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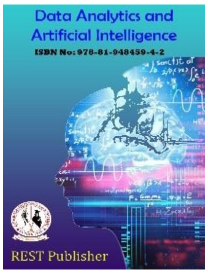

Performance Evaluation of Humanoid Robot Imitation Skills Using the MOORA Method

***Vimala Saravanan, M. Ramachandran, Chitra Periyasamy, Anusuya Mohan**
Rest Labs, Kaveripattinam, Krishnagiri, Tamilnadu, India
*Corresponding Author Email: vimalarsri@gmail.com

Abstract: *One of the key challenges in developing humanoid robots is enabling them to imitate human actions and behaviors accurately. This abstract explores the concept of humanoid robot imitation, highlighting its significance, challenges, and potential applications. Imitation is a fundamental aspect of human learning and social interaction. Humans learn by observing and imitating the actions of others, which is essential for acquiring new skills and adapting to various situations. This natural ability to imitate is a crucial factor in the development of humanoid robots, as it allows them to integrate seamlessly into human environments and assist with tasks that require human-like movements and behaviors. Understanding imitation in robots can lead to the development of more capable and versatile machines that can perform tasks in human environments***.** *As robots become more integrated into human workplaces and daily life, it's essential for them to interact seamlessly with humans. Research on imitation helps improve the ability of robots to collaborate effectively with humans, enhancing productivity and safety in shared spaces. Humanoid robots have the potential to play significant roles in social settings, like companions for the elderly, educational assistants for children, or customer service agents. Understanding imitation in robots can enhance their ability to engage socially and build trust with humans. Versatile with unique alternatives a new method for optimization is proposed MOORA. This method is objective denotes the matrix of responses of the alternatives, however, proposing better policies, which rates are used. Well established. Multi-objective another method for optimization is used for comparison, reference point method. Then, various competitions this proved to be the best choice among the methods. From the result Alter 3 is in got first rank where as Ameca is in lowest rank***.**

Keywords: *Humanoid Robots, Motion Capture Data, Balancing***,** *biped humanoid robot, human motion, imitation, Learning, dance, motion capturing system*

1. INTRODUCTION

The concept known as "Incremental Learning of Gestures by Imitation in a Humanoid Robot" involves a research or developmental approach in which a humanoid robot learns various gestures and movements by observing and emulating human actions over time. Through repeated interactions and feedback from humans, the robot gradually enhances its motor skills and comprehension of gestures. The term "incremental learning" signifies that the robot accumulates knowledge progressively rather than all at once, facilitating adaptable and flexible behavior. This area of study holds significant importance in advancing human-robot interaction because it enables robots to recognize and respond to nonverbal cues from humans, thereby enhancing their capabilities in domains such as social robotics, assistive technology, and collaborative tasks [1]. One of the primary goals of humanoid robotics research centers on enabling effective interaction between humans and robots. The success of this interaction hinges on various factors, including a humanoid robot's capability to function seamlessly in human-centric environments and its proficiency in communication. To enhance its social acceptance, a robot must adapt its actions and capabilities to mimic human characteristics. In particular, a robot's ability to move and gesture in a human-like manner greatly influences its appearance and impact on users. Consequently, controlling a robot's motion remains a challenging aspect and continues to be a pivotal research area in humanoid robotics. Addressing this challenge, imitation emerges as a natural solution, wherein the user assumes the role of a teacher, demonstrating how to perform a specific task, and the robot endeavors to replicate the action based on the observed demonstration. The advantages of employing this imitation approach are evident, as demonstrated in , where an anthropomorphic arm successfully balanced a pole on its first attempt after observing a human's actions. The concept of imitation can be comprehended through two primary categories in the realm of robotics: motion imitation and imitation learning [2].The complex and interdisciplinary field of simultaneously tracking and balancing humanoid robots to mimic human motion capture data involves the integration of robotics, computer vision, and biomechanics. This entails the development of algorithms and control systems that enable humanoid robots to replicate intricate human motions recorded through motion capture technology. The tracking aspect focuses on the real-time monitoring of the robot's position and orientation using sensors and cameras, allowing it to precisely emulate human movements. Achieving a lifelike resemblance to ideal human motion requires addressing challenges related to sensor fusion, kinematic modeling, and motion estimation. Balancing plays a vital role in this process. Humanoid robots must continuously adjust their posture and weight distribution to maintain stability while performing dynamic and sophisticated maneuvers. Balancing algorithms make instant adjustments to joint angles and torque distribution, especially when the robot diverges from the reference motion or encounters unexpected disturbances. Achieving simultaneous tracking and balancing in humanoid robots for mimicking human motion capture data is a formidable technological challenge.

Furthermore, success in this field not only enhances our comprehension of human movement but also has practical applications in areas such as robotics-assisted therapy, entertainment, and human-robot collaboration. In these applications, robots need to interact with humans safely and naturally by accurately mirroring human actions with grace and precision[3]A humanoid robot that acquires gesture skills through imitation achieves this by observing and mimicking human movements. This is accomplished by employing a combination of sensors, machine learning algorithms, and motor control systems. Initially, the robot uses its sensory equipment, including cameras and accelerometers, to capture and interpret the movements and postures demonstrated by a human instructor. After processing, these sensory inputs are transformed into a format that the robot's control system can utilize. Through the application of advanced machine learning techniques like deep neural networks, the robot gradually learns to associate observed gestures with the corresponding motor commands required to replicate them accurately. With consistent practice and improvement, the robot refines its motor skills, adapting its actions to closely resemble those of the human model. This iterative process allows the robot to construct a repertoire of gestures, enabling it to communicate with people in a more natural and intuitive manner. Such capabilities have wide-ranging applications across various domains, including human-robot collaboration, assistive technology, and entertainment[4]The development of a bipedal humanoid robot capable of observing and imitating human dance movements is achieved by employing a task model primarily focused on lower body motion. This model comprises task primitives, defining "what" actions to perform, and skill parameters, specifying "how" to execute them. By applying this framework, we extract a series of task primitives and their corresponding skill parameters from human motion data. Subsequently, the robot replicates these motions under its control, resulting in lower body movements that closely resemble human actions, including various waist and leg movements.When applied to a real robot equipped with its own leg support system, the generated motions can be executed with stability. In our experimentation, we utilized the HRP-2, a more advanced robot with enhanced features such as increased body weight, actuators, and degrees of freedom in the waist. With this setup, we successfully orchestrated a robot dance performance, featuring a traditional Japanese dance, synchronized with the movements of a human grand master performing on the same stage. This achievement was made possible through the utilization of the proposed methodology and the capabilities of the HRP-2 robot [5].

The innovative Robota project has set out to create a miniature humanoid robot designed exclusively for the rehabilitation and support of children dealing with autism. Autism spectrum disorder (ASD), a complex neurodevelopmental condition, often poses challenges for youngsters in acquiring social and communication skills. To address this issue, Robota introduces a novel and enjoyable therapeutic tool. Utilizing advanced artificial intelligence algorithms and sensors, this compact humanoid robot interacts with children in a personalized manner, tailoring its responses to their specific needs and preferences. Through interactive games, exercises in verbal and non-verbal communication, and its ability to recognize emotions, Robota fosters social engagement, communication, and emotional understanding within a safe and non-threatening environment. Ultimately, the goal of Robota is to enhance the quality of life and developmental outcomes for children with autism by combining cutting-edge technology with a compassionate approach, offering them a promising path toward improved social integration and communication skills.The Learning from Observation (LFO) approach, as introduced by Ikeuchi and Suehiro in 1994, offers a method for a robot to acquire the ability to perform a task merely by observing examples demonstrated by a human instructor. This article proposes a framework for teaching dance movements, including intricate leg motions, using the LFO paradigm. When a biped humanoid robot replicates these learned dance routines, the framework empowers the robot to independently support its own body weight on its legs. This represents a distinctive endeavor in the realm of humanoid robotics. Dance performances serve as an effective means for mastering whole-body movements, and they are particularly valuable for addressing fundamental challenges associated with learning dynamic whole-body motions, given their diverse range of dynamic actions involved [7].In the latter part of the study, at the "Centre for Treatment of Autistic Disorders (CTAD)," clinical therapies for autistic children between the ages of 3 and 10 are initiated, and this phase spans a minimum of 10 weeks. The approach being employed here is the single subject approach. Within these therapy sessions, robots are integrated to assess the extent to which autistic children initiate and respond to joint attention, as well as to gauge any improvements in their social and imitation abilities. Furthermore, the aim is to create a positive, engaging, and stimulating learning environment for students with autism. Additionally, therapists are being trained to incorporate robots at different stages of the treatment process [8]The system consists of three main components: memorization for replicating movements, real-time control for balancing the robot, and generating different postures. The robot's learning of balance and motion replication relies on identifying crucial poses. The similarity between these poses is evaluated using dissimilarity values, which are associated with the prohibited spatiotemporal patterns in simultaneous joint motion. The key poses derived from human demonstrator movements are adapted through a Q-Learning process. This process considers the robot's kinematic constraints and maintains its balance during imitation, addressing differences in mechanical structures and joint counts between the robot and human demonstrators. Furthermore, the rewards provided to the robot aim to encourage it to perform consecutive postures while also helping it maintain balance, even in cases where it lacks knowledge about the ankle joint. These adjusted key postures are stored in databases for future playback or the creation of new movements in an organized manner. The results of the experiment demonstrate that a robot can autonomously learn to mimic human motions by adapting poses from demonstrator movements to its stable static states. Hidden Markov Models (HMMs) serve the purpose of capturing generalized patterns from repetitive robot movements. These models undergo a training phase where they learn the distinctive characteristics or key elements of each demonstrated movement. Only those key elements that consistently appear across all demonstrations are identified using the same HMM and considered when reproducing the movement. Furthermore, we illustrate the application of HMMs in dual-arm tasks, where they are employed to uncover the temporal relationships between the movements of both arms. To mimic the replication of dual-arm actions and generate lifelike joint configurations based on monitored hand trajectories, we constructed a model of the human upper body. The research outcomes are presented and thoroughly discussed [10].Adults possess the capacity to recognize social cues that underlie shared attention, such as indicators like eye gaze or pointing gestures. These abilities enable infants to establish common experiences and play a vital role in the development of more intricate communication skills, which, in turn, serve as the fundamental building blocks for more complex concepts like metaphor and analogy. In this chapter, we explore the evolution of these social capabilities, drawing from evidence in developmental psychology and social development issues such as autism, along with a focus on joint attention skills. Furthermore, we introduce Cog, an upper-torso humanoid robot designed partly to investigate the construction of intelligent robotic systems by mirroring a developmental progression analogous to that of humans. Our robot is designed to learn how to interact with humans using natural social communication, much like a toddler learns social norms and skills through interactions with caregivers. Additionally, we consider the critical role of imitation in advancing a system from basic visual behaviors to more sophisticated social abilities. We will present data from a facial and ocular detection system, which serves as the foundation for this developmental sequence, and demonstrate how this system can replicate a person's head movements [11]Teaching a robot new information can be a time-consuming and labor-intensive task. To expedite this process, we've developed a unique template-based method for mimicking robot arm movements. This method leverages a combination of techniques focused on minimizing distortion and energy consumption. Essentially, our algorithm selects a previously observed path demonstrated by a human and constructs a new path in a different context by mapping invariant feature locations present in both the original demonstration and the new situation. This One-Shot Learning algorithm is versatile and can handle simple point-to-point routes as well as more complex tasks involving specific waypoints. What sets our approach apart from traditional methods is that it doesn't require costly real-time computations for accuracy or extensive training for generalization. We have tested and implemented this algorithm practically on the iCub humanoid robot, particularly in the context of playing tic-tac-toe. Its effectiveness has been statistically validated through cross-validation during grasping tests [12] Motion mimicry using humanoid robots involves a three-stage process for its implementation. The initial stage comprises collecting human motion data, followed by the adaptation of this data, and finally, adjusting the ankle angle on the supporting foot (or feet) of the humanoid robot. The acquisition of human motion data involves identifying and tracking 13 markers placed on a person's body using a webcam, and subsequently, recording and storing the relative positions of these markers for each motion in a motion database. The modification of motion data aims to ensure that the robot's zero moment point remains within the stable region, which is achieved by simulating the recorded motion data. Finally, the adjustment of ankle angles on the supporting foot (or feet) relies on measurements from force sensors located on the robot's soles. This adjustment enables the humanoid robot to imitate human movements while maintaining real-time balance. The experimental results demonstrate the robot's ability to faithfully replicate various gymnastic movements performed by humans[13]The primary objective is to utilize a camera-like device, specifically the Microsoft Kinect, to establish a natural interface with the human body for the purpose of remotely controlling a humanoid robot, namely the Aldebaran Robotics Nao robot. In our approach, we do not employ any sensors attached to or placed around the user; instead, we rely solely on gesture-like movements to manipulate the humanoid robot. Furthermore, this study illustrates how Kinect-like devices can enable teleoperation through fundamental mathematical principles. The research presented here encompasses two main tasks: the real-time simulation of independent movements of a human's neck, arms, and legs, as well as the recognition of predefined human movements to instruct the robot in performing specific actions. It's important to clarify that although we use the term "imitation," this work does not fall under the category of imitation learning, as it does not involve the use of learning algorithms. Instead, we employ a real-time mapping of human postures to the robot, facilitating mimicry of movements [14].

2. MATERIAL AND METHODS

2.1Benefit Score: the specific meaning of a "benefit score" can vary widely depending on the context in which it is used. It generally refers to a rating or assessment of the advantages, value, or benefits associated with a particular situation, product, service, or decision. The criteria for calculating such a score would depend on the specific domain or purpose for which it is used.

2.2Durability: In manufacturing, durability is a critical consideration when designing and producing goods. Manufacturers aim to create products that can withstand the rigors of regular use without breaking or deteriorating prematurely. For example, durable construction materials, such as concrete or steel, are used in building infrastructure because of their ability to withstand weathering and stress. Consumer Goods: In the context of consumer goods, durability is a key factor when choosing products such as appliances, electronics, and vehicles. Consumers often seek products that will last a long time and provide good value for their investment. Automotive Industry: Cars and other vehicles are expected to be durable, as they are subjected to various environmental and mechanical stresses. Durability testing is a common practice in the automotive industry to ensure that vehicles can withstand harsh conditions and long-term use.

2.3Cost $: Cost, often referred to simply as "$" or "dollar cost," is a fundamental economic concept that represents the monetary value associated with acquiring goods or services. It encompasses not only the price of the item itself but also any additional expenses or sacrifices incurred in the process. These expenses can include taxes, shipping fees, maintenance costs, and opportunity costs, which represent the value of the next best alternative foregone when a particular choice is made. Understanding cost is crucial for businesses and individuals alike, as it plays a central role in decision-making processes, budgeting, pricing strategies, and evaluating the feasibility and profitability of various endeavors. By analyzing and managing costs effectively, individuals and organizations can optimize resource allocation and make informed choices to achieve their financial goals.

Method: Rational multi-objective analysis (MOORA) This optimization was achieved. The second MOORA property is dimensionless numbers. The foundation will be this. Ultimately compares the disparities in wellbeing throughout Lithuania's 10 counties in light of all the goals. The three affluent districts stand in stark contrast to some of the least fortunate ones. A key issue that symbolizes income is the labor migration from all other districts to Vilnius district. Condemned is automatic redistribution. Instead Commercialization and industrialization should develop in some areas [15].concrete multi-objective optimization The system can be simultaneously improved within restrictions or more conflicting attributes (notes). Design issues with products and multi-goal optimization .There are various areas where the best decisions must be made. 2. or between competing interests when there are commercial exchanges. Increasing sales and lowering product costs enhancing performance while lowering automobile fuel consumption, minimizing weight while amplifying problems, and[16]. MOORA requires little to no setup because the literature implies that it takes time and has a constant personality [17].The MOORA device is a decision-support tool for picking college students who get scholarships in order to boost academic success. The institution has a tool meant to help with decision-making called MOORA that may be used to tackle a variety of issues. Utilizing a machine selection process, scholarship candidates can be chosen swiftly to increase educational performance while benefiting needy students [18]. Amazing is MOORA. A green multi-criteria selection method for a thorough analysis of options that deals with significant heterogeneity and a variety of helpful components. For the purpose of effectively resolving complicated decision-making issues, the MOORA approach is presented. This method typically produces grades that are rigidly contradicting. Thinks about and tries to choose the optimal solution while taking into account both favorable and unfavorable standards. Some of MOORA's decisions are rewarded for their technique [19].A MOORA is a technique for multi-objective optimization. There are several types of traits and techniques that are used for some people to go through and progress at the same time. MOORA is all about trying different things. a useful approach strategy. Constraints [20].The MOORA method is able to remember all characteristics and their respective weights, leading to a higher evaluation of alternatives. The MOORA approach may be simple to understand and apply. The suggested method is generic and is applicable to any size and quality combining the features leads to more precise targeting and a more straightforward decision-making process. Additionally, this strategy can be applied to any type of decision problem[21].MOORA, or multiple criteria or multiple features, stands for multi-goal optimization based mostly on ratio analysis. Optimization is an upgrading mechanism that simultaneously considers two or more attributes that are in dispute (notes). This timed offers a wide range of programmers for decision-making in the contentious and a difficult aspect of the environment of the supply chain Choosing the location of the warehouse, the supplier, the product, and the method design are only a few examples. MOORA can be employed when the best options are needed [22].According to the failure prioritizing achieved by the use of the extension in MOORA, it is evident that every single failure that has been identified is listed in excellent priorities. In other words, the suggested strategy seeks to mitigate a number of significant drawbacks of RPN score and also for selection method in regular MOORA Provides reliability by connecting the use of range idea. Ultimately, deliver logical results to the decision-maker. of this method The comparison of the outcomes with the two various conventional procedures reveals that complete prioritization of catastrophes is carried out and that disasters are discovered[23].THE ANALYSIS BY MOORA Again, the study of earlier scholars is more recent, and as a result, MOORA and MOOSRA techniques are thought to utilize the most recent statistics available. for the first method of selection Basically. As a result of the explanation above, MOORA and MOOSRA method is used for the choice problem. Complementary, resulting in variety and non-conventional In a production setting, this approach is quite reliable. If this ratio is expressed, it is advantageous at the expense of the denominator. It is a favored performance for measuring economic welfare because the value becomes the same for the ratio. As a result, this MOORA and The MOOSRA methodology is compatible from an ideological standpoint with other mounting performance evaluation approaches [24].both the ratio device and the benchmark MOORA technique with component component. We choose the kind and significance of goals and options because our simulation of port planning is all that is important to us. The relevant parties include local, state, and federal governments as well as cooperating organizations. Only implicitly is consumer sovereignty related to the industrial process. However, authorities have also been regarded as legitimate clients' representatives [25].teamwork by MOORA Information that is subjective, unreliable, and contradictory CNC machine tool supplied to address value issues atmosphere for making decisions. Because this period of time combines the fuzziness and aids the decision-makers in integrating a variety of fuzzily expressed language variables. The various MULTI-MOORA Ranking orders provided by regions are discussed in this page. The outcome is summed up through comparison [26]

3. RESULT AND DISSCUSSION

TABLE 1. Humanoid robot and imitation

	Benefit Score	**Durability**	**Cost $**	**Accuracy (%)**
Ameca	3.5	4	20000	90
Alter 3	4	5	18000	95
ARMAR-6	3	6	22000	85
Astro	3.8	4.5	19500	92
Apollo	4.5	3.5	17800	98

Table 1 shows comparison of humanoid robot and imitation This represents the overall perceived benefit of each robot. Higher scores indicate a higher perceived benefit. Based on the benefit scores, "Apollo" has the highest score (4.5), followed by "Astro" (3.8), "Ameca" (3.5), "ARMAR-6" (3), and "Alter 3" (4). Durability is an essential factor, especially in robotics, as it affects long-term performance and maintenance costs. "Alter 3" has the highest durability rating (5), followed by "Astro" (4.5), "Ameca" (4), "ARMAR-6" (6), and "Apollo" (3.5). Cost is a significant consideration for most projects. "Apollo" is the most affordable robot, priced at $17,800, followed by "Alter 3" at $18,000, "Astro" at $19,500, "Ameca" at $20,000, and "ARMAR-6" at $22,000. Accuracy is crucial for tasks requiring precision. "Apollo" has the highest accuracy rating (98%), followed by "Alter 3" (95%), "Astro" (92%), "Ameca" (90%), and "ARMAR-6" (85%).

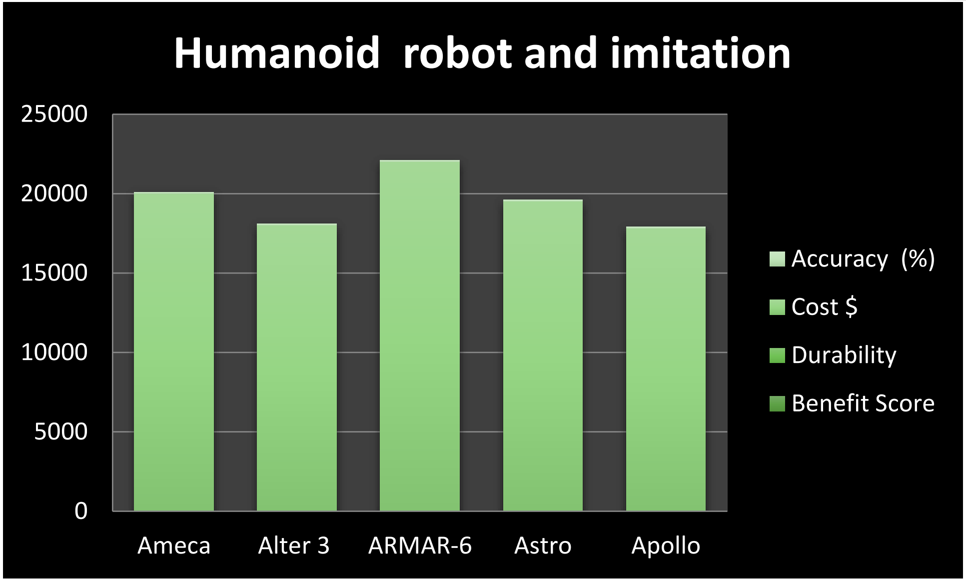

FIGURE1. Humanoid robot and imitation

Figure1 illustrates the graphical representation of Humanoid robot and imitation.

TABLE 2. Divide & Sum

12.2500	16.0000	400000000.0000	8100.0000
16.0000	25.0000	324000000.0000	9025.0000
9.0000	36.0000	484000000.0000	7225.0000
14.4400	20.2500	380250000.0000	8464.0000
20.2500	12.2500	316840000.0000	9604.0000
71.9400	**109.5000**	**1905090000.0000**	**42418.0000**

Table 2 shows the Divide & Sum matrix formula used this table.

TABLE 3. Normalized Data

Normalized Data			
Benefit Score	Durability	Cost $	Accuracy (%)
0.4127	0.3823	0.4582	0.4370
0.4716	0.4778	0.4124	0.4613
0.3537	0.5734	0.5040	0.4127
0.4480	0.4300	0.4468	0.4467
0.5306	0.3345	0.4078	0.4758

$$X_{n1} = \frac{X1}{\sqrt{(X1)^2 + (X2)^2 + (X3)^2 \ldots}} \ldots \ldots \ldots \ldots \ldots (1)$$

Table 3 shows the various Normalized Data, Alternative: Ameca, Alter 3, ARMAR-6, Astro, Apollo Evaluation preference: Benefit Score, Durability, Cost $, Accuracy (%). Normalized value is obtained by using the formula (1).

TABLE 4. Weight

Weight			
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25

$$X_{wnormal1} = X_{n1} \times w_1 \ldots\ldots\ldots\ldots \quad (2)$$

TABLE 5. Weighted normalized decision matrix

Weighted normalized decision matrix			
0.1032	0.0956	0.1146	0.1092
0.1179	0.1195	0.1031	0.1153
0.0884	0.1433	0.1260	0.1032
0.1120	0.1075	0.1117	0.1117
0.1326	0.0836	0.1020	0.1190

Table 4 shows weight and Table 5 shows the Weighted normalized decision matrix, Alternative: Ameca, Alter 3, ARMAR-6, Astro, Apollo Evaluation preference: Benefit Score, Durability, Cost $, Accuracy (%). The weighted default result is calculated using the matrix formula (2).

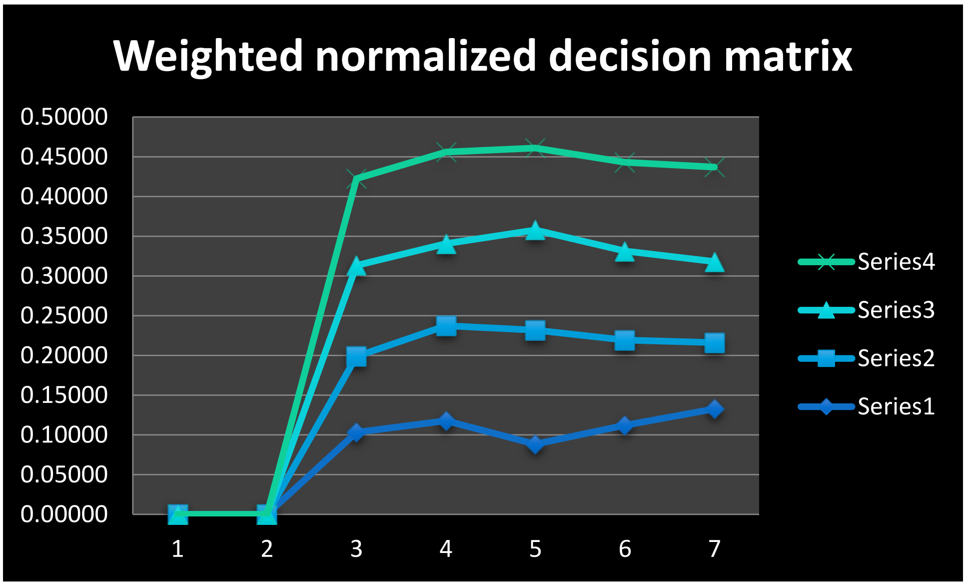

FIGURE 2. Weighted normalized decision matrix

Figure 2 illustrates the graphical representation of weighted normalized decision matrix.

TABLE 5. Assessment value & Rank

Assessment value	**Rank**
-0.0251	5
0.0189	1
0.0026	2
-0.0039	3
-0.0047	4

$$\text{Assesment value} = \sum X_{wn1} + X_{wn2} - X_{wn3} \qquad (3).$$

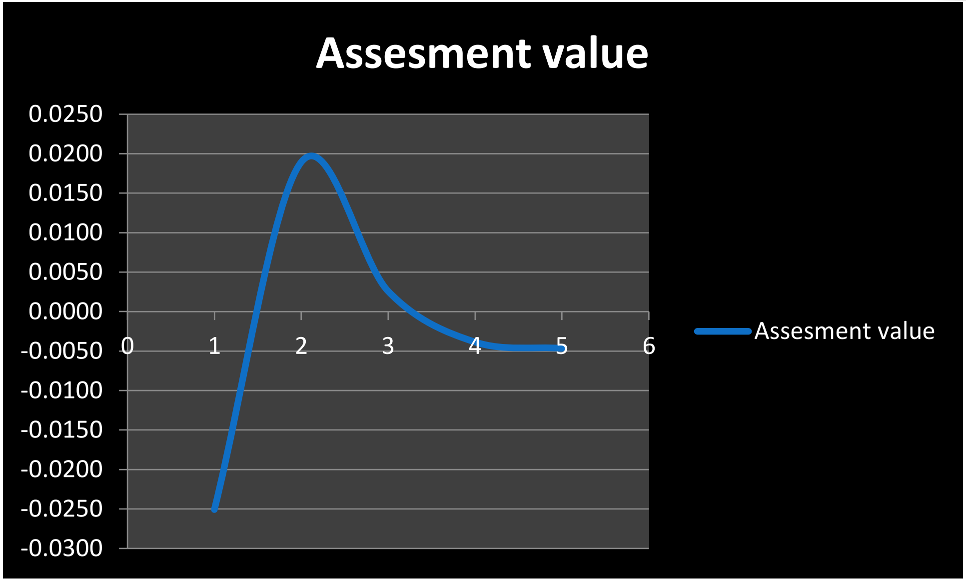

FIGURE 3. Assessment value

Figure 3 shows illustrate graphical representation of assessment value

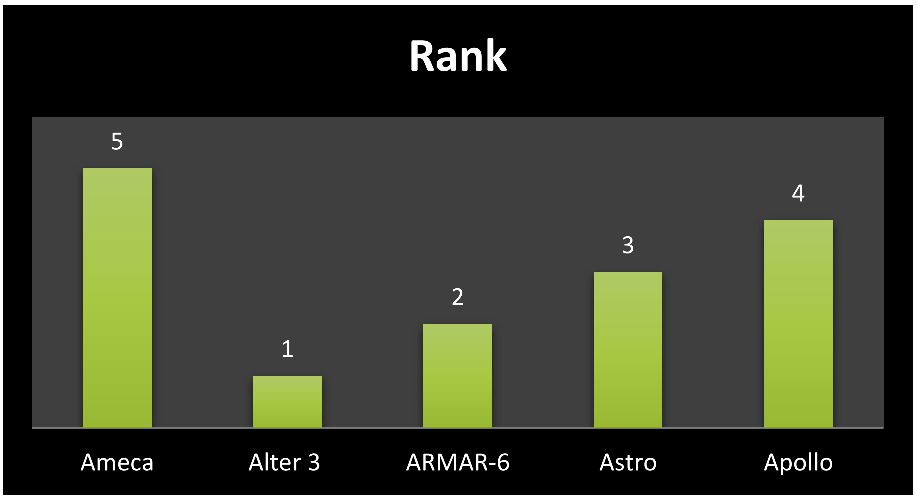

FIGURE 4. Rank

Figure 4 shows the graphical view of the final rank of this paper Astro is in 3rd rank, ARMAR-6 is in 2nd rank, Apollo is in 4th rank, Ameca is in 5th rank, and the Alter 3 is in 1st rank. The final result is done by using the MOORA method.

4. CONCLUSION

Humanoid robots and imitation represent a compelling and transformative intersection of technology and human interaction. These remarkable machines, designed to mimic human form and behavior, have the potential to revolutionize various facets of our society. Humanoid robots have already made significant strides in industries such as healthcare, manufacturing, and customer service, where their ability to replicate human movements and perform intricate tasks with precision is invaluable. Moreover, they hold promise in aiding individuals with disabilities, providing companionship to the elderly, and even assisting in disaster response scenarios, where their human-like abilities can prove life-saving. However, the imitation aspect of humanoid robots raises intriguing questions about the ethical and societal implications of blurring the lines between human and machine. As these robots become more sophisticated in replicating not just physical appearance but also emotions and cognitive abilities, we must grapple with concerns related to privacy, identity, and employment. The potential for humanoid robots to deceive or manipulate humans is a pressing issue that must be carefully monitored and regulated. Nonetheless, imitation in humanoid robots also offers tremendous opportunities for enhancing human-robot collaboration and improving human lives. By imitating human gestures, expressions, and communication styles, these robots can foster more natural and intuitive interactions, making them more accessible and user-friendly. They can serve as effective tools for education, therapy, and social integration, particularly for individuals with social or emotional challenges. Humanoid robots and imitation are poised to play an increasingly influential role in our society. Their ability to replicate and imitate human qualities presents both promise and peril. It is imperative that we strike a balance between harnessing the advantages of these robots in various domains while establishing robust ethical frameworks to safeguard against potential misuse. The future of humanoid robots lies in our ability to responsibly navigate this fascinating frontier, where technology and humanity converge.

REFERENCES

[1]. Calinon, Sylvain, and Aude Billard. "Incremental learning of gestures by imitation in a humanoid robot." In *Proceedings of the ACM/IEEE international conference on Human-robot interaction*, pp. 255-262. 2007.

[2]. Do, Martin, Pedram Azad, Tamim Asfour, and Rudiger Dillmann. "Imitation of human motion on a humanoid robot using non-linear optimization." In *Humanoids 2008-8th IEEE-RAS International Conference on Humanoid Robots*, pp. 545-552. IEEE, 2008.

[3]. Sreeram, Indraneel, and Venkata Praveen Kumar Vuppala. "HTTP flood attack detection in application layer using machine learning metrics and bio inspired bat algorithm." *Applied computing and informatics* 15, no. 1 (2019): 59-66.

[4]. Raja, SM Naveen, Gayatri Parasa, Thangiah Sathish Kumar, Kondalarao Punati, Pradeep Balasubramani, Koppuravuri Gurnadha Gupta, G. Bhuvaneswari, Y. S. Lalitha, and Sami Anand. "A reforming municipal waste management model with the internet of things (IoT) for smart garbage tracking and optimization." In *MATEC Web of Conferences*, vol. 392, p. 01117. EDP Sciences, 2024.

[5]. Yamane, Katsu, and Jessica Hodgins. "Simultaneous tracking and balancing of humanoid robots for imitating human motion capture data." In *2009 IEEE/RSJ International Conference on Intelligent Robots and Systems*, pp. 2510-2517. IEEE, 2009.

[6]. Calinon, Sylvain, and Aude Billard. *Learning of gestures by imitation in a humanoid robot*. No. BOOK_CHAP. Cambridge University Press, 2007.

[7]. Nakaoka, Shinichiro, Atsushi Nakazawa, Fumio Kanehiro, Kenji Kaneko, Mitsuharu Morisawa, and Katsushi Ikeuchi. "Task model of lower body motion for a biped humanoid robot to imitate human dances." In *2005 IEEE/RSJ International Conference on Intelligent Robots and Systems*, pp. 3157-3162. IEEE, 2005.

[8]. Billard, Aude, Ben Robins, Jacqueline Nadel, and Kerstin Dautenhahn. "Building robota, a mini-humanoid robot for the rehabilitation of children with autism." *Assistive Technology* 19, no. 1 (2007): 37-49.

[9]. Nakaoka, Shin'ichiro, Atsushi Nakazawa, Fumio Kanehiro, Kenji Kaneko, Mitsuharu Morisawa, Hirohisa Hirukawa, and Katsushi Ikeuchi. "Learning from observation paradigm: Leg task models for enabling a biped humanoid robot to imitate human dances." *The International Journal of Robotics Research* 26, no. 8 (2007): 829-844.

[10]. Taheri, A. R., M. Alemi, A. Meghdari, H. R. Pouretemad, and S. L. Holderread. "Clinical application of humanoid robots in playing imitation games for autistic children in Iran." *Procedia-Social and Behavioral Sciences* 176 (2015): 898-906.

[11]. VUPPALA, VENKATA PRAVEEN KUMAR, PAZHANIRAJAN SAMBANDAM, and INDRANEEL SREERAM. "An efficient point-of-interest recommendation for LOcation-based social networks system with spatio-temporal model." (2022).

[12]. Lin, Jin-Ling, and Kao-Shing Hwang. "Balancing and reconstruction of segmented postures for humanoid robots in imitation of motion." *IEEE Access* 5 (2017): 17534-17542.

[13]. Asfour, Tamim, Pedram Azad, Florian Gyarfas, and Rüdiger Dillmann. "Imitation learning of dual-arm manipulation tasks in humanoid robots." *International journal of humanoid robotics* 5, no. 02 (2008): 183-202.

[14]. Scassellati, Brian. "Imitation and mechanisms of joint attention: A developmental structure for building social skills on a humanoid robot." In *International Workshop on Computation for Metaphors, Analogy, and Agents*, pp. 176-195. Berlin, Heidelberg: Springer Berlin Heidelberg, 1998.

[15]. Suresh, G., G. Bhuvaneswari, G. Manikandan, and P. Shanthakumar. "Chronological bald eagle optimization based deep learning for image watermarking." *Expert Systems with Applications* 238 (2024): 121545.

[16]. Wu, Yan, and Yiannis Demiris. "Towards one shot learning by imitation for humanoid robots." In *2010 IEEE international conference on robotics and automation*, pp. 2889-2894. IEEE, 2010.

[17]. Liu, Hsin-Yu, Wen-June Wang, Rong-Jyue Wang, Cheng-Wei Tung, Pei-Jui Wang, and I-Ping Chang. "Image recognition and force measurement application in the humanoid robot imitation." *IEEE Transactions on instrumentation and measurement* 61, no. 1 (2011): 149-161.

[18]. VENKATESWARARAOCHEEKATI, DR D. NATARAJASIVAN, and DRS INDRANEEL. "GENERIC FRAMEWORK FOR EARLY PREDICTION OF HEART DISEASE USING LEARNING METHOD." Journal of Theoretical and Applied Information Technology 100, no. 17 (2022).

[19]. Mekala, Sreenivas, M. Bhuvana, Dev Brat Gupta, Vinod Bhatt, Pankaj Kunekar, and Geetha Manoharan. "Natural Language Processing and Deep Learning Techniques to Improve Sentiment Analysis in Social Media Texts."

In *2023 6th International Conference on Contemporary Computing and Informatics (IC3I)*, vol. 6, pp. 1751-1755. IEEE, 2023.

[20]. Murugamani, C., Santosh Kumar Sahoo, Pravin R. Kshirsagar, Boppuru Rudra Prathap, Saiful Islam, Quadri Noorulhasan Naveed, Mohammad Rashid Hussain, Bui Thanh Hung, and Dawit Mamiru Teressa. "Wireless communication for robotic process automation using machine learning technique." *Wireless Communications and Mobile Computing* 2022, no. 1 (2022): 4723138.

[21]. Gogulamudi, Subbarao, V. Mahalakshmi, and Indraneel Sreeram. "Rain Streaks Removal in Images using Extended Generative Adversarial-based Deraining Framework." *International Journal of Advanced Computer Science and Applications* 14, no. 4 (2023).

[22]. Zuher, Fernando, and Roseli Romero. "Recognition of human motions for imitation and control of a humanoid robot." In *2012 Brazilian Robotics Symposium and Latin American Robotics Symposium*, pp. 190-195. IEEE, 2012.

[23]. Beaver, William H., and Joel S. Demski. "The nature of financial accounting objectives: A summary and synthesis." *Journal of Accounting Research* (1974): 170-187.

[24]. Hines, Ruth D. "Financial accounting: in communicating reality, we construct reality." *Accounting, organizations and society* 13, no. 3 (1988): 251-261.

[25]. Malarvizhi, N., and V. Rhymend Uthariaraj. "A broker-based approach to resource discovery and selection in Grid environments." In *2008 International Conference on Computer and Electrical Engineering*, pp. 322-326. IEEE, 2008.

[26]. Kumar, VV Praveen, Vutukuri Sai Mounika, Bandaru Gayathri, Yelchuri Venkata Sudheshna, Kaki Sandhya, and Gogulapati Glory. "IOT ENABLED REAL-TIME DIGITAL CAMPUS NOTICE BOARD." *International Journal of Engineering Research and Science & Technology* 21, no. 2 (2025): 1307-1316.

[27]. Kumar, Bishwajeet, and A. Ranjith Kumar. "Topographic-Heterogeneous Energy Based (T-HEB) Routing Protocol for Wireless Sensor and IoT Based Networks." In *2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN)*, pp. 650-655. IEEE, 2023.

[28]. Varma, P. Bharat Siva, Prathap Adimoolam, Yamini Lahari Marna, Anantharamaiah Vengala, VS Divya Sundar, and MVT Ram Pavan Kumar. "Enhancing robust object detection in weather-impacted environments using deep learning techniques." In *2024 2nd International Conference on Self Sustainable Artificial Intelligence Systems (ICSSAS)*, pp. 599-604. IEEE, 2024.

[29]. Hines, Ruth D. "Financial accounting knowledge, conceptual framework projects and the social construction of the accounting profession." *Accounting, Auditing & Accountability Journal* 2, no. 2 (1989): 0-0.

[30]. Bushman, Robert M., and Abbie J. Smith. "Financial accounting information and corporate governance." *Journal of accounting and Economics* 32, no. 1-3 (2001): 237-333.

[31]. Aswathy, R. H., and N. Malarvizhi. "A design of lightweight ECC based cryptographic algorithm coupled with linear congruential method for resource constraint area in IoT." *Journal of Ambient Intelligence and Humanized Computing* 14, no. 5 (2023): 5097-5106.

[32]. Naveen Kumar Polisetty, S., T. Sivaprakasam, and S. Indraneel. "A Narrative Framework with Ensemble Learning for Face Emotion Recognition." In *Intelligent Computing and Applications: Proceedings of ICDIC 2020*, pp. 159-167. Singapore: Springer Nature Singapore, 2022.

[33]. Patthi, Sridhar, and T. Sathish Kumar. "Improving Medical Knowledge and Diagnostic Accuracy of Type-2 Diabetes Mellitus Through Probabilistic GRU-Oriented Problem-Based Learning." In *2024 2nd International Conference on Artificial Intelligence Trends and Pattern Recognition (ICAITPR)*, pp. 1-6. IEEE, 2024.

[34]. Eskew, Robert K., and Robert H. Faley. "Some determinants of student performance in the first college-level financial accounting course." *Accounting Review* (1988): 137-147.

[35]. Srivani, Alla, Gurram VeeraRaghavaiah, Nagaraju Dasari, and Srinivasa Rao Bogireddy. "Emerging Trends in Chat GPT for Computational Material Science." *Methods* (2024).

[36]. Bhuvneswari, G., and G. Manikandan. "Recognition of ancient stone inscription characters using histogram of oriented gradients." In *Proceedings of International Conference on Recent Trends in Computing, Communication & Networking Technologies (ICRTCCNT)*. 2019.

[37]. Sreeram, Indraneel, and Venkata Praveen Kumar Vuppala. "Voice Enabled ATMS and Deployment of Wavelets for Recognition and Authentication of Voice Based Inputs." *i-Manager's Journal on Computer Science* 4, no. 4 (2016): 25.

[38]. Ragavan, V. K., N. S. Nithya, Anantharamaiah Vengala, Balambigai Subramanian, and C. Ambhika. "Refractive Index Biosensor–Based Detection of Mycobacterium Tuberculosis Using Sea Lion Political Optimizer and Deep Learning." *Plasmonics* (2025): 1-19.

[39]. Chakraborty, Shankar. "Applications of the MOORA method for decision making in manufacturing environment." *The International Journal of Advanced Manufacturing Technology* 54, no. 9 (2011): 1155-1166.

[40]. Selvarani, P., Annamalai Suresh, and N. Malarvizhi. "Secure and optimal authentication framework for cloud management using HGAPSO algorithm." *Cluster Computing* 22, no. Suppl 2 (2019): 4007-4016.

[41]. Shanthala, P. T., and D. Annapurna. "An improved IoT based security model for fitness tracker using quantum fruit fly optimization improved faster RCNN." *International Journal of Information Technology* 15, no. 7 (2023): 3623-3629.

[42]. Akkaya, Gökay, BetülTuranoğlu, and Sinan Öztaş. "An integrated fuzzy AHP and fuzzy MOORA approach to the problem of industrial engineering sector choosing." *Expert Systems with Applications* 42, no. 24 (2015): 9565-9573.

[43]. Siregar, Victor MarudutMulia, Mega RomaulyTampubolon, EkaPratiwiSeptaniaParapat, Eve Ida Malau, and Debora Silvia Hutagalung. "Decision support system for selection technique using MOORA method." In *IOP Conference Series: Materials Science and Engineering*, vol. 1088, no. 1, p. 012022. IOP Publishing, 2021.

[44]. Dabbagh, Rahim, and Samuel Yousefi. "A hybrid decision-making approach based on FCM and MOORA for occupational health and safety risk analysis." *Journal of safety research* 71 (2019): 111-123.

[45]. Ramesh, A., K. Pradeep Reddy, M. Sreenivas, and Para Upendar. "Feature selection technique-based approach for suggestion mining." In *Evolution in Computational Intelligence: Proceedings of the 9th International Conference on Frontiers in Intelligent Computing: Theory and Applications (FICTA 2021)*, pp. 541-549. Singapore: Springer Nature Singapore, 2022.

[46]. Sutarno, S., M. Mesran, S. Supriyanto, Y. Yuliana, and A. Dewi. "Implementation of Multi-Objective Optimazation on the Base of Ratio Analysis (MOORA) in Improving Support for Decision on Sales Location Determination." In *Journal of Physics: Conference Series*, vol. 1424, no. 1, p. 012019. IOP Publishing, 2019.

[47]. Kumar, KRN Kiran, and K. Bhavani. "Folded spined cube: new topology in interconnection networks." In *2022 6th International Conference on Computing Methodologies and Communication (ICCMC)*, pp. 314-319. IEEE, 2022.

[48]. Tito, Madan Mohan, Srinivasulu Thiruveedula, Sathish Kumar, Ajith Sundaram, U. Pavan Kumar, and Sneha Kapoor. "Designing a machine learning model to predict susceptibility to drug addiction." In *2024 1st International Conference on Advances in Computing, Communication and Networking (ICAC2N)*, pp. 1670-1675. IEEE, 2024.

[49]. Reddy, K. Ramakrishna, T. Sathish Kumar, Sreenivasulu Gogula, Abhisek Sethy, Veeraswamy Ammisetty, M. N. Sharath, Koppuravuri Gurnadha Gupta, Ravi Kiran, and Lavish Kansal. "Harnessing sensor fusion and AI for accurate accident detection and classification in the safety of smart cities." In *MATEC Web of Conferences*, vol. 392, p. 01102. EDP Sciences, 2024.

[50]. Attri, Rajesh, and Sandeep Grover. "Decision making over the production system life cycle: MOORA method." *International Journal of System Assurance Engineering and Management* 5, no. 3 (2014): 320-328.

[51]. Dey, Balaram, BipradasBairagi, Bijan Sarkar, and SubirSanyal. "A MOORA based fuzzy multi-criteria decision making approach for supply chain strategy selection." *International Journal of Industrial Engineering Computations* 3, no. 4 (2012): 649-662.

[52]. Kumar, A. Ranjith, R. Vinoth, and Padmanathan Kasinathan. "Opposition Based Artificial Flora Algorithm for Load Balancing in LTE Network." *Wireless Personal Communications* 118, no. 1 (2021): 141-159.

[53]. Mohan, VakaMurali, MalliKarjuna Reddy, and KRN Kiron Kumar. "A New Approach to Optical Networks Security: Attack-Aware Routing and Wavelength Assignment." In *IJCA Special Issues on "2nd National Conference-Computing, Communication and Sensor Network" CCSN*. 2011.

[54]. Ghoushchi, SaeidJafarzadeh, Samuel Yousefi, and Mohammad Khazaeili. "An extended FMEA approach based on the Z-MOORA and fuzzy BWM for prioritization of failures." *Applied Soft Computing* 81 (2019): 105505.

[55]. Sarkar, Asis, S. C. Panja, Dibyendu Das, and Bijon Sarkar. "Developing an efficient decision support system for non-traditional machine selection: an application of MOORA and MOOSRA." *Production & Manufacturing Research* 3, no. 1 (2015): 324-342.

[56]. Brauers, Willem Karel M. "Multi-objective seaport planning by MOORA decision making." *Annals of Operations Research* 206, no. 1 (2013): 39-58.

[57]. Sahu, Anoop Kumar, Nitin Kumar Sahu, and Atul Kumar Sahu. "Application of modified MULTI-MOORA for CNC machine tool evaluation in IVGTFNS environment: an empirical study." *International Journal of Computer Aided Engineering and Technology* 8, no. 3 (2016): 234-259.

[58]. Annapurna, D. "Efficient data transmission model for internet of things application." In *2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV)*, pp. 343-348. IEEE, 2021.

[59]. Pillai, Rohan, Rashmi Rao, Challa Rahul Prasad, and Apoorva Rao Iragavarapu. "DBSCAN-R: A machine learning approach for routing in opportunistic networks." In *2022 IEEE International Conference on Electronics, Computing and Communication Technologies (CONECCT)*, pp. 1-6. IEEE, 2022.

[60]. Ramya Sharma, Chinnasami Sivaji, M. Ramachandran, Prabakaran Nanjundan, "An Analysis on Sustainable Automotive Car Body Material Using Weighted Sum method", REST Journal on Emerging trends in Modeling Manufacturing, 10(3) September 2024, 9-18.

[61]. Shrivastava, Neeraj, Pushpa Tewari, S. Sujatha, Srinivasa Rao Bogireddy, Neeraj Varshney, and Vinod Sharma. "Natural Language Processing for Conversational AI: Chatbots and Virtual Assistants." In *2025 IEEE International Conference on Interdisciplinary Approaches in Technology and Management for Social Innovation (IATMSI)*, vol. 3, pp. 1-6. IEEE, 2025.

[62]. Murugamani, C. "Authenticating and Securing Ad-Hoc Networks using Gateway Selection Algorithm." *Journal of Excellence in Computer Science and Engineering* 3, no. 2 (2017).

[63]. Rani, Dr V. Vasudha, D. Vasavi, and K. Kumar. "Significance of multilayer perceptron model for early detection of diabetes over ml methods." *J. Univ. Shanghai Sci. Technol* 23, no. 08 (2021): 148-160.

[64]. Kumar, T. Sathish, Martin Margala, S. Siva Shankar, and Prasun Chakrabarti. "Enhance the growth of agriculture by predicting crop diseases using optimization and deep learning." *International Journal of System Assurance Engineering and Management* (2025): 1-12.

[65]. Chandrasekar Raja, Ramya sharma, M. Ramachandran, Vidhya Prasanth, "A Review on Selecting material suitable for a statically loaded thermal conductor using the TOPSIS Method", Journal on Applied and Chemical Physics, 3(4), December 2024, 1-12.