IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 3, October 2025
Impact Factor: 7.67

The Evolution of Brain-Computer Interfaces: From Medical Rehabilitation to Mainstream Consumer Electronics

Mr. Rushikesh Vijay Dhatinge[1], Mr. Shetsandi Mohammad Kaif Khajabhai[2], Mr. Tosif Liyakat Khadke[3], Prof. Kosgiker GM[4]
UG Students, Department of Electronics & Telecommunication Engineering[1,2,3]
Professor, Department of Electronics & Telecommunication Engineering[4]
Brahmdevdada Mane Institute of Technology, Solapur, Maharashtra, India

Abstract: *A Brain-Computer Interface (BCI) is a technology that establishes a direct connection pathway between human brain activity and external devices. This system is revolutionary because it allows for communication and control without relying on any peripheral muscle movement. This paper explores the significant evolution of BCI technology. It traces its development from its origins in medical rehabilitation, where it served patients with severe motor disabilities, to its current expansion into the realm of mainstream consumer electronics. The paper highlights the core methods of signal acquisition, processing, and translation, which are the foundational processes that enable brain signals to control complex external devices such as prosthetics, wheelchairs, or various digital systems. Furthermore, emerging BCI applications are discussed, including those in immersive gaming, smart devices, and deep integration with artificial intelligence. Finally, the paper addresses the critical ethical challenges inherent in this technology, such as user privacy, data security, and the potential for societal inequality, to provide a comprehensive understanding of how BCI has evolved from a specialized medical tool into a major step in human-machine interaction.*

Keywords*:* Brain-Computer Interface (BCI), EEG, Rehabilitation, Consumer Electronics, Neurotechnology, Ethics

I. INTRODUCTION

I. Brain-Computer Interfaces (BCIs) represent a rapidly evolving and significant area of research. This interdisciplinary field fundamentally bridges the domains of neuroscience, artificial intelligence (AI), and human-machine interaction. The foundational principle of these systems is the establishment of a direct pathway that communicates signals from the brain to computers or other external devices. This technology is notable because it entirely bypasses the body's traditional pathways of neuromuscular control.

II. Historically, BCIs were developed almost exclusively for medical rehabilitation. Their primary purpose was to restore communication and control for individuals with severe motor disabilities. However, in recent years, the technology has transcended its original purpose and has now entered mainstream applications. Today, BCI applications can be found in consumer-grade virtual reality (VR) headsets, interactive gaming peripherals, and smart home automation systems. This rapid expansion from niche medical tech to consumer electronics has been driven by key technological advancements, particularly in the fields of deep learning and the development of non-invasive EEG (Electroencephalogram) sensors. These innovations have worked together to significantly improve the signal quality, classification accuracy, and overall usability of modern BCI systems

DOI: 10.48175/IJARSCT-29359

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 3, October 2025
Impact Factor: 7.67

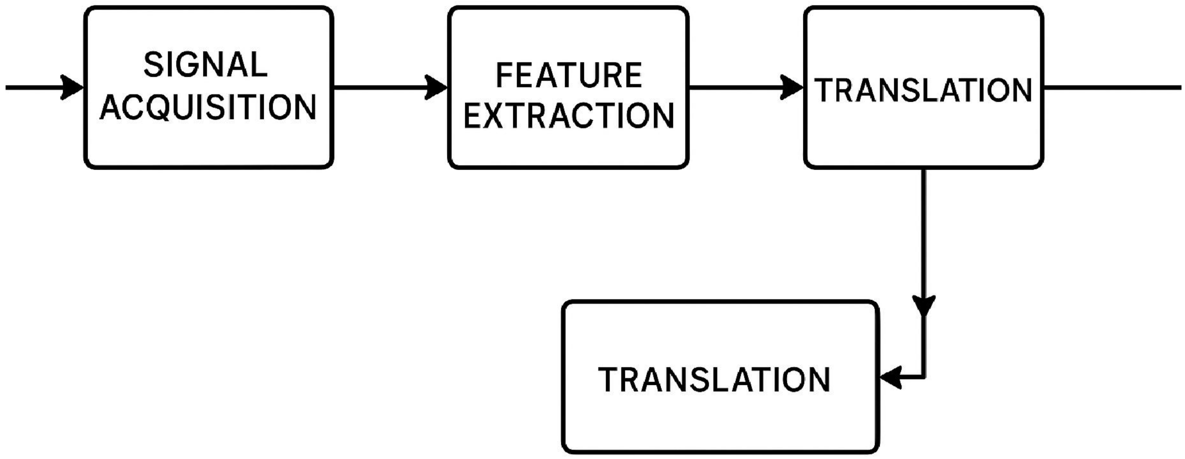

Fig. 1. EEG-Based Brain-Computer Interface System Architecture

II. LITERATURE REVIEW

The foundation of modern BCI research was detailed by Wolpaw et al. (2002), who presented a foundational study on EEG-based BCIs designed for communication and control. Their work was pivotal in demonstrating the feasibility of real-time translation of neural signals into commands. Building on this, Nicolas-Alonso and Gomez-Gil (2012) provided a comprehensive review of BCI systems. Their review emphasized the critical role that feature extraction and classification algorithms play in determining the performance and reliability of a BCI system.

More recent advances in the field leverage the power of machine learning (ML) and deep neural networks (DNNs) to decode complex EEG patterns. This approach has significantly enhanced the adaptive learning capabilities of BCI systems, allowing them to better adjust to individual users and minimize interference from signal noise. The rapid convergence of BCI with everyday technology is illustrated in key studies, such as those by Allison et al. (2007) and Musk et al. (2019) . These works highlight the field's progression toward both accessible consumer technologies and highly advanced, high-bandwidth neural implant

III. METHODOLOGY

A typical BCI system, such as the EEG-based architecture shown in Figure 1, comprises five essential stages: signal acquisition, pre-processing, feature extraction, translation, and finally, the control output.

The process begins with signal acquisition. In this stage, non-invasive EEG electrodes are placed on the scalp to capture the faint electrical activity of the brain. This raw signal is then passed to the pre-processing stage. Here, the signal is amplified to make it usable and then digitally filtered. This filtering is a crucial step to remove artifacts—unwanted noise in the signal—that are commonly caused by non-brain activity such as eye movement, muscle tension, or environmental interference.

Once the signal is cleaned, it moves to feature extraction. In this stage, specific signal processing techniques are applied to identify relevant patterns or features in the brain activity that correspond to the user's intent. Common methods utilized for this include Fast Fourier Transform (FFT), Wavelet Transform, and Common Spatial Pattern (CSP).

These extracted features are then fed into the translation stage, which employs classification algorithms. Algorithms such as Support Vector Machines (SVM), Convolutional Neural Networks (CNNs), and Recurrent Neural Networks (RNNs) are trained to interpret the data patterns. The algorithm classifies the brain signal features into specific, actionable commands. These commands form the control output, which is sent to an external device, allowing the user to control robotic arms, drones, smart home systems, or virtual avatars using only their thoughts.

IV. ANALYSIS AND DISCUSSION

Analysis and Discussion

The analysis of BCI systems reveals that overall performance is critically dependent on two main factors: the quality of the acquired neural signal and the sophistication of the machine learning models used for translation. High-quality, noise-free signals combined with powerful, adaptive algorithms are essential for a reliable system.

In medical applications, BCIs have shown significant promise for rehabilitation. They are increasingly used to assist patients who have suffered from strokes or spinal cord injuries. These systems often work by restoring movement or communication capabilities through neurofeedback mechanisms, helping patients retrain neural pathways. Beyond medicine, the technology provides new avenues for immersive control in the entertainment sector. BCIs offer novel ways for users to interact with virtual environments, particularly in gaming and augmented reality (AR) applications.

Despite this progress, significant limitations remain that affect the reliability and widespread adoption of current BCI systems. These challenges include the non-stationary nature of EEG signals (meaning they can change characteristics over time), the issue of cognitive fatigue in users who must maintain intense focus, and the lengthy calibration time often required to tune the system to a specific individual's brain patterns. To overcome these issues, researchers are actively developing hybrid BCIs. These systems improve control accuracy and adaptability by combining EEG signals with other biological signals, such as EMG (electromyography, from muscles) or EOG (electrooculography, from eye movement.

V. CHALLENGES AND ETHICAL CONCERNS

While BCI technologies promise immense potential for human augmentation and rehabilitation, they also raise profound and complex ethical challenges that must be addressed. The primary concern is related to privacy. Brain data is arguably the most inherently private data a person has, and its potential misuse could lead to unprecedented violations of mental privacy.

Several key issues must be navigated. These include establishing clear legal lines of data ownership, developing security protocols to prevent unauthorized neural data collection, and mitigating the risks of AI bias within the classification algorithms, which could lead to discriminatory outcomes. Addressing these problems will require the development and enforcement of strict governance frameworks. Furthermore, affordability and accessibility are major concerns. BCI technologies are currently expensive to develop and implement. If they are not managed and distributed equitably, they hold the potential to widen existing socioeconomic gaps, creating a divide between those who can afford cognitive enhancements and those who cannot.

VI. FUTURE SCOPE

The future of BCIs likely lies in their deep and seamless integration with other advanced technologies, including artificial intelligence (AI), the Internet of Things (IoT), and cloud computing. This convergence will be necessary to enable the development of real-time, personalized applications that can adapt to a user's needs dynamically.

Next-generation BCIs are expected to move beyond simple motor control. Researchers are actively exploring their potential to enhance cognitive performance, for example, by improving memory retention or focus, and even to assist in emotional regulation by providing real-time feedback on mental states. The ultimate goal for consumer technology is the development of fully non-invasive systems that can seamlessly and intuitively interact with everyday devices, such as smartphones, AR/VR headsets, and other wearable technologies. To ensure the public trust and safety required for such large-scale BCI deployment, the development of ethical AI principles and robust, secure data transmission protocols will be central to all future research and development.

VI. CONCLUSION

In conclusion, BCI technology has undergone a remarkable evolution. It has transformed from highly specialized medical rehabilitation tools into a viable platform for intelligent human-machine symbiosis. By merging the complex insights of neuroscience with the powerful processing capabilities of artificial intelligence, BCI technology holds the potential to revolutionize critical sectors, including healthcare, education, and entertainment.

However, to realize the full, positive potential of this technology, a sustained commitment to interdisciplinary research and the establishment of robust ethical governance are vital. The future of BCIs is twofold: it is poised to not only restore capabilities that have been lost due to injury or illness but also to fundamentally expand the boundaries of human cognition and interaction with the digital world

VII. ACKNOWLEDGMENT

I wish to seize this opportunity to sincerely thank all of those who have guided, supported, and encouraged me during the completion of this project titled " The Evolution of Brain-Computer Interfaces: From Medical Rehabilitation to Mainstream Consumer Electronics” Most importantly, I would like to thank my project guide, for his/her priceless guidance, continuous encouragement, and constructive feedback during every stage of this project. I would also like to thank [IR Dr. KAZI K.S.], Head of the Department of Electronics and Telecommunication Engineering, for providing the required facilities, resources and inspiration in completing this work. Life is a journey; I would also like to thank all the faculty members & staff of the department for their valuable suggestions and technical assistance. Their guidance has been a crucial factor in developing the understanding of the subject and the quality work produced in this projec

REFERENCES

[1] H. Haas, L. Yin, C. Chen, and S. Videv, LiFi: Revolutionizing Wireless Communication, Cambridge University Press, 2021.

[2] S. Rajagopal, R. D. Roberts, and S. K. Lim, “IEEE 802.15.7 Visible Light Communication: Modulation Schemes and Dimming Support,” IEEE Communications Magazine, vol. 50, no. 3, pp. 72–82, Mar. 2012.

[3] T. Komine and M. Nakagawa, “Fundamental analysis for visible-light communication system using LED lights,” IEEE Transactions on Consumer Electronics, vol. 50, no. 1, pp. 100–107, Feb. 2004.

[4] D. Karunatilaka, F. Zafar, V. Kalavally, and R. Parthiban, “LED Based Indoor Visible Light Communications: State of the Art,” IEEE Communications Surveys & Tutorials, vol. 17, no. 3, pp. 1649–1678, 2015.

[5] H. Haas, “High-speed wireless networking using visible light,” SPIE Newsroom, pp. 1–3, Apr. 2013.

[6] A. Jovicic, J. Li, and T. Richardson, “Visible Light Communication: Opportunities, Challenges and the Path to Market,” IEEE Communications Magazine, vol. 51, no. 12, pp. 26–32, Dec. 2013.

[7] N. Kumar and D. K. Jain, “Li-Fi–Based Data Transmission and Its Comparison with Wi-Fi,” International Journal of Computer Applications, vol. 975, no. 8887, pp. 1–5, 2014.

[8] P. Pathak, X. Feng, P. Hu, and P. Mohapatra, “Visible Light Communication, Networking, and Sensing: A Survey, Potential and Challenges,” IEEE Communications Surveys & Tutorials, vol. 17, no. 4, pp. 2047–2077

[9] F. Zafar, D. Karunatilaka, and R. Parthiban, “Dimming schemes for visible light communication: approaches, challenges and future directions,” IEEE Wireless Communications, vol. 22, no. 2, pp. 29–35, Apr. 2015.

[10] J. Armstrong and B. J. Schmidt, “Comparison of asymmetrically clipped optical OFDM and DC-biased optical OFDM in AWGN,” IEEE Communications Letters, vol. 12, no. 5, pp. 343–345, May 2008.

[11] L. Grobe et al., “High-speed visible light communication systems,” IEEE Communications Magazine, vol. 51, no. 12, pp. 60–66, Dec. 2013.

[12] Z. Ghassemlooy, W. Popoola, and S. Rajbhandari, Optical Wireless Communications: System and Channel Modelling with MATLAB, 2nd ed., CRC Press, 2019.

[13] S. Dimitrov and H. Haas, Principles of LED Light Communications: Towards Networked Li-Fi, Cambridge University Press, 2015.

[14] Y. Wang, N. Chi, Y. Wang, L. Tao, and J. Shi, “Network architecture of a high-speed visible light communication local area network,” IEEE Photonics Technology Letters, vol. 27, no. 2, pp. 197–200, Jan. 2015.

[15] A. Sevincer, A. Bhardwaj, M. Bilgi, M. Yuksel, and N. Pala, “LIGHTNETs: Smart lighting and mobile optical wireless networks—A survey,” IEEE Communications Surveys & Tutorials, vol. 15, no. 4, pp. 1620– 1641, 2013.

[16] H. Haas, “Wireless Data from Every Light Bulb,” TED Talk, 2011. [Online]. Available: https://www.ted.com/talks/harald_haas_wireless_data_from_every_light_bulb

[17] IEEE Xplore Digital Library, "Li-Fi Communication Systems." [Online]. Available: https://ieeexplore.ieee.org
[18]ScienceDirect, "Visible Light Communication (VLC) Research Articles." [Online]. Available: https://www.sciencedirect.com
[19] SpringerLink, "Li-Fi and Visible Light Communication for 6G and IoT Applications." [Online]. Available: https://link.springer.com
[20] H. Haas, L. Yin, C. Chen, and S. Videv, LiFi: Revolutionizing Wireless Communication, Cambridge University Press, 2021.
[21] S. Rajagopal, R. D. Roberts, and S. K. Lim, "IEEE 802.15.7 Visible Light Communication: Modulation Schemes and Dimming Support," IEEE Communications Magazine, vol. 50, no. 3, pp. 72–82, Mar. 2012.
[22] T. Komine and M. Nakagawa, "Fundamental analysis for visible-light communication system using LED lights," IEEE Transactions on Consumer Electronics, vol. 50, no. 1, pp. 100–107, Feb. 2004.
[23] N. Kumar and D. K. Jain, "Li-Fi–Based Data Transmission and Its Comparison with Wi-Fi," International Journal of Computer Applications, vol. 975, no. 8887, pp. 1–5, 2014.
[24] P. Pathak, X. Feng, P. Hu, and P. Mohapatra, "Visible Light Communication, Networking, and Sensing: A Survey, Potential and Challenges," IEEE Communications Surveys & Tutorials, vol. 17, no. 4, pp. 2047–2077, 2015.
[26] F. Zafar, D. Karunatilaka, and R. Parthiban, "Dimming schemes for visible light communication: approaches, challenges and future directions," IEEE Wireless Communications, vol. 22, no. 2, pp. 29–35, Apr. 2015.
[27] J. Armstrong and B. J. Schmidt, "Comparison of asymmetrically clipped optical OFDM and DC-biased optical OFDM in AWGN," IEEE Communications Letters, vol. 12, no. 5, pp. 343–345, May 2008.
[28] L. Grobe et al., "High-speed visible light communication systems," IEEE Communications Magazine, vol. 51, no. 12, pp. 60–66, Dec. 2013.
[29] Z. Ghassemlooy, W. Popoola, and S. Rajbhandari, Optical Wireless Communications: System and Channel Modelling with MATLAB, 2nd ed., CRC Press, 2019.
[30] S. Dimitrov and H. Haas, Principles of LED Light Communications: Towards Networked Li-Fi, Cambridge University Press, 2015.
[31] Y. Wang, N. Chi, Y. Wang, L. Tao, and J. Shi, "Network architecture of a high-speed visible light communication local area network," IEEE Photonics Technology Letters, vol. 27, no. 2, pp. 197–200, Jan. 2015.
[32] A. Sevincer, A. Bhardwaj, M. Bilgi, M. Yuksel, and N. Pala, "LIGHTNETs: Smart lighting and mobile optical wireless networks—A survey," IEEE Communications Surveys & Tutorials, vol. 15, no. 4, pp. 1620–1641, 2013.
[33] H. Haas, "Wireless Data from Every Light Bulb," TED Talk, 2011. [Online]. Available: https://www.ted.com/talks/harald_haas_wireless_data_from_every_light_bulb
[36] IEEE Xplore Digital Library, "Li-Fi Communication Systems." [Online]. Available: https://ieeexplore.ieee.org ScienceDirect, "Visible Light Communication (VLC) Research Articles." [Online]. Available: h ttps://www.sciencedirect.com
[37] SpringerLink, "Li-Fi and Visible Light Communication for 6G and IoT Applications." [Online]. Available: https://link.springer.com
[38]. K S K, (2024c). Vehicle Health Monitoring System (VHMS) by Employing IoT and Sensors, Grenze International Journal of Engineering and Technology, Vol 10, Issue 2, pp- 5367-5374. Available at: https://thegrenze.com/index.php?display=page&view=journalabstract&absid=3371&id=8
[39]. K S K, (2024e). A Novel Approach on ML based Palmistry, Grenze International Journal https://thegrenze.com/index.php?display=page&view=journalabstract&absid=3344&id=8
[40]. K S K, (2024f).IoT based Boiler Health Monitoring for Sugar Industries, Grenze International Journal of Engineering and Technology, Vol 10, Issue 2, pp. 5178 -5185. Available at: https://thegrenze.com/index.php?display=page&view=journalabstract&absid=3343&id=8
[41]. Keerthana, R., K, V., Bhagyalakshmi, K., Papinaidu, M., V, V., & Liyakat, K. K. S. (2025). Machine learning based risk assessment for financial management in big data IoT credit. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.5086671

[42]. KKS Liyakat, (2024a). Explainable AI in Healthcare. In: Explainable Artificial Intelligence in healthcare System, editors: A. Anitha Kamaraj, Debi Prasanna Acharjya. ISBN: 979-8-89113-598-7. DOI: https://doi.org/10.52305/GOMR8163

[43]. KKS Liyakat, (2024b). Machine Learning (ML)-Based Braille Lippi Characters and Numbers Detection and Announcement System for Blind Children in Learning, In Gamze Sart (Eds.), Social Reflections of Human-Computer Interaction in Education, Management, and Economics, IGI Global. https://doi.org/10.4018/979-8-3693-3033-3.ch002

[44]. Kulkarni S G, (2025). Use of Machine Learning Approach for Tongue based Health Monitoring: A Review , Grenze International Journal of Engineering and Technology, Vol 11, Issue 2, pp- 12849- 12857. Grenze ID: 01.GIJET.11.2.311_22 Available at: https://thegrenze.com/index.php?display=page&view=journalabstract&absid=6136&id=8

[45]. Kutubuddin, KSK Approach in LOVE Health: AI-Driven- IoT(AIIoT) based Decision Making System in LOVE Health for Loved One, GRENZE International Journal of Engineering and Technology, 2025, 11(1), pp. 4628-4635. Grenze ID: 01.GIJET.11.1.371_1

[46]. Liyakat, K.K.S. (2023a). Machine Learning Approach Using Artificial Neural Networks to Detect Malicious Nodes in IoT Networks. In: Shukla, P.K., Mittal, H., Engelbrecht, A. (eds) Computer Vision and Robotics. CVR 2023. Algorithms for Intelligent Systems. Springer, Singapore. https://doi.org/10.1007/978981-99-4577-1_3

[47]. Liyakat K. S. (2024). ChatGPT: An Automated Teacher's Guide to Learning. In R. Bansal, A. Chakir, A. Hafaz Ngah, F. Rabby, & A. Jain (Eds.), AI Algorithms and ChatGPT for Student Engagement in Online Learning (pp. 1-20). IGI Global. https://doi.org/10.4018/979-8-3693-4268-8.ch001

[48]. Liyakat. (2024a). Machine Learning Approach Using Artificial Neural Networks to Detect Malicious Nodes in IoT Networks. In: Udgata, S.K., Sethi, S., Gao, XZ. (eds) Intelligent Systems. ICMIB 2023. Lecture Notes in Networks and Systems, vol 728. Springer, Singapore. https://doi.org/10.1007/978-981-99-3932-9_12 available at: https://link.springer.com/chapter/10.1007/978-981-99-3932-9_12

[49]. Liyakat, K. K. (2025a). Heart Health Monitoring Using IoT and Machine Learning Methods. In A. Shaik (Ed.), AI-Powered Advances in Pharmacology (pp. 257-282). IGI Global. https://doi.org/10.4018/97983693-3212-2.ch010

[50]. Liyakat. (2025c). IoT Technologies for the Intelligent Dairy Industry: A New Challenge. In S. Thandekkattu& N. Vajjhala (Eds.), Designing Sustainable Internet of Things Solutions for Smart Industries (pp. 321-350). IGI Global. https://doi.org/10.4018/979-8-3693-5498-8.ch012

[51]. Liyakat. (2025d). AI-Driven-IoT(AIIoT)-Based Decision Making in Kidney Diseases Patient Healthcare Monitoring: KSK Approach for Kidney Monitoring. In L. Özgür Polat & O. Polat (Eds.), AIDriven Innovation in Healthcare Data Analytics (pp. 277-306). IGI Global Scientific Publishing. https://doi.org/10.4018/979-8-3693-7277-7.ch009

[52]. Liyakat. (2026). Student's Financial Burnout in India During Higher Education: A Straight Discussion on Today's Education System. In S. Hai-Jew (Ed.), Financial Survival in Higher Education (pp. 359-394). IGI Global Scientific Publishing. https://doi.org/10.4018/979-8-3373-0407-6.ch013

[53]. M Pradeepa, et al. (2022). Student Health Detection using a Machine Learning Approach and IoT, 2022 IEEE 2nd Mysore sub section International Conference (MysuruCon), 2022. Available at: https://ieeexplore.ieee.org/document/9972445

[54]. Mahant, M. A. (2025). Machine Learning-Driven Internet of Things (MLIoT)-Based Healthcare Monitoring System. In N. Wickramasinghe (Ed.), Digitalization and the Transformation of the Healthcare Sector (pp. 205-236). IGI Global Scientific Publishing. https://doi.org/10.4018/979-8-3693-9641- 4.ch007

[55]. Mulani AO, Liyakat KKS, Warade NS, et al. (2025). ML-powered Internet of Medical Things Structure for Heart Disease Prediction. Journal of Pharmacology and Pharmacotherapeutics. 2025; 0(0). doi:10.1177/0976500X241306184

[56]. Vaishnavi Ashok Desai, (2025). AI and Sensor Systems Revolutionizing Intoxication and Smoking PreDetection. Journal of Control & Instrumentation. 2025; 16(3): 15–26p.

[57]. N. R. Mulla, (2025). Pipeline Pressure and Flow Rate Monitoring Using IoT Sensors and ML Algorithms to Detect Leakages, Int. J. Artif. Intell. Mech. Eng., vol. 1, no. 1, pp. 20–30, Jun. 2025.

[58].N. R. Mulla, (2025a). Nuclear Energy: Powering the Future or a Risky Relic, International Journal of Sustainable Energy and Thermoelectric Generator, vol. 1, no. 1, pp. 52–63, Jun. 2025.
[59]. Nikat Rajak Mulla, (2025b). Sensor-based Aircraft Wings Design Using Airflow Analysis, International Journal of Image Processing and Smart Sensors, vol. 1, no. 1, pp. 55-65, Jun. 2025.
[60]. N. R. Mulla, (2025c). A Study on Machine Learning for Metal Processing: A New Future, International Journal of Machine Design and Technology, vol. 1, no. 1, pp. 56–69, Jun. 2025.
[61]. Nikat Rajak Mulla, (2025d). Sensor-based Aircraft Wings Design Using Airflow Analysis, International Journal of Image Processing and Smart Sensors, vol. 1, no. 1, pp. 55-65, Jun. 2025.
[62]. N. R. Mulla, (2025e). Node MCU and IoT Centered Smart Logistics, International Journal of Emerging IoT Technologies in Smart Electronics and Communication, vol. 1, no. 1, pp. 20-36, Jun-2025.
[63]. Nikat Rajak Mulla,(2025f). Air Flow Analysis in Sensor-Based Aircraft Wings Design. Recent Trends in Fluid Mechanics. 2025; 12(2): 29– 39p.
[64]. Nikat Rajak Mulla,(2025g). IoT Sensors To Monitor Pipeline Pressure and Flow Rate Combined with MlAlgorithms to Detect Leakages. Recent Trends in Fluid Mechanics. 2025; 12(2): 40–48p.
[65]. Nikat Rajak Mulla, (2025h). Nano-Materials in Vaccine Formation and Chemical Formulae's for Vaccination. Journal of Nanoscience, NanoEngineering & Applications. 2025; 15(03).
[66]. Odnala, S., Shanthy, R., Bharathi, B., Pandey, C., Rachapalli, A., & Liyakat, K. K. S. (2025). Artificial Intelligence and Cloud-Enabled E-Vehicle Design with Wireless Sensor Integration. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.5107242
[67]. P. Neeraja, R. G. Kumar, M. S. Kumar, K. K. S. Liyakat and M. S. Vani. (2024), DL-Based Somnolence Detection for Improved Driver Safety and Alertness Monitoring. 2024 IEEE International Conference on Computing, Power and Communication Technologies (IC2PCT), Greater Noida, India, 2024, pp. 589-594, doi: 10.1109/IC2PCT60090.2024.10486714. Available at: https://ieeexplore.ieee.org/document/10486714
[68]. Upadhyaya, A. N., Surekha, C., Malathi, P., Suresh, G., Suriyan, K., & Liyakat, K. K. S. (2025). Pioneering cognitive computing for transformative healthcare innovations. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.5086894.
[69]. Priya Mangesh Nerkar, Bhagyarekha Ujjwalganesh Dhaware. (2023). Predictive Data Analytics Framework Based on Heart Healthcare System (HHS) Using Machine Learning, Journal of Advanced Zoology, 2023, Volume 44, Special Issue -2, Page 3673:3686. Available at: https://jazindia.com/index.php/jaz/article/view/1695
[70]. Priya Nerkar and Sultanabanu, (2024). IoT-Based Skin Health Monitoring System, International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS). 2024, 13(11): 5937-5950. https://doi.org/10.31032/IJBPAS/2024/13.11.8488
[71]. S. B. Khadake, A. B. Chounde, A. A. Suryagan, M. H. M. and M. R. Khadatare, (2024). AIDrivenIoT(AIIoT) Based Decision Making System for High-Blood Pressure Patient Healthcare Monitoring, 2024 International Conference on Sustainable Communication Networks and Application (ICSCNA), Theni, India, 2024, pp. 96-102, doi: 10.1109/ICSCNA63714.2024.10863954.
[72]. S. B. Khadake, P. S. More, R. J. Shinde, K. P. Kondubhairi and S. S. Kamble, (2025). AI-Driven IoT based Decision Making for Hepatitis Diseases Patient's Healthcare Monitoring: KSK Approach for Hepatitis Patient Monitoring, 2025 7th International Conference on Intelligent Sustainable Systems (ICISS), India, 2025, pp. 256-263, doi: 10.1109/ICISS63372.2025.11076213.
[73]. S. B. Khadake, K. Galani, K. B. Patil, A. Dhavale and S. D. Sarik, (2025a). AI-Powered-IoT (AIIoT) based Bridge Health Monitoring using Sensor Data for Smart City Management- A KSK Approach, 2025 7th International Conference on Intelligent Sustainable Systems (ICISS), India, 2025, pp. 296-305, doi: 10.1109/ICISS63372.2025.11076329.
[74]. S. B. Khadake, B. R. Ingale, D. D. D., S. S. Sudake and M. M. Awatade, (2025b). Kidney Diseases Patient Healthcare Monitoring using AI-Driven-IoT(AIIoT) - An KSK1 Approach, 2025 7th International Conference on Intelligent Sustainable Systems (ICISS), India, 2025, pp. 264-272, doi: 10.1109/ICISS63372.2025.11076397.