

# Power Generation using Footstep

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**Abstract:** *The power generation system describes how the kinetic energy from human footsteps is converted into electrical energy using transducers like piezoelectric sensors or mechanical systems. This non-conventional, pollution-free energy is stored in batteries and can power small, localized devices like street lights, mobile chargers, or displays. Such systems offer a sustainable solution to meet growing energy demands, particularly in public, high-traffic areas, and reduce reliance on traditional fossil fuels.*

**Keywords:** Footstep power, Piezoelectric energy, Renewable energy, Kinetic conversion, Sustainable system

## I. INTRODUCTION

With the rapid growth of population and technology, the demand for electrical energy has increased tremendously. Traditional sources of energy such as coal, oil, and natural gas are limited and contribute significantly to environmental pollution. Hence, there is a growing need to explore alternative methods of power generation that are both renewable and sustainable[1-22].

One such innovative approach is power generation using footsteps, which utilizes the energy produced by human movement. Every step taken by an individual exerts mechanical pressure on the ground surface, and this energy can be effectively converted into electrical energy using piezoelectric sensors or mechanical pressure-based generators. The generated energy can be stored in batteries and later used for lighting systems, sensors, or charging small electronic devices.

This concept is particularly beneficial in crowded public areas such as railway stations, shopping malls, footpaths, and schools, where a large number of people walk daily. By implementing such systems, a significant amount of energy can be harvested from human activity, thereby reducing the dependency on conventional energy source.[23-50]

Imagine a city that breathes with you, where the very pulse of its inhabitants fuels its life. Not with the roar of generators or the distant hum of power plants, but with the rhythmic taps, thuds, and scrapes – the humble, constant rhythm of human movement. We walk, we run, we dance. Every step we take, every ounce of pressure exerted, is a fleeting burst of kinetic energy that, for millennia, has simply dissipated into the ground beneath us. But what if we could capture that? What if our daily commute, our stroll through the park, even our restless pacing, became a personal, portable power station? This isn't science fiction; it's the burgeoning reality of footstep power generation[51-90].

At its core, this ingenious technology seeks to harvest the mechanical energy of a footfall and convert it into electrical energy. Picture smart tiles embedded in pavements, dance floors, or train station platforms. These tiles conceal clever mechanisms – perhaps piezoelectric crystals that generate a charge when compressed, or electromagnetic generators that spin with each depression, or even hydraulic systems that push fluid to drive a turbine. Each method, distinct in its engineering, shares the same audacious goal: to transform wasted motion into usable electricity.

The implications are vast and exhilarating. Think of the bustling city square, its thousands of daily visitors inadvertently powering the streetlights above them, or charging communal phone booths. Imagine subway stations, where the rush-hour crush lights up the platforms and powers the ticketing machines. Festivals and concerts could become self-sustaining in terms of basic power needs, with the energy of jumping crowds illuminating the stage. Beyond urban centers, consider remote communities, where a simple path could provide enough energy for a water pump or essential medical equipment, reducing reliance on fossil fuels or costly grid extensions. Even individual applications abound –



insoles that charge your smartphone as you walk, or wearable devices that draw power from your own movement [91-106].

The appeal isn't just novelty; it's a powerful stride towards sustainability. Footstep power offers a decentralized, clean energy source that is literally generated where and when it's needed most, by the very people who will use it. It reduces carbon footprints, lessens the strain on traditional power grids, and empowers communities to become more energy independent. It transforms a ubiquitous, often overlooked human activity into a resource, fostering a deeper connection between our actions and their environmental impact.

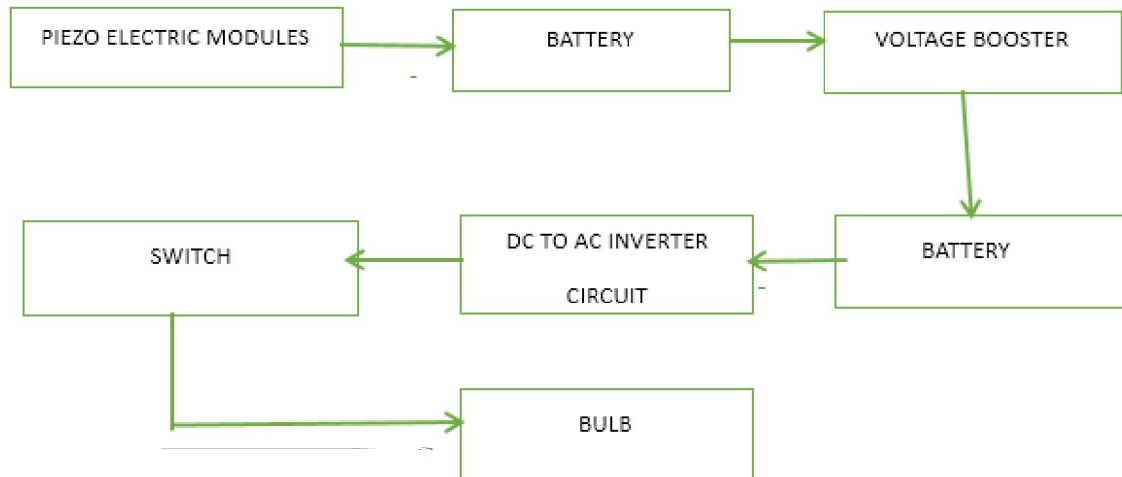
Of course, challenges remain. Efficiency, scalability for large-scale energy demands, and the cost of implementation are significant hurdles. A single step generates only a small amount of power, meaning broad application requires vast networks and optimized capture systems. Yet, with ongoing research and material science advancements, these obstacles are steadily being overcome, pushing the technology closer to widespread adoption.

The dream of footstep power generation is more than just about lighting a bulb; it's about reimagining our relationship with energy. It's about a future where our cities hum not with the roar of industry, but with the quiet, persistent rhythm of life itself – a world where every step we take is a step towards a brighter, more sustainable tomorrow. It's the ultimate fusion of human activity and environmental responsibility, proving that sometimes, the most revolutionary power sources are found right beneath our feet.

## II. LITERATURE REVIEW

The development of the Footstep Power Generation System has evolved through continuous innovation and experimentation, focusing on energy harvesting technologies and sustainable design. Early research emphasized converting mechanical pressure from footsteps into electrical energy using piezoelectric materials, which generate voltage when subjected to mechanical stress. Studies demonstrated that piezoelectric sensors could effectively harness kinetic energy from human movement in high-traffic areas. Subsequent works focused on enhancing power output and storage efficiency through optimized circuit design, rectification techniques, and improved energy storage systems such as lithium-ion batteries and supercapacitors. Integration of microcontroller-based systems allowed for efficient monitoring, data acquisition, and energy management. Researchers also explored hybrid models combining piezoelectric and electromagnetic mechanisms to increase conversion efficiency.

## III. METHODOLOGY



### 1. Piezoelectric Modules

The system starts with piezoelectric modules placed under the floor tiles.

When a person steps on the tiles, mechanical pressure is applied to these modules.

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The piezoelectric effect converts this mechanical pressure into a small electric voltage (AC).

## **2. Battery (Initial Storage)**

The AC voltage from the piezo modules is collected and stored in a battery for later use.

This allows the energy generated from footsteps to be available even when no one is stepping.

## **3. Voltage Booster**

The stored voltage from the battery may be low.

A voltage booster circuit increases this voltage to a usable level for powering devices.

## **4. DC to AC Inverter (12V to 220V)**

Many household devices require AC voltage, so a DC to AC inverter converts the stored DC voltage from the battery into AC voltage. In this system, the inverter steps up the voltage from 12V DC to 220V AC.

## **5. Switch & Load (Bulb)**

# **IV. RESEARCH AND REVIEWS**

Recent research on footstep power generation systems has focused on improving energy harvesting efficiency, material performance, and system integration. Early designs primarily used piezoelectric sensors such as PZT and PVDF to convert mechanical pressure into electrical energy. Later studies introduced hybrid models combining piezoelectric and electromagnetic methods to enhance power output. Researchers have optimized rectifier and storage circuits for better voltage regulation and energy storage. Experimental implementations in public areas like railway stations and walkways have proven the system's feasibility for powering small loads such as LEDs and chargers. Despite progress, challenges related to durability, cost, and large-scale application remain. Emerging innovations such as nanomaterial-based sensors, flexible flooring systems, and IoT-enabled monitoring offer promising directions for future sustainable energy solutions.

The Footstep Power Generation System was successfully developed, assembled, and tested under various conditions to evaluate its performance and efficiency. The system was designed to convert mechanical pressure energy from human footsteps into usable electrical energy. During testing, it was observed that when an individual stepped on the platform, mechanical energy was converted into electrical energy through the piezoelectric sensors. The output voltage and current varied depending on the weight of the individual and the applied force.

The generated energy was stored in a rechargeable battery via a rectifier circuit and voltage regulator to ensure stable DC output. The stored energy was then used to power small electrical devices such as LEDs, mobile chargers, and digital displays. Multiple steps in succession produced a cumulative voltage increase, confirming that the system is more efficient in areas with heavy pedestrian traffic such as railway stations, shopping malls, airports, and footpaths.

The performance of the system demonstrated that it is capable of providing a clean, renewable, and sustainable source of energy without dependence on external power supply. The system components functioned reliably during the testing phase, and no significant loss of energy was observed due to friction or wiring resistance. This proves the practical viability of the design for small-scale power generation and public utility applications.

## **Discussion**

The concept of footstep power generation is based on the principle of energy conversion, where mechanical energy from human movement is transformed into electrical energy. As the demand for clean and renewable energy sources grows, this technology offers a practical way to utilize otherwise wasted energy in high-footfall areas. By harvesting energy from footsteps, it contributes to energy conservation, environmental protection, and sustainability goals.

Moreover, this system encourages public awareness of renewable energy by demonstrating a simple yet impactful method of power generation. It can help reduce the burden on non-renewable energy resources and minimize carbon emissions. The generated power may not be sufficient for large-scale application but can effectively be used for lighting, information displays, and charging low-power devices in public areas.

In the future, improvements in piezoelectric materials, mechanical design, and energy storage technology can significantly enhance output efficiency. Integration with smart city infrastructure can make this system a green energy innovation, promoting a more sustainable and energy-efficient environment.



## V. CONCLUSION

The Footstep Power Generation System demonstrates a practical and innovative method of producing electrical energy from human movement. By converting mechanical energy from footsteps into usable electricity, the project highlights a sustainable and eco-friendly approach to meet small-scale power requirements. The system performed effectively during testing, generating enough energy to operate low-power devices like LEDs and mobile chargers.

This technology is particularly useful in high-footfall areas such as railway stations, shopping malls, and footpaths, where continuous pedestrian movement can produce significant energy output. With further enhancement in piezoelectric materials, design efficiency, and energy storage systems, the project holds great potential for real-world implementation.

## VI. FUTURE SCOPE

The system can be installed in high footfall areas like railway stations, airports, shopping malls, bus stops, and schools to generate useful electrical energy.

With improved piezoelectric materials and better mechanical design, the energy conversion efficiency can be significantly increased.

Integration with smart city infrastructure can enable real-time monitoring and management of generated power.

The generated energy can be used for street lights, corridor lighting, and mobile charging stations in public areas.

Use of advanced energy storage systems like lithium batteries or supercapacitors can improve power retention and stability.

## REFERENCES

- [1]. KK Selim, K. K.; "Energy Harvesting Floor Tile Using Piezoelectric Patches for Low-Power Applications," *Energy* / Springer (article), 2024. [SpringerLink](#)
- [2]. S. Sharma; "A review of piezoelectric energy harvesting tiles," *Renewable & Sustainable Energy Reviews* (review), 2022. [ScienceDirect](#)
- [3]. N. Sezer; "A comprehensive review on the state-of-the-art of piezoelectric energy harvesting," *Energy Reports* (review), 2021. [ScienceDirect](#)
- [4]. J. Gołabek et al.; "A Review of Recent Advances in Human-Motion Energy Harvesting (PENGs, TENGs, hybrids)," *MDPI* (review), 2024. [PMC](#)
- [5]. "A Comprehensive Review of Energy Harvesting From Kinetic Low-Frequency Sources," *Advanced Materials Technologies* (review), 2025. [Wiley Online Library](#)
- [6]. K. K. Selim; "Piezoelectric Sensors Pressed by Human Footsteps for Practical Electrical Energy," *Energies* / *MDPI*, 2024. [MDPI](#)
- [7]. W. Lin; "Study on Human Motion Energy Harvesting Devices," *MDPI Sensors/Technologies*, 2023. [MDPI](#)
- [8]. "Energy Harvesting Floor Tile: Design & Evaluation (frequency up-conversion techniques)," *ScienceDirect / Procedia/Conference* (Asadi et al.), 2023. [ScienceDirect](#)
- [9]. "Study on footstep power generation using piezoelectric tile," ResearchGate (prototype / educational project). [ResearchGate](#)
- [10]. P. Thainirarn et al.; "Triboelectric Energy-Harvesting Floor Tile," *MDPI / Sensors & Applications*, 2022. [PMC](#)
- [11]. M. He; "Study of a Piezoelectric Energy Harvesting Floor Structure Using Force-Amplification and Beam Arrays," *Energies* / *MDPI*, 2019. [MDPI](#)
- [12]. O. Puşcaşu et al.; "Powering lights with piezoelectric energy harvesting floors," research report / accepted manuscript (energy floors), 2018. [researchprofiles.herts.ac.uk](#)
- [13]. R. R. Moussa; "Energy generation in public buildings using piezoelectric tiles," *ScienceDirect / Energy Procedia* (case studies), 2022. [ScienceDirect](#)
- [14]. G. Wang; "Low-cost and compact piezoelectric energy harvesting floor tile" (SPIE conference paper), 2024. [spiedigitallibrary.org](#)



- [15]. S. M. Hossain; "Energy harvesting from human foot movement," *Journal / T&F* (overview & experiments), 2021. [Taylor & Francis Online](#)
- [16]. "Generation of Electricity Using Footstep Power" (SciTechnol / peer-review article / demonstration & overview). [scitechnol.com](#)
- [17]. L. Olatomiwa; "Piezoelectric Floor Mat Systems for Sustainable Energy in High-Traffic Areas," *SaudiJ/engineering* (2025). [Scholars Middle East Publishers](#)
- [18]. "Investigating the Energy Generation Potential of Piezoelectric Flooring in Educational Buildings" (ResearchGate / case study). [ResearchGate](#)
- [19]. Review: "Review of piezo-electric sensor-based power generation (footsteps)" (AIP/ACP review), 2024. [AIP Publishing](#)
- [20]. "High Foot Traffic Power Harvesting Technologies and Case Study (Al-Haram Mosque)," *Applied Sciences / MDPI*, 2025. [MDPI](#)
- [21]. J. I. Roscow et al.; "Freeze cast porous barium titanate for enhanced piezoelectric energy harvesting," *arXiv*, 2019 — materials/microstructure for improved PEH performance. [arXiv](#)
- [22]. Y. Zhang et al.; "Enhanced pyroelectric and piezoelectric properties of PZT with aligned porosity," *arXiv*, 2019 — porous PZT for harvesting. [arXiv](#)
- [23]. S. Yao et al.; "Optimal design of Piezoelectric Energy Harvesters for bridge infrastructure," *arXiv* (design & placement optimization), 2023. [arXiv](#)
- [24]. B. Zhao et al.; "A Graded Metamaterial for Broadband Piezoelectric Energy Harvesting," *arXiv* (metamaterials for broadband low-frequency harvesting), 2022. [arXiv](#)
- [25]. Wired (Pavegen news): "Pavegen's power-generating floor ... Oxford Street" — Pavegen commercial tile & field deployments (background on industrial systems). [WIRED](#)
- [26]. Wired (People-Power Lights 2012 Olympic Walkway) — early Pavegen / demonstration installations. [WIRED](#)
- [27]. Wired (2008): "Power generating floor in train stations" — Tokyo/Shibuya piezo mat demo and early deployments. [WIRED](#)
- [28]. "A review of piezoelectric energy harvesting tiles" — Delft research PDF copy (full review PDF). [TU Delft Research Portal](#)
- [29]. "Energy Harvesting Floor Tile Using Piezoelectric Patches" (ResearchGate PDF / Selim et al. extended preprint). [ResearchGate](#)
- [30]. "A Review of Footstep Energy Harvesting Systems" (comprehensive review — ResearchGate / recent), 2025 (survey of piezoelectric, triboelectric, rack-and-pinion, Pavegen, hybrid systems). [Resea](#)
- [31]. Altaf O. Mulani, Arti Vasant Bang, Ganesh B. Birajadar, Amar B. Deshmukh, and Hemlata Makarand Jadhav, (2024). IoT Based Air, Water, and Soil Monitoring System for Pomegranate Farming, *Annals of Agri-Bio Research*. 29 (2): 71-86, 2024.
- [32]. Bhawana Parihar, Ajmeera Kiran, Sabitha Valaboju, Syed Zahidur Rashid, and Anita Sofia Liz D R. (2025). Enhancing Data Security in Distributed Systems Using Homomorphic Encryption and Secure Computation Techniques, *ITM Web Conf.*, 76 (2025) 02010. DOI: <https://doi.org/10.1051/itmconf/20257602010>
- [33]. C. Veena, M. Sridevi, K. K. S. Liyakat, B. Saha, S. R. Reddy and N. Shirisha, (2023). HEECCNB: An Efficient IoT-Cloud Architecture for Secure Patient Data Transmission and Accurate Disease Prediction in Healthcare Systems, *2023 Seventh International Conference on Image Information Processing (ICIIP)*, Solan, India, 2023, pp. 407-410, doi: 10.1109/ICIIP61524.2023.10537627. Available at: <https://ieeexplore.ieee.org/document/10537627>
- [34]. D. A. Tamboli, V. A. Sawant, M. H. M. and S. Sathe, (2024). AI-Driven-IoT(AIIoT) Based Decision-Making- KSK Approach in Drones for Climate Change Study, *2024 4th International Conference on Ubiquitous Computing and Intelligent Information Systems (ICUIS)*, Gobichettipalayam, India, 2024, pp. 1735-1744, doi: 10.1109/ICUIS64676.2024.10866450.



- [35]. H. T. Shaikh, (2025). Empowering the IoT: The Study on Role of Wireless Charging Technologies, *Journal of Control and Instrumentation Engineering*, vol. 11, no. 2, pp. 29-39, Jul. 2025.
- [36]. H. T. Shaikh, (2025b). Pre-Detection Systems Transfiguring Intoxication and Smoking Using Sensor and AI, *Journal of Instrumentation and Innovation Sciences*, vol. 10, no. 2, pp. 19-31, Jul. 2025.
- [37]. K. Rajendra Prasad, Santoshachandra Rao Karanam et al. (2024). AI in public-private partnership for IT infrastructure development, *Journal of High Technology Management Research*, Volume 35, Issue 1, May 2024, 100496. <https://doi.org/10.1016/j.hitech.2024.100496>
- [38]. KKS Liyakat. (2023). Detecting Malicious Nodes in IoT Networks Using Machine Learning and Artificial Neural Networks, *2023 International Conference on Emerging Smart Computing and Informatics (ESCI)*, Pune, India, 2023, pp. 1-5, doi:10.1109/ESCI56872.2023.10099544. Available at: <https://ieeexplore.ieee.org/document/10099544/>
- [39]. KKS Liyakat, (2024). Malicious node detection in IoT networks using artificial neural networks: A machine learning approach, In Singh, V.K., Kumar Sagar, A., Nand, P., Astya, R., & Kaiwartya, O. (Eds.). *Intelligent Networks: Techniques, and Applications* (1st ed.). CRC Press. <https://doi.org/10.1201/9781003541363>
- [40]. K. Kasat, N. Shaikh, V. K. Rayabharapu, and M. Nayak. (2023). Implementation and Recognition of Waste Management System with Mobility Solution in Smart Cities using Internet of Things, *2023 Second International Conference on Augmented Intelligence and Sustainable Systems (ICAISS)*, Trichy, India, 2023, pp. 1661-1665, doi: 10.1109/ICAISS58487.2023.10250690. Available at: <https://ieeexplore.ieee.org/document/10250690/>
- [41]. 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>
- [42]. K S K, (2024e). A Novel Approach on ML based Palmistry, *Grenze International Journal of Engineering and Technology*, Vol 10, Issue 2, pp- 5186-5193. Available at: <https://thegrenze.com/index.php?display=page&view=journalabstract&absid=3344&id=8>
- [43]. 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>
- [44]. 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>
- [45]. 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>
- [46]. KKS Liyakat, (2024b). Machine Learning (ML)-Based Braille Lipi 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>
- [47]. 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>
- [48]. 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
- [49]. 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/10.1007/978-981-99-4577-1\\_3](https://doi.org/10.1007/978-981-99-4577-1_3)
- [50]. 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>
- [51]. Liyakat. (2024a). Machine Learning Approach Using Artificial Neural Networks to Detect Malicious Nodes in IoT Networks. In: Udgate, 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](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](https://link.springer.com/chapter/10.1007/978-981-99-3932-9_12)
- [52]. 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/10.4018/979-8-3693-3212-2.ch010>
- [53]. 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>
- [54]. 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.), *AI-Driven Innovation in Healthcare Data Analytics* (pp. 277-306). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-7277-7.ch009>
- [55]. 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>
- [56]. M Pradeepa, et al. (2022). Student Health Detection using a Machine Learning Approach and IoT, 2022 *IEEE 2<sup>nd</sup> Mysore sub section International Conference (MysuruCon)*, 2022. Available at: <https://ieeexplore.ieee.org/document/9972445>
- [57]. 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>
- [58]. 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](https://doi.org/10.1177/0976500X241306184)
- [59]. 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.
- [60]. 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.
- [61]. 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.
- [62]. 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.
- [63]. 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.
- [64]. 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.
- [65]. Nikat Rajak Mulla, (2025f). Air Flow Analysis in Sensor-Based Aircraft Wings Design. *Recent Trends in Fluid Mechanics*. 2025; 12(2): 29– 39p.
- [66]. Nikat Rajak Mulla, (2025g). IoT Sensors To Monitor Pipeline Pressure and Flow Rate Combined with ML-Algorithms to Detect Leakages. *Recent Trends in Fluid Mechanics*. 2025; 12(2): 40–48p.



- [67]. Nikat Rajak Mulla, (2025h). Nano-Materials in Vaccine Formation and Chemical Formulae's for Vaccination. *Journal of Nanoscience, NanoEngineering & Applications*. 2025; 15(03).
- [68]. Odnala, S., Shanthi, 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>
- [69]. 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>
- [70]. Prashant K Magadam (2024). Machine Learning for Predicting Wind Turbine Output Power in Wind Energy Conversion Systems, *Grenze International Journal of Engineering and Technology*, Jan Issue, Vol 10, Issue 1, pp. 2074-2080. Grenze ID: 01.GIJET.10.1.4\_1 Available at: <https://thegrenze.com/index.php?display=page&view=journalabstract&absid=2514&id=8>
- [71]. Priya Mangesh Nerkar, Bhagyarekha Ujjwalganesha 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>
- [72]. 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>
- [73]. S. B. Khadake, A. B. Chounde, A. A. Suryagan, M. H. M. and M. R. Khadatare, (2024). AI-Driven-IoT(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.
- [74]. 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.
- [75]. 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.
- [76]. 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.
- [77]. Sayyad. (2025a). AI-Powered-IoT (AIIoT)-Based Decision-Making System for BP Patient's Healthcare Monitoring: KSK Approach for BP Patient Healthcare Monitoring. In S. Aouadni & I. Aouadni (Eds.), *Recent Theories and Applications for Multi-Criteria Decision-Making* (pp. 205-238). IGI Global. <https://doi.org/10.4018/979-8-3693-6502-1.ch008>
- [78]. Sayyad (2025b). AI-Powered IoT (AI IoT) for Decision-Making in Smart Agriculture: KSK Approach for Smart Agriculture. In S. Hai-Jew (Ed.), *Enhancing Automated Decision-Making Through AI* (pp. 67-96). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-6230-3.ch003>
- [79]. Sayyad (2025c). KK Approach to Increase Resilience in Internet of Things: A T-Cell Security Concept. In D. Darwish & K. Charan (Eds.), *Analyzing Privacy and Security Difficulties in Social Media: New Challenges and Solutions* (pp. 87-120). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-9491-5.ch005>



- [80]. Sayyad, (2025). KK Approach for IoT Security: T-Cell Concept. In Rajeev Kumar, Sheng-Lung Peng, & Ahmed Elngar (Eds.), *Deep Learning Innovations for Securing Critical Infrastructures*. IGI Global Scientific Publishing. DOI: 10.4018/979-8-3373-0563-9.ch022
- [81]. Sayyad (2025d). Healthcare Monitoring System Driven by Machine Learning and Internet of Medical Things (MLIoMT). In V. Kumar, P. Katina, & J. Zhao (Eds.), *Convergence of Internet of Medical Things (IoMT) and Generative AI* (pp. 385-416). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-6180-1.ch016>
- [82]. Shinde, S. S., Nerkar, P. M., SLiyakat, S. S., & SLiyakat, V. S. (2025). Machine Learning for Brand Protection: A Review of a Proactive Defense Mechanism. In M. Khan & M. Amin Ul Haq (Eds.), *Avoiding Ad Fraud and Supporting Brand Safety: Programmatic Advertising Solutions* (pp. 175-220). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-7041-4.ch007>
- [83]. SilpaRaj M, Senthil Kumar R, Jayakumar K, Gopila M, Senthil kumar S. (2025). Scalable Internet of Things Enabled Intelligent Solutions for Proactive Energy Engagement in Smart Grids Predictive Load Balancing and Sustainable Power Distribution, In S. Kannadhasan et al. (eds.), *Proceedings of the International Conference on Sustainability Innovation in Computing and Engineering (ICSICE 24), Advances in Computer Science Research 120*, [https://doi.org/10.2991/978-94-6463-718-2\\_85](https://doi.org/10.2991/978-94-6463-718-2_85)
- [84]. SLiyakat, K. (2024a). AI-Driven IoT (AIoT) in Healthcare Monitoring. In T. Nguyen & N. Vo (Eds.), *Using Traditional Design Methods to Enhance AI-Driven Decision Making* (pp. 77-101). IGI Global. <https://doi.org/10.4018/979-8-3693-0639-0.ch003> available at: <https://www.igi-global.com/chapter/ai-driven-iot-aiiot-in-healthcare-monitoring/336693>
- [85]. SLiyakat, K. (2024b). Modelling and Simulation of Electric Vehicle for Performance Analysis: BEV and HEV Electrical Vehicle Implementation Using Simulink for E-Mobility Ecosystems. In L. D., N. Nagpal, N. Kassarwani, V. Varthanan G., & P. Siano (Eds.), *E-Mobility in Electrical Energy Systems for Sustainability* (pp. 295-320). IGI Global. <https://doi.org/10.4018/979-8-3693-2611-4.ch014> Available at: <https://www.igi-global.com/gateway/chapter/full-text-pdf/341172>
- [86]. SLiyakat, S. (2024c). Machine Learning-Based Pomegranate Disease Detection and Treatment. In M. Zia Ul Haq & I. Ali (Eds.), *Revolutionizing Pest Management for Sustainable Agriculture* (pp. 469-498). IGI Global. <https://doi.org/10.4018/979-8-3693-3061-6.ch019>
- [87]. SLiyakat, S. (2024d). Computer-Aided Diagnosis in Ophthalmology: A Technical Review of Deep Learning Applications. In M. Garcia & R. de Almeida (Eds.), *Transformative Approaches to Patient Literacy and Healthcare Innovation* (pp. 112-135). IGI Global. <https://doi.org/10.4018/979-8-3693-3661-8.ch006> Available at: <https://www.igi-global.com/chapter/computer-aided-diagnosis-in-ophthalmology/342823>
- [88]. SLiyakat, S. (2024e). IoT Driven by Machine Learning (MLIoT) for the Retail Apparel Sector. In T. Tarnanidis, E. Papachristou, M. Karypidis, & V. Ismyrlis (Eds.), *Driving Green Marketing in Fashion and Retail* (pp. 63-81). IGI Global. <https://doi.org/10.4018/979-8-3693-3049-4.ch004>
- [89]. SLiyakat, S. (2024f). Artificial Intelligence (AI)-Driven IoT (AIoT)-Based Agriculture Automation. In S. Satapathy & K. Muduli (Eds.), *Advanced Computational Methods for Agri-Business Sustainability* (pp. 72-94). IGI Global. <https://doi.org/10.4018/979-8-3693-3583-3.ch005>
- [90]. SLiyakat, K. (2025). Machine Learning-Powered IoT (MLIoT) for Retail Apparel Industry. In T. Tarnanidis, E. Papachristou, M. Karypidis, & V. Manda (Eds.), *Sustainable Practices in the Fashion and Retail Industry* (pp. 345-372). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-9959-0.ch015>
- [91]. SLiyakat, K. S. (2025a). Braille-Lippi Numbers and Characters Detection and Announcement System for Blind Children Using KSK Approach: AI-Driven Decision-Making Approach. In T. Murugan, K. P., & A. Abirami (Eds.), *Driving Quality Education Through AI and Data Science* (pp. 531-556). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-8292-9.ch023>
- [92]. SLiyakat, K. S. (2025b). AI-Driven IoT (AIoT)-Based Decision-Making System for High BP Patient Healthcare Monitoring: KSK1 Approach for BP Patient Healthcare Monitoring. In T. Mzili, A. Arya, D. Pamucar, & M. Shaheen (Eds.), *Optimization, Machine Learning, and Fuzzy Logic: Theory, Algorithms, and*



- Applications (pp. 71-102). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-7352-1.ch003>
- [93]. SLiyakat, K. S. (2025c). Advancing Towards Sustainable Energy With Hydrogen Solutions: Adaptation and Challenges. In F. Özsungur, M. Chaychi Semsari, & H. Küçük Bayraktar (Eds.), *Geopolitical Landscapes of Renewable Energy and Urban Growth* (pp. 357-394). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-8814-3.ch013>
- [94]. SLiyakat, K. S. (2025d). AI-Driven-IoT (AIoT) Decision-Making System for Hepatitis Disease Patient Healthcare Monitoring: KSK1 Approach for Hepatitis Patient Monitoring. In S. Agarwal, D. Lakshmi, & L. Singh (Eds.), *Navigating Innovations and Challenges in Travel Medicine and Digital Health* (pp. 431-450). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-8774-0.ch022>
- [95]. SLiyakat, K. S. (2025e). AI-Driven-IoT (AIoT)-Based Jawar Leaf Disease Detection: KSK Approach for Jawar Disease Detection. In U. Bhatti, M. Aamir, Y. Gulzar, & S. Ullah Bazai (Eds.), *Modern Intelligent Techniques for Image Processing* (pp. 439-472). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-9045-0.ch019>
- [96]. SLiyakat, K. S. (2025f). AI-Powered-IoT (AIoT)-Based Decision-Making System for BP-Patient Healthcare Monitoring: BP-Patient Health Monitoring Using KSK Approach. In M. Lytras & S. Alajlan (Eds.), *Transforming Pharmaceutical Research With Artificial Intelligence* (pp. 189-218). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-6270-9.ch007>
- [97]. SLiyakat, K. S. (2025g). A Study on AI-Driven Internet of Battlefield Things (IoBT)-Based Decision Making: KSK Approach in IoBT. In M. Tariq (Ed.), *Merging Artificial Intelligence With the Internet of Things* (pp. 203-238). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-8547-0.ch007>
- [98]. SLiyakat, K. S. (2025h). KK Approach to Increase Resilience in Internet of Things: A T-Cell Security Concept. In M. Almaiah & S. Salloum (Eds.), *Cryptography, Biometrics, and Anonymity in Cybersecurity Management* (pp. 199-228). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-8014-7.ch010>
- [99]. SLiyakat, K. S. (2025i). KK Approach for IoT Security: T-Cell Concept. In R. Kumar, S. Peng, P. Jain, & A. Elngar (Eds.), *Deep Learning Innovations for Securing Critical Infrastructures* (pp. 369-390). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3373-0563-9.ch022>
- [100]. SLiyakat, K. S. (2025j). Hydrogen Energy: Adaptation and Challenges. In J. Mabrouki (Ed.), *Obstacles Facing Hydrogen Green Systems and Green Energy* (pp. 205-236). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-8980-5.ch013>
- [101]. SLiyakat, K. S. (2025k). Roll of Carbon-Based Supercapacitors in Regenerative Breaking for Electrical Vehicles. In M. Mhadhbi (Ed.), *Innovations in Next-Generation Energy Storage Solutions* (pp. 523-572). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-9316-1.ch017>
- [102]. SLiyakat, S. (2025l). AI-Driven-IoT (AIoT)-Based Decision Making in Drones for Climate Change: KSK Approach. In S. Aouadni & I. Aouadni (Eds.), *Recent Theories and Applications for Multi-Criteria Decision-Making* (pp. 311-340). IGI Global. <https://doi.org/10.4018/979-8-3693-6502-1.ch011>
- [103]. SLiyakat, S. (2025m). Machine Learning-Driven Internet of Medical Things (ML-IoMT)-Based Healthcare Monitoring System. In B. Soufiene & C. Chakraborty (Eds.), *Responsible AI for Digital Health and Medical Analytics* (pp. 49-86). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-6294-5.ch003>
- [104]. SLiyakat, S. (2025n). Transformation of Agriculture Effectuated by Artificial Intelligence-Driven Internet of Things (AIoT). In J. Garwi, M. Dzingirai, & R. Masengu (Eds.), *Integrating Agriculture, Green Marketing Strategies, and Artificial Intelligence* (pp. 449-484). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-6468-0.ch015>
- [105]. 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>.



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

