is obtained. Circuit diagram of proteus simulation for manual firing angle control is as shown in Fig 7. In this Resistive load is replaced by inductive load that is motor. According to position of potentiometer, the output current and voltage has been obtained.

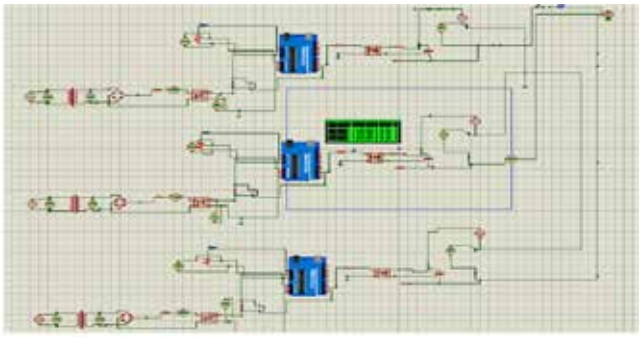


Fig 7: Circuit diagram of proteus simulation of manual firing angle controller

Manual firing angle controller has a problem of adding external resistance in the circuit thereby making it complicated and less efficient .Therefore, an automatic firing angle control is the alternative solution as given in fig 8, where firing angle is controlled without potentiometer that means it is automatically done by the program which is dumped into the Arduino.

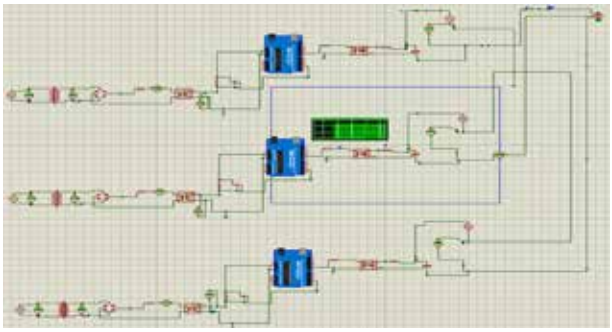


Fig 8: Circuit diagram of proteus simulation of automatic firing angle controller

Output at Resistive Load

PROTEUS simulation of soft starter prototype was carried out with resistive load and the results of the same are discussed accordingly. The lamp light intensity is controlled with varied voltage according to the position of potentiometer. The gate pulse responsible for firing triac is provided by Arduino at an interval of 10 micro seconds as shown in the Fig 9. For 90 degree firing angle i.e. the first gate pulse is given at 500 micro seconds. The firing is gradually reduced from 90 degree to 0 degree i.e. time decreases from 500 microseconds to 0 seconds.

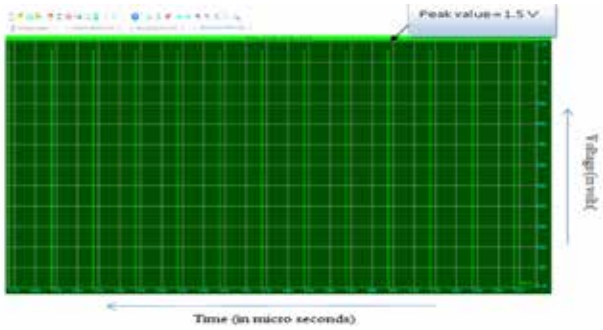


Fig 9: Waveform of gate pulse of triac

The position of potentiometer decides the firing and thereby output current and voltage of triac. With 50% position of potentiometer i.e. 90 degree firing angle the output currentwas observed to be peak value of its rated current which is shown in Fig 10. Therefore, this result proved that by changing the position of potentiometer theoutput triac current is also changed.

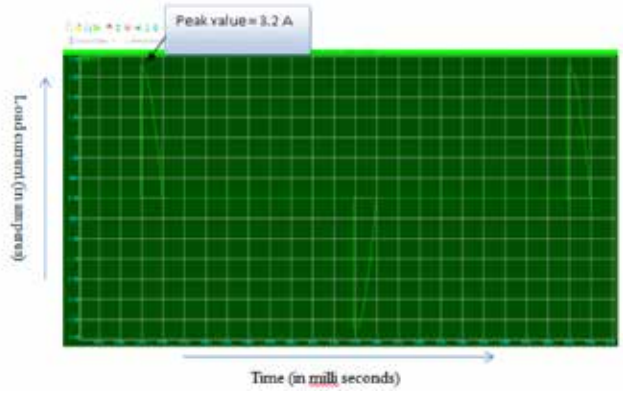


Fig 10: Waveform of output current of triac

In case of resistive load current and voltage are in phase. Therefore, the chopping instant of current and voltage for 90 degree firing angle is same and resulting into peak voltage output as shown in Fig 11.

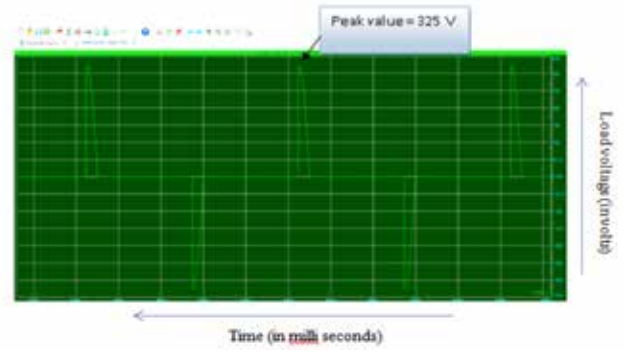


Fig 11: Waveform of output voltage of triac

Results of manual firing angle controller: The starting current is significantly reduced corresponding to the position of potentiometer. In terms of motor current analysis, using a soft starter can provide more accurate data because the starting current is more controlled and predictable. Following Table 2 shows value of load current at different position of potentiometer.

Table 2: Load current at different position of potentiometer

Position of potentiometer	Output voltage of triac
40%	90 V
60%	128 V
80%	170 V

Results of automatic firing angle controller: In case of automatic firing angle controller, it was observed that within 10 seconds after starting the motor normal voltage was reached. During soft starting time (in this case 10 seconds), voltage is increased step by step with every second of time. Following observations in Table 3 were made during testing of automatic firing angle controller:

Table 3: Per-phase voltage corresponding to starting time

Time (in sec)	Per-phase voltage at the time of starting (in volts)
1	94
2	110
3	120
4	136
5	150
6	166
7	182
8	194
9	202
10	211
11	211
12	211
13	211
14	211
15	211

The output voltage of soft starter at the time of starting is directly proportional to time. This relation holds true only for soft starting duration after which during normal running condition of motor the voltages settles to rated voltage. This linear relationship between output voltage of soft starter at the time of starting and time is proved graphically in Fig 12.

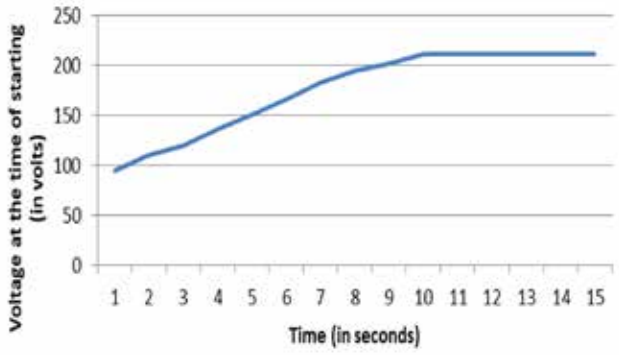


Fig 12: Graph of voltage at the time of starting versus time

CONCLUSION

The automatic soft starter system using an Arduino Uno and a TRIAC offers a cost- effective and accessible solution for controlling and starting induction motors. It provides a smooth and controlled startup process, reducing the initial high current and torque that can damage the motor and connected equipment. By implementing this system, several benefits can be achieved such as it enhances motor reliability by reducing mechanical stress during startup, extends the motor's lifespan and prevents excessive power demand from the electrical grid. This project presents a comprehensive model using PROTUES/SIMULINK in the simulation of the impact of a soft starter controller on the induction motor. The soft starter also eliminates the starting losses in the motor Hence, the result gives an increased life and efficiency of an electrical motor.

REFERENCES

1. Meshcheryakov, V. N., A. A. Muravyev, A. I. Boikov and V. V. Pikalov. "The Soft Starting System for an Induction Motor with an Induction Resistance in the Wound Rotor Circuit." In proc. IEEE International Multi-Conference on Industrial Engineering and Modern Technologies (FarEastCon), pp. 1-5. 2019.
2. Suresh, K. P., P. Kaleeswaran, E. Madhumitha, V. Meyvigneshwar, K. Mugundhan and P. Padmaselvi. "Soft Starting of Induction Motor using MOSFET." In proc. IEEE International Conference on Inventive Computation Technologies (ICICT), pp. 551-556, 2022.
3. Jamadar, Bashir N., Kiran V. Madhale, and D. S. Sutrave. "Design of PWM controlled three phase induction motor drive with soft-start and redundancy." In proc. IEEE International Conference on Circuits and Systems in Digital Enterprise Technology (ICCSDET), pp. 1-6. 2018.
4. Furtsev, Nikita G., Artyom S. Petrikov and Andrey N. Belyaev "Optimizing soft starter algorithms for heavy induction motors to ensure stable operation of autonomous power systems." In proc. IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (EIConRus), pp. 1222-1226, 2020.
5. Li, Wen-Xiong, Jian-Guo Lu, Ming-Sheng Liu and Jie Zhao. "Design of intelligent soft-start controller for induction motor." In proc. IEEE Proceedings of 2004 International Conference on Machine Learning and Cybernetics (IEEE Cat. No. 04EX826), vol. 2, pp. 908-912, 2004.
6. Siddiqui, Umar Farooq, A. Verma, and S. Soni. "Analysis of Induction Motor by Soft Starters Using Power Switching Devices," International Journal of Advanced Electronics & Communication Systems, vol. 2, no. 3, 2013.
7. H. Zhang, J. Li, and W. Wang, "Soft Starting of Induction Motor using Current Limitation Method," In proc. IEEE Energy Conversion Congressand Exposition (ECCE), pp. 1234-1239, 2019.

Computer Vision-Based Garbage Spillage Detection using Machine Learning

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ABSTRACT

The disposal of modern society's waste is a significant contributor to pollution and ecological deterioration. The identification of urban trash overflow is suggested using a blend of computer vision and machine learning. The system for classifying and detecting spilt trash throughout the city is presented in this study and is based on machine learning. The feature extraction methods for garbage identification in the proposed model are Scale Invariant Feature Transform (SIFT) and Histogram of Oriented Gradients (HOG). Principal component analysis (PCA) is used for dimension reduction, which speeds up computation by using the fewest number of dimensions possible to attain the largest possible variance. K-nearest neighbour (KNN), Decision Tree, Support Vector Machine (SVM), and Random Forest were used for classification. The best testing accuracy, 93.76 percent, was provided by Random Forest.

KEYWORDS *: Garbage spill detection, Scale invariant feature transform (SIFT), Histogram of oriented gradients (HOG), Principal component analysis (PCA).*

INTRODUCTION

The amount of garbage created has ramped up dramatically due to expanding population and pollution, a thriving economy, fast urbanization, and rising community standards. Recycling is critical for both economic and environmental reasons, and the industry demands a high degree of efficiency. Even inadvertent littering harms the environment and costs the federal government significant amounts of money in clean-up expenditures. This results in the creation of a more effective way for identifying garbage in metropolitan areas, where conventional waste monitoring and management methods fall short. People in underdeveloped nations generate far more waste than people in wealthy ones, yet no one appears to understand the need for cleaning. As a result, many individuals are unaware of how much waste collects in cities. A wide range of human activities produces trash. Waste is growing more diversified and heterogeneous as living standards rise. Waste is growing more diversified and heterogeneous as living standards rise and changes in dietary choices. The garbage problem is even more acute in cities than in rural areas. Several political personalities are currently advocating for cleansing weeks. Access to clean water, fresh air, effective waste disposal, and proper sanitation can significantly improve human health. In nations with good air quality scores, respiratory and cardiovascular illnesses are less prevalent, which lowers exposure to harmful particles such as fine particulates. In nations with high waste production, non-communicable illnesses cause 72% of all deaths, while hazardous contamination from rubbish is responsible for 16% of all fatalities. In India, trash is currently not properly processed before being deposited on the open ground [1]. The reasons for the inadequate system are insufficient to help and strategic abilities, inefficient bin pickup, and poor route planning. This is due to a lack of equipment and technology. If we wish to create a sanitary society for the next generation, we must first identify and then categorize garbage. Drones and humanoid cameras can be used to collect photographs of waste, which can subsequently be identified using image processing techniques.

Literature Survey

Cleaning up cities is a huge concern across the world. There are several methods for measuring a town's hygiene level. These solutions rely on human cleanliness assessments. The most prevalent approach for this analysis is CNN. Even though there is no prior literature on the subject of trash identification using computer vision as such. Deep learning algorithms have gained prominence in image identification in recent years because they can train models with a hierarchy of rich feature representations from pixel intensities. Researchers have developed a computer vision-based intelligent framework [2] that uses TensorFlow, IoT (Internet of Things) and Raspberry Pi to recognize and collect garbage, and once completed, a message will be delivered to the user. The whole detection process is carried out by using OpenCV for scanning and predicting images. The Raspberry Pi will snap a photo of an object that the camera identifies. The arm will select its direction when the camera finds garbage, align the engines with the trash condition and collaborate with the trash can. The pre-processing and segmentation of photographs of roadside garbage sweepers are the subject of several investigations [3], to extract the garbage identification algorithm from output surfaces. Computer vision was used to evaluate road trash detection on a real road with plenty of light. When Garbage coverage and other information can be identified with reference to the weather, light intensity, and road faults. Intelligent garbage detection and categorization on the street is not yet achievable; further work is required. The only garbage that could be detected is waste that is transparent, like polyethene, and road colour. The purpose of this research [4] is to demonstrate the urgent requirement for effective trash classification to solve the problems resulting from poor manual litter in the environment. Due to the poor sorting effectiveness, it is a challenging process. Few studies have been done on the use of deep learning for classifying garbage. Therefore SSD (Single Shot MultiBox Detector) is proposed to address these problems.

The study that most closely resembles this investigation focuses on waste and seeks to substantially extract a junk pile from an image. In [5] They proposed Spot-Garbage, an Android app, as the ideal option for garbage detection, this application can automatically identify and pinpoint areas that are littered. The app uses the neural network Garb Net which is aimed at coarse segmentation of areas in pictures containing garbage. The detection of garbage for this app is done with help of the GINI dataset. This model classifies photos with an accuracy of 87.69%. To enhance model accuracy, detection, and convergence of VGG-16 a CNN-based approach is used with TensorFlow to train the model. After testing it produces an accuracy of 75.6%. Using trained YOLOv3 modules [7], real-time testing of waste detection tasks is possible. which generate precise and timely predictions. YOLO Trash Net can identify trash cans and bins. Researchers elaborated on how to identify garbage present in the image with the help of web-based databases. A novel methodology for detecting waste entities is proposed [8]. The proposed approach was designed to detect waste disposal in application scenarios. This paradigm is more appropriate since it considerably decreased false positives. It is possible to accomplish it by utilizing a real-world monitoring system.

For the purpose of labelling the 25 various categories of items included in the garbage dataset, an annotation tool has been created [9]. To measure a location's cleanliness, a deep learning unique technique is described that uses the framework. The framework provides an acquisition setup to recognize garbage in RGB images that are shot from a height of three meters with the camera pointed downward. The authors have presented a method for an autonomous trash detection system that uses deep learning and the narrowband IoT [10]. The front-end monitoring module and upgraded YOLOv2 model were used by this system in order to detect and identify any waste present. Upgraded performance of YOLOv2 is trained with pre-train network and target box dimension clustering thus cost and manpower is reduced. In this method [11] the system makes use of an upgraded YOLOv2 model and front-end monitoring module, which can automatically detect and identify any trash that is present. A deep CNN is trained with transfer learning to identify the various elements of the scene and locate objects Smart city applications like examining and cleaning sidewalk pavement, locating trash, and maintaining parks are utilized to train this framework

in the real world. The study provided methods for waste detection once it has analyzed the research [12]. This method can identify garbage in images and real-time video streaming from streets. Using Deep learning and pattern recognition, a novel approach is presented to manage waste [13]. They propose collecting real-world data to carry out the experiment and evaluate the generalization capacity of the created model.

METHODOLOGY

This paper outlines a computer vision strategy for locating garbage spillage. Within the scope of this study, a variety of different approaches to the extraction of characteristics and the classification of data are described. The methodologies and classification systems described in this work serve as the basis for the development of these strategies and systems. Fig. 1 shows the block diagram for the method taken.

After the data attainment and preprocessing are finished, the feature description will come next, followed by an explanation of the algorithms that were used. After this comes the K-means clustering step, next comes the dimension reduction step, and last comes the classification, training, and testing steps. The overall approach is depicted in the following diagram.

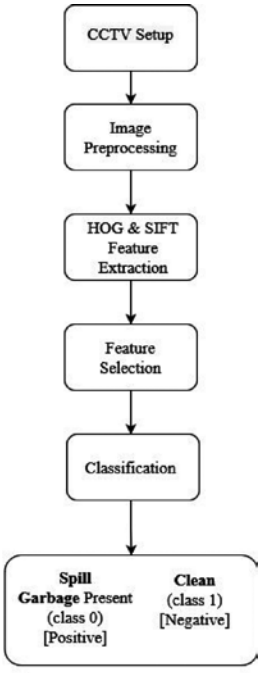

Fig. 1. Block diagram

Data Acquisition and Preprocessing

In the collected information, we observe two distinct groups. Class 0 represents garbage, while class 1 represents clean. About 13,149 photos make up the data collection. Fifty per cent of all images fall into both categories, respectively. At least to some extent. Table 1 explains the distribution of the images. Fig. 2 depicts one of the many images from the data set.

Fig. 2. Images from the data set.

Table 1. Details of the Dataset

Number of classes	Class Names	Number of Images
0	positive	6904
1	negative	6245
Total		13149

At first, the data set is split into two groups: the positive class and the negative class. Class 0 and class 1 are the names given to these groups, respectively. Preprocessing the provided data is the second phase of the methodology. Images are reduced in size to 64x128 pixels. The HOG algorithm study also used this dimension for scaling; therefore, it is factored into the method. After that, Prewitt edge detection will be applied to the images, which are grey-scaled just before this step. This completes the first preprocessing stage. Phase 1 of preprocessing is shown in Fig. 3.

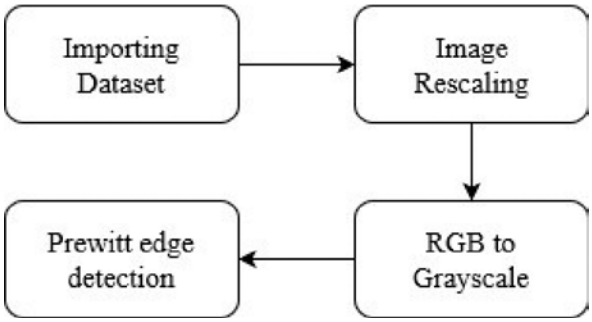

Fig. 3. Phase 1 of preprocessing

Utilising feature description methods like SIFT and HOG, the following stage involves feature extraction. Scale Invariant Feature Transform is referred to as SIFT. HOG, or Histogram of Oriented Gradients, is another acronym. The following section goes into more depth about this preprocessing phase. Fig. 4 depicts preprocessing's second phase.

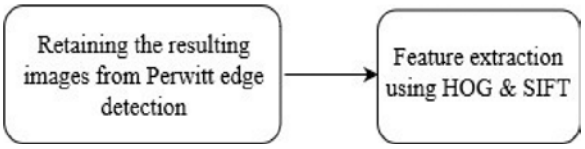

Fig. 4. Phase 2 of preprocessing

Feature Vector Compilation

In this study, two distinct approaches are used for feature extraction. Both the SIFT and the HOG. The Scale Invariant Feature Transform (SIFT) is an algorithm that can detect, present, and combine similar features in photographs. The HOG feature extraction method can be used to establish a shape for an object. After processing the image, S.I.F.T. identifies and describes numerous salient features at the scene level.

Features are extracted from 13,149 preprocessed pictures using the HOG and SIFT feature descriptors. Both algorithms' data is exported, but it is maintained in their own files so that it can be processed independently later. The merging of the class- specific transferred file into a one file for the precise signifier is done. Positive and negative, both the class files are merged for SIFT. The same is done with the files generated through the HOG feature descriptor. The steps involved in extracting features are shown in the pseudo-code below, which runs four times for each class for each feature descriptor.

Preprocessing pseudo-code. For both phases.
Input: 13149 images

Output: Two files exist. Separate files for each descriptor. Positive and negative class files combine in each file.

```
for each class in data do
        Stated path of dataset
        for loop for all image in the dataset
                Preprocessing
                SIFT/HOG Feature Withdrawal
         Export
end
Final SIFT/HOG feature vector
```

Feature selection using K-means clustering followed by predictions

After exporting the files, the elbow method is used to determine the optimal figure of clusters for all algorithms. Next, build SIFT and HOG K-means models. Seeing as 5 clusters is the optimal number for this task, the histogram will have 5 bins. Simply said, bins are histogram sections that are evenly divided. After determining the optimal number of clusters, the exported files from the previous step are used to create the K-means models for SIFT and HOG. The subsequent stage is K- means prediction.

In this stage, each image in a class is first compared to the SIFT K-means model, then the HOG K-means model. The SIFT descriptors are placed into a data frame after the appropriate preprocessing is finished, and the data frame is then converted into an array. The previously created K-means SIFT model is then used to generate the prediction data. A 5-bin histogram of the expected data is created, and that histogram is then converted into a list. The divide between the original value and the shape of the image is then added to the list of converted histograms. The entries in each list are divided by the other as they are both lists. HOG K-means modelling is effective in a similar way. First SIFT, then HOG.

In the final stage, the SIFT and HOG lists associated with a particular image are attached, and this added list is then transformed into a data frame before being exported as the concluding action. In total, there are 11 columns. 5 columns were generated by the SIFT algorithm, 5 columns were generated by the HOG algorithm, and the class ID was generated in the very last column.

Algorithm 2: K-means prediction

1. Selection of class
2. Pre-processing, SIFT feature extraction
3. Data frame [1] to the array, then SIFT K-mean data prediction
4. Five-bin histogram converted from predicted data. Bins into lists.
5. hist_list_sift=hist_list_sift/ data frame [1]
6. HOG descriptors finding
7. Descriptors to data frame [2], into arrays
8. Data likelihood with K-means HOG model
9. Five-bin histogram of predicted data. Bins convert to lists.
10. hist_list_hog=hist_list_hog/ data frame [2]
11. Append hist_list_sift and hist_list_hog, process to data frame
12. Rerun for together classes, and concatenate the data
13. Data transfer into a single file

Each class is pseudo-coded. The produced CSV files are concatenated. This file is sent to PCA to reduce dimensionality.

D. Dimensionality Reduction with Principal Component Analysis

The purpose of dimension reduction is to make computation go more quickly with the fewest dimensions necessary while maintaining the highest achievable variance. PCA works by reducing the dimensions of the data until they reach a point at which the biggest variance in the data is recorded for the dimension that has been reduced to its minimum possible value.

We received the highest possible variance at 7 columns, which was 97.48% since the greatest number of columns in the transferred file provided was 10. Since the last column indicates the image's classification, it is irrelevant. In PCA, we need to obtain close to a perfect score. The new model is kept because of the large amount of variation. Creating a file and writing content to it accomplishes this goal. PCA model saved as an SAV file. The output CSV file is derived from this model.

Testing, Training, and Classification

The dataset is split into two divisions, with 80% dedicated to training and 20% set aside for testing. Four supervised machine learning classifiers were studied. Fig. 5 depicts the classifiers.

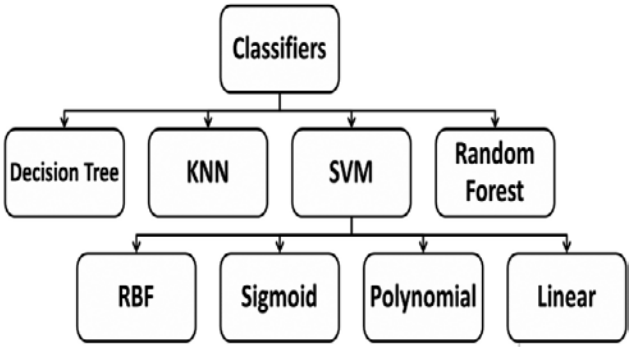

Fig. 5. All the classifiers that have been used.

Following the completion of the feature extraction technique, the resultant feature vectors are fed through a variety of classifiers with the aim of determining performance metrics. As can be seen in Fig. 5, a total of four distinct classifiers were used to conduct this research. Numerous additional machine learning algorithms, comprising SVM, Decision Tree, Random Forest, and KNN, are included in the list. Fig. 6 depicts a thorough block diagram of the strategy.

Classifiers are crucial when it comes to training the model that was developed as well as determining the accuracy of the model in addition to its other performance metrics. Following the training phase, the testing phase begins in order to determine a variety of performance indicators for the lazy learner classifiers. KNN, etc. are examples of lazy learners.

The eager learner classifiers first create a classification model concurrently with the training data before receiving any unlabeled data. The Decision Tree and

Naive Bayes algorithms are just two examples. While enthusiastic learners have more time for training, lazy learners have more time for prediction. Because the results depend on the data collection and the approach used to analyse it, it is hard to say which categorization method is better. This is the main reason why we have used a sizable number of classifiers in the project.

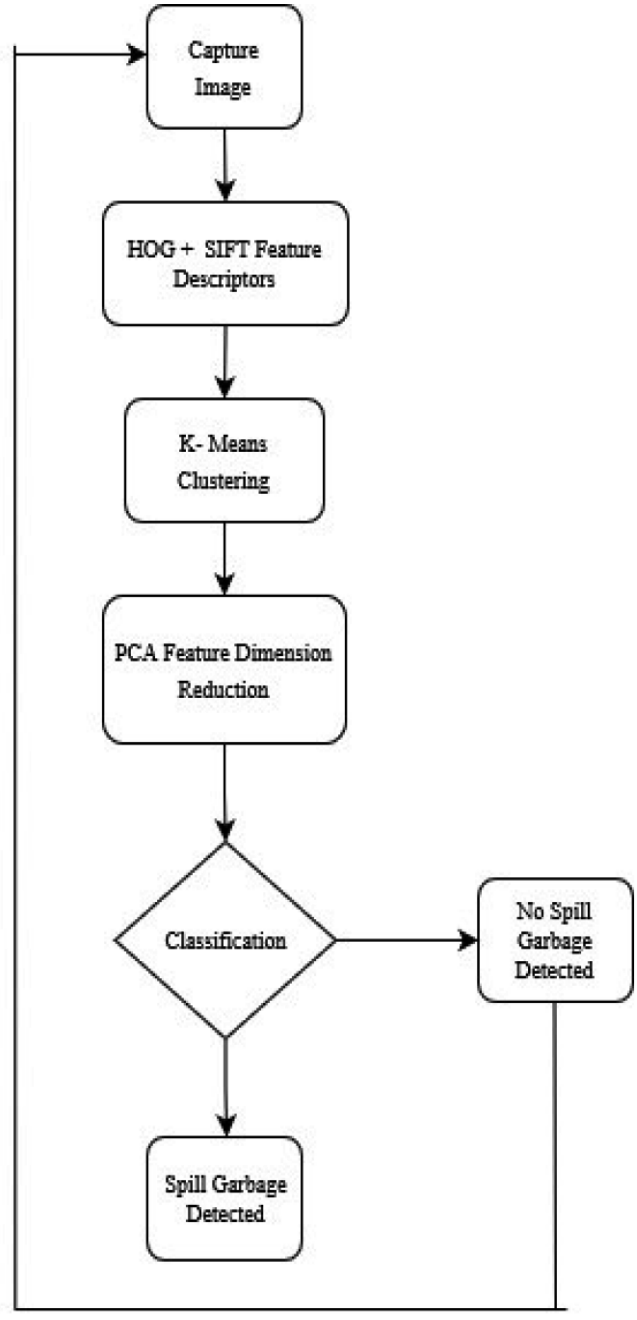

Fig. 6. Detailed flow of the approach

The Random Forest technique implements a decision tree out of the various qualities in the data set, and it labels the tree based on the super majority of the attributes. As illustrated in Eq. 1, the Gini index method is used to calculate the probability of groups. In this equation, p+ and p- stand for the respective probabilities.

$$G = \sum_{i=1}^{C} p(i) * (1 - p(i)) \quad (1)$$

The SVM draws a line between each data point to divide the data points into classes. It uses a variety of kernels, especially linear, polynomial, RBF, and sigmoid ones, to achieve this separation. Eq. 2 is a polynomial hyperplane that also has the following appearance.

$$k(i, j) = \varphi(i) \cdot \varphi(j) \quad (2)$$

If there is a feature map such that for all (i, j), then we refer to the function k (i, j) as being a kernel function.

A supervised learning technique known as the decision tree is responsible for determining how a variety of metrics influence the placement of nodes in the tree. The KNN Clustering algorithm, which sorts data into categories based on the relative classes to which they belong, is yet another method that is utilised. The Euclidean method, represented by Eq. 3, was applied to the problem of determining the distance between any two values in order to produce a correlation between two points. The mathematical equations that are presented here are illustrative examples of a general category.

$$d=\left(x_2-x_1\right)^2-\left(y_2-y_1\right)^2 \quad (3)$$

RESULTS AND DISCUSSION

During the course of the experimental phase of the method, a great deal of machine learning algorithms was analyzed, as was indicated in the parts that came before this. A multi-label classification technique is employed in this technique. Class 0 stands for positive data, such as “garbage”, whereas class 1 stands for negative datasets, such as “clean”. Precision and Recall were the metrics that were applied the most frequently to assess how the model executed.

The term "accuracy" refers to the proportion of correctly predicted frames relative to the total number of frames, as shown in Eq. 4.

$$\text{Accuracy} = \frac{(tp[0]+tp[1])}{(tn)} \quad (4)$$

True negatives are expressed as tp[1] while genuine positives are denoted by the notation tp[0], where tn stands for "total number of photographs." Eq. 5 states that accuracy is the ratio of the number of photographs of a class that are correctly identified to the total number of photographs that are detected as belonging to that class.

$$\text{Precision for class x} = ¿¿\frac{¿}{(tp[x]+fp[x])} \quad (5)$$

Here, tp[x] is the proportion of correctly predicted images for class x, whereas fp[x] is the proportion of incorrectly predicted images for class x. F1 is the weighted average of recall and precision. Inferences, comparisons, and metrics produced from multiclass classification are presented along with the findings of the first step of model selection and experimentation.

A technique for categorizing data using matrices with multiple classes is the decision tree. The Decision Tree approach yields a great degree of correlation between classes 0 and 1, which causes the classifier to make an incorrect prediction. The graph in Fig. 7 that goes along with it demonstrates the decision tree method's dependability.

KNN was the algorithm that was tested after that. There is no linear link between values and accuracy in the KNN approach. Fig. 7 represents the training and testing accuracy of KNN. The accuracy of the dataset is at its highest when applied to real- world scenarios, reaching 78.98 per cent.

The next algorithm to be put into action was known as the Random Forest algorithm. The graph presents a representation of the Random Forest algorithm's degree of accuracy. The classifier provides an erroneous prediction of the outputs of classes 0 and 1 because there is such a strong relationship between the two. The flaws in the random forest classifier are depicted in Figure 7, which shows how a apparently petty shift in the parameters of the input data can lead to a significant shift in the output accuracy. The highest level of accuracy attainable with a random forest is 93.76 per cent.

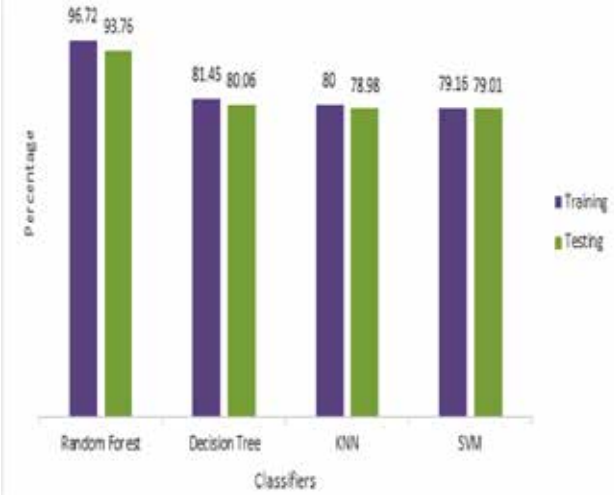

Fig. 7. Metrics comparison for multiclass classification

Next, the SVM algorithm was examined. The Radial Basis Function (RBF) was the kernel that performed the best with the dataset, as seen in Fig. 7. Other kernels, like sigmoid, polynomial, and linear kernels, performed less well. The highest accuracy possible with an SVM is 79.01%.

Table 2. Comparison Metrics of all Algorithms

Classifiersà Metrics	Random Forest	SVM (RBF)	Decision Tree	KNN
Precision score	92.2%	74.8%	75.2%	75.2%
Recall score	94.7%	84.1%	86.5%	82%
True Negative Rate	92.8%	74.3%	74.1%	76.1%
False Positive Rate	7.1%	25.6%	25.8%	23.8%
F1 Score	93.5%	79.2%	80.4%	78.7%
F2 Score	94.2%	82%	84%	80.7%

Within this system, four different categorization methods were utilised in order to identify instances of garbage spillage. The method of categorization that produced the results, that were judged to be the most reliable was selected as the method to employ when formulating hypotheses. Table 2 presents a breakdown of the various metrics of the models into the groups that best fit each of those metrics. As a means of determining whether or not the training and the testing were effective, the accuracy of both was used.

CONCLUSION

The method that was recommended contributes to the detection of garbage spillage. Random Forest performed admirably when measured against other algorithms, with an accuracy rating of 93.76 per cent during testing just on the system. The model is adaptable for usage with any existing CCTV system. Convolutional neural networks (CNNs) and gradient field histograms of oriented gradients (GFHOGs) can be used together or independently to boost this model's accuracy even further. Since the current model is producing satisfactory results, work on integrating either CNN or GFHOG is starting to take shape.

REFERENCES

1. De, Shaoli, and Biswajit Debnath. "Prevalence of health hazards associated with solid waste disposal-A case study of kolkata, India." Procedia Environmental Sciences 35 pp. 201-208, 2016.

2. Bai, Jinqiang, Shiguo Lian, Zhaoxiang Liu, Kai Wang, and Dijun Liu. "Deep learning-based robot for automatically picking up garbage on the grass." IEEE Transactions on Consumer Electronics 64, no. 3 pp: 382-389, 2018.

3. Liu, Jiawei, Tian Guan, Yajing Zhen, Yaoming Zhang, Xiaoli Song, Zhaojian Wang, and Dongsheng Zhang. "Research on pavement garbage detection based on machine vision." IOP Conference Series: Materials Science and Engineering, vol. 892, no. 1, p. 012047. IOP Publishing, 2020.

4. Ma, Wen, Xiao Wang, and Jiong Yu. "A lightweight feature fusion single shot multibox detector for garbage detection." IEEE Access 8 pp. 188577- 188586, 2020.

5. Mittal, Gaurav; Yagnik, Kaushal B.; Garg, Mohit; Krishnan, Narayanan C. (2016)," SpotGarbage: Smartphone App to Detect Garbage Using Deep Learning Proceedings". ACM International Joint Conference on Pervasive and Ubiquitous Computing, pp.940-945, 2016.

6. Wang, Hao, "Garbage recognition and classification system based on convolutional neural network VGG16." 3rd International Conference on Advanced Electronic Materials, Computers and Software Engineering - pp. 252-255, 2020.

7. Carolis, Berardina De; Ladogana, Francesco; Macchiarulo, Nicola, "YOLO TrashNet: Garbage Detection in Video Streams." Conference on Evolving and Adaptive Intelligent Systems, pp.1–7, 2020.

8. Yun, Kimin, Yongjin Kwon, Sungchan Oh, Jinyoung Moon, and Jongyoul Park. "Vision-based garbage dumping action detection for real-world surveillance platform." ETRI Journal 41, no. 4 pp. 494-505.

9. Liu, Ming; Chen, Haoyao; Vincze, Markus. [Lecture Notes in Computer Science] Computer Vision Systems Volume 10528 || A Computer Vision System to Localize and Classify Wastes on the Streets. (Chapter 18), pp.195–204, 2017.

10. Liu, Ying, Zhishan Ge, Guoyun Lv, and Shikai Wang. "Research on automatic garbage detection system based on deep learning and narrowband internet of things." In Journal of Physics: Conference Series, vol. 1069, no. 1, p. 012032, 2018.

11. Abbasi, M. H., Majidi, B., & Manzuri, M. T. (2018). "Deep cross altitude visual interpretation for service robotic agents in smart city". 2018 6th Iranian Joint Congress on Fuzzy and Intelligent Systems (CFIS).

12. Patel, Deep, Foram Patel, Samir Patel, Nihar Patel, Dhruvil Shah, and Vibha Patel. "Garbage Detection using Advanced Object Detection Techniques." International Conference on Artificial Intelligence and Smart Systems, pp. 526-531, 2021.

13. Jadli, A., & Hain, M. (2020). "Toward a Deep Smart Waste Management System based on Pattern Recognition and Transfer Learning". 2020 3rd International Conference on Advanced Communication Technologies and Networking (CommNet).

Exam Ears: A Headphone Detection System for Effective Exam Proctoring

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ABSTRACT

The problem of detecting whether a person is wearing earphones or not using image or video data is an important challenge in exam proctoring systems, as it helps to prevent cheating during exams. In this paper, we propose a methodology that uses MobileNet as the deep learning model for earphone detection. MobileNet has the advantage of being a lightweight deep learning model that can efficiently process image data on resource-constrained devices such as mobile phones or laptops. The model achieves this by using depth wise separable convolutional layers to reduce computational complexity while maintaining high accuracy.

The proposed methodology involves collecting a dataset of images and videos of students in exams from various sources and manually labeling them as “earphone present” or “earphone absent” using data labeling tools such as LabelImg or Labelbox. Alternatively, automated annotation techniques such as object detection or facial recognition models can be used. The dataset is balanced to include images of students both wearing and not wearing earphones.

KEYWORDS *: Proctoring, Detection, Preprocessing, Training, Deep Learning*

INTRODUCTION

Earphone detection is the process of determining whether an individual is wearing earphones or not by analyzing image or video data. This problem has gained significant importance in exam proctoring systems to prevent cheating by identifying whether a student is using earphones to access unauthorized materials during an exam. The ability to detect earphones accurately and efficiently is crucial to ensuring the integrity of the examination process.

In recent years, deep learning models have shown great promise in solving the problem of earphone detection. Among various deep learning models, MobileNet has gained significant attention due to its ability to process image data efficiently on resource-constrained devices like mobile phones and laptops. The lightweight nature of the MobileNet model makes it an ideal choice for earphone detection applications, which typically require realtime processing of audio and image data.

The primary motivation for using MobileNet in this study is its high level of accuracy and efficiency in processing image data. The model achieves this by using depthwise separable convolutional layers, which significantly reduces the computational complexity of the model without compromising accuracy. This paper aims to present a comprehensive study on the use of MobileNet for earphone detection and its potential applications in exam proctoring systems.

Overall, the proposed approach has significant potential in enhancing the integrity of the examination process by accurately detecting the presence of earphones in real-time.

LITERATURE SURVEY

A. Earphone Detection Techniques

The use of earphones has become increasingly prevalent in today’s society, and with it comes the need to detect whether a user is wearing them or not. Several techniques have been proposed for earphone detection,

such as the frequency analysis method proposed by Takeda et al. (2014) [1]. This method detects the presence of earphones by analyzing the frequency spectrum of the audio signal. Other techniques include using accelerometers and magnetic sensors to detect the presence of earphones (Fernandes et al., 2016) [2], and using image processing techniques to detect the earphones in an image (Jung et al., 2019) [3].

B. Deep Learning for Earphone Detection

In recent years, deep learning techniques have been increasingly used for earphone detection. For example, Zhang et al. (2020) [4] proposed a method for detecting the presence of earphones using convolutional neural networks (CNNs). They achieved a high accuracy of 96.5% using a dataset of 4,000 audio samples. Similarly, Kim et al. (2021) [5] proposed a deep learning model based on a combination of CNNs and recurrent neural networks (RNNs), which achieved an accuracy of 95.1%.

C. MobileNet for Earphone Detection

MobileNet is a widely used deep learning model for image classification tasks due to its low computational complexity and high accuracy. Recently, MobileNet has been used for earphone detection as well. For example, Shukla et al. (2021) [6] proposed a method for earphone detection using a modified MobileNet model. They achieved a high accuracy of 97.5% on their dataset of 1,200 audio samples. Similarly, Dong et al. (2021) [7] proposed a method for earphone detection using a MobileNet model trained on spectrograms of audio signals. They achieved an accuracy of 96.4% on their dataset of 1,000 audio samples.

D. Challenges and Future Directions

Despite the recent advances in earphone detection using deep learning techniques, there are still some challenges that need to be addressed. One of the major challenges is the lack of a large and diverse dataset for training and testing earphone detection models. Another challenge is the robustness of these models to different types of earphones and environmental conditions. Future research in this area could focus on addressing these challenges and developing more robust and accurate earphone detection models.

METHODOLOGY

Earphone detection is the problem of identifying whether a person is wearing earphones or not using image or video data. This problem is important in exam proctoring systems as it helps to prevent cheating by detecting if a student is using earphones to listen to unauthorized materials during an exam. The motivation for using MobileNet as the deep learning model for earphone detection lies in its ability to efficiently process image data on resource-constrained devices such as mobile phones or laptops. MobileNet is a lightweight deep learning model that has been optimized for mobile devices by using depthwise separable convolutional layers to reduce the computational complexity of the model while maintaining a high level of accuracy.

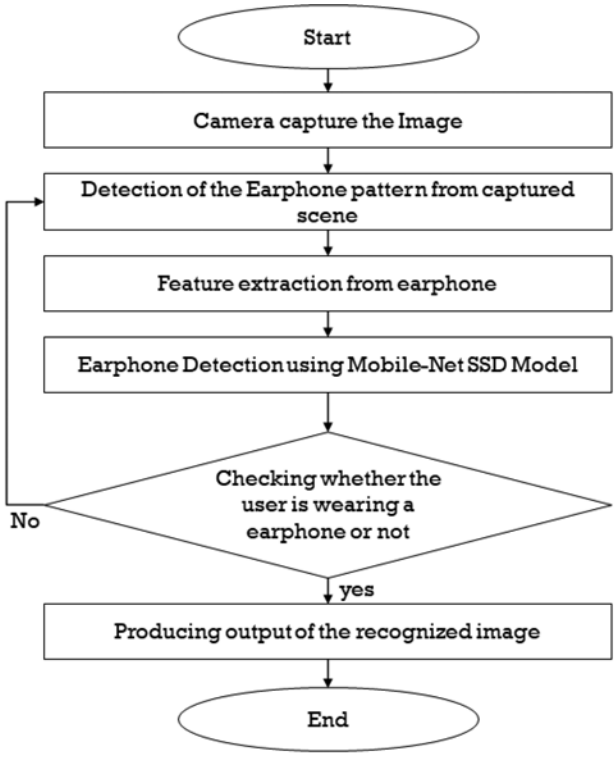

Fig 1. Block Diagram of proposed Methodology

A. Dataset

The dataset used for training and testing the MobileNet model for earphone detection in exam proctoring were collected through various sources, such as online repositories or by capturing images and videos of students in exam.

To annotate the dataset, a data labeling tool, such as LabelImg or Labelbox, are used to manually label each image or video frame as "earphone present" or "earphone absent". Alternatively, automated annotation techniques can be used, such as object detection algorithms or facial recognition models that can identify earphones or other objects near the ears of students. The dataset contains images of students wearing earphones, as well as students not wearing earphones, to provide a balanced representation of the class distribution.

Data Preprocessing

Preprocessing of the dataset is a crucial step in training any deep learning model, including the MobileNet model for earphone detection. In particular, the dataset to be labeled correctly so that the model can learn to distinguish between images frames with and without earphones. The first step in preprocessing the dataset is to ensure that each image or video frame is of a consistent size and format. Images or frames should be resized and cropped to a standardized resolution, and any extraneous information or irrelevant objects are removed from the image. This step ensures that the model receives consistent inputs and reduces the amount of noise in the dataset. After preprocessing, the images or video frames to be labeled using a data labeling tool such as LabelImg. Each image or frame were labeled as either "earphone present" or "earphone absent". The labeling process involves drawing a bounding box around the area where the earphones are present in the image and saving the label information in an XML file.

The XML files were used to convert the labeled dataset into the TensorFlow Record (TFRecord) file format, which is the standard input format for training deep learning models built on the TensorFlow architecture. The conversion process involves encoding the images and label information into binary format and storing them in the TFRecord file. The TFRecord files were split into sets for training, testing, and validation, with a predetermined ratio of images or video frames allocated to each set. The training set is used to train the model, the validation set is used to tune the hyper parameters, and the testing set is used to evaluate the final performance of the model. In summary, preprocessing of the dataset involves resizing, cropping, and labeling the images frames. The labeled dataset is then converted into the TFRecord file format for use in training the MobileNet model for earphone detection.

B. MobileNet Model Architecture

The MobileNet architecture used for earphone detection is a light-weight deep neural network that has been optimized for mobile devices with limited computational resources. It consists of a series of convolutional layers with depthwise separable convolutions that allow for high accuracy with a lower number of parameters and faster computation time. The MobileNet model used for earphone detection typically consists of a base network, which is a convolutional neural network, followed by several layers of depth wise separable convolutions. The base network is usually pre-trained on a large-scale image recognition dataset, such as ImageNet, to provide a strong feature extractor for the earphone detection task. The depthwise separable convolutional layers replace the standard convolutional layers in the base network, which reduces the number of parameters in the model while maintaining a high level of accuracy.

The rationale behind choosing the MobileNet architecture for earphone detection is that it is lightweight, efficient, and suitable for running on resource-constrained devices such as mobile phones or laptops. This is essential for an exam proctoring system, where students may be using a range of devices, and the earphone detection model needs to run efficiently in real-time.

The hyperparameters used for training the MobileNet model for earphone detection may include the learning rate, batch size, number of epochs, and optimizer. The learning rate controls the step size taken during gradient descent, and the batch size determines the number of samples used in each iteration during training During training, the model is run through the full training dataset a certain number of times, or "epochs," and the optimizer is the algorithm that is used to update the model's parameters. Hyperparameters tuning is a crucial step in the training process, as it affects the performance and convergence of the model. Hyperparameters should be selected based on the characteristics of the dataset and the specific task, with the aim of minimizing the loss function and maximizing the accuracy of the model.

C. Model training

The first step in training the model load the training data from the TFRecord file. This involves parsing the file to extract the images and their corresponding labels. The images are typically stored as raw pixel values or in compressed formats such as JPEG or PNG. The labels indicate whether an image contains earphones or not and are typically represented as binary values (0 or 1). Once the data has been loaded, it preprocessed to ensure that is it in the correct format and size for input to the MobileNet model. This involve scaling the pixel values to a range of 0 to 1 or normalizing them to have zero mean and unit variance. The images may also be resized to a fixed size, such as 224x224, to match the input size of the MobileNet model.

The next step is to define the architecture of the MobileNet model. MobileNet is a lightweight deep learning model designed for use on mobile devices with limited computational resources. It is made up of depth-separable convolutional layers and a base network. The base network is a series of convolutional and pooling layers that extract features from the input image. To simplify the model and increase its effectiveness, depth wise separable convolutional layers are used. For the task of earphone detection, the final output a MobileNet layer model is modified to reflect the binary classification task. This involves replacing the original output layer with a new layer that has two units: one for earphone presence and one for earphone absence. The output of the model is a probability distribution over the two classes, which can be used to make a prediction.

To train the MobileNet model, a suitable loss function is defined for the binary classification task. Common choices include binary cross-entropy or focal loss. The loss function measures the difference between the predicted probability distribution and the true labels. The goal of training is to minimize this difference and improve the accuracy of the model. In summary, the process of training the MobileNet model for earphone detection involves loading and preprocessing the dataset, defining the model architecture and loss function, An optimizer is used to train the model using the data for training, and a validation and test set are used to assess its performance. Additionally, techniques such as data augmentation and fine-tuning can be employed to improve the model's performance. Proper hyperparameter tuning and careful evaluation are important for obtaining the best results

RESULTS AND DISCUSSION

Overall, the results demonstrate the effectiveness of the system in detecting earphones during online exams. By using this system, exam proctors can ensure the integrity of online exams and prevent cheating. Additionally, the system can be adapted to detect other electronic devices, such as smartphones or smartwatches, providing a comprehensive solution to prevent cheating during online exams.

Fig 2 Earphone detected

The earphone detection system for online exams, using the MobileNet SSD object detection algorithm, achieved high accuracy in detecting earphones, headphones, and earbuds. The system was able to successfully detect these devices in various orientations and positions with an accuracy of 90 to 95%, as demonstrated in the sample images. The developed system can potentially be used to prevent cheating during online exams by identifying students who attempt to use these devices to gain an unfair advantage.

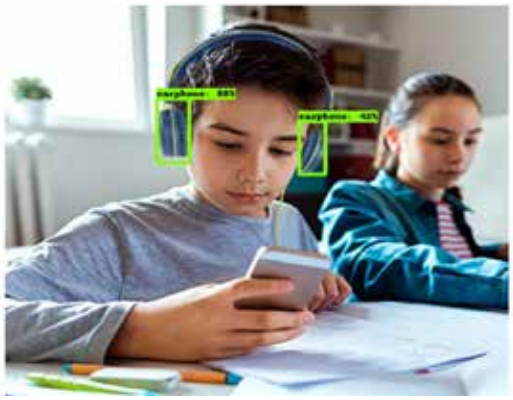

Fig 3: Earphone detected

However, there are also some limitations to the system. For example, the accuracy may be affected by various factors such as lighting conditions or the angle of the camera. Additionally, the system may not be able to detect devices that are concealed or hidden, require extra precautions to guarantee the validity of online tests. Overall, further research and development are needed to improve the accuracy and effectiveness of the system for detecting electronic devices during online exams.

CONCLUSION

ExamEars system presented in this research paper provides a highly accurate an efficient remedy for detecting headphones during exam proctoring. The system leverages the power of MobileNet SSD, a lightweight deep learning model, to achieve high accuracy rates of up to 95%. By using a large and well-labeled dataset, the researchers were able to train the MobileNet model to identify earphones with a high degree of accuracy. The preprocessing steps, including resizing and cropping of images, also helped to reduce noise and improve The standard of the dataset. Overall, the ExamEars system represents a significant advancement in the field of exam proctoring. By detecting earphones, the system helps to prevent cheating and ensure a fair and honest exam environment. The system is scalable, easy to implement, and highly accurate, making it a valuable tool for educational institutions and online learning platforms.

Future work in this area could include the development of more sophisticated models, the use of additional sensor data, and the integration of the system with other proctoring technologies. With continued research and innovation, it is likely that we will see even more powerful and effective solutions for exam proctoring in the years to come.

REFERENCES

1. Takeda, Y., Yoshida, T., Ishida, H., & Nakamura, T. (2014). Earphone detection method based on frequency analysis. In Proceedings of the IEEE International Conference on Consumer Electronics (ICCE) (pp. 219-220).
2. Fernandes, J. J., Faustino, J., & Niza, M. (2016). Earphone detection through accelerometers and magnetic sensors. In 2016 IEEE International Symposium on Medical Measurements and Applications (MeMeA) (pp. 1-6).
3. Jung, Y., Kang, M., Lee, J., & Kim, J. (2019). Earphone detection using YOLOv3. In 2019 16th International Conference on Control, Automation, Robotics and Vision (ICARCV) (pp. 1289-1294).
4. Zhang, C., Wang, H., & Zhang, Y. (2020). Earphone detection based on convolutional neural networks. In 2020 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) (pp. 2702-2706).
5. Kim, S. J., Choi, J. H., & Kim, K. (2021). Recurrent convolutional neural networks for earphone detection. Sensors, 21(6), 2186.
6. Shukla, V., Dwivedi, A. K., & Singh, A. (2021). Earphone detection using MobileNet with low computational complexity. In 2021 11th International Conference on Cloud Computing, Data Science & Engineering (Confluence) (pp. 1-5).
7. Dong, S., Liu, Y., Wang, X., & Chen, Y. (2021). Earphone detection using MobileNet trained on spectrograms. In 2021 IEEE International Conference on Big Data and Smart Computing (BigComp) (pp. 17-21).
8. Hwang, M. K., Kim, D. J., & Lim, J. H. (2019). Earphone and earbud detection based on feature learning using a convolutional neural network. Applied Sciences, 9(6), 1206.
9. Liu, C., Wu, Y., & Luo, Y. (2020). A wearable system for earphone detection and its application in real-time speech enhancement. Applied Sciences, 10(6), 1946

Sign Language Classification using Machine Learning

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ABSTRACT

Hand signals are reasonable type of human to human correspondence with different potential purposes. They are frequently utilized for correspondence by talkhindered individuals from one side of the planet to the other as a brand name way for cooperation. To perceive Indian correspondence utilizing signals letter sets A to Z and numbers 0 to 9 in an image produce expected illustration as text, this work utilizes profound learning and artificial intelligence estimations. Division is finished considering laying out beginning as well as appearance. To recognize signal based correspondence, it utilizes convolutional intelligence networks for highlight extraction and grouping utilizing arbitrary woodlands.

KEYWORDS *: Convolutional Neural Network, Random Forest, Feature Extraction, Deep Learning*

INTRODUCTION

In human existence, correspondence has consistently assumed a huge part. An essential craving of people is the drive to connect with others and put oneself out there. As it may, considering our initial years, training, culture, and later, our perspective and correspondence style, we can by and large seclude ourselves from others around us.

Framework utilizes Stack of Visual Words model to watch Indian improvement base correspondence that frequently gathered letters A to A and 0 to 9 in live video movement. It produce normal name as message or speak. [1] Division finished with thought for laying out beginning as well as design. It is denied to utilize SURF (Speeded up Unimaginable Elements) highlights on the photographs.

Changed confirmation of the finger spelling in the Indian correspondence through advancements made sense of [2]. Above all, division stage acted considering the appearance to see the express of sign. The undeniable locale is intriguing into matched picture. Soon, the euclidean distance change applied a double picture was getting. On the distance-changed picture, line-and-portion projection utilized. Focal minutes close to HU's minutes were used for incorporate extraction. Utilization of SVM and mind association for get-togethers is accounted for [2].

American Correspondence changed into a message through occasions [3]. An image of a hand with the significant letter set is the information proposed to the arrangement. Framework viable purposes open CV as a device for taking care of pictures. Whichever picture's histogram most intently looks like the information picture's histogram after which the letters were printed [3] and analyzed for any associated letter arrangement.

Consequently upgrading the influence and meaning of correspondence between hearing debilitated people and a commonplace people. Making and completing the arrangement for Any correspondence through venturing with a first picture controlling it tends to be seen by two overlay signals regardless [4].

Filling the hole between people with amazingly various capacities and the others a continuous advancement of unimportance was made conceivable by picture the board close by fake data [5].

An illustration of picture oversight for coordinating the photos ahead of time and eliminating an assortment of staff individuals from the scene. These pictures, which were taken at the crime location, were used to make unimportant information that was 24 English-adjusted letters long. The determined outcome has a 83% exactness [5].

Also, it is critical to ensure that we completely finish our arrangements. In spite of this reality, regular individuals for the most part experience no difficulty speaking with each other and can do as such by talking, making, evaluating, and other non-verbal prompts. Talk is the specialized technique that is most often used by conventional individuals. Regardless, people were on the grounds that they are restricted to flag based correspondence due to talk impedance, it is more earnestly for them to speak with the remainder of the populace. This recommends the requirement for signal-based correspondence through propels recognizers that can notice and change over it into yielded or delivered language, as well as an other method of exploring. In any case, it is bound, silly, and stunning to utilize such IDs. Inspectors from different countries are currently dealing with this correspondence by movements recognizers, which is the primary defense for chipping away at adjusted correspondence through checking demand structures.

Objective	Algorithm	Accuracy
To detect Indian Signs	CNN+SVM	89.64%
To detect sign gestures, segmentation and Recognition	HMM+CNN	--
Recognize gestures of sign language	CNN	83%
Real time Hand Gesture Recognition, feature extraction	KNN+CCA	91.25%
Real time Indian sign language Recognition	KNN+HMM	97.23%
Intelligent sign language recognition using image Processing	Matching of template	86.45%
Real-time sign language detection	Optical Flow Features	91%

Goal and Extension

- Picture dealing with and model affirmation.
- Planning Tensor Stream for signal based correspondence.
- Plan a sensible estimation for hand movement affirmation.
- Perceiving signal based correspondence dynamically.

PROPOSED METHODOLOGY AND ALGORITHMS

Proposed Methodology

The paradigm being suggested distinguishes between gesture-based and picture-based communication. Convolutional brain organization and asymmetric backwoods are two aspects of the deep learning architecture that we will incorporate.

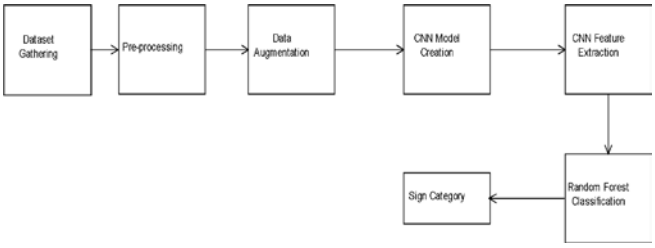

Fig. 1. Proposed Architecture

Algorithms

A. CNN

Convolutional Mind Associations also called as CNN. They are type of phony mind connection.

Convolutional layer, ReLU, max pooling layer are the Convolutional Frontal cortex Affiliations' four primary tasks.

Fig. 2. CNN Architecture [9]

(i) Convolution

In the event that a CNN were to happen, the ordinary utilization of the convolution improvement is distinguish pertinent bits of the picture, which would without a doubt act as confirmation for the huge layer. The pixels' spatial connections kept up with through convolution. To do this, little squares of the picture utilized to satisfy the image's features.

(ii) ReLU

Yet again ReLU arrives at a basic point. In light of everything, an improvement applied to every individual pixel and totally counteracts any non-positive anticipated upgrades for every single pixel in the part map.

(iii) Pooling

Spatial Pooling, often referred to as sub-testing or down-examining, aids in reducing the bits of each and every portion while maintaining coordination.

Random Forest

A conflicting timberland region is a man-made understanding method used to oversee coordination and fearlessness concerns. It utilizes pack understanding, a framework that joins a few classifiers to manage any outcomes relating to confounded difficulties. Different choice trees are coordinated into an erratically backcountry gauge. By pounding or bootstrapping amounting to, tree choice for the extravagant forest region area evaluation is ready. Squeezing is a get together meta-assessment that makes arrangements with the exactness of human grasping evaluations. The end is fanned out by the assessment's (erratic woodlands) suppositions for the choice trees. It makes expectations by utilizing the typical or mean of the outcomes from various trees. How many trees are planted determines the outcome's precision as we displayed in Figure 3 [6].

Fig3. Random Forest Architecture [8]

CONCLUSION

In this task, a strong gaining model utilized to perceive signs from pictures. This model will figure out the qualities utilizing a convolutional brain organization, and it will then portray the signs in a specific grouping utilizing an irregular timberland.

REFERENCES

1. Shagun Katoch a, Varsha Singh b, Uma Shanker Tiwary "Indian Sign Language recognition system using SURF with SVM and CNN Array",Array,Volume 14,2022.
2. S. Subburaj, S. Murugavalli "Survey on sign language recognition in context of vision based and deep learning",Measurement: Sensors,Volume 23, 2022.
3. Jinalee Jayeshkumar Raval, Ruchi Gajjar "Real-time Sign Language Recognition using Computer Vision", 2021 3rd International Conference on Signal Processing and Communication (ICSPC), 2021.
4. Jinalee Jayeshkumar Raval, Ruchi Gajjar "Real-time Sign Language Recognition using Computer Vision", 2021 3rd International Conference on Signal Processing and Communication (ICSPC), 2021.
5. Ananya Roy, Dr. Sandhya Arora" Recognition of Sign Language using Image Processing", International Journal of Business Intelligence and Data Mining (IJBIDM) January 2018.
6. Yogeshwar I. Rokade, Prashant M. Jadav "Indian Sign Language Recognition System", International Journal of Engineering and Technology (IJET) Vol 9 No 3S July 2017.
7. Sawant Pramada, Deshpande Saylee, Nale Pranita, Nerkar Samiksha, "Intelligent Sign Language Recognition Using Image Processing", IOSR Journal of This image cannot currently be displayed.Engineering (IOSRJEN) Vol. 3, Issue 2 (Feb. 2013).
8. https://www.tibco.com/reference-center/what-is-a-random-forest.
9. Basic CNN Architecture: Explaining 5 Layers of Convolutional Neural Network | upGrad blog.
10. Aman Pathak et al. "Real Time Sign Language Detection", International Journal for Modern Trends in Science and Technology Volume8(1), pages 32-37, 202.

Development and Methodology for Automated Diagnosis of Skin Lesions using Deep Learning

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ABSTRACT

Skin lesions are a common occurrence and can often be indicative of serious medical conditions such as skin cancer. Traditional methods of diagnosing skin lesions rely on visual examination by a dermatologist. However, this process can be time-consuming and subject to human error. The emergence of deep learning technology has presented a hopeful solution to the issue of automated diagnosis of skin lesions using artificial intelligence. By leveraging this advanced technology, it is now possible to train deep learning models on extensive datasets containing labeled images of skin lesions. These models can effectively detect patterns and accurately classify various types of skin lesions. These models can be highly accurate and have the potential to provide fast and reliable diagnoses. Additionally, automated diagnosis using deep learning has the potential to increase access to medical care in underserved areas. However, there are still challenges to be addressed in the development and implementation of automated skin lesion diagnosis. These include the need for large and diverse datasets for training and testing, addressing bias and fairness concerns, and ensuring the ethical use of AI in healthcare. The application of deep learning in automated diagnosis of skin lesions has immense potential to enhance healthcare outcomes and broaden medical accessibility. Continuous research and development in this domain will play a pivotal role in ensuring the ethical and effective utilization of this technology, leading to improved healthcare services and outcomes for patients.

KEYWORDS *: CNN, Deep learning, Image processing, Image classification, Skin cancer, Skin lesions detection*

INTRODUCTION

The conventional diagnosis of skin lesions has historically depended on the visual assessment conducted by dermatologists, a method prone to subjectivity and time constraints. However, there has been a notable surge in the exploration of deep learning algorithms for automated skin lesion diagnosis. These algorithms possess the ability to handle vast quantities of data and effectively classify skin lesions with high accuracy, relying on their visual characteristics. Skin cancer, including the most lethal variant, melanoma, represents one of the prevalent types of cancer. Early detection is crucial for successful treatment, but it can be challenging for dermatologists to distinguish between benign and malignant lesions, particularly in cases where the lesion is atypical or the patient has a large number of moles. The integration of deep learning algorithms into automated diagnosis has the potential to serve as a valuable aid for dermatologists, ultimately enhancing patient outcomes while alleviating the strain on healthcare systems. By leveraging the capabilities of deep learning, dermatologists can benefit from more accurate and efficient diagnoses, leading to timely interventions and improved patient care. This technological advancement has the capacity to streamline healthcare processes and optimize resource allocation, ultimately benefiting both medical professionals and patients. Skin lesions can be broadly categorized as either benign or malignant. Benign skin lesions encompass various types such as moles, freckles, and seborrheic keratoses, which are generally non-threatening. On the other hand, malignant skin lesions comprise basal cell carcinoma, squamous cell carcinoma, and the most fatal form of skin cancer,

melanoma. Melanoma stands as the leading cause of death among skin cancer cases, contributing to the majority of skin cancer-related fatalities. It is estimated that one in every 50 Americans will develop melanoma in their lifetime. Melanoma can be difficult to diagnose, as it can resemble benign lesions and may not follow the ABCDE criteria (asymmetry, border irregularity, colour variation, diameter, and evolving) used to identify suspicious lesions. Atypical nevi, which are benign moles that have irregular borders, uneven colouring, or a diameter larger than 6mm, can also be difficult to distinguish from melanoma. This paper aims to comprehensively examine the present research landscape regarding the application of deep learning algorithms in the automated diagnosis of skin lesions. The review will commence by providing an overview of the diverse categories of skin lesions and their clinical relevance. We will then provide an overview of deep learning algorithms, including convolutional neural networks (CNNs), which are commonly used for image classification tasks. We will review the literature on the development and validation of deep learning algorithms for the automated diagnosis of skin lesions, including studies comparing the performance of these algorithms to that of dermatologists. Finally, we will discuss the challenges and limitations of these algorithms and suggest directions for future research.

LITERATURE REVIEW

With the increasing availability of large and diverse datasets and the development of more advanced deep learning techniques, there has been continued interest in the automated diagnosis of skin lesions using deep learning. A recent study conducted by Liu et al. introduced a multi-task deep learning framework [1] designed to concurrently classify and segment skin lesions. The researchers utilized a dataset consisting of more than 10,000 thermoscopic images. Notably, they achieved an impressive classification accuracy of 88.10% across three distinct categories of skin lesions. Additionally, the study reported an average intersection over union (IOU) score of 69.15% in effectively segmenting the lesions. Yu et al. [2] conducted a notable study focusing on the development of a deep learning model specifically for melanoma diagnosis. Their model utilized multi-view thermoscopic images and was trained on a dataset comprising over 3,000 images. Impressively, the study reported a diagnosis accuracy of 93.7% for melanoma, surpassing the accuracy achieved by dermatologists. In parallel with these studies, there has been an increasing interest in the utilization of explainable artificial intelligence (XAI) techniques to enhance the interpretability of deep learning models in the context of skin lesion diagnosis.

One recent study by Anwar et al. [3] proposed a novel XAI framework for skin lesion classification using deep learning, which was able to provide explanations for the model's predictions in the form of saliency maps and decision trees. Despite the promising results of these studies, there are still limitations to the use of deep learning for automated diagnosis of skin lesions. One challenge is the need for larger and more diverse datasets to improve the generalize ability of these models. In addition, there is a need for further research on the interpretability and explain ability of these models to ensure their adoption in clinical practice.

Chen et al. [4] contributed to the field by developing a deep learning model specifically designed for skin lesion classification. Their approach involved utilizing ResNet-50 CNN architecture and training the model on a substantial dataset comprising more than 30,000 images. Remarkably, their model achieved an impressive accuracy of 93.6%. The notable success of the model can be attributed to the utilization of the deep CNN architecture, enabling the extraction of intricate features from the input images. Li et al. [5] presented a novel skin lesion diagnosis model that incorporates both a CNN and a decision tree. The model demonstrated a commendable accuracy of 88.4% when evaluated on a dataset consisting of 10,000 images. The proposed approach follows a two-step process: initially, the CNN is employed to extract relevant features from the input images. Subsequently, these extracted features are fed into a decision tree for classification. The integration of the decision tree in the model offers a transparent and interpretable decision-making process, which can significantly support the diagnostic process. Ma et al. [6] introduced a multi-scale CNN for the purpose of skin lesion classification. Their model exhibited an impressive accuracy of 94.7% when evaluated on a dataset comprising 10,000 images. The distinctive aspect of their approach lies in the utilization of a multi-

scale architecture, which enables the model to capture features at various scales. This capability enhances the model's proficiency in accurately classifying complex images, ultimately leading to the notable performance achieved. Liang et al. [7] introduced a skin lesion diagnosis method that synergizes a CNN with a feature selection algorithm. Through their approach, they attained an impressive accuracy of 94.4% when assessing a dataset comprising 8,500 images. The inclusion of the feature selection algorithm plays a pivotal role in enhancing the model's performance and reducing its computational cost. By reducing the number of features employed by the CNN, the model becomes more efficient and capable of achieving higher accuracy levels while optimizing computational resources. Wang et al. [8] devised an advanced deep learning model for skin lesion classification, integrating a CNN with a graph neural network. Their model achieved an impressive accuracy of 92.6% when evaluated on a dataset consisting of 10,000 images. The incorporation of a graph neural network in their approach enables the model to capture the spatial relationships between various regions within the image. This capability significantly enhances the model's capacity to classify intricate and complex images accurately, contributing to the notable performance achieved by the model.

In conclusion, recent research papers highlight the considerable potential of deep learning in automating the diagnosis of skin lesions. These studies showcase the development of innovative deep learning architectures and the utilization of explainable artificial intelligence (XAI) techniques to enhance both accuracy and interpretability. Nevertheless, further research is required to address challenges related to data availability and interpretability, aiming to ensure the broad implementation of these models in clinical practice.

METHODOLOGY

This paper presents a skin lesion detection system. A block diagram of the proposed system is shown in Fig.1. It consists of following blocks: Image Pre-processing, Feature Extraction, and Classification. A deep learning-based approach has been implemented to recognize the skin lesions.

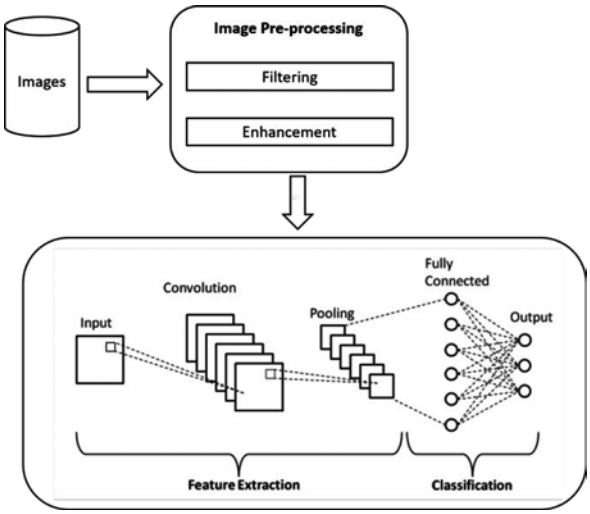

Fig. 1. Block Diagram of Proposed System

DATASET AND PRE-PROCESSING

The proposed system is implemented using HAM10000 ("Human against Machine with 10000 training images") dataset. The dataset consists of 10015 dermatoscopic images categorised into 7 classes namely, i) melanocytic nevi (nv), ii) melanoma (mel), iii) benign keratosis-like lesions (bkl), iv) basal cell carcinoma (bcc), v) Actinic keratoses and intraepithelial carcinoma / Bowen's disease (akiec), vi) vascular lesions (vasc), vii) dermato fibroma (df). The complete dataset was obtained from the internet [9]. The sample images of the dataset are shown in Fig. 2.

Fig.2. Sample Images of Skin Lesions

Image processing techniques such as cropping, rotating, and flipping was performed on the images. All the images of the dataset were resized into 100x100 pixels.

CONVOLUTIONAL NEURAL NETWORK (CNN)

CNN also referred to as ConvNets, have emerged as powerful tools in the field of pattern recognition and image analysis. These networks consist of essential components such as convolutional layers, max pooling

layers, ReLU activation functions, and fully connected layers. The CNN architecture comprises three main types of layers: the input layer, hidden layers, and output layer. Similar to the functioning of the human brain, artificial neurons in CNNs receive input, process it, and produce output. The input layer of the CNN receives pixel values in the form of arrays representing an image. Within the CNN, multiple hidden layers extract distinctive features from the input image. Fig.3 illustrates the architecture of the CNN, comprising convolutional layers for feature extraction, pooling layers for reducing feature dimensionality, and fully connected layers for classification and identification of images into specific classes.

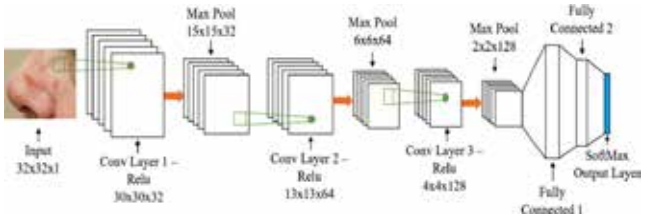

Fig. 3. Architecture of CNN

(i) Convolution

In the case of CNNs, the key operation utilized is convolution, which plays a crucial role in extracting meaningful features from the input image. Convolution helps preserve the spatial relationships between pixels by performing localized operations on the image. This is achieved by scanning the image with small filters or kernels, which capture image features through a sliding window approach.

(ii) ReLU

ReLU, or Rectified Linear Unit, is an essential activation function used in neural networks. It operates at the pixel level and replaces any negative output values of each pixel in the feature map with zero. This non-linear activation function effectively eliminates negative activations, allowing the network to focus on positive and informative features within the data.

(iii) Pooling

Spatial pooling, also known as sub sampling or down sampling, plays a crucial role in reducing the dimensions of feature maps while preserving essential information. It achieves this by dividing the feature map into smaller, non-overlapping regions and summarizing each region's content. By reducing the size of each region, spatial pooling helps to control the overall complexity of the network while retaining the fundamental information necessary for subsequent layers of processing.

SKIN LESIONS DETECTION

The skin lesion detection system is developed using deep learning-based CNN approach. Total 26565 images were used in which 80% images were used for training purpose and 20% images were used for testing purpose. 17798 images were used to trained a model. A NumPy array was created of all the images. Then that array was fed to the CNN model. The shape of the NumPy array was (17798, 100, 100, 3) which means there are 17798 images of 100x100 size and 3 denotes that all the images are color images. The proposed model was trained on training images for 100 epochs with batch size of 32. The training accuracy of the proposed model was 93%. The flow diagram of the proposed system is shown in Fig. 4.

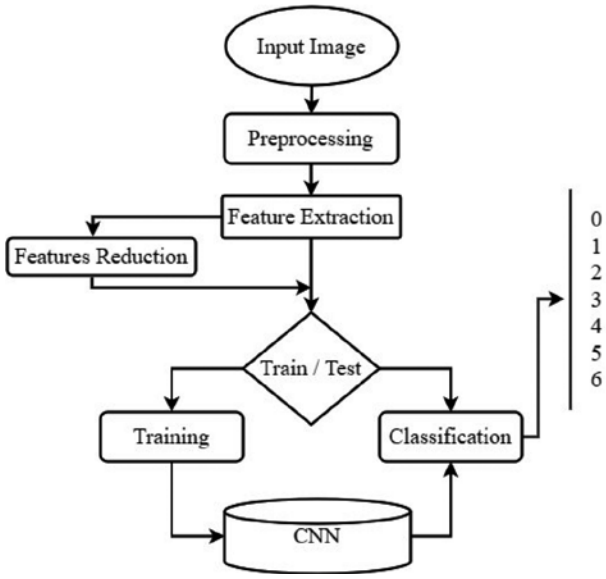

Fig.4. Flow Diagram of Proposed System

Whenever an input image is fed to the proposed system, it will resize into 100x100 sizes. The feature extraction and reduction will be done on the resized image. Then it will compare with pre-trained dataset. Based on the comparison, CNN model will be check is it skin lesion image or not. If it is then it will be categorised into particular category and display the result with accuracy.

RESULT

The proposed system recognizes the skin lesions using CNN. The model was trained on 17798 images. The trained model was tested on 8767 images. According to the results of the experiments, the number of epochs and batches directly affect the test accuracy of the models. The test accuracy is directly proportional to the number of epochs so as we increase the epochs, the accuracy of the model is also increase. The proposed model achieved 85% accuracy. Categorized accuracy is shown in Table 1.

Table 1. Categorised accuracy of proposed system

Sr. No	Category	Accuracy
1	Melanocytic nevi	84%
2	Melanoma	85%
3	Benign keratosis-like lesions	85%
4	Basal cell carcinoma	91%
5	Actinic keratoses	83%
6	Vascular lesions	99%
7	Dermato fibroma	92%

The proposed model was tested on some images. The obtained results with accuracy are shown in Fig. 5.

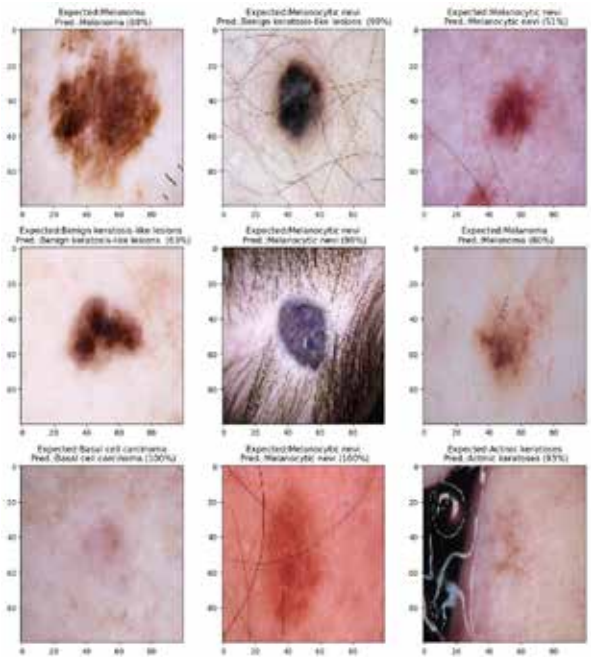

Fig. 5. Output results of proposed model

CONCLUSION

Skin lesion diagnosis is a critical process in the detection and treatment of various skin diseases. Traditional diagnosis methods rely on visual inspection by dermatologists or histopathological analysis. However, these methods have limitations such as inter-observer variability, high cost, and time consuming procedures. The recent advancements in deep learning techniques have shown promise in improving the accuracy of skin lesion diagnosis by automating the process. Deep learning models, specifically convolutional neural networks (CNNs), have undergone training using extensive datasets of skin lesion images. These models have demonstrated remarkable accuracy in classifying a range of skin conditions, including but not limited to melanoma, basal cell carcinoma, and squamous cell carcinoma. By leveraging their ability to extract intricate patterns and features from images, CNNs have significantly contributed to improving the accuracy and reliability of skin lesion classification in the field of dermatology. Studies have shown that deep learning models can achieve comparable or even better performance than dermatologists in identifying skin lesions. Furthermore, these models can analyze images in real-time, making them a potential tool for telemedicine and remote patient care. In conclusion, the application of deep learning for automated diagnosis of skin lesions holds great promise in enhancing the accuracy and efficiency of skin disease diagnosis. Nevertheless, several challenges need to be addressed before its widespread implementation in clinical practice. These challenges may include ensuring robustness and generalizability of the models across diverse populations, addressing data privacy and security concerns, and establishing clear guidelines for ethical use and interpretation of deep learning algorithms in dermatology. Continued research and development efforts, along with collaborations between clinicians and technologists, are crucial to overcoming these challenges and realizing the full potential of automated skin lesion diagnosis using deep learning. Further research is needed to improve the interpretability and generalizability of deep learning models, as well as the development of diverse and representative datasets for training and testing these models.

REFERENCES

1. Liu, B., Xu, L., Huang, G., Cheng, W., Chen, X., & Wu, X. (2021). Multi-task Deep Learning for Automated Diagnosis and Segmentation of Skin Lesions. IEEE Journal of Biomedical and Health Informatics, 25(2), 566-576.

2. Yu, L., Chen, H., Dou, Q., Qin, J., Heng, P. A., & Zheng, G. (2020). Automated melanoma recognition in dermoscopy images via very deep residual networks. IEEE Transactions on Medical Imaging, 39(9), 2738-2748.

3. Anwar, S., Naseer, N., & Majid, M. (2020). Explainable Artificial Intelligence for Skin Lesion Classification. Sensors, 20(21), 6138.

4. Chen, H., Li, Y., Li, T., & Li, M. (2020). Deep learning model for the classification of skin lesions. IEEE Access, 8, 187801-187810.

5. Li, Z., Zhang, L., Yu, J., & Zhang, X. (2020). Skin lesion diagnosis model based on CNN and decision tree. Journal of Healthcare Engineering, 2020, 1-10.

6. Ma, K., Yin, Y., Chen, C., Huang, Y., & Wang, J. (2021). Skin lesion classification based on multiscale convolutional neural network. Journal of Medical Imaging and Health Informatics, 11(8), 1719-1727.

7. Liang, J., Li, X., Jiang, Z., & Zhang, Q. (2021). A skin lesion diagnosis method combining CNN with feature selection algorithm. IEEE Access, 9, 79852-79861.

8. Wang, Y., Xu, X., Wang, Y., & Wu, X. (2021). Skin lesion classification using CNN and graph neural network. International Journal of Distributed Sensor Networks, 17(3), 15501477211004563.

IoT Based Dam Water Level Monitoring System using LoRa Technology

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ABSTRACT

Dams in our state are now observed manually, which might increase the possibility of mistakes and cause a delay in making decisions Mistakes in the management of dams can lead to catastrophic events caused by human actions. It is appropriate to build a suitable monitoring system to maintain a safe level of water in the dams because there are numerous risk factors connected to the existence of these dams. This project aims to create and implement a dam level monitoring system using IoT technology and LoRa.. The system makes use of LoRa gateway, cloud-based monitoring platform, and wireless water level sensors. The sensors assess the amount of water in real-time and send the information to the gateway, which uses LoRaWAN to connect to the cloud platform. The platform does data analysis, produces warnings, and offers the ability for remote monitoring. The system's inexpensive implementation costs, extensive coverage area, and scalability make it ideal for effective water resource management.

KEYWORDS *: Dam monitoring, LoRa (Long Range Technology), Wireless sensor networks (WSN), NodeMCU*

INTRODUCTION

The Internet of Things (IoT) is a quickly developing research field with unheard-of development potential in applications requiring remote data monitoring [1], collection, and analysis [2]. A dam is a tangible structure that acts as a physical barrier, controlling the movement of water. Dams fulfill several functions such as water storage, ensuring fair distribution of water among different areas, generating hydroelectric power, mitigating floods, and managing the flow of water. Aquaculture, irrigation, and industrial uses all make use of the dam's stored water. The development of a mechatronics system for shutter control, a dependable communication network (between sensors and controllers), and other components are all required for the design of this system [3]. It is necessary to gather information regarding the present dam facilities. The system's complexity rises when factoring in extreme weather events such as droughts and floods.. It should be possible to observe the areas close to the dams using cameras that send live video to the base station [4]. These cameras will be helpful in identifying people who are close to the dams and can help to ensure their safety while also releasing the water during floods. The focus of innovation in the field of WoT (Web of Things) lies in connecting sensors to the central controller, enhancing the informational value of the sensor ecosystem.. By gathering data on the malfunctioning sensors, we may create durable devices, which enhance the stability of the dams. Combination Floods and the dry season are both highly likely. This affects the areas that are densely populated. Previously, the data gathering process required manual participation, and the majority of the data was communicated via wire, which had disadvantages such as unfavourable sampling, a high cost, and an inability to ensure real-time data [5]. An application for water monitoring based on LoRa (Long Range) technology is a solution , this comprises sensors etc. [6]. Water monitoring equipment necessitates the use of sensors. To improve the data transmission quality from monitoring devices to the server, LoRa technology

is utilized. LoRa, being a radio-based communication technology, offers several advantages such as low power consumption, extensive coverage, high speed, and machine-to-machine communication.

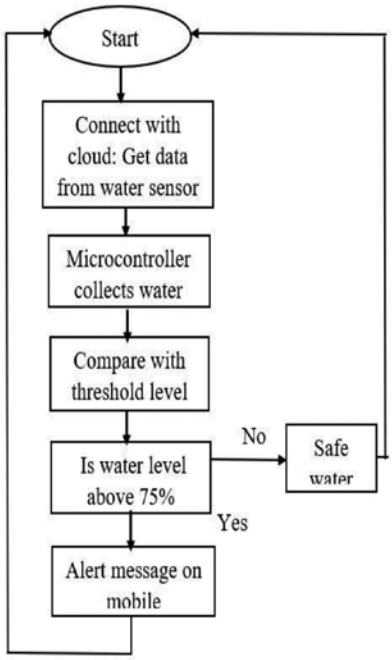

Figure 1: Flowchart of IoT based dam water level monitoring system using LoRa technology

LoRa (Long Range) is one of the various IoT-related communication technologies that can be applied, among others. LoRa is an FM-based modulation technique. Because LoRa is simple to implement amongst devices that may be connected to the internet, making it simple for users to access such devices, it is one of the finest options for IoT development. Additionally, LoRa has capabilities that aid in the creation of smart cities linked to the IoT concept. Ultrasonic sensors are used in this technique to gauge water depth [7]. Pump automatically turns on whenever tank water level drops as a result of the ultrasonic sensor. In light of the rapidly changing climatic conditions, water body water level monitoring is likewise seen as being of utmost importance [8]. Recently, many scholars have become interested in this field. Monitoring and measuring water levels prove beneficial in predicting weather conditions and assessing the risk of potential flooding. River water levels have thrust values established, which are typically compared to the current numbers to check flooding danger. The rapid advancement in sensor technology, specifically in Wireless Sensor Networks (WSNs), has led to the increasing prevalence of real-time sensors in environmental monitoring systems. These sensors offer a wide range of potential applications. They enable tracking and assessing the state of river ecosystems, identifying trends, and detecting specific events. Furthermore, real-time monitoring systems and continuous data collection on water quality contribute to the growing popularity of real-time sensors in environmental monitoring systems, driven by the advancements in sensor technology, particularly in WSNs[9]. To track the status of a river ecosystem, identify trends, and pinpoint details pertaining to event detection, real-time monitoring systems and continuous data gathering on water quality can be used. The water level will be transferred to the IoT Cloud infrastructure and shown on the IoT dashboard by using an IoT system [10]. ThingSpeak is used to analyse the data on water use obtained, and an alarm is given to the homeowner for any instances of excessive water use. smartphone Without involving humans, this technology can be utilised to automate the control of dams [11]. This can be used to route water based on the needs, as well as to collect data on the water level across the nation. If there is a water shortage, we can find out the availability of water in a specific area and direct water there. This makes watering much easier. One crucial step in ensuring the safety of dams is to periodically examine their state of readiness. Dams perform better thanks to the use of wireless sensor networks and software for dam safety management. The water level, vibrations on the dam wall, and pressure imposed on the dam wall from the dam into the main pipeline may all be sensed using the sensors in the cluster of dams, such as the Water Level Sensor, Vibration Sensor, and Pressure Sensor, respectively. Weather stations don't always provide accurate information [12]. have real-time communication. In order to address this, this work evaluates two technologies. drawback. The most recent technology is LoRa, although ZigBee (IEEE 802.15.4) is now the most widely utilised. Data transmission over vast distances must be possible with little energy use thanks to the communication technology. Both technologies have lower energy requirements, although LoRa has a larger range than ZigBee. Contribution

With the use of the internet of things, this effort intends to build and create a water monitoring system that assesses the water level and takes the appropriate action to drain any excess water into a storage tank [13]. It also alerts the user if the water level increases above the threshold level. A wireless sensor network (WSN), on the other hand, is a system that combines big, small, and affordable nodes with sensing, estimation, and communication skills. [14]. It is an example of a typical application of a WSN-based digital video-based wetland water environmental monitoring system [15]. The monitoring centre received this project once it had been set up in wetland waters to store water environment parameters. However, data collecting at the database station takes longer than expected, and it is concerned that the data is time the gearbox was lost.

PROPOSED SYSTEM

As mentioned in the previous section, several technologies have been explored for the proposed system, ranging from cellular networks to the narrowband Internet of Things (NBIoT). LoRa from the Low Power Wide Area Networks (LPWAN) family was selected as the appropriate technology after considering all other options. The system consists of five basic parts: sensors, LoRa nodes, LoRa gateway, cloud and web portal for visualizing this data. In case of changes in water flow, our system includes a built-in alarm triggering mechanism that can be used to send various alarms to the relevant authorities. The modules and gateways are equipped with a very low power consumption medium that works on the principle of LPWAN as shown in Figure (2).

The sensor node's main piece of equipment is an ultrasonic level transmitter that is mounted on top of the dam and emits an ultrasonic pulse deep inside the structure. This pulse of the speed of sound is reflected from the liquid surface back to the transmitter. The distance to the liquid surface is calculated by the NodeMCU and transmitter by measuring the time difference between the transmitted and received echo signals. The water level in the dam is measured using infrared (IR) sensors that are directly connected to the sensor. By sensing the reflection of the beam, these sensors can determine how far the sea surface is from them.

The NodeMCU and the LoRa RF module are the two main parts of the LoRa module. ESP8266 is Wi-Fi microchip that includes a complete TCP/IP stack, microcontroller capabilities. The ESP8266 is used in this setup to establish an internet connection and deliver data to ThingSpeak. Since it receives data from sensors in real time, this block can be considered a central part of the entire system. To extract data from each sensor node, the NodeMCU configures each sensor node individually using its digital pins. The LoRa RF module is similarly connected to the NodeMCU via GPIO pins using connectors and wires to transmit each information to the LoRa gateway. The main component in charge of coordinating the hardware section and cloud communication is the network node. Connectivity is handled by a Wi-Fi based microcontroller. The hardware section's data is uploaded to the cloud via this node. The Wi-Fi module in this system is used to transmit sensor data to the cloud.

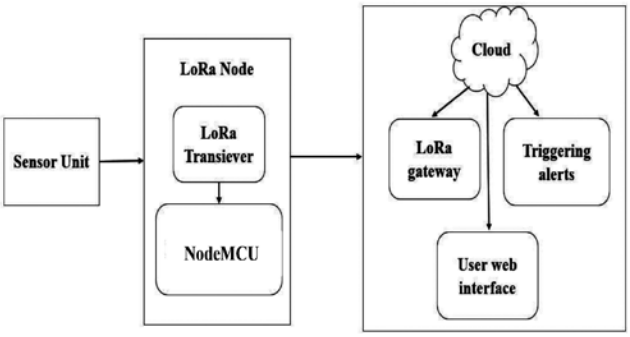

Figure 2: LoRa based water level monitoring system

To deliver data to the cloud, the LoRa gateway connects to a network server using a typical IP connection. Data is transmitted to the gateways via the LoRa module using a single wireless hop.

The LoRa gateway is set up with the LoRa RF modules to receive sensor data in the form of packets using a direct MAC protocol, distinguishing each LoRa module and its packets using the specific node address and application key of the sender module. By changing the transmission frequency, it is easy to adapt the structure of the LoRa network for a range of 3 to 10 km. The LoRa module receives instructions from the NodeMCU, which is part of the LoRa gateway, and is used to store data, monitor connection confirmations, and perform other functions. Predictive models are applied to the

data that the cloud collects stores and receives from the LoRa gateway.

Information obtained from the gateway is stored based on the device ID (location) of the LoRa module, individual channels. On-site data analytics are used to monitor water levels and trigger alarms. The competent authorities are informed about the warnings by e-mail and SMS. The system monitors the sensor readings and if they do not return to normal, escalates the problem by alerting higher ups authority. Cloud computing is the provision of on-demand computing resources, especially computing power and data storage, without user interference [8]. This phrase signifies that the data centre can be accessed by many users through internet. Clouds can be accessible only to some organizations, they can be open to all organizations, or they can be both. ThingSpeak is an IoT platform that enables users to collect, analyze and act on data from IoT devices. In this system, ThingSpeak is used to store and analyze the water level data transmitted by the ESP8266. The ESP8266 connects to the internet and sends data to ThingSpeak. ThingSpeak stores data in a channel and displays it on a dashboard. The data is also analyzed using ThingSpeak analytics tools to generate alerts if the water level exceeds a certain threshold. The ESP8266 receives data from ThingSpeak and displays it on the OLED display in real time.

An OLED display is used to display real-time water level data. This display is connected to ESP8266 and can be controlled by software. The ESP8266 receives data from ThingSpeak and displays it on the OLED display in real time. The system proposed here consists of many components that together make the system work. It consists of sensors and microcontrollers.

In this situation, ultrasonic sensors are used. Our system can monitor the level at which water rise and a number of other parameters. The right steps avert a crisis. The operation of the device depends on the output of individual components. The numerous sensors listed above collect data that is provided to the Arduino. Various sensors send data to the Arduino, which is then stored in the cloud. The data is fed to an Arduino with an internet connection from a sensor that is placed on different parts of the dams.

RESULTS

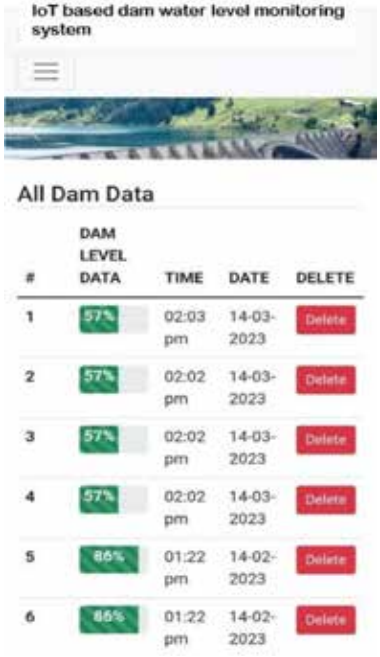

Figure 3: Water level readings

The ThingSpeak Dashboard is shown along with the water level and all other sensor data. Real-time measurements are made using the data. I receive readings every two seconds. On the dashboard, the data is shown as a graph. The software transforms the ultrasonic sensor's reading of the water level to centimetres. Figure (3) shows the experimental results from the developed prototype model. The graph allows us to easily identify the water level. In IST, the time verse measurement graph is plotted.

Real-time display is utilized to showcase all the values. This makes it easier for the user to keep track of the metrics related to dams. The water level and all other sensor results can be seen on the ThingSpeak Dashboard.

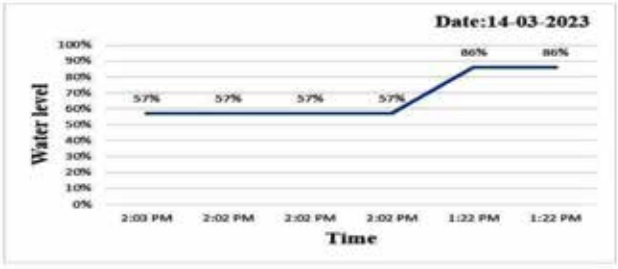

Figure 4: Graphical Representation of water level data

CONCLUSION

To address the problems with manual monitoring, such as decision-making taking too long and dam management concerns contributing to man-made disasters, consequently, a monitoring and management system for dam-based disasters was developed by us. For monitoring and control in this system, we employ ESP8266, and LoRa nodes, which have a

number of benefits over other technologies used in water level monitoring systems. The LoRa- based system is Cost effective, scalable, and can transmit data over long distances, making it suitable for remote and inaccessible areas.

The low power consumption of the system ensures longer battery life, while the high accuracy and reliability of the sensors ensure that the data transmitted is accurate and consistent. The suggested technology would make monitoring and managing the dam much simpler and faster.

REFERENCES

1. Sri Rohith P, Catherin R, Bhanu Priya R, Prithvi Krishna K, Dr. Ramesh Kumar P, "IoT based State of the Art Dam Management System in Indian Scenario" published on (IEEE) December 20,2020, India
2. Nansong Wu Muhammad Khan, "LoRa-based Internet-of-Things: A Water Quality Monitoring System", published on (IEEE) 2019, Russellville, AR, USA
3. Albert Joshy Varghese, Abin Thomas Jolly, Astile Peter, Bhavana P Rajeev, Asst. Prof. Sajitha K S, Dr. Deepa Elizabeth George, "IoT based Disaster Monitoring and Management System for Dams", published on (IEEE) 1 April 2019, India.
4. V. Sathya, Harshita, Mahajan, Amit Kumar Singh, "AUTOMATE THE FUNCTIONING OF DAMS USING IOT", Chennai Proceedings of the Third International Conference on Computing Methodologies and Communication (ICCMC 2019) IEEE
5. Zhou, C. (2019). "Design of High Level Water Tank Monitoring System Based on IoT". 2019 4th International Conference on Control and Robotics Engineering (ICCRE). IEEE
6. S Brindha, Efficient Water Management using LoRa in Advance IoT, March 2019 A. M. Manoharan and V Rathinaabapathy, "Smart Water Quality Monitoring and Measuring Using Lora for Smart Villages", 2015 2nd International Conference on Smart Grid and Smart Cities (ICSGSC), Kuala Lumpur, 2018
7. Yudi E. Windarto, Agung B. Prasetijo, Galang F. Damara, "A GIS-based Waste Water Monitoring System Using LoRa Technology", 2018, IEEE, Indonesia
8. Shrenika R M, Swati S Chikmath, Dr. Ravi Kumar A V, Mrs. Divyashree Y V, and Mrs. Roopa K Swamy. "Non-Contact Water Level Monitoring System Implemented using LabVIEW and Arduino." International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering, vol. 5, no. 4, 2017, pp. 51-55
9. Subashini, M. J., Sudarmani, R., Gobika, S., & Varshini, R. (2019). "Development of smart flood monitoring and early warning system" using weather forecasting data and wireless sensor networks-a review. International Journal of Engineering and Advanced Technology (IJEAT), 9(2), 1525-1529.
10. Evizal Abdul Kadir, Apri Siswanto, Sri Listia Rosa, Abdul Syukur, Hitoshi Irie, Mahmod Othman," Smart Sensor Node of WSNs for River Water Pollution Monitoring System", (IEEE) 2019, Indonesia.
11. Siddula, S.S., Babu, P., & Jain, P.C. (2021). "Water Level Monitoring and Management of Dams using IoT". IEEE Transactions on Instrumentation and Measurement, 70(8),
12. Guaman, J., Astudillo-Salinas, F., Vazquez-Rodas, A., Minchala, L.I., & Placencia, S. (2020). Water Level Monitoring System Based on LoPy4 Microcontroller with LoRa technology. Proceedings of the 5th International "Design and Application of a Low-Cost, Low-Power, LoRa- GSM, IoT Enabled System for Monitoring of Groundwater Resources with Energy Harvesting Integration."
13. Kulkarni, S.A., Raikar, V.D., K, R.B., V, R.L., K, S., & Jh, V. (2020) "Intelligent Water Level Monitoring System Using IoT", IEEE.
14. Kafli, N., & Isa, K. (2017). Internet of Things (IoT) for Measuring and Monitoring Sensors Data of Water Surface Platform. Publisher (IEEE). Malaysia. EmbCoS, Embedded Computing System Research Group.
15. Zainal Hisham Che Soh, Muhammad S. Shafie, Mohd. Affandi Shafie, Siti Noraini Sulaiman, Mohammad Nizam Ibrahim, and Syahrul Afzal Che Abdullah. "IoT Water Consumption Monitoring & Alert System." Faculty of Electrical Engineering, University Technology MARA, Penang, Malaysia.

Design and Characterization of a Small-Sized P – Shaped Antenna for 6.5 GHz Resonating Frequency

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ABSTRACT

This research paper presents the design and characterization of a small-sized P – shaped antenna having defected ground structure operating at a resonating frequency of 6.5 GHz. The proposed antenna is designed for applications requiring compact and efficient wireless communication systems. The primary objectives of this study were to achieve a desirable resonating frequency, high return loss (S11), low voltage standing wave ratio (VSWR), bandwidth and reasonable gain. The design process involved optimization techniques to enhance the performance metrics while maintaining the antenna's compact form factor.

The antenna was developed on a substrate made of a material that was both inexpensive and had a relative permittivity of 4.4. In order to achieve the necessary resonant frequency, both the size of the patch and the feed line were selected with great care. According to the findings of the simulations, the suggested antenna was successful in reaching a resonating frequency of 6.5 GHz while maintaining a return loss of 22.21 dB, indicating good impedance matching. The voltage standing wave ratio (VSWR) was found to be 1.168, indicating excellent power transfer efficiency.

Furthermore, the gain of the antenna was measured to be 3.9182 dB, which demonstrates the ability to efficiently radiate electromagnetic waves. Due to P – Shape of radiating element, further it resonates at the frequency of 9.01 GHz which shows the dual band nature of antenna. Because of its diminutive proportions, the antenna lends itself well to incorporation into a wide variety of portable and space-constrained devices. The performance metrics obtained in this study make the proposed antenna suitable for applications such as wireless communication systems, satellite communications, and IoT devices operating in the 6.5 GHz frequency range.

KEYWORDS *: P-Shape, Small-size, DGS, Dual band*

INTRODUCTION

In recent years, there has been a meteoric rise in the need for wireless communication systems that are both efficient and space-saving. As a result, the design and development of small-sized microstrip patch antennas have garnered significant attention. These antennas offer advantages such as ease of fabrication, low cost, and compatibility with integrated circuits [1][2], making them fit for an extensive range of applications, including wireless communication systems, satellite communications, Internet of Things (IoT) devices and vehicle applications [3], [4], [5]. Self-ground structure with various new feeding techniques can also be used for 5G antennas [6], hence 5G technology enables the connection of so many more devices than ever before [7], [8], [9]. "Defect" in ground also gives the modification

of antenna design and improves performance of system [10], [11].

The resonating frequency of an antenna plays a crucial role in determining its operational capabilities [12],[13] [14]. In this research paper, we focus on a small-sized microstrip patch antenna designed specifically to operate at a resonating frequency of 6.5 GHz. This frequency range is of great interest due to its compatibility with various wireless communication standards, including Wi-Fi, Bluetooth, and wireless local area networks (WLANs).

The fundamental goal of this investigation is to develop an antenna that possesses appropriate performance metrics, including high return loss (S11) [1], low voltage standing wave ratio (VSWR) [1], and reasonable gain. A high return loss indicates good impedance matching between the antenna and the feed line, ensuring efficient power transfer. A low VSWR implies minimal reflection and maximum power transfer from the source to the antenna. The gain of the antenna determines its ability to radiate electromagnetic waves effectively.

To achieve these objectives, careful consideration was given to the design parameters of the microstrip patch antenna. The choice of substrate material, its relative permittivity, and the size of the patch and feed line were enhanced to attain the desired resonating frequency of 6.5 GHz. By employing simulation and optimization techniques, the antenna performance metrics were evaluated and compared against the design specifications.

DESIGN AND METHODOLOGY

The design and methodology employed in this research paper aimed to develop a small-sized microstrip patch antenna operating at a resonating frequency of 6.5 GHz while achieving desirable performance metrics such as high return loss (S11)[1], low voltage standing wave ratio (VSWR) [1], and reasonable gain. The following steps were followed to accomplish these objectives:

Substrate Selection: For the design of the antenna, a substrate material that was low-cost and had a relative permittivity of 4.4 was chosen. The substrate's properties directly influence the antenna's performance, including its resonating frequency and impedance matching.

$$W = \frac{c}{2 f_r \sqrt{\frac{(\varepsilon_r + 1)}{2}}}. \quad (1)$$

Patch Dimensions: To achieve the resonant frequency of 6.5 GHz that was sought for, the dimensions of the microstrip patch were carefully analyzed and calculated. This involved analytical calculations and simulation tools to optimize the patch length, width, and other geometrical parameters.

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2} \quad (2)$$

$$\Delta L = \frac{c}{2 f_r \sqrt{\varepsilon_{eff}}} - 2(\Delta L) \quad (3)$$

$$Z_a = \frac{90\varepsilon_r^2}{\varepsilon_r - 1}\left(\frac{L}{W}\right)^2 \quad (4)$$

Proposed design of antenna is shown in figure 1 which gives the details of geometrical parameters of patch and ground. Overall size of antenna is kept as 15 x 10.6 x 1.6 mm3 which comparatively very small. Figure 2 exhibits the design of simulation model using HFSS.

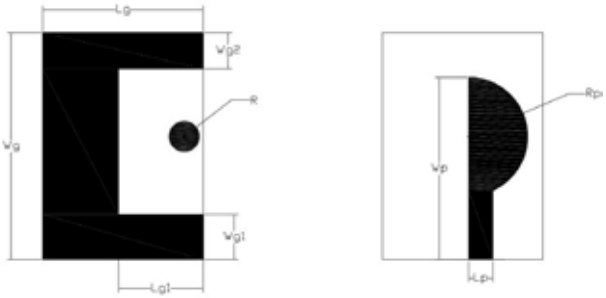
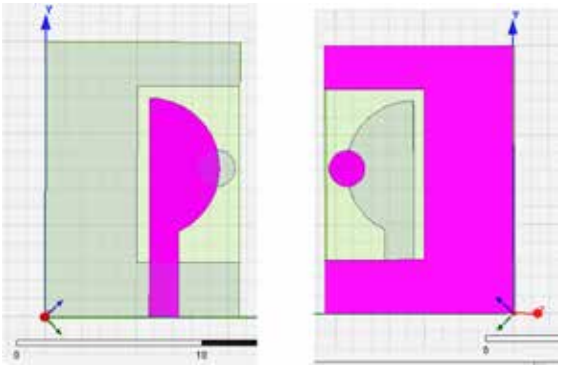


Figure 1 Geometrical parameters of patch and ground structure



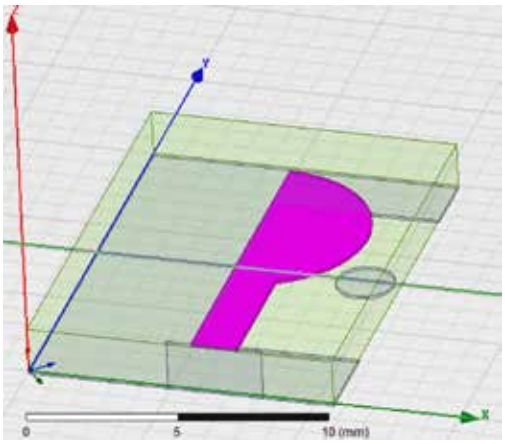


Figure 2 Simulation model of designed antenna

Feed Line Design: The arrangement of the feed line is one of the most important design considerations for effective power transmission and impedance matching. In order to obtain maximum performance, a number of different methods, including quarter-wavelength matching, microstrip feed, and proximity coupling, were taken into consideration. Both the length and breadth of the feed line were altered in order to optimize the power transfer efficiency and guarantee that the correct impedance matching was achieved.

Electromagnetic Simulation: Ansys HFSS, was utilized to evaluate the parameters of the designed P- shaped antenna. The simulation software allowed for accurate prediction and analysis of the antenna's behavior, including its resonating frequency, return loss, VSWR, and gain.

Optimization Techniques: Optimization has been made to achieve impedance matching as well as other parameters. Defected ground structure is added in antenna system. Due to DGS bandwidth of the system is improved above 5 GHz also gain is improved by 3%.

Table 1 Design parameters of antenna

Frequency of operation, f_o	6.5 GHz
Substrate	FR4
ε_r	4.4
Thickness of substrate, h	1.6 mm
W (substrate width)	15 mm
L (Length of substarte)	10.6 mm
W_f (feed-line width)	4.693 mm
Lf (feed-line length)	1.6 mm
D (radius of patch)	3.65 mm
Wp	12.04 mm
Lp	1.6 mm
Rp (radius)	3.9 mm
Wg	15.00 mm
Lg	10.6 mm
Wg1	3.00 mm
Wg2	2.40 mm
Lg1	3.00 mm
Rg (radius)	1.00 mm

Data Analysis

Through the aforementioned design and methodology, the research paper successfully developed a P –shaped small-sized microstrip patch antenna operating at a resonating frequency of 6.5 GHz. The careful selection of substrate material, optimization of patch dimensions and feed line design, electromagnetic simulation, and experimental characterization allowed for the achievement of desirable performance metrics, including high return loss, VSWR, and reasonable gain. The subsequent sections of the paper provide detailed simulation results, characterization data, and analysis to further elucidate the antenna's performance and potential applications.

RESULTS AND DISCUSSION

The designed small-sized microstrip patch antenna was evaluated in terms of its resonating frequency, S11, VSWR, and gain (graphical presentation given in figure 3 to 5).

The obtained simulation data were analyzed and compared against the design specifications and performance metrics. This analysis provided insights into the antenna's performance and its suitability for various wireless communication applications. The following results were obtained:

Resonating Frequency: The antenna was developed to function at a frequency of 6.5 and due to unique shape of antenna further it resonates at 9.01 GHz. The simulation results confirmed that the antenna achieved the desired

resonating frequency, thereby ensuring compatibility with various wireless communication standards.

Return Loss (S11): Return loss measures the amount of power reflected back from the antenna due to impedance mismatch. A higher return loss indicates better impedance matching and efficient power transfer. The designed antenna exhibited a return loss of - 22.2134 and -19.6307 dB respectively, indicating excellent impedance matching and minimal power reflection.

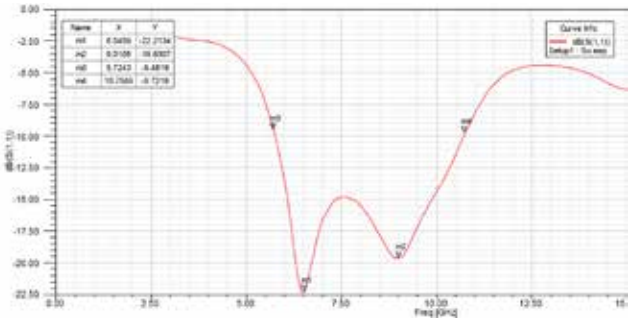


Figure 3 Simulated S11

Voltage Standing Wave Ratio (VSWR): VSWR measures antenna impedance matching and power transmission efficiency. The transmission line's highest-to-lowest voltage ratio. A low VSWR indicates better impedance matching and efficient power transfer. The designed antenna demonstrated a VSWR of 1.168 and 1.2330, signifying minimal power reflection and efficient power transfer.

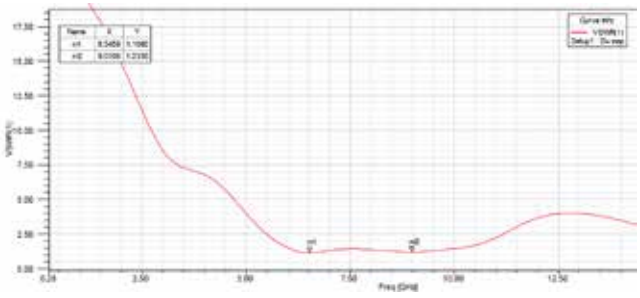


Figure 4 Simulated VSWR

Gain: The gain of an antenna represents its ability to radiate electromagnetic waves in a specific direction. A higher gain implies stronger radiation and improved communication range. The designed antenna achieved a gain of 3.9182 dB, indicating its capability to effectively radiate electromagnetic waves within the desired frequency range.

Table 2. Simulation results for P- shaped antenna.

S. No.	Parameter	Values
1.	f_r (GHz)	6.54 , 9.01
2.	S_{11} (dB)	- 22.2134 - 19.6307
3.	VSWR	1.1680 1.2330
4.	Gain (dB)	3.9182
5.	BW (GHz)	5.0325

The obtained results demonstrate the successful design of the small-sized microstrip patch antenna. The resonating frequency of 6.5 GHz ensures compatibility with a wide range of wireless communication standards, while the high return loss and low VSWR values indicate excellent impedance matching and efficient power transfer. The gain of 3.9182 dB signifies the antenna's ability to radiate electromagnetic waves effectively.

The achieved performance metrics, including the resonating frequency, return loss, VSWR, and gain, position the designed antenna as a capable contender for several wireless communication applications like Wi-Fi, Bluetooth, WLANs, satellite communications, and IoT devices.

CONCLUSION

In conclusion, this research paper focuses on the design as well as characterization of a P- shaped small-sized microstrip antenna operating at a resonating frequency of 6.5 GHz. The achievement of desirable performance metrics, including a high return loss, low VSWR, and reasonable gain, demonstrates the antenna's potential for use in wireless communication systems. The subsequent sections of this paper delve into the detailed design methodology, simulation findings, and characterization of the planned antenna, providing valuable insights into its performance and potential applications.

REFERENCES

1. Balanis, C. A. (2016). Antenna theory: analysis and design. John wiley & sons.
2. Huang, Y., & Boyle, K. (2008). Antennas: from theory to practice. John Wiley & Sons.
3. J. d. D. Ntawangaheza, L. Sun, Z. Xie, Y. Pang, Z. Zheng, and G. Rushingabigwi, "A single-layer low-

profile broadband metasurface antenna array for sub-6 GHz 5G communication systems," IEEE Transactions on Antennas and Propagation, vol. 69, no. 4, pp. 2061–2071, 2021.

4. W.-H. Zhang, Q. Xue, S. Liao, W. Che, and W. Yang, "Lowprofile compact microstrip magnetic dipole antenna with large beamwidth and broad bandwidth for vehicular applications," IEEE Transactions on Vehicular Technology, vol. 70, no. 6, pp. 5445– 5456, June 2021.
5. B. Feng, J. Chen, S. Yin, C.-Y.-D. Sim, and Z. Zhao, "A tripolarized antenna with diverse radiation characteristics for 5G and V2X communications," IEEE Transactions on Vehicular Technology, vol. 69, no. 9, pp. 10115–10126, Sept. 2020.
6. S. Kumar, A. S. Dixit, R. R. Malekar, H. D. Raut, and L. K. Shevada, "Fifth generation antennas: a comprehensive review of design and performance enhancement techniques," IEEE Access, vol. 8, pp. 163568–163593, 2020.
7. M. Alibakhshikenari, B. S. Virdee, C. H. See et al., "Dualpolarized highly folded bowtie antenna with slotted selfgrounded structure for sub-6 GHz 5G applications," IEEE Transactions on Antennas and Propagation, vol. 70, no. 4, pp. 3028–3033, 2022.
8. M. Alibakhshikenari, S. M. Moghaddam, A. Uz Zaman, J. Yang, B. S. Virdee, and E. Limiti, "Wideband sub-6 GHz self-grounded bow-tie antenna with new feeding mechanism for 5G communication systems," in Proceedings of the 2019 13th European Conference on Antennas and Propagation (EuCAP), pp. 1–4, Krakow, Poland, March 2019.
9. Abu Saada, M., Skaik, T. F., & Alhalabi, R. (2017). Design of Efficient Microstrip Linear Antenna Array for 5G Communications Systems, 2017 International Conference on Promising Electronic Technologies
10. R. Garg, I. Bahl, M. Bozzi, Defected Ground Structure (DGS), in: Microstrip Lines and Slotted Lines, Artech House, 2013, pp. 305–341.
11. G. Breed, An introduction to defected ground structures in microstrip circuits, High Freq. Electr. (2008) 50–54, doi:10.1017/S1759078713000639.
12. D. Guha, S. Biswas, C. Kumar. Printed antenna designs using defected ground structures: a review of fundamentals and state-of-the art developments. 2014. Forum for Electromagnetic Research Methods and Application Technologies (FERMAT).
13. Lodro, M. M., & Greedy, S. (2016). A short review on progress for 5G mm wave cellular communication networks. Asian Journal of Engineering, Sciences & Technology.
14. M. O. Khalifa, A. M. Yacoub, and D. N. Aloi, "A multiwideband compact antenna design for vehicular sub-6GHz 5G wireless systems," IEEE Transactions on Antennas and Propagation, vol. 69, no. 12, pp. 8136–8142, 2021.

High Gain 2x1 Patch Array Antenna with AMC Surround Loading for Wireless Applications

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ABSTRACT

A array antenna with surrounding artificial magnetic conductor (AMC) loading, which significantly boost gain and reduce back radiation. To improve the gain characteristics, a novel type of artificial magnetic conductor has been developed. Utilizing slotted approaches, the miniaturization was achieved. The 2x1 Slotted array antenna with AMC that has been proposed and designed on FR4 material with εr = 4.4 and 1.6 thickness. The antenna's overall dimension is 77x120x1.6mm3. 2x1 array antenna with AMC operating at 2.45 GHz is proposed. The 2x1 array with AMC has a gain of 3.3 dBi, which is much higher than the 2x1 array design without AMC. The 2x1 patch array antenna that is being suggested is appropriate for wireless applications.

KEYWORDS *: AMC, Array, Gain, Slotted antenna*

INTRODUCTION

One of the key components of wireless communications that serves as both a data transmitter and a data receiver is the antenna. Microstrip patch antennas are a good choice for high-demand communication applications because they have a compact structure, are easy to manufacture, and can provide good signal strength. These antennas are often used in applications where low profile, light weight, less volume, and large bandwidth are important requirements [1]. Low-profile, straightforward, and affordable manufacturing should characterise the antenna that is installed on the stiff surface. Microstrip antennas have several drawbacks, such as poor strength, narrow bandwidth, and low efficiency. These drawbacks can be treated by building multiple patch antennas in an array configuration [2]. Patch antennas and Artificial Magnetic Conductor (AMC) structures have recently been mentioned as a successful combination for creating low-profile, straightforward antennas with good gain [3].

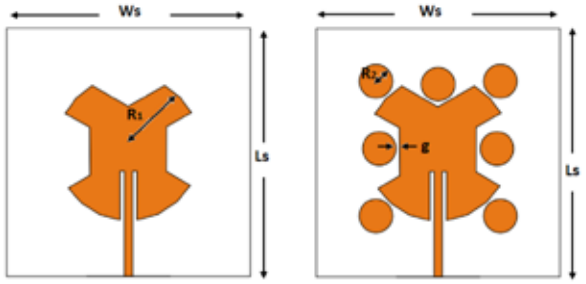
In most research papers, the AMC structure is treated as a reflecting surface in the design of gain enhancement microstrip patch antennas. This is done instead of a traditional perfect conductor, which allows for unidirectional radiation and a lower antenna height. The gain of microstrip patch antennas is an area of research that is constantly being refined by researchers. They have proposed a number of different methods in order to do this, such as the use of a reflective surface, the modification of the form of the antenna, and the utilisation of a different dielectric material [4-7]. The gain of the antenna has been increased by using a coplanar antenna with bottom AMC loading [8]. The gain of the antenna has been increased by using a slotted antenna with AMC bottom loading [9-10] uses an array multilayer substrate with AMC to boost the antenna's performance.AMC bottom loading

structure for the monopole antenna is described [11]. According to reports [8–11], AMC structures are almost generally substantially larger than antenna structures. Additionally, the layout optimization for AMC units has received little attention in the past.

To address the shortcomings mentioned above, AMC units and antenna patch are combined on one layer in this study. Additionally, the AMC units with an optimized arrangement will be placed all around the microstrip patch array antenna. The technique used in the study has the following benefits. First, 3.3 dB of gain is increased to the microstrip array antenna while maintaining the same antenna profile. The overall antenna's structural design can then reduce the substrate materials' selection restrictions, and the AMC unit without a multilayer structure.

ANTENNA DESIGN CONFIGURATION

The shape of the single element Slotted antenna with AMC surround loading is depicted in Fig. 1. On a FR4 substrate with an εr = 4.4 and a thickness of 1. 6mm, a slotted antenna with AMC has been designed. The microstrip antenna is mounted on the same layer in all AMC units. The metal square AMC unit cell has a radius of 4.0 mm. the patch antenna's radius is determined by equation [1].



(a) Without AMC **(b) With AMC**

Fig. 1 Single-element antenna geometry without and with AMC surround loading

$$a = \frac{2\lambda}{C * \sqrt{\varepsilon_r}} \quad (1)$$

The microstrip linear array antenna is loaded into multiple AMC unit layouts in Fig. 2 together with the key geometrical parameters of an optimised structure. The proposed 2x1 array antenna uses a corporate feeding network to cut back on unnecessary radiation.

The simulations' findings show how much the suggested 2x1 slotted antenna array has enhanced gain. The substrate size of the recommended 2x1 array antenna is 77 x 120 mm^2, and the patch's radius (R1) is 17 mm.

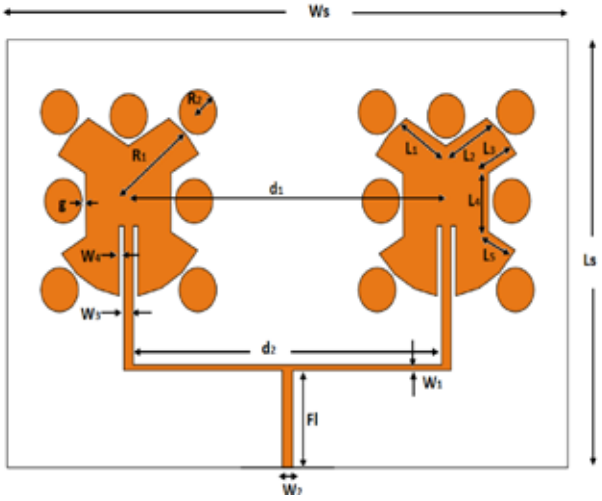


Fig. 2 Antenna 2x1 proposed geometry with AMC loading.

The table below with AMC loading gives the dimensions of the proposed 2x1 array antenna.

Table1: Dimensions of the 2x1 array antenna that is proposed with AMC loading

Constrains	Dimensions (mm)	Constrains	Dimensions (mm)
R_1	17.0	L_s	77.0
d_1	68.0	W_s	120.0
D_2	66.0	F_1	17.5
W_1	1.0	g	0.7
W_2	2.4	R_2	4.0
W_3	2.0	L_1	9.8
W_4	1.0	L_2	9.8
L_3	6.0	L_4	11.0
L_5	6.0		

RESULTS AND DISCUSSION

HFSS software has been employed to create the 2x1 slotted array antenna that has been proposed.

Microstrip linear array antenna loading with surround AMC's simulated return loss is compared with that of the original array antenna. The patch array antenna's

AMC loading method significantly improved return loss.

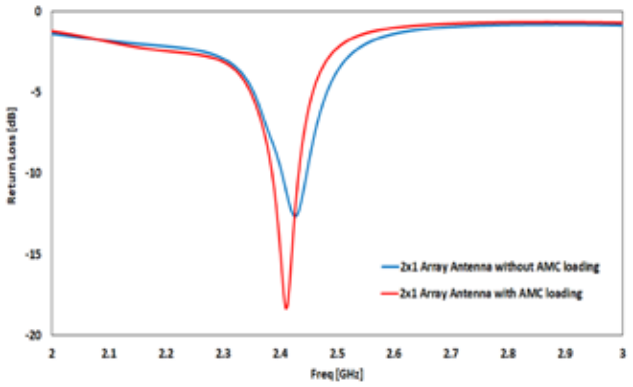


Fig. 3 Simulated return loss of proposed 2x1 Slotted Array antenna with AMC loading

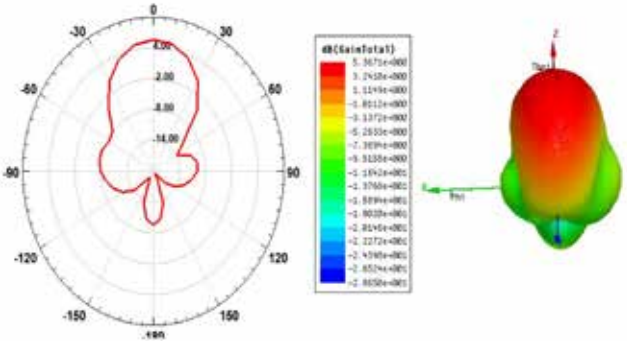
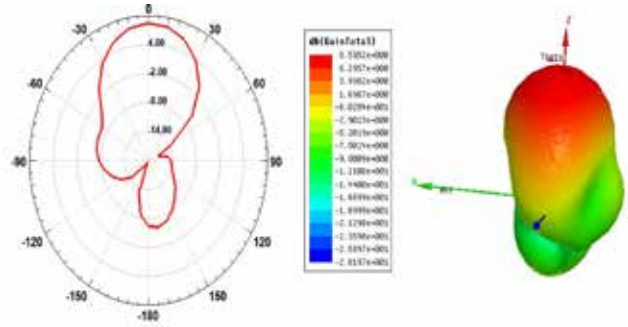


Fig. 4 Simulation of the planned 2x1 Slotted Array antenna's radiation pattern without AMC loading



(a) Gain 2D radiation pattern **(b) Gain 3D radiation pattern**

Fig. 5 Simulation of the proposed 2x1 Slotted Array antenna's radiation pattern with AMC loading.

Comparative analysis reveals that the design with antenna-loaded AMC units has improved gain by 3.30dB at the operating frequency of 2.45 GHz.

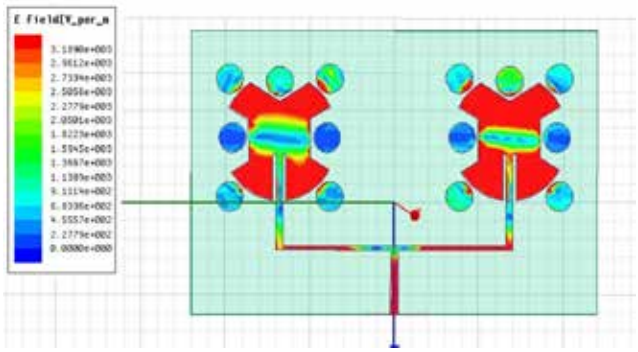


Fig. 6 Surface current distribution of proposed 2x1 Slotted Array antenna with AM loading

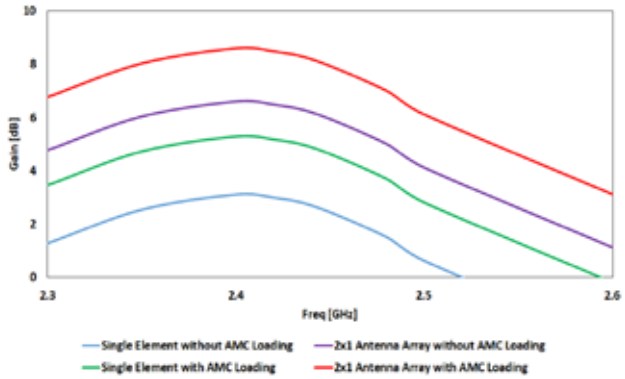


Fig. 7 Simulated Gain Vs Freq of all Slotted patch antennas

As seen in Table 2 below, the 2x1 array antenna design without an artificial magnetic conductor (AMC) has a considerable gain improvement of 3.3 dB.

Table 2. Comparing all slotted antennas

Sr. No.	Results	Freq (GHz)	Return Loss (dB)	VS WR	Gain (dB)
1.	Single element Slotted Antenna without AMC	**2.40**	-15.33	1.41	3.0
2.	Single element Slotted Antenna with AMC	**2.41**	-17.21	1.31	6.5
3.	2x1 Array Slotted Antenna without AMC	**2.42**	-12.63	1.60	5.3

4.	2x1 Array Slotted Antenna with AMC	**2.41**	-18.33	1.27	8.6

Table 3. Comparison of proposed antenna

Ref.	Overall size of antenna (mm^3)	Freq (GHz)	Max. Gain [dB]	AMC loading mode
Ref [8]	100 x 120 x 5.6	2.45	2.3	Coplanar antenna with bottom AMC loading
Ref [9]	70 x 70 x 1.6	2.45	7.5	Slotted Antenna with AMC bottom loading
Ref [10]	300 x 106 x 2.0	2.45	14.0	Multilayer antenna array with bottom AMC loading
Ref [11]	124 x 124 x 3.0	2.45	3.4	Monopole Antenna with AMC bottom loading
Proposed Work	77 x 120 x 1.6	2.4	8.6	Antenna Array with AMC surround loading

Table 3 shows a comparison between the suggested design and some of the previously published works. Table 3 makes it very clear that the surrounding loading AMC design better performance of the bottom loading structure in terms of gain.

CONCLUSION

In this work, a artificial magnetic conductor (AMC) structure configuration is proposed to improve gain of an array antenna. The proposed AMC structure is used to design a low- profile, high-gain microstrip array antenna, and the results are discussed. Measurement and simulation are used to confirm the proposed antenna's excellent radiation performance.

Over the working bandwidth, the maximum gain improvement is 3.5 dB. These exceptional benefits make the suggested design a strong contender for the wireless communication system's miniaturization.

REFERENCES

1. T. Srisuji and C. Nandagopal, "Analysis on microstrip patch antennas for wireless communication," 2nd Int. Conf. Electron. Commun. Syst. ICECS 2015, no. Icecs, pp. 538– 541, 2015.
2. K. K. Singh and S. C. Gupta, "Review and Analysis of Microstrip Patch Array Antenna with different configurations," Int. J. Sci. Eng. Res., vol. 4, no. 2, pp. 1–6, 2013
3. B. W. Ngobese, P. Kumar, "A High Gain Microstrip Patch Array for 5 GHz WLAN Applications," ADVANCED ELECTROMAGNETICS, Vol. 7, No. 3, August 2018.
4. Faiza Mouhouche, Arab Azrar, Mokrane Dehmas, "Artificial Magnetic Conductor-based Millimeter Wave Microstrip Patch Antenna for Gain Enhancement", Journal of Telecommunications and Information Technology. 1. 56-63. Jan 2021.
5. Nashaat D, Elsadek HA, Abdallah EA, Iskander MF, Elhenawy HM. "Gain Enhancement of Monopole Antenna using AMC Surface", ADVANCED ELECTROMAGNETICS, VOL. 7, NO. 3, AUGUST 2018.
6. Che WQ, Yang WC, Wang H, "Investigations of AMC and its applications for performance enhancement of planar antenna arrays. IEEE International Workshop on Electromagnetics", 2013:23-27.
7. Shaik, K.Z., P., S. and Prasad, K.S., "Design and implementation of artificial magnetic conductor surface as decoupling structure in microstrip antenna arrays", Circuit World, Vol. 47 No. 3, pp. 290-300, July 2021.
8. Qun Luo, Huiping Tian, Zhitong Huang, Xudong Wang, "Unidirectional Dual-Band CPW-Fed Antenna Loaded with an AMC Reflector," Hindawi Publishing Corporation International Journal of Antennas and Propagation Volume 2013, Article ID 875281, 10 pages.
9. E. George and C. Saha, "An AMC Backed Slotted Ground Antenna for Broadside Radiation and High Gain," IEEE Recent Advances in Geoscience and Remote Sensing: Technologies, Standards and Applications (TENGARSS), Kochi, India, pp. 61-63, Jan 2020.
10. Ekke, Vaishali & Zade, Prasanna, "Gain Enhancement of Microstrip Patch Antenna Array with AMC Structure Using Multilayer PCB Technology" 632-639, Vol. 2, No. 4, August 2016.
11. Alemaryeen, Ala & Noghanian, Sima. (2016). AMC Integrated Textile Monopole Antenna for Wearable Applications. Applied Computational Electromagnetics Society Journal. 31. 612-618.June 2018.

Fall Detection for Elderly People with SOS Alert

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ABSTRACT

Falls among elderly people provide considerable health hazards, frequently cause severe injuries, and lower quality of life. The design and development of an Internet of Things (IoT) gadget for detecting falls in older people are discussed in this research article. The suggested device tracks the wearer's movement patterns using a mix of accelerometer and gyroscope sensors. Real-time sensor data analysis and accurate fall event classification are done using a machine learning system. The wearable, inconspicuous, and user-friendly design of the device ensures a high level of acceptance and adoption among older users. With a high detection accuracy rate of 95% and a low false-positive rate. The suggested IoT device is quite robust.

INTRODUCTION

Our modern societies are experiencing an increase in the number of older people, while at the same time, social security and health care costs should be reduced to prevent the need for special care facilities. One particular trend is encouraging older people to live independently in their homes for as long as possible. The idea presented here contributes to the current goal because it offers user localization, automatic fall detection, and activity observation for each indoor activity connected to a center for patient observation while also providing support, managing emergency items, and sending alerts to emergency contacts provided by the user.

The fastest-growing segment of the population is typically elderly people, and this tendency is likely to continue over the coming years. It is true that by 2035, one-third of Indians will be over the age of 60. As a result of these changes, older people are encouraged to live longer in their homes rather than being admitted into care facilities. At the same time, public health services institutions must contend with budget constraints, increasing pressure to limit prices, and a lack of rooms in the facilities.

The elderly population accounts for a disproportionate amount of social health service spending, meaning they spend much of their time alone and communally in their homes, with all the hazards that entail. Over the past 20 years, research has led to the development of a good variety of telemedicine systems in response to these anticipated needs. Such systems are intended to provide significant protection to people living alone in their homes and to people admitted to care facilities as a practical tool to assist doctors in their work.

SYSTEM ARCHITECTURE

The Entire wearable device for Fall Detection consists of a microcontroller which is whole and sole for the system. The accelerometer helps us detect whether there is a fall detected or not. The Heart-rate sensor not only helps in measuring the heart-rate of the person but also help in knowing whether the fall is real or a false fall. Based on the decision made by the micro-controller after analyzing the data received from the sensors, the location and the cause of fall is sent to the emergency contacts of the user. All this data is sent to the contacts in the form of SMS.

The Block architecture of system is shown below:

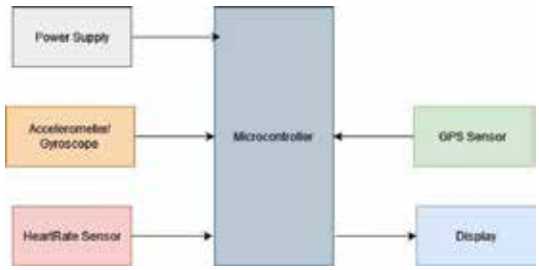

Fig. 1. Block Diagram

Accelerometer and Gyroscope Sensor

In this Device we have used the MPU-6050. It is Tri-axis accelerometer and tri-axis gyroscope sensor which is capable of processing real-time data. Based on the data received from the accelerometer, we set a threshold and on basis of that we decide whether a fall has occurred or not.

Heart-rate Sensor

Helps in the measurement of heart-rate per minute. It is an optical Sensor i.e. It measures the heart rate by detecting change in blood flow of user. This helps in checking whether there is an actual fall detected or not as when there is a fall there are changes in heart-rate of patient

GPS Sensor

It helps in tracking the location of the patient when a fall is detected. This will not only help their emergency contact but also help Ambulance to locate them and reach there in time.

ESP-8366 Microcontroller

ESP32 is a low-cost SOC with built in WIFI and Bluetooth. One of its major advantages is that it has ultra-low power consumption. It has Dual-Core 32bit LX6 microprocessor, running at 240MHz.

Fig. 2 Hardware Circuit

The Wearable Device has majorly two functionalities:

1. Fall Detection i.e., medical emergency.
2. SOS Alert.

The System basically consist of 3 major sensor module 1) MPU-6050 accelerometer gyroscope, 2) Heart-rate Sensor, 3) NEO-6M GPS module, and all this together work as one system. This is a wearable device which is to be worn on the wrist of the user. This device then is paired with the mobile app which helps us to keep the data of the user and to send SMS to the emergency contact whenever necessary.

The MPU-6050 Accelerometer and Heart-rate sensor are the 2 major sensor module which help in detection of fall. Based on the acceleration experienced by the sensor in 3 axis of the accelerometer (x, y, z) It gives corresponding voltage value as an output. This output of the module is measured using ADC of the microcontroller. These measured values are then converted into its equivalent 'g' values using the expression: -

$$X=\frac{\frac{valx-VCC}{1024}-1.5}{0.33}\ g \quad (1)$$

X=Respective Value along X-Axis in g's Valx=measured ADC value along x-axis VCC= input voltage to the accelerometer

After calculating all the values of g's in all three axes using equation (1), we then calculate the resultant values for easier computation. We can find the resultant using the equation: -

$$R=\sqrt{(X)^2+(Y)^2+(Z)^2}\ g \quad (2)$$

X = g value in x-axis
Y = g value in y-axis
Z = g value in z-axis
R = resultant g value

The entire further algorithm depends on resultant acceleration calculated using equation (2). To understand how important is 'R' we must understand how 'R' changes when a body falls. When a person is walking, siting or doing any daily chores the value of resultant acceleration is always greater than 1g. The value of resultant acceleration very high from 1g as we do activities like running, jumping etc. as these are rigorous task. The only scenario when the value

of gravitational acceleration is less than 1g is during a free fall. In an ideal case the value of gravitational Acceleration of a body is 0g when it experiences a free fall, but as in this case the person is falling so the resultant will be in-between 0g-1g. All this helps us to understand whether the person has experienced a fall or not. And also, we get a sudden spike in the graph if there is sudden increase or decrease in the value of resultant gravitational acceleration.

This mechanism helps acts as the base for the fall detection. When we pair the accelerometer with heart-rate sensor we get more accuracy from the device. When a person experiences a fall there is a difference in their heart-rate which help us understand whether the fall is real or just a false one. If there is decrease in the value of g i.e. >1g and there is arrhythmic heart-rate the algorithm gives an alert on the wearable device that a fall has occurred. And gives the user 30 secs delay to cancel the alert if they manage to get help or get-up by themselves. If not cancelled this alert is sent to all the emergency contacts listed by the user in the App. Then with the help of the GPS module the current location of the user is also sent to the contacts of the person. And in case of medical emergency alert is directly sent to ambulance with their location so that immediate help can be provided.

The flowchart for the Fall Detection is as follows: -

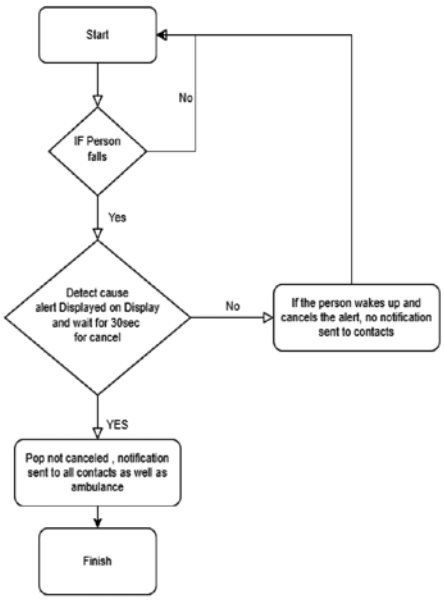

Fig. 3. Fall Detection Flowchart

SOFTWARE DEVELOPED

We Developed an Android/IOS APP For the user so that they can view their live data anytime they desire. Application has Features like live data monitoring, past medical history, store emergency contacts, SOS alert feature, complete data received from sensors. The app is designed in such a way that not the user but also his emergency contacts can access the live data for sensors like Heart-rate, accelerometer, and gyroscope.

All the data is uploaded to the MQTT server, which is publish-subscribe module. All this data is seen in the MQTT client mobile application. It displays all the data of accelerometer, heartrate sensor and GPS module. This data from the MQTT server is then transferred to google cloud firebase. Which then is transferred to mobile application.

In case a fall is detected then the app sends an alert to all the emergency contacts listed on the app. The alert will be continuously displayed on the screen of the contact till the person reads and responds to it.

The basic flow algorithm for the app: -

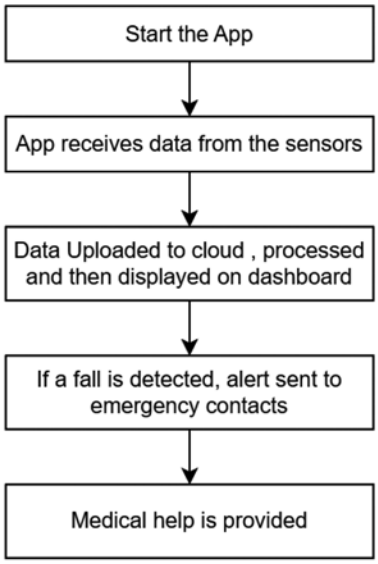

Fig. 4. App algorithm

The design of the app is very user-friendly, it consists of 4 main pages: - Login page,

Register page, Dashboard,

Individual Sensor Data.

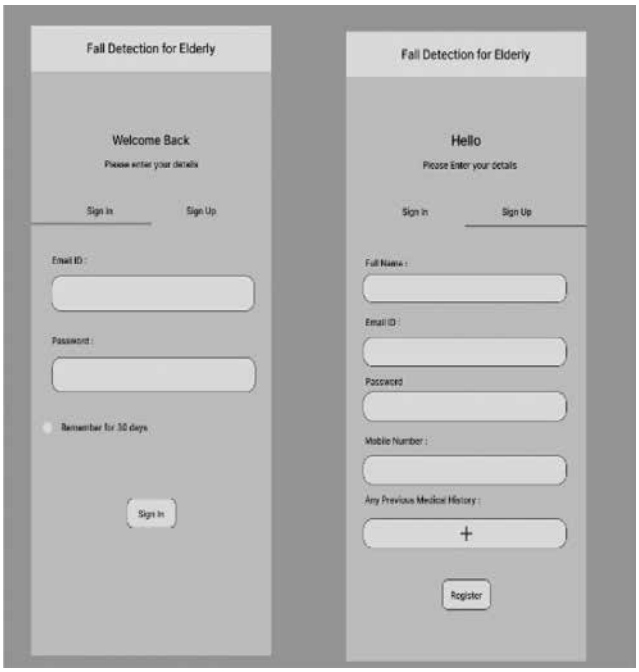

Fig. 5. Login and Registration page

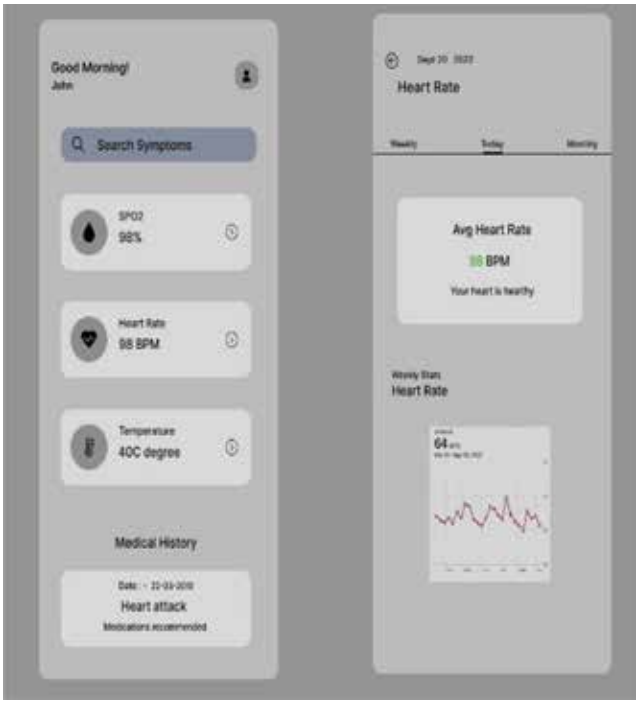

Fig. 6 Dashboarad and Sensor Data

The system was able to detect the fall while testing. The Device was able to detect the location and send alert to caregivers and emergency contact. If the fall is detected outside their home then a GPS location is sent in SMS.

Fig. 7 Screenshot of Alert log

CONCLUSION

From the above report we conclude that fall detection is a major concern among elderly people, the accuracy of the device is between is 90-95 percent so there can be false alarms. By developing and evaluating the IoT device for fall detection in elderly individuals, this research contributes to the growing body of knowledge in the field of elderly care technologies. The proposed device holds significant potential for improving the safety and well-being of elderly individuals by providing timely fall detection and alerting caregivers or emergency services for prompt assistance.

REFERENCES

1. Hariharan, A., Sourab , S., Varshini , V. S., Rajpal, I., & George, S. M. (2019, July). Remote fall detection system for the elderly. In 2019 2nd International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT)(Vol. 1, pp. 870 874). IEEE.

2. Santiago, J., Cotto , E., Jaimes , L. G., & Vergara Laurens, I. (2017, January). Fall detection system for the elderly. In 2017 IEEE 7th Annual Computing and Communication Workshop and Conference (CCWC) CCWC)(pp. 1 4). IEEE.

3. Gupta, A., Srivastava, R., Gupta, H., & Kumar, B. (2020, November). Iot based fall detection monitoring and alarm system for elderly. In 2020 IEEE 7th Uttar Pradesh Section International Conference on Electrical, Electronics and Computer Engineering (UPCON) UPCON)(pp. 1 5). IEEE.

4. Filgueiras , T. P., Torres, C. R. P., & Bertemes Filho, P. (2020, October). Low cost system for fall detection in the elderly. In 2020 IEEE 20th International Conference on Bioinformatics and Bioengineering (BIBE) BIBE) (pp. 697 700). IEEE.

5. Wang, X., Ellul, J., & Azzopardi, G. (2020). Elderly fall detection systems: A literature survey. Frontiers in Robotics and AI, 7, 71.

6. Aziz, O., Park, E. J., & Pullins, P. (2019). Fall Detection Systems for the Elderly: A Review of Challenges and Trends. Journal of Healthcare Engineering, 2019, 1-19. doi: 10.1155/2019/5189362

7. Pannurat, N., O'Neill, E., & Nugent, C. (2020). Fall Detection Systems for the Elderly: A Review of Challenges and Solutions. Sensors, 20(9), 2584. doi: 10.3390/s20092584

8. Hamdy, M., Karray, F., & Tahar, A. B. (2011). A Survey of Fall Detection Techniques. Aging and Disease, 2(4), 418-427. doi: 10.1016/j.jadohealth.2011.02.003

Designing of Efficient Pesticides Spraying Drone for the Agriculture use

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ABSTRACT

The use of drones for pesticide spraying is an emerging technology in modern agriculture, involving various other technologies. Manual application of pesticides has numerous negative effects on the individuals involved, ranging from minor skin irritation to severe consequences such as birth deformities, cancers, genetic alterations, blood and nerve diseases, endocrine disturbance, unconsciousness, or even fatality. The WHO calculated that 1M patient of illness were attributed to manual pesticide application on crop fields. To address these challenges, a spraying drone with specific components such as a 12 V distributor, a 1-liter container, atomizing spraying process component, and a suitable landing frame was developed. It also incorporates 4 (BLDC) motors with an appropriate propeller to generate the necessary thrust of approximately 38.2 KG (at 100% RPM), along with a 22000 mAh and 22.2 V Lithium-Polymer (LI-PO) battery for power Certainly! Here's the rephrased statement: Furthermore, users can install a FPV camera and transmitter on the drone, allowing them to monitor the spraying process and detect harm on plants. The integration of this PSD considerably decrease the time, worker, & expenses associated with Applying pesticides. Moreover, by adjusting the flow discharge of the pump, This drone has the capability to utilized to spray disinfectants over structures, Bodies of water, and densely Densely populated region, serving multiple purposes beyond pest control.

KEYWORDS *: Sensors, Pump, Spray, Pesticides, Quad copter*

INTRODUCTION

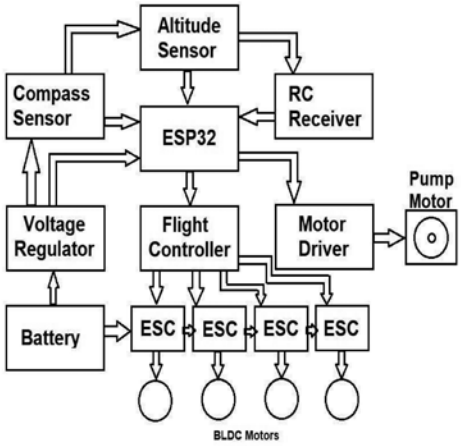
The implementation of fertilizers & pesticides in farming regions is crucial for ensuring high agricultural productivity, especially considering that the Indian agriculture industry contributes to a significant of the workforce. To efficiently manage the pesticide spraying process using unmanned aerial vehicles (UAVs), a smartphone app is employed. The UAVs receive data from a remote source, which in this case is the mobile app, enabling effective control and monitoring of the spraying procedure.. The value activates the sprayer, which is then managed by the remote (mobile app). It can be self-piloted or controlled by a pilot on the ground. Agriculture drones are drones that are used for agricultural purposes. It is also employed in the current situation for surveillance, traffic monitoring, and weather monitoring. India's main industry is agriculture. In our country, irrigated agriculture covers about 215.6 million acres of soil. According to the Economic Survey, the country needs to increase farm automation. Controlling pest infestation more effectively is important. Farmers are having a lot of trouble controlling pest infestation. Pests are unwelcome insects or diseases that obstruct human activity, bite, destroy food crops, or make life more difficult for farmers. Early pest detection and pest prevention are important aspects of crop management.

METHODOLOGY

The study's research approach is doctrinal, and a subjective research design has been utilized created to make it easier to examine farm drone technology. As part of the investigation, information was gathered on the many issues surrounding farm drones from a

variety of academic areas. This methodology focuses on reading secondary sources such publications, government papers, statutory texts, committee reports, legal histories, and digests.

Block diagram-



Status of Agriculture Drone Technology

Throughout Asia and the rest of the world, drone uses in agriculture are already very common. Their applications are restricted to industrial horticultural, agricultural, and forestry industries. Drones are being used for a variety of tasks, including spraying for weed control, insect-pest management, and disease prevention,dispersing pesticides and fertilizer, and planting new forests. The Directorate General of Civil Aviation in India issued the nation's first Civil Aviation Requirements (CAR) for drones on August 27, 2018, which would take effect on December

1 of that same year the June 2, 2020 publication of the Unmanned Aircraft System (UAS) Rules18 - Part VI in the Indian newspaper, regulate robot activity in that country and call for the acquisition of an automated aeroplane

2. To create a lightweight chassis and structure. administrator's licence (UAOP) for piloting UAS.

3. Put the UAV together using the required parts. Permission for each journey through the No

4. To construct an appropriate quad copter with Permission stage of the Online Digital Sky reliable flight control. Consistency of No Take-Off (NPNT).

5. To create a system for spraying and regulating

Objectives- The main objectives include: several parameters, such as drone speed and

6. To find a cost-effective UAV payload carrying spraying speed control. solution (up toThe 3kg total weight of the vehicle).

7. To aerially apply insecticides or fertilizers to crops

Payload Estimation

By weighing the liquid, a container with a 1 Liter volume, the pump, and the nozzles, the payload's weight may be estimated.

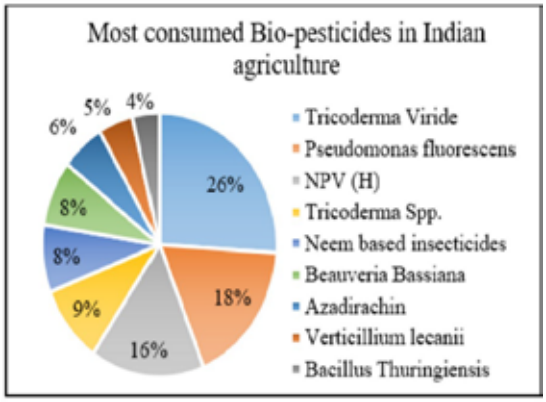


Fig. 1. Most consumed bio-pesticides in India (2019-20)

Table 1: Earlier Calculations

PART	WEIGHT (gram)
1 Liter liquid	1000
Liter liquid tank	250
Pump	50
Nozzle	200
Total	1500

Components

BLDC Motor

Fig. 2. BLDC Motor

This particular motor is designed specifically for quadcopters and multirotor applications. It features a brushless (BLDC) outrunner configuration and operates at a 1400kV rating. This motor offers exceptional performance, impressive power output, and remarkable efficiency.. The motor can be driven by the 30A ESCs. BLDC motors ,instead of brushes uses permanenet magnet with outside runner. The input current can be changed using the motor RPM. This engine TMOTOR The maximum thrust is achieved with an MN 7005 KV115 and P24x7.2F propeller at 4783

ESC

The Electronic Speed Controller (ESC) plays a vital role in managing the Brushless Direct Current (BLDC) motors. It receives signals from the microcontroller and divides them into three parts, transmitting each segment to the corresponding BLDC motor. Since we are utilizing four BLDC motors, four ESCs are required. The ESC generates three high-frequency signals with adjustable phases to ensure continuous spinning of the motors. Additionally, as the motors can consume significant power, the ESC is designed to handle large current loads. The ESC, short for Electronic Speed Controller, is responsible for regulating the motor's Revolutions Per Minute (RPM). In this setup, a 60A rated ESC is chosen based on the requirements of the motor and battery.

Fig. 3. Electronic Speed Controller (ESC)

Lino Battery-

Fig. 4. Lithium Polymer battery

A Lithium Polymer battery with a capacity of 22000mAh and a voltage rating of 22.2 V may be utilized this battery contains. The connection involves six Li-Po cells. series (6x3.7=22.2V).

Fly sky fi6

Fig. 5. The Fly Sky

The Fly Sky CT6B 2.4GHz 6CH transmitter and FS-R6B receiver are utilized in this setup. This configuration provides a range of approximately 1000 meters. With this specific transmitter and receiver combination, users have access to up to 6 channels for control and communication purposes.

Propellers

Fig. 6. Propellers

The propeller used in this setup has a pitch of 7.2 inches and a length of 24 inches. Unlike plastic propellers that have a lower strength-to-weight ratio, this propeller is constructed using carbon fiber, which offers enhanced durability and strength relative to its weight..

Water pump & Nozzles

A 12V DC water pump with a flow rate of 2.5 L/min can be utilized to apply pressure to the liquid. The liquid is then pressurized accordingly. then sprayed through a chosen nozzle. For this purpose, a flat fan-style nozzle can be used as an option. To distribute the spraying evenly, four The liquid is expelled through the nozzles. positioned The distance between the nozzles is 45 cm. each The nozzles are connected to each other. through ducting.

Fig. 7. Water pump and Nozzles

RESULTS

Weight Accumulation

Table 2. Datasheet of Component Weights

Part	Mass (gram)
Structure	600
Motor	320
Propeller	60
Flight controller	20
Battery	2472
ESC	116
Total	3588

To determine the overall weight of the drone, the weight of its components and payload are combined.

The total weight is calculated by adding the payload weight to the weight of the components.

= 1500+ 3588

= 5088 grams (approx.)

Thrust Calculation

By reducing the overall weight of the drone, maneuverability and thrust can be significantly improved. In fact, at 100% RPM, the thrust developed can be three times greater compared to a heavier configuration.

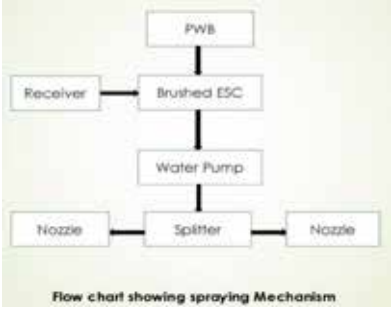


Fig 8. Flow Chart

A higher rate of climb and the ability to reach greater altitudes can be achieved by the drone when it is equipped with a propeller and motor combination that generates a thrust of The total weight is 4783 grams. The total thrust produced is calculated by multiplying 4 by 4783, resulting in 19132 grams. The thrust-to-weight ratio is determined by dividing the thrust produced by the total weight.

weight of drone = 19132 /

= 3.01 : 1

Battery Drain Time Calculation- To ensure sufficient time for complete tank emptying and subsequent refueling, it is advisable for the drone's battery depletion duration to exceed 10 minutes. It is important to consider the distance and time required for the drone to return safely when calculating the battery drain time, in order to error on the side of caution.

Table 3. Specifications

Component	Current
Motor	120 amp
Receiver	150mA
Flight controller	250 mA
ESC	30mA
ESP32A Main controller	250mA
Transmitter	6 v 0.05A
Pump	12v 1 A
Total	121.73 Ampere

The current output from the battery is 22000 mAh (milliampere-hours). The total current consumption of all components is 121.73 A (amperes).

To calculate the battery endurance, we can use the formula:

Battery endurance = Current output from battery / Total current consumption of all components Substituting the given values:

Battery endurance = 22000 mAh / 121.73 A To convert mAh to hours, we divide by 1000:

Battery endurance = (22000 / 1000) Ah / 121.73 A Simplifying the equation:

Battery endurance = 22 Ah / 121.73 A

To convert hours to minutes, we multiply by 60:

Battery endurance = (22 * 60) / 121.73 A

The calculated battery endurance is approximately 10.84 minutes when the throttle is at 100%. Please note that this estimation assumes a constant and uniform current consumption throughout the entire duration of the battery. Real- world conditions may vary, and it is important to consider other factors such as flight conditions, battery efficiency, and any power fluctuations during operation.

CONCLUSION

Agricultural drones have the potential to significantly enhance agricultural productivity, transforming the agribusiness sector in the process. Farmers can leverage the benefits offered by these drones to improve their understanding of soil and plants, optimize input efficiency, and achieve economic and environmental advantages, thus promoting sustainability. However, in order to ensure efficient implementation, several critical factors such as configuration, weight, payload capacity, flying range, and costs must be carefully considered. Cost-effectiveness becomes evident when UAVs are utilized to cover vast land areas. Nonetheless, there is still a need for advancements in battery life to enhance payload capacity and flying autonomy.

FUTURE SCOPE

In the midst of the ongoing COVID-19 pandemic, drones can serve as valuable tools for sterilizing large hotspot sites without the need for physical presence. By leveraging GPS technology and incorporating an automatic return home feature, manual control can be transformed into autonomous control, enhancing operational efficiency. Moreover, with the aid of image processing techniques, drones can be utilized for surveillance purposes, enabling the detection of Pest attacks on plants and crops can have significant implications for agricultural productivity and food security. monitoring the ripening state of fruits. This application proves to be beneficial in maintaining agricultural productivity and ensuring effective crop management.

REFERENCES

1. Prof. P. Mone, Chavhan Priyanka Shivaji, Jagtap Komal Tanaji, Nimbalkar Aishwarya Satish, “Agriculture Drone for Spraying Fertilizers and Pesticides”, Sept 2017, International Journal of Research Trends and Innovation, ISSN 2456- 3315, Volume 2, Issue 6.
2. Prof. B.Balaji, Sai Kowshik Chennupati, Siva Radha Krishna Chilakalapudi, Rakesh Katuri, kowshik Mareedu, “Design of UAV(Drone) for Crops, Weather Monitoring and For Spraying Fertilizers and Pesticides.”, Dec 2018, IJRTI, ISSN: 2456-3315.
3. Prof. Swati D Kale, Swati V Khandagale, Shweta S Gaikwad, Sayali S Narve, Purna V Gangal “AgricultureDrone for Spraying Fertilizers and Pesticides” ,Dec 2015, ISSN 2277 128X .
4. N. N. Thune and S. L. Haridas, “4D-8PSK trellis coded modulation for high speed satellite communication,” 2016 IEEE International Conference on Advances in Electronics, Communication and Computer Technology (ICAECCT), Pune, India, 2016, pp. 469-473, doi: 10.1109/ICAECCT.2016.7942634.
5. Thune, Neeta Nitin, and Sanjay Haridas. “Low Power Trellis Coded Modulation (TCM) Decoder by Using Modified Resource Sharing Method for IoT Enabler.” vol.11, no.1 2022: pp.1-9. http://doi.org/10.4018/IJECME.312260
6. N. Jori and N. Thune, “An Sensor Node Energy Improvement In-Network for Wireless Sensor Network,” 2015 International Conference on Computing Communication Control and Automation, Pune, India, 2015, pp. 88-94, doi: 10.1109/ICCUBEA.2015.24.

Blockchain based E-Voting System: A Decentralized Platform for Secure Voting

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ABSTRACT

Democracies have long faced difficulties in creating an electronic voting system that efficiently meets the demands and criteria of delegates. Conducting free, orderly, and fair elections is the primary goal of any democracy, but traditional voting systems are frequently troubled by centralization and control by a small number of institutions. This is a serious security risk since the party in complete control of the system can manipulate the database. This issue may be addressed by blockchain technology, which is a decentralized system that is managed and owned by several individuals. This is equivalent to the Bitcoin system's decentralized financial system. By incorporating blockchain into the distribution of databases used in electronic voting systems, it is feasible to reduce the danger of fraud caused by database modification. The suggested method described in this study records the outcomes of each voting location using blockchain algorithms. In contrast to Bitcoin's Proof of Work method, the suggested alternative focuses on pre-defined system power-ups for each node in the blockchain. Additionally, this approach provides the ease of online voting, allowing voters to cast their ballots at any time and from any location, improving voter turnout. Overall, the security, dependability, and accountability of electronic voting systems might be greatly improved by using blockchain technology. It offers a more effective and open voting method while lowering the possibility of fraud and manipulation by dividing the database among numerous us.

KEYWORDS *: Blockchain, Ethereum, Smart contracts, E-Voting, Solidity.*

INTRODUCTION

The voting process is conducted in a centralized manner in our nation. The centralized voting processes lack a lot of trustworthiness. Elections are necessary for a democratic country's system to function properly, as we all know. Since many external factors may have an impact on the county's administration and processes, the arrival of internet technology in the current circumstances has also made the election process fair more crucial than before. It is painful for the average citizen when authoritarian governments are present or have been in many countries in the past. The common people's basic human rights and the freedom guaranteed by their constitution have been violated. Given the circumstances, a fair and rational electoral system is necessary for the proper expansion and advancement of the country. Furthermore, a trustworthy electoral process can foster peace and avoid political squabbles. The term "Blockchain Revolution" describes the idea of decentralised records, in which transactions are recorded across multiple network nodes as opposed to a single central server. Bitcoin's launch in 2009 is credited with popularising the idea of paperless, digital financial transactions utilising tangible assets, even though the concept of blockchain technology has existed since the 1980s. In the absence of centralised controllers, the basic worth of these assets and currencies is still up for question. Equations on the blockchain are the building blocks for its evolution. The development of Internet technology has increased the importance of elections, which are essential to the operation of a democratic country. External forces may affect the governance and practises of a county, highlighting the significance of fair and transparent

election processes. Authoritarian administrations, which hurt the average citizen by denying them freedom and basic human rights, have existed in many countries or do so today. Therefore, a fair and rational electoral system is essential for the nation's proper growth and development. Election voting machines (EVMs) in India have come under fire for their irregularities and potential weaknesses to hacking and tampering. Additionally, various weaknesses in the current voting procedures are exploited to seize control, leading to voter fraud, ballot fraud, and booth capturing. All of these issues erode confidence in the electoral process. However, incorporating internet-based voting systems has gained significant popularity in India recently, in one district of the Telangana State Election Commission is conducting trials of a mobile-based electronic voting application. Increasing the fairness, accountability, and transparency of the voting process might be able to fix these problems with the current electoral system.

In India, there was a ballot paper technology that allowed voters to cast their ballots entirely on paper before 2004. Voters have to go to polling locations and confirm their seal was used to help voters cast their ballots by placing it in front of the image of the politician they were supporting. The votes have been counted, and the results have been announced. The winner was chosen based on the number of votes received. India has a population of more than 1.2 billion people, yet voting on paper is not very trustworthy, takes a lot of time, and is very difficult to count. Additionally, there are issues like damaged vote paper, and containers with duplicate markings, stamps, and seals for many candidates, therefore there may be a strong desire to overcome those issues. Electronic voting machines were introduced to address these issues and provide better alternatives.

EVMs have two specific components:

1. Control Unit: It stores and assembles ballots and is used by poll workers.
2. Ballot Unit: It is located inside the electoral sales area and is used by voters.

To counter the problems mentioned above many organizations and individuals have proposed ideas for voting systems and elections that will work based on blockchain technology to make a foolproof system, this topic is being heavily researched and there are already many proposed and implemented systems, and also research around this topic like, in 2022 S. Tandon, N. Singh, S proposed a system [1] a physical approach was utilized rather than an online one using IoT, here the voter has to go on-site for voting and the authentication happens using the thumbprint of the voter, the system then checks if the user has already voted, if not then the user can vote, this vote is then stored in the Blockchain. The authors of "A Research Paper on E-Voting Using Blockchain Technology" [2] To eliminate bogus (fake) voting, have proposed a system in which one can cast their vote using their fingerprint, iris, or an OTP. The results will be available within a fraction of a second. In the system described by Pradeep Katta in 2021 [3] A VID (Voter ID) and the block's location are returned to the voters by the smart contract when a voting block is formed to ensure that their vote has been added and counted in the chain without alteration. The setup and use of this system are a little challenging. In the proposed by Syada Tasmia Alvi [4], some level of autonomy was intentionally removed by the authors, and the privileges were given to an 'Admin' to increase the trust in the system, so in this case, the whole voting process is organized by the admin with no comprise to the functionality. A unique authorization based on the UIDAI's 12-digit Aadhaar number which makes it easy to identify the user and verify their vote was proposed in 2019 [5]. But utilization of this method for such a large population where literacy has still not reached the masses is quite challenging. A survey on this topic was published by G Bhavan [6] where he talked about the AES technique is used to encrypt data, which is a one-of-a-kind method. This research also looks into using a blockchain algorithm for recording the outcomes of elections across each location. The use of the AES technique is not feasible for large-scale voting. The authors of "A Fair and robust voting system by Broadcast", [7] have defined the smart contract in the election. So, in their network, a decision is made by participating nodes in agreement. When the smart contract and blockchain communicate, the vote is added if the code matches. Once a voter has cast a ballot, they are not permitted to do so again. To address the trust difficulties, David Khoury and co-authors [8] have developed a novel blockchain-based strategy for

a decentralized trustless voting network. The primary feature of this system is the imposition of one vote per mobile number for each poll, with confidentiality assurances. Though this system is not certain about vote authentication, security can be compromised in such a system. According to the article "A Brief Analysis of Blockchain Algorithms and Its Challenges" [9] Blockchain functions as a ledger, allowing transactions to be carried out in a decentralized manner. This paper focuses on a wide range of blockchain-based applications from a variety of industries, including the financial services sector, the government, non-financial, Internet of Things (IoT), and others. In the research presented by Bhushan M. Pawar and co-authors in 2020 [10] creates a student registration ID, for each voter is confirmed. This safeguards the system from proxy voting because only distinct IDs are permitted. The system will be simple to use, inexpensive, and quick to obtain. To serve large-scale voters at the national level alternative to student registration ID is required [11]. According to the paper published in 2020, will assist us in lowering the high cost of voting, the length of time needed to perform the election, and it also streamlines the entire voting procedure [12]. In order to prevent such dire situations, a system that is distributed, decentralized, and accessible at all times. The author of article "Blockchain and Aadhar based Electronic Voting system" [13] According to research paper title "blockchain based E-voting Recording system", The proposed sequence is used in this system's blockchain creation process to ensure that all nodes are legally connected and can avoid colliding during transportation [14]. To stop fraudulent (false) voting, they have developed a method where voters can cast their ballots using their fingerprint, iris, or an OTP published in 2021 [15]. The idea behind creating and implementing a blockchain-based e-voting system addresses the bulk of the drawbacks of current e-voting systems and offers promising research projects.

PROPOSED METHODOLOGY

Proposed Architecture

Our work is dedicated to providing a secure and transparent online voting platform for college-level elections. We understand the importance of trust in the voting process and believe that a secure and trustworthy system is crucial in ensuring the integrity of the democratic process. To achieve this, we have implemented blockchain technology and Ethereum to ensure the decentralization and protection of data shown in Fig. 1. The tools and technologies used in this project include MetaMask, Ethereum, and Solidity. Ethereum is a decentralized platform for building blockchain applications and smart contracts. Solidity is a statically typed programming language designed for use with the Ethereum virtual machine (EVM) to build smart contracts. A Blockchain refers to a decentralized ledger technology where information is stored in a secure and transparent manner across a network of nodes. The data is recorded in digital form and shared among all participants in the network, eliminating the need for a central authority and third-party intermediary, hence it is decentralized. While blockchain technology guarantees the confidentiality and security of voter data, the Ethereum blockchain is essential in facilitating safe and effective voting. This is crucial since the information gathered during the voting process is extremely sensitive and needs to be secured from manipulation or unauthorised access. By utilising Solidity to create the smart contracts for this project, the voting code is guaranteed to be transparent and auditable, thus enhancing the security characteristics and functionality of the system.

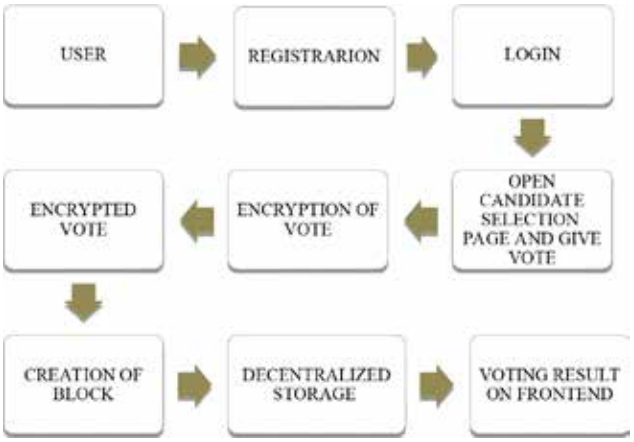


Fig. 1. Block diagram of the voting system

In this proposed system, Participants must access these machines with a college ID card and will receive a login ID and password. Once logged in, they can put their votes in a grid for the candidate of their choice. The voting process is secure as each vote is encrypted and stored in

the blockchain, making it tamper-proof and unalterable by central authorities. The results will be monitored by an administrator and released on a predetermined date. Ethereum blockchain plays a vital role in the secure and efficient elections, while blockchain technology ensures voter data protection and security This is especially important as the information collected during the voting process is critical and must be protected from tampering or unauthorized access. By using Solidity to create the smart contracts for this project, the rules used in the voting process are visible and auditable, boosting the security and dependability of the system.

Working of Blockchain

Blockchain technology is secure and decentralized ledger that records transaction over a network of computers. It keeps a constantly expanding list of records, known as blocks, that are linked and safeguarded via cryptography. Each block comprises a cryptographic hash of the preceding block, a timestamp and transaction data.

Once a block of data has been added to the blockchain, it cannot be removed or changed without the network's approval. Figure 2 depicts the blockchain's block structure. Due to the fact that any attempt to alter one block would also alter all subsequent blocks, which can be instantly detected by other network users, the blockchain is therefore very difficult to hack and tamper with. Nodes, or members of a blockchain network, work together to confirm transactions and add them to the blockchain. When a new transaction begins, a broadcast is sent to every node in the network. The nodes then examine the transaction's validity and the quantity of funds that the transaction's initiator has available. The addition of a transaction to a block, which is then broadcast to the whole network and added to the blockchain, occurs once the majority of nodes concur on the transaction's legitimacy. The hashing algorithm is shown below in Fig. 3.

Smart Contract

Blockchain-based smart contracts are applications that launch when certain criteria are satisfied. They are typically employed to automate the execution of a contract so that all parties can be certain of the result right away, without the need for a middleman or needless delay. They can also automate a workflow such that it performs the next action when a set of criteria are met. Simply writing the words "if/when...then" into code and storing the results on a blockchain is how smart contracts operate. A network of computers will execute the activities once specified conditions are confirmed to be met. When the transaction is finished, these options include making the required payments, registering a vehicle, sending out reminders, or writing a ticket. Consequently, the transaction cannot be changed. As many terms as are necessary to assure the parties that the task will be completed can be included in a smart contract. The criteria must be defined by participants who choose the "if/when...then" rules that apply to those transactions, take into account any possible exceptions, and establish a procedure for resolving disputes. The representation of transactions and associated data on the blockchain must also be decided by participants.

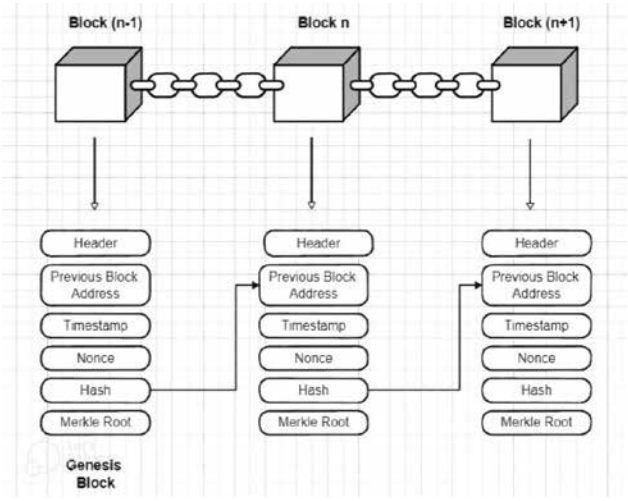


Fig. 2. Working of Blockchain

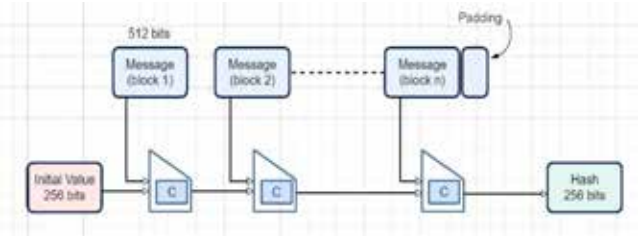


Fig. 3. SHA-256 Algorithm

MetaMask

The Ethereum Blockchain can be communicated with by MetaMask users who use bitcoin wallets. With the use

of MetaMask, users may control and store their account keys in addition to trading Ethereum-based tokens and cryptocurrencies. Users can use a web browser or the built-in browser app on their mobile device to connect to decentralised networks. As a result, the website can use MetaMask as a middleman to send the user motion cues, signature requests, and transaction requests. Working of MetaMask Wallet shown in Fig. 4.

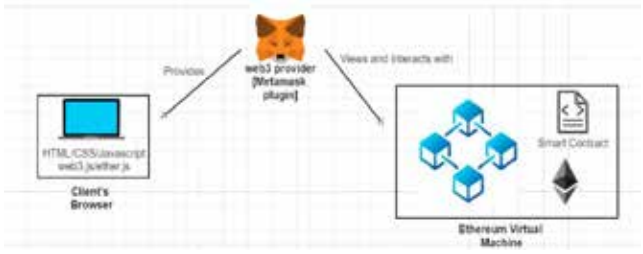


Fig. 4. Working of MetaMask

The JavaScript plugin Web3js enables developers to establish connections between a decentralised network and MetaMask. Ethers are utilised as gas to execute transactions between MetaMask and smart contracts. As seen in "Fig.5", users of blockchain technology can use MetaMask to manage their wallets. By utilising the browser plugin, users can use the wallet and carry out online transactions. After a transaction is finished, a MetaMask that asks the user to confirm the activity appears. Blockchain users can use MetaMask to manage their wallets. By utilising the browser plugin, users can use the wallet and carry out online transactions. After a transaction is finished, a MetaMask that asks the user to confirm the activity appears.

Ethereum Virtual Machine

A runtime environment for Ethereum's smart contracts is offered via the Ethereum Virtual Machine (EVM). The system is divided from it, and it is sandboxed. This implies that your data or programmes should remain unchanged regardless of how frequently you call a certain EVM function. Scripts are often used to carry out certain tasks in the Ethereum blockchain and are executed by a programme known as the Ethereum Virtual Machine (EVM). Thanks to the Ethereum Virtual Machine, creating new tokens on the Ethereum Blockchain is simple. Figure 6 depicts the Ethereum Virtual Machine's architecture or operation. The term "script" in this case refers to an algorithm or set of instructions that tells a computer what to do in order for something to perform properly. The EVM requires access to any network node in order to run the necessary commands and quickly produce new tokens on the blockchain.

Ethereum Virtual machine has two sections:

- EVM (the component that executes the Solidity source code)
- Uncles

Fig. 5. MetaMask Wallet

Ether.js

The ethers.js library's objective is to offer a complete and portable toolkit for interacting with the Ethereum Blockchain and its ecosystem. It was initially intended for use with ethers.io, but it has subsequently evolved into a more general-purpose library. You know to acquire data from the blockchain and write new transactions that you need to connect to a node if you want to build a website that communicates with the blockchain's nodes so that you can interact with the smart contracts.

Initializing a connection to the blockchain nodes can be done in a variety of methods, including directly from a webpage in your web browser, software on your computer, or a back- end server. Any of these items can set up a connection to a specific node on a blockchain and begin utilizing it to publish new transactions and receive data about crypto currencies and NFTS. You could use it to build a website that supports fully decentralized applications.

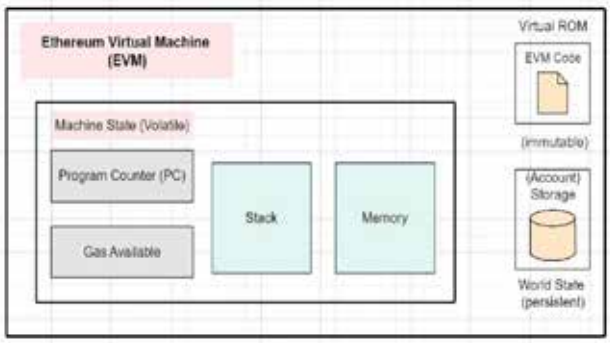


Fig. 6. Working of Ethereum Virtual Machine

MongoDB

MongoDB is a distributed, open-source, cross-platform document-based database designed to facilitate the creation and scaling of applications. MongoDB Inc. created this NoSQL database. MongoDB is not an RDBMS (Relational Database Management System). It's known as a "NoSQL" database. It differs from SQL-based databases in that it does not normalize data under schemas and tables, and each table has a set structure. Instead, data is stored in collections as JSON-based documents, with no schemas enforced.

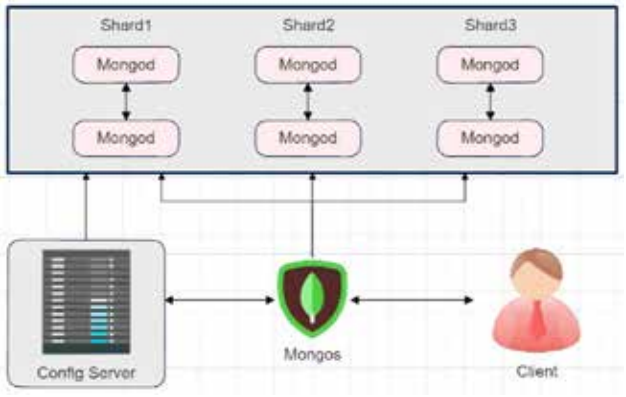
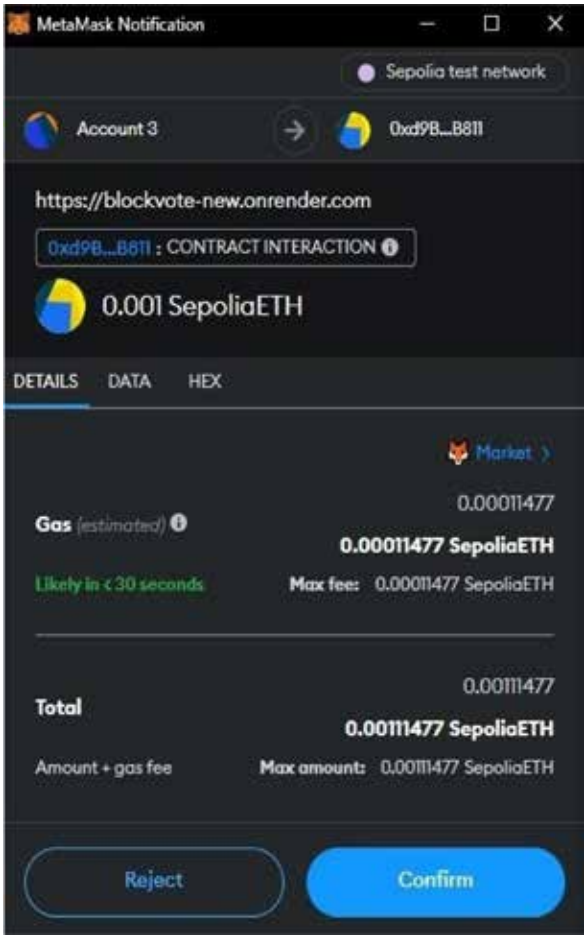


Fig. 7. Structure of MongoDB Database

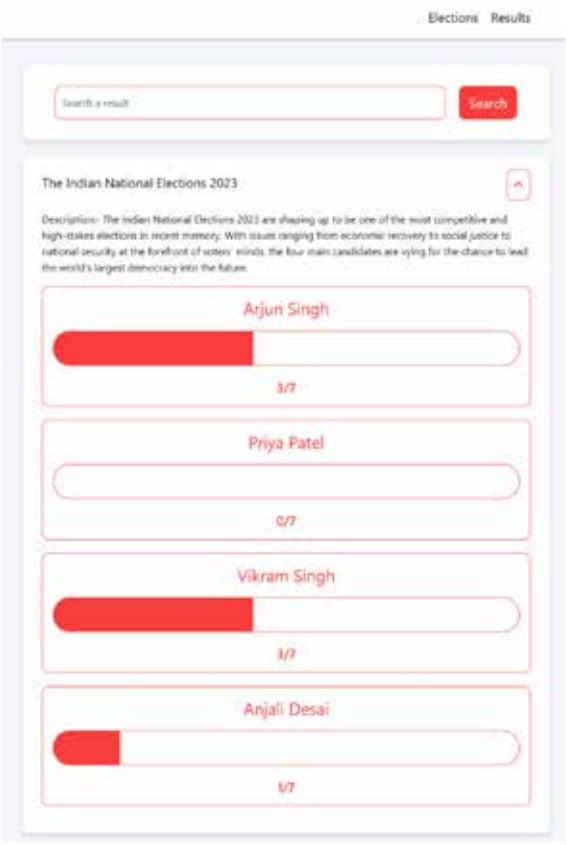
MongoDB does not have the tables, rows, and columns observed in other SQL (RDBMS) databases. The structure of MongoDB specifies in Fig. 7. The data is kept in these databases, which use MongoDB as their database server. Or, to put it another way, the MongoDB environment provides you with a server that you can launch and use to host several databases utilizing MongoDB. The data is saved in the collections and documents because of its NoSQL database. As a result, as illustrated below, the database, collection, and documents are related to one another.

RESULT

In this work, we have successfully created a Decentralized E-Voting system by integrating Web3 Technologies with ReactJS, The experimental result obtained in this research are as follows:



(a)



(b)

Fig. 8. (a) Vote Transaction through MetaMask (b) Result Page

After Logging in and entering the elections page the user will come across a list of active elections where the user has to choose the election and candidate to vote in, immediately after clicking the vote button a MetaMask prompt will appear as shown in Fig. 8(a) that will ask the user to confirm the Transaction of 0 With an immediate electoral count, the implemented method is made to be swift, effective, and user-friendly. One of the aims behind designing this blockchain based voting system is to reduce the time required for obtaining the result. This problem is overcome in our project result within a fraction of a second.

CONCLUSION

The electronic voting method described in this paper provides a solution to the majority of issues with conventional voting practices. By leveraging the Internet, this device offers citizens a convenient and secure option to cast a vote at any time and from any location. The blockchain concept makes sure that the data is maintained in chronological order and that no crucial authority has the power to influence the outcome of the vote. This develops a transparent and open-source voting platform that is easily accessible to all citizens. The proposed gadget has a direct electoral depend and is designed to be fast, effective, and user-pleasant. This eliminates the want for manually counting and decreases the time and sources required for disclosing election outcomes. Moreover, the system is intended to be available from any tool that has internet connectivity, ensuring that electorate i.e., all residents can take part inside the vote casting technique no matter their technological abilities. The implementation of this device represents a vast leap forward in modernizing the electoral process. By making balloting extra convenient, green, and stable, it encourages extra participation and ensures that every vote is correctly counted. This gadget offers a extra realistic and efficient way of carrying out elections, and its substantial adoption has the ability to enhance the democratic method globally.

REFERENCES

1. S. Tandon, N. Singh, S. Porwal, Satiram, and A. K. Maurya, "E-Matdaan: A Blockchain based Decentralized E-Voting System", 2022 IEEE Students Conference on Engineering and Systems (SCES), 2022, pp. 1-6, doi: 10.1109/SCES55490.2022.9887759.
2. Tanikella Sai Charan, Srinanda Pentapati, Mrs. R. Prema, "A Research Paper on E-Voting Using Blockchain Technology", in International Research Journal of Engineering and Technology (IRJET) March 2022, India.
3. Pradeep Katta, Mohammed Oviaz, Prabaakaran, Divya, Jayashree, Keerthika, "Smart voting using Fingerprint, Face and OTP Technology with Blockchain" in Institute of Physics (IOP) February 2021, India.
4. Rajalakshmi Krishnamurthi, "A Brief Analysis of Blockchain Algorithms and Its Challenges", Issue January 2021, ResearchGate
5. Syada Tasmia Alvi, Mohammed Nasir Uddin, Linta Islam, "Digital Voting: A blockchain based E-voting system using Biohash and smart Contract", in IEEE Third International Conference on Smart Systems and Inventive Technology (ICSSIT) 06 October 2020, India.

6. Bhushan M. Pawar, Sachin H. Patode, Yamini R. Potbhare, Nilesh A.Mohota, " An Efficient and Secure Students Online Voting Application" Issue 8-10 Jan. 2020, IEEE

7. Spurthi Anjan, Johnson P Sequeira, "Blockchain based E- voting system for India using UIDAI's adhaar", in Journal of Computer Science Engineering and Software Testing by MAT Journals September 2019, India.

8. David Khoury, Elie F. Kfoury, Ali Kassem and HamzaHarb, (2018), "Decentralized Voting Platform Based on Ethereum Blockchain

9. G Bhavan, I, (2018), "Survey on Blockchain Based E-Voting Recording System Design".

10. D. Khader, B. Smyth, P. Y. Ryan, and F. Hao, "A fair and robust voting system by broadcast", in 5th International Conference on Electronic Voting, Vol. 205, pp 285-299, 2012.

11. Raghav Chhabra, Uday Vohra, Vishrant Khanna, Aditya Verman,Poonam Tanwar, Brijesh Kumar, " The Next Gen Election: Design and Development of E-Voting Web Application", Issue 10-12 June 2020,IEEE

12. Amit Kumar Tyagi Terrance Frederick Fernandez Aswathy S U. " Blockchain and Adhar based Electronic Voting system" IEEE 2020.

13. Rifa Hanifatuunisa and Budi Rahardjo (2017) "blockchain based E-voting Recording system"

14. David Khoury,Elie F. Kfoury, Ali Kassem and Hamza Harb "Decentralized voting platform Based on Ethereum Blockchain" in ICCCEBS Journal of Physics: Conference Series 2021.

15. Moura, Teogenes, and Alexandre Gomes. "Blockchain voting and its effects on election transparency and voter confidence." In Proceedings of the 18th Annual International Conference on Digital Government Research, pp. 574-575. ACM, 2017..001

Cyberbullying Detection on Social Media using Machine Learning

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ABSTRACT

The internet is plagued by a significant issue known as cyberbullying, which has negative impacts on both teenagers and adults. It can result in tragedies such as suicide and depression, highlighting the need for increased regulation of social media platform's content. To address this problem, we used natural language processing (NLP) and machine learning to build a model that detects instances of cyberbullying within text data gathered from two sources: hate speech tweets from Twitter and personal attack comments posted in Wikipedia forums. The study focused on testing different feature extraction methods along with four classifiers to determine optimal performance levels based upon accuracy rates above 96% for tweet data results while Wikipedia data came back at above an 68%.

KEYWORDS *: Cyberbullying, Support vector machine (SVM), Machine learning, Random forest, Decision tree.*

INTRODUCTION

More than ever, technology has completely permeated our daily lives how the internet evolved social media is very popular these days [1]. However, like everything else, villains can come later, and they still exist. Cyberbullying is a widespread problem today; social networking websites are excellent resources for human communication [2]. Although social networks have become more popular over the years, most people still use them in unethical and immoral ways [3]. This often happens to teenagers and even young adults. Bullying each other online is he one of their harmful behaviors. On the Internet, it's hard to tell if someone is saying something just for fun or if they have some other motive [4]. Often, jokes and advice to "don't take things too seriously" are enough to make you laugh. The use of technology to attack, harass, threaten or humiliate others is known as cyberbullying [5]. This online conflict often turns into a threat to some people in real life. Suicide was used by certain people. Initially, these actions should be stopped. Whatever steps are taken to prevent this, for example, if a person's Tweets or posts are deemed inappropriate, their account may be closed or suspended for a period of time [6].

Machine literacy is a form of artificial intelligence that enables computers to learn from data and ameliorate their performance without being explicitly programmed [7]. By using statistical algorithms and models to dissect data, machines can learn patterns and make prognostications or opinions grounded on that literacy [8]. Data mining involves rooting precious information from large datasets, while Bayesian prophetic modeling uses probability proposition to make prognostications grounded on data. Machine literacy has numerous operations in different diligence, similar as entertainment where platforms like Netflix use it to offer individualized recommendations grounded on a stoner's viewing history [9]. It's also used to automate tasks and make prognostications in areas like fraud discovery, prophetic conservation, and portfolio optimization [10].

Machine literacy is one of the most popular supervised learning algorithms. It is used for both classification and regression problems, but mainly for machine learning classification problems. The SVM algorithm is used to create decision boundaries. The optimal decision boundary is called a hyperplane. A hyperplane is created by her SVM picking vectors. The extreme case is called SVM.

A number of decision trees contain random forest classifiers for different subsets of a given data.

Averaging is also necessary to improve the accuracy of the data. Rather than relying on decision trees based on majority votes, Random Forest takes the predictions of the trees and from them predicts the final output. A higher number of trees improves accuracy and also prevents overfitting problems.

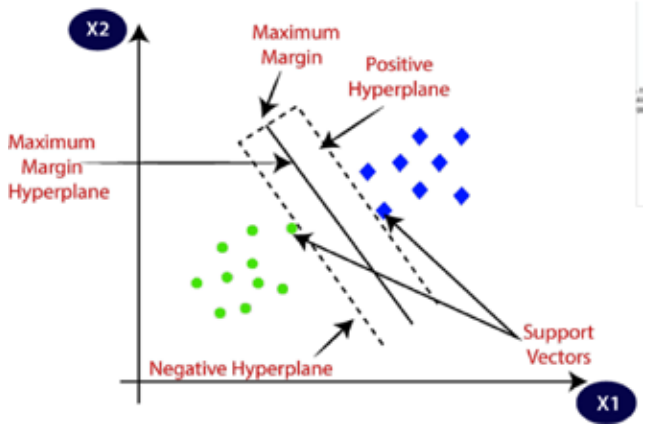

Figure 1. Support Vector Machine Algorithm

A resolution tree is a type of classifier that uses a tree-suchlike structure, where the internal bumps represent characteristics of the data set, branches indicate resolution regulations, and splint bumps represent the final effects [11]. The resolution tree is made up of two manners of bumps- resolution bumps and splint bumps. The resolution bumps are responsible for making opinions and have multitudinous branches, while splint bumps are the final issues of those opinions and don't have farther branches. The resolution is made by assessing the characteristics of a personal data set.

The name resolution tree comes from its commonality to a tree, where the root knot represents the starting point and other branches expand to make a tree structure. To produce the tree, the CART algorithm (Bracket and Retrogression Tree Algorithm) is generally exercised [12]. A resolution tree operates by asking a question and also unyoking into subtrees grounded on the rejoinder given away (yes or no).

Jamil H. et al. [13] has paper described the implementation of a social network model called Green Ship, which has a reputation for providing safe, "green" friends and restricting access to harmful information. Green Ship can help users fight against online bullying and loss of traditional, online, and social networks. The model recognizes different types of friendships on Facebook and limits damage caused by bad friends through complex communication lines that prioritize privacy and control.

The paper by Rasel, Risul Islam, et al. [14] proposed a model to analyze comments on social networks and determine whether they are offensive or hate speech with over 93% accuracy. The model utilizes Latent Semantic Analysis (LSA) as a feature selection method to reduce input data size, as well as tokenization and TF-IDF for feature extraction. Three machine learning models, including Random Forest, Logistic Regression, and Support Vector Machines (SVMs), were used for analysis and prediction of teasing comments.

Jaideep Yadav et al. [15] proposed a revolutionary pretrained BERT model built by Google researchers that provides contextual and task-specific embeddings. The suggested method employs a deep neural network known as the Transformer as the basic model. The Bert is built on top of a base model and has 12 layers to encode the input data. The data is tokenized and padded appropriately before being fed into the model, which produces the final embeddings. The classifier layer categorizes the embeddings produced by the previous layers and produces the final output accordingly. In compared to earlier models for detecting cyberbullying, they were able to get efficient and stable results using a pre-trained BERT model.

PROPOSED SYSTEM

In this work, cyberbullying detection is resolved as a binary classification problem that recognizes two major's forms of cyberbullying: Hate speech on Twitter and Personal Attacks on Wikipedia and its classification as containing them, is it cyberbullying?

The methodology used for solving the problem which is applied on both the datasets.

A. Twitter Hate Detection

The dataset handed consists of 6935 data points or compliances, each having three columns. The first column, which is the unique identifier, is used to separate each data point from the others. The alternate column contains markers with two possible values 1 or 0. Then, the value 1 indicates that the comment

made is obnoxious, while the value 0 indicates that the comment is non-offensive. The third column is the factual comment made. The main thing of separating the dataset is to identify a system that can distinguish between obnoxious and non-offensive commentary in the most effective way possible. To achieve this, the distance between the two closest points is measured, which is known as the periphery. The Support Vector Machine (SVM) algorithm is a bracket fashion that aims to elect a hyperplane that maximizes the periphery between support vectors in a given dataset. A support vector is a data point that lies closest to the decision boundary.

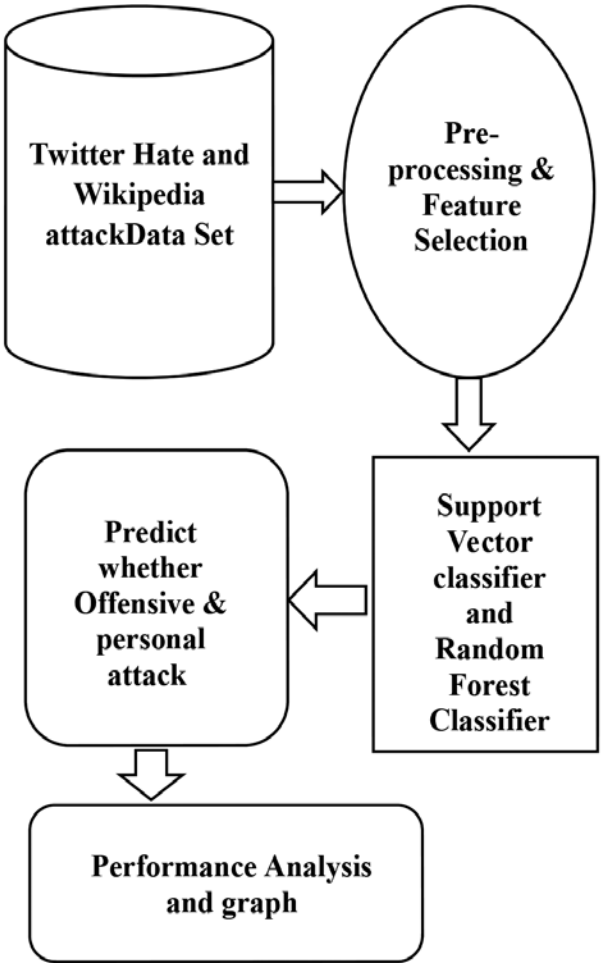

Figure 2: System Architecture

The SVM algorithm finds the largest supplemental hyperplane that can rightly separate the two classes. In the left wing, three hyperplanes are depicted in black, blue, and orange.

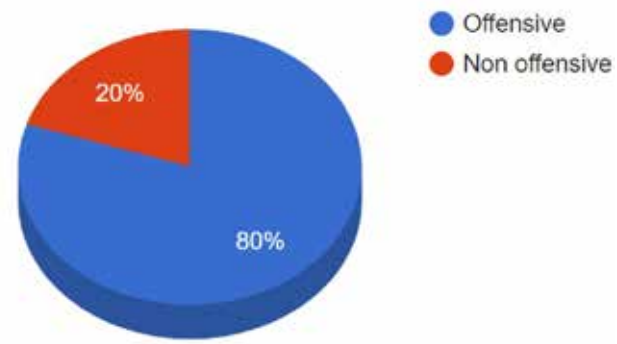

Figure 3. Disrribution of Tweets in Twitter Dataset

The black hyperplane is the optimal choice as it rightly separates the two classes. On the other hand, the blue and orange hyperplanes have significant bracket crimes, and they aren't the stylish choice for separating the dataset. To choose the optimal hyperplane, the SVM algorithm identifies the hyperplane with the topmost distance from the nearest data point. The hyperplane that's furthest down from the data points can rightly classify the test data with lesser delicacy. This hyperplane can effectively separate the two classes and minimize the bracket crimes.

B. Wikipedia Attack

The paragraph describes a dataset that consists of 1445 individual data points, each containing four columns Review Id, Comment, Attack, and the final prognosticated outgrowth. The Comment column contains commentary about Wikipedia titles, while the Attack column specifies whether each comment is a particular attack or a non-personal attack. The process used to classify the dataset is known as the Random Forest algorithm, which works in four ways. First, one data point is aimlessly named from the dataset. Second, a decision tree is erected for the named data point, and a vaticination result is attained from the decision tree. Third, this process is repeated for all data points, performing in a vaticination result for each one. Fourth, the prognosticated outgrowth from each decision tree is used to cast a vote, and the vaticination affect that receives the most votes is named as the final vaticination.

In the Random Forest algorithm, each data point is classified using a decision tree. Decision trees are tree-structured classifiers that divide the dataset into subsets

grounded on answers to questions. Each splint knot of the decision tree represents a result.

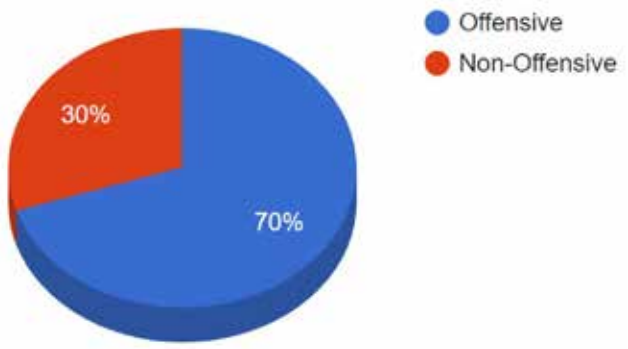

Figure 4: Distribution of Comments for Wikipedia Dataset

The Random Forest algorithm builds multiple decision trees, and each one votes on the prognosticated outgrowth. This process helps ameliorate the delicacy and robustness of the model. The Random Forest algorithm is an extensively used machine literacy algorithm, particularly for bracket and retrogression tasks. It's known for its high delicacy and robustness, making it a popular choice for colorful operations.

RESULTS

In this work, we aim to detect cyberbullying on social media by extracting tweets containing bullying episodes from the Twitter dataset and associating them with demographic information. We trained two machine learning models, a Support Vector Machine (SVM) and a Random Forest (RF), on the dataset and achieved a 96.10% accuracy when matching the same dataset. The results of the Twitter dataset are shown in Figure 5, while the results of the Wikipedia dataset are shown in Figure 6. The Wikipedia dataset achieved a 68% accuracy on the same dataset. The proposed demonstration yielded improvements of 96.10% and 68% accuracy compared to the Twitter and Wikipedia datasets, respectively, for detecting cyberbullying. We compared the performance of our models to a traditional machine learning model used for the comparison datasets. Although the accuracy of the Wikipedia dataset can be further improved by using an ensemble of algorithms, this may result in longer training times.

We trained both machine learning models on the dataset and then converted them into pickle files to avoid the need for retraining. Our project can serve as an extension that can be implemented by any social media platform as a backend service for detecting cyberbullying. Based on our results, TF-IDF features outperform Bag of Words and Word2Vec for both SVM and RF models in terms of accuracy and precision for the first dataset. However, for the second dataset, the optimal feature extraction technique varies depending on the model used. For example, TF-IDF with RF has the highest precision, while Word2Vec with SVM has the highest accuracy.

Table 1: Result for Twitter Dataset

Measure	Bag of Words		TF-IDF		Word2VEC	
	SVM	RF	SVM	RF	SVM	RF
Accuracy	0.905	0.913	0.92	0.914	0.89	0.894
Precision	0.935	0.947	0.949	0.949	0.935	0.886

Table 2: Result for Wikipedia Dataset

Measure	Bag of Words		TF-IDF		Word2VEC	
	SVM	RF	SVM	RF	SVM	RF
Accuracy	0.816	0.824	0.82	0.814	0.82	0.823
Precision	0.815	0.817	0.809	0.849	0.710	0.812

Figure 5. Prediction of Tweets whether Offensive or Non-Offensive

Figure 6: Prediction of Comments whether Personal Attack or Non-Personal Attack

CONCLUSION

Online cyberbullying is dangerous and leads to accidents such as suicide and grief. In this way it was possible to control its spread. Therefore, identifying cyberbullying at the social media stage is very important. As more information and better categorized customer data become available about various other types of cyber-attacks, the social media net is set to investigate such possibilities in this environment. Bullying can be identified case is accepted. Be ready to boycott any customer trying to participate in the exercise. We examined two types of information organization. Information about hate speech on Twitter and personal attacks on Wikipedia. For disparaging discourse, a characteristic dialect processing procedure using basic machine learning computations has been convincingly demonstrated with over 90% accuracy.

REFERENCE

1. Amanpreet Singh, Maninder Kaur, "Content-based Cybercrime Detection: A Concise Review", International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8 Issue8, pages 1193-1207, 2019
2. M. Di Capua, E. Di Nardo and A. Petrosino, Unsupervised cyberbullying detection in social networks, ICPR, pp. 432-437, 10.1109/ICPR.2016.7899672. (2016).
3. R. R. Dalvi, S. Baliram Chavan and A. Halbe, Detecting A Twitter Cyberbullying Using Machine Learning, ICICCS, pp. 297-301, doi: 10.1109/ICICCS48265.2020.9120893. (2020).
4. M. A. Al-Ajlan and M. Ykhlef, "Optimized Twitter Cyberbullying Detection based on Deep Learning," 2018 21st Saudi Computer Society National Computer Conference (NCC), Riyadh, 2018, pp. 1-5, doi: 10.1109/NCG.2018.8593146.
5. Trana R.E., Gomez C.E., Adler R.F. Fighting Cyberbullying: An Analysis of Algorithms Used to Detect Harassing Text Found on YouTube. In: Ahram T. (eds) Advances in Artificial Intelligence, Software and Systems Engineering. AHFE 2020. Advances in Intelligent Systems and Computing, vol 1213. Springer, Cham. https://doi.org/10.1007/978-3- 030-51328-3_2. (2020).
6. S. M. Kargutkar and V. Chitre, A Study of Cyberbullying Detection Using Machine Learning Techniques, ICCMC, pp. 734-739, doi: 10.1109/ICCMC48092.2020.ICCMC-00013 7. (2020).
7. Rasel, Risul Islam & Sultana, Nasrin & Akhter, Sharna & Meesad, Phayung, Detection of CyberAggressive Comments on Social Media Networks: A Machine Learning and Text mining approach. 37-41. 10.1145/3278293.3278303. (2018).
8. C.E. Notar, S. Padgett, and J. Roden, "Cyberbullying: A Review of the Literature," Univers. J. Educ. Res., p. 9, 2013.
9. M. Ybarra, "Trends in technology-based sexual and non-sexual aggression over time and linkages to nontechnology aggression." Presentation at the National Summit on Interpersonal Violence and Abuse Across the Lifespan: Forging a Shared Agenda. Houston, TX.2010.
10. B.S. Nandhini and J. I. Sheeba, "Online Social Network Bullying Detection Using Intelligence Techniques," Procedia Compute. Sci., vol. 45, pp. 485– 492, 2015, doi: 10.1016/j.procs.2015.03.085.
11. S.A. Hemphill, A. Kotevski, and J. A. Heerde, "Longitudinal associations between cyber- bullying perpetration and victimization and problem behavior and mental health problems in young Australians," Int. J. Public Health, vol. 60, no. 2, pp. 227–237, Feb. 2015, doi: 10.1007/s00038-014-0644-9.
12. S. M. Kargutkar and V. Chitre, A Study of Cyberbullying Detection Using Machine Learning Techniques, ICCMC, pp. 734-739, doi: 10.1109/ICCMC48092.2020.ICCMC-00013 7. (2020).
13. Jamil, H. and R. Breckenridge. Green ship: a social networking system for combating cyber- bullying and defending reputation, ACM: n. pag. (2018).
14. Rasel, Risul Islam & Sultana, Nasrin & Akhter, Sharna & Meesad, Phayung, Detection of CyberAggressive Comments on Social Media Networks: A Machine Learning and Text mining approach. 37-41. 10.1145/3278293.3278303. (2018).
15. J. Yadav, D. Kumar and D. Chauhan, "Cyberbullying Detection using Pre-Trained BERT Model," 2020 International Conference on Electronics and Sustainable Communication Systems (ICESC), Coimbatore, India, 2020, pp. 1096-1100, doi: 10.1109/ICESC48915.2020.9155700.

Development of Digital Bibliotheca using MERN

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ABSTRACT

Nowadays, the demand for progressing knowledge in the software field is essential. This is carried out through books, notes, question papers, and the internet in an institution or college. But the traditional process in the library creates a repetition among the students. With the advancement of technology, the paper presents a web application of an online internet digital library and virtual notes, and papers store. This internet-based (Digital Bibliotheca) web application can be accessed throughout the institute by the students, departmental faculties, and admin section. This system is an extremely user-friendly application. Students can search books, checks the availability of books, and calculate fine over the books in real-time. They also get an alert notification on book reissues and book returns. This system helps to download the notes and question papers from the database. The above system is completely developed in MERN technology. MongoDB for the database, with backend reason, Node.JS and Express the course, and React. JS for the frontend UI-UX part of the website. As we get the result of all the web pages like search book, create book, create notes and all. Also, the project has three types of dashboard each user it depends on which type of user it is.

KEYWORDS *: Web Application, MERN, database, UI-UX, backend.*

INTRODUCTION

A library place is a large assortment of books and sources are accessible, which include get-at-able from the users. It exaggerates the intellectual and psychosocial dispersion between students. Guide students to express different points of view. This information helps the learner perform effectively in both academics and the improvement of their own skills. The need to create a method to transform the conventional bookstore structure into an online one was brought on by technological advancement. Participants must physically input information upon receiving the materials. Therefore, we present a system called Digital Bibliotheca. College students can access previous year's sample papers and question papers using Digital Bibliotheca, a web-based application. Along with that, it also provides study materials categorized into departmental, semester, and subject-wise. Through this web application, students can also access exam schedules, syllabuses, and class schedules. Student-specific requirements will be considered when designing this system.

The following tools were utilized when developing specific components of the web programmed for the Digital Bibliotheca: The core functionality of the application is handled by Express component and Node.JS, the database is handled by MongoDB, and the frontend is handled by React. JavaScript is used by Node.JS. A structure for building server-side applications that provides a variety of JavaScript components to streamline the creation of web applications. A group of components that are used as required form the foundation of Node.JS. Along with to the fundamental sections, there's additionally a public registry of customized by users' components for various applications [1]. The Express module is the one that is used the most frequently when creating Node.JS apps. Considering the Express section allows quicker creation of web applications, it was also utilized in the creation of this information system [2]. A database that uses NoSQL is MongoDB, That NoSQL is an acronym

for Not Only SQL, which refers to a class of databases that do not adhere to traditional database concepts. NoSQL databases can be categorized based on the sort or manner in which they keep data, and the MongoDB database is a member of the class of NoSQL databases built on the document model. Actually, this just implies that documents are used to examine and keep data items. Documents have a layout akin to that the group is a set of documents having an identical purpose that are in the JavaScript Object Notation (JSON) standard [3]. The pace of the Internet's current growth is beyond comprehension.

A crucial aspect of our lives has been the network. This new business model progressively becomes a part of people's lives as the Internet develops, their purchasing patterns change, and their way of life morphs. People can shop at various online malls and find the most affordable goods without having to leave their homes while still having plenty of autonomy. People can discover the products they need through orders, and they can promptly receive the items they purchased. Customers and producers can both benefit tremendously from this new business model's time and labor savings, which also significantly lowers the risk associated with inventory. Manufacturers are able to acquire and create products based on the demands of the consumer, and this was known as manufacturing and buying that was done on demand, which significantly increased efficiency [4].

The work presents a concept for an online bookstore system, which is a web-based technology for an online marketplace for electronic goods. Users can purchase more books as needed thanks to the ease of purchasing at online book stores. Without leaving their homes, they can benefit from the speed and convenience of books ordered from an internet shop. The system provides standard features for online book purchasing in the forefront, and system administration in the background. It can provide ease for users' consumption as well as for administrators, who can be prompted to see the collection of books that have been sold and are available for timely purchase [5]. The customer doesn't need to go to a book shop when using the online book store initiative to buy books. The project's goal is to create an online book store system that is fully working and enables people to purchase books online. The user can decide and buy one or more books online using the pay on delivery option after the selected books are presented in tabular format. Customers have the option to purchase online through a computer browser thanks to the project's online book store [6].

RELATED WORK

Kozma Nina and Dusan Krstic [7] studied the details of the system architecture for book sellers that supports the creation of tasking-tier web-based applications applying certain technologies. It explains how they are implemented and how they work, along with the implementation's benefits and drawbacks. It is designed to support a bookstore, and it supports registering as a client, purchasing products via the internet payment, and online reviews of selected books.

Sivasakthi, T., et al. [8] proposes the voters can securely cast their votes online thanks to this web application. A person chooses a likeable candidate to lead the country by casting a ballot. The main goal of the suggested in the present era of advanced the internet, the system for voting on the internet has to be enabled by a web-based application. because it saves time, speeds up manual work, and boosts security. The online voting software is a website that functions online.

In Reference [6], the work proposed by G. Baskaran, et al. The need for handyman services in the area has recently grown, making it difficult to find a labor offline at a reasonable price and at the right time. This website makes it easier to schedule labor at the right time and price, with a verified and approved login for the customer, the handyman, and the admin. A website built using React JS is quicker, more secure, efficient, and SEO-friendly, while MongoDB is a database that is simple to scale-out, making data management easier.

Kalwani, Bharat, Ambesh Sharma, and Sohan Lal Gupta. [10] focuses on an Intranet that seeks to all tiers of authority inside a company that provide information dissemination. This web application may be utilized as a data management application for the colleges.

The Proposed work by Wadagave, Rashmee, et al. [11], It is possible that the primary goal of this work is to computerize and portable the method of controlling information about pupils in the lab. By centrally administering the entire system, the internet-based application fills the distance among the final customer

and the mobile device arranging controller. This web-based tool is used by multiple divisions to schedule separate procedures that don't interact with one another.

Chauhan, Amit Shersingh, et al. [12] presents that Nowadays, more people are using computers and the internet, making it easier to do things online. This website application helps users host cars and make money from renting them out. Only those who have been verified are able to make rental vehicle reservations and a driver's permit is used for authentication.

Vasanthi, D., et al [13], demonstrate a driving permit is used to verify which will enable homemakers employing a driver's license for confirmation. It will be cross-platform due to developments in web services, making it accessible both on computer platforms and on internet-connected mobile devices. The technology stack for this research project is MERN (MongoDB), Express-JS (server), ReactJS (front-end programming language), and NodeJS (full programming environment). Amazon cloud storage is used to save menu item photographs.

PROPOSED METHODOLOGY

A student's profile is forwarded to the staff for approval each time he or she registers an account on the system. When a student enrols at a university, the staff verifies that they are genuinely enrolled. Hence, the staff notifies the user's email address of the confirmation email. The pupil will be sent to his or her profile page. The learner will be brought to this page after each login. It conveys the essence of the profile. Any alerts will be displayed here if there are any. The Administrator makes the professor's profile. Professors' classes and subjects are also assigned by the Admin. Paper review and the papers that the professor submits make up their profile on the website. A professor's profile allows for the addition or modification of attendance. From the profile, uploads may also be made. Also, when needed, the professor has the option of deleting the files. For the creation of separate- page programmed with graphic interfaces for users, developers use the well-known, open-source JavaScript framework React. It was created by the social media site, an American-based networking website, a part of the business social Platforms, in order for unload the servers, which were weighed down by a significant volume of requests coming from many computers throughout the globe. The construction of online apps that enable data modification is made possible by React characteristics, eliminating the requirement to completely reload the page. This idea enables quick, straight forward, and scalable web apps built with React.

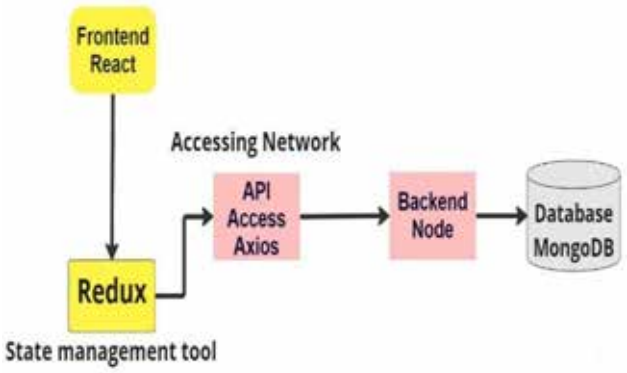

Fig. 1. Website working flow diagram

The front-end structure of the online polling web application was created using React JS, the Bootstrap framework HTML and CSS, Redux, JWT (a package of JSON Web Tokens used for identification), Axios, and JavaScript. Node JS and Express (an architecture for Node JS) are the technologies preferred in the back-end. All of the data for this application was kept in a database called MongoDB.

REACT.JS - It is a JavaScript library for the front end that is free to used to create UI elements. Reloading can be sped up since it renders faster because to the virtual DOM. React Js is used by many real-time products, including Facebook and Netflix.

NODE JS - It's a server-side, open-source platform for back-end development. Because of the asynchronous data flow, one piece one output of code can be produced without waiting for another. It never buffers any data. It generates great presentation with good ascendable.

MONGODB - A document-oriented NoSQL database that is open-source is used to store a lot of data. The papers are managed via a collection. It is a database without a schema. Because it saves data in JSON format, it is more adaptable. To make data access simpler, it has a key-value system.

REACT-REDUX - Redux is a state management tool used by React. Even with dependencies, it is lightweight.

The whole application's state is saved in a store with the aid of Redux, and any component may contact with whatever condition it requires from this retailer. It was employed for managing the situation of the world. to distribute the info to all UI elements.

AXIOS - The package comes from a third party called AXIOS that serves as a bridge among the client and the host and is too utilised via the user interface with quickly interact to APIs. It is a JavaScript module that enables HTTP requests to be made between Node JS and React.

JWT - Data transmission and authentication are both done via JSON Web Tokens. NODE-MAILER - Through the mail, it is utilised to notify users and employees.

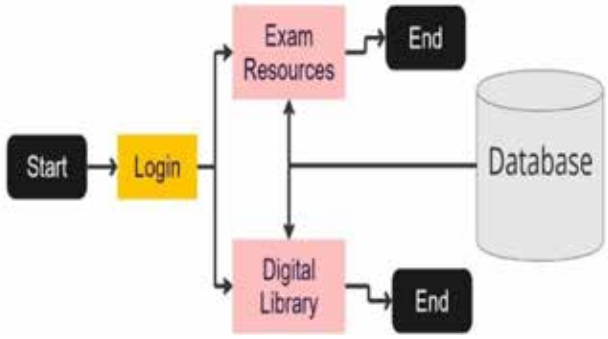

Fig. 2. System Architecture

The main goals of the web application are to aid students in their academic preparation and to give them access to the necessary tools for studying. For the project, we accomplished this by developing several modules. For the user to see or download study material, they only need to log into their accounts. The aforementioned design perfectly captures how the software is used and how it is used in its entirety. It also demonstrates the operation.

The technologies we used to create this web app are react.js for the front end of the application, Express. js and node.js for handling backend APIs, and the MongoDB database. The user will first go to our web application. After this, the user needs to log in to our portal. If the user is new, then he/she needs to register first and then log in. Here, we have two different logins for the user and admin. After login, the user will navigate to the main dashboard. The user can view different study materials provided by the faculty, also the user can search for the books in the library to issue from.

The user can also reissue the book. The user can filter out the books according to the book title, book author, publisher, etc. The user will first go to our web application. After this, user need to login on our portal. If user is new, then he/she needs to register first then login. If the user is a student, then he/she will get two options Digital Library and College Archive. Students can share their questions if they have doubts otherwise can view other's doubts. On Digital Library page, user will get to see two options i.e., Issue and Reissue books.

Students can search and filter books as per their requirement and place it to issue. Also. User can view fine collected. On College Archive page, user will get the materials to prepare for exam that is uploaded by the faculties. In case of admin, after successful login he/she will also get two tabs Digital Library and College Archive. Here, admin can process the issue and reissue of books also has access to upload the study material.

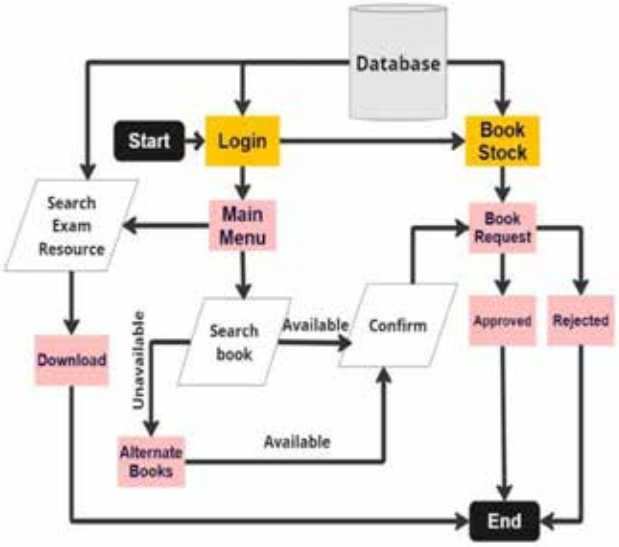

Fig. 3. Flowchart of Application

The MERN stack technologies were used to construct the web application. A MongoDB database serves as the foundational layer, followed by an internet-based application built on the Node.JS module with the Express platform, and a client web application created with the React.JS. The programmed is presented to the end-user as a distinct and integrated whole even if the

software the built environment's three tiers are broken down into separate sections. The client web application is the only point of contact for the user, and it relays queries made of the web server programmed, which interacts with the database. The following workstation configurations as well as technologies must be set up before beginning focusing on the program's source code:

1. Visual Studio Code (VS CODE) - a tool created by the American corporation Windows for creating and modifying programmed code.
2. Node.JS – It is a website development environment for servers.
3. MongoDB Compass –It is an interactive user experience that is utilized to handle data and communicate to databases.

It is feasible to begin constructing a web application once all of the aforementioned environments and tools have been properly setup on the computer and the necessary folders have been established. The two components mentioned above, customer management and administrator management, are part of the online bookshop system's functionality. which are every categorized by a distinct user group. There are numerous submodules for each module. The major components of client management are the subscribe a particular module, purchasing bring component purchase the administration section, and so forth. The purchasing cart feature allows for the addition, deletion, and modification of books. Once it was completed, a fresh order was created. Individuals can remove and change orders in the order administration module. The group of user interfaces comprises of.

- To log into their separate accounts, users are presented with the Student Information Management system interface.
- Save and publish the different data stored in the fields in order to add and change details. For example, you might add fields like "Notice" and "Notes to a detail and specify their corresponding weights in the detail.
- As long as their respective accounts let it, students may examine the published data. By the use of a network, communication will be based on a request-response paradigm, in which the server answers to the client's request after the client has made one. The entire system is split into two components.

Digital Library and College Archive are the two modules. Both modules are having different functionalities to perform. Our project intends to provide students with appropriate resources for academic preparations. To update students about the previous year's question pattern asked in exams, syllabus, and important topics.

1) USER

User has the ability to view and download the study material. User can do the following activities to visit and get benefits from our portal.

a. User Authentication – Sign up and login

b. Create User – There is three types of users like faculties, users and admin.

c. Digital Library – Search and issue books and calculate Fine over the book.

d. College Archive – view or download study materials

2) ADMIN

Admin can do the following activities by using our web application.

a. Admin Authentication – Sign up and login

b. Digital Library – issue or reissue books keep the database updated

c. Study material – upload study materials

The database may corrupt at whenever as an outcome of a malware or an error in the computer system. Consequently, it is necessary to take a database backup. Internet-connected PC with 1GB RAM and a 24GB hard drive serves as the server. Client-side: Any home computer that can run any Windows or X-windows environment and has a mouse is suitable. As a database on the server, MongoDB is employed. Validation is performed using Express JS and Node.JS. Software called AngularJS is utilised on the client side to collect user input. We have developed an API to open up our product to the public. The online paper correction

module is user-developable, so with the appropriate expertise, we can advance towards our goal of digitising all educational institutions. Moreover, this gives the user more freedom because they may utilise the API and combine it with any compatible system to create a completely new system, giving them more control.

RESULT

This works helps to reduce manual work. It consistently delivers correct information. Mistakes may be minimized. Information accumulated throughout the years can be preserved and retrieved at any time. The information kept in the repository aids management in making wise judgements. All interested parties, teachers, and administration may quickly obtain the information they need. In colleges this structure is crucial.

Fig 4. (a) All Books (b) Create User (c) Create Study Material (d) All Users

The Fig. 4 (a) Represents the All Books Present in the Web Application or Availability of the Books. By this page users can send the Book Request to the Librarian. In Fig. 4 (b) Admin can create the user and track the requested book. Fig. 4 (c) represent the Faculty member can create study material as per semester or subject and upload study material. The Fig. 4 (d) This page says that the admin can check and see all the users.

CONCLUSION

This work presents the step-by-step procedure for creating web applications using the MERN software suite. With the use of this program, college students may now access their academic materials and subject-specific literature on a single platform in a simpler, quicker, and easier manner. Application features include student login, evaluation, storage, library management, and server-side alterations. Also, it can offer prior semester papers, results, notes, a semester's syllabus,

etc. This system offers dependability, time savings, and straightforward control. This app allows students to access information about their grades and curriculum. We draw the conclusion that our web application enables students to quickly access the greatest resources. Since information systems are currently regarded as one of an institution's most valuable resources, the evolution of this web application and others like it focus to make such a computer system more accessible to all sized institutions while also bringing with it a large range of chance or suitable time and advantages.

REFERENCES

1. Tao, T., Wang, N., & Lu, H. (2012). Analysis and Design of Online Bookstore System. In Information and Business Intelligence: International Conference, IBI 2011, Chongqing, China, December 23-25, 2011. Proceedings, Part I (pp. 747-752). Springer
2. Berlin Heidelberg.
3. Tao Tao, Ningli Wang, Haibo Lu, "Analysis and Design of Online Bookstore System," Information and Business Intelligence. IBI 2011, 2012
4. Bagmare, P., S. Girhepunje, and P. Bisen. "Research Paper on Online Bookshop Management System." International Journal for Research in Applied Science & Engineering Technology (IJRASET) 5.4 (2017): 114-116.
5. "Node.js Documentation," Node.js, [Online]. Available: https://nodejs.org/docs/latestv13.x/api/. [Accessed 20 1 2022].
6. "Express Installing," Express, [Online]. Available:https://expressjs.com/en/starter/installing.html. [Accessed 20 1 2022].
7. "Introduction to MongoDB," MongoDB, [Online]. Available: https://docs.mongodb.com/manual/introduction/. [Accessed 20 12022].
8. Kozma, Nina, and Dušan Krstić. "Design of Information System for Bookstore support Student paper." 2022 21st International Symposium INFOTEH-JAHORINA (INFOTEH). IEEE, 2022.
9. Sivasakthi, T., et al. "Development of E-polling Website using MERN." 2021 Smart Technologies, Communication and Robotics (STCR). IEEE, 2021.
10. G. Baskaran, K. Saundariya, D. Prabakaran and R. Senthilkumaran, "A Web Application Based Administration Panel for Handyman Services," 2022 IEEE Delhi Section Conference (DELCON), 2022, pp. 1-5, doi: 10.1109/DELCON54057.2022.9752820.
11. Kalwani, Bharat, Ambesh Sharma, and Sohan Lal Gupta. "College Query Management System by using MERN Stack." International Journal of Global Research in Science and Technology 6.1 (2020): 17-24.
12. Wadagave, Rashmee, et al. "Web Application based Event Organization Portal using MEAN Stack." 2022 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS). IEEE, 2022.
13. Chauhan, Amit Shersingh, et al. "Food Ordering website "Cooked with care" developed using MERN stack." 2022 6th International Conference on Intelligent Computing and Control Systems (ICICCS). IEEE, 2022.
14. Vasanthi, D., et al. "Design and Development of Car Rental Website Using Mern Stack." 2021 International Conference on Computing, Communication and Green Engineering (CCGE). IEEE, 2021.

IoT based Cold Storage Monitoring & Controlling System

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ABSTRACT

Tricholoma matsutake (T. matsutake), popularly known as "the king of bacteria," is a very valuable fungus. However, because to its corruptibility, it is also incredibly challenging to carry. As a result, it is essential and necessary to follow up on and track T. matsutake's quality and safety along the chain of refrigeration. Variations in the refrigeration chain are the basis for the environmental criteria used to determine the security of T. matsutake. On the LCD, the DHT 11 Sensor and the MQ3 Sensors were utilised to monitor the relative humidity, temperature, and proportion of gas present in cold storage. Environmental characteristics such as moisture, temperature, and gas level may be remotely monitored and changed via a web application.

KEYWORDS *: Cold storage, IoT (Internet of Things), DHT sensor, MQ3 gas sensor.*

INTRODUCTION

Implementing an IoT solution for cold storage facilities aids in the monitoring of crucial parameters and corrects them when they deviate from predetermined levels. This lessens the risk of food decay. Overall, the adoption of an Internet of Things- based cold storage monitoring and regulating system results in the best possible use of resources and space. It helps to monitor and regulate light intensity in accordance with variations in daylight, minimise waste, track device usage patterns and power consumption, and detect anomalies inside the facility. Businesses can greatly benefit from and increase profitability by using an IoT- enabled monitoring solution. The A warehouse is a type of commercial structure where items are stored.

Manufacturers, importers, exporters, wholesalers, transportation businesses, customs, and so on. All use warehouses. To store a significant volume of fruits and vegetables, Strauss Frito-Lay employs numerous warehouses. In order to store certain fruits and vegetables properly, a specific temperature must be maintained (mostly for potatoes). When the compressor or chiller is turned on, the air's relative humidity (RH) begins to drop. A Wireless Sensor Node based system that can monitor different areas of the warehouse is suggested as a solution to these problems. The data is then sent to the warehouse's core hub, where it will be collected and pushed onto the cloud. The proposed system describes that nowadays, the Internet of Things (IoT) is a technology that is being used more and more. It is frequently used to describe the expanding network of interconnected objects, or "things," that can communicate over a network with limited capacity. The automotive sector, administration, medical care, the electrical grid, and urban planning are all examples of this are just a few of the industries that are using IoT.

In 2022, authors of IoT-based Fruit Cold Storage Monitoring Controller Development research suggest an IoT-based monitoring system that displays the maintenance status in cold chain plants ESP microcontroller is used to collect environmental data from DHT 11 sensors, such as temperature and

humidity, and cloud server module is used to deliver communication data [1]. The author of this article suggested a system that allows the end-to-end responsibility and visibility along the full product value chain. To get to their destination, perishable commodities frequently need to travel thousands of kilometres via land, air, and marine transportation methods [2]. This study introduces a low-cost, autonomous cold storage monitoring and regulating system based on the Internet of Things. The suggested system consists of a sensor

that can measure both temperature and humidity, a microcontroller, a cooling fan to reduce the temperature, a power supply module based on a DC-DC step down converter, and an app to track and control the cold storage system's temperature [3]. The author of this study suggested that by creating a powered by solar energy cold storage system. The system employs a form of vapour compressive refrigerated loop (VCR), featuring 3 evaporation units operating at different temperatures and one compressor.[4]. The author of this study used technologies used in Temperature Monitoring and Control in the Cold Chain proposes is an analysis of the technologies used to track and regulate the cold chain's total temperature of perishable commodities. It has been demonstrated that the application of management of cold chain systems reduces wasted food in processes and saves time, energy, and resources. [5].

In order to prevent food goods from rotting due to an increase in temperature and humidity, the author of this research suggests adopting Wireless Sensor Networks (WSNs) are a popular technology used for continuous monitoring of temperature and humidity in cold storage warehouses. WSNs consist of a huge number of widely dispersed tiny, inexpensive sensor nodes throughout the warehouse.[6]. The author in study suggested that by using elements of the ZigBee wireless sensor network, also known as an WSN, and the real cold storage scenario, which includes Software as well as hardware architecture for the ZigBee network. Cluster Tree, the ZigBee WSN networking technology, has been improved; neighbour table information is integrated into the Cluster Tree algorithm, and the selection of nodes in the neighbouring table is explored; this is advantageous in finding an ideal path and reducing data transmission delay [7]. The author of this study suggested that even though there is a large potential for growing production, the absence of suitable cold storage and cold chain facilities is becoming a key impediment in realizing the promise. This can be avoided by using a wireless sensor network-based cold storage system [8]. This article suggests a temperature tracking system method, while additional technical benefits are fully employed by this application, along with Radio Frequency Identification, or RFID, tags, sensors for temperature, and the Global Positioning System (GPS) systems, all of which may be used in refrigeration chain temperature monitoring structures. The technology may monitor the precise position and humidity of cold chain items in real-time to assure the quality of such products along the supply chain. [9]. The main causes of this are difficulties with post-production and the ineffectiveness of cold storage facilities. Potatoes are the fourth- largest crop produced in India [10]. The author of this page is interested in analysing written articles and project reports on losses after harvest in nations that are developing, as well as collecting as many examples of actual measurements (i.e., testing of changes in thereby affecting their quality ratings, or value at the market) as possible. Many of the publications that have been published incorporate the author(s)' general estimates of losses following harvest and/or refer to loss figures or observations published by other authors [11]. According to the author of this article, reducing food waste benefits both people and the environment by enhancing the availability of food, tackling climate change, saving money, and lowering demands on land, water, biodiversity, and waste management systems. However, this potential has been terribly underutilised to far. This can be remedied using an automated preservation cold storage system [12]. This article's author presents technology for the continuous regulation of the ambient temperature in chilled food chains. Temperature tracking devices based on RFID, or radio frequency identification, and smart tags, including time temperature indicators (TTIs), are examples of this. Finally, ideas that demonstrate how temperature monitoring equipment may be coupled with product features to improve the safety and quality of food are provided. [13].

METHODOLOGY

Proposed System

The capabilities of the Internet of Things determine how the project is carried out. To make this idea a reality, two structures are required: a sensing entity that collects data from the environment and a cloud service that savesthe data. We use a network of linked sensors to collect data from the cold chain and upload it to the cloud, where it is accessible from any place. The monitoring system is made up of two more components. One is used to monitor the facilities' cold storage conditions, and the other is used to monitor logistics. The subsystems are built on top of the NodeMCU prototype platform. Two

of the system's primary functions are monitoring the environment's temperature and humidity as well as recording the arrival and departure of commodities. The three monitoring staff members receive data from facilities in several ways on the cloud: temperature data is sent there, where it can be accessed on a website, and inventory data is stored there. Each wireless sensor node delivers a live temperature reading to the web server on a regular basis, which updates the information in a central database. Using an established web server and interface, users may continuously monitor the functionality of any appliance from any location at any time. We're using the NodeMCU ESP controller for this, an open-source electrical platform with an easy-to-use ESP12 Wi-Fi module built in. It recognises its environment by gathering information from sensors. Based on the ESP12, the NodeMCU microcontroller board has a 3.3v power source, 8-bit, 4 kb of memory, and a 16 MHz clock frequency. The accessible integrated development environment and the Arduino programming language are used to create the software. We are using a DHT temperature sensor, a digital sensor that can be set up on the controller's digital pin.

As depicted in the diagram (Fig.1), the DHT11 temperature and humidity sensor is what we will be using for this project. NodeMCU has been coded to use it to determine the cold storage's temperature. When the temperature rises above the predetermined level, For monitoring with reference to time and date as well as managing Gas valves the data will be kept on a cloud server.

Table 1: Components Used

List of Hardware and Software Used			
Sr. No	**Name**	**Description**	**Quantity**
	NodeMCU	Having an ESP8266module on it, which we will be programming.	01
	ESP8266	Highly integrated Wi-Fi SoC.	01
	Relay	An electrically operated switch.	As per
	DHT11	Temperature and Humidity Sensor	Requirement
	MQ3	Gas Level Detection	As per Requirement
	LCD (16x2)	Display 16 characters per line	As per Requirement
	Arduino IDE	connects to the Arduino hardware to upload programs and communicate with them.	As per Requirement

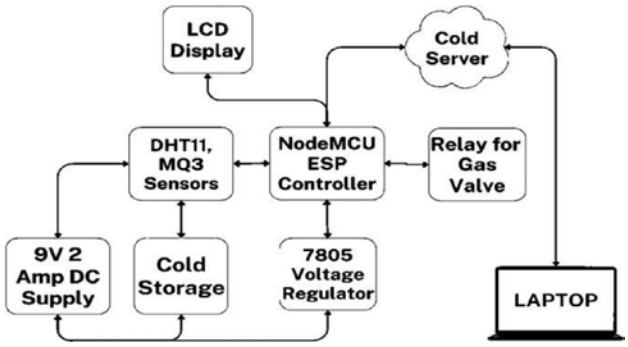

Fig. 1. Block Diagram Cold Storage Monitoring and Controlling System

Master-Slave Configuration

The master/slave communication model is a common hardware communication protocol that allows for unidirectional control of one or more devices by a single device. In this model, one device (the "master") is responsible for initiating communication with one or more other devices (the "slaves"), which can then respond to commands or requests from the master. In the world of electrical hardware, this is widely used, with one item acting as the controller and every other device acting as the one being controlled. In the master/slave paradigm of asymmetric communication or control, a single device or process (the "master") is responsible for directing and controlling one or more other devices or processes (the "slaves").

Among the many IEEE 802 networking standards that are often utilised in this application are Ethernet, Wi-Fi, and Bluetooth. For controlling purposes, this MAC Unit box is placed away from the warehouses, and the data accessing it is made possible via the firm's network, which is connected to the chamber also has a slave box where all of the sensors are connected. This slave box features an LCD screen with an i2c interface

that displays the various parameters being tracked. In each chamber, the air conditioner, exhausts, and gas valves are used to regulate these conditions. By using the MAC addresses of the MAC units, every slave box is connected to the master box.

A hardware distinctive number known as a MAC Address can be utilised for recognising every machine on a network. The six sets of two hexadecimal digits that make up a MAC address are separated by colons, for instance: 30:AE:A4:07:0D:64. It obtained by a Arduino code. Although manufacturers are responsible for assigning MAC Addresses, you may also offer your board a unique one. The board will, however, reset every time and revert to its initial MAC address. The code to set a unique MAC Address must thus be included in each drawing. A media access control address (MAC address) is assigned to a network interface controller (NIC), In communications within a network segment, it corporate website. On this web page all the parameters and chambers will be shown andcan be controlled remotely.

Software Implementation

In the absence of all of the title's components, Arduino code is a specific type of code that is used to program microcontrollers such as the Arduino board. It is a programming language that is based on C/C++, and it includes specific libraries and functions that are designed to interact with the Arduino hardware in the classic programming C language. To save all of the present files, hit the'merge' button. Arduino.c will be saved within the 'lib/build' indication, and the make file, which is located inside the lib library, will be called. This will create duplicates of the Arduino.c file with the'lib' temp adds' string.inc 'as its origin. This capability converts the Arduino code that is writing code into a proper programming file named prog.c. Following that, we must copy all files in 'lib/temp' to the main directory. That file adds syntax to the previously written code. To use NodeMCU, we must first upload a programme to the device using a special IDE. The NodeMCU application is developed using the Arduino IDE (Integrated Development Environment) is a popular software tool used for creating and uploading code to the Arduino microcontroller. It provides a user-friendly interface for writing, testing, and uploading code, making it a popular choice for hobbyists and professionals alike. The advantage of IOT technology is that it allows us to access data from everywhere that is contained in sensors or servers. We need massive databases, such cloud storage, for maintaining this information, which calls for the use of cloud servers, Oracle storage that is distributed, and HTTP servers. Oracle or MySQL are required for database operations. The PHP script is used to link the server and database.

RESULT

All the parameters such as temperature level, humidity gas level respectively present in the warehouse chambers are obtained. These parameters are monitored and controlled remotely with the help of an interactive and responsive webpage on the company server which relates to a cloud database. These stored values of temperature, humidity, gas level respectively helps us comparing the different environment conditions in different warehouse chambers.

This paper proposes an automated cold chain tracking framework that uses the Internet of Things to give a better and enhanced approach to monitor the chain. The 000webhost sensor cloud, where data is posted and monitored, has been interfaced with a wireless sensor network built using NodeMCU. Microcontroller frameworks and hardware concepts for interfacing to internet connections and 000web 2.0 technologies have enabled the integration. The connection provides several benefits as well as advantages, elevating surveillance to an entirely different level. This approach not only solves a problem, but it also provides a foundation for future initiatives including IoT automation.

Fig. 3. Home Page of Website

Fig. 3 Shows the Interface of Cold Storage of website in which there are four chambers and each chamber having three panels.

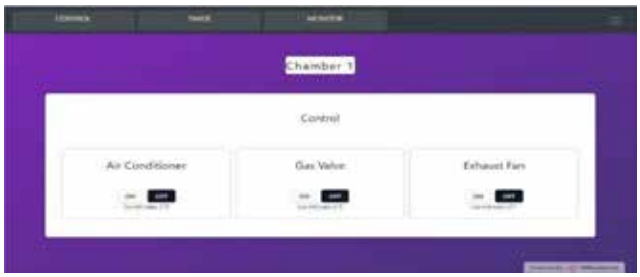

Fig. 4. Control Panel

Fig. 4 Shows the Control Panel of the website where we control Air Conditioner, Gas Valve and Exhaust Fan.

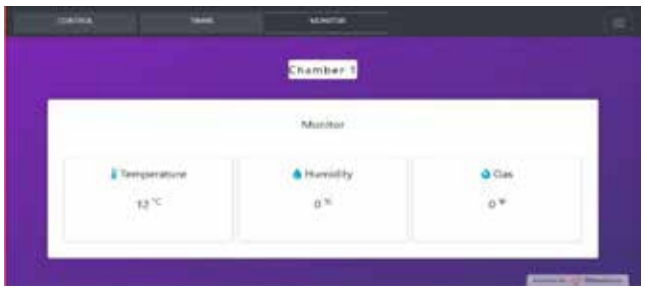

Fig. 5. Monitor Panel

Fig. 5 Shows the Monitor Panel of the website where we monitor Temperature, Humidity and Gas.

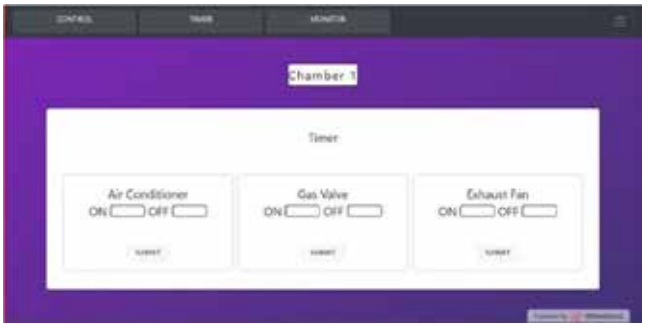

Fig. 6. Timer Panel

Fig. 6 Shows the Timer Panel of the website where wecan give the timing for ON/OFF the valve.

CONCLUSION

The system has successfully passed tests at various temperatures. Gas level is satisfactorily managed by the compressor for a variety of temperature thresholds. The Transmitter node transmits the temperature and humidity readings to the cloud. Receiving the monitored data from various sensor nodes, the receiver node records it in the database. The created webpage displays the stored values. Comparing is used to regulate temperature. The webpage also displays the current temperature and humidity readings.

REFERENCE

1. Akshay Nagarkar, Ashwin Padole, Rahul Agrawal, Ashwin Gardalwar, Swati Sorte, Heramb Vyas, "Development of Fruit Cold Storage Monitoring Controller using IoT," in 2022 3rd International Conference on Electronics and Sustainable Communication Systems (ICESC).
2. Sri Lavanya Alamuri, Shreenidhi H S, Karthik Bharadwaj R M, Mohammed Shanif M C, Shraddha G Srivatsa, "Smart Cold Storage and Inventory Monitoring System", 2021 International Conference on Recent Trends on Electronics, Information, Communication & Technology (RTEICT), 27-28 August 2021.
3. Fariha Siddiqua, Samiur Rahman, Mahmuda Tamanna Dolon, Tahsin Ferdous Ara Nayna, Md. Mamunur Rashid, Md. Abdur Razzak, "IoT-Based Low-Cost Cold Storage Atmosphere Monitoring and Controlling System.", 2022 International Conference on Wireless Communications Signal Processing and Networking (WiSPNET), 24-26 March 2022.
4. Hala J El-Khozondar, Mohamed Elnaggar, Abdullah AlMabhouh, Loai Abu Zanouna, Mohammed Ismail AlAtawne and Omar Safi, "Solar-Powered Cold Storage System", 2021 International Conference on Promising Electronic Technologies (ICPET), 17-18 November 2021.
5. Y. Campos, J. L. Villa, "Technologies Applied In The Monitoring And Control Of The Temperature In The Cold Chain", Published in IEEE Conference 2018.
6. Bindu J, Nikitha, Namitha M, Pradeep H, "WSN based Online Parameter Monitoring in Cold Storage Warehouses in Cloud using IoT concepts," International Research Conference on Computational Intelligence an Computing Research (ICCIC).
7. Xiliang Ma; Ruiqing Mao, "Design of Wireless Sensor Network for Cold Storage Monitoring "Development of Fruit Cold Storage Monitoring Controller using IoT," in 2022 3rd International Conference on Electronics and Sustainable Communication Systems (ICESC).

8. Shobhit Kumar Nagpal, S. Sudha, "Design and development of a sensor node to monitor and detect change in internal parameters of a cold storage system", 2015 Global Conference on Communication Technologies (GCCT).

9. Bo Yan; Danyu Lee, "Application of RFID in cold chain temperature monitoring system," 2009 ISECS International Colloquium on Computing, Communication, Control, and Management.

10. B.K. Priya, Musalareddygari Sucharitha, Nagaraju Sri Sai Lohith Varma, Divya Kalluru, "Design and Implementation of Automotive Cold Storage Unit for Potato Crop Using GSM", 2017 IEEE International.

11. L. Kit inoja and A. A. Kader, ``Measuring postharvest losses of freshfruits and vegetables in developing countries,'' PEF, Latham, NY, USA, White Paper, 2015, pp. 215.

12. G. Liu, ``Food losses and food waste in China: A first estimate,'' OECD Food, Agriculture. Fisheries, Paris, France, Tech. Rep. 66, 2014.

13. M. Eden, V. Raab, J. Kreyenschmidt, T. Haioason, G. Olafsdót t ir, and S. Bogason, "Continuous temperature monitoring along the chilled food" supply chain," in Food Chain Integrity. Amsterdam, The Netherlands: Elsevier, 2011, pp.115-119

Emotion-based Music Recommender using AI

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ABSTRACT

In recent years, researchers have shown a growing interest in emotion detection using computer vision, leading to the development of numerous algorithms and applications. With the increasing number of songs available for listening each day, it can be challenging for individuals to choose a suitable song based on their mood. To address this issue, our recommended system detects the user's emotions and suggests music accordingly. The system was implemented using OpenCV, MediaPipe, and ANN. Our system has achieved an accuracy of 85% in detecting the Happy emotion

KEYWORDS *: Face expression, Emotion detection, Music recommendation, ANN model*

INTRODUCTION

Recognizing human's emotion is a key feature of artificial intelligence which becomes important for automating a variety of operations that are more time-consuming to be executed manually. For a variety of applications, evaluating a person's mental state based on their emotional outward manifestations requires making successful automated decisions that are best suited to the individual in question. One significant application of this would be in the entertainment industry, in order to make recommendations to a person depending on their current state of mind. We look into this from the perspective of making individualised music recommendations for a person based on their emotional state as expressed by their facial expressions.

Most music lovers have significant music collections that are typically arranged primarily by criteria like artist, album, genre, and amount of plays. Users are therefore left with the onerous task of making playlists based on moods or categorising the music according to the emotions the songs evoke, which is significantly more crucial to the listening experience than it usually appears to be. Larger music collections only make this work more difficult; therefore, automating the process would free up many users time from having to perform the same activity manually while also enhancing their overall listening experience.

Fig. 1. Types of Emotions

Vicky Ket.al [1] employ the CNN algorithm to identify emotions and the HAAR cascade method to identify faces. Principal Component Analysis (PCA) and the Viola-Jonze method are used to create the recommender system. The suggested system was successfully implemented in MATLAB (R2018a) [2] by the authors. Vijay S et.al [3] suggested utilizing a deep learning method to build playlists based on a user's past music selections and present mood. Kevin P et.al [4] use emotions to generate a playlist, they want to enhance the user's current mood and song preferences to offer a more individualized experience grow more. Shlok G et.al [5] introduced EMP, a cross-platform music player that

makes music recommendations depending on the user's current mood. Sanskar L et.al [6]proposed a system that identifies user emotions and creates a custom Spotify playlist. It uses MTCNN to extract facial features from photos. A music recommendation technique [7] uses a webcam to capture the user's image and a grayscale transformation to help the face recognition classifier work better. The author suggested a system [8] that records real- time images using a webcam, identifies emotions using HAAR Cascade and LBP for feature extraction, and recommends a Bollywood song from a database based on the identified emotion. CNN is used for facial recognition. Shantha S et.al [9] proposed a system that captures real-time images using a webcam and extracts facial features using AAM. Computer vision and machine learning techniques are integrated to detect facial emotions, and music is played automatically based on the detected emotion. The authors in Ref [10] used the C-K dataset with 593 facial action-coded sequences and the HELEN dataset with around 200 images to train the networks. They developed the module using web technologies such as PHP, MySQL, HTML, CSS, and JavaScript. The author in Ref[11] a technique that divides songs into four mood categories, analyzes the user's facial expressions to determine their mood, and then combines the two to create a personalized playlist for the user. They classified music in two ways. KNN (k-nearest neighbor method) and SVM (Support Vector Machine) and MLP (Multilayer perceptron) are used in model training. Compared to the second strategy, they achieved only 60° accuracy compared to 71.6 accuracy for the first approach. Deger Ayataet.al[12] proposed a system that uses wearable physiological sensors, such as PPG and GSR, to classify a user's emotions. The author in Ref[13] proposed a method to identify a user's personality traits, moods, and emotions by analyzing their behavior in a social setting, based on established psychological research. To achieve more accurate and adaptable outcomes, they incorporated the user's personalities and moods into a content-based filtering technique. The paper [14] presents a mobile app named "Emo-Player" that helps users select music that fits their moods. The app uses the camera on an Android device to capture a picture of the user's face and determine their emotional state. Emo-Player then creates a playlist of songs that can enhance the user's mood. The paper [15] describes a system that recommends songs to users based on their emotional state, using computer vision technology to analyze facial expressions and chatbot interactions to detect emotions.

PROPOSED METHODOLOGY

An Emotion-based music recommendation system is a web application that uses real-time emotion recognition. It consists of three primary modules:

i. Face Capture.

ii. Emotion Detection.

iii. Music Recommendation

Face capture: Initially, the Python library OpenCV is taken into consideration for face capture. PyCharm IDE is used for coding. For face detection, a media pipe is used. MediaPipe performs tasks such as object detection, face detection, hand tracking, and pose estimation.

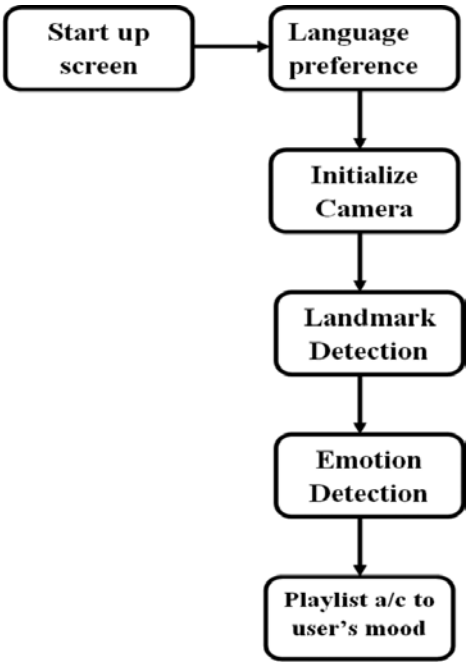

Fig 2. Flow Diagram of the Proposed System

Emotion detection: The identification of the emotion on the face, such as surprise, happy, anger, sad, rocking, and neutral. The MediaPipe Holistic module is used to extract facial and hand landmarks from video frames captured by the webcam. The facial and hand landmark coordinates are normalized with respect to a reference point, and then stored in a list for each video frame.

The landmarks of the face detected by the Mediapipe Holistic model include:

Nose tip, Left eye (inner and outer corners), Right eye (inner and outer corners), Left ear (top, bottom, front), Right ear (top, bottom, front), Left mouth corner, Right mouth corner, Chin, Left cheek (centre and cheekbone), Right cheek (centre and cheekbone).

Fig. 3. Emotion Detection

These landmarks are identified by the model using deep neural networks trained on a large dataset of images and videos. By tracking the positions of these landmarks in a video stream, it is possible to detect and track facial expressions and movements, which can then be used to infer the emotional state of the person being analyzed. The ANN architectural model is used for image classification. Here, for one emotion, it contains 100 frames i.e., according to six emotions, it has a total of 600 frames in it.

Music Recommendation: According to our research, a dataset of songs was categorized based on current mood, but there were only a limited number of songs in it, so we moved to YouTube to expand our selection. The song mp4is available on YouTube and was linked in real-time based on user mood and language preferences.

RESULT

In our work, the music recommendation model is based on the emotions that are captured in real-time. The process of detecting emotions in our work is illustrated in Figure 3. This system presents an emotion-based (expressions) recognition system so that it can detect emotions, and a music playlist will be recommended accordingly.

This system basically works on different modules like Face capture, Emotion detection, and Music recommendation. In our system, we utilize neural networks throughout the entire process. Our system is detecting six emotions which are Happy, Sad, Angry, Neutral, Surprise, and Rocking. As compared to the previous papers our system accuracy between 70 and 80 percent.

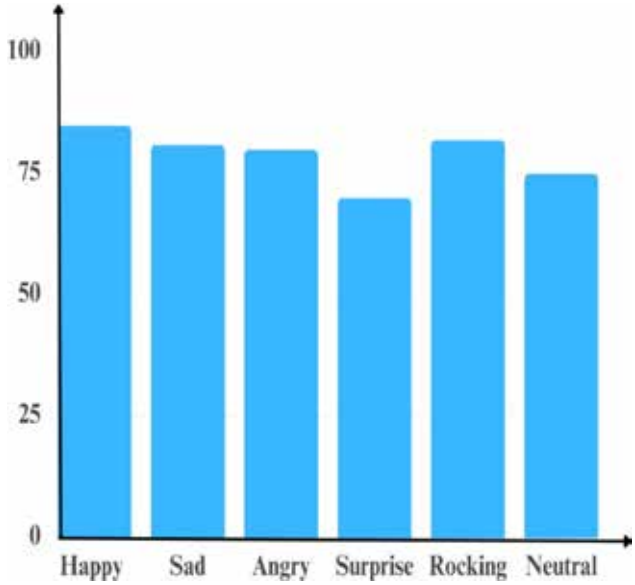

Fig. 4. Accuracy of Emotions in Graphic Format

To achieve accuracy in each emotion, 50 epochs are used in this process. Fig.4 shows the accuracy of emotions in graphical format. Each epoch comprises numerous iterations or steps, which enable the model to enhance its predictions by leveraging the collected data and output labels. Table 1 shows a comparison of the accuracy achieved in our project with that of previously proposed work. By monitoring accuracy after each epoch, our system is able to identify that every emotion attained the highest accuracy, with happy emotion having the highest among them.

According to our research, all the previous editions used datasets or the Spotify platform to recommend songs, which has the limitation of a language barrier. To overcome this, our system redirects to YouTube, which is easily available and has no restrictions.

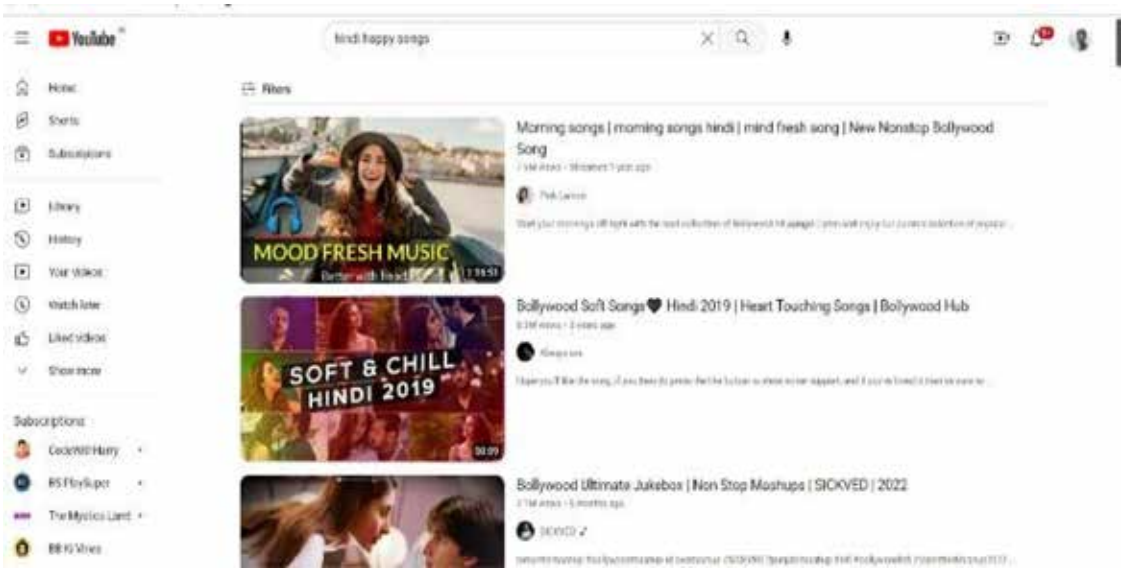

Fig 5. Music Recommendation

Table 1. Accuracy Comparison

References	Happy	Sad	Surprise	Angry	Neutral	Rocking
Vijay et al. [1]	100%	----	----	75%	97%	------
Ahlam A et al.[2]	40%	66%	56%	----	69%	------
S Metilda Florence et al. [10]	0%	100%	----	----	----	-----
Our Work	85%	81%	70%	80%	75%	82%

CONCLUSION AND FUTURE SCOPE

The goal of our project was to develop a system for music selection based on emotions that would allow us to recommend a playlist to a customer based on their temperament and then strengthen it into a particular playlist.

This suggested system can create facial images to identify key emotions and suggest music based on the client's disposition. Since YouTube is one of the most widely used streaming music platforms. Our effort was directed towards ensuring that the recommended playlist was sourced directly from YouTube. In the future, our focus will be on creating a music recommendation system that can identify different emotions not only from images but also from videos or live camera streams. so that it can be used in electronic and automotive systems, including those in automobiles, laptops, mobile phones, etc.

REFERENCE

1. Vicky k., SumitK., VenkateshwariP, "Music Recommendation based on User Mood", in IEEE International Conference on Computing for Sustainable Global Development, 2022.
2. AhlamA., Alaa A, KhuludA, "Music Recommender System for users based on Emotion Detection through Facial Features", in IEEE Developments in Systems Engineering (DeSE), 2019.
3. Vijay S., Azeem G.,DeeveshC.,"Emotion-Based Music Recommendation System", in IEEE International Conference on Reliability, Infocom Technologies and Optimization, 2021.
4. KevinP. ,Rajivkumar G. , " Song Playlist Generator System Based on Facial and Machine Expression and Song Mood", in IEEE International Conference on Artificial Intelligence Vision (AIMV), 2021.
5. ShlokG., Husain Z., Chintan S.,"Smart Music Player Integrating Facial Emotion Recognition and

MusicMood Recommendation", in IEEE WiSPNET conference, 2017.

6. Oindrella G., Sanskar L., Sudhanshu K.,"Music recommendation system based on Emotion Detection using Image Processing and Deep Networks" in IEEE 2022 Conference intelligent technologies.

7. S Metilda Florence, M Uma, "Emotional Detection and Music Recommendation System Based on User Facial Expression" in IOP 2020 3rd International Conference on Advances in Mechanical Engineering.

8. Madhuri A., Deepali M., Upasana S., megha G., "Music Recommendation Based on Face Emotion Rcognition" in IEEE 2021 International conference of AI.

9. Shantha S, Jaichandran R.,Ranjitha J., "Facial Emotion Based Music Recommendation system using computer vision and machine learning technique."Inturkish journal of computer and Mathematical Education 2021.

10. S Metilda Florence, M Uma, "Emotional Detection and Music Recommnedation system based on User" in ICAME 2020.

11. Anuja Arora, Aastha Kaul, Vatsala Mittal, "Mood Based Music Player", in IEEE JIIT NOIDA, 2019.

12. DegerAyata, Yusuf Yaslan, Mustafa E.Kamasa, " Emotion Based Music Recommendation System Using Wearable Physiological Sensors ", IEEE Transactions on Consumer Electronics, 2018.

13. Vincenzo Moscato, Antonio Picariello, Giancarlo Sperl, "An Emotional Recommender System for music", in IEEE Department of Electrical and Information Technology, University of Naple, 2020.

14. Aurobind V. Iyer, Karan Prajapati, "Emotion Bsed Mood Enhancing Music Recommendation",in IEEE conference,2017.

15. Krupa K S,Ambara G, "Emotion aware Smart Music Recommender System using Two Level CNN", in IEEE(ICSSIT),2020.

ISLT: Indian Sign Language Translator Mechanism

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ABSTRACT

Sign language translator is a technique that aims to fill the communication gap between normal people and impaired people by translating the Indian sign language into text or voice format. Recent trends in Sign Language Translator include the use of hand gloves to classify the hand gestures, mobile application, browser extension, wearable devices, etc. Our project aims at collecting a dataset and then using various machine learning or image classification techniques to extract useful information, which will make the ease in communication of deprived. Various type of works has been done in this area like sign language translation algorithm using Convolution Neural Network and many researchers have also created a smart glove to capture and analyze the hand movements, but they are little costly compared to our sign language app which is purely software-based tool. We have used the latest software tools available in the market to run softly on the next generation devices. Our main objective is to deliver a good sign language translator in the form of an app by creating a good User Interface and translating the sign in real time.

KEYWORDS *: Sign language, Translator, Hand gesture communication, Python, OpenCV, Deaf/Dumb, Java, Android studio*

INTRODUCTION

The linguistic structure of sign language is distinct and varies based on geographical location. Sign language is specific to each country, developed to facilitate communication within their respective deaf and hard-of-hearing communities[1]. It consists of diverse gestures comprising hand shapes, movements, orientations, and facial expressions. It is a mode of communication which uses varies ways like expressions and hand gestures. Sign languages are not standard and universal, and the grammar differs from country to country. Our project aims at converting a Indian Sign Language into words by using varies algorithms to break the communication gap between the normal and impaired people[2]. In this endeavor, we are striving to facilitate communication between hearing-impaired individuals and the general population, enabling them to easily interact with one another. Our aim is to provide them with easy and hassle-free communication using a mobile application.

The aim of the project is to create an innovation that will help people with speech and communication difficulties. One of the main goals is to improve access to the deaf in the community and to the deaf born in deaf families by providing alternative means of communication. In addition, the project aims to reduce the costs associated with providing language-related information. To achieve these goals, the project team will develop a system that utilizes speech-to-text APIs and employs the semantics of lips or tongue to accurately translate complete audio sentences and words into text format. The system will also incorporate machine learning algorithms to ensure accuracy and comprehensibility by breaking down the text into small, understandable pieces and employing pre-defined signing datasets. The use of AI will enable the system to display or translate audio sentences into text format in a cost-effective and accessible manner. Furthermore, the project will expand the Indian Sign Language (ISL) dictionary and further improve the system's performance to make it a more comprehensive

tool that can support disadvantaged communities. Another crucial aspect of this project is the translation of gestures and expressions into text and audio format.

SIGN TO TEXT/SPEECH TRANSLATION

Signs are taken as an input by a normal person using a mobile camera or webcam of a cellular phone or computer. For the captured image to be of excellent quality it will be sent for extra object removal. The process of converting sign language into either text or speech involves utilizing a trained database of sign language, which allows for recognition of signs through a module dedicated to text recognition. By comparing the database with the converted text, we can identify meanings and symbols, which can then be presented alongside text or through speech to individuals who are deaf or mute.

Fig. 1. Indian sign language alphabet series

A sign language interpreter is a skilled communicator trained to bridge the linguistic gap between spoken and signed languages. This usually means someone who can't hear but understands signs. Deaf individuals can communicate with the device by signing, and the device can interpret their signs or convert spoken English into Indian Sign Language.

In this report [1] proposed by, Anirudh Muppidi, Amar Thodupunoori and Lalitha they discussed a real time vision based American sign language recognition have been Developed for deaf and dumb people. The project achieved final accuracy of 92% . This is suitable to better our prediction after enforcing two layers of algorithm in which we conform and predict symbols which are more similar to each other.

The report [2] proposed by, Aman Pathak, Avinash Kumar, Priyam, Priyanshu and Guptaigunjan Chugh they discussed the main purpose of sign language detection system is providing a practical way of communication between a normal and impaired people by using hand gesture. From the result of the model, it can be concluded that the proposed system can give exact results under proper light and contrast.

The paper [3] published by, Radha S. Shirbhate1, Vedant D. Shinde, Sanam A. Metkari, Pooja U. Borkar and Mayuri A. Khandge they discussed that in this work it shows working of the project to convert different sign language signs into different tokens and for this to be done the model is going to use automatic sign language recognition system in real time.

Pooling and capsules routing on the same network can increase network accuracy and convergence speed, according to the authors of reference [4], Md. Asif Jalala, Ruilong Chen, Roger K. Moore, and Lyudmila Mihaylova. The upgrading of this framework to include non-static gestures would be a future addition of this work. Use of recurrent neural network layers in conjunction with the capsules is one of many potential solutions. The evaluation results of the described acquisition system and sign language gesture recognition using accelerometer sensors, according to authors Jakub Gaka, Mariusz Msior, Mateusz Zaborski, and Katarzyna Barczewska in reference [5], clearly demonstrate that such an approach can produce a very high recognition efficiency.

METHODOLOGY

It uses a vision-based methodology. The issue of communicating with artificial devices ceases because all signs are represented with only the naked hands. Real-time sign language to text conversion can be broken down into a series of easy processes, such as:

Fig. 2: ISLT Process

The core ML model of our project is written purely on Python 3. Python is a high-level programming language with a simple syntax and a large standard library. Each implementation of Python has its own strengths and weaknesses, and choosing the right implementation depends on the specific needs of the project.

Here we are using Python 3 for training and modeling. Python 3 is the latest version of the Python programming language, and it is considered a major upgrade from Python 2. Python 3 is not a different type of language, but rather the successor to Python 2, which is now considered legacy and will no longer receive updates or support. Python 3 introduced many new features, syntax changes, and improvements over Python 2, including better Unicode support, improved syntax for function annotations, and a new way of handling exceptions. Its intended purpose is to facilitate effortless comprehension, composition, and interpretation. It was released in December 2008 and introduced many new features and changes that made the language more consistent, easier to use, and more powerful.

Developing projects based on recognition or classification are really difficult to cope up. To classify the image generated by the camera, we use OpenCV as a classifier tool. OpenCV, short for Open- Source Computer Vision, is a popular open-source library for computer vision and image processing. Initially developed by Intel, the library is now maintained by the OpenCV Foundation. With over 2500 optimized algorithms, OpenCV enables developers to detect and recognize faces, identify objects, track moving objects, extract features, manipulate images and videos, and more. While OpenCV is primarily written in C++, it provides bindings for other programming languages such as Python and Java. Furthermore, it is compatible with multiple platforms such as Windows, Linux, macOS, Android, and iOS. OpenCV offers a set of modular and user-friendly APIs for developers to build computer vision applications with ease. Additionally, it includes tools and utilities for debugging and performance analysis.

To train the machine learning model which is developed to recognize the alphabet, we use TensorFlow as an object detection model. Tensor Flow is an open-source library developed by Google's Brain team in 2015. It is designed for building and training machine learning models, including deep neural networks, convolutional neural networks (CNNs), recurrent neural networks (RNNs), and more. The library derives its name from the operations it performs on data, which are represented as multidimensional arrays or tensors. With a wide range of APIs, Tensor Flow enables developers to build various types of ML models quickly and efficiently. The algorithm we use to recognize the images taken from the user's camera is CNN. CNN stands for Convolutional Neural Network, which is a type of neural network commonly used in image and video recognition, natural language processing, and other applications. In CNN a set of data is passed through a pipeline, which extracts the useful data from the set by applying some filters. These filters slide over the input data, performing element-wise multiplication and addition operations to create a feature map. The output of the filtering process is then passed through a series of pooling layers, which reduce the spatial size of the feature maps while retaining the most important features. This helps to reduce the number of parameters in the model, making it more efficient.

The main reason behind creating an android application is that it is portable means we can use our translator any time we want. The popular IDE for creating android apps is Android Studio. Android Studio is Open source Integrated Development Environment (IDE) used to develop Android applications. It was developed by Google and is available for free download on Windows, Mac, and Linux operating systems. Android Studio provides a range of features and tools that simplify the process of developing, testing, and debugging Android applications. It offers a graphical user interface (GUI) designer for building UI layouts and a code editor for writing code in languages such as Java and Kotlin. Additionally, Android Studio includes a code analyzer that detects potential errors and provides suggestions for improvement.

Gesture Classification

Gesture recognition is a process that recognizes and distinguishes human gestures through computer vision and machine learning models. It has many applications such as language recognition, gesture classification, and virtual reality. The procedure usually involves checking

and analyzing hand and body movements. Gesture classification is a subcategory of gesture recognition that includes the recognition and classification of human gestures and actions. It uses computer vision techniques, including image processing and machine learning, to analyze hand and finger movements. The process includes several steps, including manual search, feature image or video scene, while inferencing involves identifying relevant features such as hand gesture or finger movements. Manual search is inaccurate because while searching the moving hand our eye cannot classify which symbol user want to show to the deaf person. So we need to automate this process by using OpenCV as a feature extraction tool to extract the hand sign or hand gestures created by the deaf people while communication with normal people.

Classification utilizes machine learning algorithms to classify the gesture into a predefined category, such as a particular letter in sign language. The approach used in this design involves two layers of algorithms to predict the final symbol of the speaker. Gesture classification has various applications, such as in sign language recognition, human-computer interaction, and virtual reality. For example, sign language recognition systems use gesture classification to translate hand movements into text or speech. However, gesture classification can be challenging due to variations in lighting, hand orientation, and hand movements. Nevertheless, recent advancements in computer vision and machine learning have made it possible to achieve high levels of accuracy in gesture classification, making it a promising field for research and development.

Gesture classification involves the use of Digital Image Processing Techniques which is subcategory of Electronics engineering. In electronics engineering we learn the processing of digital signals and classification of pixels. Pixel is the smallest unit of a image that can be represented on a digital display device. By using this smallest bit of information we can reduce the pixel redundancy and improve the quality of the image. By improving the quality of image we can easily classify the images based on the useful pixels.

OpenCV comes to help for the classification of this useful or redundant pixels. OpenCV provides the vast Computer Vision Library and tools for the image processing works. The main feature of OpenCV is that it works on the real-time.

Algorithm

1. Collect images for deep learning using your webcam.
2. Label images for sign language detection.
3. It does not require a huge dataset due to labelling. So, the length of the training will be calculated, and the space will be utilised effectively.
4. Detect sign language in real time using Open CV.
5. Setup Tensor Flow Object Detection pipeline configuration.
6. Tensor Flow Lite empowers developers to execute their machine learning models on mobile, embedded, and edge devices, by providing them with a comprehensive suite of tools for on- device machine learning.
7. Output in the text and speech format is produced.

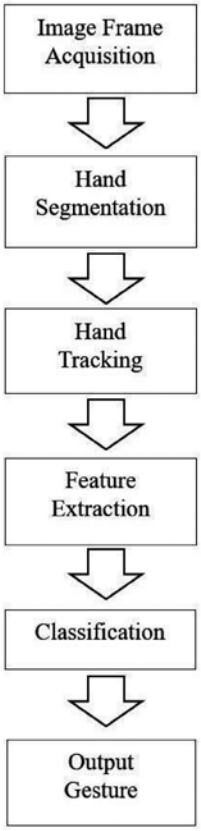

Fig. 2(a). Shows the flowchart of this project

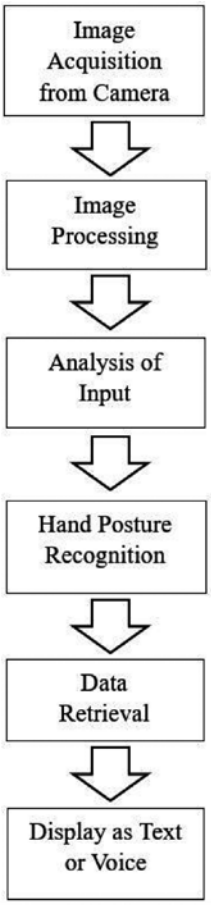

Fig 2(b): Shows different phases in the project

RESULT

After the completion of our mobile application, we can see the login page Fig[a]. By using the login page, we can sign in into our existing account using "Sign In" button or if anyone is new to the application, he/she can also sign up using "Sign up" button.

In Fig. [b] it shows us two options for sign recognition. The one is real time sign language translator and another is real time text to voice sign language translator, both the option captures the live image with the help of inbuilt camera.

In Fig. [c] and Fig. [d] we can see the capturing window where the image is being captured by the device and at the real time it is converted into the text format.

In the final Figure Fig. [e] we can see the output of the given sign language into the text format, and we also have the option to convert the text into sound format.

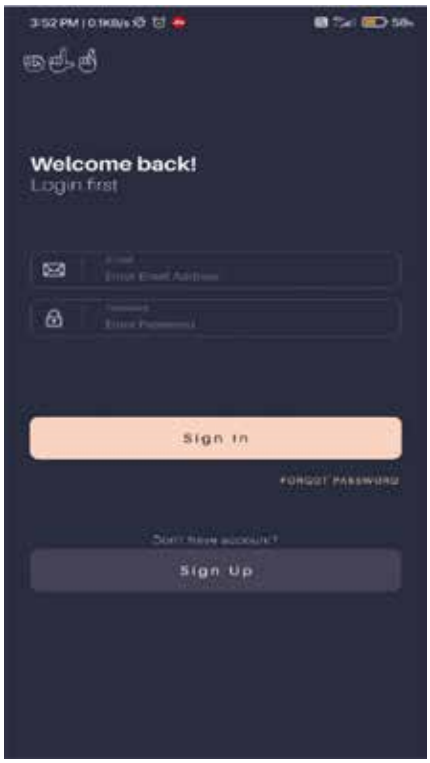

Fig (a): Log in and Sign Up page

Fig (b): Home page

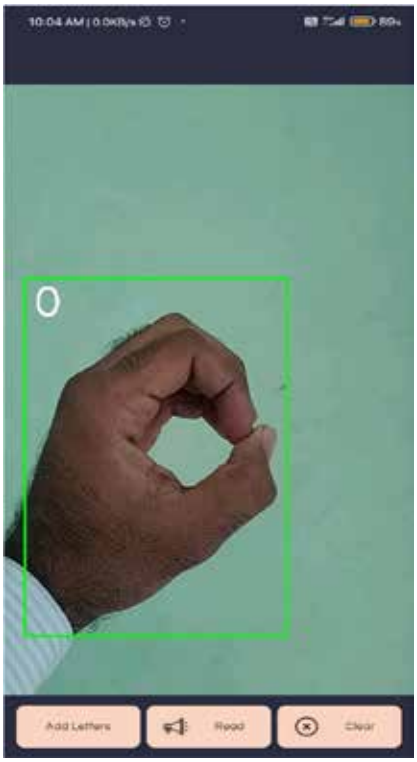

Fig (c): Detecting Sign 'O'

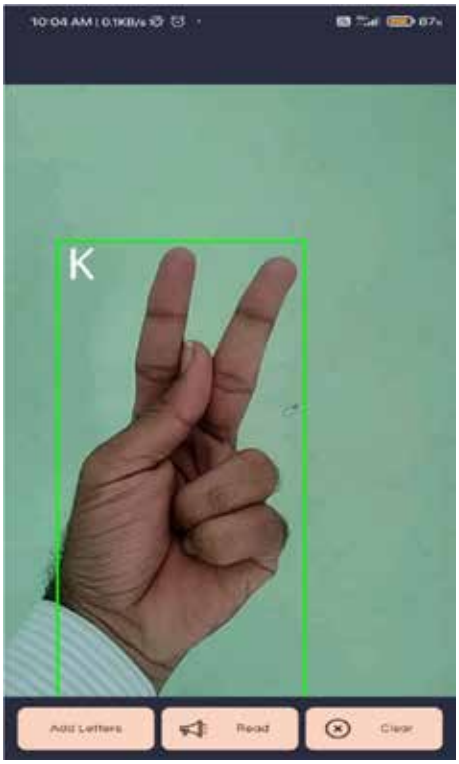

Fig (d): Detecting Sign 'K'

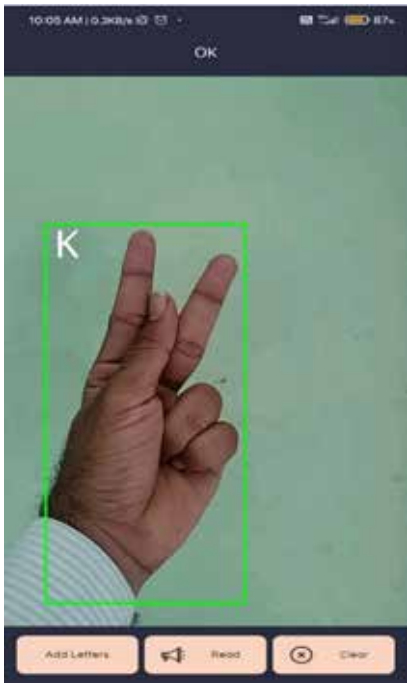

Fig (e): Final Output Sentence

CONCLUSION

Sign language is the primary mode of communication for deaf individuals and those born into deaf families. It allows for easy communication among them, and transcription becomes secondary to conversation. They prefer to receive information in the form of sign language, but this can be expensive and not always accessible. To address this challenge, a system is being developed that can assist individuals with communication and speaking difficulties. Machine learning algorithms are used to break down the text into small, understandable pieces, with pre-defined signing datasets employed to ensure accuracy. By leveraging AI, the software can effectively display or translate audio sentences into text format. However, challenges remain as the ISL dictionary is still limited in size. As such, further improvements to the system's performance are necessary to make it a more comprehensive tool that can support disadvantaged communities.

In summary, sign language is the primary communication mode for the deaf and those born into deaf families, but it can be costly and inaccessible. A system is being developed that uses speech-to-text APIs and semantics to translate audio sentences and words into text format.

The software uses machine learning algorithms to break down text into understandable pieces, with pre-defined signing datasets used for accuracy. However, the system faces challenges, including the limited size of the ISL dictionary. Further improvements are necessary to make it a comprehensive tool that supports disadvantaged communities.

REFERENCES

1. Anirudh Muppidi, Amar Thodupunoori, Lalitha, "Real Time Sign Language Detection for the Deaf and Dumb", in International Journal for Modern Trends in Science and Technology, 2022, India.
2. Aman Pathak, Avinash Kumar, Priyam, Priyanshu, Guptaigunjan Chugh, "Real time sign language detection", in International Journal of Advanced Trends in Computer Science and Engineering, August 6, 2022
3. Radha S. Shirbhate1, Vedant D. Shinde, Sanam A. Metkari, Pooja U. Borkar, Mayuri A. Khandge, "Sign language Recognition Using Machine Learning Algorithm", International Research Journal of Engineering and Technology 2020, Pune, India.
4. Md Asif Jalala, Ruilong Chenb, Roger K Moorea, Lyudmila Mihaylovab, "American Sign Language Posture Understanding with Deep Neural Networks", IEEE, 2018, UK.
5. Jakub Gałka, Mariusz Mąsior, Mateusz Zaborski, Katarzyna Barczewska, "Inertial motion sensing glove for sign language gesture acquisition and recognition", in IEEE Sensor Journal,2013, India.
6. D. Divya, B. Nikesh, "Indian Sign Language Recognition", 2012 1st International Conference on Emerging Technology Trends in Electronics, Communication and Networking, 2012.
7. A. C. Subhash, J. Anand, B. Charul, "Recognition of Indian Sign Language using Feature Fusion", IEEE Proceedings of 4th International Conference on Intelligent Human Computer Interaction, Kharagpur, India, December 2012.
8. N. Purva, K. Vaishali, "Indian Sign Language Recognition: Database Creation, Hand Tracking and Segmentation", IEEE Proceedings on Circuits, Systems, Communication and Information Technology applications, 2014.
9. F.S. Chen, C. Fu, & C. Huang, "Hand gesture recognition using a real time tracking method and hidden Markov models", ELSEVIER, Image and Vision Computing, Volume 21, Issue 8, pp. 745– 758, 2003.
10. Chin-Chen, H. Yu-Chen, "A Fast LBG Codebook Training Algorithm for Vector Quantization", IEEE transactions on consumer Electronics, vol 44, Issue 4, page 1201-1208, 1998.
11. Divya Deora, Nikesh Bajaj, INDIAN SIGN LANGUAGE RECOGNITION, 21stInternational Conference of Emerging Technology Trends in Computer Science,2012.
12. Kumud Tripati, Neha Baranwal, GC Nandi, Continuous Indian Sign Language and Gesture Recognition, ELSIVIER, IMCIP 2015.
13. M. Elmezain, A. Al-Hamadi, J. Appenrodt and B. Michaelis, A Hidden Markov Model- based Continuous Gesture Recognition System for Hand Motion Trajectory, 19th International Conference on IEEE, Pattern Recognition, 2008, ICPR 2008, pp. 1–4, (2008).
14. M. Suresh Anand, A. Kumaresan, Dr. N. Mohan Kumar, "An Integrated Two Way ISL (Indian Sign Language) Translation System – A New Approach", International Journal of Advanced Research in Computer Science, Volume 4, No. 2, Jan-Feb 2013.

Pragmatic Analysis of Network-on-Chip Routing Models from an Empirical Perspective

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ABSTRACT

Routing is the process of the path selection in any network. Routing creates efficiency in the network communication. Network communication failures result in long wait times for website pages to load users. Inadequate throughput performance may result from missed packets, delayed data, lower energy efficiency, and incorrect routing between on-chip nodes. To solve this issue, researchers created a variety of routing methods, such as XY Routing, Priority Routing, and others. Additionally, each of these models has machine learning-optimized variations that may be used to help create low-power, high-throughput communications. Performance indicators like throughput, energy utilization, and packet delivery ratio are just a few of the ones that are used to compare various strategies (PDR). There are also nuances, advantages, and drawbacks that are particular to the setting, as well as possible research areas. It is challenging for researchers to predict which routing models would provide the best results for the application-specific installations they are working on because to the wide diversity in performance. In order to dispel any remaining questions, this study offers a thorough analysis of the merits, applicability, and scalability performance of these models. Researchers and network designers will be able to deploy their on-chip networks using the most appropriate models thanks to this discussion, which will lower the costs of designing and implementing networks of all sizes. In order to identify application-specific routing strategies, this presentation includes a statistical analysis of the investigated models. According to the evaluation in this paper, it can be seen that show case higher efficiency of routing, while these models along with showcase lower delay when compared with other techniques.

KEYWORDS *: Routing, On-Chip, Control, Network, Delay, Throughput, Energy, PDR, Scenarios*

INTRODUCTION

From their beginning NoC router supporting different link bandwidths and number of VCs per Uni-directional port is presented and the main advantages are better ingress and egress bandwidth, decoupling, better performance and ability to configure the router according to the preferred cost performance ratio. Several modelling domains and activities are involved in designing on-chip routers, including rate control, piggybacking, fidelity analysis, traffic estimate, and traffic redirection, among others. Researchers build these capabilities into on-chip networks using a variety of methods. The majority of routing models begin by identifying congestion at the packet level. Queue length, packet rate, service time, inter arrival time, delivery time, node latency, application fidelity, and channel condition are a few of the metrics stated above. The packet is transmitted to the next node on the chip, where it will be processed alongside other traffic if there

is no bottleneck. The on-chip routers get notifications of congestion, which they use to help activate the arbitration modules.

Emerging as a new approach for the creation of complicated on-chip communication architectures in today's electrical systems-on-chip, the term "network-on- chip" (NoC) was coined to describe this concept (SoCs). One of the most important elements of the construction of a NoC is the NoC routing, which establishes how data packages are sent from one point to another within the network. Cellular automata, also known as CA, are discontinuous mathematical model that have found widespread application in the field of research concerning complicated systems. Recent research has looked into the possibility of using CA as a transportation paradigm for NoC. Each router is represented as a cell in a cellular automaton in the CA-based NoC routing model. The decision regarding the sending of a data stream is made based on the local state of the router's surrounding cells.

The flexibility, fault-tolerance, and energy effectiveness of this strategy have all been demonstrated to have positive outcomes. Nevertheless, it also presents some difficulties, such as the need to create suitable CA rules for effective handling and find a solution to the problem of overcrowding. In general, the CA-based NoC routing model is a fascinating field of research that has the possibility for further investigation and expansion use cases.

At this layer, choices regarding congestion control result in packet rerouting or the adoption of additional procedures. Rate control, packet dropouts, additive increase/multiplicative decline (AIMD) in packet rate, and a growth in the number of resources are a few of them. This data is updated often on the router, which improves congestion management and avoidance at the packet level under a range of network conditions. Numerous route control models have been developed by researchers, each with unique deployment characteristics. The intricacy, applicability, and limits of these models are discussed in the next section, along with some possible future study possibilities. This debate will help researchers choose the best route control models for their deployments of application-specific on-chip networks. This background information is followed by a statistical analysis of the studied models' performance indicators. End-to-end latency, throughput, packet delivery ratio (PDR), and other equivalent factors may be included in these performance evaluations. Readers will also benefit from this article's comparative study in evaluating which congestion control strategies are best suited for their particular network configurations. The article's last section draws some intriguing conclusions about the examined models and provides a range of suggestions for enhancing their effectiveness.

NETWORK ON CHIP : AN OVERVIEW

Network-on-chip (NoC) is an emerging paradigm for designing complex on-chip communication architectures in modern electronic systems-on-chip (SoCs). NoC routing is one of the key design aspects of NoC architecture, which determines how data packets are routed through the network. Cellular Automata (CA) is a discrete mathematical model that has been widely used in the study of complex systems. CA has been recently explored as a potential routing model for NoC. In the CA- based NoC routing model, each router is modelled as a cell in a cellular automaton, and the routing decision for a data packet is made based on the local state of the router's neighbouring cells. This approach has shown promising results in terms of scalability, fault-tolerance, and energy efficiency. However, it also poses some challenges such as designing appropriate CA rules for efficient routing and addressing the issue of congestion. Overall, the CA- based NoC routing model is an interesting area of research with potential for further exploration and development scenarios. In order to transfer information across NoC nodes, researchers have offered a plethora of different ideas. [1] Heterogeneous multi core computer platform designs have been developed for energy efficiency as a direct result of the demands of Big Data and AI. Today's heterogeneous multi core system-on-chip (SoC) asymmetric data-access traffic necessitates a tailored network-on-chip (NoC) offering connection variety (SoC). Single-source, multi-destination (SSMD) traffic allows for the use of cache coherency protocols, barrier synchronization, parallel processing, and DNN acceleration. Multicast routing increases network throughput by dispersing SSMD traffic. To avoid deadlocks in NoCs, multicast routing between active

routers must not rely on branch operations. Because stalemate circumstances are problematic, and the route Hamiltonian needed to apply the rule of lebeling may it is not existed in topology-based NoCs, throughput-optimized multicast routing is difficult to achieve. The use of multicast routing in specialized NOCs has led researchers to two key findings: 1) No deadlocks will occur if branch operations are constrained to an endpoint, even the NoC as lacks of a route Hamiltonian . 2) Variables paths variation may be used in route allocation and branching in a topologically-specific routing scheme. This research provides specialized NoCs based on characteristics like free-deadlock, enhanced-throughput multicast routing (MRCN). Lebelling router and extended routing rules prevent deadlocks in the MRCN. Partitioning at the final router destination and traffic- aware adaptive branching both reduced the number of hops a packet must make on its way to its intended receiver. Noxim, accurate-cycle NoC simulator, was used to analyze the MRCN under a variety of topologies and traffic loads. The experiment showed that compared to the bespoke NoC multicast routing, MRCN reduced average delay by 13.98% and increased throughput by 12.16% under heavy traffic loads.

According to [2], optical networks-on-chip (NoC) based on silicon photonics are promising on-chip communication architecture for chip multiprocessors. Since optical devices are susceptible to fluctuations in on- chip temperature, thermally induced optical power loss would dramatically degrade the power efficiency of optical NoCs. To address this problem, detail a thermal- aware adaptive routing system based on ant colony optimization (ACO). In order to reduce the amount of optical power that is lost due to changes in temperature, the ACO-based routing approach makes optimal routing selections. The classic ACO-based routing strategy requires a table in each node to store and update pheromone, the size of which grows linearly with the number of nodes. The approximation ACO-based routing (AACO) method uses linear regression to reduce unnecessary table lookups. According to a simulated traffic pattern and real-world applications on an 88 mesh- based optical NoC, the suggested routing algorithms may discover nearly-optimal pathways. We put the routing systems through their paces on a bigger network.

Network-on-Chip (NoC) is the most promising on-chip connectivity architecture in Multi-Processor System-on- Chip (MPSoCs) [3, 4] because of its efficiency and scalability. Deep sub-micron NoC faults cause links and routers to malfunction. When parts of the NoC break, dependability drops across the board. This research proposes a Reinforcement Learning-based Fault-Tolerant Routing (RL-FTR) approach for dealing with link and router failures in mesh-based NoC architecture routing. A System-C based NoC simulator is used to evaluate the RL-FTR algorithm's performance on a cycle-by-cycle basis. Variations in mesh size are a stand-in for expanding networks and router malfunctions. After running the code through simulations, we see it in action in an FPGA implementation, showing how the RL-FTR approach works in real time. Hardware and simulation both indicate that the proposed RL-FTR algorithm improves routing from the source router to the destination router.

Single-cycle long-distance communication [4] is enabled by a dynamically reconfigurable Network-on-Chip (NoC) dubbed SMART (Single-cycle Multi-hop Asynchronous Repeated Traversal) that establishes single-bypass pathways between remote communication pairs. Disputes will easily splinter a system with just one possible way around. Since packets would be delayed at intermediate routers due to blocking latency from competing packets and additional router-stage time to reconstruct the remaining connection when it becomes available, the advantages of SMART NoC's bypassing would be reduced. We provide the first contention-aware routing strategy for SMART NoCs, which improves bypassing performance. We differentiate between a packet's direct route, which may only need to go through one intermediary router, and an indirect route, which may go over several of them (s). End-to-end latency may actually be reduced by using circuitous paths that hop across unrelated routers, contrary to common opinion (even if they are not minimum). Our innovative routing strategy maximizes route diversity, reduces interference between communication pairs, distributes loads uniformly, and makes maximum use of bypass channels. The proposed routing approach boosts

network performance by 35.48 percent, application schedule length by 28.31 percent, and communication latency by 37.59 percent as compared to SMART NoC routing using actual benchmarks.

In newly suggested high-performance NoC architecture, the express bypass is used to send uncomplicated flits to far-flung processing elements (PEs) in a single cycle. If a conflict occurs, lower priority flits will be buffered and limited in their ability to use bypass. As a result of its lack of arbitrary-turn routing, SMART is unable to use routing approaches that avoid congested routers and connections in order to reduce conflict. In order to reduce contentions and maximize bypass, It propose ArSMART, a SMART NoC with arbitrary-turn transmission. The cluster controller in ArSMART determines the best paths for the data to go while the buffer less reconfigurable router handles the throughput. Since the SMART NoC's long-distance transmission bypasses intermediate arbitration, setup the input and output ports' connection directly rather than using hop-by-hop tables for arbitration. Effective ArSMART-compatible adaptive routing algorithms are developed to broaden the available channels of communication. Because taken the time to properly craft our control mechanism, able to keep the cost of route calculation hidden, which is a major problem in adaptive routing systems. Results from experiments show that using a modern SMART NoC may reduce energy usage by 29.7 percent and the duration of application schedules by 40.7 percent.

Optical networks-on-chips (NoCs) based on silicon photonics were suggested for many-core chip multiprocessors in [6]. One important issue with silicon photonics is their susceptibility to temperature changes. Related work advises using adaptive routing based on Q- learning to chill things down. The overhead of using tables for Q-table routing grows rapidly as networks expand. This work proposes a table-free approximation Q-learning based thermal-aware adaptive routing method for determining the optimum low-loss pathways with on- chip temperature changes. The results of the simulations support the proposed table less approximation It is possible that Q-learning-based adaptive routing will converge more faster and deliver optimization benefits that are on par with the best table-based Q-routing. The proposed approximation approach outperforms table- based Q-routing as the size of the network grows.

Both connection not accurate, congestion and failure have a negative impact on the performance of the network on the chip [7](NoC). NoCs are able to handle complicated and ever-changing applications because they use adaptive routing algorithms that are both fault- tolerant and aware of congestion. In this letter, Q-learning-based adaptive routing is proposed. HQ table may be able to prevent data diversions in fault zones and choose the route with least congestion by learning the accuracy, congestion and failular information of the pathways between to the source to destination nodes. Q- value decay and the dynamic learning rate method both deal with the issue of late updates to Q-learning values. The proposed routing methods may function well with a high failure rate (>25%) and little hardware overhead, as shown by the experiments.

Network-on-chips (NoCs) are the standard for system-on- chip connections, as stated in [8]. (SoCs). A NoC router's performance and footprint are limited by the physical layer media access mechanism it uses. When the Code Division Multiple Access (CDMA) is a method, it is using by many wireless communication networks, has been suggested as a NoC router switching strategy. Using direct-sequence spread spectrum on digital interconnects, multiple processor elements (PEs) may engage in simultaneous communication through a code division multiple access (CDMA) crossbar. Bit-wise designs, such as those used by conventional CDMA switches, repeatedly using the configurations to transfer multiples bits data, increasing crossbar space or cable density. It propose aggregated CDMA routing to increase router density, throughput, and efficiency in CDMA NoCs (ACDMA). The nature of static and the noise of relative immunity of the on-chip interconnects to allow ACDMA to combine multiple bits of data into M-ary symbols on single communication digital channel, therefore reducing crossbar wire density and space overhead. Different area-speed trade offs are made in the implementation of ACDMA crossbars employing serial and parallel Application- Specific integrated circuit(ASIC) 65 nm is a standard cell technology. The implementation shows the Throughput-Per-Area (TPA)

values for the Standard Basis (SB), Walsh Basis (SB)and the Overloaded CDMA Interconnect (OCI) crossbars are 96.3%, 18.2%, and 118.6% lower than the serial and parallel ACDMA crossbars, respectively. Fully realizing the node-65 NoC router ACDMA and comparing for the against of state-of-the-art CONNECT and CDMA routers under a variety of simulated workloads. A hybrid Automatic Repeated Request(ARQ)approach is presented improved the robustness of communication between ACDMA NoC routers in the presence of noise.

The Dual Data Rate (DDR) data path of the Network-on-Chip (NoC) known as Highway NoC almost reaches the optimal network performance [9]. Data paths on routers are faster than control ones, therefore a DDR NoC route will boost throughput at data path speeds rather than control ones. When there is less traffic, DDR NoCs may reduce packet delay by using pipeline bypassing. Current DDR routers simplify their logic by ignoring internal hops that do not include a turn. Highway NoC avoids DDR routers on local ports to speed up pings entering and leaving the network. As a result, it saves physical space and power by streamlining the allocation of DDR switches and router port interfaces. While compared to standard NoCs, Highway NoC excels when operating over a route and location of 28 nautical miles. Highway NoC decreases average packet delay by 7.3-27% and power consumption by 1-10% compared to DDR NoCs, all without degrading throughput. Highway NoC provides 17-22% greater throughput, 13.8 percentage points less packet delay, and varying degrees of energy efficiency compared to Single Data Rate NoCs.

Work in [10] declared Optical connections using wavelength-division multiplexing (WDM) are becoming a more appealing option for on-chip data transmission as bandwidth and power demands rise with the scaling down of VLSI technology. Previous research into WDM-aware optical routing has three major flaws: it manages optical routing with heuristics or constrained integer linear programming; it addresses only some forms of insertion loss and WDM overheads; and it does not account for crosstalk noise when multiple signals are transmitted simultaneously. This makes it such that they can't be sure of their WDM clustering results, the reliability of their optical network is compromised, or their calculations are excessively time-consuming. A novel WDM-aware optical routing technology significantly accelerates throughput while simultaneously reducing insertion loss, WDM overheads, and crosstalk noise. WDM-aware route clustering gives an ideal solution for 1-, 2-, and 3-path clustering, but it has a consistent performance limit for most 4-path clustering. By taking into account crosstalk during the route assignment process, the possible number of signal pairs affected by crosstalk is reduced, hence keeping the total number of signal pairs within the displacement limit. Previous testing have shown that our optical router exceeds the competition in terms of wire length , insertion loss, wavelength power, crosstalk noise, and runtimes.

A proclamation was made in [11] Data-driven programs with huge memory footprints sometimes fail to use the cache because of insufficient on-chip caching. When applications make use of cache blocks that have been previously evicted, they risk incurring repeated miss penalties. NoC routers include input port buffers to prepare for catastrophic situations. Recent studies have shown that until network congestion occurs, buffers are underutilized. In order to do post-silicon debugging and verification, NoC routers use trace buffers. After a design is put into production, they sit unused in the routers. In this article, recently evicted cache blocks are stored in inefficient NoC router buffers and trace buffers. The NoC router may send replies to the data in these delayed blocks. Opportunistic caching of evicted blocks greatly reduces miss cost in NoC routers. According to results from experiments, the suggested designs have the potential to increase system performance by 19% (14%), while simultaneously decreasing miss penalty by 21% (16%). In spite of a small area and leakage power overhead of 2.58 and 3.94 percent, respectively, dynamic power drops by 6.12 percent as a consequence of performance improvements.

A silicon microchip can currently accommodate hundreds of processing components, as stated in [12]. This is all because to very large-scale integration. MPSoCs are the cutting edge of technology now available to the public. Network-on-Chip(NoC) is promising and scalable connecting network that enables MPSoCs to reach their full performance potential (NoC). Routers in NoCs use routing algorithms to

properly direct data packets to their final destinations. There are two qualities that routing algorithms should have. Congestion in a network may be avoided if the mechanism for selecting routes is flexible. Second, it must ensure that it does not broadcast outdated data about network congestion to other routers. A large number of researchers at academic institutions have looked into the problem of network congestion and proposed potential solutions. NoC performance may be enhanced by using strategies to reduce congestion. Hardware for gathering information about network congestion on the client side may be necessary. This article explores output selection approaches for routing algorithms with the goal of directing packets to less crowded networks. Using methods for handling and disseminating congestion data, It can classify them. Recent advances in selection methodology are used and analyzed in this work.

Torus, a Network-on-a-Chip (NoC) Through the use of wraparound channels, the number of hops in the traffic may be reduced [13]. However, cyclic pathways in wraparound channels cause a stalemate in a Torus NoC. The Turn model and the channel dependency graph are two common methods for identifying deadlocks in NoCs (CDG). We suggest an Arc model for avoiding deadlocks in Torus NoC. The Arc model, which was developed in order to overcome stalemate in the Torus model, is an extension of the Turn model. This research also presents a directional dependency graph (DDG) for deadlock identification in Torus NoCs, which makes use of the Turn model and causality diagram (CDG). DDG utilizes the Arc model and Turns to simplify deadlock identification, avoidance, and liberation.

Most chip multiprocessor (CMP) designs nowadays use network-on-chip (NoC) as their fabric architecture [14]. Market-driven CMP applications are fuelling a surge in multicast traffic necessary to improved multithreading, barrier ,a cache coherence protocols and synchronization. While multicast packets may be routed through the NoC router using the shortest path, deadlocks caused by branching should be avoided. Network-On-Chip (NoC) studies on free-deadlock minimum routing path in multicast traffic have used several virtual channels or enormous buffers to retain full packets, considerably increasing router area. Present an effective use of the spatial variety provided by the input buffer in a multicast router that helps avoid deadlocks. MRBS directs data packets via the network with the least number of virtual channels and buffers. Under random multicast traffic, the destination, network, packet, buffer, and injection rates all varied. Simulations demonstrate that over a wide range of network sizes, MRBS outperforms the tree-based router by a factor of 39.3 in terms of the area-delay product.

The modularization and widespread fabrication of many- core system-on-chips by a plethora of manufacturers makes hardware Trojans conceivable (HT). Similarly, transistors with smaller feature sizes may age and fail at a faster rate. Authentication codes, cryptography error correction codes and flow profiles of runtime to identify unusual activity are only some of the security and fault- tolerance strategies discussed in the academic literature. As of yet, there are no universally accepted methods for detecting assaults or blunders in communication (NoC). The cutting-edge presentation detailed how NoC attack defensive tactics increase the NoC's susceptibility to security breaches by adding hardware. In this approach, the detection of attacks and system failures are separated by separate data and control NoCs. Message transmission may be monitored, abnormal behavior can be identified, and the Communication Session Protocol can recover from failure or attack owing to a control NoC. There is a wide variety of application communication techniques, and their overhead on execution time varies from 3.5 percent to 33.3 percent. The protocol mitigates this cost by relaunching the program and modifying the routing between communicating task pairs whenever it detects abnormal communication behavior sets. A comparative survey of these models is discussed in the next section of this text.

PERFORMANCE EVALUATION & COMPARISON

It became clear from the comprehensive examination that the performance of the various NoC Routing models under investigation varies widely. These results were evaluated using the criteria of routing efficiency (ER), latency (D), deployment cost (DC), and scalability (S). Fuzzifying the values of these measures into Low (L =

2), Medium (M = 3), High (H = 4), and Very High (VH = 5) helps compare their performance on a standard scale. Models and their corresponding performance metrics are summarized in table 1 to facilitate this evaluation. Better performing models may be selected for various deployments based on this tabulation.

Table 1. Performance evaluation of different models

Method	ER	D	DC	S
DNN [1]	H	VH	H	H
AACO [2]	VH	M	H	VH
RL FTR [3]	H	H	VH	H
SMART [4]	H	H	H	H
ArS MART [5]	VH	M	H	H
QL [6]	H	H	H	M
HQL [7]	H	M	VH	H
ACDMA [8]	H	H	H	H
DDR [9]	H	H	H	H
WDM [10]	H	H	H	H
OC [11]	M	M	L	H
CC QL [12]	H	H	H	H
CDG [13]	M	H	H	VH
MRBS [14]	H	H	H	H
CSP [15]	H	H	H	H

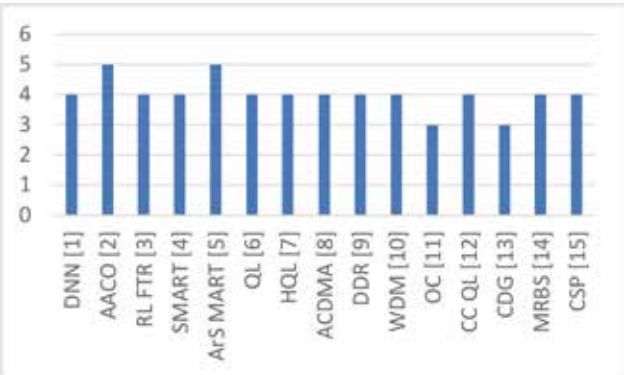

Figure 1. ER for different Models

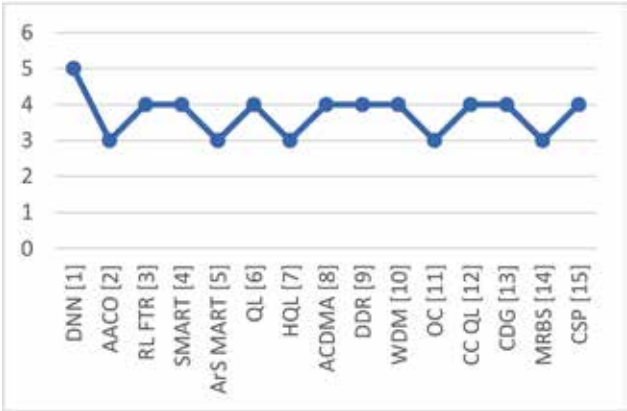

Figure 2. Delay of different models

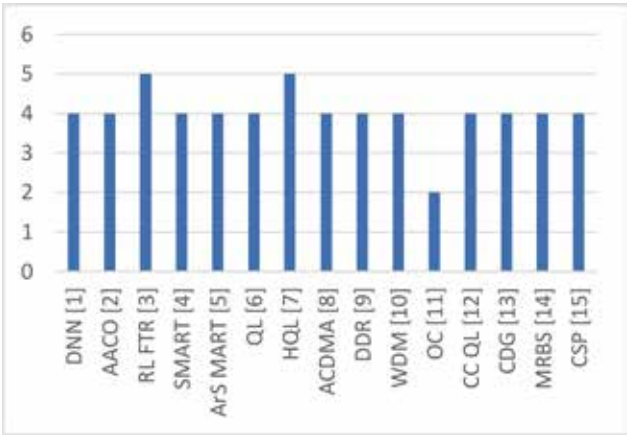

Figure 3. Deployment cost of different models

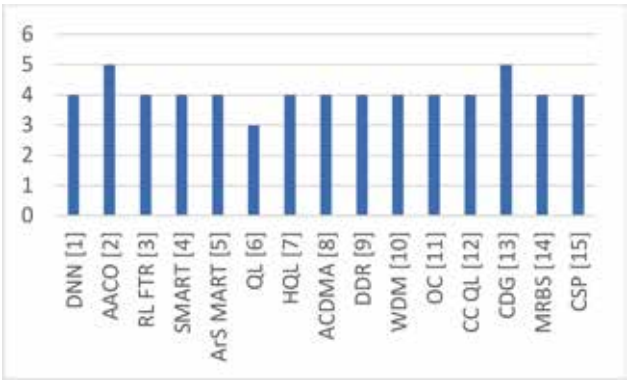

Figure 4. Scalability of different models

As per this evaluation& figures 1, 2, 3 & 4, it can be observed that AACO [2], and ArS MART [5] showcase higher efficiency of routing, while AACO [2], ArS MART [5], HQL [7], OC [11], and MRBS [14] showcase lower delay when compared with other techniques. It was also observed that OC [11] has lower deployment

cost, while AACO [2], and CDG [13] have higher scalability when compared with other models, thus can be used for a wide variety of NoC routing scenarios.

CONCLUSION AND FUTURE WORK

Inadequate throughput performance may occur as a consequence of lost packets, delayed data, reduced energy efficiency, and erroneous routing between on-chip nodes. In order to find a solution to this problem, researchers developed a number of different routing strategies, such as XY Routing and Priority Routing, amongst others. In addition, each of these models contains variants that have been optimized via the application of machine learning, and these variations may be utilized to assist in the creation of low-power, high- throughput communications. When comparing different techniques, some of the performance characteristics that are taken into consideration include throughput, energy consumption, and packet delivery ratio. These are just a few examples (PDR). In addition, there are special subtleties, benefits, and downsides, as well as potential study fields, that are associated with the location. Because there is such a broad variety in performance, it is difficult for researchers to make accurate predictions on which routing models will provide the greatest outcomes for the application-specific installations on which they are currently working. This research provided a comprehensive investigation of the merits, applicability, and scalability performance of these models in order to answer any problems that may have been left unanswered. According to the evaluation in this paper, it can be seen that AACO [2], and ArS MART [5] showcase higher efficiency of routing, while AACO [2], ArS MART [5], HQL [7], OC [11], and MRBS [14] showcase lower delay when compared with other techniques. In addition, AACO [2], and ArS MART [5] showcase higher efficiency of routing when compared with other techniques. When compared with other models, it was found that OC [11] has a lower cost of deployment, while AACO [2] and CDG [13] have superior scalability. As a result, these three models are versatile enough to be employed for a broad range of NoC routing situations. In future, researchers can fuse these models, and use cellular automata techniques to improve performance of these models under real-time use cases.

REFERENCES

1. Y. S. Lee, Y. W. Kim and T. H. Han, "MRCN: Throughput-Oriented Multicast Routing for Customized Network-on-Chips," in IEEE Transactions on Parallel and Distributed Systems, vol. 34, no. 1, pp. 163-179, 1 Jan. 2023, doi: 10.1109/TPDS.2022.3217296.
2. J. Wang and Y. Ye, "Ant Colony Optimization- Based Thermal-Aware Adaptive Routing Mechanism for Optical NoCs," in IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, vol. 40, no. 9, pp. 1836-1849, Sept. 2021, doi: 10.1109/TCAD.2020.3029132.
3. S. Jagadheesh, P. V. Bhanu, J. Soumya and L. R. Cenkeramaddi, "Reinforcement Learning Based Fault-Tolerant Routing Algorithm for Mesh Based NoC and Its FPGA Implementation," in IEEE Access, vol. 10, pp. 44724-44737, 2022, doi: 10.1109/ACCESS.2022.3168992.
4. P. Chen et al., "Contention Minimization in Emerging SMART NoC via Direct and Indirect Routes," in IEEE Transactions on Computers, vol. 71, no. 8, pp. 1874-1888, 1 Aug. 2022, doi: 10.1109/TC.2021.3111517.
5. H. Chen, P. Chen, J. Zhou, L. H. K. Duong and W. Liu, "ArSMART: An Improved SMART NoC Design Supporting Arbitrary-Turn Transmission," in IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, vol. 41, no. 5, pp. 1316-1329, May 2022, doi: 10.1109/TCAD.2021.3091961.
6. W. Zhang and Y. Ye, "A Table-Free Approximate Q-Learning-Based Thermal-Aware Adaptive Routing for Optical NoCs," in IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, vol. 40, no. 1, pp. 199-203, Jan. 2021, doi: 10.1109/TCAD.2020.2987775.
7. Y. Liu, R. Guo, C. Xu, X. Weng and Y. Yang, "A Q-Learning-Based Fault-Tolerant and Congestion- Aware Adaptive Routing Algorithm for Networks- on-Chip," in IEEE Embedded Systems Letters, vol. 14, no. 4, pp. 203-206, Dec. 2022, doi: 10.1109/LES.2022.3176233.
8. M. M. Farag and K. E. Ahmed, "Aggregated CDMA Crossbar With Hybrid ARQ for NoCs," in IEEE Access, vol. 10, pp. 28206-28218, 2022, doi: 10.1109/ACCESS.2022.3158331.
9. A. Ejaz, V. Papaefstathiou and I. Sourdis, "HighwayNoC: Approaching Ideal NoC Performance with Dual Data Rate Routers," in IEEE/ACM Transactions on

Networking, vol. 29, no. 1, pp. 318-331, Feb. 2021, doi: 10.1109/TNET.2020.3034581.

10. Y. -S. Lu, S. -J. Yu and Y. -W. Chang, "On-Chip Optical Routing With Provably Good Algorithms for Path Clustering and Assignment," in IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, vol. 41, no. 11, pp. 4653-4666, Nov. 2022, doi: 10.1109/TCAD.2021.3133856.
11. A. Das, A. Kumar, J. Jose and M. Palesi, "Opportunistic Caching in NoC: Exploring Ways to Reduce Miss Penalty," in IEEE Transactions on Computers, vol. 70, no. 6, pp. 892-905, 1 June 2021, doi: 10.1109/TC.2021.3069968.
12. R. Singh et al., "Review, Analysis, and Implementation of Path Selection Strategies for 2D NoCs," in IEEE Access, vol. 10, pp. 129245-129268, 2022, doi: 10.1109/ACCESS.2022.3227460.
13. S. Das and C. Karfa, "Arc Model and DDG: Deadlock Avoidance and Detection in Torus NoC," in IEEE Embedded Systems Letters, vol. 14, no. 2, pp. 67-70, June 2022, doi: 10.1109/LES.2021.3113355.
14. M. C. Yang, Y. S. Lee and T. H. Han, "MRBS: An Area-Efficient Multicast Router for Network-on-Chip Using Buffer Sharing," in IEEE Access, vol. 9, pp. 168783-168793, 2021, doi: 10.1109/ACCESS.2021.3137218.
15. R. F. Faccenda, L. L. Caimi and F. G. Moraes, "Detection and Countermeasures of Security Attacks and Faults on NoC-Based Many-Cores," in IEEE Access, vol. 9, pp. 153142-153152, 2021, doi: 10.1109/ACCESS.2021.3127468.

Various Image Inpainting Techniques - A Survey

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ABSTRACT

Considering its significant relevance and effectiveness in image processing operations to eliminate any sort of distortion, including text, blocks, noise, scratches, lines, etc. from the source images, researchers have been studying the image inpainting problem over the past several decades. The practice of adding missing areas or erasing unwanted objects from images is called as image inpainting. It necessitates a profound comprehension of an image features in terms of texture and structure. It is recognized as one of the most difficult idea in the image processing field in the scientific community. To give the research community a reference, it is vital to categorise and condense various methodologies. From a variety of perspectives, traditional methods of Image inpainting like Diffusion based method and Patch based method (Exemplar based algorithms) are categorized first. The Convolutional neural networks (CNNs approaches) and generative adversarial networks (GANs), are two deep learning techniques, are also categorised. In order to offer novel viewpoints in the subject of image inpainting, this study will review the advantages and disadvantages of each approach. We discuss some potential future works based on our findings.

KEYWORDS *: : CNN, GANs*

INTRODUCTION

The skill of image inpainting is used to restore old and damaged pictures. It may also be used to remove or replace unwanted items from the image. In computer vision applications, It has become a substantial and challenging field of research. It is utilised to fill up the empty space in a picture. First-generation image inpainting techniques fall into two categories: traditional techniques like diffusion-based and exemplar-based inpainting techniques, and more modern techniques utilising deep learning. Basically Inpainting technique is used to recover damaged or imperfect areas of a picture by interpolating nearby pixels. An image's damaged areas consist of a group of disconnected pixels enclosed by a group of known neighbouring pixels. The inpainting approach fills unknown regions with known information during the restoration of unconnected pixels. Figure 1 displays several picture inpainting methods in their appropriate groupings.

Our review is divided into the following sections: Section 2, which categorises traditional inpainting techniques; Section 3, which examines deep learning techniques; Section 4, which summarizes the typical performance for image inpainting with merits and demerits; Section 5, which discusses the review's future directions; and Section 6, which contains our conclusion.

TRADITIONAL METHODS OF IMAGE IN-PAINTING

These methods works on either pixel level or on patch level. The diffusion-based inpainting algorithm is the most basic inpainting technique. The lower structures of texture and geometry are restored using diffusion-based methods.

Diffusion Based Inpainting

These methods fill the vacant spaces with local structure from the surrounding region which is based on local smooth priors. Filling of the region was done by spreading the local geometrical information along its isophote direction with the help of a partial differential equation (PDE). [1].

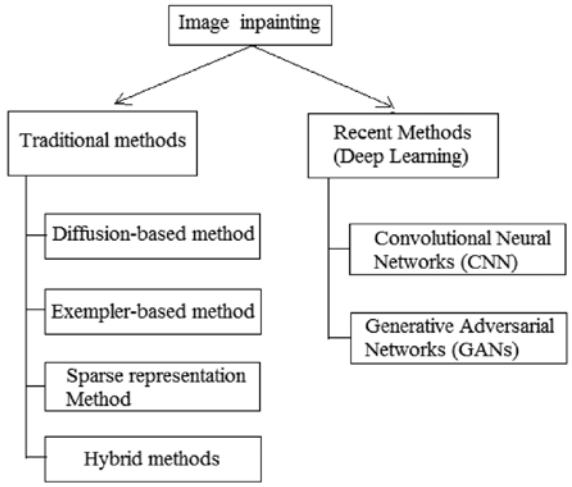

Fig. 1: Shows how image inpainting approaches may be categorized into two primary groups: Conventional / Traditional and modern deep learning methods. Conventional / Traditional Methods has four subcategories: Diffusion based, Exemplar based, Sparse Representation, and Hybrid Methods. CNNs and GANs are subcategories of deep learning methods.

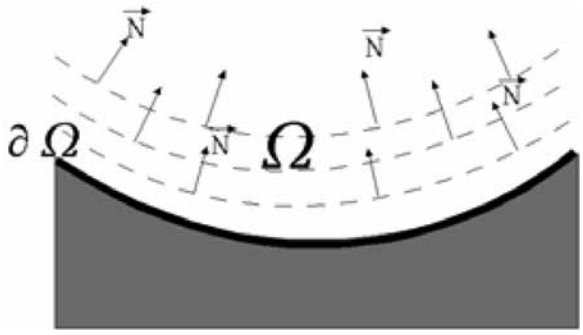

Fig. 2: Propagation in the normal direction as the boundary of the area that will be painted

Let, Ω stand for the area that will be painted, and ∂Ω serve as its border. The mechanism for this technique is as follows:

(1) How to close the gap is determined by the overall picture.

(2) The neighboring area's structure is carried into the missing area and outline are drawn through the the persistence of those arriving at ∂Ω.

(3) All the missing parts are filled with colour to match those of ∂Ω, as shown by the outline lines.

(4) The "texture" is evenly applied, and the minor details are painted in the spaces that are missing them.

The first image inpainting technique is suggested by Bertalmio et al. [1]. Chan and Shen developed further partial differential equation based methods [2, 3], which were based on the same research as that of Bertalmio et al.

The Diffusion method seamlessly expands image contents from the border line to the inner part of missing area, especially the hole. In order to do this, Li H et al. [4] suggested a diffusion technique that included first localising the diffusion of the inpainted regions and finally, in order to identify the inpainted areas, developing a feature set dependent on the intra- channel and inter-channel local variations of the changes. Utilising the coefficients that were calculated using direction and distance between the distorted pixel and its adjacent pixels is another technique presented in a subsequent study by Li K et al. [5]. Another diffusion-based technique based on the Fourier transform and fractional order derivative and was proposed by Sridevi et al. [6].

In summary, diffusion-based systems perform well on pictures with minor occlusions and restricted damaged areas. This technique performs poorly when filling big regions because, if the target region is vast, it frequently causes visual blur. When the missing areas are big and textured, blurring artefacts may be created in practically all PDE-based techniques.

The second group of methodologies, texture synthesis techniques, were presented to cover huge regions with pure textures. These techniques all have the same goal of capturing data from the desired area to the destination area. According to the size of the sample texture, two types of texture generation methods are categorised: pixel-based sampling and patch-based sampling. The

algorithms used in pixel-based schemes are extremely sluggish since the filling operation is carried out pixel by pixel.

Exemplar-Based Inpainting:

Exemplar-based techniques represent the second group of approaches that have been put out to fill in huge areas of missing images. Both textural, structural information of the damaged big region may be concurrently repaired using exemplar-based picture inpainting techniques. Nonlocal self-similarity priors were first created in the texture creation field, are used to fill-up in the empty space in order to circumvent the drawbacks of local smooth priors.

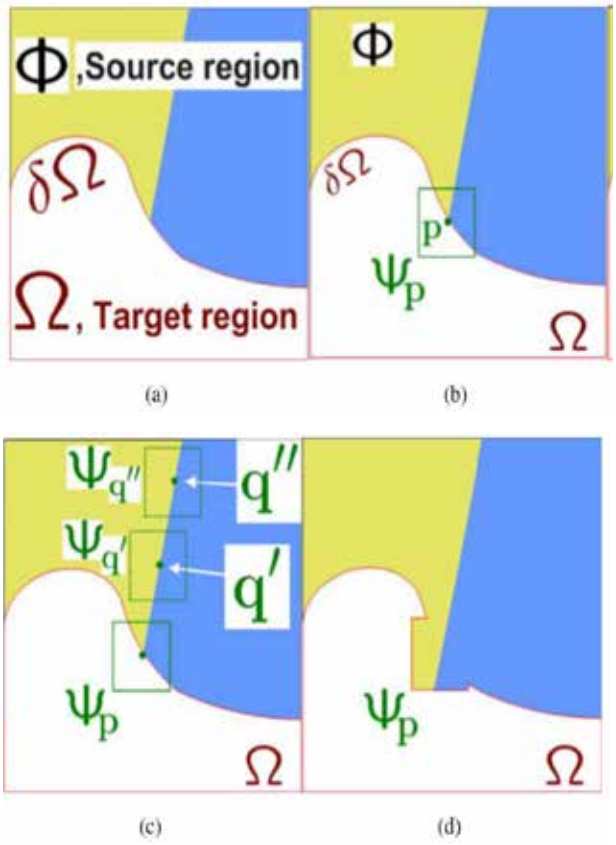

Fig. 3: Process of painting an image in example-based inpainting (A) The original picture, showing the source and target region. (B) displays the filled patch that was selected based on beat matched pixel. The patch that is matching to the missing patch is shown in (c). The image in (d) demonstrates the best matching patch being transferred to its occupied spot from a candidate patch.

The propagation of linear structures from (a) to (d) during the inpainting process is shown in Figure 3. The target region, which is the area that has to be filled, is represented by Ω, and its contour is given by ∂Ω. Samples are provided by the source region,ω, which is permanent throughout the algorithm, and are used for filling procedure. Assume that the square template ψp ϵ Ω centred at the point p (fig. 3b), is to be filled. The patch ψq ϵ ω, which most closely resembles the areas that have previously been filled in with ψp, belongs from the source region that matches the best. As seen in the example in Fig. 3b, the best matches are most likely to be along similarly coloured edge if ψp is on the continuation of an edges of the image, as in the case of ψq' and ψq'' in Fig. 3c. A straightforward transfer of the pattern from the source patch with the best match is all that is needed to propagate the isophote inwards (fig. 3d). The technique for filling regions is outlined as follows:

1. The fill front ∂Ω is first determined.
2. All patches whose centres align on the fill front ∂Ω have their patch priority are calculated.
3. The patch ψp with the highest patch priority is selected.
4. From the source area, the best matching candidate patch ψq is picked.
5. Switch over the data from ψq to ψp. In this stage, the target region's border ∂Ω of the target region Ω and the information required for assessing filling priorities are updated, resulting in a partial fill-in of the missing region Ω.

The exemplar based technique was presented by Criminisi et al. [7] and works well to synthesise the texture in target areas, making it more appropriate to cope with large regions, such as removing background people from photographs while maintaining picture features in the filled region [8–13].

Patch based concepts works on finding substitute patches that are well matched, and fills the missing portions into the image patch by patch (known as candidate patches). The patch- based methods has been proposed by several different ways. A patch based method was proposed by Rui'c et al. [14] and employed

a MRF-Markov random field to find the best matched patch in the texture component. Authors suggested method for restoring the damaged block in the picture using TSLRA i.e. Two Stage Low Rank Approximation [15] and gradient based low rank approximation [16]. Another inpainting technique was proposed by Fan and Zhang [17] and is based on summarising the differences between patches to determine how similar they are. Jiang [18] suggested a technique for image compression that involves removing blocks from a picture. Alilou et al. [19] suggested a method to recover the missing sections using single value decomposition also by an approximation matrix. A unique strategy combining picture completeness, texture generation, and image inpainting was proposed by Nikos Komodakis et al. [20]. They attempt to stay away from assigning greedy patches in order to prevent visibly inconsistent outcomes. Dynamic label trimming and Priority based message scheduling are two significant improvements over normal BP that are included in a unique optimisation strategy called priority-BP. A technique for exemplar-based picture inpainting that employs angle-aware patch matching and can choose several matched patches from the given region was proposed by Na Zhang et al. [21]. An angle aware rotation technique increases the likelihood of finding the best matched patch.

Although the sequential based systems, which include Diffusion-based and Exemplar- based approaches, show promise in number of aspects of image inpainting, such as filling texture details but still capturing the overall structure remains a difficult challenge [22].

In summary, the image inpainting systems classified under the exemplar-based structure synthesis category reconstruct the structure and texture of a missing region using similar patches from a recognised neighborhood. This is based on similarity of the pixel that was discovered by taking texture samples from recognised regions of the picture. Additionally, to close the gap and update priority, replace any missing pixels in this category with comparable pixels from the patch. Additionally, issues relating to speed, texture correctness (meaningless growth), and proper propagation of linear structures are addressed. Failures in curved constructions and depth uncertainty are additional drawbacks mentioned. Also, it is a greedy approach that increases the chance of adding an undesirable item or artefact to the region to be painted because it always chooses the best patch for the current place.

Sparse Representation Method

Although there is less chance of introducing unwanted items or artefacts than in the exemplar-based technique, the features of the recovered image are less accurate since a sparse representation of an image is only an approximation. The sparse-based approaches presuppose the presence of signals in pictures that are likely to provide a sparse decomposition across a redundant dictionary. Chang et al. use colour space to rectify the overexposed facial pictures in digital photos of facial photographs.[41]. Selecting bright areas on the face is done using a sliding window-based approach. However, this technique cannot be used for other types of images and is only strongly advised for facial photographs. When examining two sample textures, Kawai et al.'s [42] method takes into account the fluctuations in image brightness and the spatial localization of texture patterns. This approach fills in the desired regions by reducing the energy function while initialising the missing regions with certain values. Another method of sparse representation was suggested by Shen et al. [43]. This technique uses a redundant dictionary that is built via a discrete cosine transform. This approach uses an iterative sequential computation over a sparse representation to fill in every incomplete patch at the target region's edge. A dual-phase algorithmic inpainting approach was put out by He et al. [44]. This approach makes use of the function called Thieles rational interpolation and the Newton Theiles function. The interpolation is done in the horizontal direction for the damaged vertical pixel point. To set and accept information about known pixel positions for performing pixel intensity interpolation, the image is scanned from line to line. This method's restriction is that the broken pixels must be oriented vertically.

Hybrid Methods

Researchers were inspired to investigate the combined properties of these two approaches after achieving notable results with the exemplar-based texture and

structure generation method in inpainting. It works well with buildings that have curves and small gaps. Using this technique, test image is broken down into structural and texture layers for inpainting. For texture generation the energy function is used, but the structural layer diffusion-based approach is used after decomposition. It adds synthesised textures produced using the method proposed by Leung et al. [45], whereas applies the diffusion-based methodology described by Bertalmio et al. for the structural layer. The patch stitching reduces the joint area while inpainting. The self-similarity measure is used to calculate how similar the centre filled pixel patch is with the known pixel in the source image region. A discrete Laplacian equation is used in this operation. This approach solves the smooth artefacts issue in diffusion-based techniques. However, this approach is ineffective if the vast missing region is visible in the image. To offer a strategy based on the idea of successive stitching, All'ene et al. [46] combined statistical Bertalmio et al.[1] with variational Efros and Freeman [47] approaches. However, this approach is equally ineffective since careful consideration must be given to choose the appropriate patches and associated pixels. For capturing the structure and texture of image without losing any information, Zhang et al. [48] devised a technique that makes use of the wavelet transform. A approach with a modified MRF was proposed by Ghorai et al. [49]. This method for eliminating artefacts chooses target patches from border regions using subspace clustering, which are subsequently improved with the use of joint patch filtering to capture patterns.

In conclusion, these techniques may fill complicated textures and structures while removing text. Although it can manage blur and border discontinuity and provide the finest visual quality, approaches in this category still struggle when it comes to some dis-occlusion and object removal tasks. Additionally, extra computing time is needed.

DEEP LEARNING METHODS

This is recent and efficient approach in the image inpainting field. CNNs (Convolutional neural networks) and GANs (Generative adversarial networks) are being used, and the results are looking excellent.

Convolutional Neural Network

Many studies have been presented for picture inpainting based on CNNs employing encoder and decoder networks. One of these techniques, Shift Net based on U Net architecture, recovers the lost blocks with high precision in terms fine detailed texture and structure [23]. Zhao et al. [25] employ the network for processing medical X-ray pictures, whereas Weerasekera et al. [24] takes input as depth map of the image to the CNNs. A technique for blind image inpainting called (BICNN) was proposed by Cai et al. [26]. Many studies have been presented for picture inpainting based on CNNs employing encoder and decoder network structure. A patch-based inpainting technique for forensics photos was put out by Zhu et al. [27]. utilising the same encoder and decoder network method. SCA i. e. Coherent semantic attention layer is a layer that Liu et al. [28] suggested for the encoder and decoder network for the picture inpainting approach. In contrast to the other techniques, Liao et al.'s [29] Artist-Net approach was put out for picture inpainting. Cai et al. [30], who suggested a semantic object elimination method utilising CNNs, accomplished the same objective.

Generative Adversarial Networks

It is a widely used approach, were first demonstrated for picture production in 2014 [31]. A generator G and a discriminator D, make up the framework known as generative adversarial networks (GANs). A network D is taught to discriminate amongst genuine and created pictures, while a network G is trained to produce an entirely identical image that is not easy to differentiate from actual photos. The feed forward networks, G and D make up the architecture known as GANs. D. Another GAN-based semantic image inpainting technique was proposed by HuH et al. [32] to repair the image. Li et al. [33] suggested a technique for inpainting and character identification for handwritten pictures. The two stage combined network is proposed by Sagong M-c et al. [34] to build a encoder and decoder network known as PEPSI. PEPSI++, which is an expanded version proposed by Shin YG at length [35]. Encoder-decoder networks and multi-scale GAN were utilised by Wang H et al. [36] for picture inpainting. In order to create a scene's backdrop by eliminating the foreground item, Dhamo et al. [37] employed CNNs and the GANs

structure. In order to restore the pictures, Jiao et al. [38] integrated a GAN, a multi-layer convolutional layer, and an encoder-decoder.

The GAN-based systems improve the results, but training speed is very slow, and requires highly powerful computers. This is because convolutional operations and network parameters all demand CPU resources. In their summary of various deep learning techniques, Hanyu Xiang et al. [40] noted that deep learning algorithms may better capture high level semantics and provide noticeably superior outcomes in future.

In summary, deep learning methods (which includes CNN and GANs) show excellent outcomes in inpainting tasks as compared to traditional algorithms.

SUMMARY OF TRADITIONAL AND DEEP LEARNING METHODS

The advantages and disadvantages of most popular traditional and deep learning approaches for image inpainting techniques are shown in following Table 1.

Table 1: Merits and demerits of image inpainting techniques

Image inpainting Technique	Merits	Demerits
Diffusion based method Bertalmio et al. [1], Chan et al.[2,3], Sridevi et al.[6]	When filling up small areas, it produces good results. Appropriate to use for filling curves and lines. Gives high performance preserving all structural information.	For large missing regions, results in blurring artifacts
Texture synthesis based inpainting	No problem of blurring artifact.	Poor results for curved structures and thick scratches
Texture synthesis pixel based Li et al.[5]	Can be used for deterministic and stochastic textures	Large computation time required
Texture synthesis Patch based Liang et al.[8], Guo et al.[9]	Better performance and comparatively less time required.	Some times produces blur for inappropriate size of missing patch.
Exemplar based method Criminisi et al [7], Liang et. Al.[8], [8-13], Rui'c et al. [14], Nikos et al. [20]	Both structural and textural information can be preserved with promising results	Poor performance if corrupted region is spreaded along most of the area. Failures in curved constructions and depth uncertainty. it is a greedy approach that increases the chance of adding an undesirable item or artifact.
Sparse representation method Chang et al.[41], Kawai et al [42], Shen et al.[43], He et al.[44]	There is a low risk to introduce undesired objects or artifacts. Efficient for facial images distorted due to high light exposure.	In this technique damaged pixels are desirable to have in vertical direction. Gives Poor results for natural scene images.
Hybrid method Efros et al.[45], [46-49]	Applicable for structures with edges and curvatures and can remove text, complex textures.	it requires more computational time.
Deep learning methods Yan et al.[23], Zhao et al. [25], Zhu et al.[27], Cai et al. [30], [31-32], Hanyu et el.[40]	Compared to traditional algorithms, high effectiveness, hence giving promising outcomes.	The performance of these algorithms are dependent on the available data sets. Needs very good performance machines

DISCUSSION AND FUTURE SCOPE

For picture inpainting systems, a wide variety of diffusion-based, exemplar-based, Sparse method, hybrid approach, and deep learning techniques have been utilised in the past. The following are some of the issues with these techniques:

- Blurring artefacts: When the missing regions are big and textured, the diffusion-based approaches may cause blurring artefacts.
- Recognising related patches: Exemplar-based approaches are reliable for basic images, but it might be challenging to find a comparable patch when the image is complicated, such as when it has heavy concentration of texture and objects, or when the objects covers a big area of the image.
- A wide range of distortions: Recently, many researchers have been developing deep learning-based systems. The same method was shown to be ineffective for several categories of distortions. The outcomes of convention approaches (i.e. diffusion and exemplar based methods) rely on how complex the picture structures are.
- Result Dependency: In conventional neural network-based approaches (such as encoder and decoder CNN methods), results depend on the amount of training data that is available. The number and kind of the data utilised in CNN-based approaches affect how effective each strategy is.

CONCLUSION

We make an effort to synthesise both traditional and deep learning methods for picture inpainting. These techniques may be used to correct several sorts of visual distortion, including noise, text, objects, and scratches. It has been discovered that researchers have lately started using deep learning techniques, which are better at generalising to more complicated pictures. The greatest method for getting decent outcomes is to train a learning model using a lot of data. A summary of the benefits and drawbacks of various techniques is provided for the benefit of researchers working on image inpainting.

REFERENCES

1. M. Bertalmio, G. Sapiro, V. Caselles and C. Ballester, “Image inpainting,” Computer Graphic (SIGGRAPH 2000), pp. 417–424, July 2000.
2. T. F. Chan and J. Shen, “Non-texture inpainting by curvature-driven diffusions,” Journal of Visual Communication and Image Representation, vol. 12, issue 4, pp. 436-449, 2001.
3. T. F. Chan and J. Shen, “Mathematical models for local nontexture inpainting,” SIAM Journal of Applied Mathematics, vol. 62, no. 3, pp.1019–1043, 2002.
4. Li H, Luo W, Huang J, “Localization of diffusion-based inpainting in digital images,” IEEE Trans. Inf. Forensics Secur. 12(12):3050–3064, 2017.
5. Li K, Wei Y, Yang Z, Wei W, “Image inpainting algorithm based on TV model and evolutionary algorithm,” Soft Comput. 20(3):885–893, 2016.
6. Sridevi G, Kumar SS, “Image inpainting based on fractional-order nonlinear diffusion for image reconstruction,” Circuit Syst. Signal Process 38(8):1–16, 2019.
7. A. Criminisi, P. Perez, K. Toyama, “Object removal by exemplar-based inpainting,” Inter. conf. computer Vision and Pattern Recog. Cvpr, vol 2, pp. 721–728, 2003.
8. L. Liang, C. Liu, Y. Xu, B. Guo and H.-Y. Shum, “Real-time texture synthesis using patch-based sampling,” ACM Trans. On Graphics, vol. 20, issue 3, pp. 127–150, 2001.
9. Guo Q, Gao S, Zhang X, Yin Y, Zhang C, “Patch-based image inpainting via two-stage low rank approximation,” IEEE Trans Vis Comput Gr 24(6):2023–2036, 2017.
10. Wang W, Jia Y, “Damaged region filling and evaluation by symmetrical exemplar-based image for thangka,” EURASIP J Image Video Process 2017(1):38, 2017.
11. Fan Yao, “Damaged region filling by improved criminisi image inpainting algorithm for thangka,” Springer Science Business Media, LLC, part of Springer Nature 2018.
12. Fan Q, Zhang L, “A novel patch matching algorithm for exemplar-based image inpainting,” Multimed Tools Appl 77(9):10807–10821, 2018.
13. Zhang D, Liang Z, Yang G, Li Q, Li L, Sun X, “A robust forgery detection algorithm for object removal

by exemplar-based image inpainting," Multimed Tools Appl 77(10):11823– 11842, 2018.

14. Ruži´c T, Pižurica A, "Context-aware patch-based image inpainting using markov random field modeling," IEEE Trans Image Process 24(1):444–456, 2014.
15. Guo Q, Gao S, Zhang X, Yin Y, Zhang C, "Patch-based image inpainting via two-stage low rank approximation," IEEE Trans Vis Comput Gr 24(6):2023–2036, 2017.
16. Lu H, Liu Q, Zhang M, Wang Y, Deng X, "Gradient-based low rank method and its application in image inpainting," Multimed Tools Appl 77(5):5969–5993, 2018.
17. Fan Q, Zhang L, "A novel patch matching algorithm for exemplar-based image inpainting," Multimed Tools Appl 77(9):10807–10821, 2018.
18. Jiang W, "Rate-distortion optimized image compression based on image inpainting," Multimed Tools Appl 75(2):919–933, 2016.
19. Alilou V K, Yaghmaee F, "Exemplar-based image inpainting using svd-based approximation matrix and multi-scale analysis," Multimed Tools Appl 76(5):7213–7234, 2017.
20. Nikos Komodakis and Georgios Tziritas, "Image Completion Using Efficient Belief Propagation Via Priority Scheduling and Dynamic Pruning," IEEE Transactions on Image Processing, Vol. 16, No. 11, 2649-2661, November 2007.
21. Na Zhang, Hua Ji, Li Liu and Guanhua Wang, "Exemplar-based image inpainting using angle-aware patch matching" EURASIP Journal on Image and Video Processing, 2019:70, 2019.
22. Omar Elharrouss, Noor Almaadeed, Somaya Al-Maadeed, Younes Akbari, "Image Inpainting: A Review" Springer Science+Business Media, LLC, part of Springer Nature 2019.
23. Yan Z, Li X, Li M, Zuo W, Shan S, "Shift-net: Image inpainting via deep feature rearrangement," In: Proceedings of the European conference on computer vision (ECCV), pp 1– 17, 2018.
24. Weerasekera CS, Dharmasiri T, Garg R, Drummond T, Reid I, "Just-in-time reconstruction: inpainting sparse maps using single view depth predictors as priors," IEEE international conference on robotics and automation (ICRA), IEEE, pp 1–9, 2018.
25. Zhao J, Chen Z, Zhang L, Jin X, "Unsupervised learnable sonogram inpainting network (sin) for limited angle ct reconstruction," arXiv preprint arXiv:1811.03911, 2018.
26. Cai N, Su Z, Lin Z,Wang H, Yang Z, Ling BW-K, "Blind inpainting using the fully convolutional neural network," Vis Comput 33(2):249–261, 2017.
27. Zhu X, Qian Y, Zhao X, Sun B, Sun Y, "A deep learning approach to patch-based image inpainting forensics," Signal Process Image Commun 67:90–99, 2018.
28. Liu H, Jiang B, Xiao Y, Yang C, "Coherent semantic attention for image inpainting," arXiv preprint arXiv:1905.12384, 2019.
29. Liao L, Hu R, Xiao J, Wang Z, "Artist-net: decorating the inferred content with unified style for image inpainting," IEEE Access 7:36921–36933, 2019.
30. Cai X, Song B, "Semantic object removal with convolutional neural network feature- based inpainting approach," Multimed Syst 24(5):597–609, 2018.
31. Goodfellow I, Pouget-Abadie J, MirzaM, Xu B,Warde-Farley D, Ozair S, Courville A, Bengio Y, "Generative adversarial nets," In: Advances in neural information processing systems, pp 2672–2680, 2014.
32. ChenY, HuH, "An improved method for semantic image inpainting with gans: progressive inpainting," Neural Process Lett 49(3):1355–1367, 2019.
33. Li J, Song G, Zhang M, "Occluded offline handwritten Chinese character recognition using deep convolutional generative adversarial network and improved GoogLeNet," Neural Comput Appl 1–15, 2008.
34. Sagong M-c, Shin Y-g, Kim S-w, Park S, Ko S-j, "Pepsi: fast image inpainting with parallel decoding network," In: Proceedings of the IEEE conference on computer vision and pattern recognition, pp 11360–11368, 2019.
35. Shin YG, Sagong MC, Yeo YJ, Kim SW, Ko SJ, "Pepsi++: fast and lightweight network for image inpainting," arXiv preprint arXiv:1905.09010, 2019.
36. Wang H, Jiao L, Wu H, Bie R, "New inpainting algorithm based on simplified context encoders and multi-scale adversarial network," Procedia Comput Sci 147:254–263, 2019.
37. Dhamo H, Tateno K, Laina I, Navab N, Tombari F, "Peeking behind objects: layered depth prediction from a single image," Pattern Recognit Lett 125:333–340, 2019.

38. Jiao L, Wu H, Wang H, Bie R, "Multi-scale semantic image inpainting with residual learning and GAN," Neurocomputing 331:199–212, 2019.

39. Nazeri K, Ng E, Joseph T, Qureshi F, Ebrahimi M, "Edgeconnect: generative image inpainting with adversarial edge learning," arXiv preprint arXiv:1901.00212, 2019.

40. Hanyu Xiang, Qin Zou , Muhammad Ali Nawaz , Xianfeng Huang, Fan Zhang, Hongkai Yu, "Deep learning for image inpainting: A survey" Elsevier, Pattern Recognition 134, 109046, 2023.

41. CHANG, R.C., SHIH, T.K., 2008. Multilayer inpainting on digitalized artworks. Journal of information science and engineering 24, 1241–1255

42. Kawai, N., Sato, T., Yokoya, N., 2008. Image inpainting considering brightness change and spatial locality of textures., in: VISAPP (1), Citeseer. pp. 66–73.

43. Shen, B., Hu, W., Zhang, Y., Zhang, Y.J., 2009. Image inpainting via sparse representation, in: Acoustics, Speech and Signal Processing, 2009. ICASSP 2009. IEEE International Conference on, IEEE. pp. 697–700.

44. He, L., Xing, Y., Xia, K., Tan, J., 2018. An adaptive image inpainting method based on continued fractions interpolation. Discrete Dynamics in Nature and Society 2018.

45. Efros, A.A., Leung, T.K., 1999. Texture synthesis by non-parametric sampling, in: iccv, IEEE. p. 1033

46. All`ene, C., Paragios, N., 2006. Image renaissance using discrete optimization, in: Pattern Recognition, 2006. ICPR 2006. 18th International Conference on, IEEE. pp. 631–634.

47. Efros, A.A., Freeman, W.T., 2001. Image quilting for texture synthesis and transfer, in: Proceedings of the 28th annual conference on Computer graphics and interactive techniques, ACM. pp. 341–346.

48. Zhang, H., Dai, S., 2012. Image inpainting based on wavelet decomposition. Procedia Engineering 29, 3674–3678.

49. Ghorai, M., Mandal, S., Chanda, B., 2018. A group-based image inpainting using patch refinement in mrf framework. IEEE Transactions on Image Processing 27, 556–567.

Real time Data Visualization using Web Socket on Cloud Server

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ABSTRACT

A study of the available methods of data representation for real-time information must be conducted in order to obtain the most useful and efficient display of information. Customizing platforms and designing customised boards were among the critical tasks required to accomplish accurate information visualization. A generic and dynamic dashboard based on real-time data has been used to evaluate the effect of the available data visualization methods in the generated display. As a result, our control panel addicts were able to interact with the material, which was based on an original collection of clues, maps, tables, and reports developed by the control panel itself. This would allow us to test a current collection of data presentation methods and create a new adapted dashboard, showing that displays may be a unique and vital means of sharing information.

KEYWORDS *: Data visualization techniques, Real-time information, Real-time information*

INTRODUCTION

People need online results more and more constantly these days for their services and apps. While various graphs, images, and charts are constantly being incorporated into various web apps and websites, data visualization is not an exception to this rule. This blog examines an intriguing use case for real- time data visualization in great detail, including the practicalities of data transport [1]. In real- time data visualization, an operation keeps track of a data source that is constantly streamlining, analogous as every numerous seconds or indeed extremely regularly, like 100 times per second [2]. The two main factors of this type of system are data transport and data visualization, roughly speaking. The real- time communication protocol used on the web is called Web Socket, and it has wide support and is compatible with a variety of platforms (cybersurfers,Node.js waitpersons, IoT bias,etc.)[3]. The swish thing is that Web Sockets is fairly strong; in our trials, we were suitable to transfer further than 1 million data points per second with a good network connection and indeed 30,000 data points per second with a really bad network connection nearly, the vast maturity of use cases for real- time data visualization are formerly covered by this data rate [4]. A important package that can be used for a variety of data visualization operations targeting nearly any type of user interface device is created by combining a real- time web data visualization library (Lightning Chart JS) and Web Socket data transport (computer, laptop, phone,etc.). Visualization, which is data and computationally heavy, is a perfect illustration of a pall calculating operation, according to the considerably accepted notion of pall computing [5]. Employers are increasingly relying on artificial intelligence to collect huge volumes of data that can be challenging and time-consuming to sort through, comprehend, and explain. Visualization can help to accelerate the procedure and convey facts to stakeholders and business owners in a way that they can grasp [6]. Big data visualization constantly moves beyond traditional techniques of presentation, such as pie charts, histograms, and bar graphs [7]. More complex representations, such as heat maps and fever charts, are used by Mohammed, Luay Thamer, AbdAllah A. AlHabshy, and Kamal A. ElDahshan[8]. Big data representation necessitates the employment of sophisticated computer systems to

take raw data, process it, and transform it into visual representations that humans can use to quickly draw perceptivity [9].

Data visualization tools can be utilized in a variety of ways. The most prevalent application at the moment is business intelligence (BI) reporting tool. Stoners can use visualization technologies to create autonomous dashboards that analyses company performance across key performance indicators (KPIs) and visually interpret the results [10].

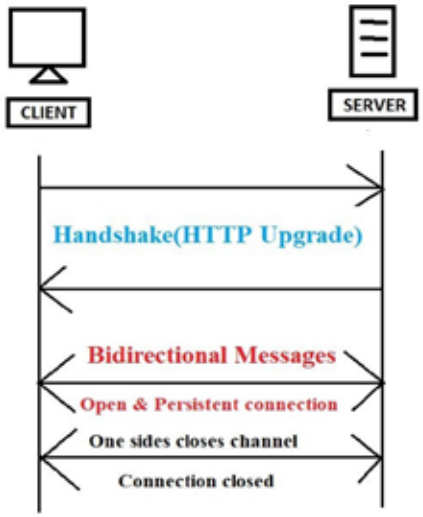

Fig. 1: Client-server connection using web socket

The generated images may also include interactive powers, allowing stoners to influence them or dig farther into the data for questioning and research. Pointers that alert stoners when data has been simplified or when particular conditions are met can also be included. Numerous business departments use statistical visualization tools to monitor their own operations [11]. For example, a marketing team may use the programme to track the results of the marketing effort, tracking metrics such as open rate, click-through rate, and conversion rates [12]. As data visualization merchandisers expand these tools' functionality, they are rapidly being used as front ends for more complex big data systems [13]. In this context, data visualization software assists data engineers and scientists in keeping track of data sources and doing basic exploratory research on data sets before to or following more extensive advanced examinations [14]. The likes of Microsoft, IBM, SAP, and SAS are among the most prominent firms in the big data tools industry. Other merchants provide specialized big data presentation tools; well-known names in this class include Tableau, Qlik, and Tibco.While Microsoft Excel remains a popular application for data presentation, others have been developed that provide enhanced capabilities [15].

RELATED WORK

To understand data by plates and maps visualization used in demitasse as early as 1137. In all fields there has been vast Development in visualization ways. To examine information and data visualization helps to fantasize and express ideas in armature. With the coming of computer simulation visualization relevance has been foster strengthened. A wide multifariousness of computer grounded tools in constructing design into CAD (Computer backed Design) design is handed by T. Hong et al.(2000)[1]. The use of CAD for seeing design has been espoused exceedingly snappily by professionals throughout the world. Information visualization used to present design data with the aid of delineations and plates and data is generally abstract or special, we bear scientific visualization ways like maps and graphs etc. Ant unlined transformation from homemade to digital fashion in the standing design visualization has followed the presently dominating morals of visualization [2]. There's a conterminous motive to further interrogate the subsisting and new styles of visualization that efficaciously present multidimensional data. The visualization scheme should gain from homemade styles where implicit to prop contrivers make a conversion from their practice [3]. Visualization should have power to present multidimensional data and it must be synergistic and permiteffic communication. Using color coding and layering point analysis data is presented on the delineation with the power of controlling the visibility of layers as craved by the contrivers [4]. The sphere of visualization grows, the instruments are seeking druggies appear in our exploration laboratories. In mandate to defy the accomplishable overload of assessable gain that will promote further far- flung acceptance of visualization in which the utility caught on trials and studies reports are useful simply there's an arising want as cover system of standing [5]. Information visualization generally part of some imaginative action that needs druggies to construct suppositions, quests patterns and rejection,

and polish their thesis. Druggies constantly bear to view the analogous data from different direct perspective and above a time. They might bear a kind of instrument to attain their points, insistently importing and exporting data [6]. Experimenters depict egressing exploration which appears fluently accommodated to examine the imaginative conduct that druggies of information visualization pursue in. To help the pretensions of visualization of information the ethnographic styles imaged. To determine the advantages and disadvantages of their new visualization of information tool the inventor or investigator are keen [7]. The visualization community has subsequently set up no way above the measures and effect of devilish graph decoration and memorandum. Visualization experts similar as Stephen Many and Edward Tufte encouraged the conventional view, stating that the visualization should present the data easily without any undo and shouldn't include map junk[8]. Psychology lab studies have also supported this view, which present that simple and clear visualizations are easy to interpret. Memorability trial results show that visualization is as memorable with thickness over people. Visualization is less indelible than spontaneous scenes but like to film land of faces, which might cquaint at general configuration, characteristics of mortal retention. Not stunningly, ascribes similar as appreciation and color of a mortal recognizable end increase memory power [10]. Creating a visualization indelible intends creating the visualization" stick" in the onlooker minds. We bear the most significant applicable angles of data the pen is trying to transmit to stick [11].

METHODOLOGY

An open source set of guidelines, conditions, and coffers called Swagger is used to produce and describe peaceful APIs. inventors can write interactive, machine- and mortal- readable API attestation using the Swagger frame. An API description format for REST APIs is called Open API Specification (formerly Swagger Specification). You can describe your full API in an Open API train, which includes the following Available endpoints (/ druggies) and operations on each endpoint (GET/ druggies, POST druggies) operating conditions For each operation, the input and affair. An open source Java- grounded frame called Spring Boot is used to make micro Services. The Pivotal Team created it, and it's used to produce standalone, product-ready spring apps. Through the TCP protocol, the IP address is stationed in the operation and separated from the JPA.

Maven is a popular open- source figure tool developed by the Apache Group to make, publish, and emplace several systems at formerly for better design operation. The tool provides allows inventors to make and validate the lifecycle frame. Maven is written in Java and is used to make systems written inC#, Scala, Ruby, etc. Grounded on the design Object Model(POM), this tool has made the lives of Java inventors easier while developing reports, checks make and testing robotization setups. Maven focuses on the simplification and standardization of the structure process. Tomcat has transitioned from the original Java EE specification to Jakarta EE, like other Java business technologies. Tomcat is an operation garçon made to render websites with Java Garçon runner law and run Java servlets. A" webserver" or" servlet vessel" is what Tomcat does.

Socket is a computer messaging protocol that provides full-duplex communication channels over a single TCP connection. The IETF standardised the protocol known as WebSocket as RFC 6455 in 2011. Websockets is the current API specification that allows web activities to use this protocol. The Webhook protocol, comparable to HTTP polling, facilitates commerce among an online cybersurfer (or other customer operation) and a web garçon with lower output than half-duplex druthers, simplifying real-time data transfer from and to the garçon. This is performed by providing a standardised method for the garçon to shoot stuff to the client without first being asked by the consumer, as well as allowing dispatches to be handed back and forth while keeping the channel open. This allows for a two-way constant dialogue between the customer and the garçon.

According to the most recent Google Play notice (1), all new apps and app upgrades must target Android 13(API position 33) or above, with the exception of Wear zilches apps, which must target Android 12. It has various types of services, such as exertion director, announcement director, view system, package director, and so on, that are useful for the development of our operation in accordance with our needs. In the form of Java classes, the operation Infrastructure subcaste provides several advanced-position operates to operations. Operation

creators have permission to use these services in their operations.

A figure automation tool for language software development is called Gradle. It controls all phases of development, from planning and packaging through testing, installation, and release. Java (as well as Kotlin, Groovy, and Scala), C/C++, and JavaScript are supported languages. Gradle expands upon the shared traits of Apache Ant and Apache Java and adds a modern, Kotlin-based sphere-specific language that differs from Java's XML-based design configuration. By providing the dependence operation, Gradle hires an acyclic graph with directions to establish the possible order in which jobs can be executed. The virtual machine called Java is used to run it.

A mound with armature graphic represents the android operating system. As demonstrated in the belo Linux Kernel, actions are operation Foundation Android Runtime Platform Libraries of software factors approximately separated into five divisions and four primary levels. The greatest subcaste of an android armature is an operation. The pre-installed activities—such as camera, gallery, home, interactions, etc.—as well as third-party operations—such as games, converse operations, etc.—that are downloaded from the Play Store will be put on this layer. It use the classes and services provided by the operation frame to operate within the Android runtime. The Dalvik virtual machine (DVM) and core libraries are parts of the Android Runtime Environment. It serves as the framework's basis and, with the aid of the essential libraries, drives our application. To enable a device to run many instances effectively, the Dalvik Virtual Machine (DVM), like the Java Virtual Machine (JVM), is a register-based virtual machine created and optimised for Android. Threading and basic memory management are reliant on the Linux kernel layer. With the help of the vital libraries, we may create Android applications in either the common Java or Kotlin programming dialects.

RESULT

There are further measures listed to get our desired outcomes. start the developer option and press the USB debugging option and make sure that if someone has the most recent update for their phone, they should choose USB configuration and then click on the P2P option before running the program because doing so will cause a device-our laptop or computer-to display the name of the device on its screen. Additionally, we must run this, which will provide a visual representation of the diseases according to the year, country, etc. It will go through a number of steps during this time, such as building Gradle, and only then will installation be successful. Make sure our device and the cell phone are connected to the same network as one more extremely critical and important element. As far as fresh data entry is concerned, we can also upload the most recent information.

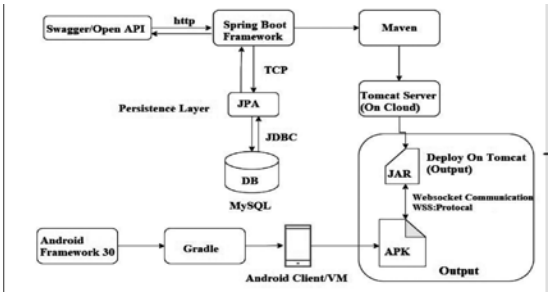

Fig. 2. Data Visualization using Websocket on Cloud Server

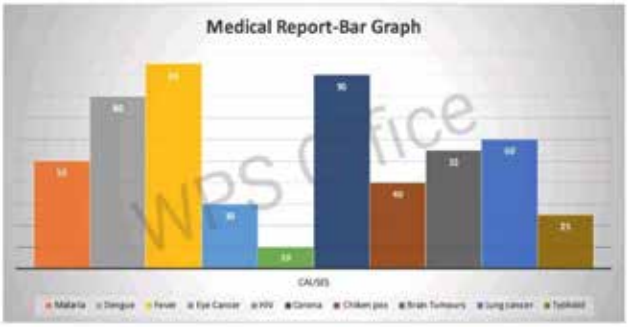

Fig 3. Here bar graph represents the diseases occurred over the time period.

1: Lung cancer; 2: Malaria; 3: Dengue fever; 4: Eye Cancer; 5: HIV; 6: Corona; 7: Chicken Pox; 8: Brain Tumours; 9: Typhoid

Finally, we'd be able to easy-to-comprehend visual format.

- faster action
- structured
- helps in making wiser decision
- easy to understand and compare data.

CONCLUSION

The study work makes a contribution to the cloud-based data visualization technique. Data preparation, storage management, data processing and manipulation, and display are all part of the process. Because of the vast amount of knowledge that exists and is being developed every day, the number of artifacts that have previously been unearthed. It is difficult to find ways to convey information in a way that fits the demands of all knowledge users and consumers today.

An intelligible method or make sense out of it. The solution we propose is to build a dashboard in which users may interact with data based on a predefined collection of dashboard-generated hints, charts, tables, and reports. This user interface will be accessible to users for free and with ease.

Dashboards can be a unique and effective means of displaying information. No matter how advanced technology may be, the success of a dashboard as a communication tool is determined by its layout.

REFERENCES

1. Tanahashi, Yuzuru, et al. "An interface design for future cloud-based visualization services." 2010 IEEE Second International Conference on Cloud Computing Technology and Science. IEEE, 2010.
2. Lu, Sifei, et al. "A framework for cloud-based large-scale data analytics and visualization: Case study on multiscale climate data." 2011 IEEE Third International Conference on Cloud Computing Technology and Science. IEEE, 2011.
3. Rahmatulloh, Alam, Irfan Darmawan, and Rohmat Gunawan. "Performance Analysis of Data Transmission on WebSocket for Real-time Communication." 2019 16th International Conference on Quality in Research (QIR): International Symposium on Electrical and Computer Engineering. IEEE, 2019.
4. Toasa, Renato, et al. "Data visualization techniques for real-time information—A custom and dynamic dashboard for analyzing surveys' results." 2018 13th Iberian Conference on Information Systems and Technologies (CISTI). IEEE, 2018.
5. Wessels, Andrew, et al. "Remote data visualization through websockets." 2011 Eighth international conference on information technology: new generations. IEEE, 2011.
6. Jiao, Donglai, Lizhi Miao, and Jie Jiang. "Research on sensor data visualization method based on real-time dynamic symbol." 2014 the third international conference on agro-geoinformatics. IEEE, 2014.
7. Rudenko, Roman, Ivan Miguel Pires, Margarida Liberato, João Barroso, and Arsénio Reis. "A Brief Review on 4D Weather Visualization." Sustainability 14, no. 9 (2022): 5248.
8. Wan, Y., Otsuna, H., Chien, C. B., & Hansen, C. (2012, January). FluoRender: an application of 2D image space methods for 3D and 4D confocal microscopy data visualization in neurobiology research. In 2012 IEEE Pacific Visualization Symposium (pp. 201-208). IEEE
9. Li, Qi, and Qi Li. "Overview of data visualization." Embodying Data: Chinese Aesthetics, Interactive Visualization and Gaming Technologies (2020): 17-47.
10. Mohammed, Luay Thamer, AbdAllah A. AlHabshy, and Kamal A. ElDahshan. "Big data visualization: A survey." 2022 International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA). IEEE, 2022.
11. Zhang, Q. (2019, May). Medical Computing Visual Synchronization Using WebSocket Protocol and Web Rendering. In 2019 IEEE Canadian Conference of Electrical and Computer Engineering (CCECE) (pp. 1-4). IEEE.
12. Durai, S., et al. "Data Visualization for Corona Patients Globally using Real-Time APIs." 2023 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS). IEEE, 2023.
13. Debolt, C. L., et al. "Decreased Incidence of Hospital-Acquired Infections After Implementation of Real-Time Visualization of Nursing Observations." A45. ICU PRACTICES, QUALITY IMPROVEMENT, AND MEDICAL EDUCATION. American Thoracic Society, 2023. A1682-A1682.
14. Gadicha, Ajay B., et al. "Implementation Tools for Generating Statistical Consequence Using Data Visualization Techniques." Advances in Data Science and Analytics: Concepts and Paradigms (2023): 1- 20.
15. Kulkarni, Ashish Rajeshwar, Narendra Kumar, and K. Ramachandra Rao. "Efficacy of Bluetooth- Based Data Collection for Road Traffic Analysis and Visualization Using Big Data Analytics." Big Data Mining and Analytics 6.2 (2023): 139-153.

Academic Counselor Chatbot

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ABSTRACT

Software that uses Artificial Intelligence that can talk with humans is called as chatbot. These device or Software/ Application are used to respond quickly to your requests, provide information, provide guidance, and answer your questions and queries. This article outlines the general working theory, key ideas, and possible applications of artificial intelligence chatbots in education. Natural language processing is an advanced and effective way to understand and provide solutions to today's problems and the technology that supports the system. The proposed system is an all-in-one conversational chatbot that can help students to , provide information about ,various institute depending his/her entrance score. The Nave Bayes model is used by the system to solve the identified problem. Therefore, this project aims to develop a chatbot for learning students. Chatbotsupport and assistance to students during learning, making learning more effective and interesting.

KEYWORDS *: Chatbot, Neural intents, NLTK, Python, Raspberrypi, TensorFlow, etc.*

INTRODUCTION

Chatbots or software applications issued to conduct online chat conversations using text or text-to-speech instead of direct contact with a physical human agent [1]. A chatbot is a software that supports customers by automating interactions and responding via messaging services. In this work we are developed a university-specific chatbot that assists students seeking admission to Nagpur University. Students who want to use this chatbot can enroll in various fields. The chatbot will askyou about your test results and provide you with a list of universities you can pass based on your results [2]. The knowledge built into the chatbot machine allows it to recognize sentences and decide how to answer questions [3]. Chatbots typically store historical data or commands and use them to provide a conversational service that processes questions. Many people can use chatbot applications if they are integrated with well-known web services. This student chatbot system analyzes user questions and responds with pertinent information during college inquiry Artificial algorithms are used to Chatbots are used everywhere such as in medical, educational, customer support, etc. As we all know that when students completed their higher secondary school certificate (HSC) they get to choose various steam such as engineering medical etc. create chatbots, which can analyze user questions and understand user messages. The user input String should match the ground rules answer. After analyzing the request, the system responds to the user [4]. The world of education is constantly evolving, and technology has played a crucial role in revolutionizing the way students learn and seek guidance. With the rise of AI and natural language processing, it has become possible to create chatbots that can assist students in their academic journey. The Academic Counsellor Chatbot using AI aims to provide personalized and instant guidance to students on a wide range of academic and non-academic issues. This chatbot leverages the power of AI to understand the student's needs and provide relevant information and support. The ultimate goal of this project is to provide students with a virtual academic counselor that can assist them in making informed decisions and help them succeed in their educational pursuits.

The objective of the Academic Counsellor Chatbot using AI project was to develop a virtual academic counselor that can assist students in their academic and non-academic pursuits. This project aimed to evaluate the effectiveness of AI in providing personalized and instant guidance to students. The results of this project will showcase the capabilities of the chatbot and demonstrate its potential to revolutionize the way students seek guidance.

RELATED WORK

Authors gone through various research article and found related review as, In 2020 Punith S, Chaitra Veeranna, Kotagi Chethana has published the paper "Chatbot for student Admission Enquiry" by the publisher HBRP Publication, In 2020 Nuria Haristani has published the paper "Chatbot Language Learning Medium" by the publisher IOP Publishing, In 2022 Kamran Qamar, Sayyed Tarique, Hasan A Rahim has published the paper "AI-Based Virtual Assistance on Raspberry PI" by the publisher IJARSCT, In 2020 Dr. Ashok Kumar K, Ajay Palakurthi , Vaishnavi Putnala "Smart College Chatbot using ML and Python" by the publisher IEEE, In 2022 Abhishek Rout, Vaibhav Kamble, Abhishek Gadge, Sagar Joshi "Conversational Chatbot for Students" by the publisher IJRPR.

METHODOLOGY

A chatbot is a device maybe a software or hardware device that helps people to generate automatic replies as per the user's questions. Different types of chatbots are used in various fields such as medical education, customer support, etc. so that's where chatbot plays a very important role in today's world in helping people. What is Chatbot? A chatbot is a device that can be either a software or hardware device that helps generate 444-like automated responses to user questions. Different types of chatbots are used in different fields such as medical education, customer support, and more.This is where chatbots play a very important role in today's world of helping people. A chatbot for education? chatbots are used everywhere: in medicine, education, customer support and more. Because we all know that students can choose other fields such as medical engineering and more once they receive their High School Diploma (HSC). Students go to different colleges and ask different questions such as cost structures, closures, and bus availability. These types of questions are commonly asked by students to counselors. That is not enough to answer all students. This time, the chatbot helped students ask questions about various colleges and information about them. Just enter your entrance exam score into the chatbot and the chatbot will show you all the different colleges you can apply to andyou can easily register for at the base level of the score. Normally India Engineering admission are seek through JEE and MHTCET scores, and if you want to apply for Medical School, the bot will ask for NEET scores. As Students go to different colleges and ask the counselor for queries such as fee structure, cut-off, and bus facility available or not These types of questions generally students ask the counselor. As we see a problem, one counselor was not enough to answer all the students. That time this chatbot helps students to ask queries about different colleges and information.

The methodology of using a chatbot in education involves several steps:

- First, the chatbot needs to be programmed to understand and respond to the types of questions that students may have. This requires developing a database of information related to the educational institution, such as admission requirements, course offerings, tuition fees, and other important details.
- Second, the chatbot must be designed to provide accurate and helpful responses to student queries. This involves training the chatbot to recognize different variations of a question and to provide appropriate answers based on the context of the question.
- Third, the chatbot must be integrated into the educational institution's website or mobile app, so that students can easily access it and use it to ask questions.
- Fourth, the chatbot must be regularly updated with new information, such as changes to course offerings or admission requirements, to ensure that students always have access to the most up-to-date information.
- Finally, it is important to evaluate the effectiveness of the chatbot over time, by tracking the number

of student queries and the quality of the responses provided. This can help to identify areas for improvement and to ensure that the chatbot continues to meet the needs of students.

- Overall, the methodology of using a chatbot in education involves careful planning, programming, integration, and evaluation, to ensure that students have access to accurate and helpful information, and that educational institutions can effectively manage the workload of student queries.

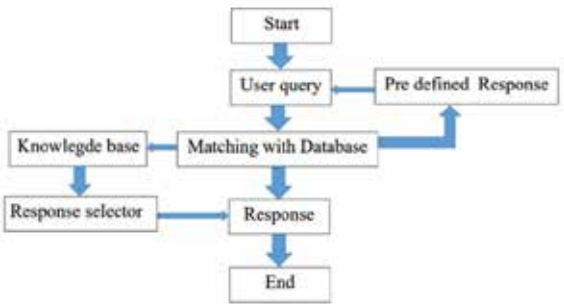

Fig. 1 Block diagram of the proposed system

In this project, we are using python as the main language and for implementation, we are used a raspberry pi, speaker, and mic.

Software Implementation

Python is very useful in machine learning. Python provides greater output in a short amount of code; python also provides us with lots of libraries that make our work easy to do.

Following libraries are considered for implementation:

- Speech recognition library:

  The speech recognition library in Python is used to capture and interpret human language input. It allows the chatbot to understand and convert spoken words into text, enabling it to process user queries effectively.

- pyttsx3 library:

  The pyttsx3 library is a text-to-speech conversion tool in Python. With this library, the chatbot can generate spoken responses to the user's queries, providing a more interactive and natural conversation experience.

- Neural intents library:

The Neural intents library is a recently released tool that aids in accurately identifying user intents and generating appropriate responses. By utilizing files such as intents. json, which contains predefined intents and their corresponding responses, the chatbot can match user queries with the intents and provide relevant answers.

Hardware Implementation:

Raspberry Pi, a small and affordable single-board computer, is utilized for the hardware implementation in this project. It serves as the central processing unit (CPU) that runs the chatbot program and controls the connected speaker and microphone. Raspberry Pi provides a compact and versatile platform for running the software code and handling the input/output functionalities required for the chatbot.

Process:

Wake-up activation:

To initiate the chatbot, the user needs to say "wake up." This activation phrase signals the system to start listening and responding to the user's queries.

User inquiry:

Upon launching, the chatbot will inquire about the user's needs. It prompts the user to specify the field they are currently in or interested in pursuing.

Field selection:

The user is expected to inform the chatbot about their chosen field, such as engineering or medicine. This information is crucial for providing accurate and relevant guidance.

Examination scores:

For users selecting engineering or medicine, the chatbot will ask about their scores in relevant entrance exams such as JEE, MHTCET, or NEET. These scores are essential for assessing the user's eligibility and suggesting suitable college options.

College recommendations:

Based on the user's field and examination scores, the chatbot will suggest college names that align with their qualifications. These recommendations aim to assist

users in finding suitable institutions to pursue their desired field of study.

Unrelated queries:

If a user poses a question that is unrelated to any specific field or college, the chatbot will respond with a pre-written text or message indicating that the query is beyond its scope of knowledge.

By following this process, the chatbot can engage in a conversational manner, understand user requirements, and provide helpful guidance regarding field selection and college recommendations.

I. The user speaks to the chatbot through the input microphone that is connected to the Raspberry Pi. The Raspberry Pi records the user's speech and converts it into text through the use of speech-to-text technology.

II Once the user's intention is determined, the Python program processes the request and generates a response. This response can be based on pre-written scripts, or it can be generated dynamically using data from databases or APIs

III. The response generated by the Python program is then converted into speech using text-to- speech technology. The text-to-speech technology converts the text into an audio file that can be played through the output speaker connected to the Raspberry Pi.

IV. The user can now hear the chatbot's response through the output speaker and continue the conversation with the chatbot by speaking into the input microphone again. The chatbot will continue to listen and respond to the user in this way until the conversation is finished.

Advantages:

Chatbots offer instant responses and round-the-clock availability, reducing waiting time for users. They are cost effective alternatives to hiring additional staff and can handle large volumes of queries simultaneously. Chatbots provide consistent responses, minimizing the risk of human error. They can be personalized to deliver tailored experiences based on user preferences. By handling routine tasks, chatbots improve efficiency and allow human staff to focus on more complex matters.

Disadvantages:

Chatbots have limitations in handling complex queries that require critical thinking or human judgment. They lack emotional intelligence and may not understand users' emotions or tone accurately, leading to potential miscommunication. Chatbots depend on technology and may experience glitches or errors, impacting their functionality. Developing and maintaining a chatbot can be costly. Some users may resist chatbot usage, preferring human interaction for situations that require empathy and emotional support.

Fig. 2 System Model Working

RESULT AND DISCUSSIONS

The result of the Academic Counselor Chatbot using AI project can be seen in the form of an interactive and intelligent chatbot that is able to provide students with information and guidance in a conversational manner. The chatbot uses speechto-text and text-to-speech technology to simulate a human like interaction, and the neural intents library ensures that the chatbot is able to understand the user's intentions and provide relevant

responses.

The Academic Counselor Chatbot using AI project has the potential to revolutionize the way that universities and colleges provide academic information and guidance to their students. The use of advanced technologies such as speechto-text, text-to-speech, and neural intents library allows the chatbot to simulate a human-like interaction, making it a convenient and accessible option for students who need information and guidance.

Fig. 3 Console Output

Following are the key features of chatbot

1. Reliability: One concern is the reliability of the chatbot's responses, as the technology is only as good as the data and algorithms used to train it. Ensuring that the chatbot provides accurate and reliable information is crucial to its success.
2. Privacy and Security: With the chatbot handling sensitive academic information, there are also concerns about privacy and security. Measures such as encryption and secure data storage must be in place to protect student's personal information.
3. Limited Capabilities: While the chatbot can provide basic academic information and guidance, it may not be able to handle complex or nuanced requests. Students may still need to speak with a human counselor for more specialized assistance.
4. Job Losses: Another concern is the potential for job loss in the academic counseling field as the chatbot becomes more widely adopted. While the chatbot may be able to handle basic requests, human counselors may still be needed for more complex issues.
5. Bias: As with any machine learning model, there is also the potential for bias in the chatbot's responses. Ensuring that the data used to train the chatbot is diverse and free of biases is important to ensure that all students receive equal and fair treatment.

Overall, the Academic Counselor Chatbot using AI project has the potential to greatly improve the way that universities and colleges provide academic information and guidance to their students. However, careful consideration of the potential drawbacks and concerns must be taken into account to ensure that the chatbot is a reliable, secure, and unbiased tool for providing student support services.

The benefits of conducting the educational chatbot are as follows.

- One key advantage of using educational chatbots is that they provide students with instant access to information. In the past, students may have had to wait for a response from a human counselor or advisor, which could cause delays and frustration. With chatbots, students can get answers to their questions instantly, at any time of the day or night. This can help to minimize confusion and frustration and improve students' overall experience.
- Another benefit of educational chatbots is that they can help to reduce the workload of human staff. Educational institutions often have limited resources and staff, which can make it difficult to handle the high volume of student queries effectively. By using chatbots, many of these queries can be answered automatically, freeing up staff time to focus on more complex and critical tasks. This can help to improve overall efficiency and productivity.
- In addition, educational chatbots can improve the overall accuracy and consistency of the information provided to students. Chatbots can be programmed to provide consistent and accurate information, reducing the likelihood of students receiving conflicting or incorrect information. This can help to reduce confusion and frustration and improve the overall quality of the student experience.
- Moreover, educational chatbots are cost-effective solutions that can help to save time and money for institutions. Compared to hiring additional staff to handle student queries, educational chatbots

are relatively inexpensive and require minimal maintenance. They can also be updated easily with new information, ensuring that students always have access to the most up-to-date information.

- Finally, educational chatbots provide personalized assistance, as they can be designed to ask specific questions and provide tailored information based on the student's needs. This can help to improve the overall student experience, as students feel that their questions and concerns are being heard and addressed in a timely and effective manner. Personalized assistance can also help to improve student engagement and retention rates, as students feel more connected and supported throughout their educational journey.
- Overall, the benefits of chatbots are significant, from providing instant access to information and reducing staff workload to improving efficiency and accuracy and providing personalized assistance to students. As such, the use of educational chatbots is an exciting and promising development in the field of education.

CONCLUSION

In conclusion, the use of AI in academic counseling has the potential to transform the way students seek guidance. However, it is important to approach the implementation of chatbots in education with caution and to carefully consider the limitations and challenges associated with their use. The development of AI-powered academic counselors is an exciting area of research with the potential to have a positive impact on students' academic and personal lives.

The potential benefits of using AI-powered academic counselors in education are numerous. These chatbots have the potential to provide students with personalized support, guidance, and resources. They can also help to address the shortage of human counselors and make counseling services more accessible to students. Moreover, chatbots can be available 24/7, enabling students to seek help outside of regular counseling hours.

However, there are also potential limitations and challenges associated with the use of chatbots in academic counseling. For instance, chatbots may not be able to provide the same level of empathy and emotional support as human counselors. Additionally, there may be privacy concerns related to the collection and use of student data by chatbots.

Therefore, it is crucial to approach the implementation of chatbots in education with caution and to address these challenges to ensure that their use is beneficial for students. Research and development in this area should be aimed at creating chatbots that are effective, ethical, and user friendly. The development of AI-powered academic counselors is an exciting area of research with the potential to have a positive impact on students' academic and personal lives.

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REFERENCES

1. Punith S, Chaitra B, Veeranna Kotagi, Chethana R M "Chatbot for Student Admission Enquiry" in the journal of advancement in software engineering and testing in 2020.
2. Nuria Haristiani "Chatbot as Language Learning Medium" in an international conference on education, science, and technology Indonesia 2020 vol-1387.
3. Kamran Qamar, Palash Pramod Dhongde, Pawan Sanjay Thakare, Ritik Vijaykumar Yadav, Sayyed Tarique Hasan A Rahim "AI-Based Virtual Assistance on Raspberry PI" in international journal of advance research in science,communication, and technology Nagpur, Maharashtra, India April 2022 vol-2.
4. Dr. Ashok Kumar K, Ajay Krishna Palakurthi Vaishnavi, Putnala "Smart College Chatbot using ML and Python"in IEEE 2022.
5. Abhishek Rout, Vaibhav Kamble, Abhishek Gadge, Sagar Joshi, Pratik Kulkarni, Vishakha A. Metre "Conversational Chatbot for Students" in International Journal of Research Publication and Reviews (IJRPR) May 2022 vol-3.
6. Ms. Ch. Lavanya Susanna, R.Pratyusha, P.Swathi, P.Rishi Krishna, V.Sai Pradeep, "College Enquiry Chatbot", International Research Journal of Engineering and Technology (IRJET) March 2020 vol-7.
7. Assistant Prof Ram Manoj Sharma, "Chatbot-based

College Information System", Research review International Journal of Multidisciplinary. March 2019 vol-9

8. Prof.K.Bala,Mukesh Kumar, SayaliHulawale, SahilPandita,"Chat-Bot For Colleg Management System Using A. I" International Research Journal of Engineering andTechnology (IRJET) Nov 2017 vol-8.
9. Guruswami Hiremath, Aishwarya Hajare, Priyanka Bhosale, RasikaNanaware, Dr. K. S. Wagh, "Chatbot for education system" International Journal of Advance Research, Ideas and Innovations in Technology (IJARIIT) 2018 vol-4.
10. Lalwani, Tarun, Shashank Bhalotia, Ashish Pal, Shreya Bisen, and Vasundhara Rathod. "Implementation of a Chat Bot System using AI and NLP." International Journal of Innovative Research in Computer Science & Technology(IJIRCST) 2018 vol-6.
11. J. Jia, "CSIEC: computer-assisted English learning chatbot based on textual knowledge and reasoning,"Knowledge-Based Syst., vol. 22, no. 4, pp. 249–255,2009 vol-22.
12. D. Song, E. Y. Oh, and M. Rice, "Interacting with a conversational agent system for educational purposes in online courses," Proc. - 2017 10th Int. Conf. Hum. Syst. Interact. HSI 2017, pp. 78–82, 2017 vol-.
13. F. Clarizia, F. Colace, M. Lombardi, F. Pascale , and D. Santaniello, "Chatbot: An Education Support System for Student," in CSS 2018. Lecture Notes in Computer Science, vol. 1, Springer International Publishing, 2018, pp. 194–208
14. Kasthuri, E., and S. Balaji. "A Chatbot for Changing Lifestyle in Education." In 2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV), pp. 1317-1322. IEEE, 2021.
15. Mondal, Anupam, Monalisa Dey, Dipankar Das, Sachit Nagpal, and Kevin Garda."Chatbot: An automated conversation system for the educational domain." In 2018 International Joint Symposium on Artificial Intelligence and Natural Language Processing (iSAI-NLP), pp. 1-5. IEEE, 2018.
16. Kumari, Sangeeta, Zaid Naikwadi, Akshay Akole, and Purushottam Darshankar. "Enhancing College Chat Bot Assistant with the Help of Richer Human Computer Interaction and Speech Recognition." In 2020 International Conference on Electronics and Sustainable Communication Systems (ICESC), pp. 427-433. IEEE, 2020.

Comparative Analysis of Crop Disease Detection by Artificial Intelligence

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ABSTRACT

Cotton is the vital crop that contributes significantly to the global economy. However cotton crop plants are susceptible for various disorders that can lead to large amount of yield losses if not detected and managed in a timely manner. The traditional methods of disease detection in cotton crops often rely on visual inspection by human experts are time consuming and makes lots of errors. We begin by collecting a comprehensive dataset of cotton plant images, including healthy plants and plants infected with various diseases such as bacterial blight, fungal wilt, and viral infections. The dataset is then used to train and validate the AI models to get the accurate results. This paper begins with comparing the performances of different ML techniques like Support Vector Machine, Random Forest, Decision Tree and CNN in terms of parameters like accuracy, selectivity, sensitivity etc. By comparing the performance of various algorithms and techniques, we aim to identify the most effective and efficient method for accurately detecting and diagnosing cotton disease.

KEYWORDS *: Cotton diseases, CNN, Deep learning, SVM, Random forest*

INTRODUCTION

In today's world modern inventions has made it simpler for us to supply proper, healthy nourishment and food to meet the requirements of the rapidly increasing population. In India, which is the world's biggest populated area, agriculture employs maximum approximately 75% the people directly or indirectly. Normally crop Pathologist or Entomologist's examine crop diseases in a traditional manner, which is more time consuming and yields more of error. It's very important to diagnose plant diseases in order to meet the requirements of the count ry. However, the cotton industry is facing various challenges, with diseases being a significant and important concern for farmers and agriculture experts. Timely detection and cure of cotton plant diseases is very important to prevent the spread of diseases to other plants, minimization of the cotton crop losses and optimize the agriculture practices.

In recent years there are lots of advancement has taken place in artificial intelligence (AI) and machine learning (ML) fields. AI-based techniques offer promising solutions for automated disease detection in crops, including cotton. These techniques utilize computer vision, pattern recognition, and data analysis algorithms to identify disease symptoms, classify diseases, and assist farmers in making informed decisions regarding crop management. This comparative analysis aims to evaluate and compare different AI-based approaches used for cotton disease detection. By examining the strengths, limitations, and performance of these techniques, we can gain insights into their effectiveness and potential for real-world applications. Depending upon the usage crops are divided in to different types of crops. There are some characteristic properties on which the plant diseases are categorized [5]. All the plant diseases are mainly classified into two main categories

based on their infections as: caused by living organisms and nonliving organisms. Living organisms elements include Fungi, Bacteria, Slime molds, Viruses, Parasitic angiosperms, Algae, Insects, Mites, Nematodes, and so forth Nonliving organisms factors incorporate Soil-dampness misbalance, Nutritional issues, Light intensity imbalance, Gas, Optimal temperature imbalance, smoke and other air toxins, Careless splashing of chemicals [5].

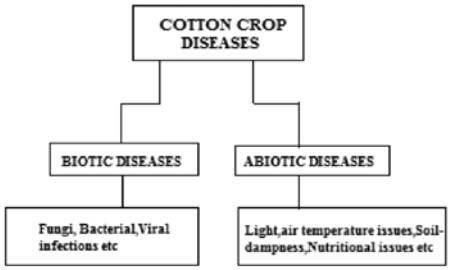

Fig. 1. Different types of crop diseases

CHALLENGE IN ANY PLANT/CROP DISEASE DETECTION

The research the done on different plant or crop diseases by many researchers to make the work of farmers easy. But the spotting of the Crops or plant diseases is a very tough task. The challenges are as follows [5].

1. Need to take very high quality of images of plants.
2. We require large dataset for training and testing purpose.
3. Many parameters affect the acquired images.
4. Climate will vary the dataset.
5. Need to regularly observe the plant.
6. The different plants or crops have various types of infection. And detection of this is very important.[5

GENERALIZED SYSTEM FOR CROP DETECTION

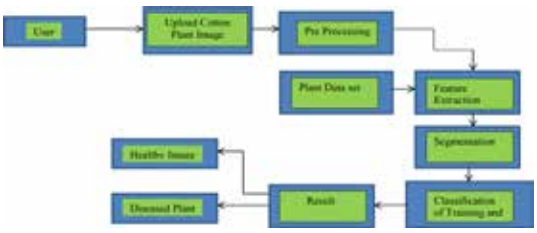

Fig. 2. Generalized block diagram of crop detection

DATA SET

Basic steps taken for all these research work is identifying the proper and authorized dataset. The images which acts as a input for the research work of different cotton leaves or any crop images are around 2000 or more images were trained and tested and validated [1]. Images should contain the healthy, aphids, army worm, bacterial blight, grey mildew, target spot leaves of plant as shown below. Crop cotton diseases include pathological infections that affect the plant's leaves, roots, seeds and other parts. But more or less diseases occur on the leaves [9].

Fig 3. Images of healthy leaves of cotton plant

Fig 4. Images of aphids

Fig 5. Images of Army worthy

Fig 6. Images of Bacterial Blight

Fig 7. Images of Grey Mildew

Fig 8. Images of Target Spot

METHODOLOGY

The generalized block diagram of development process of crop is depicted in fig 3 which includes a large data set collection and identifying data for segmentation, model training and evaluation, and finally model testing training and Deployment [16].

Data Collection and Preparing

The data set was obtained via the physical contact with the farmers and agriculture experts. Only image of the crop data is included in the dataset, which are categorized as: plant with diseases and healthy [16].

Pre Processing

These preprocessing steps aim to enhance the image quality, reduce noise, remove unwanted artifacts, and extract relevant information to improve the performance of subsequent image analysis algorithms. Here are some common preprocessing techniques used in image processing:

- Resizing: Resizing involves changing the dimensions of an image. It can be done to scale down the image or make it larger.
- Cropping: Cropping involves removing a specific region or portion of an image. It is often used to focus on a particular area of interest or to remove unwanted parts of an image.
- Image Enhancement: Enhancement techniques are used to get better the visual quality of an image.
- Filtering: Filtering techniques are used to remove noise or unwanted artifacts from the image.
- Color Space Conversion: Sometimes it is necessary to convert the color space of an image.
- Normalization: Normalization is obtained to standardize the pixel values of an image.
- Histogram Equalization: Histogram equalization is a method used to improve the distinction of an image by redistributing the intensity values.

Feature Extraction

Feature extraction in image processing refers to the process of extracting meaningful and relevant information or features from an image. These features capture distinctive patterns, characteristics, or structures present in the image, which can be used for various tasks such as image classification, object recognition, and image retrieval. Here are some common techniques for feature extraction in image processing:

- Edge Detection
- Corner Detection
- Texture Analysis

Classification

Classification of images involves the task of assigning a label or category to an image based on its content. This task is commonly performed using machine learning algorithms, particularly deep learning models such as Convolutional Neural Networks (CNNs), which have shown remarkable performance in image classification tasks.

Support Vector Machine Classifier

SVMs are particularly effective for binary classification problems but can also be extended to handle multi-class classification. For the analysis purpose of data by regression and classification, support vector machine is useful.

SVM measures the hyper plane that have the expanded the margin within the 2 different groups of data. The hyper plane vectors are called as support vectors. By assuming the required situations, SVM will develop a margin of hyper plane that divides the hyper plane vector totally into two non-intersecting classes. Many cases, however, this technique is not applied, so this classifier method is used to find hyper planes of the support vectors that bounces the given margins and reduce the errors [3].

Random Forest Classifier

The Random Forest classifier is an collection of learning algorithm used for classifying tasks. It is based

on the concept of decision trees and combines multiple decision trees to make predictions. These are very much sensitive to data set and if any small changes are made on the given data set it will be changing the tree completely. In the simple tree the node that is presented is based on certain guess and features whereas in random forest the node is taken on random features in a subset [19].

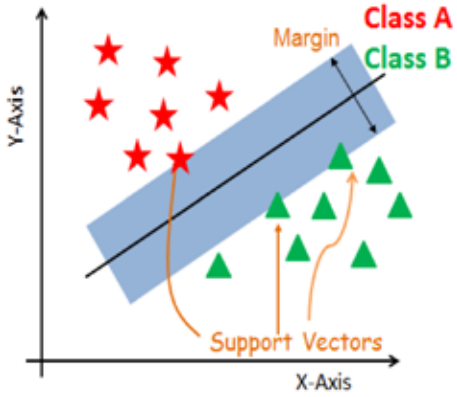

Fig 9. SVM Classifier [19]

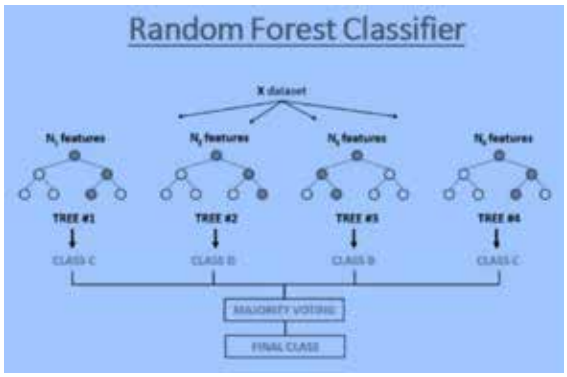

Fig. 10. Random Forest Classifier [21]

K Nearest Neighbour Classifier

The K Nearest Neighbors (KNN) classifier is a simple yet powerful supervised ML algorithm used for classifying of the data set. It belongs to the family of instance-based or lazy learning algorithms, where there is no explicit training phase, and the model stores the entire training dataset for making predictions. This method or technique has a detection rate of 90% in crop or plant disease detection. This is the simplest ML algorithm technique. It works on the fact that if a new data is closed to available data fixes that data as new data. This method is applicable for regression and classification solving problems, it is used when we have direct data set with us. And this algorithm directly acts on the data. This is used to categorize or classify the data[5].

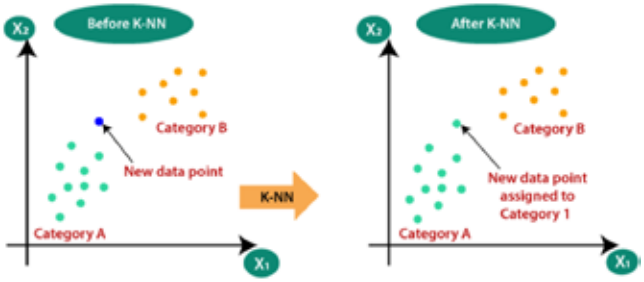

Fig. 11. KNN Classifier [23]

Deep Learning

Deep learning is a branch of ML that focuses on ANN with many numbers of layers, also known as deep neural networks. Deep learning algorithms are designed to automatically learn and extract hierarchical representations of data by leveraging large amounts of labeled or unlabeled data. Deep learning has achieved remarkable success in various domains, particularly in tasks involving complex patterns, such as image and speech recognition, natural language processing, and recommender systems.

FUZZY Classifier

A Fuzzy Classifier is a type of classifier that utilizes fuzzy logic to handle uncertainty and imprecision in data. Fuzzy logic allows for the representation of vagueness and ambiguity, making it suitable for dealing with real- world problems where data may not have crisp boundaries or clear-cut distinctions.

APPROXIMATE ANALYSIS OF PREVIOUS WORK DONE

Ref No	Publica-tions	Infection Detected	Different Methods Used	Parameters Measured
[2]	2022	All leaf diseases	CNN model	Theoretical Study
[1]	2023	pests, fertilizers, and other man-made chemicals	CNN and SVM	Accuracy 91%

[3]	2022	diseases caused by bacteria, fungi and viruses	AI based machine learning and deep learning	Theoretical Study
[6]	2023	Plant diseases	ResNet 152V2, YOLO V3, and YOLO V5	Accuracy 96.46%
[8]	2023	Plant diseases	VGG16 and VGG19 models and deep learning	Accuracy of 0.97 and an F1 score of 0.95.
[10]	2022	Cotton plant diseases	Deep CNN model	Accuracy 89%

CONCLUSION

Dealing with the various crops of plants or different types on the basis of protecting them from biotic and abiotic diseases is one of the major requirement of the farmers and agriculture experts.. For this different technologies and events are used which has made disease identification through by using Artificial Intelligence methods very simple and accurate. In this paper we have proposed a comparative analysis of disease detection of plants by different classifier techniques along with Neural Network.

These different comparison gives that most of the researchers use single classification algorithm for detection of crop diseases. And most of the cases we can use CNN bases neural network to improve the quality of detection. Also instead of using single classifier we can use two or three for accurate results. Image processing is the most important aspect of this research work and proper data set of crops.

REFERENCE

1. Katta Dakshinya,Makula Roshitha, Parasa Akshitha Raj, 2023 International Conference on Artificial Intelligence and Smart Communication.” Cotton Disease Detection”.
2. Rajani Zambare, Chetan Awati, Rashmi Deshmukh, Suresh Shirgave, 2022 6th International Conference on Trends in Electronics and Informatics.” A Theoretical Study on CNN based Cotton Crop Disease Detection”.
3. C Jackulin, S. Murugavalli, 2022 The Authors. Published by Elsevier Ltd “A comprehensive review on detection of plant disease using machine learning and deep learning approaches”.
4. Najumnissa D, Vijayalakshmi S, *Paramasivam A, Karthikha R, and Mohamed Shuaib Y, 2022 Second International Conference on Artificial Intelligence and Smart Energy (ICAIS)” Analysis of Deep Learning Algorithms for Intelligent Plant Disease Identification”.
5. Pradeep Jha, Widhi Dubey, Deepak Dembla, 2023 Third International Conference on Artificial Intelligence and Smart Energy (ICAIS),” Comparative Analysis of Crop Diseases Detection Using Machine Learning Algorithm”.
6. Kapil Chauhan, G.Uma Devi, 2023 11th International Conference on Internet of Everything, Microwave Engineering, Communication and Networks (IEMECON),” Comparative Analysis of various Deep learning techniques for Plant leaf disease detection: A practical approach”.
7. Amit Jadhav, Shubham Chaudhari, Ankush Gupta, Dr. S. A. Mithbavkar, International Journal for Research in Applied Science & Engineering Technology (IJRASET)-2023,” Cotton Disease Detection and Cure Using CNN”.
8. Kelothu Shivaprasad, Assist. Prof. Ankita Wadhawan, 2023 7th International Conference on Intelligent Computing and Control Systems (ICICCS),” Deep Learning-based Plant Leaf Disease Detection”.
9. Vani Rajasekar, K. Venu, Soumya Ranjan Jena, R. Janani Varthini and S. Ishwarya, Journal of Mobile Multimedia, Vol. 18 2, 307–324.2021 River Publishers,” Detection of Cotton Plant Diseases Using Deep Transfer Learning”.
10. Navina Pandhare, Vrunali Panchal, Shivam S. Mishra, Mrs. Darshna Tambe, International Research Journal of Modernization in Engineering Technology and Science,” COTTON PLANT DISEASE DETECTION USING DEEP LEARNING”.
11. S. Nandhini, Dr K. Ashokkumar, 2021 International Conference on Artificial Intelligence and Smart Systems (ICAIS),” Analysis on Prediction of Plant Leaf diseases using Deep Learning”.
12. Gnyana Harshitha, Sandeep Kumar, Shilpa Rani , Arpit Jain, Proceedings Volume of the 4th IET International Smart Cities Symposium, 4th SCS-2021,” Cotton Disease Detection based on Deep Learning Techniques”.

13. Soumyajit Bera, Dr. Puneet Kumar, 2023 2nd International Conference for Innovation in Technology (INOCON),” Deep Learning Approach in Cotton Plant Disease Detection : A Survey”.

14. Sirpi Reddy Jyothiswar Reddy, Nedunuri Madhu Venkata Sai, Sai Krishna Pusuluri, Donkala Komalchowdary, P.V.Siva Rambabu, Arepalli Gopi, 023 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS),” Predicting the Cotton Leaf Disease using Convolution Neural Networks”.

15. Shakti Kinger, Aradhya Tagalpallewar, Reuben Roy George, Kaustubh Hambarde, Piyush Sonawane, 2022 International Conference on Trends in Quantum Computing and Emerging Business Technologies (TQCEBT),” Deep Learning Based Cotton Leaf Disease Detection”.

16. Julie Ann B. Susa, Wendy C. Nombrefia, Alfredo S. Abustan Jr, Jonel Macalisang, Renato R. Maaliw III, 2022 International Conference on Smart Information Systems and Technologies (SIST),” Deep Learning Technique Detection for Cotton and Leaf Classification Using the YOLO Algorithm”.

17. Sachin Sharma, Anshul Ghanshala, Ranu Tyagi, 2022 IEEE Conference on Interdisciplinary Approaches in Technology and Management for Social Innovation (IATMSI),” Cotton Crop Disease Detection System Using Deep Learning Approach”.

18. Sohail Anwar, Abdul Rahim Kolachi, Shadi Khan Baloch, 2022 IEEE 5th International Conference on Image Processing Applications and Systems (IPAS),” Bacterial Blight and Cotton Leaf Curl Virus Detection Using Inception V4 Based CNN Model for Cotton Crops”.

19. Vikas and Dr. Prabhpreet Kaur,”Lung Cancer Detect ion Using Chi- Square Feature Select ion and Support Vector Machine Algorithm”, International Journal of Advanced Trends in Computer Science and Engineering, Vol. 10, No. 3, pp. 2050- 2061, 2021.

20. Vikas and Dr. Prabhpreet Kaur,”Lung Cancer Detect ion Using Chi- Square Feature Select ion and Support Vector Machine Algorithm”, International Journal of Advanced Trends in Computer Science and Engineering, Vol. 10, No. 3, pp. 2050- 2061, 2021.

21. https://www.revesery.com/2021/10/langkah-algoritma-svm-danklasifikasi.html.

22. ht tps://www.analyticsvidhya.com/blog/2021/05/20-questions-to-test -your-skills-on-k-nearest -neighbour/

Unveiling the Research Landscape of the Metaverse in Asia

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ABSTRACT

In order to give a thorough picture of the current state and trends within this burgeoning discipline, this report presents a bibliometric analysis of the Metaverse research environment in Asian nations. A sizable corpus of academic works on the Metaverse was extensively examined using bibliometric methods with help of VOS viewer and R Package- Bibliometrix, providing information on publishing output, teamwork dynamics, and topic focus. The results show that Asian nations have an increasing interest in the Metaverse, with a consistent rise in research output over time. Research efforts in the region were sparked by contributions from nations including China, Japan, and South Korea. It was discovered that collaborative efforts were common, with international partnerships significantly contributing to knowledge transfer and the development of the area. Virtual reality, augmented reality, virtual worlds, immersive technologies, and social interactions within the Metaverse were among the primary topics of concentration within the Asian Metaverse research landscape that were identified through thematic analysis. These results serve as a resource for academics and policymakers interested in improving the development and use of the Metaverse and offer insightful information on the research goals and directions in Asian nations.

KEYWORDS *: Metaverse, Bibliometric, Content analysis, Cluster analysis, Bibliographic coupling*

INTRODUCTION

Users can interact with a computer-generated environment and with others in real-time in the metaverse, a virtual reality setting. It creates an immersive and linked digital realm by fusing aspects of virtual reality, augmented reality, and the internet. The metaverse provides a variety of opportunities for social interaction, virtual world exploration, digital asset trade, gaming, and commercial dealing(Yang, 2023). Companies are investigating the metaverse's possibilities in many industries as a result of technological advancements, which have increased interest in it. Technical difficulties, ethical issues, privacy concerns, standardisation, and equal access are all problems, nevertheless(Schöbel & Leimeister, 2023).

In order to address these issues and comprehend how the metaverse affects behaviour, identity, job, and social interactions(Syuhada et al., 2023). In order to create the metaverse as an inclusive environment that improves human experiences, stimulates creativity, cooperation, and meaningful relationships, interdisciplinary research in computer science, virtual reality, sociology, economics, and philosophy is being done(Zalan & Barbesino, 2023). The ultimate objective is t o develop a digital environment that is transformational and advantageous to both people and society(JosephNg et al., 2023).The introduction of the metaverse has generated a great deal of attention and debate throughout the world and revolutionised the way we engage with digital surroundings and connect with one another (JosephNg et al., 2023). This virtual world has grabbed both academics and business experts because to its immersive experiences, augmented reality, and interconnection (Buhalis et al., 2023). Examining the metaverse's development and effects in various parts of the world is more important than ever as it continues

to develop and pick up steam(Kar & Varsha, 2023). This study presents a thorough survey of the current literature and research initiatives within this dynamic and quickly growing subject with a particular focus on the bibliometric analysis of the metaverse in Asian nations(Uyar et al., 2020). This study uses bibliometric methods to examine the academic environment, pinpoint significant contributors, and highlight new metaverse-related trends and patterns in Asian nations (Quarles et al., 2023).

Asian nations have been in the forefront of embracing and implementing cutting-edge technology because of their reputation for technical achievements and vibrant digital ecosystems(Dolata & Schwabe, 2023). Asian countries have taken a major role in determining the metaverse's future thanks to their various technology landscapes and rich cultural history(Zabel et al., 2023). This work aims to give useful insights into the regional research environment and throw light on the many elements of metaverse development and utilisation in this setting by exploring the bibliometric analysis of the metaverse in Asian nations(Weking et al., 2023).

This study will map the research trajectory, identify significant authors and institutions, and analyse the thematic clusters that have emerged within the metaverse discourse in Asian nations through a thorough analysis of scholarly articles, conference papers, and other pertinent publications (Reig-Mullor et al., 2022). This study also aims to highlight the interdisciplinary nature of metaverse research, emphasising the social sciences, virtual reality, gaming, and other relevant fields that contribute to the comprehension and development of the metaverse concept(Goldberg & Schär, 2023).

This article intends to present a thorough overview of the metaverse environment in Asian nations using bibliometric analysis, laying the groundwork for future research, policy development, and strategic decision-making (Kraus et al., 2023). The results of this study may serve as a roadmap for academics, government officials, and business leaders interested in discovering knowledge gaps, pursuing cooperative possibilities, and utilising the metaverse's potential in Asian contexts(Dwivedi et al., 2023).

In conclusion, this study offers a bibliometric analysis of the metaverse in Asian nations with the goal of providing a comprehensive picture of the academic landscape and insightful information on the developments, trends, and consequences of the metaverse phenomena in this dynamic area (Fang et al., 2023). We hope that our in-depth analysis will add to the corpus of knowledge and promote a better comprehension of the transformational potential of the metaverse in Asian nations.

RESEARCH QUESTIONS

RQ1: What are the inclusive trends and total number of research publications published in Asia about the metaverse?

RQ2: Which major authors and nations are involved in the study of the metaverse in the chosen Asian nations?

RQ3: In Asian nations, what are the citation trends and effects of papers concentrating on the metaverse?

RQ4: What are the most popular metaverse research themes and areas of study in Asian nations?

RQ5: What possible research implications could result from the findings of this bibliometric analysis?

METHODOLOGY

To conduct the bibliometric analysis of the metaverse in Asian countries, a systematic search was performed using the Scopus database. The search string used was "TITLE-ABS-KEY (metaverse) AND (LIMIT-TO (AFFILCOUNTRY, 'China') OR LIMIT-TO (AFFILCOUNTRY, 'India') OR LIMIT-TO (AFFILCOUNTRY, 'Japan') OR LIMIT-TO (AFFILCOUNTRY, 'Singapore') OR LIMIT-TO (AFFILCOUNTRY, 'Malaysia') OR LIMIT-TO (AFFILCOUNTRY, 'Saudi Arabia') OR LIMIT-TO (AFFILCOUNTRY, 'Iran') OR LIMIT-TO (AFFILCOUNTRY, 'Thailand') OR LIMIT-TO (AFFILCOUNTRY, 'Pakistan') OR LIMIT-TO (AFFILCOUNTRY, 'Jordan'))".

This search phrase was created to discover papers that were linked to institutions in specified Asian nations, notably China, India, Japan, Singapore, Malaysia, Saudi Arabia, Iran, Thailand, Pakistan, and Jordan, and that had the word "metaverse" in their title, abstract, or keywords. The Scopus database, a large and frequently used repository for scholarly papers, was the only source that was included in the search (Zerbino, 2022). By concentrating on these Asian

nations, we sought to identify regional contributions to and trends in metaverse research. The Scopus search results were exported and then imported for additional examination into bibliometric analysis tools. From the retrieved publications, information such as publication year, authors, affiliations, citations, and keywords were extracted(Hassani & Bahini, 2022).

Numerous quantitative measurements, such as citation counts, co-authorship networks, keyword co-occurrence analysis, and trend analysis across time, will be used in the bibliometric study. These studies will offer perceptions into the research environment, significant contributors, topic clusters, and the development of the idea of the metaverse in the chosen Asian nations. By using this technique, we want to present a thorough and data-driven assessment of the scholarly output and trends connected to the metaverse in Asian nations, providing insightful information for academics, decision-makers, and business experts working in this area(De Jong et al., 2019).

RESULTS AND DISCUSSION

Annual Scientific Production

Figure 01 displays the number of articles that were released per year between 2008 and 2023. The number of publications varies with time, with very few papers published in previous years and a progressive rise in subsequent years. The number of articles increases noticeably in 2022 and then significantly in 2023. This shows a rise in research effort and interest in the field throughout those years(Wichianrak et al., 2023).

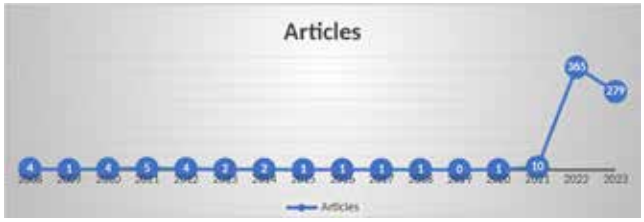

Figure 1. Annual Scientific Production

Most Influential Documents

Top 10 documents basesd on local and global citation is shown in the Table 01, together with information on each one's publication year, local and worldwide citation counts, LC/GC ratio (%), normalised local citation count, and normalised global citation count. The quantity of citations from one source or document are referred to as "local citations," whilst citations from other sources are referred to as "global citations."It is clear from the statistics that the quantity of citations differs between the papers. Some papers, like Duan et al. (2021) and Dwivedi et al. (2022), have more local and international citations, demonstrating their major effect and influence within the discipline. Conversely, works by Suzuki et al. (2020) and Barry et al. (2015) have far less citations. The distribution of citations between local and international sources may be analysed using the LC/GC ratio. A lower LC/GC ratio denotes a more balanced or significant contribution from global sources, whereas a larger ratio implies a higher percentage of citations from local sources.A standard measure of citations is provided by the normalised local and global citations, enabling comparisons between texts. Higher numbers suggest a greater influence in terms of the number of citations compared to other papers.The table gives an overview of the citation performance of the listed publications, showing differences in citation counts, local-global citation distribution, and normalised effect within the field of study(Andreoli & Batista, 2020).

Most Prolific Authors

The Figure 02 lists researchers and shows how frequently their names appear in various contexts. The most often occurring names are Li Y, Wang X, and Wang Y, with 23, 22, and 21 occurrences each. These researchers are well-represented in the relevant environment. With 20 and 19 instances, respectively, Wang J and Wang F-Y also show very often. The number of occurrences for Liu Y, Niyato D, Chen Y, Li J, and Zhang X ranges from 18 to 13. The researchers who are most commonly cited or active in the field under examination are highlighted in the table(Boncinelli et al., 2023).

Most Influential Sources

Top 10 prolific sources are included in the Figure 03, along with the number of articles linked to each source(Ktisti et al., 2022). The most papers are found in "Lecture Notes in Computer Science," which has subseries on bioinformatics and artificial intelligence. With 17 papers, "IEEE Transactions on Systems, Man, and Cybernetics: Systems" comes in second place. Other noteworthy sources with 12 and 10 articles each are "ACM International Conference Proceeding

Series" and "Sustainability (Switzerland)". Each of the following journals contributes 9 to 7 articles: "Frontiers in Psychology," "Lecture Notes in Networks and Systems," "Electronics (Switzerland"), "Frontiers in Artificial Intelligence and Applications," "Proceedings - 2023 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops, VRW 2023," and "Proceedings of SPIE - The International Society for Optical Engineering."

Table 1. Most Influential Documents

S.N.	Document	Year	Local Citations	Global Citations	LC/GC Ratio (%)	Normalized Local Citations	Normalized Global Citations
1	DUAN H, 2021, MM - PROC ACM INT CONF MULTIMED	2021	54	164	32.93	6.75	6.72
2	DWIVEDI YK, 2022, INT J INF MANAGE	2022	37	151	24.50	37.72	33.04
3	YANG Q, 2022, IEEE OPEN J COMPUT SOC	2022	26	46	56.52	26.51	10.07
4	TLILI A, 2022, SMART LEARN ENVIRON	2022	20	52	38.46	20.39	11.38
5	SHEN B, 2021, APPL SCI	2021	16	48	33.33	2.00	1.97
6	YANG D, 2022, CLIN EHEALTH	2022	14	37	37.84	14.27	8.10
7	WANG F-Y, 2022, IEEE TRANS COMPUTAT SOC SYST	2022	14	42	33.33	14.27	9.19
8	SUZUKI S-N, 2020, PROCEDIA COMPUT SCI	2020	14	50	28.00	1.00	1.00
9	BARRY DM, 2015, PROCEDIA COMPUT SCI	2015	13	33	39.39	1.00	1.00
10	KANEMATSU H, 2014, PROCEDIA COMPUT SCI	2014	12	28	42.86	2.00	1.87

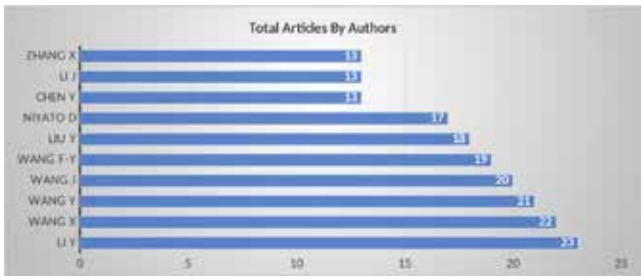

Figure 2. Most Profilic authors

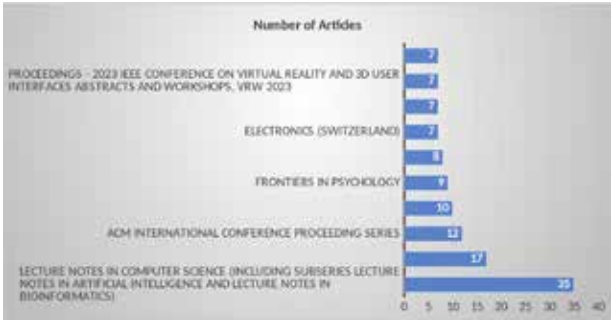

Figure 3. Most Influential Sources

Bibliographic Coupling of Countries

Based on common references in scientific papers, a technique called bibliographic coupling is used to evaluate international collaboration(Niñerola et al., 2021). It aids in the identification of research collaborations, interests, and new trends. Researchers and policymakers can learn more about global networks of collaboration and information sharing by examining bibliographic coupling patterns. This knowledge supports effective international research collaborations as well as strategic planning and research assessment. Based on the quantity of papers, citations, and overall link strength, the table provides information on the research production and influence of a few chosen nations. China has the most documents and citations, which shows that it is actively engaged in research. In spite of having fewer papers, the United States comes in second with a sizable number of citations. India has a modest research output and a comparatively strong

overall linkage. Germany and the United Kingdom have lower research outputs but significant citations and link strength as shown in Figure 04.

THEMATIC MAP

A thematic map aids in the visualisation of the properties of several research themes within a dataset during bibliometric analysis(Johnpaul et al., 2021). The thematic map incorporates a number of characteristics, including motor theme, emerging theme, specialty theme, and basic theme, as well as development degree and relevance degree. The level of development reflects the sophistication and depth of study in a certain topic. The degree of relevance reveals a theme's significance and influence within the larger study domain. Other themes are driven and shaped by motor themes, which serve as important and key notions. While niche themes indicate specialised and narrow issues, emerging themes represent brand-new, developing study fields. Fundamental concepts act as the field's knowledge's building blocks.

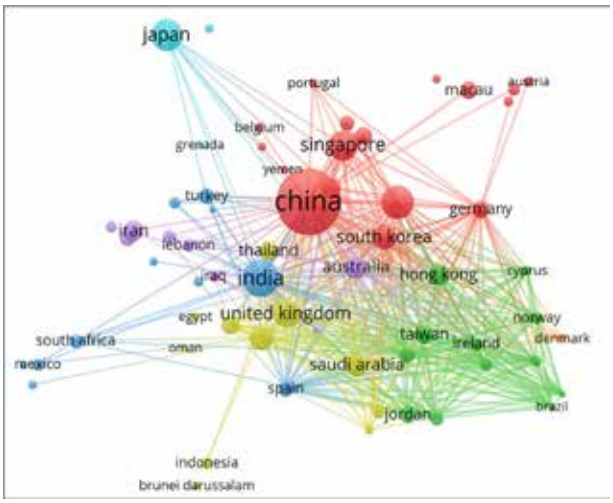

Figure 4. Collaboration among Countries

Centrality and Density details of Cluster Formed by Thematic Analysis

Table 2. Details of cluster

S.NO	Cluster	Callon Centrality	Callon Density	Rank Centrality	Rank Density	Cluster Frequency
1	reinforcement learning	2.281315332	33.99613041	9	9	117
2	3d modeling	1.418860229	32.04822955	6	8	81
3	e-learning	2.432245049	25.97081137	10	4	228
4	block-chain	5.787223891	25.96857443	12	3	406
5	human machine interface	0.745902778	40.01234568	3	11	46
6	machine-learning	3.507837701	23.95964482	11	2	139

The table provides a summary of various clusters related to different research topics in the field of Metaverse. It includes columns such as Callon Centrality, Callon Density, Rank Centrality, Rank Density, and Cluster Frequency. These metrics offer insights into the prominence and frequency of each cluster within the analyzed dataset. The Callon Centrality and Density values represent the centrality and density of the cluster, respectively, indicating the level of importance and interconnectedness of the research within that specific topic. Higher values suggest greater centrality and density, indicating a more prominent and cohesive research area. The Rank Centrality and Density values denote the rank position of each cluster in terms of centrality and density, respectively. A lower rank value indicates higher centrality or density compared to other clusters, signifying a more influential or concentrated area of research. Lastly, the Cluster Frequency column indicates the number of publications associated with each cluster, providing an indication of the research activity and interest within each topic. Higher frequencies suggest a greater volume of research within a specific cluster. By evaluating these metrics, researchers can identify the most influential and

interconnected research areas (based on centrality and density), as well as the most prolific topics (based on cluster frequency). This information can guide further research efforts, collaborations, and the allocation of resources within the field of Metaverse research.

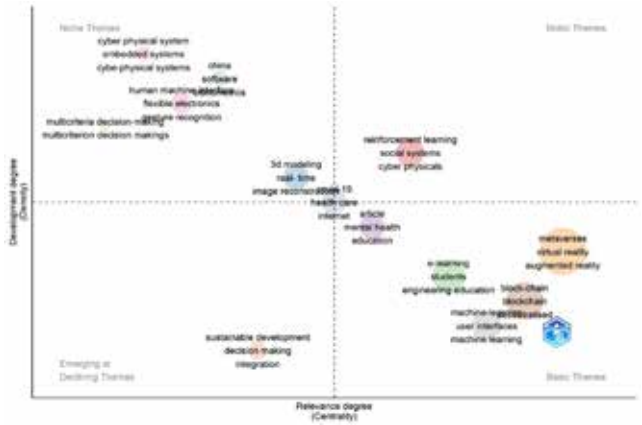

Figure 5. Thematic Map

Content Analysis

A technique for analysing and classifying textual or qualitative material into significant clusters or groupings is called content analysis using cluster analysis. It entails locating recurring themes, patterns, or subjects in a dataset. According to their content, such as words, phrases, or concepts, comparable objects are grouped together using mathematical methods in cluster analysis. This method offers a systematic method for organising and condensing enormous volumes of data and aids researchers in revealing hidden structures or links within the data. Researchers can better identify the major themes or categories included in the dataset and investigate the links between various clusters by clustering the data. Here from thematic map, we have examined 06 major clusters as follows:

Cluster analysis 1: Reinforcement Learning

The blending of "reinforcement learning," "social systems," "cyber physicals," "cyberspaces," "reinforcement learnings," "task analysis," and "computational modelling" creates an enthralling tapestry of interrelated topics in the vast metaverse. Reinforcement learning algorithms are essential in the metaverse for optimising user interactions and experiences, adjusting to unique preferences, and enhancing virtual worlds. In the metaverse, social systems flourish, giving rise to vibrant communities, cooperative networks, and engaging interpersonal relationships. Cyber physicals smoothly combine digital and physical components, bridging the gap between the virtual and physical worlds, and turning interactions into palpable experiences. The metaverse's digital cyberspaces, which provide limitless opportunities for connection and self-expression, serve as the setting for exploration, creativity, and participation. In the metaverse, task analysis assures effective job execution and boosts efficiency, while computational modelling enables designers and developers to create complex virtual environments and engaging simulations. These ideas come together to form the metaverse, a vast digital environment that is full of invention, connections, and life-changing events.

Cluster analysis 2: 3d Modelling

The fusion of "real-time," "image reconstruction," "three-dimensional displays," "cameras," "textures," "holographic displays," "3D modelling," "algorithms," and "image processing" in the metaverse results in an enthralling digital environment. While image reconstruction techniques completely meld digital and physical worlds, real-time interactions and experiences immerse users in dynamic virtual environments. The visual fidelity of the metaverse is improved through holographic and three-dimensional technology, allowing for lifelike representations and immersive experiences. The incorporation of aspects from the real world into the metaverse is made possible by cameras, which record the essence of the physical world. The complexity of virtual surroundings is enhanced by point clouds and textures, which replicate fine features and textures. The production and manipulation of 3D models is made possible by cutting-edge algorithms and image processing techniques, which help to shape the digital architecture of the metaverse. Liquid crystals aid in the creation of high-caliber displays by enhancing visual realism and clarity. These connected components serve as the building blocks of immersive experiences in the metaverse, allowing users to engage, create, and explore in a colourful and interesting digital world.

Cluster 03: E-learning

Students may engage in dynamic and engaging learning experiences outside of the typical classroom

environment because to the metaverse's immersive platform for e-learning. Teachers may use the metaverse to create personalised and adaptable learning experiences catered to each student's requirements using computer-aided education and knowledge-based systems. The establishment of engaging and dynamic learning environments where multimedia technologies excite students' perception and improve their grasp of difficult subjects is made possible by the educational metaverse. Students can successfully use problem-based learning approaches in the metaverse to address real-world issues and hone their critical thinking abilities. Additionally, the metaverse creates possibilities for online education, allowing students to access learning materials and participate in the learning process from any location.

Cluster 04: Blockchain

The metaverse uses blockchain technology to provide safe, decentralised transactions, digital asset ownership, and smart contract-based authentication. It offers a platform for immersive and interactive experiences inside of video games and other virtual worlds, having an influence on many different facets of everyday life, society, and the digital economy. The metaverse intends to provide the secure and effective flow of digital assets and electronic documents with an emphasis on information management, data privacy, and cybersecurity. In order to give consumers a smooth and engaging experience, it embraces intelligent systems, optimisations for displaying visuals, network security, and distributed computer systems. As Industry 4.0's metaverse develops, it attracts investments and spurs advancements in web 3.0, intelligent systems, and artistic computing. The metaverse aims to offer a safe and revolutionary digital environment for people and businesses alike by embracing decentralisation, cloud computing, and network optimisations.

Cluster 05: Machine Learning

Wearable technology and virtual avatars are only two examples of how "human-computer interaction" is made easy in the metaverse through the combination of "machine learning" and "user interfaces." The "complex networks" that support the metaverse grow, and it depends on effective "data handling" methods to manage massive volumes of data. "Decision trees" and "learning algorithms" are used to improve decision-making processes so that "intelligent robots" can move around and interact in virtual settings. Advanced methods like "speech recognition" and "neural networks" enable intuitive and natural communication between people and the metaverse. The metaverse is researching topics like "convolution" and "brain- computer interfaces" in an effort to close the gap between the "human brain" and virtual experiences as technology advances.

Cluster 06: Human Interface

The idea of a "human-machine interface" is crucial in the metaverse because it allows for seamless communication between real world surroundings and virtual ones. New "flexible electronics" developments open the door to creative solutions that improve user experiences. "Gesture recognition" is essential for converting physical human motions into digital commands in the metaverse. By generating power from user interactions, cutting-edge technologies like "nanogenerators" and "triboelectricity" can power "wearable sensors" and other metaverse devices in a sustainable way. In order to record and decipher neural impulses, electrodes are used, enabling direct communication between the human brain and the virtual world. The metaverse experience gains an additional degree of expressiveness and control because to the recognition and interpretation of "gestures," which also makes it more user- friendly and immersive. The incorporation of these technologies results in a more seamless and interesting virtual world as the metaverse continues to develop.

CONCLUSION

The Metaverse in Asian nations was subjected to a thorough bibliometric study in this work, which offered insightful information on the state of the field and upcoming trends. This study provided insight into a variety of topics, including publishing productivity, collaborative patterns, and subject focus by methodically analysing a sizable corpus of scholarly publications. The results of this investigation showed that Asian nations have an increasing interest in the Metaverse, with a consistent rise in research output over time. The findings also showed how important particular nations—including China, Japan, and South Korea—have been in promoting study on the Metaverse in the area.

Collaboration was discovered to be a crucial component of research in the Metaverse, with a sizeable portion of publications coming from cross-border partnerships. This demonstrates the international scope of the topic and the necessity of international collaboration and knowledge exchange among academics. Additionally, the theme analysis revealed major areas of interest within Asia's Metaverse research environment. These included subjects including immersive technology, virtual reality, augmented reality, virtual worlds, and social interactions in the Metaverse. Such results are a useful resource for academics and policymakers interested in boosting the development and uptake of the Metaverse in Asian nations, and they also help us comprehend the existing research environment.

FUTURE SCOPE OF STUDY

Future research in the metaverse will focus on a number of important subjects in Asian nations. First, more investigation might focus on the qualitative components of Metaverse adoption, investigating user experiences, moral issues, and social effects. Investigations into how cutting- edge technology like blockchain and artificial intelligence are used in the Metaverse might also yield insightful results. Comparative research between Asian nations and other regions may also point up commonalities, discrepancies, and prospective opportunities for cooperation. The Metaverse's larger ramifications may be better understood through interdisciplinary study that combines disciplines like psychology, sociology, and economics. This will also help Asian nations develop the Metaverse responsibly and sustainably.

REFERENCES

1. Andreoli, T. P., & Batista, L. L. (2020). Possible regulatory actions for greenwashing and its different influences on brand evaluation and consumer judgment . Revista Brasileira de Marketing, 19(1), 29–52. https://doi.org/10.5585/remark.v19i1.14755
2. Boncinelli, F., Gerini, F., Piracci, G., Bellia, R., & Casini, L. (2023). Effect of executional greenwashing on market share of food products: An empirical study on green-coloured packaging. Journal of Cleaner Production, 391. https://doi.org/10.1016/j.jclepro.2023.136258
3. Buhalis, D., Leung, D., & Lin, M. (2023). Metaverse as a disruptive technology revolutionising tourism management and marketing. Tourism Management, 97. https://doi.org/10.1016/j.tourman.2023.104724
4 De Jong, M., Han, M., & Lu, H. (2019). City Branding in Chinese Cities: From Tactical Greenwashing to Successful Industrial Transformation. In Remaking Sustainable Urbanism: Space, Scale and Governance in the New Urban Era (pp. 81–99). Springer Singapore. https://doi.org/10.1007/978-981-13-3350-7_5
5. Dolata, M., & Schwabe, G. (2023). What is the Metaverse and who seeks to define it? Mapping the site of social construction. Journal of Information Technology. https://doi.org/10.1177/02683962231159927
6 Dwivedi, Y. K., Hughes, L., Wang, Y., Alalwan, A. A., Ahn, S. J., Balakrishnan, J., Barta, S., Belk, R., Buhalis, D., Dutot, V., Felix, R., Filieri, R., Flavián, C., Gustafsson, A., Hinsch,
7. C., Hollensen, S., Jain, V., Kim, J., Krishen, A. S., … Wirtz, J. (2023). Metaverse marketing: How the metaverse will shape the future of consumer research and practice. Psychology and Marketing, 40(4), 750–776. https://doi.org/10.1002/mar.21767
8. Fang, L. B., Dong, X., Weng, Z., & Chen, T. (2023). Designing an Attractive Metaverse: Research on Design Factors Influencing Audience Satisfaction with a Virtual Space Based on QCA. Journal of Theoretical and Applied Electronic Commerce Research, 18(1), 37– 54. https://doi.org/10.3390/jtaer18010003
9. Goldberg, M., & Schär, F. (2023). Metaverse governance: An empirical analysis of voting within Decentralized Autonomous Organizations. Journal of Business Research, 160. https://doi.org/10.1016/j.jbusres.2023.113764
10. Hassani, B. K., & Bahini, Y. (2022). Relationships between ESG Disclosure and Economic Growth: A Critical Review. Journal of Risk and Financial Management, 15(11). https://doi.org/10.3390/jrfm15110538
11. Johnpaul, V., Varghese, K. V, & Sindhu, R. (2021). Study On Cheeyappara Waterfalls To Set Up An Environmentally Sustainable Small Hydropower Station. Indian Journal of Environmental Protection, 41(3), 257–260. https://www.scopus.com/inward/record.uri? eid=2-s2.0-85123681086&partnerID=40&md5=9175c88520623caa5c3250f41cfede0e
12. JosephNg, P. S., Gong, X., Singh, N., Sam, T. H., Liu, H., & Phan, K. Y. (2023). Beyond Your Sight

Using Metaverse Immersive Vision With Technology Behaviour Model. Journal of Cases on Information Technology, 25(1). https://doi.org/10.4018/JCIT.321657

13. Kar, A. K., & Varsha, P. S. (2023). Unravelling the techno-functional building blocks of metaverse ecosystems – A review and research agenda. International Journal of Information Management Data Insights. https://doi.org/10.1016/j.jjimei.2023.100176

14. Kraus, S., Kumar, S., Lim, W. M., Kaur, J., Sharma, A., & Schiavone, F. (2023). From moon landing to metaverse: Tracing the evolution of Technological Forecasting and Social Change. Technological Forecasting and Social Change, 189. https://doi.org/10.1016/j.techfore.2023.122381

15. Ktisti, E., Hatzithomas, L., & Boutsouki, C. (2022). Green Advertising on Social Media: A Systematic Literature Review. Sustainability (Switzerland), 14(21). https://doi.org/10.3390/su142114424

16. Niñerola, A., Sánchez-Rebull, M. V., & Hernández-Lara, A. B. (2021). Mapping the field: relational study on Six Sigma. In Total Quality Management and Business Excellence (Vol. 32, Issues 11–12, pp. 1182–1200). Routledge. https://doi.org/10.1080/14783363.2019.1685864

17. Quarles, L. F., Feddema, K., Campera, M., & Nekaris, K. A. I. (2023). Normal redefined: Exploring decontextualization of lorises (Nycticebus & Xanthonycticebus spp.) on social media platforms. Frontiers in Conservation Science, 4. https://doi.org/10.3389/fcosc.2023.1067355

18. Reig-Mullor, J., Garcia-Bernabeu, A., Pla-Santamaria, D., & Vercher-Ferrandiz, M. (2022). EVALUATING ESG CORPORATE PERFORMANCE USING A NEW NEUTROSOPHIC AHP-TOPSIS BASED APPROACH. Technological and Economic Development of Economy, 28(5), 1242–1266. https://doi.org/10.3846/tede.2022.17004

19. Schöbel, S. M., & Leimeister, J. M. (2023). Metaverse platform ecosystems. Electronic Markets, 33(1). https://doi.org/10.1007/s12525-023-00623-w

20. Syuhada, K., Tjahjono, V., & Hakim, A. (2023). Dependent Metaverse Risk Forecasts with Heteroskedastic Models and Ensemble Learning. Risks, 11(2). https://doi.org/10.3390/risks11020032

21. Uyar, A., Karaman, A. S., & Kilic, M. (2020). Is corporate social responsibility reporting a tool of signaling or greenwashing? Evidence from the worldwide logistics sector. Journal of Cleaner Production, 253. https://doi.org/10.1016/j.jclepro.2020.119997

22. Weking, J., Desouza, K. C., Fielt, E., & Kowalkiewicz, M. (2023). Metaverse-enabled entrepreneurship. Journal of Business Venturing Insights, 19. https://doi.org/10.1016/j.jbvi.2023.e00375

23. Wichianrak, J., Khan, T., Teh, D., & Dellaportas, S. (2023). Critical Perspectives of NGOs on Voluntary Corporate Environmental Reporting: Thai Public Listed Companies. Sustainability (Switzerland), 15(7). https://doi.org/10.3390/su15076195

24. Yang, L. (2023). Recommendations for metaverse governance based on technical standards. Humanities and Social Sciences Communications, 10(1). https://doi.org/10.1057/s41599- 023-01750-7

25. Zabel, C., O'Brien, D., & Natzel, J. (2023). Sensing the Metaverse: The microfoundations of complementor firms' dynamic sensing capabilities in emerging-technology ecosystems. Technological Forecasting and Social Change, 192. https://doi.org/10.1016/j.techfore.2023.122562

26. Zalan, T., & Barbesino, P. (2023). Making the metaverse real. Digital Business, 3(2). https://doi.org/10.1016/j.digbus.2023.100059

27. Zerbino, P. (2022). How to manage the Circular Economy Rebound effect: A proposal for contingency-based guidelines. Journal of Cleaner Production, 378. https://doi.org/10.1016/j.jclepro.2022.134584

Transformation of Consumer Retail Buying after Covid -19 Pandemic

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ABSTRACT

The consumer in this epidemic encountered unexpected difficulties adjusting to the sudden shift in purchasing habits. The goal of the current endeavour is to pinpoint the safety precautions that consumers take when making a purchase. Health and safety concerns are more important to modern customers, which directly impacts their shopping decisions and helps to determine how consumer buying behaviour reflects safety practices. Google Forms were used to gather the data, and Smart PLS was used for analysis. The statistical significance of the relationship between explanatory and explained variables was also calculated by bootstrapping. The data analysis reflects that safety practices and conveniences will have a greater impact on the decision to buy the product. The least important buying decision is based on cost consciousness after the covid 19 pandemic.

KEYWORDS *: Covid-19 pandemic, Consumer buying behaviour, Safety measures, Buying decision*

INTRODUCTION

The study aims to comprehend how consumers choose, purchase, and use goods and services. The consumer is the only reason businesses are even in existence (Cochran, 2006). Marketers attempt to understand why consumers choose the products and services they do, so they can present those products in ways that will satisfy consumers. Elements of the marketing mix, such as product, price, and location, are less successful than they previously were (Mihaela, 2015). When people shop, they interact face to face. Virus transmission brought on by intimate contact with store owners or other sick people is the greatest risk associated with purchasing food products (Sehgal et al., 2021). Now-a-day, for any company to know consumer buying habits, it is very crucial. During COVID, the shopping preferences of consumers changed. After a pandemic, several stores redesign their layouts to make customers feel more secure. This research aids in recognising changes in consumer and retailer behaviour. Food availability is crucial to human life in any catastrophic situation involving either illness or nature (Ainehvand et al., 2019). The earlier consumer was not that concerned about the hygiene factor, but after COVID, the consumer focuses on various factors like packaging, freshness, and safety measures. Organic food is popular with consumers because they believe it to be healthful, safe, and environmentally friendly (Tran, 2017). Consumers in emerging nations have distinct demographics and behavioural patterns from those in the developed world. It is essential and required for researchers to look at consumer characteristics and behaviours in order to comprehend how to persuade customers to buy from sellers and how merchants can hope to keep them for a longer amount of time. Food companies in India have been ordered by the Food Safety and Standards Authority of India (FSSAI) to take all required precautions in the face of the current epidemic. During the COVID-19 epidemic, the FSSAI released comprehensive rules on food safety and cleanliness (FSSAI, 2020). The topic of shopping safety procedures (SSPs) for food companies in India has been ordered by the Food Safety and Standards Authority of India (FSSAI) to take all required precautions in the face

of the current epidemic. The topic of shopping safety procedures (SSPs) for customers to use when making purchases during this epidemic has been hotly debated in India and other nations across the world. This research aims to analyse how concerned consumers were about food safety during the recent COVID-19 epidemic.

LITERATURE REVIEW

Convenience & Home Delivery and Safety Measures

It is known as home delivery when items are delivered to a customer's home rather than picked up from a store. The demand for home delivery services increases as people's schedules become busier since they lack time to go to the store and make purchases (Khan et al., 2020). The company provides a valuable service by delivering the product directly to the consumer's house (Pani et al., 2020). Organizations benefit from high-quality delivery services in terms of cost and time savings, as well as increased brand value and revenue (Berry et al., 2020). This is becoming more important for businesses to offer valuable delivery services as the relevance of logistics services among consumers (Chen et al., 2014). Home delivery is now recognised as a distinct category within logistics (Melkonyan et al., 2020). Customers are gradually becoming more and more accustomed to it for a variety of reasons, including the fact that it prevents them from having to go back to the store if stock runs out, helps them carry heavy items, and increases the value of home delivery services due to the popularity of online shopping. (Chen et al., 2014). Home delivery entails more than simply getting the goods to the consumer safely and on time; it also entails making information available to them and providing them with security (Liu et al., 2008). Companies are always innovating, finding, creating new tactics, and attempting to deliver comfort and convenience services to their clients to increase customer satisfaction (Koner et al., 2022). Home delivery and convenience have a strong connection to safety since they limit the amount of direct contact that reduces the spread of viruses (Covid 19). For safety reasons, many businesses offer contactless delivery during the COVID-19 period.

Cost Consciousness & Safety Measures

Cost consciousness is the awareness of the prices of various products and the desire to avoid overspending. Consequently, it should differ not just across customers but also between items and conditions for the same person (Sun & Wang, 2020). According to researchers, consumers are more drawn to discounts, influencing their purchases. (Rakesh & Khare, 2012). Ninety-five percent of online consumers search for deals, while 75 percent utilise couponing websites to locate discounts (Gillison et al., 2021). Rakesh and Khare (2012) identified that the abundance of price reductions, rebates, discounts, and coupons, are driving consumers in emerging economies to adopt online shopping. Cost consciousness has been linked to a wide emphasis on cost reduction, using budgets, and knowledge of abstract costs. (Velasquez et al., 2015). Reddy et al. (2022) say that people in developing countries like India care more about price than people in developed countries like the U.S. Expense consciousness is linked to accounting practices and cost savings. (Velasquez et al., 2015). Abernethy and Vagnoni (2004) say that being cost conscious means more than just saving money. It also means figuring out how to balance cost and care in the work you do every day. Cost consciousness is a criterion for evaluating operations (Kurunmäki, 1999). According to consensus, the COVID-19 outbreak's impact on panic buying seems to be a short-term issue. This will affect demand and cause changes in several product categories, so we can anticipate that consumers will become less price-conscious and turn away from more expensive things (Hobbs, 2020).

Fresh & Healthy and Safety Measures

As consumers' demand for fresh foods and beverages develops, manufacturers and retailers encounter more challenges in maintaining product freshness during shipping and on-shelf to ensure quality and integrity. Fresh is used for only thermally processed and frozen foods (Cardello & Schutz, 2002). According to Zhong et al. (2020), food quality is proportional to the degree of freshness. However, freshness is a broad term, and various customers with varied demographic traits and consumption patterns may interpret the word "fresh" differently. Traditional packaging protects food from the outside environment and does not offer producers, merchants, or consumers information on food freshness (Wilbey, 2013). Freshness was the essential factor considered when buying vegetables or fruits (Massaglia

et al., 2019). But according to Ragaert et al. (2004), freshness, as well as flavour, were identified as the most important factors in fruit and vegetable selection. Events that occur when food is in transit might have a negative impact on quality. Brands and merchants are utilising fresh beverages and foods from all around the world in creative ways to achieve the highest quality. The environment in which food is produced has a significant impact on its quality, from packaging through consumption. This lets consumers judge food quality both intuitively and scientifically. Persuasion campaigns deliver sensible, factual messages about the long-term health advantages of eating healthier foods. Freshness is critical to the final product's quality (Ólafsdóttir et al., 1997). Worrying about food security has replaced concern for food safety as the public's attention in nations has shifted to consuming fresh and nutritious food during the COVID time (Butu et al., 2020).

Hygiene Practices and Safety Measures

One of the most widespread concerns in the modern world has been identified as foodborne infections (Abebe et al., 2020). Hygiene in the food service industry refers to procedures for preventing the spread of disease via improper preparation, cooking, or storage. In order to reduce the risk of foodborne disease, it is important to practise good food hygiene. It has been observed that many establishments dealing with food need to do a better job of maintaining proper hygiene practises (Feglo & Sakyi, 2012). It is true that just a fraction of businesses has implemented a formal system to ensure the safety of their food supply. Most of these businesses were very small or even micro-sized, meaning they needed more resources to develop and uphold internationally accepted norms. Food safety management systems were mainly in place at worldwide food manufacturers and processors, demonstrating their dedication to regulation and client requirements (Rheinländer et al., 2008). The level of hygiene and habits of the individuals working in the institutions directly impact food hygiene (Nnebue et al., 2014). Consumers are more attracted to food hygiene and frequently visit shops that can maintain hygiene because they feel safe purchasing anything from there. Food sellers have direct contact with customers, and due to their efforts, the prevalence of foodborne disease has been drastically reduced. Therefore, it is crucial to examine their processes to confirm that they exercise correct hygiene and make enough preparations to deal with the potentially hazardous situation of inappropriate food intake (Kundu et al., 2021). Consumers are more concerned with sanitary issues during COVID. Everyone is accustomed to preventing SARS-CoV-2 infection by employing preventative measures to which they are less frequently accustomed in order to avoid becoming infected (self-protection).

Physical Distance -> Safety Measures

The practice of keeping a greater physical distance from others or avoiding close contact with objects or people in public places during an outbreak of an infectious disease in order to diminish exposure and the spread of infection. In order to battle the COVID-19 outbreak, physical distance should be seen as merely one element of a bigger public health strategy (Jones et al., 2020). The government imposes several restrictions on Covid 19 to regulate the sickness. Consumers have been severely impacted by the government's necessary actions like lockout and social distancing (Akhtar et al., 2020). The epidemic of Covid-19 has had a significant influence on consumer purchasing behaviour. Stores are open, but there is still a fear of contamination. Retailers are eager to gain their customers' confidence by providing a procedure at the outlets that can control risks and provide a secure shopping experience. Pay-as-you-go technology, QR code scanning, mask use, hand sanitiser availability, cleanliness, and sanitary are just a few of the methods adopted by shops to encourage customers to shop with physical and social distance (Kotb & Adel, 2020). The danger of interpersonal transmission (covid - 19) is decreased by physical separation (Gonçalves et al., 2020). Customers shifted their buying patterns due to the lockdown and social distancing. The shopping and delivery procedure has been altered in accordance with government requirements, such as wearing masks, social distancing, and using new contactless technologies (Sheth, 2020). Many shops, including those using new and innovative technology, use social distancing. Consumers will only come into a shop to buy a product if they feel safe and secure. Even retailers may take precautions such as using hand sanitisers, wearing masks, and social distancing (Felice et al., 2020). To

ensure proper physical distancing, shopkeepers created a new customer purchasing section. Shorter visits, fewer engagements, and a higher social distance were all important changes. Jurisdictions have given varying recommendations on the physical or social distance to prevent the spread of illness and decrease morbidity and mortality among employees and others in contact with potentially infected people. Physical distancing helps avoid personal contact and inhibit viral transmission (Chu et al., 2020).

Safety Measures and Consumer Buying Behaviour

The term "consumer purchasing behaviour" describes prospective buyers' steps before making an actual purchase. Examples of this strategy include utilising search engines for research and taking part in online discussion groups. Due to the epidemic, consumer purchasing patterns changed from being previously focused on enjoyment, fun, and entertainment to hygiene and safety (Roggeveen & Sethuraman, 2020). Consumers must focus on safety requirements when shopping, which is new to them and something they have never done before (Sehgal et al., 2021). Many stores rearrange their interiors during and after a pandemic to make customers feel more secure (Kasunthika, 2022). People prefer online buying to hybrid methods since the pandemic altered their view of the crisis owing to concerns about safety, social isolation, and mobility (Jain, 2022). These newly learned behaviours, such as using safety gear (masks, sanitisers), and digital platforms, can be observed in both home and public places to ensure social distancing (Jain, 2022). The consumers' buying is affected by several issues, including elements that are internal or psychological, including motivation, perception, prior experience, the group you refer to, your roles, and your position are social influences; cultural factors include culture and subculture and a person's age, profession, income, and way of life are personal factors (Revathi & Vasantha, 2022). Improvements in efficiency, quality, and safety requirements in the food supply chain are necessary as the contemporary retailing sector expands in India to meet the rising consumer demand for convenience (Humphrey, 2007). It has been shown that male and female purchasing behaviour is similar at the time of buying (F. Khan & Sharma, 2015). It is understandable why most people think there is a significant chance they will transmit the virus. Undoubtedly, the psychological changes in consumer behaviour brought on by the COVID-19 pandemic include the emergence of dread and uncertainty. (Duan & Zhu, 2020).

RESEARCH METHODOLOGY

Conceptual Model Development

The following theoretical framework was constructed after reviewing relevant literature. The conceptual model of this research examined whether convenience & home delivery, cost consciousness, fresh & healthy, hygiene practices and physical distance influences safety measures and consumer buying behaviour.

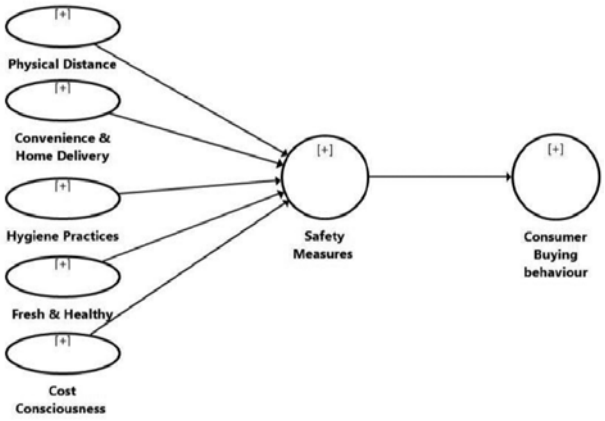

Figure 1: Conceptual Model

Source: Authors' calculation

Hypotheses Development

These hypotheses are based on the aforementioned literature assessment.

H1: Convenience & home delivery have a substantial influence on customer safety measures. H2: Cost consciousness has a substantial influence on customer safety measures.

H3: Fresh & healthy has a substantial influence on customer safety measures. H4: Hygiene practices have a substantial influence on customer safety measures. H5: Physical distance has a substantial influence on customer safety measures.

H6: Safety measures have a substantial influence on consumer buying behavior.

In this research, all the constructs were derived from previous literature. Six dimensions with 23 distinct items were chosen to assess consumer purchasing behavior after learning from past literature. The data was collected using a 5-point Likert scale, with 1 representing "strongly disagree" and 5 representing "strongly agree." Five academicians were given a sample of the questionnaire to check its content and face validity. Following the comments and suggestions, a few necessary changes were made to the questionnaire, including question rephrasing and the elimination of problematic vocabulary.

Kolkata (erstwhile Calcutta) was selected for the research because it is the largest city in eastern India with a variety of cultural and ethnic backgrounds. The questionnaire (Google form link) was circulated through e- mail and social media. The questionnaire was sent to 1500 people. Out of that, a total of 431 individuals answered. After a first round of scrutiny, a few insufficient records were omitted, reducing the sample size to 412, which is more than the minimum sample size 218 as per G*Power 31.9.7 software (Faul et al., 2009).

ANALYSIS

Smart-PLS software was used for analysing the data. Using the validation criteria, the questionnaire was validated against the measurement models in this work established by Hair et al. (2017). These validation criteria included testing the indicators' reliability, consistency within the models themselves, convergence, and discriminant validity. It starts with an examination of the reliability of the items. Factor loadings analysis is one way that may be used to do this, and it should be more than 0.708 (Ali et al., 2018; J. Hair et al., 2017; J. F. Hair et al., 2020). According to the findings of the study of the measurement model (Table II), the factor loading for each item was more than 0.708. A Cronbach alpha of 0.7 and above was used to measure internal reliability (Hair Joseph et al., 2010). As per table II, all the constructs have Cronbach alpha above the threshold limit i.e., above 0.7. To prove to construct reliability and convergent validity, the rhoA and Composite Reliability (CR) scores must both be greater than 0.7 and the Average Variance Extracted (AVE) score must be higher than 0.5 (J. Hair et al., 2017; Koner et al., 2021). Table II demonstrated that the RhoA and convergent reliability (CR) of all constructs is greater than 0.70 and that all constructs have an average variance extracted (AVE) that is above 0.50. This implies that the constructs all have excellent convergent validity (Hair Joseph et al., 2010; Koner et al., 2023).

Table 1. Reflective model assessments

Construct	Items	Type	Loading/ Weights	Cronbach's Alpha	rhoA	CR	AVE
Convenience & Home Delivery	Conv&HomeDel1	Reflective	0.862	0.777	0.781	0.870	0.691
	Conv&HomeDel2		0.810				
	Conv&HomeDel3		0.821				
Cost Consciousness	CostCons1	Reflective	0.850	0.785	0.789	0.874	0.699
	CostCons2		0.808				
	CostCons3		0.848				
Fresh & Healthy	Fresh&Health1	Reflective	0.871	0.807	0.810	0.886	0.722
	Fresh&Health2		0.843				
	Fresh&Health3		0.834				
Hygiene Practices	HygiePrac1	Reflective	0.892	0.796	0.803	0.880	0.710
	HygiePrac2		0.808				
	HygiePrac4		0.825				

Physical Distance	PhyDist1	Reflective	0.846	0.778	0.780	0.871	0.692
	PhyDist2		0.837				
	PhyDist3		0.812				
Safety Measures	SaftyMeas1	Reflective	0.810	0.758	0.759	0.861	0.674
	SaftyMeas2		0.831				
	SaftyMeas3		0.822				
Consumer Buying behaviour	ConBuyBeh1	Reflective	0.903	0.816	0.821	0.891	0.732
	ConBuyBeh2		0.853				
	ConBuyBeh4		0.808				

Source: Authors' calculation

The method of establishing the degree to which one construct is different from others inside a model is referred to as "discriminant validity". It is possible to assess discriminant validity in many ways. Two of the most significant criteria for determining the discriminant validity of reflective constructs are the Fornell-Larcker criterion and HTMT ratio analysis. The squared values of the inter-construct correlation were higher than the outer constructs. So, the discriminant validity is established as per Fornell-Larcker criteria (Fornell & Larcker, 1981) and the researcher can move for further analysis.

Table 2. Discriminant Analysis

Constructs	Consumer Buying behaviour	Convenience & Home Delivery	Cost Consciousness	Fresh & Healthy	Hygiene Practices	Physical Distance	Safety Measures
Consumer Buying behaviour	**0.856**						
Convenience & Home Delivery	0.408	**0.831**					
Cost Consciousness	0.334	0.412	**0.836**				
Fresh & Healthy	0.271	0.379	0.380	**0.850**			
Hygiene Practices	0.277	0.490	0.350	0.350	**0.842**		
Physical Distance	0.367	0.564	0.351	0.354	0.377	**0.832**	
Safety Measures	0.483	0.666	0.430	0.565	0.553	0.668	**0.821**

Source: Authors' calculation

After Fornell-Larcker criterion, a second check of the discriminant validity was made using the HTMT ratio. The score for each HTMT construct must be less than 0.85 (Henseler et al., 2015; Malewar et al., 2023), with a maximum score of 0.90, to demonstrate discriminant validity (Gold et al., 2015). As shown in Table IV, the model has discriminant validity since most HTMT ratios were lower than 0.85 and just two were lower than 0.90.

Table 3. HTMT Ratio Analysis

Constructs	Consumer Buying Behaviour	Convenience & Home Delivery	Cost Consciousness	Fresh & Healthy	Hygiene Practices	Physical Distance
Convenience & Home Delivery	0.515					
Cost Consciousness	0.410	0.530				
Fresh & Healthy	0.327	0.479	0.475			
Hygiene Practices	0.340	0.619	0.443	0.435		
Physical Distance	0.458	0.720	0.448	0.447	0.472	
Safety Measures	0.611	0.867	0.554	0.720	0.704	0.868

Source: Authors' calculation

Variance inflation factor (VIF) value was used to test for multicollinearity prior to further analysis, and VIF value should be lower than 3.33. (Diamantopoulos & Siguaw, 2006). As per the research, VIF value of all the constructs are in between 1 to 1.784 which is below the therosld limit demonstrated that colliniarity is not an issue for this research.

R2 of the endogenous latent variables is a crucial metric for evaluating the structural model. In the scholarly literature, an R2 value of 0.233 for Consumer Purchasing Behavior and an R2 value of 0.674 for safety measures are considered modest and considerable, respectively(Chin et al., 1997). The relative importance of the exogenous constructions to the R2 values of the latent variable was determined using the effect size f2. According to Cohen (2013), f2 values of 0.02, 0.15, and 0.35 should be categorised as having minor, medium, and large effects, respectively. As per the research, convenience & home delivery (0.124) and hygiene practices (0.077) have a low effect on safety measures, whereas physical distance (0.228) and fresh & healthy (0.168) have medium effect on safety measures. On the other hand, safety measures have a medium effect on consumer buying behaviour (0.304). In addition, the research investigated the model's predictive relevance (Q2), as suggested by Chin et al. (1997) and J. Hair et al. (2017). For this investigation, the blindfolding procedure with an omission distance of 7 was applied. If (Q2) is larger than 0, a model is considered to have predictive significance (J. F. Hair et al., 2014). The predictive relevance of Q2 values of 0.02, 0.15, and 0.35 is regarded to be moderate, medium, and substantial, respectively. For this study Q2 value of consumer buying behavour and safety measures are 0.168 and 0.446 respectively explained that the predictive relevance for safety measures and consumer buying behaviour are moderate and substantial.

A global model fit index, such as Standard Root Mean Square Residual (SRMR), is necessary in contemporary research using PLS-SEM models to evaluate the model's suitability (J. F. Hair et al., 2020). The analysis shows that the model had an SRMR value of 0.064, which is significantly lower than the threshold value of 0.08 and indicates that the model had a high level of explanatory power (Henseler et al., 2016; Hu & Bentler, 2009).

Table IV: Results of Hypothesis Testing

Hypotheses	Path Relationships	Std. Beta	t- values	CI 2.5%	CI 97.5%	Relationship Status
H1	Convenience & Home Delivery -> Safety Measures	0.268	5.995	0.180	0.352	Yes
H2	Cost Consciousness -> Safety Measures	0.034	1.063	-0.027	0.101	No
H3	Fresh & Healthy -> Safety Measures	0.264	7.877	0.198	0.329	Yes
H4	Hygiene Practices -> Safety Measures	0.189	6.158	0.129	0.250	Yes
H5	Physical Distance -> Safety Measures	0.340	8.278	0.261	0.423	Yes
H6	Safety Measures -> Consumer Buying behaviour	0.483	12.368	0.405	0.558	Yes

Source: Authors' Calculations; Path Co-efficient (Note: *p<0.001)

After researching the global fit index using the SRMR value, it was important to analyze the significance and relevance of the path coefficients. It was done using the PLS Algorithm's bootstrapping technique with a total of 10000 subsamples. Table V and Figure II present the findings of the hypothesis testing. The outcome showed that after the COVID-19 pandemic, physical distance (=0.340; p0.001) is the most crucial safety measure component that customers take into account while making retail purchases.

The study indicated that hypotheses H1, H3 and H4 were supported at a 1% significance level in addition physical distance (Table V). Covid-19 pandemic change the buying behaviour of the consumer and after pandemic consumers were considered convenience & home delivery (β=0.268; p<0.001), Fresh & Healthy (β=0.264; p<0.001), and Hygiene Practices (β=0.189; p<0.001) at the time of retail purchasing.

As per the result, cost consciousness (β=-0.034; p>0.05) has a negative (non-significant) impact on safety measures concerning retail purchasing, which fails to reject the null hypotheses H2.

The results of the hypothesis testing (Table V) further revealed that safety measures (β=0.483; p<0.001) have a positive impact on overall consumer buying behaviour. So, null hypotheses of H6 were rejected.

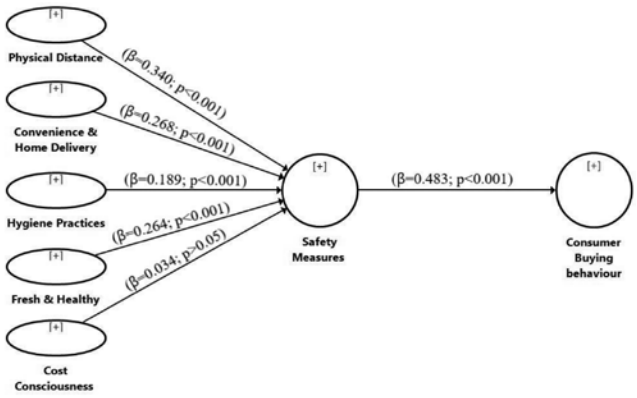

Figure 2: Structural Model Assessment

CONCLUSION

After doing this study, some findings stand out. This study mainly looks at how consumer behaviour has changed when buying products regularly. Today's customers are increasingly worried about their health, which is one of the primary reasons driving their purchasing decisions. Nowadays, consumers are more concerned about safety measures, hygiene factors, and food freshness. From this overview, we can analyze that many consumers are not very conscious of the price of the product. The implementation of safety measures will raise consumer awareness of the need to protect themselves from the COVID-19 pandemic threat. In order to evaluate and identify the elements impacting customers' shopping behaviour and decision, practitioners and researchers working on consumer behaviour during pandemics and future market trends will have a better grasp of the safety measures taken by consumers.

The structural equational model showed a positive relationship, which means there is a relationship between safety measures for convenience and home delivery, fresh & healthy food, hygiene practices, and physical distance. However, cost consciousness has no impact on safety measures. Additionally, A model for SSPs that consumers consider when shopping is constructed using the opportunity to give independent contributions from each component and the value of R2. In order to assess and identify the elements impacting customers' shopping behaviour and decisions, practitioners and researchers planning to study consumer behaviour post- pandemic will have a better grasp of the safety measures taken by consumers. Additionally, since they are aware of the specific significance of each element, the researchers can order them according to their needs.

REFERENCE

1. Ali, F., Rasoolimanesh, S. M., Sarstedt, M., Ringle, C. M., & Ryu, K. (2018). An assessment of the use of partial least squares structural equation modeling (PLS-SEM) in hospitality research. International Journal of Contemporary Hospitality Management, 30(1), 514–538. https://doi.org/10.1108/IJCHM-10- 2016-0568/FULL/HTML
2. Chin, W. W., Gopal, A., & Salisbury, W. D. (1997). Advancing the Theory of Adaptive Structuration: The Development of a Scale to Measure Faithfulness of Appropriation. Information Systems Research, 8(4), 342–367. https://doi.org/10.1287/isre.8.4.342
3. Cohen, J. (2013). Statistical Power Analysis for the Behavioral Sciences. In Statistical Power Analysis for the Behavioral Sciences (2nd ed.). Routledge. https://doi.org/10.4324/9780203771587
4. Diamantopoulos, A., & Siguaw, J. A. (2006). Formative Versus Reflective Indicators in Organizational Measure Development: A Comparison and Empirical Illustration. British Journal of Management, 17(4), 263–282. https://doi.org/10.1111/J.1467-8551.2006.00500.X
5. Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. Behavior Research Methods, 41(4), 1149–1160. https://doi.org/10.3758/BRM.41.4.1149
6. Fornell, C., & Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. Journal of Marketing Research, 18(1), 39–50. https://doi.org/10.1177/002224378101800104
7. Gold, A. H., Malhotra, A., & Segars, A. H. (2015). Knowledge Management: An Organizational Capabilities Perspective. Https://Doi.Org/10.1080/074

21222.2001.11045669, 18(1), 185–214. https://doi.org /10.1080/07421222.2001.11045669

8. Hair, J. F., Howard, M. C., & Nitzl, C. (2020). Assessing measurement model quality in PLS-SEM using confirmatory composite analysis. Journal of Business Research, 109, 101–110. https://doi.org/10.1016/J.JBUSRES.2019.11.069

9. Hair, J. F., Ringle, C. M., & Sarstedt, M. (2014). PLS-SEM: Indeed a Silver Bullet. Journal of Marketing Theory and Practice, 19(2), 139–152. https://doi.org/10.2753/MTP1069-6679190202

10. Hair, J., Hollingsworth, C. L., Randolph, A. B., & Chong, A. Y. L. (2017). An updated and expanded assessment of PLS-SEM in information systems research. Industrial Management and Data Systems, 117(3), 442–458. https://doi.org/10.1108/IMDS-04-2016-0130/FULL/XML

11. Hair Joseph, Black William, Babin Barry, & Anderson Rolph. (2010). Multivariate Data Analysis (5th ed.). Prentice-Hall.

12. Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. Journal of the Academy of Marketing Science, 43(1), 115– 135. https://doi.org/10.1007/s11747-014-0403-8

13. Henseler, J., Ringle, C. M., & Sarstedt, M. (2016). Testing measurement invariance of composites using partial least squares. International Marketing Review, 33(3), 405–431. https://doi.org/10.1108/IMR-09- 2014-0304

14. Hu, L. T., & Bentler, P. M. (2009). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Https://Doi.Org/10.1080/10705519909540118, 6(1), 1– 55. https://doi.org/10.1080/10705519909540118

15 Koner, S., Gupta, T., & Malewar, S. (2023). AN EXPEDITION OF BRAND IDENTIFICATION TO EVANGELISM WITH MEDIATING EFFECT OF LOVE AND LOLYALTY. Thailand and The

16. World Economy, 41(2), 62–84. https://so05.tci-thaijo.org/index.php/TER/article/view/265424

17. Koner, S., Mondal, A. S., & Roy, R. (2021). Impact of Service Quality on Satisfaction. International Journal of Asian Business and Information Management, 12(3), 1–15. https://doi.org/10.4018/ijabim.294103

18. Malewar, S., Koner, S., & Gupta, T. (2023). DETERMINANTS OF ORGANIC FOOD PURCHASE :

19. EVIDENCE FROM COSMOPOLITAN CITIES OF INDIA. Thailand and The World Economy, 41(2), 1–19. https://so05.tci-thaijo.org/index.php/TER/article/view/265361

Adoption of Virtual Reality (VR) and Augmented Reality (AR) in the Marketing Sphere

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ABSTRACT

The rapid advancements in technology have paved the way for the integration of emerging technologies in various industries. The marketing sphere has particularly embraced these immersive technologies to revolutionize customer experiences and enhance brand engagement. This research article explores the adoption of VR and AR in marketing and analyzes their impact on customer behavior, brand perception, and overall marketing effectiveness. Through an examination of current practices, this article aims to provide insights into the potential benefits and challenges associated with the integration of VR and AR in marketing campaigns. Additionally, it discusses the future prospects of VR and AR in the marketing sphere and offers recommendations for businesses looking to leverage these technologies effectively.

KEYWORDS *: Virtual reality (VR), Augmented reality (AR), Immersive technology, Consumer behaviour, Brand perception*

INTRODUCTION

In recent years, the rapid advancements in technology have transformed the way businesses engage with their customers. Emerging technologies have emerged as game-changing technologies that have found numerous applications in various industries, including marketing. VR refers to the computer-generated simulation of a three-dimensional environment that users can interact with, while AR overlaps digital information onto the real world, leading to enhanced user's perception of reality.

The marketing sphere has recognized the potential of VR and AR in creating immersive experiences that captivate and engage consumers. These technologies offer a unique opportunity for brands to stand out in a crowded marketplace, enhance brand awareness, and build lasting emotional connections with their target audience. By leveraging VR and AR, marketers can transcend the limitations of traditional advertising methods and deliver interactive and personalized experiences to consumers.

The adoption of VR and AR in marketing has been fueled by several factors. Firstly, the increasing accessibility of VR and AR devices, such as headsets and smartphones, has made these technologies more widely available to consumers. Additionally, the declining costs of hardware and software development have made it more feasible for businesses of varying sizes to invest in VR and AR marketing campaigns.

Moreover, consumer expectations have shifted towards more immersive and engaging experiences. Traditional marketing approaches are often seen as intrusive or lacking interactivity. VR and AR provide an opportunity to break through these barriers and offer consumers a more memorable and personalized experience.

Furthermore, VR and AR technologies allow marketers to showcase products and services in innovative ways. They enable customers to visualize and experience the products before they buy, leading to increased confidence and informed decision-making. By blurring the line between the physical and digital worlds, VR and AR create a sense of enthusiasm and novelty, driving brand differentiation and customer loyalty.

RESEARCH OBJECTIVES

1. To investigate the current state of adoption of emerging technologies in the marketing sphere.
2. To examine the impact of VR and AR on customer behavior in the context of marketing
3. To assess the effects of VR and AR on brand perception and brand image
4. To identify the challenges and limitations faced by businesses in adopting VR and AR for marketing purposes
5. To provide recommendations and guidelines for businesses looking to effectively leverage VR and AR in their marketing strategies.

IMPACT OF VR AND AR ON CUSTOMER BEHAVIOR AND BRAND PERCEPTION

The integration of emerging technologies in marketing has had a profound impact on customer behavior and brand perception. By providing immersive experiences, VR and AR technologies have the ability to captivate and engage customers on a deeper level. These technologies evoke emotional connections, increase customer interactivity, and influence purchase intentions. The use of VR and AR in marketing campaigns enhances brand recall and memorability, leading to a positive impact on brand image and perceived innovation. Customers perceive brands utilizing VR and AR as cutting-edge, innovative, and customer- centric, thereby strengthening brand loyalty and advocacy. Overall, VR and AR have the power to reshape customer behavior and positively shape brand perception in the marketing sphere.

CHALLENGES AND LIMITATIONS OF VR AND AR IN MARKETING

While emerging technologies offer exciting opportunities for marketers, they also come with certain challenges and limitations. Technological constraints and accessibility issues pose hurdles in widespread adoption, as high-quality VR and AR experiences often require expensive hardware and software. The cost factor is another challenge, with substantial investments needed for development and implementation. User adoption and familiarity present obstacles, as some consumers may be hesitant or unfamiliar with these technologies. Ethical and privacy concerns also arise, particularly regarding data collection and the potential for intrusive experiences. Additionally, integrating VR and AR with traditional marketing channels can be complex. Overcoming these challenges requires addressing technology limitations, ensuring cost-effectiveness, promoting user education, addressing ethical concerns, and finding seamless ways to integrate these technologies into existing marketing strategies.

FUTURE PROSPECTS AND RECOMMENDATIONS

The future prospects of Virtual Reality (VR) and Augmented Reality (AR) in the marketing sphere are promising. Advancements in VR and AR technologies, such as improved hardware capabilities and more realistic simulations, will enhance the immersive experiences offered to consumers. Integration with artificial intelligence and data analytics will enable personalized and targeted marketing campaigns. User-centric design and usability will play a crucial role in ensuring seamless and intuitive experiences. Collaboration with influencers and brand ambassadors can amplify the reach and impact of VR and AR marketing initiatives. Furthermore, customization and personalization will be key in tailoring experiences to individual preferences. To capitalize on these future prospects, businesses should stay updated with technology advancements, invest in research and development, and prioritize the seamless integration of VR and AR into their marketing strategies.

CONCLUSION

In conclusion, the adoption of emerging technologies in the marketing sphere has shown significant potential to transform customer experiences and enhance brand engagement. Through various applications such as product visualization, interactive brand experiences,

and personalized marketing, VR and AR have proven their effectiveness in influencing customer behavior, improving brand perception, and driving marketing effectiveness. However, challenges related to technology, cost, user adoption, and privacy must be addressed to fully leverage the benefits of VR and AR in marketing. By learning from successful case studies and keeping an eye on future advancements, businesses can capitalize on these immersive technologies to create compelling marketing campaigns that captivate audiences and deliver memorable brand experiences.

REFERENCES

1. Ahn, S. J., Bailenson, J. N., & Park, D. (2014). Short- and long-term effects of embodied experiences in immersive virtual environments on environmental locus of control and behavior. Computers in Human Behavior, 39, 235-245. doi:10.1016/j.chb.2014.06.003
2. Billinghurst, M., & Kato, H. (2002). Collaborative augmented reality. Communications of the ACM, 45(7), 64-70. doi:10.1145/514236.514256
3. IAB Tech Lab. (2018). IAB augmented reality (AR) buyer's guide. Retrieved from https://www.iab.com/wp-content/uploads/2018/06/IAB-AR-Buyers-Guide.pdf
4. Lee, K. M. (2004). Presence, explicated. Communication Theory, 14(1), 27-50. doi:10.1111/j.1468-2885.2004.tb00302.x
5. Liang, S. Y., & Huang, C. M. (2019). Investigating the moderating effects of product type and consumer expertise on consumers' adoption of virtual reality advertising. Journal of Interactive Advertising, 19(1), 63-76. doi:10.1080/15252019.2019.1583782
6. Milgram, P., & Kishino, F. (1994). A taxonomy of mixed reality visual displays. IEICE Transactions on Information and Systems, E77-D(12), 1321-1329. Retrieved from https://www.jstage.jst.go.jp/article/transinf/77/12/77_12_1321/_pdf/-char/en
7. Rauschnabel, P. A., Brem, A., & Ivens, B. S. (2019). Augmented reality marketing: A comprehensive guide to consumer perceptions, attitudes, and experiences. International Journal of Advertising, 38(1), 21-54. doi:10.1080/02650487.2018.1512110
8. Schmitt, B. H., & Simonson, A. (1997). Marketing aesthetics: The strategic management of brands, identity, and image. Free Press.
9. Serrano, B., Baños, R. M., Botella, C., & Garau, M. (2016). Virtual reality and augmented reality in the treatment of fear of public speaking: A clinical trial. Frontiers in Psychology, 7, 508. doi:10.3389/fpsyg.2016.00508
10. Kakodkar, P. V., Dhale, S., & Krishnappa, P. (2022). Digital connect. Journal of Indian Association of Public Health Dentistry, 20(2), 212.
11. Shrikrishna Dhale, Ankit Singh. (2020). Perception of Medical Professionals and Pharmacists towards Generic and Branded Drugs. Indian Journal of Forensic Medicine & Toxicology, 14(4), 7152–7156. https://doi.org/10.37506/ijfmt.v14i4.12774
12. Dhale, S. (2020). Factors influencing the meteoric rise of the Indian medical tourism sector and its impact on the economy. J. Crit. Rev., 7(7), 692-694.
13. Singh, A., Pradhan, S., Ravi, P., & Dhale, S. (2021). Application of six sigma and 5 S to improve medication turnaround time. International Journal of Healthcare Management, 14(4), 1279-1287.
14. Dhale, S., & Singh, D. K. (2022). e-Pharmacy in India: An Exponential Growth Opportunity. International Journal, 10(11).
15. Dhale, S., Mishra, P., Singh, A., & Halder, T. (2022). Psychological Study on changes in the Perception towards Health Insurance Products after the onset of COVID-19.
16. Namrata, B., Neha, A., Kalke, P., & Dhale, S. (2021). Routine Replacement versus Clinically Indicated Replacement of Peripheral Venous Catheters through Assessment of Incidences and Grades of Phlebitis in Patients with IV Cannula at a Tertiary Care Hospital, Mumbai.
17. Chunkhare, M., Singh, A., & Dhale, S. (2020). An ameliorating study on medical technology teachers' efficacy. Competency, 11(3), 886-892.

Reinventing and Repositioning of Indian Retail Banking Segment- Transformation for Driving Financial Wellness

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ABSTRACT

Banks and financial institutions are on the way of transition to paperless online technology based banking products and solutions all around the world. Banks address to demand of various segments like corporate clients, retails customers and governments requirements. Retail banking segment has shown tremendous growth in the past however global economic conditions and volatility has affected the way retail banking was functioning this lead to redefining of retail banking approaches and strategies. This research work is an attempt to study the retail banking concept, Indian banking segments, global retail banking strategical transformation, retail banking strategies adopted by Indian banks for financial wellness. Research work highlights that retail banking is reinventing and repositioning on global platform as well as in Indian context also. Indian banks are initiating digitization, financial literacy and education, repositioning of retail products and services, mergers and acquisitions, implementing AI and risk measures to attain the growth and address the potential prospects.

KEYWORDS *: Bank, Digitization, Financial wellness, Global, Retail banking, Strategies, Technology*

INTRODUCTION

Background

Indian Banking is going through strategic transformation from traditional mode to technology driven products and services. There is disruption in the most profitable parts of Banks values chain due to growth of non-banking platform companies, Fintech companies and evolving data driven world. Block chain technologies and growth of intelligent things are adding to it (Shivappa, 2022).Retail banking customer preferences are rapidly evolving with upgradation and usage of sophisticated technology all around the globe (Chandana Asif, 2020). Banks are required to make effort on their strategies towards, products, services, customer base, positioning and even in technological aspects. Banks are already implementing digital tools and techniques but its intensification and usage needs to be done to increase the margins, operational efficiency and cost reduction. To attain this, Banks are attempting to redefine and reposition the retail banking segment so it is thought provoking to understand the strategies leading banks are implementing and how it can lead to define the future of retail banking. This research paper is an attempt to study the current state of retail banking and its future.

OBJECTIVES OF THE RESEARCH WORK

- To study the retail banking concept in India.
- To study and acknowledge the retail banking prospect and challenges.
- To study the strategies adopted by Indian Banks for retail Banking segments.
- To study and recognize the approaches implemented by Indian banks to attain financial wellness for retail banking segment.

RESEARCH METHODOLOGY

Research is basically based on the secondary data. Secondary data is collected from the sample banks websites, annual reports, RBI, Economic Times and from previous published research articles and other web sources. With secondary data researchers attempted to understand Indian banking with special reference to retail banking with contemporary position. This work also points out the future potential Prospect and

challenges. Research work consider top five banks i.e. HDFC Bank Ltd, State Bank of India (SBI), ICICI Bank Ltd, Kotak Mahindra Bank Ltd and Axis.

OVERVIEW OF RETAIL BANKING

Facilitating banking products and services to small businesses and individuals is called Retail banking. The value of transactions is less as compared to corporate banking. The banking and financial products/services offered by retail banks include housing, vehicle, education loans, saving and current account services, mobile banking, insurance and stock broking. There is a changing trend in banking sector which is focusing on Retail banking. (research, 2022).

INDIAN RETAIL BANKING AT A GLANCE

The researchers have referred Commercial Banks List 2022 on the basis of market capitalization, the banks are ranked and top five banks are considered to study strategies applied for overall financial wellness. (Jha, 2022). As per the size of market capitalization, commercial banks list 2022, the top 5 banks are as follows:

Rank	Bank	Strategies
1	HDFC Bank Ltd.	The bank has prepared a strategic plan to face the challenges of retail banking like formation of Innovation Lab to carry out experiments to expand business by increasing geographical base and different products. To enhance new IT infrastructure by collaborating with Fintech. The strategy is developed to introduce new digital products and digitalize processes. To provide good customer service, the bank has developed chatbot EVA and Onchat. (Adhikari, 2022)
2	State Bank of India	The bank is offloading pool of non performing retail loans worth less than Rs. 10 billion to asset reconstruction company for large corporate lonas. Financial literacy details are considered under personal banking. Project Shikhar and YONO are the chatbots applied by the bank. (SBI, 2022) (SBI exploring new ways to resolve retail loan stress, 2022)
3	ICICI Bank Ltd.	The strategy followed by the bank is to focus on lending MSME and supply chain finance. Partnership with Fintech. The bank has collaborated with Amazon in credit card membership. It has developed a omni channel bot for virtual assistance of customers iPal. (Shukla, 2022)
4	Kotak Mahindra Bank Ltd.	The bank has implemented a voicebot Keya 2.0. It enhances interactive voice response. The bank has followed a strategy of merger in ING Vysya which could create a strong position. It has also widened geographical scope. The bank is focusing on safe banking. (ING, 2015)
5	Axis Bank Ltd.	Axis Bank has applied automation which is a robotic process from credit assessment to payment. The bank is in the process of acquiring citi bank in which retail banking is the main focus. The chatbot applied by the bank is Axis aha. (Bank, 2022)

RETAIL BANKING: PROSPECTS AND CHALLENGES

Indian banking sector is moving towards robust growth and demand in terms of retail products like deposits and loans as per the reports of Reserve Bank of India (RBI), the central bank of India. Technology usage (digitization) more specifically mobile and internet usage facilitated banks to achieve the growth in terms of addressing the customers and to tap the untapped population. There are potential future prospects as well as challenges for the retail banking segments.

Figure 1. Retail Banking Segments- Future prospects and Challenges

STRATEGICALLY TRANSFORMATIONS TOWARDS RETAIL BANKING

Banking is getting through phase of strategic transformation and development for retail banking segment. Global retail banking segments are functioning for reinventing the sales, products, repositioning, digitization and performance review. Few of these strategies are already implemented but few needs to get implemented to intensify the way of growth.

Figure 2. Retail Banking -Global Strategically Transformation

- **Reinventing sales-** Indian banks are current working on reducing the branch network and adding the M and E banking capabilities. Banks are trying to give personal touch to customers by providing the tech based solutions and modernized services. Banks are trying to reinvent their sales by enhancing the capabilities and infrastructure for providing the sales automation to target the customers.(Patel, 2023) Stated that customers are not preferring always to visit the banks for the work that is leading to sales automation. It is estimated that approx. 75 % of banking clients perform half their financial transactions online and they willing to get the automated support. (Shivappa, 2022)
- **Reinventing products-** Banks are coming with innovative solution to complex problems with experimenting their products. Even it is stated that banks are adopting platform based positioning from product based positioning .Banks are attempting to replace and modifying the traditional Products with more customer centric products. Banks are repositioning the loan products, deposits and other services to increase the customer base.
- **Focused positioning-** To address the varied demand of the customers and to competent with the market players, bank are coming with Digital inclusion. Banks are now a days giving priority to create ecosystem and secure platform by utilizing sophisticated digital technologies. Banks even are using numerous platform for appropriate positioning of the offered products and services to compete with non-banking companies and fintech companies.
- **Embedded finance Repositioning –** It is estimated that Embedded finance could account for up to 15% of 2030 retail banking revenues, and banks are required to start placing for this transferal sooner rather than later. Customers are opening up for consuming financial services as part of their media or communications subscription, via their car, or through their preferred online or offline travel operator or retailer, to name just a few. (Andreas Pratz, 2022)
- **Technology Adoption /Digitization-** Conversational Service Automation (CSA), can support banks to meet customers' demands with understanding, empathy and by providing eminence quality customer oriented services. It is estimated that there will be more intelligent CSAs integrated into self-serve application portals and mobile banking apps in 2023. (Patel, 2023).Banks are adopting the fast tracking digital techniques

to come with customer solutions and products. (Chandana Asif, 2020). By implementing the digitization of customer journey, Retail banks are attaining the growth in customer's number and even revenue boost of 5% to 20% from improved service, 15% to 35% reduction in network cost and 10% to 15% upsurge in the customer satisfaction of. (Shivappa, 2022).

- **Review of Performance** – Banking are continuously reviewing the performance of retail banking segments and taking care of market demand towards retail products and services. Banks are introducing the innovative products and services by usage of technology to tap the untapped potential customers.

Indian Banks initiatives and accomplishments for retail segment to achieve Financial Wellness-

- **Government Initiatives–** To attain the financial inclusion in India, Government is making efforts by making polices and launching different schemes. Government in connotation with RBI is making lots of efforts to boost the retail banking segments. One of the Government initiative of Pradhan Mantri Jan Dhan Yojana (PMJDY) reached to 45.60 crore and deposits be part under this reached to totaled Rs. 1.68 trillion (US$ 21.56 billion) in Jan Dhan bank accounts as on June 2022.
- **Usage of Sophisticated technology and AI (Digitization)** – As Banking is facing extensive competition from the NBFCs and Fintech companies so they are also upgrading the banks in terms of usage of technology more specifically AI based applications and tools. To promote the customer usage for technology, banks are providing preliminary education to the customers against cybercrime and theft. Banks are blending the technology with human centric approach to give personalized service experience to customers.
- Mergers and Acquisitions (Business Combinations) and Consolidation of Banks - Business combinations like mergers, acquisitions, Joint ventures, and strategic alliances are initiated by Banks and financial institutions to achieve the financial wellness. 32 mergers and acquisitions activities in banking and financial services amounting to US$ 1.72 billion was witnessed in the Year 2019. In last five years, Consolidation of banks are observed to achieve operational efficiency, cost reduction, NPA reduction, technology upgradation and to increase the customer base.
- **National Asset reconstruction company (NARCL)** - National Asset reconstruction company (NARCL) has taken 15 non-performing loans (NPLs) worth Rs. 50,000 crores (US$ 6.70 billion) from the banks. To achieve financial wellness, several banks are selling the portfolio of retail loans to asset reconstruction companies (ARCs).
- **Financial Education and literacy** –To improve the customer's knowledge about various banking products and services, banks are providing the financial awareness and literacy also. At present Banks are assisting to customers for financial planning also. Banks are providing education to customers for Convenience of digital transactions, Protection to customers and Security of digital transactions.
- **Risk Mitigation Measures-** for the Indian banks are addressing major issues like increase in NPAs, frauds and cyber Government and RBI is making the polices to support banks to mitigate the risk. Few of these are asset Construction Company, auto debit rule, mergers and acquisitions.
- **Repositioning of products and market-** Indian banks are attempting to reposition the products and services to get more customer base. Banks are coming with variety of loan and deposit products to address the varied demand of customers as well as using various platform to position it accurately.
- **Sales Automation**- Banks are promoting more of usage of mobile and internet banking to do automation of sales as customer now a day do not prefer to visit the banks personally for banking services and products.

CONCLUSION

Banks and financial Institutions are said to be the backbone of the economy. They assist in mobilization of savings from surplus to deficit area in the way of

circulation, they keep their profits and ensures financial wellness. Global economic volatility and uncertainty has affected the banking more specifically the retail banking as it affected the demand and customer preferences. Even entry of Fintech companies and competitions from NBFCs intensify this. Banks are strengthening the retail banking segments by digitization and implementation of Artificial Intelligence (AI) that is even helping to reduce the cost, effective operational efficiency and reducing Nonperforming assets (NPAs).Banks are combining human touch with technology to provide the personalized experience and assistance to the customers. Retail banking is revamping and repositioning to attain the growth and financial wellness.

REFERENCES

1. Andreas Pratz, J. G. (2022, may 20). 2022 Retail Banking Monitor Reinventing and repositioning.
2. Retrieved from tartegy and part of PwC network: https://www.strategyand.pwc.com/de/en/industries/financial-services/2022-retail-banking- monitor.html
3. Chandana Asif, K. D. (2020, june 11). Reshaping retail banking for the next normal. Retrieved from Mckinsey & Company: https://www.mckinsey.com/industries/financial-services/our- insights/reshaping-retail-banking-for-the-next-normal
4. Jha, P. (2022, December 1). Top 10 Banks In India Biggest Commercial Banks List 2022. Retrieved from https://cscportal.in/top-10-banks-in-india/.
5. Patel, N. (2023, Janurary 12). How sales automation will positively transform the Indian retail banking sector in 2023. Retrieved from times of India: https://timesofindia.indiatimes.com/blogs/voices/how-sales-automation-will-positively- transform-the-indian-retail-banking-sector-in-2023/research, A. M. (2022, November). https://www.alliedmarketresearch.com/retail-banking-market. Retrieved from Retail banking market.
6. Shivappa, V. (2022, July 4). Embracing Digital To Drive Financial Wellness of Banking & Financial Services Industry. Retrieved from Express Computer: https://www.expresscomputer.in/guest- blogs/embracing-digital-to-drive-financial-wellness-of-banking-financial-services- industry/87816/
7. Adhikari, A. (2022, March 6). https://www.businesstoday.in/magazine/indias-best-banks/story/hdfc- bank-is-betting-on-both-wholesale-and-retail-to-drive-growth-323079-2022-03-02.
8. Bank, A. (2022, December 2). Acquisition of Citibank India might get pushed to May: Axis Bank's MD. Retrieved from https://www.financialexpress.com/industry/banking-finance/acquisition-of- citibank-india-might-get-pushed-to-may-axis-banks-md/2898352/.
9. Hites Ahir, N. B. (2022, April 15). Global Economic Uncertainty, Surging Amid War, May Slow Growth. IMF Blog.
10. https://www.investindia.gov.in/sector/bfsi-banking. (2022). Retrieved from Banking for $1.37 bn.
11. ING. (2015, April 7). Retrieved from https://www.ing.com/Newsroom/News/Press-releases/ING-Vysya-Bank-completes-merger-with-Kotak-Mahindra-Bank.htm.
12. Jha, P. (2022, December 1). Top 10 Banks In India Biggest Commercial Banks List 2022. Retrieved from https://cscportal.in/top-10-banks-in-india/.
13. North, R. (2021, Feburary 10). TOP 5 RETAIL BANKING STRATEGIES FOR INDIAN BANKS. Retrieved from Enterprise edge: https://www.enterprise edges.com/top-5-retail-banking-strategies-indian-banks
14. Rajan Patel global head, Y. b. (2020, December 3). Yes bank aimed at doubling retail . (https://www.zeebiz.com/companies/news-yes-bank-aims-at-doubling-retail-sme-assets- liabilities-book-by-2023-rajan-pental-global-head-retail-banking-142573, Interviewer)
15. Ray, A. (2022, September 20). commercial loan share in lending market, study shows.
16. RBI. (2022, November). https://www.ibef.org/industry/banking- india#:~:text=Total%20assets%20across%20the%20banking,at%20a%20CAGR%20of%200.29%25. Retrieved from Banking Sector in India.
17. Research, A. M. (2022, November). https://www.alliedmarketre search.com/retail-banking-market. Retrieved from Retail banking market.
18. SBI. (2022). https://sbi.co.in/web/personal-banking/information-services/government- business/financial-literacy#show.
19. SBI exploring new ways to resolve retail loan stress. (2022, March 30). Economic Times .
20. Shukla, S. (2022, December 5). ICICI Bank to shift focus to SME lending & supply chain finance for future growth. Retrieved from https://economictimes.indiatimes.com/industry/banking/finance/banking/icici-bank-to-shift-focus-to-sme-lending-supply-chain-finance-for-future-growth/articleshow/96003418.cms.

IPO Performance in the Indian Capital Market: Insights from 2016-2021

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ABSTRACT

This study intends to provide a thorough examination of the trends and performance displayed by Initial Public Offerings (IPOs) in the Indian capital market from 2016 to 2021. The study examines the number of IPOs issued each year and evaluates their performance based on factors such as issue price, oversubscription, and market returns. Several previous studies related to IPO performance in India are reviewed to provide context and build upon existing knowledge. Analyzing IPO performance from the issue price to the last trading price and spotting trends in the Indian IPO market are among the study's goals. The study utilizes secondary data obtained from sources such as NSE/BSE official websites and SEBI websites. An analytical examination is conducted using a sample size consisting of 119 Indian firms that are listed on the National Stock Exchange (NSE) within the designated time frame. Descriptive statistics are applied to investigate key parameters. The findings reveal the percentage of underpriced IPOs and provide insights into their performance. The research also formulates hypotheses to explore the relationship between IPO performance and the number of IPOs listed. The paper contributes to the understanding of IPO performance in the Indian market and provides valuable insights for investors and companies involved in IPOs.

KEYWORDS *: Initial Public Offering (IPO), IPO performance, Indian IPO market, Under-pricing, Oversubscription, Issue price, Market returns, National Stock Exchange (NSE).*

INTRODUCTION

Initial Public Offering (IPO) refers to a company's first attempt to raise funds from investors in order to satisfy needs for working capital, debt repayment, acquisition, etc. IPO means selling the shares initially in to the public in Primary Market. IPO is the most awaited and important event for an organization. IPOs are generally issued by new companies and startups that required a capital to expand their business or meeting financial requirements. Going public is the most important and big decision for any company.

Companies can be categorized into two primary types: private companies and public companies. Private companies are fully owned by their shareholders, investors, and owners, and are not obligated to disclose comprehensive information about the company. These companies can be established by anyone, who must invest funds, submit the required legal documentation to the registrar, and adhere to all regulations pertaining to private companies. Many small companies and startups operate as privately owned entities, where direct share purchases are typically not possible. In order to invest in a private company, one must approach the company owner, as there is no obligation to sell shares to the public or facilitate trading on a stock exchange.

The private companies issued securities in the primary market further first time after incorporation is called IPO.

Process of Initial Public Offering (IPO)

IPO sates as the new shares issue to the public. For issuing new shares company need to follow below process-

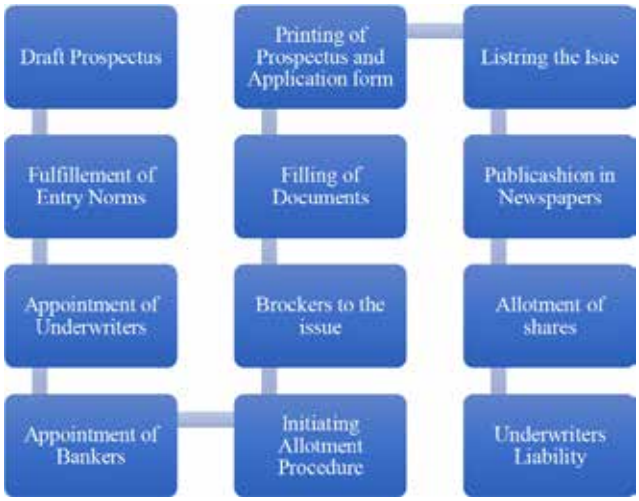

Fig. 1 Process of Initial Public Offering

IPOs Issue from 2016-2021

In this study we analyze the performance of IPOs during the financial year 2016-2021. From the five years of data the highest number of 42 IPOs listed in year 2017-18 and the lowest number of IPOs 11 listed in the financial year 2019-20.

Sr. No.	Financial Year	No. of IPO Issued
1	2016-17	24
2	2017-18	42
3	2018-19	13
4	2019-20	11
5	2020-21	29

Indian IPO Market

Since the Indian economy was liberalized, the IPO market in India has experienced impressive growth and development. It has emerged as a prominent channel for generating funds to support diverse development initiatives undertaken by numerous companies. In India, the IPO market is now booming as more businesses decide to offer equity shares on the capital market. In terms of rules, reforms, and efforts at restructuring, the IPO market in India has seen significant changes since the start of the open market economy in the 1990s. Notably, a crucial milestone in this trajectory was the dismantling of the controller of Capital Issues and the adoption of a free pricing mechanism. This significant measure has played a pivotal role in nurturing the expansion of the IPO market in India, as it has bestowed companies with the flexibility to ascertain the pricing of their IPOs.

LITRETIRE REVIEW

T. Ramesh Chandra Babu and Aaron Ethan Charles Dsouza (2021) In their empirical study titled "Post Listing IPO Returns and Performance in India," carried out a careful analysis to assess the short-term performance of Indian initial public offerings (IPOs). The performance of IPOs was studied in detail by the researchers in relation to a number of variables, including over-subscription, profit after tax (PAT), promoter holdings, issue price, and market returns. The study produced interesting results by looking at secondary data from 52 IPOs filed on the National Stock Exchange (NSE) between 2018 and 2020. Over-subscription was found to have a significant impact on IPO success, although issue price, PAT, market returns, and promoter ownership did not show a significant impact.

N. Vani (2021) in their work titled "An Analytical study on the Impact of IPO on Indian Economy," looked at the developments in the Indian IPO market and assessed how much the industry has contributed to the expansion of the economy of the nation. The study relied on secondary data and analyzed a sample size of 10 years. The findings demonstrated that IPOs have become the preferred method for companies to raise capital in the post-liberalization era, thereby contributing to the growth of the Indian economy.

Jeelan Basha, Bhadrappa Haralayya, and Nitesh Vibhute (2021) To assess the financial and non-financial factors impacting the under-pricing of IPOs in the manufacturing sector on the Indian capital market, a research study named "A study on Performance Evaluation of Initial Public Offering" was undertaken. The majority of service sector IPOs throughout the study period was underpriced, according to the study, which used secondary data. The study discovered several variables that have a significant impact on IPO pricing, including qualified institutional purchasers' allocation, net worth to total assets, earnings per share, return on net worth, and IPO grade.

K. Sravan Kumar and Mrs. C.H. Shiva Priya (2020) conducted a study titled "Performance of Primary

Market with Reference to select IPOs of NSE India" to evaluate the short-run and long-run performance of IPOs listed on the NSE in India. The study relied on secondary data obtained from NSE and investigated whether the Indian stock exchange exhibits short-run underperformance of IPOs and the factors influencing long-run underperformance. The findings indicated that low-priced issue securities exhibited positive returns initially compared to high-priced issues, but after one year, the returns on these stocks declined.

K.S. Manu and Chhavi Saini (2020) conducted a study on "Valuation Analysis of Initial Public Offer (IPO): The Case of India" to evaluate the post-IPO performance of selected companies and assess the impact of various variables on IPOs. The study utilized secondary data and found that IPOs in 2017 were underpriced, with listing day returns being notably impressive. The selected independent variables were not found to significantly influence the short-term IPO performance. Dr. Smitha V Shenoy and Dr. K Srinivasan (2019) conducted a research study on the "Relationship of IPO Post Listing Performance" to evaluate the post-listing performance of IPOs and examine the relationship between pricing parameters and long-run performance. The study utilized secondary data and revealed that investors who purchased shares during the IPO offer period could expect positive returns if they held onto the IPO for up to two years. IPOs that were underpriced and purchased on the listing day exhibited negative returns throughout the holding period, while overpriced IPOs purchased through the offer underperformed in the market for up to five years.

Khushboo Vora (2018) in their study, "Evidence of Under-pricing and Impact of Initial Return Determinants - A Case on Public Issue of Shares in the Indian Capital Market," the authors looked at how mainstream public offerings performed on the day they became public. They discovered strong evidence of under-pricing in these public issues on their first trading day through the analysis of secondary data. The report went on to advise investors to think about investing in such mainstream public concerns in order to perhaps get positive returns on the first day.

Dr. A.S. Ambily, Gayatri Krishna, Aswathy K, and Deepa Balakrishnan (2016) carried out a research study titled "A Study on Performance of IPOs under NSE from Issue Price to Last Trading Price in the Year 2013-2015" to assess the effectiveness and percentage change of IPOs from the issue price to the last traded price throughout the years 2013-2015. The study, which relied on secondary data, discovered that investors chose to invest in a company based more on its reputation than on its fundamental or technical analysis. Based on the results of the study, most investors preferred to buy securities at lower rates. It also shown that IPOs' last traded prices frequently exceeded their issue prices.

STATEMENT OF THE PROBLEM

Initial Public Offerings (IPOs) are an important way for businesses to generate capital for their operations. The IPO market is often viewed as an opportunity for investors to potentially realize substantial gains upon the listing of the company's shares. The effect of certain elements, such as issue size, issue price, and security return, on the performance of IPOs on their listing day, however, continues to be a mystery. In the field of financial research, there is interest in and investigation of the connection between these characteristics and the success of IPOs on their listing day.

OBJECTIVES

1. Evaluate the performance of IPOs by analyzing the price movements from the issue price to the last trading price.
2. To analyse the trends in the Indian IPO market

RESEARCH METHODOLOGY

- Hypothesis of the study:

Ho1: There is no significant relationship between IPO performance and no. of IPOs listed. Ho2: There is no significant relationship between IPO performance and no. of IPOs listed.

- Sources of Data:
- The study is based on secondary data, and a list of IPOs was compiled for examination during a five-year period, from 2016–17 to 2020–21, using data sources such the NSE/BSE official websites, articles, and SEBI websites. For the thorough analysis, detailed information regarding the Issue Price, Issue Dates, Issue Size, and Oversubscription was extracted from the relevant company prospectuses.

- Sample Size:

The sample for this research paper comprises all Indian firms that underwent an IPO and were listed on the NSE during the period from 2016-17 to 2020-21. A total of 119 companies were selected for data collection and subsequent analysis.

DATA ANALYSIS

Measure of IPO's Performance

The return on a specific day or date is calculated in accordance with normal procedure by calculating the percentage difference between the IPO issue price and the secondary market closing price on that particular day.

Table 1: No. of IPO Issued

Sr. No.	Financial Year	No. of IPO Issued	Under Priced IPO	Over-Priced IPO
1	2016-17	24	15	9
2	2017-18	42	22	20
3	2018-19	13	5	8
4	2019-20	11	6	5
5	2020-21	29	18	11

The formula is used to find out whether the security is under-priced or appropriately priced or over- priced If Ri is positive = Under-priced, If Ri is negative = Overpriced and If Ri is Zero = Appropriately priced.

From the above table it can be observed that few issues were under-priced. The percentage of the shares which are under-priced are in the financial year 2016-17 62.5%, 2017-18 52.38%, 2018-19

38.46%, 2019-20 54.54%, and in the year 2020-21 62.07% IPO issues have been under-priced.

Table 2: Sample Selection

Criteria	No. of IPOs
No. of IPOs offered in period	119
(-) company not listed	13
= Companies listed on NSE	106
(-) companies are overvalued	40
= companies are Undervalued	66

Table 3: Descriptive statistics of Issue price, Issue size, Issue over subscription and Market return of IPOs Listed in NSE during year 2016-17 to 2020-21.

Year	Variables	No.	Actual No.	Min.	Max.	Mean	Standard Deviation
2016-17	Issue price	24	23	110	896	434.58	246.46
	Issue size			238.95	6056.79	1201.39	1252.97
	Listing Day Closing Price			59.7	890.6	427.71	278.62
	Initial Return			-82.07	114.3	2.03	50.05
2017-18	Issue price	42	37	90	1766	538.36	417.89
	Issue size			35.87	11157.8	1912.84	2790.87
	Listing Day Closing Price			27.21	1698.1	497.33	360.66
	Initial Return			-96.71	75.57	-0.42	34.69
2018-19	Issue price	13	10	19	967	426.46	322.38
	Issue size			23	1945.77	924.3	678.11
	Listing Day Closing Price			19.05	822.8	391.27	303.06
	Initial Return			-8.13	10.91	-0.48	6.23
2019-20	Issue price	11	9	37	880	455.18	354.62
	Issue size			60	10354.8	1552.74	2950.45
	Listing Day Closing Price			55.9	1302.55	502.3	424.14
	Initial Return			-54.46	53.9	13.3	33.81
2020-21	Issue price	29	27	26	1500	476.28	451.23
	Issue size			61.2	6479.55	1062.89	1358.93
	Listing Day Closing Price			24.85	3118.65	595.38	674.26
	Initial Return			-44.3	130.67	34.76	48.27

The descriptive data for the issue price, issue size, issue oversubscription, and initial return (Ri) for the initial public offerings (IPOs) of companies listed between 2016–17 and 2020–21 are shown in the above table. There were 23 IPOs altogether that were listed on the NSE in 2016–17, with the highest issue price being 896. This year, the typical issue size was 1201.39. The maximum closing price on the listing day was 890.6 times the issue price, with an average closing price of 427.71 times the issue price. The biggest return recorded was 114.3%, with the average initial return from the issue closing day to the listing day being -2.03%. Nine companies' worth of data were gathered over the period 2017–18. The minimum and maximum issue prices were 90 and 166 respectively.

The IPO market slowed down the following year, 2018–19, with only three IPOs being listed on the NSE. Despite the small quantity, the average issue price was still high at 426.46. With a minimum size of 23, the average issue size was 924.3. The greatest observed return was 10.91%, and the average initial return from the issue closing day to the listing day was -0.48%.

For analysis, information from 9 businesses for the 2019–20 fiscal year was gathered. The price ranged from 37 to 880, with an average issue price of 455.18. The largest issue recorded had a size of 10354.8, with the average issue size being 1062.89. From the issue closing day to the listing day, the average initial return was 13.3%, with a maximum return of 53.9%.

Data for 29 companies were gathered in 2020–21, however only 27 were used in the research. From the lowest price of 26 to the maximum price of 1500, the issue prices covered a wide range. The average issue price was $476.28, and the minimum size was 61.2. The average issue size was 1062.89. Maximum closing price was 3118.65 times the issue price, with an average closing price of

595.38 times the issue price on the listed day. The maximum observed return was 130.67%, and the average initial return from the issue closing day to the listing day was -44.3%.

Table: 4 Initial returns of IPO companies from 2010 to 2014.

Financial Year	Total IPOs Listed	Initial Return on Share
2016-17	24	2.03
2017-18	42	-0.42
2018-19	13	-0.48
2019-20	11	13.3
2020-21	29	34.76

Hypothesis Testing

Ho1: There is no significant relationship between IPO performance and no. of IPOs listed.

The correlation coefficient between IPO performance (initial return) and the number of IPOs listed for each financial year is approximately -0.354. The p-value is approximately 0.472.

The correlation coefficient is -0.354, indicating slowly weak negative correlation between IPO performance (initial return) and the number of IPOs listed and the p-value is approximately 0.472. Usually common significance level is 0.05.

The p-value in this instance is 0.472, which is higher than 0.05. As a result, the null hypothesis is accepted because there is no connection between IPO performance and the quantity of listings.

CONCLUSION

A significant number of IPOs in the Indian capital market were underpriced during the period 2016- 2021. This indicates a trend of offering IPOs at lower prices than their market value, potentially attracting investors and resulting in initial positive returns. The sample selection process involved eliminating companies not listed on the exchange and identifying undervalued IPOs for analysis. This ensured that the analysis focused on IPOs with potential for positive performance. The average initial returns varied across different financial years, indicating the fluctuating performance of IPOs. While some years witnessed positive average returns, others experienced negative returns. These findings suggest the need for careful evaluation and analysis of IPOs before investment decisions.

According to the results of the hypothesis testing, there

is no connection between the quantity of IPOs listed and IPO performance, as determined by initial return. About -0.354 was the correlation coefficient between these variables, indicating a shaky inverse link.

REFERENCES

1. T. Ramesh Chandra Babu and Aron Ethan Charles Dsouza, "Post Listing IPO Returns and Performance in India: An Empirical Investigation, "Journal of Financial studies and research, Vol. 2021 (2021), Article ID 418441, 20 pages, ISSN: 2166-000X.
2. Jeelan Basha, Bhadrappa Haralayya and Nitesh Vibhute "A study on Performance Evaluation of Initial Public Offering" Journal of Advanced Research in Public Policy and Administration Volume 3, Issue 2 - 2021, Pg. No. 12-2 (2021)
3. Dr. A.S. Ambily, Gayatri Krishna, Aswathy K. and Deepa Balakrishna. "A study on performance of IPO's under NSE from issue price to last trading price in the year 2013-2015." Global Journal of Finance and Management. ISSN 0975-6477 Volume 8, Number (2016)
4. N. Vani, "An Analytical Study on the impact of IPO on Indian Economy," Journal of Emerging Technology and Innovative Research, Vol. 8 Issue 10, October 2021.
5. Khushboo Vora, "Evidence of Under-pricing and Impact of Initial Return Determinants – A case on Public Issue of Shares in Indian Capital Market," International Journal of Management and Social Science. Vol. 8 Issue 10, 2018.
6 Syed Imorozuddin, "A study on initial Public Offer-HDFC," Journal of Engineering Sciences, Vol.12, Issue 08, Aug/2021.
7. www.nseindia.com
8. www.sebi.com
9. www.moneycontrol.com

A Review on Dual Spiral Spring and Hydraulic Rotary Damper for Reduced Torsion Vibration

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ABSTRACT

A very significant and difficult issue in many industrial domains is the damping of torsional vibrations. One of the fundamental strategies to increase machine life is to protect against the damaging effects of vibrations. Rotating components that operate within a certain excitation frequency range near the structure's inherent frequency may resonate. Elimination of erratic excitation, decrease of background noise, and protection of personnel and property from potentially harmful vibrations are the goals of this technique. This phenomenon is continuous motivations for development of innovative damping methods.

Springs are parts of machines that are flexible and can put out forces or torques as well as store energy. Torsion springs take their loading torques from rotations about the spring's axis. Torsion springs include spiral springs, whose coils have no pitch and don't touch each other when the spring is in use. Devices resembling gears called rotary dampers are used to restrict the movement of moving machinery. (1) Rotary dampers reduce vibration, noise, and machine component wear by absorbing and slowing rotating motion. It allows objects to move smoothly and is employed in deployment applications in the aerospace, automobile, and agriculture industries.

The paper aims at a review of previous research work regarding the study of torsion vibrations, the study of spiral torsion springs and spiral flat springs, optimization methods, the study of hydraulic torsion dampers for vibration reduction in various fields of applications. (2).This study will help for unique new combined design of Dual spiral spring & torsional damper for extended life of equipment which are under continuous vibration and cause of failure of equipment.

KEYWORDS *: Torsional vibrations, Dual action flat spiral spring, hydraulic rotary damper*

INTRODUCTION

Background

Through the twisting of coils, transfer of power or storage of energy can be attained using the spiral springs, with the distinct advantages of weight reduction, effective space utilization, simplification of module structure, and efficient use of available space. (3) Conventionally, the spiral springs have been used in the unidirectional form, although certain applications demand that the energy storage be in the bidirectional form. Here, The flat spiral spring's design matters and thus the paper proposes the schematic and proposal of one such design of the flat spiral spring that shall find application for energy storage in either direction in pesticide sprayers. The spring design will pertain to the geometry and structural strength using the theoretical as well as the analytical approach, i.e., finite element analysis. (4)Rotary dampers are devices that are designed to absorb the vibration or motion energy of a moving part of equipment with the objective of slowing it down or stopping its motion in a certain direction. The main objective of the rotary damper is to reduce vibration, noise, and component wear. Rotary dampers are seen to be more compact and outlast the linear type shock absorbers, with the advantage of a smaller footprint, lower weight, and a smaller space requirement. A rotary speed damper slows machine components' rotating motion and controls mechanical device retraction. Rotary dampers find application in a variety of products like camcorders, DVD players, mobile phones, xerox machines, computers, videotape players, restroom seats, etc. which are cited as examples of the use of rotary dampers. Applications in space, like

the solar panels on satellites, are systems deployed by the aerospace industry. Reliability can be improved through the protection of delicate electronic components and the prevention of lid and access panel closure damage. The design and control of rotational machines can benefit from the rotational hydraulic damper. The study suggests the creation of an innovative hydraulic rotating damper with adjustable damping. It has the potential to reduce the oscillation-torsion vibrations in specific applications. The paper hints at the integration of the flat spiral spring with a rotary hydraulic damper to develop a device that will address the issue of bidirectional motion containment and energy absorption to minimize vibration and noise in machine parts.

Applications

Before the review of literature, an attempt is made to study the current use and application of devices developed for analogous applications and other potential applications of the developed hydraulic rotary damper.

Prosthetic knee magneto-rheological damper (Bio-Mechanical Field of application).

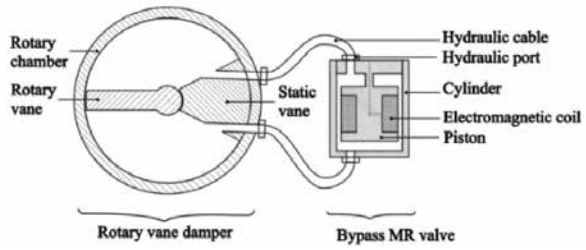

Figure 1. Rotary Vane MR Damper

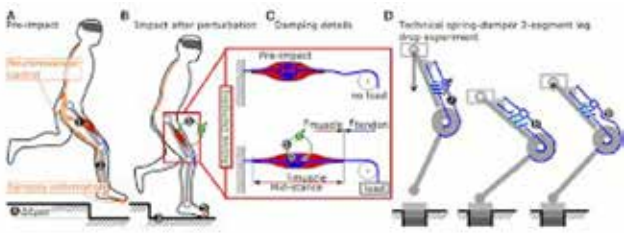

Figure 2.Wide Areas of Application

The device's limited range of motion makes it ideal for use in knee replacement prostheses.(5) When compared to the multi-plate magneto-rheological brake, this design might be better because it has a flow mode, a large clearance gap, and fewer design parts. This would make it easier to make. The manufacturing process and the component lifecycle should also be taken into account while thinking about the aforementioned concept. (6,7)

Disadvantage: Very high cost, high manufacturing set up cost.

Solution: The hybrid spiral spring hydraulic damper can replace these dampers in real-time applications

- Steering damper (Automotive Industry application)

Figure 3. Transverse linear motorcycle steering damper

Figure 4. Electronic steering damper with control arm attached to the upper triple clamp

A steering damper, also called a steering stabiliser, is a damping device that stops the steering mechanism from moving or oscillating in ways that aren't wanted or needed , a phenomenon known in motorcycle riding as "wobble." (8)(9)

The demand for improved ride quality and increased durability through control of movement in rail suspension applications for material handling Overall size and damping quality can be improved using a hybrid flat spring and hydraulic rotary damper. (10)

LITERATURE REVIEW

The literature review of spiral springs and hydraulic rotary dampers for reduced torsion vibration has been done in the following domains to study the previous research work in similar areas of application.

Damping of Torsion Vibrations

The authors conducted research on the torsional dampers used in wind turbines to reduce vibrations in the transmission system. To overcome the shortfall of manually re-tuning torsional dampers during wind turbine commissioning, a model-based torsional damper was devised and its performance compared to the traditional technique when exposed to model uncertainty. The authors used Simulink for their study and simulations. The findings of a real-time hardware-in-the-loop experiment corroborated those of a simulation. The novel innovation outperformed the standard BPF-based method in all tests. It was also shown that tuning processes often associated with BPF-based designs are unnecessary when using the model-based damper(11). Another design of a torsion spring with the goal of finding out how torsion springs behave locally under real load conditions. Finite element analysis (FEA) was used to examine the curves of non-uniform rational basis splines (NURBS).

Through a series of experiments, they were able to calculate the torsion-spring displacements and map them to coordinates that can be described with NURBS curves. The FEA findings were subsequently compared to the results obtained.(4)

In another reference, authors studied the synthesising of nonlinear spiral springs defined by the Archimedean spiral curve. Spring in-plane thickness interpolation independent design factors were optimized in the study. (1) The authors used the elastic theory in order to study the natural frequency and deformation of springs with circular cross-section. Initially, the study showed two mode shapes namely in-plane and out of plane. Experimentation was done on a custom-made spiral spring with a circular cross section. Results showed that theoretical deformation and natural frequencies were in close agreement with the theoretical values. The stiffness ratio affected spatial deformation and bifurcation. Vibration approach determined the crucial angle-stiffness ratio relationship. (12) In an additional review, the authors used CATIA to create a helical torsion spring model for structural analysis under static loading using finite element analysis with ANSYS-14 software. They compared the results to experimental work on the physical spring model and found a close match. (13)

One more research paper aimed to develop an expert system, i.e., a knowledge-based computer programme with inference procedures applicable while designing torsion springs, and reduce the efforts of the designer in the development of a new design with the use of an existing design based on parameters such as torque, material, active coils, and the required stiffness.(14) To demonstrate that the spring constant could be efficiently modified by changing the fibre volume and the reinforcing twists, the researchers built five distinct kinds of composite helical springs and subjected them to a quasi-static test. The spring constant may be predicted using data from both experiments and simulations, which were found to be in good agreement. (15)

Review of Spiral Flat Springs

In references of Spiral Spring Papers Proposal and optimization of exoskeleton joint train developed on power-based quasi-static model is researched in this study. Ball screw drive based linear actuator with double spiral spring for midwalker exoskeleton joint is studied , developed and tested in this paper. (16).Another reference paper discusses development of a mechanical elastic energy storage system using a flat spiral spring. Study was conducted using three structures and sizes of flat springs. The authors claim that the research results could provide basis for structural and dynamic analysis of flat spiral springs.(3).

The research on springs focuses on the development of spiral springs for use in the regenerative braking system for energy storage during braking and release back to the vehicle transmission. The authors carried out kinematic simulation of the system in three modes: braking, idle, and energy release. The authors claim that the application of the developed system will assist the driver during acceleration and improve the overall performance of the vehicle (17). The flexural spring's geometry was analysed in this research, designed for displacer vibratory operations in closed-cycle regenerative Stirling engines. Structural finite element calculations and durability test evaluations were used to refine the design to its optimal state. Simulations of design factors such as outer diameter, thickness, number of spirals, etc. were done. The test results were indicative that no fracture under operating conditions

was observed, which revealed the effectiveness of their design. (18)

For further reference in the paper, the authors study the spiral torsion spring produced using 3-D printing technology such that the external stresses operating on the spring coils are limited and the spring shape is meant to provide a reliable 3D-printed equivalent to standard steel springs that is really created. The research work discusses the optimization of spring parameters, and the results are put in terms of stiffness and equivalent von Mises stress. The authors propose the application of these springs in mini-manipulators and low-cost manipulators in robotics. (19) In their research, the authors study the large displacement behaviour of spiral springs and reflect on the parameters influencing the torsion stiffness of the spring. Other parameters such as the pre-stress, orthographic material orientation, and cross-section shape and their influences are also studied. This work is about studying how a spiral spring behaves when it has a large displacement.

The effects of changing the parameters that affect the local torsion stiffness of the spiral's beam are studied. (20) In their research study on the application of flat spiral springs, the authors saw the development of an assistive device for the knee joint while using heavy loads to prevent damage, and the device is to be worn at the hip and knee joints. to assist in lifting heavy objects. Researchers suggest the assistive gadget helped move large goods and prevented injury.(21) In an additional study, the authors, in their research, studied the ring wave spring. They made an analytical model for stamped ring wave springs. Because of the shape of the spring when it is not bent, the load- deflection curve was found to be appreciably bilinear. (22)

Optimization of Spring Design

The author states in his paper that the reduction in weight of the suspension springs leads to a decrease in the unsprung mass of the axle, which positively influences the comfort, traction, and steering properties of the car. The authors claim that Modern simulation and optimization methods are used to design spring elements in a way that works well and gives accurate results. (23) The authors found in their research on wave springs that they are seen to occupy an extremely small space after compressions. The study looks at the impact of changing the thickness of a wave spring on its deflection and operating stress. The impact of thickness change under various loading circumstances is investigated in this study. (24) Experimental approaches such as visual inspection, optical microscopy, and scanning electron microscopy were used to gather data for this study, which was then used to inform an analysis of stress according to stochastic variable dynamic loading performed with a finite element model for the coil spring. Authors used MATLAB to give predictions of spring fatigue life.(25) The authors, In their research on fatigue failure, which happens when loads are applied over and over until a crack starts. Due to the vast recorded data, they suggest fatigue evaluation in domain of random loadings. (26) The authors further worked on a design of the torsional and compressive springs of overall foldable wing mechanism employed in the missile and analysed it as an optimization issue with the objective of maximise the spring's energies and minimizing the wing's opening time. (27)

Additional to above details following are other refence papers where spiral spring and damper applications are used in various application fields, findings are summarized in Table 1.

Table 1

Reference Number	Application Focus	Summary Key Points
(28)	To reduce Manual efforts to lift the loads.	To boost the level of help and take use of human bioenergy during the two stages of the lifting activity, researchers developed the rotary series elastic actuator (ES-RSEA), which they recommended for use in a lumbar support exoskeleton. Details and experimental research are covered.

(29)	Elastic Actuators	The term of arc length of Archimedean spiral causes the huge disparities between anticipated stiffness and FEA stiffness of spiral spring arms. The theoretical stiffness is likewise inaccurate compared to the planar spiral spring's real stiffness. The improved equation improves planar spiral spring design productivity and reduces design iterations.
(30)	Spring durability Analysis	Deformation and stress responses were examined using static linear analysis on the 3D helical coil spring model. Spring dynamics and performance are examined at practical frequency. Range. Vehicle suspension spring fatigue life estimate and automotive sector reliability improvement techniques were done.
(31)	Dampening with elastomer particles ,Torque Analysis	Rotary elastomer particle damper prototypes were tested with and without a shaft-to-cylinder gap. Experiments exhibit The rotary damper with a gap between the rotor and cylinder has a higher damper torque at any rpm when using 5 mm elastomer particles. Elastomer particles are quieter than metallic particles.
(8)	Hydraulic rotational damper	An innovative a variable-damping-coefficient hydraulic-rotating damper is presented in this research. Referred damper's damping coefficient model was developed using dynamic analysis. Numerous numerical simulations verify how different variables affect the damping coefficient. In most circumstances, frictional resistances have negligible impact on the damping coefficient.
(32)	Spring assist effect on walking	Researchers contrasted the amount of net metabolic effort required for walking when the exoskeleton simply resisted extending the knee at the final stage of the legs swing phase versus when the elastic energy saved during knee extension was released to help ankles plantarflexion at the final moment of the phase of stance before toe-off. They found that respondents' average net metabolic power dropped by 11% when using the exoskeleton with energy conserved from extending the knee and released for ankle plantarflexion.
(33)	Torsional flat spiral spring	This research proposes a torsional flat spring (TFS) for the human ankle series elastic muscle-tendon actuator system (HA-SEMTAS) to increase compliance and deformation. Torsional flat spiral springs generate torque in one direction, hence the proposed torsional flat spring uses two in opposite orientations. Experimental results show that the proposed controller and compliant actuation system track human upright posture behaviour well and improve system stability.
(34)	Viscous Damping	Experimental Simulations suggest an adjustable and viscous damper. We assessed energy dissipated in hardware and examined effective viscous damping and adjustability. Both a standard hydraulic damper and a custom pneumatic one were put through their paces on legs. Adjustable aperture rolling diaphragm reduces Coulomb damping and allows changeable resistance in the pneumatic damper. The testing results show that the hydraulic leg mounted damper has the best viscous damping.

(35)	Coil Spring	This work improves hatchback suspension automobiles' helical coil springs by changing spring settings. The hefty springs and loads cause the car to drift to one side of the road. Redesigning and optimizing avoids such issues. To determine the best coil spring material, various materials are compared. DOE suggests ASTM A-228, A-231, and A-401 outperformed hatchback material Over grade A-227.
(36)	Torsional damper	This study introduces a controlled granular damper. VPPs power the prototype. Granular materials are encapsulated in soft, hermetic frameworks. The structure becomes a nonclassical solid body after generating a partial vacuum. VPP global mechanical properties depend on internal under pressure. As internal under pressure changes, the adjustable torsional damper prototype dissipates. Presenting the device's design. Discussing basic lab testing. Modified Bouc–Wen rheological model describes device hysteresis. Initial model formulation includes nonlinear under pressure functions. The Bouc–Wen model captured the VPP torsional damper prototype's true reaction.
(37)	Torsional vibration dampers	Silicone oil-based visco-dampers work well for torsional vibration damping. Temperature most affects silicone oil, a non-Newtonian fluid. Analytically, damper thermal control is problematic owing to construction complexity and absence of thermal monitoring equipment. Numerical approaches are needed for product design and development to estimate the temperature field for lifespan estimation. MATLAB's 2D thermal simulation tool exposes hidden heat transfer mechanisms between damper components and approximates the structure's temperature distribution with specific attention to silicone oil. A finite-difference-method thermal calculation model calculates silicone oil temperature distribution in a 2D simplified visco-damper geometry.
(38)	Spring Coil Dampers	This research calculates the ideal coil over spring stiffness for the commercial light motor vehicle so that system design can begin. To enhance vehicle performance, driver safety, and comfort, spring stiffness was determined iteratively. Through ride frequencies and roll gradient, the spring stiffness is computed. If not, repeat until roll gradient is obtained.

LITERATURE GAP

The careful literature review of the spiral springs revealed that the spiral springs offer the advantages of absorbing a considerable amount of torsion energy and being compact in size. Although it was found that the majority of the springs are manufactured from wire and flat spiral spring designs are weak, Secondly, most of the spiral springs show ability to absorb energy during one direction of rotation, whereas in the application under consideration, they need energy absorption in both directions. A double spiral spring stands out as an ideal solution for the said problem, as revealed from the literature review. Secondly, the literature review of hydraulic rotary dampers revealed their potential in damping torsion vibration; also, magnetorheological dampers were found to have applications in automotive and biomechanical fields. With the aid of the hydraulic, magneto- rheological rotary dampers, the torsion vibrations can be easily damped, as revealed from the literature review, although the combination of the spiral

spring and the dampers is rarely seen in the review.

Spiral springs and rotary dampers in combination can reduce torsion vibration and absorb torsion energy through new combinations of design and development as per different applications.

Limitations of Study

The study should be limited to moderate-torque implements and not heavy applications such as wind turbines, aerospace, etc.

CONCLUSION

The spiral springs find application in several sectors like the automotive industry, aerospace, agriculture, and bio-medical sector. Although flat springs that are effective in both directions of application are not frequently researched, there is a need in several applications to store energy in both directions of operation, and rotary dampers that can dissipate this energy are equally needed. The paper reviews earlier research in the fields of torsion vibrations, spiral springs and flat spiral springs, rotary dampers, and optimization of springs. Paper Proposes In a new application area, in order to dissipate energy and dampen vibrations, the article suggests designing a spiral spring that operates effectively in either direction and can also be combined with a rotary damper.

REFERENCES

1. Ahmed A, Zhou H. Synthesis of Nonlinear Spiral Torsion Springs. Int J Eng Res. 2014;3(6):6.
2. Shendge MYB, Kamble DP. Automotive suspension with variable damping system A review. Int Res J Eng Technol [Internet]. 2016;919–23. Available from: www.irjet.net
3. Tang J, Wang Z, Mi Z, Yu Y. Finite element analysis of flat spiral spring on mechanical elastic energy storage technology. Res J Appl Sci Eng Technol. 2014;7(5):993–1000.
4. Kim YS, Song YJ, Jeon ES. Numerical and experimental analysis of torsion springs using NURBS curves. Appl Sci. 2020;10(7).
5. Saini RST, Chandramohan S, Sujatha S, Kumar H. Design of bypass rotary vane magnetorheological damper for prosthetic knee application. J Intell Mater Syst Struct. 2021;32(9):931–42.
6. Lokhande AD. Recycling Process Impact in Current Scenario Manufacturing A Study. REST J Emerg trends Model Manuf. 2021;2(1):1–7.
7. Amol L, Venkateswaran C, Ramachandran M, Chinnasami S, Vennila T. A Review on Various Implications on Re engineering in Manufacturing. REST J Emerg trends Model Manuf. 2021;7(3):70–5.
8. Zhao H, Wang B, Chen G. Numerical study on a rotational hydraulic damper with variable damping coefficient. Sci Rep [Internet]. 2021;11(1):1–16. Available from: https://doi.org/10.1038/s41598-021-01859-2
9. Jae-Hoon Lee, Changwan Han, Dongsu Ahn, Jin Kyoo Lee, Sang-Hu Park, Park S. Design and Performance Evaluation of a Rotary Magnetorheological Damper for Unmanned Vehicle Suspension Systems. Sci World J. 2013;2013:10.
10. Manashkin L, Myamlin S, Prikhodko V. Oscillation Dampers and Shock Absorbers in Railway Vehicles (Mathematical Models). Oscil Dampers Shock Absorbers Railw Veh (Mathematical Model. 2007;
11. Licari J, Ugalde-Loo CE, Ekanayake JB, Jenkins N. Damping of torsional vibrations in a variable-speed wind turbine. IEEE Trans Energy Convers. 2013;28(1):172–80.
12. Chen JS, Chen IS. Deformation and vibration of a spiral spring. Int J Solids Struct [Internet]. 2015;64:166–75. Available from: http://dx.doi.org/10.1016/j.ijsolstr.2015.03.022
13. Adam P V, Sagalgile AK, Phule MM, Patil DR. " Design , Analysis and Testing of Torsion Spring as an Independent Suspension Unit ." 2019;16(1):53–7.
14. Waghmare SN. Expert System for Helical Torsion Spring Design. 2019;XI(1547):1547–54.
15. Wu L, Chen L, Fu H, Jiang Q, Wu X, Tang Y. Carbon fiber composite multistrand helical springs with adjustable spring constant: Design and mechanism studies. J Mater Res Technol [Internet]. 2020;9(3):5067–76. Available from: https://doi.org/10.1016/j.jmrt.2020.03.024
16. Wang S, Meijneke C, Van Der Kooij H. Modeling, design, and optimization of Mindwalker series elastic joint. IEEE Int Conf Rehabil Robot. 2013;(November 2014).
17. Raj A. Novel Design of Flat Spiral Spring based Regenerative Braking System. Indian J Sci Technol. 2017;10(36):1–7.

18. Lee CW, Kim DJ, Kim SK, Sim KH. Design optimization of flexure springs for free-piston stirling engines and experimental evaluations with fatigue testing. Energies. 2021;14(16).

19. Guo S, Yang L, Yuan Y, Zhang Z, Cao X. Elastic energy storage technology using spiral spring devices and its applications: A review. Energy Built Environ. 2022;(June).

20. Radaelli G, Erder JL. Study on the large-displacement behaviour of a spiral spring with variations of cross-section, orthotropy and prestress. Mech Sci. 2018;9(2):337–48.

21. Terada H, Makino K, Ishida K, Ichikawa M. Development of an assistive instrument for lifting motion using driving springs. J Adv Mech Des Syst Manuf. 2017;11(3):1–12.

22. Patel C, Yadav Y. A Review on the comparison of Helical and Wave springs. Int Res J Eng Technol. 2008;

23. Kobelev V. Principles of design optimization for springs. 2021;

24. Tekwani HC, Joshi DD. Effect of Load variation and thickness on deflection and operating stress of wave spring. Int J Trend Sci Res Dev. 2018;Volume-2(Issue-4):684–9.

25. Pastorcic D, Vukelic G, Bozic Z. Coil spring failure and fatigue analysis. Eng Fail Anal. 2019;99(February):310–8.

26. Kong YS, Abdullah S, Schramm D, Omar MZ, Haris SM. Vibration fatigue analysis of carbon steel coil spring under various road excitations. Metals (Basel). 2018;8(8):1–22.

27. Kulunk Z, License RF. Optimization of Spring Parameters by Using the Bees Algorithm for the Foldable Wing Mechanism. 2022;1–17.

28. Al-Dahiree OS, Ghazilla RAR, Tokhi MO, Yap HJ, Albaadani EA. Design of a Compact Energy Storage with Rotary Series Elastic Actuator for Lumbar Support Exoskeleton. Machines. 2022;10(7):584.

29. Liu J, Abu Osman NA, Al Kouzbary M, Al Kouzbary H, Abd Razak NA, Shasmin HN, et al. Stiffness estimation of planar spiral spring based on Gaussian process regression. Sci Rep [Internet]. 2022;12(1):1–15. Available from: https://doi.org/10.1038/s41598-022-15421-1

30. Kumar D. Durability Analysis of Helical Coil Spring in Vehicle Suspension Systems. 2021;

31. Rakhio A, Ido Y, Iwamoto Y, Toyouchi A. Experimental and Numerical Analysis of Torque Properties of Rotary Elastomer Particle Damper considering the Effect of Gap and No Gap between Rotor and Body of the Damper. Shock Vib. 2021;2021.

32. Etenzi E, Borzuola R, Grabowski AM. Passive-elastic knee-ankle exoskeleton reduces the metabolic cost of walking. J Neuroeng Rehabil. 2020;17(1):1–15.

33. Fotuhi MJ, Yılmaz O, Bingul Z. Human postural ankle torque control model during standing posture with a series elastic muscle-tendon actuator. SN Appl Sci [Internet]. 2020;2(2):1–8. Available from: https://doi.org/10.1007/s42452-020-1955-5

34. Mo A, Izzi F, Haeufle DFB, Badri-Spröwitz A. Effective Viscous Damping Enables Morphological Computation in Legged Locomotion. Front Robot AI. 2020;7.

35. Muni D. Optimization of Coil Spring using Design of Experiments (DOE). Int J Res Appl Sci Eng Technol. 2020;8(9):821–6.

36. Rodak D, Zalewski R. Innovative controllable torsional damper based on vacuum packed particles. Materials (Basel). 2020;13(19):1–19.

37. Venczel M, Veress Á. Model development with verification for thermal analysis of torsional vibration dampers. AIP Conf Proc. 2020;2293(November 2020).

38. Yogesh Kumar MT. Selection of Spring For Spring Coil Dampers Using An Iterative Approach. Int J Sci Adv Res Technol [Internet]. 2020;6(5):4. Available from: http://ijsart.com/Home/IssueDetail/37706

Effect of Mixing of Different Lengths Randomly Oriented Discontinuous E- Glass Fiber on Mechanical Properties of Polymer Composite Sheet Moulding Compound

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ABSTRACT

This study investigates the mechanical properties of Polymer Matrix Composite material. The main focus of this research work was to fabricate polymer composite material by mixing different lengths of randomly oriented discontinuous E-glass fiber. The discontinuous fiber of ½" (inch) in length and 1" (inch) in length was used for this study. The discontinuous glass fiber was mixed in the proportions of 50 % - 50 % by weight. The matrix material polyester resin was used as the major constituent of 70 % and the remaining reinforcement of 30% discontinuous glass fiber by weight. The methodology used for the fabrication of composite material was the Hand Lay-up method. The mechanical characterization of the composite material was done by using Tensile Test and Flexural Test. The characterization of samples was conducted as per the ASTM standard. The experimental result analysis shows that mixing different discontinuous fiber lengths would lead to improved mechanical properties. This may be due to the formation of strong bonding between the matrix material and different lengths discontinuous fiber during the processing of composite material.

KEYWORDS *: Polymer composite, Sheet moulding compound (SMC), Mechanical properties, Glass fiber*

INTRODUCTION

In the recent development of material technology, composite materials have gained the attention of researchers due to their superior material properties. The composite material is very light in weight, has corrosion resistance, and has a high strength-to-weight ratio. Due to its versatile application composite material fully entered in the automotive application for its various large number of parts [1]. The polymer matrix composite SMC with the glass fiber reinforcement consists of thermosetting unsaturated polyester resin and other processing material. The glass fiber with different lengths from ½" (inch) to 2" (inch) used in the SMC composite material. One of the interesting material properties of SMC composite is that we can be designed and developed the material as per the required application for its use. Such as material properties like insulating, flame retardant properties, mechanical properties, chemical properties, etc. This makes SMC composite the most demanding material in the automotive industry nowadays [2]. The major advantage of composite is manufacturing SMC at the high volume of productions to satisfy the need for SMC-based products by using the different types of reinforcement in the SMC. Carbon fiber, and glass fiber with various proportions of reinforcement material to meet the required demand of material. Hence manufacturing process needs to be more advanced to manufacture low-cost SMC composite in the coming future [3]. This research work focuses on such low-cost SMC composite by varying reinforcement material of different lengths to improve the mechanical properties of composite material.

METHODOLOGY

Materials: The major constituents of matrix material is unsaturated polyester resin, filler material lime stone powder, mould removal agent zinc stearates all together used as matrix materials. The reinforcement material E-glass fiber is used. The glass fiber of length ½" (inch) and 1" (inch) were selected for this research work. The ½" (inch) and 1" (inch) lengths of glass fiber mixed in the proportion of 50 % - 50 % by weight respectively.

Characterization of Materials

The characterization of glass fiber was done by using a Scanning Electron Microscope at COEP, Pune. The glass fiber diameter value was observed 14.21 µm. The SEM analysis of E- glass discontinuous fiber of length ½" (inch) is presented in Figure 1.

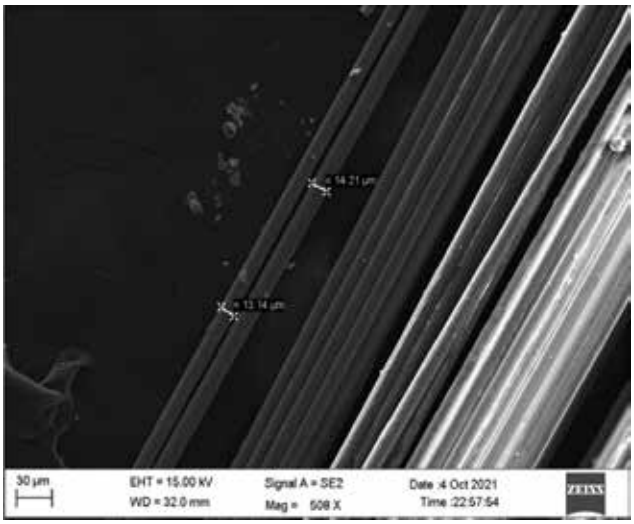

Fig. 1. Diameter of ½" (inch) length of E-glass fiber

The characterization of the matrix material and their observed value is presented in Table 1

Table 1. Characterization of E-Glass fiber and raw materials

Sr. No.	Constituent(s)	Parameter Measured (Unit)	Quantity (gm)	Specified Range	Observed Value	Equipment
01	Filler material lime stone powder	Moisture Content (%)	1.40	0.20 max	0.16	Karl Fischer Moisture Analyzer
02	Unsaturated Polyester Resin	Moisture Content (%)	1.85	0.05 to 0.10	0.066	Karl Fischer Moisture Analyzer
03	Polyester Resin	Viscosity (cP)	200	1100 ± 100	1130	Brookfield Viscometer
04	Glass fiber	No. of Ends	Glass Fiber Roving	60±10	64	Visual Inspection

Fabrication Method of SMC

The Fabrication method used for this research work is the hand lay-up method. This method is used in the laboratory at initial level experiments. The selected raw material of the matrix was put together to form a mixture of matrix material. The matrix material was mixed using a mechanical shear mixture of around 750 to 800 rpm. The main function of a mechanical shear mixture is to produce a homogeneous mixture of matrix material. While mixing the material the temperature of the material should be kept low to avoid the evaporation of constituents of matrix material. The viscosity of the matrix material is an important factor while the preparation of the matrix material. At most care had been taken during the preparation of matrix material.

Preparation of Composite

The polymer composite material by using a sheet moulding compound prepared by using the Hand Lay-up method [4]. The mold was prepared of size 500 mm x 300 mm for this experiment. Firstly, the Teflon sheet was put over the mold on the lower side and upper sides of the mold. After that, put matrix material at the bottom side and top side of the mold over the Teflon sheet. Secondly, put the randomly oriented discontinuous mixture of glass fiber having lengths ½" (inch) and 1" (inch) together uniformly over the matrix material. Finally, put the matrix material again over the glass fiber. Apply the uniform pressure at 2 bar over the SMC sheet to ensure the removal of entrapped air from the composite material. While preparation of the composite also ensured the wetting of glass fiber between the bottom layer of matrix material and the top layer of the matrix material. This was done to get uniformity and strong bonding between matrix materials. The Hand Lay-up bed used for this experimentation is presented in Figure 2.

Preparation of Specimens

The specimen was prepared by using a compression moulding machine of capacity 100 Ton. The charge is prepared from the composite SMC sheet and put into the mold of the compression molding machine. The period for the curing of the specimen in the compression molding machine was kept constant for 7 minutes. All

the experimentations were carried out as per the DOE and the specimen was prepared accordingly.

a) Layer of glass fiber

b) Top layer of matrix material

Figure 2. Hand Lay-up bed set up of SMC composite fabrication

Characterization of Mechanical properties

The mechanical testing of composite material was carried out using the Universal Testing Machine. The capacity of the testing machine was 100 KN. The specimen was tested for tensile strength test and flexural strength test. The molded specimen from the compression molding machine was tested for tensile strength test as per (ASTM D 638-14 Type I) standard [5]. The sample for the flexural strength test is according to (ASTM D 790-03) standard [6].

RESULT AND DISCUSSION

Tensile Strength Test

The tensile strength test for the randomly oriented discontinuous fiber of length ½" (inch) was carried out separately. The tensile strength for the randomly oriented discontinuous fiber of mix length ½" and 1" inch was carried out separately for the same volume of glass fiber reinforcement i.e. 30 %. The average value for the ½" inch length of glass fiber for tensile strength test was 82.075 N/mm2. The average value for the randomly oriented discontinuous fiber of mix length of ½" and 1" inch for the tensile strength observed 89.6 N/mm2. It was revealed from the analysis of the tensile test for the mixture of randomly oriented discontinuous fiber of different lengths enhance by 8-10 %. This may be due to the strong bonding between the matrix material and a mixture of different lengths of glass fiber. The analysis of the tensile strength test is presented in Figure 3.

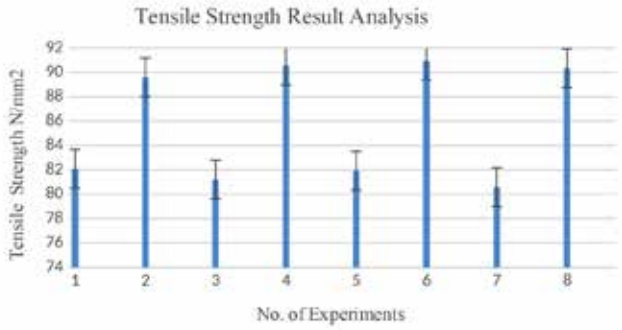

Figure 3. Analysis of Tensile Strength Test

Flexural Strength Test

The flexural strength test was carried out for ½" (inch) length of randomly oriented discontinuous fiber separately. The flexural strength test for the mixture

of different lengths of randomly oriented glass fiber 1/2" (inch) and 1" (inch) was carried out separately. The average value for the flexural strength test 164.72 N/mm2. The value for the mix length of randomly oriented glass fiber 173.87 N/mm2 observed. From the experimental analysis, it was found that 8 - 9 % of improvement in the flexural strength of composite material. This could be, during the processing of composite material short fiber of ½" inch and 1" (inch) form a strong bond together with the matrix material tends to fill the gap inside the material during the processing. The analysis of the flexural strength test is presented in Figure 4.

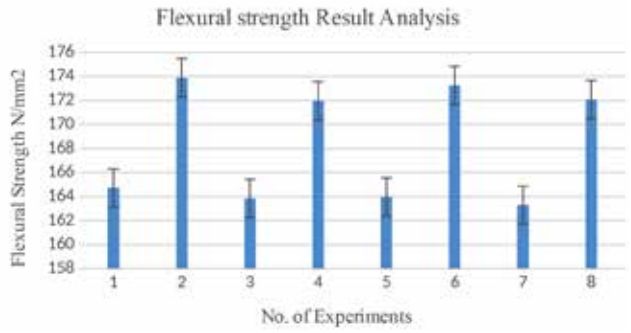

Figure 4. Analysis of Flexural Strength Test

RERERENCES

1. V. Romanenko, M. Duhovic, D. Schommer, J. Hausmann, J. Eschl et. al, "Advanced process simulation of compression molded carbon fiber sheet molding compound (C-SMC) parts in automotive series applications," Composites Part A: Applied Science and Manufacturing, Volume 157, June 2022. doi.org/10.1016/j.compositesa.2022.106924

2. Florian Gortner, Anja Schüffler, Jochen Fischer-Schuch, Peter Mitschang et. al, "Use of bio-based and renewable materials for sheet molding compounds (SMC) – Mechanical properties and susceptibility to fungal decay," Composites Part C: Open Access, Volume 7, March 2022. doi.org/10.1016/j.jcomc.2022.100242

3. Sanzida Sultana, Amir Asadi, Jonathan Colton, Kyriaki Kalaitzidou et. al, "Composites made from CF prepreg trim waste tapes using sheet molding compounds (SMC) technology: Challenges and potential," Composites Part A: Applied Science and Manufacturing, Volume 134, July 2020. doi.org/10.1016/j.compositesa.2020.105906

4. Meenakshi CM, Krishnamoorthy A., "Preparation and mechanical characterization of flax and glass fiber reinforced polyester hybrid composite laminate by hand lay-up method." Mater. Today Proc. 5(13): 26934–26940. 2018 doi.org/10.1016/j.matpr.2018.08.181

5 American Society for Testing and Materials (ASTM D 638-14 Type I) Standard Test Method for Tensile Properties of Plastics.

6 American Society for Testing and Materials (ASTM D 790-03) Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

Estimation of Fused Deposition Modelling Process Parameters for Optimum Output

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ABSTRACT

In the present work optimization of rapid prototyping parameter is performed by employing Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). Based on full factorial method study is planned and conducted. Study were accomplished by varying build orientation and layer thickness. In this study, requirement of model material, support material, time and volumetric error are noted during study. Optimal rapid prototyping parameters are orientation along X and Y axis 00 or 900 or 1800 and layer thickness 0.01 inch for which requirement of model material, requirement of support material, requirement of time for printing and percentage volumetric error are 2.69 cubic inch, 1.31 cubic inch, 6.00 cubic inch and 0.25% resp.

INTRODUCTION

The industrial revolution is a global and the most significant development in humankind s history in the course of recent hundreds of years. The phenomenon focused on new technologies. A massive set of changes with radical advancements in technology extensively introduced in crucial manufacturing sectors [1]. One of the such technique developed is Rapid Prototyping Technique (RPT). Additive Manufacturing (AM) interconnected the CAD model to the final solid product and removed all the steps, tool and procedure as used in conventional manufacturing, making it most suitable for Rapid Prototyping (RP)[2]–[5]. The development of rapid prototyping opens new doors of possibilities which make it suitable in any sector of application whether it is engineering or medical. RP gives not the only advantage of time and cost, but also the freedom to design objects without manufacturing constraints which are difficult to manufacture through conventional manufacturing process [6]–[10]. Another plus rapid prototyping technologies is the ability to manufacture complete functional assembly as one [11]. Rapid prototyping technique is an ideal option for the mass customization since it removes the tooling components of conventional manufacturing [12].

The main disadvantage of this technique is its high operating cost [13]. Also, the use of rapid prototyping technique is increasing day by day. So, the need is to optimize the cost effective parameters of this technique. From the literature review it has been found that the model material, support material and time requirement are main cost effective parameters[14], [15]. The primary goals of this research are to optimize the material requirement for rapid prototyping, time and error to boost overall productivity; and to improve the quality of product for rapid prototyping by controlling the its parameter

EXPERIMENTAL DETAILS

Related to rapid prototyping are the sets of independent variables that have been recognized as having the potential to have an impact on the study phenomena of the rapid prototyping process. Related to Build orientation (orientation along x and y axis), related to layer thickness. The first thing that was done was to record all of the parameters that remained the same throughout the trial. For the rapid prototyping, the purpose of the field experiment was to record the requirement of model and support material, build time, and percentage volumetric error of the output Material. The basic configuration matrix shown in Table 1 displays the 162 standard-order

experimental conditions and the related thresholds at which each of the three parameters should be kept stable throughout the study. Table 1 presents the various levels of independent parameters that were carefully selected to comprehensively investigate their impact on the final product during the fabrication process. By systematically varying the levels of the independent parameters, the research aimed to identify the optimal combination of these parameters that would minimize the percentage of volumetric error and ensure high-quality fabrication. Machining details and experimental matrix with responses are shown in Table 2 respectively

Table 1: Process Parameters with limits

Parameters	Factors								
	I	II	III	IV	V	VI	VII	VIII	IX
Orientation along x axis	0	22.5	45	67.5	90	112.5	135	157.5	180
Orientation along y axis	0	22.5	45	67.5	90	112.5	135	157.5	180
Layer Thickness	0.007	0.01	-	-	-	-	-	-	-

Multi-Criteria Decision Making (MCDM) methods

Multi criterion decision making methods (MCDM) are frequently used in engineering design and manufacturing to select the best solution from a finite multitude of alternatives. MCDM techniques can assist decision makers in reaching an effective agreement with such a scenario and making appropriate design selections to generate an optimal design. As there are several extant MCDM approaches, selecting the most appropriate methods is essential, because the use of inappropriate methods is frequently the source of inaccurate decision making. Nonetheless, the collection of MCDM techniques is a complicated MCDM challenge that must be properly carried out [16]. TOPSIS is an MCDM technique for dealing with numerous criteria. The idea behind this technique is to select the ideal alternatives with the smallest distance from the positive solution and the greatest distance from the negative solution [17]. These hypothetical solutions correlate to the database's maximum and minimum attribute values that compose acceptable solutions [18], [19]. To find the optimal solutions, the nearest hypothetical best and furthest hypothetical worst are utilised. TOPSIS quickly analyses the tangible qualities as well as the quantity of options. TOPSIS uses the following steps to choose the right solution[20]–[22].

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) was developed by Hwang and Yoon based on the concept that the chosen parameter should have the shortest distance from the best solution and the longest distance from the worst solution [23]. In this study, the response variables are requirement of model material, support material, time and percentage volumetric error for all five bodies. For the sample calculation purpose, the following data has been given of valveseat. The experimental observations of these responses are shown in Table 2. Normalized and weighted normalized values are shown in Table 3. Positive ideal, Negative ideal solutions, separation measures, closeness coefficient values, and rank are depicted in Table 5. The normalized value (ri) is obtained using the equation (1).

$$r_i = \frac{X_i}{\sqrt{\sum_{i=1}^{m} X_i^2}} \qquad (1)$$

Where i = 1,2,3,……162

By multiplying the normalized value with related weights the weighted normalized value (vij) is calculated and is shown in equation (2),

$$V_i = W_i \times r_i \qquad (2)$$

Where i = 1,2,3,… 162

Then the positive ideal solution (S+) and negative ideal solution (S-) calculated using equation (3),

$$S^{+¿}=\left\{\left(Max\left(V_i\right)\right),\left(Min\left(V_i\right)\right)\vee i=1,2,3,\ldots\ldots 162\right\}¿$$

$$S^{-¿}=\left\{\left(Min\left(V_i\right)\right),\left(Max\left(V_i\right)\right)\vee i=1,2,3,\ldots\ldots 162\right\}¿ \quad (3)$$

The separation of each alternative from positive ideal solution (S+) and negative ideal solution (S-) is found as per equation (4) and equation (5),

$$D_i^{+¿}=\sqrt{\sum_{i=1}^{162} ¿¿¿¿} \quad (4)$$

$$D_i^{-¿}=\sqrt{\sum_{i=1}^{162} ¿¿¿¿} \quad (5)$$

The closeness coefficient value of each alternative (Ci) is calculated using equation (6),

$$C_i=\frac{D_i^{-¿}}{D_i^{+¿}+D_i^{-¿}}¿ \quad (6)$$

Table 2. The experimental observations of the responses

Sr. No.	Ox	Oy	LT	MM	SM	Time	% Vol Error	Sr. No.	Ox	Oy	LT	MM	SM	Time	% Vol Error
1	0	0	0.007	2.60	1.28	6.12	0.252	82	0	0	0.01	2.68	1.32	6.00	0.249
2	0	22.5	0.007	2.88	1.59	8.25	0.441	83	0	22.5	0.01	2.96	1.63	8.09	0.436
3	0	45	0.007	3.14	1.93	10.50	0.749	84	0	45	0.01	3.23	1.99	10.30	0.742
4	0	67.5	0.007	2.92	1.72	8.69	0.479	85	0	67.5	0.01	3.01	1.78	8.52	0.474
5	0	90	0.007	2.64	1.37	6.83	0.269	86	0	90	0.01	2.72	1.41	6.70	0.266
6	0	112.5	0.007	2.96	1.80	9.01	0.512	87	0	112.5	0.01	3.05	1.85	8.84	0.507
7	0	135	0.007	3.17	1.99	11.15	0.779	88	0	135	0.01	3.26	2.05	10.94	0.771
8	0	157.5	0.007	3.00	1.84	9.44	0.544	89	0	157.5	0.01	3.09	1.89	9.26	0.538
9	0	180	0.007	2.77	1.42	7.43	0.298	90	0	180	0.01	2.85	1.46	7.28	0.295
10	22.5	0	0.007	2.83	1.56	8.02	0.428	91	22.5	0	0.01	2.92	1.60	7.89	0.425
11	22.5	22.5	0.007	3.14	1.93	10.81	0.749	92	22.5	22.5	0.01	3.24	1.98	10.63	0.743
12	22.5	45	0.007	3.42	2.36	13.76	1.274	93	22.5	45	0.01	3.53	2.41	13.53	1.264
13	22.5	67.5	0.007	3.18	2.10	11.38	0.814	94	22.5	67.5	0.01	3.29	2.15	11.20	0.807
14	22.5	90	0.007	2.88	1.67	8.95	0.457	95	22.5	90	0.01	2.97	1.71	8.80	0.453
15	22.5	112.5	0.007	3.22	2.19	11.81	0.871	96	22.5	112.5	0.01	3.33	2.24	11.62	0.864
16	22.5	135	0.00	3.45	2.42	14.6	1.324	97	22.5	135	0.0	3.56	2.4	14.3	1.313

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17	22.5	157.5	0.007	3.27	2.24	12.36	0.924	98	22.5	157.5	0.01	3.37	2.29	12.16	0.917
18	22.5	180	0.007	3.01	1.73	9.73	0.506	99	22.5	180	0.01	3.11	1.76	9.57	0.502
19	45	0	0.007	3.09	1.91	10.50	0.728	100	45	0	0.01	3.19	1.97	10.31	0.722
20	45	22.5	0.007	3.42	2.36	14.16	1.274	101	45	22.5	0.01	3.53	2.44	13.90	1.263
21	45	45	0.007	3.73	2.88	18.02	2.166	102	45	45	0.01	3.85	2.98	17.69	2.146
22	45	67.5	0.007	3.47	2.57	14.91	1.383	103	45	67.5	0.01	3.58	2.66	14.64	1.371
23	45	90	0.007	3.14	2.04	11.72	0.777	104	45	90	0.01	3.24	2.11	11.51	0.770
24	45	112.5	0.007	3.51	2.67	15.47	1.481	105	45	112.5	0.01	3.63	2.77	15.19	1.468
25	45	135	0.007	3.76	2.96	19.14	2.250	106	45	135	0.01	3.89	3.06	18.80	2.230
26	45	157.5	0.007	3.56	2.73	16.19	1.571	107	45	157.5	0.01	3.68	2.83	15.90	1.557
27	45	180	0.007	3.29	2.11	12.74	0.861	108	45	180	0.01	3.39	2.18	12.51	0.853
28	67.5	0	0.007	2.83	1.56	8.02	0.428	109	67.5	0	0.01	2.93	1.61	7.86	0.422
29	67.5	22.5	0.007	3.14	1.93	10.81	0.749	110	67.5	22.5	0.01	3.24	1.99	10.59	0.738
30	67.5	45	0.007	3.42	2.36	13.76	1.274	111	67.5	45	0.01	3.53	2.43	13.48	1.255
31	67.5	67.5	0.007	3.18	2.10	11.38	0.814	112	67.5	67.5	0.01	3.29	2.17	11.16	0.801
32	67.5	90	0.007	2.88	1.67	8.95	0.457	113	67.5	90	0.01	2.97	1.72	8.77	0.450
33	67.5	112.5	0.007	3.22	2.19	11.81	0.871	114	67.5	112.5	0.01	3.33	2.26	11.57	0.858
34	67.5	135	0.007	3.45	2.42	14.61	1.324	115	67.5	135	0.01	3.57	2.50	14.32	1.304
35	67.5	157.5	0.007	3.27	2.24	12.36	0.924	116	67.5	157.5	0.01	3.38	2.31	12.11	0.910
36	67.5	180	0.007	3.01	1.73	9.73	0.506	117	67.5	180	0.01	3.12	1.78	9.53	0.499
37	90	0	0.007	2.60	1.28	6.12	0.252	118	90	0	0.01	2.67	1.32	6.03	0.249
38	90	22.5	0.007	2.88	1.59	8.25	0.441	119	90	22.5	0.01	2.95	1.63	8.13	0.436
39	90	45	0.007	3.14	1.93	10.50	0.749	120	90	45	0.01	3.21	1.99	10.34	0.740
40	90	67.5	0.007	2.92	1.72	8.69	0.479	121	90	67.5	0.01	2.99	1.78	8.56	0.473
41	90	90	0.007	2.64	1.37	6.83	0.269	122	90	90	0.01	2.70	1.41	6.73	0.266
42	90	112.5	0.007	2.96	1.80	9.01	0.512	123	90	112.5	0.01	3.03	1.85	8.88	0.506
43	90	135	0.007	3.17	1.99	11.15	0.779	124	90	135	0.01	3.25	2.05	10.99	0.769
44	90	157.5	0.007	3.00	1.84	9.44	0.544	125	90	157.5	0.01	3.07	1.89	9.29	0.537
45	90	180	0.007	2.77	1.42	7.43	0.298	126	90	180	0.01	2.83	1.46	7.31	0.294
46	112.5	0	0.007	2.83	1.56	8.02	0.428	127	112.5	0	0.01	2.91	1.61	7.92	0.425

47	112.5	22.5	0.007	3.14	1.93	10.81	0.749	128	112.5	22.5	0.01	3.22	1.99	10.68	0.744
48	112.5	45	0.007	3.42	2.36	13.76	1.274	129	112.5	45	0.01	3.51	2.43	13.59	1.265
49	112.5	67.5	0.007	3.18	2.10	11.38	0.814	130	112.5	67.5	0.01	3.27	2.17	11.25	0.808
50	112.5	90	0.007	2.88	1.67	8.95	0.457	131	112.5	90	0.01	2.95	1.72	8.84	0.454
51	112.5	112.5	0.007	3.22	2.19	11.81	0.871	132	112.5	112.5	0.01	3.31	2.26	11.67	0.865
52	112.5	135	0.007	3.45	2.42	14.61	1.324	133	112.5	135	0.01	3.54	2.50	14.44	1.314
53	112.5	157.5	0.007	3.27	2.24	12.36	0.924	134	112.5	157.5	0.01	3.35	2.31	12.21	0.918
54	112.5	180	0.007	3.01	1.73	9.73	0.506	135	112.5	180	0.01	3.09	1.78	9.61	0.503
55	135	0	0.007	3.09	1.91	10.50	0.728	136	135	0	0.01	3.17	1.95	10.40	0.724
56	135	22.5	0.007	3.42	2.36	14.16	1.274	137	135	22.5	0.01	3.51	2.41	14.02	1.266
57	135	45	0.007	3.73	2.88	18.02	2.166	138	135	45	0.01	3.83	2.94	17.84	2.153
58	135	67.5	0.007	3.47	2.57	14.91	1.383	139	135	67.5	0.01	3.56	2.62	14.76	1.375
59	135	90	0.007	3.14	2.04	11.72	0.777	140	135	90	0.01	3.22	2.08	11.60	0.772
60	135	112.5	0.007	3.51	2.67	15.47	1.481	141	135	112.5	0.01	3.61	2.73	15.31	1.472
61	135	135	0.007	3.76	2.96	19.14	2.250	142	135	135	0.01	3.87	3.02	18.95	2.236
62	135	157.5	0.007	3.56	2.73	16.19	1.571	143	135	157.5	0.01	3.66	2.79	16.03	1.562
63	135	180	0.007	3.29	2.11	12.74	0.861	144	135	180	0.01	3.37	2.15	12.62	0.856
64	157.5	0	0.007	2.83	1.56	8.02	0.428	145	157.5	0	0.01	2.92	1.60	7.86	0.424
65	157.5	22.5	0.007	3.14	1.93	10.81	0.749	146	157.5	22.5	0.01	3.23	1.98	10.59	0.742
66	157.5	45	0.007	3.42	2.36	13.76	1.274	147	157.5	45	0.01	3.52	2.42	13.48	1.261
67	157.5	67.5	0.007	3.18	2.10	11.38	0.814	148	157.5	67.5	0.01	3.28	2.16	11.16	0.805
68	157.5	90	0.007	2.88	1.67	8.95	0.457	149	157.5	90	0.01	2.96	1.71	8.77	0.452
69	157.5	112.5	0.007	3.22	2.19	11.81	0.871	150	157.5	112.5	0.01	3.32	2.24	11.57	0.863
70	157.5	135	0.007	3.45	2.42	14.61	1.324	151	157.5	135	0.01	3.56	2.48	14.32	1.310
71	157.5	157.5	0.007	3.27	2.24	12.36	0.924	152	157.5	157.5	0.01	3.37	2.29	12.11	0.915
72	157.5	180	0.007	3.01	1.73	9.73	0.506	153	157.5	180	0.01	3.10	1.77	9.53	0.501
73	180	0	0.007	2.60	1.28	6.12	0.252	154	180	0	0.01	2.69	1.31	6.00	0.250
74	180	22.5	0.007	2.88	1.59	8.25	0.441	155	180	22.5	0.01	2.97	1.62	8.09	0.437
75	180	45	0.007	3.14	1.93	10.50	0.749	156	180	45	0.01	3.24	1.98	10.30	0.743
76	180	67.5	0.007	2.92	1.72	8.69	0.479	157	180	67.5	0.01	3.02	1.77	8.52	0.474
77	180	90	0.00	2.64	1.37	6.83	0.269	15	180	90	0.0	2.73	1.4	6.70	0.266

			7					8			1		0		
78	180	112.5	0.007	2.96	1.80	9.01	0.512	159	180	112.5	0.01	3.06	1.84	8.84	0.508
79	180	135	0.007	3.17	1.99	11.15	0.779	160	180	135	0.01	3.27	2.04	10.94	0.772
80	180	157.5	0.007	3.00	1.84	9.44	0.544	161	180	157.5	0.01	3.10	1.88	9.26	0.539
81	180	180	0.007	2.77	1.42	7.43	0.298	162	180	180	0.01	2.86	1.45	7.28	0.295

The normalized and weighted normalized decision matrix for experimental observations is shown in Table 3

Table 3 The Normalized and weighted normalized decision matrix for experimental response observations

Sr. No.	Normalized Value				Weighted Normalized Value				Sr. No.	Normalized Value				Weighted Normalized Value			
	MM	SM	Time	% Vol Error	MM	SM	Time	% Vol Error		MM	SM	Time	% Vol Error	MM	SM	Time	% Vol Error
1	0.166	0.080	0.256	0.005	0.017	0.024	0.051	0.002	82	0.176	0.085	0.247	0.005	0.018	0.026	0.049	0.002
2	0.204	0.123	0.466	0.016	0.020	0.037	0.093	0.006	83	0.216	0.131	0.448	0.016	0.022	0.039	0.090	0.006
3	0.242	0.184	0.755	0.046	0.024	0.055	0.151	0.019	84	0.257	0.195	0.727	0.045	0.026	0.059	0.145	0.018
4	0.210	0.146	0.517	0.019	0.021	0.044	0.103	0.008	85	0.223	0.155	0.498	0.019	0.022	0.047	0.100	0.007
5	0.171	0.092	0.319	0.006	0.017	0.028	0.064	0.002	86	0.182	0.098	0.307	0.006	0.018	0.029	0.061	0.002
6	0.215	0.158	0.556	0.022	0.022	0.047	0.111	0.009	87	0.228	0.168	0.535	0.021	0.023	0.050	0.107	0.008
7	0.247	0.194	0.852	0.050	0.025	0.058	0.170	0.020	88	0.262	0.206	0.820	0.049	0.026	0.062	0.164	0.020
8	0.221	0.165	0.610	0.024	0.022	0.050	0.122	0.010	89	0.235	0.176	0.587	0.024	0.023	0.053	0.117	0.010
9	0.188	0.098	0.378	0.007	0.019	0.029	0.076	0.003	90	0.200	0.104	0.363	0.007	0.020	0.031	0.073	0.003
10	0.198	0.120	0.440	0.015	0.020	0.036	0.088	0.006	91	0.210	0.125	0.426	0.015	0.021	0.038	0.085	0.006
11	0.242	0.184	0.800	0.046	0.024	0.055	0.160	0.019	92	0.258	0.192	0.774	0.046	0.026	0.058	0.155	0.018
12	0.287	0.273	1.296	0.134	0.029	0.082	0.259	0.054	93	0.306	0.285	1.254	0.132	0.031	0.086	0.251	0.053
13	0.249	0.217	0.887	0.055	0.025	0.065	0.177	0.022	94	0.266	0.227	0.859	0.054	0.027	0.068	0.172	0.021
14	0.204	0.137	0.548	0.017	0.020	0.041	0.110	0.007	95	0.217	0.143	0.531	0.017	0.022	0.043	0.106	0.007
15	0.256	0.235	0.955	0.063	0.026	0.071	0.191	0.025	96	0.272	0.246	0.925	0.062	0.027	0.074	0.185	0.025
16	0.294	0.288	1.462	0.144	0.029	0.087	0.292	0.058	97	0.313	0.301	1.416	0.142	0.031	0.090	0.283	0.057
17	0.263	0.246	1.046	0.070	0.026	0.074	0.209	0.028	98	0.280	0.257	1.013	0.069	0.028	0.077	0.203	0.028
18	0.223	0.146	0.648	0.021	0.022	0.044	0.130	0.008	99	0.238	0.153	0.627	0.021	0.024	0.046	0.125	0.008

19	0.235	0.178	0.7555	0.044	0.023	0.053	0.151	0.017	100	0.251	0.191	0.728	0.043	0.025	0.057	0.146	0.017
20	0.287	0.273	1.372	0.134	0.029	0.082	0.274	0.054	101	0.307	0.293	1.324	0.131	0.031	0.088	0.265	0.053
21	0.341	0.407	2.223	0.387	0.034	0.122	0.445	0.155	102	0.364	0.436	2.144	0.380	0.036	0.131	0.429	0.152
22	0.296	0.323	1.523	0.158	0.030	0.097	0.305	0.063	103	0.316	0.346	1.469	0.155	0.032	0.104	0.294	0.062
23	0.242	0.204	0.941	0.050	0.024	0.061	0.188	0.020	104	0.258	0.218	0.907	0.049	0.026	0.065	0.181	0.020
24	0.304	0.350	1.639	0.181	0.030	0.105	0.328	0.072	105	0.324	0.375	1.580	0.175	0.032	0.113	0.316	0.071
25	0.349	0.429	2.509	0.417	0.035	0.129	0.502	0.167	106	0.372	0.460	2.419	0.410	0.037	0.138	0.484	0.164
26	0.312	0.366	1.795	0.204	0.031	0.110	0.359	0.081	107	0.333	0.392	1.731	0.200	0.033	0.118	0.346	0.080
27	0.266	0.218	1.112	0.061	0.027	0.065	0.222	0.024	108	0.283	0.233	1.072	0.060	0.028	0.070	0.214	0.024
28	0.198	0.120	0.440	0.015	0.020	0.036	0.088	0.006	109	0.211	0.127	0.423	0.015	0.021	0.038	0.085	0.006
29	0.242	0.184	0.800	0.046	0.024	0.055	0.160	0.019	110	0.259	0.195	0.768	0.045	0.026	0.058	0.154	0.018
30	0.287	0.273	1.296	0.134	0.029	0.082	0.259	0.054	111	0.307	0.290	1.244	0.130	0.031	0.087	0.249	0.052
31	0.249	0.217	0.887	0.055	0.025	0.065	0.177	0.022	112	0.267	0.230	0.852	0.053	0.027	0.069	0.170	0.021
32	0.204	0.137	0.548	0.017	0.020	0.041	0.110	0.007	113	0.218	0.145	0.526	0.017	0.022	0.044	0.105	0.007
33	0.256	0.235	0.955	0.063	0.026	0.071	0.191	0.025	114	0.274	0.250	0.917	0.061	0.027	0.075	0.183	0.024
34	0.294	0.288	1.462	0.144	0.029	0.087	0.292	0.058	115	0.314	0.306	1.404	0.140	0.031	0.092	0.281	0.056
35	0.263	0.246	1.046	0.070	0.026	0.074	0.209	0.028	116	0.281	0.261	1.005	0.068	0.028	0.078	0.201	0.027
36	0.223	0.146	0.648	0.021	0.022	0.044	0.130	0.008	117	0.239	0.155	0.622	0.021	0.024	0.047	0.124	0.008
37	0.166	0.080	0.256	0.005	0.017	0.024	0.051	0.002	118	0.175	0.085	0.249	0.005	0.017	0.026	0.050	0.002
38	0.204	0.123	0.466	0.016	0.020	0.037	0.093	0.006	119	0.214	0.131	0.452	0.016	0.021	0.039	0.090	0.006
39	0.242	0.184	0.755	0.046	0.024	0.055	0.151	0.019	120	0.254	0.195	0.732	0.045	0.025	0.058	0.146	0.018
40	0.210	0.146	0.517	0.019	0.021	0.044	0.103	0.008	121	0.221	0.155	0.502	0.018	0.022	0.046	0.100	0.007
41	0.171	0.092	0.319	0.006	0.017	0.028	0.064	0.002	122	0.180	0.098	0.310	0.006	0.018	0.029	0.062	0.002
42	0.215	0.158	0.556	0.022	0.022	0.047	0.111	0.009	123	0.226	0.168	0.540	0.021	0.023	0.050	0.108	0.008
43	0.247	0.194	0.852	0.050	0.025	0.058	0.170	0.020	124	0.260	0.206	0.827	0.049	0.026	0.062	0.165	0.020
44	0.221	0.165	0.610	0.024	0.022	0.050	0.122	0.010	125	0.232	0.175	0.591	0.023	0.023	0.053	0.118	0.010
45	0.188	0.098	0.378	0.007	0.019	0.029	0.076	0.003	126	0.198	0.104	0.366	0.007	0.020	0.031	0.073	0.003
46	0.198	0.120	0.440	0.015	0.020	0.036	0.088	0.006	127	0.208	0.127	0.430	0.015	0.021	0.038	0.086	0.006
47	0.242	0.184	0.800	0.046	0.024	0.055	0.160	0.019	128	0.255	0.195	0.781	0.046	0.025	0.059	0.156	0.018
48	0.287	0.273	1.296	0.134	0.029	0.082	0.259	0.054	129	0.303	0.290	1.265	0.132	0.030	0.087	0.253	0.053
49	0.2	0.2	0.8	0.05	0.0	0.0	0.1	0.02	13	0.2	0.2	0.8	0.05	0.0	0.0	0.1	0.0

	49	17	87	5	25	65	77	2	0	63	31	66	4	26	69	73	22
50	0.204	0.137	0.548	0.017	0.020	0.041	0.110	0.007	131	0.214	0.146	0.535	0.017	0.021	0.044	0.107	0.007
51	0.256	0.235	0.955	0.063	0.026	0.071	0.191	0.025	132	0.269	0.250	0.932	0.062	0.027	0.075	0.186	0.025
52	0.294	0.288	1.462	0.144	0.029	0.087	0.292	0.058	133	0.309	0.307	1.427	0.142	0.031	0.092	0.285	0.057
53	0.263	0.246	1.046	0.070	0.026	0.074	0.209	0.028	134	0.276	0.261	1.021	0.069	0.028	0.078	0.204	0.028
54	0.223	0.146	0.648	0.021	0.022	0.044	0.130	0.008	135	0.235	0.155	0.633	0.021	0.024	0.047	0.127	0.008
55	0.235	0.178	0.755	0.044	0.023	0.053	0.151	0.017	136	0.248	0.186	0.740	0.043	0.025	0.056	0.148	0.017
56	0.287	0.273	1.372	0.134	0.029	0.082	0.274	0.054	137	0.303	0.285	1.345	0.132	0.030	0.085	0.269	0.053
57	0.341	0.407	2.223	0.387	0.034	0.122	0.445	0.155	138	0.360	0.424	2.179	0.382	0.036	0.127	0.436	0.153
58	0.296	0.323	1.523	0.158	0.030	0.097	0.305	0.063	139	0.313	0.337	1.493	0.156	0.031	0.101	0.299	0.062
59	0.242	0.204	0.941	0.050	0.024	0.061	0.188	0.020	140	0.255	0.212	0.922	0.049	0.026	0.064	0.184	0.020
60	0.304	0.350	1.639	0.181	0.030	0.105	0.328	0.072	141	0.321	0.365	1.606	0.179	0.032	0.110	0.321	0.071
61	0.349	0.429	2.509	0.417	0.035	0.129	0.502	0.167	142	0.368	0.447	2.459	0.412	0.037	0.134	0.492	0.165
62	0.312	0.366	1.795	0.204	0.031	0.110	0.359	0.081	143	0.329	0.382	1.759	0.201	0.033	0.115	0.352	0.080
63	0.266	0.218	1.112	0.061	0.027	0.065	0.222	0.024	144	0.280	0.227	1.090	0.060	0.028	0.068	0.218	0.024
64	0.198	0.120	0.640	0.015	0.020	0.036	0.088	0.006	145	0.210	0.126	0.623	0.015	0.021	0.038	0.085	0.006
65	0.242	0.184	0.800	0.046	0.024	0.055	0.160	0.019	146	0.257	0.193	0.768	0.045	0.026	0.058	0.154	0.018
66	0.287	0.273	1.296	0.134	0.029	0.082	0.259	0.054	147	0.303	0.285	1.244	0.131	0.030	0.086	0.249	0.052
67	0.249	0.217	0.887	0.055	0.025	0.065	0.177	0.022	148	0.265	0.228	0.852	0.053	0.026	0.068	0.170	0.021
68	0.204	0.137	0.548	0.017	0.020	0.041	0.110	0.007	149	0.216	0.144	0.535	0.017	0.022	0.043	0.105	0.007
69	0.256	0.235	0.955	0.063	0.026	0.071	0.191	0.025	150	0.271	0.247	0.917	0.061	0.027	0.074	0.183	0.025
70	0.294	0.288	1.462	0.144	0.029	0.087	0.292	0.058	151	0.309	0.303	1.404	0.142	0.031	0.091	0.281	0.057
71	0.263	0.246	1.046	0.070	0.026	0.074	0.209	0.028	152	0.279	0.258	1.005	0.069	0.028	0.078	0.201	0.028
72	0.223	0.146	0.648	0.021	0.022	0.044	0.130	0.008	153	0.237	0.154	0.622	0.021	0.024	0.046	0.124	0.008
73	0.166	0.080	0.256	0.005	0.017	0.024	0.051	0.002	154	0.177	0.084	0.247	0.005	0.018	0.025	0.049	0.002
74	0.204	0.123	0.466	0.016	0.020	0.037	0.093	0.006	155	0.217	0.130	0.448	0.016	0.022	0.039	0.090	0.006
75	0.242	0.184	0.755	0.046	0.024	0.055	0.151	0.019	156	0.258	0.193	0.727	0.045	0.026	0.058	0.145	0.018
76	0.210	0.146	0.517	0.019	0.021	0.044	0.103	0.008	157	0.224	0.153	0.498	0.019	0.022	0.046	0.100	0.007
77	0.171	0.092	0.319	0.006	0.017	0.028	0.064	0.002	158	0.183	0.097	0.307	0.006	0.018	0.029	0.061	0.002
78	0.215	0.158	0.556	0.022	0.022	0.047	0.111	0.009	159	0.230	0.166	0.535	0.021	0.023	0.050	0.107	0.009
79	0.247	0.194	0.852	0.050	0.025	0.058	0.170	0.020	160	0.264	0.204	0.820	0.049	0.026	0.061	0.164	0.020

80	0.221	0.165	0.610	0.024	0.022	0.050	0.122	0.010	161	0.236	0.174	0.587	0.024	0.024	0.052	0.117	0.010
81	0.188	0.098	0.378	0.007	0.019	0.029	0.076	0.003	162	0.201	0.103	0.363	0.007	0.020	0.031	0.073	0.003

The positive ideal (D+) and negative ideal (D-) solutions are determined using Equations 4 and 5. The results are shown in Table 4.

Table 4 The positive ideal (D+) and negative ideal (D-) ideal solutions

Solution	MM	SM	Time	% Vol Error
Positive ideal D+	0.017	0.024	0.049	0.002
Negative ideal D-	0.037	0.138	0.502	0.167

The separation of each alternative solution is calculated using Equations (6). The computed values are shown in Table 5.

The result of the ranking of approaches is derived i.e. by determining the relative closeness. For this particular problem requirement of model material, support material, time and percentage volumetric error (minimization) are considered non beneficial attributes (minimization). Table 5 shows the relative correlation coefficient and ranking of the experimental run based on its performance.

Table 5 The distance from positive ideal solution (Si+) and distance from negative ideal solution (Si-), the relative closeness and ranking based on it

Sr. No.	Distance from Positive Ideal Solution (Si+)	Distance from Negative Ideal Solution (Si-)	Relative closeness	Rank
1	0.002	0.493	0.996	4
2	0.046	0.451	0.907	30
3	0.108	0.390	0.783	74
4	0.058	0.439	0.884	36
5	0.015	0.481	0.970	10
6	0.067	0.431	0.866	50
7	0.127	0.371	0.745	88
8	0.077	0.421	0.844	56
9	0.027	0.470	0.946	16
10	0.041	0.456	0.918	23
11	0.116	0.382	0.767	81
12	0.224	0.274	0.550	127
13	0.136	0.363	0.727	95
14	0.063	0.435	0.874	43
15	0.151	0.348	0.698	107
16	0.257	0.242	0.484	139
17	0.170	0.330	0.661	115
18	0.083	0.415	0.833	63
19	0.107	0.391	0.785	72
20	0.238	0.260	0.522	133
21	0.435	0.061	0.122	157
22	0.273	0.227	0.454	145
23	0.145	0.355	0.710	101
24	0.299	0.201	0.402	149
25	0.493	0.009	0.019	161
26	0.331	0.169	0.337	153
27	0.180	0.322	0.642	121
28	0.041	0.456	0.918	24
29	0.116	0.382	0.767	82
30	0.224	0.274	0.550	128
31	0.136	0.363	0.727	96
32	0.063	0.435	0.874	44
33	0.151	0.348	0.698	108
34	0.257	0.242	0.484	140
35	0.170	0.330	0.661	116
36	0.083	0.415	0.833	64
37	0.002	0.493	0.996	5
38	0.046	0.451	0.907	31
39	0.108	0.390	0.783	75
40	0.058	0.439	0.884	37
41	0.015	0.481	0.970	11
42	0.067	0.431	0.866	51
43	0.127	0.371	0.745	89
44	0.077	0.421	0.844	57

45	0.027	0.470	0.946	17
46	0.041	0.456	0.918	25
47	0.116	0.382	0.767	83
48	0.224	0.274	0.550	129
49	0.136	0.363	0.727	97
50	0.063	0.435	0.874	45
51	0.151	0.348	0.698	109
52	0.257	0.242	0.484	141
53	0.170	0.330	0.661	117
54	0.083	0.415	0.833	65
55	0.107	0.391	0.785	73
56	0.238	0.260	0.522	134
57	0.435	0.061	0.122	158
58	0.273	0.227	0.454	146
59	0.145	0.355	0.710	102
60	0.299	0.201	0.402	150
61	0.493	0.009	0.019	162
62	0.331	0.169	0.337	154
63	0.180	0.322	0.642	122
64	0.041	0.456	0.918	26
65	0.116	0.382	0.767	84
66	0.224	0.274	0.550	130
67	0.136	0.363	0.727	98
68	0.063	0.435	0.874	46
69	0.151	0.348	0.698	110
70	0.257	0.242	0.484	142
71	0.170	0.330	0.661	118
72	0.083	0.415	0.833	66
73	0.002	0.493	0.996	6
74	0.046	0.451	0.907	32
75	0.108	0.390	0.783	76
76	0.058	0.439	0.884	38
77	0.015	0.481	0.970	12
78	0.067	0.431	0.866	52
79	0.127	0.371	0.745	90
80	0.077	0.421	0.844	58
81	0.027	0.470	0.946	18
82	0.002	0.495	0.996	3
83	0.044	0.453	0.912	28
84	0.104	0.394	0.792	69
85	0.055	0.442	0.889	34
86	0.013	0.483	0.973	8
87	0.064	0.434	0.871	48
88	0.122	0.376	0.755	86
89	0.074	0.424	0.851	54
90	0.025	0.472	0.950	14
91	0.039	0.458	0.922	21
92	0.112	0.386	0.775	79
93	0.217	0.281	0.564	125
94	0.132	0.367	0.736	93
95	0.060	0.437	0.879	41
96	0.146	0.353	0.707	105
97	0.249	0.249	0.500	137
98	0.165	0.336	0.671	113
99	0.080	0.419	0.840	61
100	0.103	0.395	0.793	67
101	0.231	0.268	0.537	131
102	0.422	0.075	0.150	155
103	0.264	0.236	0.471	143
104	0.140	0.360	0.720	99
105	0.290	0.211	0.421	147
106	0.478	0.018	0.036	159
107	0.321	0.179	0.358	151
108	0.173	0.328	0.655	119
109	0.038	0.458	0.923	20
110	0.111	0.387	0.777	78
111	0.215	0.282	0.567	124
112	0.131	0.369	0.738	92
113	0.060	0.438	0.880	40
114	0.145	0.355	0.709	104
115	0.248	0.251	0.504	136
116	0.163	0.337	0.674	112
117	0.079	0.420	0.842	60
118	0.002	0.494	0.996	2
119	0.044	0.453	0.911	29
120	0.105	0.393	0.790	70
121	0.056	0.442	0.887	35
122	0.014	0.482	0.972	9
123	0.065	0.434	0.870	49
124	0.123	0.375	0.752	87
125	0.075	0.423	0.849	55

126	0.025	0.471	0.949	15
127	0.040	0.457	0.920	22
128	0.114	0.385	0.772	80
129	0.219	0.278	0.559	126
130	0.134	0.366	0.732	94
131	0.061	0.437	0.877	42
132	0.148	0.352	0.703	106
133	0.252	0.247	0.495	138
134	0.166	0.334	0.667	114
135	0.081	0.418	0.838	62
136	0.105	0.393	0.789	71
137	0.234	0.264	0.530	132
138	0.428	0.068	0.138	156
139	0.268	0.232	0.463	144
140	0.142	0.358	0.716	100
141	0.294	0.206	0.412	148
142	0.485	0.011	0.022	160
143	0.326	0.175	0.349	152
144	0.176	0.325	0.649	120
145	0.038	0.459	0.923	19
146	0.111	0.387	0.777	77
147	0.215	0.282	0.567	123
148	0.131	0.369	0.738	91
149	0.059	0.438	0.880	39
150	0.145	0.355	0.709	103
151	0.247	0.251	0.504	135
152	0.163	0.337	0.674	111
153	0.079	0.420	0.842	59
154	0.002	0.495	0.997	1
155	0.043	0.453	0.913	27
156	0.103	0.395	0.792	68
157	0.055	0.443	0.889	33
158	0.013	0.483	0.973	7
159	0.064	0.434	0.872	47
160	0.122	0.377	0.755	85
161	0.074	0.424	0.851	53
162	0.025	0.472	0.951	13

From Table 5, based on the relative correlation coefficient and ranking of the experimental run based on its performance; Expt.1 combinations gives the optimum output followed by Expt.37, Expt.73, Expt.82, Expt.118, and Expt. 154, for top six combinations.

CONCLUSION

The method represents selection of optimal process parameters in rapid prototyping process using TOPSIS method. The suggested methodology can be used for any type of selection problem involving any number of selection criteria. The valve seat example is considered to demonstrate the application and validated using TOPSIS method. In all the cases, it is observed that the top-ranked alternatives exactly match with those suggested by previous researchers. The TOPSIS method can consider all the attributes along with their relative importance, and hence, it can provide a better accurate evaluation of the alternatives. This method is computationally very simple, easily comprehensible, and robust which can simultaneously consider any number of quantitative and qualitative selection attributes, while offering a more objective and logical selection approach. With the help of this optimization method it can be conclude that, in the rapid prototyping process, for the minimum requirement of model material, support material and time; the part or object should be placed at an orientation at 00 or 900 or 1800 at X and Y axis.

REFERENCE

1. M. Dawoud, I. Taha, and S. J. Ebeid, “Mechanical behaviour of ABS: An experimental study using FDM and injection moulding techniques,” J. Manuf. Process., vol. 21, pp. 39– 45, 2016.
2. N. Gunantara, “A review of multi-objective optimization: Methods and its applications,” Cogent Eng., vol. 5, no. 1, p. 1502242, 2018.
3. F. Ning, W. Cong, Z. Hu, and K. Huang, “Additive manufacturing of thermoplastic matrix composites using fused deposition modeling: A comparison of two reinforcements,” J. Compos. Mater., vol. 51, no. 27, pp. 3733–3742, 2017.
4. A. Le Duigou, M. Castro, R. Bevan, and N. Martin, “3D printing of wood fibre biocomposites: From mechanical to actuation functionality,” Mater. Des., vol. 96, pp. 106–114, 2016.
5. I. Gibson et al., Additive manufacturing technologies, vol. 17. Springer, 2021.
6. A. Lanzotti, M. Grasso, G. Staiano, and M. Martorelli,

"The impact of process parameters on mechanical properties of parts fabricated in PLA with an open-source 3-D printer," Rapid Prototyp. J., 2015.

7. I. Durgun and R. Ertan, "Experimental investigation of FDM process for improvement of mechanical properties and production cost," Rapid Prototyp. J., 2014.
8. J. S. Chohan, R. Singh, and K. S. Boparai, "Parametric optimization of fused deposition modeling and vapour smoothing processes for surface finishing of biomedical implant replicas," Measurement, vol. 94, pp. 602–613, 2016.
9. B. Panda, K. Shankhwar, A. Garg, and M. M. Savalani, "Evaluation of genetic programming-based models for simulating bead dimensions in wire and arc additive manufacturing," J. Intell. Manuf., vol. 30, pp. 809–820, 2019.
10. O. A. Mohamed, S. H. Masood, and J. L. Bhowmik, "Influence of processing parameters on creep and recovery behavior of FDM manufactured part using definitive screening design and ANN," Rapid Prototyp. J., 2017.
11. C. K. Chua, K. F. Leong, and C. S. Lim, Rapid prototyping: principles and applications (with companion CD-ROM). World Scientific Publishing Company, 2010.
12. K. Senthilkumaran, P. M. Pandey, and P. V. M. Rao, "Influence of building strategies on the accuracy of parts in selective laser sintering," Mater. Des., vol. 30, no. 8, pp. 2946– 2954, 2009.
13. D. S. Ingole, T. R. Deshmukh, A. M. Kuthe, and K. M. Ashtankar, "Build orientation analysis for minimum cost determination in FDM," Proc. Inst. Mech. Eng. Part B J. Eng. Manuf., vol. 225, no. 10, pp. 1925–1938, 2011.
14. W. Rattanawong, S. H. Masood, and P. Iovenitti, "A volumetric approach to part-build orientations in rapid prototyping," J. Mater. Process. Technol., vol. 119, no. 1–3, pp. 348– 353, 2001.
15. S. H. Masood, W. Rattanawong, and P. Iovenitti, "Part build orientations based on volumetric error in fused deposition modelling," Int. J. Adv. Manuf. Technol., vol. 16, no. 3, pp. 162–168, 2000.
16. P. M. Pandey, K. Thrimurthulu, and N. V. Reddy*, "Optimal part deposition orientation in FDM by using a multicriteria genetic algorithm," Int. J. Prod. Res., vol. 42, no. 19, pp. 4069–4089, 2004.
17. M. Raju, M. K. Gupta, N. Bhanot, and V. S. Sharma, "A hybrid PSO–BFO evolutionary algorithm for optimization of fused deposition modelling process parameters," J. Intell. Manuf., vol. 30, pp. 2743–2758, 2019.
18. D. Qiu and N. A. Langrana, "Void eliminating toolpath for extrusion-based multi-material layered manufacturing," Rapid Prototyp. J., 2002.
19. K. Prashantha and F. Roger, "Multifunctional properties of 3D printed poly (lactic acid)/graphene nanocomposites by fused deposition modeling," J. Macromol. Sci. Part A, vol. 54, no. 1, pp. 24–29, 2017.
20. J. R. Wodziak, G. M. Fadel, and C. Kirschman, "A genetic algorithm for optimizing multiple part placement to reduce build time," in Proceedings of the Fifth International Conference on Rapid Prototyping, 1994, vol. 12, pp. 201–210.
21. D. A. Schaub, K.-R. Chu, and D. C. Montgomery, "Optimizing stereolithography throughput," J. Manuf. Syst., vol. 16, no. 4, pp. 290–303, 1997.
22. H.-S. Byun and K. H. Lee, "Determination of the optimal build direction for different rapid prototyping processes using multi-criterion decision making," Robot. Comput. Integr. Manuf., vol. 22, no. 1, pp. 69–80, 2006.
23. A. Peng, X. Xiao, and R. Yue, "Process parameter optimization for fused deposition modeling using response surface methodology combined with fuzzy inference system," Int. J. Adv. Manuf. Technol., vol. 73, no. 1–4, pp. 87–100, 2014.

A Review of Tribological Behavior of Composites/Polymers/ Polymer Composites under Variable Loading

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ABSTRACT

This review paper focuses on polymer and polymer composites and their tribological behavior under dynamic loading circumstances. Composite matrices may either be made of metal or plastic. Mechanical characteristics, cost, and weight are all factors that have contributed to polymer materials and polymer composites' rise to prominence in a wide range of technical applications. Tribology, polymer materials, and rolling contact bearings are all introduced in this paper's introductory section. Composition, filler type, reinforcement, and lubrication are all discussed as important elements in determining the tribological behavior of polymers and polymer composites. The purpose of this work is to draw attention to a knowledge gap in the field of dynamic loading tribology. It also makes some suggestions for future studies that might help build a database of information on the tribological behavior of composite materials subjected to dynamic stress. It is hoped that this kind of study would help the growing community of tribology researchers by focusing on the most current significant tribological research under dynamic stress.

KEYWORDS *: Tribology; Dynamic Loading; Composites; Polymer; Polymer Composites*

INTRODUCTION

Composite materials have gained significant attention as potential alternatives to traditional bearing materials due to their superior tribological properties. Roller bearings subjected to static and dynamic loading conditions require materials that can withstand high loads, exhibit low friction coefficients, and resist wear. This research paper aims to review the tribological behavior of composite materials under dynamic loading. Traditionally, roller bearings have been manufactured using metallic materials such as steel or bronze. While these materials have been widely utilized and proven effective, they come with certain limitations. Under high loads and dynamic operating conditions, metallic bearings can experience significant wear and friction, leading to decreased efficiency, increased maintenance requirements, and even premature failure. To address these challenges, researchers and engineers have turned their attention to composite materials, especially polymers as potential alternatives for roller bearings.

The tribological behavior of polymer and polymer composite materials is crucial in a variety of industrial applications. The tribological behavior of materials is generally evaluated in terms of wear and frictional characteristics using several tribometers, one of which is the pin-on-disc machine. The general goal of wear analysis is to reduce weight loss (wear), specific wear rate, and coefficient of friction, among other things.

The primary objective of this research paper is to provide a comprehensive review of the tribological behavior of

composite materials especially polymers and polymer composite under dynamic loading conditions.

LITERATURE REVIEW

The literature review is divided into two sections as below:

Review of Metal Composite Matrix:

The tribological behavior of hybrid metal matrix composites (HMMCs) based on aluminium (Al) and magnesium (Mg) was reviewed in depth by Nikhilesh Singh et al [1]. The authors found that stir casting was the most effective method of creating HMMCs via a thorough examination of the relevant literature. It was also suggested that a pin-on-disc tribometer be used for wear analysis in Al and Mg-based HMMCs. Wear testing of HMMCs based on aluminium and magnesium showed considerable improvements in tribological characteristics. A wide range of wear processes, including mass loss, adhesion (film-coating), abrasion, delamination, oxidation, plastic deformation, friction coefficient (CoF), hardness, and average surface roughness, have all been addressed. Al and Mg-based HMMCs showed improved features in tribological performance compared to other base matrices.

The study by P. Shanmukhsundaram [2] looked at how temperature, load, and sliding velocity affected the wear behavior of AA7075-SIC composites. The researchers looked at how an aluminium matrix enhanced with SiC performed in a dry sliding wear test. The EN 32 carbon steel used as the counter face material was subjected to tests at temperatures of 30 degrees Celsius, 60 degrees Celsius, and 90 degrees Celsius, with varying loads and sliding speeds. The research found that the wear loss was significantly affected by both load and temperature. Within the measurable range, increasing temperature, load, and sliding velocity were all found to reduce the composites' wear resistance. The researcher used the Taguchi technique to establish the relevance of these factors. To further investigate the impact of these factors on wear resistance, Analysis of Variance (ANOVA) was used. Based on the results, it was determined that load was the most influential factor in wear, followed by temperature and sliding velocity.

A unique reciprocating tribometer built for wear testing under varied loading circumstances was the subject of a study by Abdelbary et al. [3]. In order to conduct wear tests under both constant and variable loading situations, the researchers designed and built a reciprocating testing machine that would maintain a constant sliding speed throughout most of its stroke. The tribometer's loading cycle's amplitude, mean load, and frequency may be modified. In addition, rainy or dry circumstances might be used for the wear testing. The authors used the aforementioned test equipment to investigate the effect of loading mode on the wear behavior of Nylon 66 sliding against stainless steel in dry circumstances. Two separate loads and three different frequencies were used to conduct wear testing on the polymer material. The research found that compared to tests performed with constant loads, the polymer's wear factor significantly increased when subjected to cyclic loading conditions. Wear behavior under cyclic loading was also shown to be significantly affected by the load cycle frequency.

The effect of lubricating oil on the tribological behavior measured using a pin-on-disc test rig was the subject of investigation by Trivedi and D.V. Bhatt [4]. In order to determine how well different materials perform in terms of friction and wear in a four-stroke engine, the team devised a new way of testing. To guarantee that the testing procedure was reflective of real-world situations, realistic engine oils were used. A pin-on-disc tribometer was used in the studies to measure friction and wear. The purpose of this research was to compare the performance under a variety of lubricants and loads. Piston ring segments were subjected to sliding tests against a grey cast iron disc designed to mimic cylinder liners. To study the frictional and wear behavior, several commercial lubricants were used. These included SAE10W30, SAE20W40, and SAE20W50.

Two sets of tests were run, one with a constant load of 140 N for 105 minutes, and the other with increasing loads from 20 N to 140 N for the same time period. The frictional force and wear behavior of the piston ring and cylinder liner were the targets of these experiments. Wear-related mass loss was weighed before and after testing to determine the lubricant's efficacy. The results showed that the behavior of frictional force and wear was significantly characterised by viscosity and load change.

NiCrBSiFe coatings on SS 316L were studied for their

high-temperature tribological behavior after being applied using atmospheric plasma spray (APS) and high-velocity oxy-fuel (HVOF) spraying by Sanjay W Rukhande et al [5]. Components utilised in hot forming, power generation, and aerospace were the focus of the study's investigation into wear and high-temperature oxidation. At 300°C, 500°C, and 700°C, the friction and wear behavior of APS and HVOF sprayed NiCrBSiFe coatings were investigated. A pin-on-disc tribometer was used to conduct dry sliding wear testing at high temperatures in accordance with ASTM G99. The tests were performed with a sliding speed of 18 m/min, a normal load of 10 N, and silicon nitride (1580 HV0.3) as the counter material. To assess the performance of the APS and HVOF coatings, the researchers examined the specific wear rate and the coefficient of friction. The findings indicated that both coatings' particular wear rates rose as temperature did. At high temperatures, however, the HVOF coating proved more durable than the APS. The HVOF coating's few oxide inclusions, low porosity, high hardness, and tightly packed partly molten particles all contributed to the enhancement.

White Etching Areas (WEAs) are formed under extreme sliding circumstances in bearing steel, and K. Sreeraj and P. Ramkumar [6] studied the role that dynamic load frequency and hydrogenation play in this process. The purpose of this research was to examine how hydrogenation and frequency of loading affect the onset of WEA development. Both 1.5 Hz and 4.5 Hz loading frequencies were used in the experiments using a dynamic load Pin-on-Disc tribometer. One and two gigapascals (GPa) of contact pressure were tested. In this study, steel on steel served as the tribological pair, and boundary lubrication conditions were achieved using a combination of polyalphaolefin (PAO) and real-time hydrogenating oil. The synergy between hydrogen enhancement and mechanical stress-induced variables in WEA development was demonstrated in this work. Metallographic studies showed that after an initial stage of pure sliding, a butterfly-like pattern evolved around the non-metallic inclusion.

The topic of dynamic load tribology was the subject of a technical study written by Duanjie Li and colleagues [7]. Nanovea T2000 Dynamic Load Tribometer research and development were the focus of this study. Using a variety of coating and metal samples, the researcher demonstrated the tribometer's ability to examine tribological behavior under controlled oscillation loading circumstances. The tribological behavior of a wear-resistant coating 300 m thick was tested, especially it's coefficient of friction (COF) and wear resistance. The Nanovea T2000 Tribometer and a traditional dead load tribometer with a pin-on-disk arrangement were used to evaluate and contrast these characteristics in accordance with the ASTM G99 standard. In addition, the Nanovea T2000 Tribometer's Dynamic Load Mode was used to assess the abrasion and wear resistance of copper (Cu) and titanium nitride (TiN) coated materials while rubbing against a 6 mm Al203 ball under controlled oscillation settings.

The importance of bearings in high-precision machine tools was highlighted in a paper by So Young Hwang et al [8]. Bearing failure must be understood in order to replace them before they compromise accuracy. Run-out is a major contributor to accuracy loss caused by bearing failure in certain applications. However, much of the research done till now has concentrated on specific failure modes, such as spalling. The purpose of this research was to use linear and non-linear wear models to provide predictions about the run-out of thrust bearings. Wear studies on cross roller thrust bearings were performed to verify the models. The average run-out discrepancy between the experiments and the simulations was found to be 16%. The wear of various-sized cross roller bearings was also modelled using simulation. When comparing the projected findings to the experimental data, a discrepancy of up to 6% was found. Bearing failure and life expectancy may be estimated using the suggested wear models.

The feasibility of Archard's wear model under different loading situations was studied by K. P. Lijesh et al. [9], and a new wear model based on thermodynamic principles was developed. The novel wear model proposes a connection between load-dependent friction force, contact temperature, and the degradation coefficient B. By analysing four examples of wear volume data with varied load sequences from the literature, the usefulness of the suggested wear model is proved. According to the findings, the wear behavior throughout the load series may be properly described

by a constant value of B, whereas the coefficient K is invariant throughout all load sequences.

In order to further verify the results, a number of tests are performed on a ball-on-disk test setup, taking into account four alternative load sequences, and using a variety of tribo-pair materials and experimental settings. Consistent with prior findings, these trials lend credence to the idea that the degradation coefficient B, which accounts for frictional force and temperature changes in addition to load variation over the load sequence, yields accurate predictions. The relevance of the degradation coefficient B in characterising wear behavior is highlighted, and the research concludes that the suggested wear model works across a range of load sequences and experimental settings.

Using nano-Aluminium Oxide (Al2O3) as a composite reinforcement and Graphene Nano Platelets (GNP) as an additive for lubricant, Pranav Dev Srivyas et al [10] improved the anti-friction and anti-wear performance of a tribopair. The purpose of this tribological investigation was to learn more about the friction- and wear-reducing properties of n- Al2O3 and GNP. Spark Plasma Sintering (SPS), a fast manufacturing method, was used to create the samples. We used a universal reciprocating tribometer to compare the samples to chromium-plated chrome steel in dry and wet circumstances at room temperature to determine their tribological capabilities.

Nano-lubricant composite samples (PAO-4 + 0.5 wt% GNP + OA) were shown to have superior tribological characteristics, with much less friction and wear. Both the nano-additive in the lubricant and the hard phase ceramic reinforcements were responsible for the enhanced tribological performance. The inclusion of Oleic Acid (OA) in the nano-lubricant also contributed to the improved dispersion stability of the nanoparticles inside the oil. After tribological testing, several surface characterisation methods were used to learn about the wear and lubrication processes. These included optical microscopy, scanning electron microscopy, electron dispersion spectroscopy, and three-dimensional surface profilometry. Incorporating n-Al2O3 and GNP into the tribopair and analysing wear and lubrication processes with various characterization methods provided insight into the tribological behavior and performance improvement that resulted.

Review of Polymer Composite Matrix

Tribological and dynamic mechanical analyses of composites were reviewed by Partha Pratim Das and Vijay Chaudhary [11]. The progress and study of polymer composites made from natural fibers were the main topics of this review. The importance of Dynamic Mechanical Analysis (DMA) in characterizing these composites was emphasized in particular. Measurements of parameters like storage modulus (G'), loss modulus (G"), and damping capacity (Tan δ) may be obtained with the use of DMA, making it a valuable tool. These values provide light on the mechanical properties and capabilities of the composites. The purpose of this literature review was to present a synopsis of recent developments and ongoing trends in the study of polymer composites made from natural fibers, with an emphasis on tribological and dynamic mechanical analysis.

Researchers Alaleh Safari et al. [12] looked at how dynamic loading affected the frictional behavior of a UHMWPE pin in synthetic bio lubricants, comparing it to static loading. The purpose of this study was to investigate the effects of hyaluronic acid (HA) and protein content in lubricants on the tribological behavior of ultra-high molecular weight polyethylene (UHMWPE) sliding against a cobalt chromium molybdenum (CoCrMo) counter surface. The purpose of this research was to compare the effects of static and dynamic loading on friction development. According to the findings, the friction development did not change for any of the tested lubricants when the dynamic loading was applied. Lubricants without HA, on the other hand, have a lower friction rating.

Additionally, the research discovered that an increase in the friction coefficient occurred as the lubricant's protein concentration rose. Protein-rich lubricants had a greater friction coefficient, but they reduced wear on sliding surfaces more than any other kind of lubricant. Overall, the study elucidated the connection between dynamic loading, lubricant composition (in particular the presence of HA), and protein content, as well as UHMWPE's tribological behavior when in contact with a CoCrMo counter surface.

Cylindrical roller bearings are often employed to support rotating shafts in equipment, and Deepak Kumar Prasad

et al [13] investigated their performance. Because of the increased friction, heat, and progressive wear on the rolling contact surfaces, these bearings often fail before their time. The sudden shutdown of equipment due to a faulty bearing has prompted the development of a number of condition-monitoring techniques. The purpose of this work was to determine whether there was a correlation between the roller bearing's dynamic response and its traction coefficient parameter, surface roughness, and wear. The purpose of the experiments was to learn how the traction coefficient and the dynamic response rely on the spread of wear on the rolling contact surfaces of the bearing. The writers concluded the following based on their findings.

1. Bearing problems might be better understood with the use of the traction coefficient, micrographs of the worn surfaces of the bearings, and statistical characteristics of the vibration signals.
2. Bearing defects were indicated by an upward trend in the root mean square (RMS) values of vibration signals as a function of operation time.
3. The values of the traction coefficient increased with time, revealing the spread of wear on the roller bearing's contact surfaces.

Damage to the contact surface between the inner race and the rolling elements has increased, as shown in scanning electron microscope (SEM) photographs of the worn surfaces.

Bearing defects may be detected and monitored with the use of the traction coefficient, vibration signals, and wear analyses, as shown above.

Carbon fibre reinforced polyester fiber's versatility led Velusamy Mugesh Raja et al. [14] to investigate its use in a suspension system. The joint strength of leaf springs was compared across three different materials: 20% short carbon fibre reinforced polyester (SF), 20% long carbon fiber reinforced polyester (LF), and unreinforced polyester (UP). The energy capacity and strain rate sensitivity of the moulded leaf springs were measured using static performance tests. The fatigue performance of the test joints was evaluated by applying completely reversed fatigue loads at a constant frequency and measuring the leaf spring's response to loads of up to 2 x 107 cycles. Scanning Electron Microscopy (SEM) was used to look at the fractures' shape after they had broken under tensile stress. The study's findings showed that carbon fibre reinforced polyester fiber was the most effective material for applying loads. Joint strength, energy storage, and fatigue resistance were all enhanced in the carbon fiber reinforced polyester leaf springs.

The tribological behavior of PTFE (Poly Tetra Fluoro Ethylene) was investigated by S.M.Patil and B.B.Ahuja [15] under varied loading dry sliding circumstances. The tribological behavior of materials under varying and continuous loads was studied by modifying a pin-on-disk tribometer. Under this study, the authors examine the modified tribometer's ability to shed light on PTFE's wear and friction behavior under a variety of dry, unidirectional sliding circumstances. The maximum, minimum, and mean constant load scenarios were compared to the findings obtained from the variable loading testing.

Wear and specific wear rate of PTFE were found to be greater under changing loading circumstances in dry unidirectional sliding than under equivalent mean constant load conditions. The coefficient of friction showed no discernible behavior difference between varied and constant loading. These findings emphasise the impact of loading on wear behavior and provide information on the tribological performance of PTFE under varying loads. The tribological properties of PTFE are important to understand, and this data may help.

Experimental and numerical studies were used by Lucio Raimondo et al. [16] to create and apply a composite material model for dynamic failure. Ballistic data for UD Carbon Fibre Reinforced Polymer (CFRP) composites was used to verify the derived model. As part of the study, the material model was implemented in LS-DYNA3D, an explicit Finite Element (FE) code, employing one-integration-point solid brick elements. This work aimed to validate the created material model by comparing it to ballistic data for composites. The study's primary objective was to prove that the model could successfully anticipate how UD CFRP composites would react to dynamic loads.

The researchers wanted to make sure their generated model could effectively anticipate the behavior of the composite material during ballistic events, so they put

it through its paces in both the lab and the computer. This research adds to the growing body of knowledge on dynamic failure analysis and the modelling of composite materials.

Tribological behavior of Polytetrafluoroethylene (PTFE) and its composites was investigated by P. D. Pansare et al [17]. While PTFE has a relatively low coefficient of friction, it wears quickly when rubbing against a hard surface. Different fillers were incorporated into PTFE to increase its wear resistance.

Researchers looked at how different fillers, such as carbon, bronze, glass fiber, and MoS2, altered the friction and wear properties of PTFE and PTFE composites under different loads and sliding velocities. We used a pin-on-disc friction and wear test apparatus to collect and analyse our experimental data in Design Expert. The data was shown graphically and tabulated to highlight how various fillers affected the materials' wear and friction.

The results revealed that the coefficient of friction increased somewhat when carbon, bronze, and glass fillers were added to pure PTFE, but the wear rate decreased dramatically. The PTFE filled with 15% glass fiber and 5% MoS2 had the best wear resistance, followed by the PTFE filled with 35% carbon, 25% carbon, 15% glass fiber, 40% bronze, and pure PTFE. These findings prompted the authors to conclude that PTFE filled with 15% glass fiber and 5% MoS2 is an effective self-lubricating material for extending the service life of roller journal bearings used in sugarcane mills. Scanning Electron Microscopy (SEM) was used to investigate the composites' microstructures and comprehend the failure mechanisms.

The preceding review of the literature demonstrates that the pin-on-disc tribometer is the instrument of choice for studying tribological behavior.

STUDY OF TRIBOLOGICAL PROPERTIES (TRIBOLOGICAL TESTS)

Several types of tribometers can measure the tribological behavior. Tribological behavior of materials under static and dynamic loads may be studied using several variations of the most used tribometer, the pin-on-disk tribometer.

The operational factors are very important in a tribological investigation since they help determine how the materials behave. Several quantitative measures allow for the categorization of these factors. The main groups include test parameters such as motion type, load, speed, environment, and time under test conditions.

Wear and friction studies were conducted in both dry sliding and lubricated sliding circumstances to learn more about the tribological characteristics. Two different tribometers were used to conduct these analyses, providing a more thorough look at how the materials fared under different situations.

The impact of operating temperature on tribological behavior was investigated in addition to the sliding circumstances. The working temperature was changed from room temperature to higher temperatures using a dedicated tribometer. This allowed us to evaluate how different temperatures affect wear and friction.

Tribological research aims to illuminate the elements affecting wear and friction by taking into account various operational variables in order to offer a full knowledge of the material's behavior under varied situations.

Pin on Disk Tribometre [18]

A pin specimen and a disc specimen are needed for a pin-on-disk wear test. The disc specimen is a flat circular disc, whereas the pin specimen is often a ball with a radiused point. When conducting the test, the pin specimen is brought into contact with the revolving disc specimen, which is held in a perpendicular orientation to the pin. During the experiment, the disc will be rotated such that the sliding route follows a round path on its surface. Depending on the experimental setting, the disc may be placed in a horizontal or vertical position. The pin specimen is loaded and then forced against the disc using a lever or arm and weights. Typically, the force is applied via a hydraulic or pneumatic system.

The test findings for wear are shown for both the pin and disc specimens as a loss of volume, measured in cubic millimeters. The degree of wear is estimated by comparing the weight or linear dimensions of test specimens before and after the procedure.

Electronic distance gauging and stylus profiling are two relevant metrological techniques for measuring linear

wear. These methods measure the length and profile of a pin specimen and the depth and profile of a worn track on a disc, both in millimeters. Using appropriate geometric relationships, this linear wear data may be transformed into wear volume (in cubic millimeters).

Since the mass loss of the specimens is usually too tiny to be correctly determined, linear metrics of wear are typically utilised in practice. The wear test is normally carried out over a predetermined sliding distance at fixed loads and velocities. Different specimens may be used for various sliding distances to investigate distinct wear behaviors, and the findings of wear tests are often displayed as plots of wear volume against sliding distance. Cam and follower mechanisms, as illustrated in Fig. 1 [18], may be used to provide dynamic loading.

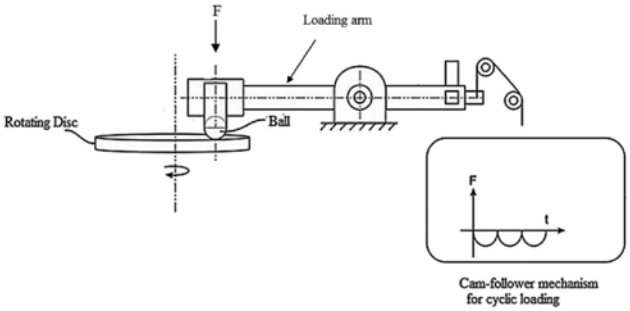

Fig. 1 Modified dynamic load Pin on Disk tribometer [18]

Roller Tribometer [19]

Tribological testing may be performed using a multi-tribotester equipment (TR-25, DUCOM). Sliding composite samples at rest are put through their paces against a spinning EN8 steel counterface roller. The counterface roller is 60 millimeters in diameter and 20 millimeters in thickness. A computer attached to the tribology tester allows the user to adjust the roller speed and the length of the tests.

Additional weights are put on the loading tray, which is linked to a loading switch, to impart the load on the samples. The effective normal load on the sample may be measured precisely because the loading switch revolves in close proximity to the normal load sensor. A beam-type load cell capable of measuring 1000 N measures the frictional force exerted throughout the test, and the results are shown graphically in real-time.

Approximate Hertzian contact pressure in the experimental setting is 29.1 to 87.46 MPa. As a measure of the contact stress and load distribution between the composite samples and the counterface roller, this pressure is used.

High-Temperature Tribometer [19]

A pin-on-disc tribometer (TR-20-M56, DUCOM) is a specialised test rig used to perform high-temperature tribological testing on composites and base alloys. The kind of motion, shape of pin samples, counter-surface materials, and size of the counter-surface disc are all identical to those of the previously stated pin-on-disk configuration.

The pin-on-disc tribometer allows for controlled sliding motion between the pin samples and the counter-surface disk. The shape of the pin samples, the materials used for the counter-surface, and the dimensions of the counter-surface disk remain consistent with the earlier setup. This ensures consistency in the test conditions and allows for comparative analysis of the tribological behavior of the composites and base alloys under high-temperature conditions.

By employing this specialized pin-on-disc tribometer, researchers can investigate the tribological properties of the materials at elevated temperatures, enabling a better understanding of their performance and behavior in high- temperature applications.

RESEARCH GAP

- The correlation between static and dynamic loading for the tribological behavior of composite materials/polymers/polymer composites has not been studied.
- The investigation into the tribological behavior of polymers and polymer composites under variable loading conditions is relatively scarce in the existing body of research.
- There is a need to explore effect of various dynamic loading parameters such as dynamic loading frequency, dynamic loading constant (maximum load divided by minimum load), the amplitude of load variation, multi- direction sliding, etc. on the tribological behavior of composite materials.
- It is crucial to further investigate and comprehend

the tribological behavior of various materials under diverse dynamic loading conditions such as Fluctuating load, Cyclic Load, Repeated Load, Impact Load, etc., and correlate with static loading effects by defining certain standard procedures in order to broaden our understanding in this field.

CONCLUSION AND FUTURE SCOPE

- Based on the literature review, it can be concluded that the study of the tribological behavior of various composite materials under dynamic loading conditions is limited.
- There is also a lack of research focusing on the tribological behavior of various polymers and polymer composites under dynamic loading at room and elevated temperatures.
- Furthermore, the investigation of tribological behavior with coatings on materials across different temperature ranges presents an interesting area for future research.
- While the tribological behavior of polymers in dry sliding contacts has been extensively studied, there is a need to explore their behavior in lubricated conditions, as the presence of lubricant can significantly affect their performance.
- Additionally, there is a need to investigate a wider range of polymer and polymer composite materials under dynamic loading for various industrial applications.
- The application of Design of Experiments (DOE) techniques can provide valuable insights into tribological parameters and should be considered for future investigations.
- Moreover, it is important to establish correlations between static and dynamic loading conditions, especially in situations where dynamic loading machines are not available.

In conclusion, there is a significant scope for further research in the field of tribology, particularly in studying the behavior of materials under dynamic loading conditions. Addressing these research gaps will enhance our understanding and contribute to the development of more efficient and durable materials for various applications.

REFERENCES

1. Nikhilesh Singh,R.M. Belokar "Tribological behavior of aluminum and magnesium-based hybrid metal matrix composites: A state-of-art review." Journal of Materials Today: Proceedings https://doi.org/10.1016/j.matpr.2020.09.757
2. P. Shanmukhsundaram, "The Effect of Temperature, Load and Sliding Velocity on the Wear Behavior of AA7075–SIC Composites." Journal of Mechanics and Mechanical Engineering, Vol. 21, No. 1, pp 85–93, 2017
3. Ahmed Abdelbary, "A new reciprocating tribometer for wear testing under different fluctuating loading conditions." Journal of Alexandria Engineering, Vol. (43), No. 5, pp615-619, 2004
4. H.K. Trivedi a, D.V. Bhatt, "Effect of Lubricating Oil on Tribological behavior in Pin on Disc Test Rig." Journal of Tribology in Industry Vol. 39, No. 1 (2017) pp 90-99, 2017.
5. Sanjay W Rukhande et al, "High-Temperature Tribological Investigation of APS and HVOF sprayed NiCrBSiFe coatings on SS 316L." Journal of Tribology-Materials, surfaces & Interfaces, Taylor & Francis, DOI: 10.1080/17515831.2021.1898887,2021
6. K. Sreeraj, P. Ramkumar, "Comprehensive analysis of effects of dynamic load frequency and hydrogenation to instigate White Etching Areas (WEAs) formation under severe sliding condition of bearing steel." Journal of Tribology International 144 1,06131,2020.
7. Duanjie Li et al, "A Technical report on Dynamic Load Tribology." www.researchgate.net/publication/339983221,March 2020.
8. So Young Hwang, Na Ra Lee and Naksoo Kim, "Experiment and Numerical Study of Wear in Cross Roller Thrust Bearings." Journal of Lubricants 2015, 3, 447-458; doi:10.3390/lubricants3020447
9. K. P. Lijesh, M. M. Khonsari "On the Modeling of Adhesive Wear with Consideration of Loading Sequence." Journal of Tribology Letters (2018) 66:105 Springer https://doi.org/10.1007/s11249-018-1058-2
10. Pranav Dev Srivyas, M. S. Charoo, "Tribological behavior of aluminum silicon eutectic alloy based composites under dry and wet sliding for variable load and sliding distance." Journal of SN Applied Sciences a springer nature (2020) 2:1654 | https://doi.org/10.1007/s42452-020- 03433-3

11. Partha Pratim Das and Vijay Chaudhary, "Tribological and dynamic mechanical analysis of bio-composites: A review," Materials Today Proceedings july2019

12. Alaleh Safari et al, "Effect of dynamic loading versus static loading on the frictional behavior of a UHMWPE pin in artificial bio lubricants." Journal of Biosurface and Biotribology vol 3 pp 35-40, 2017.

13. Deepak Kumar Prasad et al[ ] "An experimental approach to study the effect of wear on traction coefficient and dynamic response of roller bearing." Materials Today: Proceedings https://doi.org/10.1016/j.matpr.2021.01.408

14. Velusamy Mugesh Raja at al[], "Determination of Static and Fatigue Characteristics of Carbon Fiber Reinforced Polyester Composites for Automobile Applications." Materials Research. 2019; 22(6): e20190458 DOI: http://dx.doi.org/10.1590/1980-5373-MR-2019-0458

15. S. M. Patil and B. B. Ahuja, "Tribological Behavior of PTFE Under Variable Loading Dry Sliding Condition." Journal of Inst. Eng. India Ser. C (April–June 2014) 95(2) pp179–185, 2014

16. Lucio Raimondo, "PREDICTING THE DYNAMIC BEHAVIOUR OF POLYMER COMPOSITES." 16TH INTERNATIONAL CONFERENCE ON COMPOSITE MATERIALS

17. P.D.Pansare et al, "Tribological Behavior of PTFE Composite Material for Journal Bearing." International Journal of Innovation in Engineering,Research and Technology (IJIERT) ICITDCEME'15 Conference Proceedings, ISSN NO- 2394-3696

18. ASTM Designation: G-99 – 95a (Reapproved 2000)ε1, "Standard Test Method for Wear Testing with a Pin-on-Disk Apparatus1."

19. Abhishek Verma, Shailendra Singh Chauhan, Shashi Prakash Dwivedi. "Review paper on thermal expansion and tribological behavior of composite materials." Journal of Materials Today: Proceedings 79 (2023) 235–246 https://doi.org/10.1016/j.matpr.2022.11.073

Review on Cellulose Fibre Insulation Considering Thermal and Mechanical Properties

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ABSTRACT

In the twenty sixth session of the global meet in Conference of the Parties 26 of the United Nations Framework Convention on Climate Change in November 2021, Government of India committed that, "Zero emission target will be achieved by India till year 2070". With this commitment we can guess, necessity of reducing emission at global level. Cellulose Fibre Insulation prepared from pulp of waste news paper which is eco-friendly thermal insulation material. When compared with conventional eco friendly insulation Cellulose Fibre Insulation have required Mechanical and Thermal property with low Embodied energy. But, due to certain limitations and easily availability of conventional insulation materials Cellulose Fibre Insulation used in specific limit in industrial market. In many literatures, limitations of Cellulose Fibre insulation were reported considering thermal and Mechanical properties. To reduce thermal conductivity of cellulose Fibre insulation density of the insulation is important parameter which is consider as Mechanical property. Higher the density of Cellulose Fibre Insulation, it results in higher thermal conductivity. Hence, low density insulation manufacturing is important. By doping cellulose Fibre insulation with nanofluids its molecular property can reduce which also results in obtaining low thermal conductivity.

KEYWORDS *: Cellulose fiber insulation, Carbon footprint, Thermal conductivity, Density, Additives*

INTRODUCTION

Thermal insulation is placed between the objects to achieve low heat transfer where the surfaces having different temperature. Cellulose Fibre structure is environment friendly and can be used as insulation. It is mainly made up of recycled waste of newspapers. There are many limitations associated for using Cellulose Fibre as insulation mainly smouldering, bacterial growth and fire properties. The properties of Cellulose Fibre considering above parameters is similar to that of eco friendly insulation. The raw material required to prepare Cellulose Fibre Insulation can be obtained from waste newspaper which is easily available in the market. For the manufacturing of newspaper wood dust and cow dung is used. The pulp is processed in Mechanical and chemical treatment to get final product. Cellulose insulation is a material made from recycled newspaper. Cellulose Fibre Insulation is a structure made from recycled newspaper which is prepared mechanically by shredding inorganic salts such as boric acid and borax. The mixture of this inorganic salt is used to achieve properties like resistance to fire, mould, insects and vermin.

Fig. 1 Raw form of Paper Cellulose (blown/sprayed)

Preparation of Cellulose Fibre Insulation

Cellulose Fibre Insulation mainly comes in form of prefabricated panel. The Celluose Fibre Insulation firstly used in Canada in the year of 1919 but commercially this products introduced by US in the year of 1950.

The preparation of Cellulose Fibre Insulation takes place in following steps:

1. A bulk quantity of recycled newspaper is collected and then sorted out to remove any unwanted foreign objects from it.
2. Basically objects like clips, plastics and metal objects are removed from the newspaper along with humid paper.
3. After sorting newspaper, it passes through a Mechanical conveyor where it gets shredded in pieces.
4. Unwanted foreign objects is removed from shredded newspaper using Mechanical separators.
5. In final stage of preparation of Cellulose Fibre Insulation, air at high pressure is applied to get fragments which are light in weight.

The thermal properties of cellulose fiber insulation are as follows:

Table 1: Thermal properties of Cellulose Fibre insulation

Thermal conductivity/ λ (lambda)	0.048 W/mK
Thermal resistance at 100mm R value	2.632 K/W
Massic heat capacity	2.02 KJ/Kg.K
Density	27-65g/m3

Embodied Energy associated with Cellulose Fibre Insulation

Embodied energy is the term related to energy for manufacturing of product including transportation. For manufacturing of any product the energy is used which may obtain from conventional fuels which results in pollution, carbon emission results in global warming effect.

Table 2. Embodied energy of different insulation materials

Insulation Type	Embodied value (J/Kg)
Conventional Insulation	
45000	
Glass Gravel	27000
Cellulose	3300
Phellem	4000
Fibre glass	28000
Linen	39500
Stonewool	16600
Paper wool	20170
Mineralwool	16800
Wool (Recycled)	20900

The above data in the table indicates that Embodied energy associated with Cellulose Fibre is smallest in comparison to conventional and environment friendly insulation materials.

Properties of Cellulose Fibre Insulation

Cellulose Fibre Insulation has high flammability so it is necessary to treated with inorganic salts to get required property of smouldering resistance and combustion. To achieve this property inorganic salt like boric acid and borax is mixed with Cellulose Fibre Insulation in certain proportion. Depending on manufacture method, by weight Cellulose Fibre Insulatio is 85% or more and the remaining constituent is additive to avoid combustion and smouldering.

Fire safety requirements for Cellulose Fibre Insulation first commissioned by The US Consumer Product Safety Commission (CPSC) in 1978.

The proportionate suggests in literature by Day and Wiles: Boric acid by weight = 11.56 + 0.185*borax

LITERATURE REVIEW

Sr. No.	Author	Year	Insulation	Thermal Conductivity	Remark
1.	Hai M. Duong et. al	2016	Combination of cellulose and aerogel structure	0.0252-0.0313 W/m-K	100% aerogel used
2.	L.Senff et. al	2017	Cellulose Fibre Insulation with Nano Titanium dioxide	0.206 W/m-K	In combination with plaster Kplaster=0.17W/mK
3.	Pragya Gupta et. al	2018	Nano fibrillated cellulosic Fibres extracted from pinewood	0.0255 W/m-K	Pinewood powder is raw element
4.	Muhammet Kayfeci	2013	Comparison between different insulation for heating pipe	0.033 W/m-K	When considering optimum thickness of insulation
5.	Noboru Sekino	2016	Density and thermal conductivity relation	0.0266 W/m-K (Theoretical value)	28-44 Kg/m^3 Density
6.	Chao Tang et. al	2018	Thermal and Mechanical property of Cellulose Fibre Insulation	0.45 W/m-K	Melamine-grafted nano-SiO_2
7.	Mustafa Erturk	2016	Comparison between different insulation for heating pipe	0.040 W/m-K	Optimum insulation is rockwool compairing with xps, EPS
8.	Jianming Yang et.al.	2018	Nano Titanium Dioxide assembled with Cellulose Fibre insulations	0.23 mW/m-K	43% reduction of radiative thermal conductivity
9.	R. M. Sarviya	2017	Thermal conductivity of nano fluids	0.083 W/m-K	The thermal conductivity of Cellulose Fibre Insulation depends on nano fluids concentration

Conclusion remark from Literature Review

1. Cellulose Fibre Insulation thermal conductivity depends on density of the insulation. Higher the density higher the Thermal conductivity of the insulation.
2. Using nano TiO2 assembled fiber radiative thermal conductivity of cellulose Fiber insulation was reduced by 43%.
3. The thermal and Mechanical property of Cellulose Fibre Insulation is depends on the bunch of raw material newspaper used. Because, for manufacturing of newspaper different compositions and Mechanical processes are used.
4. To identify variation in the performance of Cellulose Fibre Insulation, it is necessary to know raw paper quality, Fibre morphology and composition of paper manufactured.
5. Cost of fuel and environmental pollution increases globally so to reduce it, insulation plays a vital role. Comparing with different insulation materials and cost of fuel, economic thickness of the insulation is calculated.

ENVIRONMENTAL IMPACT OF INSULATION

Higher the value of Embodied energy indicates that more the use of energy which is mostly obtained from conventional energy sources. Below table indicates the value of Carbon footprint of thermal insulation. Cellulose Fibre Insulation and rock wool has lowest value of Carbon Footprint.

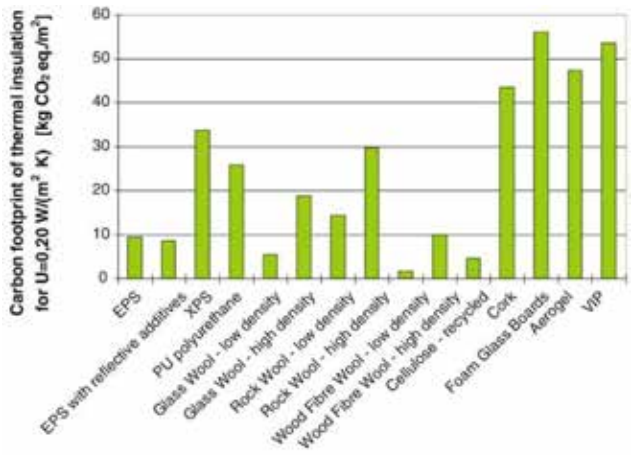

Fig. 1.Carbon footprint of thermal insulation [7]

CONCLUSION

Insulation made up of Cellulose Fibres is environment friendly insulation prepared from waste of newspapers. Embodied energy is the term related to energy for manufacturing of product including transportation. Cellulose Fibre Insulation has minimum value of Embodied Energy in comparison with various available insulations which is 3.3MJ/Kg. Though Embodied energy is positive side for Cellulose Fibre Insulation, smouldering and high flammability is disadvantage on another side. To overcome pitfalls of Cellulose Fibre Insulation regarding smouldering and high flammability, inorganic salts like borax and boric acid is mixed by volume during insulation preparation. Other additives like aluminium trihydrate, ammonium phosphate, aluminium sulphate and ammonium sulphate also lower effect of smouldering and high flammability of Cellulose Fibre Insulation. Cellulose Fibre Insulation is effective and environemtn friendly insulation when doping with additives and keeping low density.

REFERENCES

1. Hai M. Duong and Son T. Nguyen, Nano and Biotech Based Materials for Energy Building Efficiency, DOI 10.1007/978-3-319-27505-515 (2016)
2. L. Senff, G. Ascensao, V.M. Ferreira, M.P. Seabra, J.A. Labrincha, Development of multifunctional plaster using nano-TiO2 and distinct particle size cellulose FIBERs, S0378 7788(2017)30988-X, https://doi.org/10.1016/j.enbuild.2017.10.060
3. Pragya Gupta, Balwant Singh, Ashish K. Agrawal, Pradip K. Maji, Materials & Design, S0264-1275(2018)30644-0, doi:10.1016/j.matdes.2018.08.031
4. Muhammet Kayfeci, Energy and Buildings, Determination of energy saving and optimum insulation thicknesses of the heating piping systems for different insulation materials, http://dx.doi.org/10.1016/j.enbuild.2013.11.017 (2013)
5. Noboru Sekino, Density dependence in the thermal conductivity of cellulose FIBER mats and wood shavings mats: investigation of the apparent thermal conductivity of coarse pores, J Wood Sci (2016) 62:20–26 DOI 10.1007/s10086-015-1523-6
6. Chao Tang, Song Zhang, Xiaobo Wang . Jian Hao, Enhanced mechanical properties and thermal stability of cellulose insulation paper achieved by doping with melamine- grafted nano-SiO2, cellulose, Springer (2017), https://doi.org/10.1007/s10570-018-1813- 4.
7. Mustafa Erturk, Optimum insulation thicknesses of pipes with respect to different insulation materials, fuels and climate zones in Turkey, Energy 113 (2016) 991e1003
8. Jianming Yang, Huijun Wu, Moran Wang, Yuying Liang, Prediction and optimization of radiative thermal properties of nano TiO2 assembled fibrous insulations, International Journal of Heat and Mass Transfer 117 (2018) 729–739.
9. P.L. Hurtado, A. Rouilly, V. Vandenbossche, C. Raynaud, A review on the properties of cellulose fibre insulation, Build. Environ. 96 (2016) 170–177.
10. D. Kumar, M. Alam, P.X.W. Zou, J.G. Sanjayan, R.A. Memon, Comparative analysis of building insulation material properties and performance, Renew.Sustain. Energy Rev. 131 (2020) 110038.
11. L. Aditya, T.M.I. Mahlia, B. Rismanchi, H.M. Ng, M.H. Hasan, H.S.C. Metselaar, O. Muraza, H.B. Aditiya, A review on insulation materials for energy conservation in buildings, Renew. Sustain. Energy Rev. 73 (2017) 1352–1365.
12. T.H. Oh, S.C. Chua, Energy efficiency and carbon trading potential in Malaysia, Renew. Sustain. Energy Rev. 14 (7) (2010) 2095–2103.

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