



# Intelligent Foot Insole: Real Time Gait Pattern Analysis and Performance Optimization

Senthamarai kannan .A<sup>1</sup>, Bhuvana .s<sup>2</sup> Dhanusa.s<sup>3</sup>, Divagar .R<sup>4</sup>

Assistant Professor, Department of ECE, MAM School of Engineering, Siruganur, Trichy, Tamil Nadu, India<sup>1</sup>

Student, MAM School of Engineering, Siruganur, Trichy, Tamil Nadu, India<sup>2</sup>

Student, MAM School of Engineering, Siruganur, Trichy, Tamil Nadu, India<sup>3</sup>

Student, MAM School of Engineering, Siruganur, Trichy, Tamil Nadu, India<sup>4</sup>

**Publication History:** Received: 25.02.2026; Revised: 20.03.2026; Accepted: 25.03.2026; Published: 28.03.2026.

**ABSTRACT:** This project presents the design and development of an intelligent foot insole system for real-time gait analysis. The system uses embedded sensors such as force sensors, flex sensors, and an MPU6050 accelerometer to monitor walking patterns. These sensors continuously collect data related to pressure distribution, movement, and orientation of the foot. The collected data is processed using an Arduino Nano microcontroller for analysis. The system helps in detecting abnormalities like gait asymmetry, imbalance, and drop foot conditions. It provides real-time alerts using a buzzer to notify the user or caregiver. The data can also be monitored using a PC for further analysis. This system is especially useful for elderly people and rehabilitation patients. It is low-cost, wearable, and easy to use. Overall, it improves safety and supports preventive healthcare.

**KEYWORDS:** Arduino ide Iot, pressure sensor, low cost, real time monitoring.

## I. INTRODUCTION

Gait analysis is an important method used to study human walking patterns and detect abnormalities. Many elderly individuals and patients recovering from injuries face difficulties in walking properly. These issues may lead to falls, injuries, and reduced mobility. Traditional gait analysis systems are mostly used in hospitals and laboratories, making them expensive and inaccessible. They also do not provide continuous monitoring during daily activities. With the advancement of wearable technology, it is now possible to monitor gait patterns in real time. Smart insoles equipped with sensors offer a practical and efficient solution. These devices are compact, lightweight, and user-friendly. This project focuses on developing an intelligent foot insole system that continuously monitors walking patterns. It enhances patient safety and provides better healthcare support.

## II. OBJECTIVE

The main objective of this project is to design and develop a smart insole system for real-time gait monitoring. The system aims to continuously analyze walking patterns using embedded sensors. It helps in detecting abnormalities such as imbalance, irregular motion, and gait asymmetry. Another objective is to provide early detection of health issues related to walking. The system is designed to generate alerts to users and caregivers in case of abnormal conditions. It also supports remote monitoring using IoT-based communication. The project focuses on developing a cost-effective and portable solution. It ensures ease of use for both patients and healthcare providers. The overall goal is to improve safety and reduce the risk of falls.

## III. PROBLEM STATEMENT

Gait abnormalities are common among elderly individuals and rehabilitation patients. These abnormalities often lead to falls, injuries, and increased healthcare costs. Traditional gait analysis methods are limited to clinical environments and cannot provide continuous monitoring. They are expensive, bulky, and not suitable for everyday use. Manual observation by doctors may also lead to inaccurate results. Early detection of gait-related issues is difficult with existing systems. There is a need for a wearable, efficient, and reliable system for continuous monitoring. The system should be

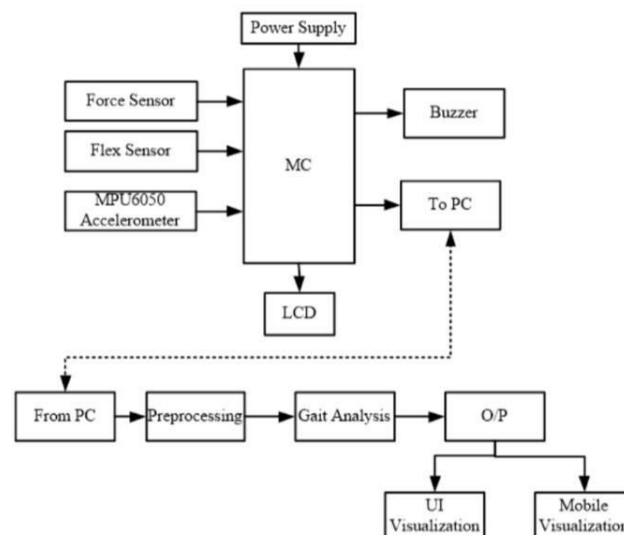


able to detect abnormalities in real time. It should also provide alerts and support remote monitoring. This project aims to overcome these challenges using smart technology.

## IV. PROPOSED SYSTEM

The proposed system consists of a smart insole embedded with multiple sensors. Force sensors are used to measure pressure applied by the foot during walking. Flex sensors detect bending and movement of the foot. The MPU6050 accelerometer measures motion and orientation in three axes. All sensor data is collected and processed using an Arduino Nano microcontroller. The system continuously monitors gait patterns and identifies abnormalities. A buzzer is used to provide alert signals when abnormal conditions are detected. The data can also be sent to a PC for monitoring and analysis. The system is compact, lightweight, and suitable for daily use. It provides real-time monitoring and improves patient safety.

## V. BLOCK DIAGRAM



## VI. DESIGN AND SELECTION OF COMPONENTS

### Arduino Nano

Arduino Nano is a compact microcontroller board used for controlling the system. It is based on the ATmega328P and operates at 5V. It has multiple digital and analog input/output pins for connecting sensors. It processes data from sensors and controls output devices. Its small size makes it suitable for wearable applications. It is easy to program using Arduino IDE. It provides reliable performance for real-time applications.

### Force Sensor

The force sensor is used to measure pressure applied by the foot. It converts physical force into an electrical signal. It helps in analyzing weight distribution during walking. It is useful for detecting abnormal pressure patterns. The sensor is sensitive and provides accurate readings. It plays a key role in gait analysis. It is widely used in wearable and medical devices.

### Flex Sensor

The flex sensor detects bending or movement of the foot. Its resistance changes when it is bent. It helps in measuring the angle of foot movement. It is useful in detecting gait abnormalities. It is flexible and easy to integrate into insoles. It provides real-time data for analysis. It enhances the accuracy of the system.



## **MPU6050 Accelerometer**

The MPU6050 is a motion tracking sensor. It includes a 3-axis accelerometer and gyroscope. It measures acceleration and orientation of the foot. It helps in detecting motion patterns and balance. It provides accurate and fast data. It is widely used in IoT and embedded systems. It improves system performance.

## **Buzzer**

The buzzer is used as an alert device. It produces sound when triggered. It alerts the user in case of abnormal gait patterns. It is simple and cost-effective. It improves safety by providing immediate feedback. It is easy to integrate with microcontrollers. It is widely used in warning systems.

## **Power Supply**

The power supply provides electrical energy to the system. It ensures stable voltage for proper operation. It includes voltage regulators and filters. It protects components from voltage fluctuations. It is designed to be compact and efficient. It is essential for wearable systems. It ensures reliable performance.

## **PC**

The PC is used for monitoring and analysis of data. It displays the collected sensor data. It helps in understanding gait patterns. It can store data for future analysis. It is useful for medical and research purposes. It improves system usability. It supports remote monitoring.

## **VII. SOFTWARE INSTALLATION**

### **Arduino IDE**

Arduino IDE is used for programming the microcontroller. It allows writing, compiling, and uploading code. It is user-friendly and widely used. It supports various libraries for sensors. It helps in debugging and testing. It is essential for system development. It ensures smooth operation of the system.

### **Proteus 8.13**

Proteus 8.13 is used for circuit simulation. It helps in testing the design before hardware implementation. It reduces errors and saves time. It allows visualization of circuit behavior. It is useful for students and engineers. It improves system reliability. It supports efficient development.

## **VIII. RESULTS AND ANALYSIS**

The system successfully monitors gait patterns in real time. Sensor data is accurate and reliable. The system detects abnormalities such as imbalance and irregular walking. The buzzer provides alerts effectively. The system performs well under different conditions. Data analysis helps in understanding walking behavior. It is useful for medical diagnosis and rehabilitation. The system proves to be efficient and practical. It can be further improved for better accuracy. Overall, the results are satisfactory.

## **IX. CONCLUSION**

The intelligent foot insole system is an effective solution for gait analysis. It helps in early detection of health issues related to walking. The system is cost-effective, portable, and user-friendly. It provides continuous monitoring and real-time alerts. It improves safety and reduces the risk of falls. The project demonstrates the usefulness of wearable technology in healthcare. Future improvements can include mobile app integration and cloud storage. The system has great potential for real-world applications. It can be used in hospitals, homes, and rehabilitation centers. Overall, it is a successful and impactful project.

## **REFERENCES**

1. F. Y. Yavuz and N. Yumusak, "Utilizing Footstep Sound Event Detection by Using CNN Techniques For Assuring Property Security," in IEEE Access, vol. 13, pp. 70760-70768, 2025, doi:10.1109/ACCESS.2025.3561076.
2. A. Salehi, A. Roberts, A. Phinyomark and E. Scheme, "Feature Learning Networks for Floor Sensor-based Gait Recognition," 2023 45<sup>th</sup> Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), Sydney, Australia, 2023, pp. 1-5, doi:10.1109/EMBC40787.2023.10340596.



3. C.Nagarajan and M.Madheswaran - 'Stability Analysis of Series Parallel Resonant Converter with Fuzzy Logic Controller Using State Space Techniques'- Taylor & Francis, Electric Power Components and Systems, Vol.39 (8), pp.780-793, May 2011. DOI: 10.1080/15325008.2010.541746
4. C.Nagarajan and M.Madheswaran - 'Experimental verification and stability state space analysis of CLL-T Series Parallel Resonant Converter' - Journal of Electrical Engineering, Vol.63 (6), pp.365-372, Dec.2012. DOI: 10.2478/v10187-012-0054-2
5. C.Nagarajan and M.Madheswaran - 'Performance Analysis of LCL-T Resonant Converter with Fuzzy/PID Using State Space Analysis'- Springer, Electrical Engineering, Vol.93 (3), pp.167-178, September 2011. DOI 10.1007/s00202-011-0203-9
6. S.Tamilselvi, R.Prakash, C.Nagarajan, "Solar System Integrated Smart Grid Utilizing Hybrid Coot-Genetic Algorithm Optimized ANN Controller" Iranian Journal Of Science And Technology-Transactions Of Electrical Engineering, DOI10.1007/s40998-025-00917-z,2025
7. S.Tamilselvi, R.Prakash, C.Nagarajan, " Adaptive sliding mode control of multilevel grid-connected inverters using reinforcement learning for enhanced LVRT performance" Electric Power Systems Research 253 (2026) 112428, doi.org/10.1016/j.epr.2025.112428
8. S.Thirunavukkarasu, C. Nagarajan, 2024, "Performance Investigation on OCF and SCF study in BLDC machine using FTANN Controller," Journal of Electrical Engineering And Technology, Volume 20, pages 2675–2688, (2025), doi.org/10.1007/s42835-024-02126-w
9. C. Nagarajan, M.Madheswaran and D.Ramasubramanian- 'Development of DSP based Robust Control Method for General Resonant Converter Topologies using Transfer Function Model'- Acta Electrotechnica et Informatica Journal , Vol.13 (2), pp.18-31, April-June.2013, DOI: 10.2478/aei-2013-0025.
10. C.Nagarajan and M.Madheswaran - 'DSP Based Fuzzy Controller for Series Parallel Resonant converter'- Springer, Frontiers of Electrical and Electronic Engineering, Vol. 7(4), pp. 438-446, Dec.12. DOI 10.1007/s11460-012-0212-0.
11. C.Nagarajan and M.Madheswaran - 'Experimental Study and steady state stability analysis of CLL-T Series Parallel Resonant Converter with Fuzzy controller using State Space Analysis'- Iranian Journal of Electrical & Electronic Engineering, Vol.8 (3), pp.259-267, September 2012.
12. C.Nagarajan and M.Madheswaran, "Analysis and Simulation of LCL Series Resonant Full Bridge Converter Using PWM Technique with Load Independent Operation" has been presented in ICTES'08, a IEEE / IET International Conference organized by M.G.R.University, Chennai. Vol.no.1, pp.190-195, Dec.2007
13. Suganthi Mullainathan, Ramesh Natarajan, "An SPSS and CNN modelling based quality assessment using ceramic materials and membrane filtration techniques", Revista Materia (Rio J.) Vol. 30, 2025, DOI: <https://doi.org/10.1590/1517-7076-RMAT-2024-0721>
14. M Suganthi, N Ramesh, "Treatment of water using natural zeolite as membrane filter", Journal of Environmental Protection and Ecology, Volume 23, Issue 2, pp: 520-530,2022
15. 3. U. Wickramarathne, M. Jayawickrama and S. Tissera, "Predictive Analytics-Driven Wearable System for E. Macdonald, R. Larracy, A. Phinyomark and E. Scheme, "Underfoot Pressure-Based Left and Right Foot Classification Algorithms: The Impact of Footwear," in IEEE Access, vol. 11, pp. 137937-137947, 2023, doi: 10.1109/ACCESS.2023.3340620.
16. 4. R. Guo et al., "A Shoe-Integrated Sensor System for Long- Term Center of Pressure Evaluation," In IEEE Sensors Journal, vol. 21, no. 23, pp. 27037-27044, 1 Dec.1, 2021, doi:10.1109/JSEN.2021.3116249.
17. 5. S. Basheer, K. K. Nagwanshi, S. Bhatia, S. Dubey and G. R. Sinha, "FESD: An Approach for Biometric Human Footprint Matching Using Fuzzy Ensemble Learning," in IEEE Access, vol. 9, pp.26641-26663, 2021, doi: 10.1109/ACCESS.2021.3057931.
18. 1/9/2026 2
19. **Kiran, A., Rubini, P., & Kumar, S. S. (2025).** Comprehensive review of privacy, utility and fairness offered by synthetic data. *IEEE Access*.
20. **Gopinathan, V. R. (2024).** Real-Time Financial Risk Intelligence Using Secure-by-Design AI in SAP-Enabled Cloud Digital Banking. *International Journal of Computer Technology and Electronics Communication*, 7(6), 9837-9845.
21. **Udayakumar, R., Elankavi, R., Vimal, R., & Sugumar, R. (2023).** Improved Particle Swarm Optimization with Deep Learning-Based Municipal Solid Waste Management in Smart Cities. *Environmental & Social Management Journal*, 17(4).
22. **Anand, L. (2023).** An Intelligent AI and ML-Driven Cloud Security Framework for Financial Workflows and Wastewater Analytics. *International Journal of Humanities and Information Technology*, 5(02), 87-94.



23. **Soundappan, S. J. (2020).** Big Data Analytics in Healthcare: Applications for Pandemic Forecasting. *International Journal of Advanced Research in Computer Science & Technology*, 3(1), 2248-2253.
24. **Rajasekar, M. (2024).** Real-Time Predictive DevOps Intelligence for Risk-Aware Digital Business Processes in Cloud and SAP Ecosystems. *International Journal of Advanced Research in Computer Science & Technology*, 7(4), 10713-10718.
25. **Poornima, G., & Anand, L. (2024, May).** Novel AI Multimodal Approach for Combating Against Pulmonary Carcinoma. In *2024 5th International Conference for Emerging Technology (INCET)* (pp. 1-6). IEEE.
26. **Prabha, P. S., & Rengarajan, A. (2025).** Adaptive Cloud Resource Allocation Using Attention-Driven Deep Reinforcement Learning. *Engineering, Technology & Applied Science Research*, 15(6), 29334-29340.
27. **Jagadeesh, S., & Sugumar, R. (2017).** A Comparative study on Artificial Bee Colony with modified ABC algorithm. *European Journal of Applied Sciences*, 9(5), 243-248.
28. **Varma, K. K., & Anand, L. (2025, March).** Deep Learning Driven Proactive Auto Scaler for High-Quality Cloud Services. In *International Conference on Computing and Communication Systems for Industrial Applications* (pp. 329-338). Singapore: Springer Nature Singapore.
29. **Kumar, S. A., & Anand, L. (2025).** A Novel EEG-Based Deep Learning Framework for Enhancing Communication in Locked-In Syndrome Using P300 Speller and Attention Mechanisms. *KSII TRANSACTIONS ON INTERNET AND INFORMATION SYSTEMS*, 19(11), 3841-3855.
30. **Poornima, G., & Anand, L. (2025).** Medical image fusion model using CT and MRI images based on dual scale weighted fusion based residual attention network with encoder-decoder architecture. *Biomedical Signal Processing and Control*, 108, 107932.
31. **Archana, R., & Anand, L. (2025).** Residual u-net with Self-Attention based deep convolutional adaptive capsule network for liver cancer segmentation and classification. *Biomedical Signal Processing and Control*, 105, 107665.
32. **Kumar, S. A., & Anand, L. (2025).** A Novel EEG-Based Deep Learning Framework for Enhancing Communication in Locked-In Syndrome Using P300 Speller and Attention Mechanisms. *KSII Transactions on Internet and Information Systems*, 19(11), 3841-3855.
32. **Rengarajan, A. (2025).** Cloud-Based AI-Driven Threat Detection Framework for Smart Grid Cybersecurity. *International Journal of Future Innovative Science and Technology*, 8(6), 16065.
33. **Murugeswari, B., Sudharson, K., Panimalar, S. P., Shanmugapriya, M., & Abinaya, M. (2020).** SAFE-Secure Authentication in Federated Environment using CEG Key code.
34. **Raj A. A., & Sugumar, R. (2023).** Early Detection of COVID-19 with Impact on Cardiovascular Complications using CNN Utilising Pre-Processed Chest X-Ray Images. *2023 International Conference on Applied Intelligence and Sustainable Computing (ICAISC)*, IEEE.
35. **Jagadeesh, S., & Sugumar, R. (2017).** A Comparative study on Artificial Bee Colony with modified ABC algorithm. *European Journal of Applied Sciences*, 9(5), 243-248.
36. **Selvi, G. V., Anbarasan, A. B., Murthy, B. A., & Prabavathy, S. (2023).** An Application Oriented Integrated Unequal Clustering Algorithm for Wireless Sensor Network. In *Underwater Vehicle Control and Communication Systems Based on Machine Learning Techniques* (pp. 140-154). CRC Press.
37. **Sruthi, R. S., Ananya, S., & Murugeswari, B. (2010).** Web Based Virtual Control System Laboratory and On-Line Temperature Control of Electrophoresis Equipment using LabVIEW. *International Journal of Computer Applications*, 975, 8887.
38. **Vimal Raja, G. (2021).** Mining Customer Sentiments from Financial Feedback and Reviews using Data Mining Algorithms. *International Journal of Innovative Research in Computer and Communication Engineering*, 9(12), 14705-14710.
39. **MATHEW, A. R. (2025).** Neurosecurity and Brain-Computer Interfaces.
40. **Soundappan, S. J. (2024).** AI-Driven Customer Intelligence in Enterprise Lakehouse Systems Sentiment Mining Governance-Aware Analytics and Real-Time Data Synchronization. *International Journal of Advanced Engineering Science and Information Technology (IJAESIT)*, 7(5), 14905.
41. **Mathew, A. (2025).** Human-AI Collaboration in Security Operations: Measuring Alert Trust, Automation Bias, and Analyst Upskilling in AI-Augmented SOC Environments. *International Journal of Computer Technology and Electronics Communication*, 8(5), 11375-11380.
42. **Soundappan, S. J. (2022).** AI-Based Fault Detection and Isolation for Reliability in Modern Power Systems. *International Journal of Research Publications in Engineering, Technology and Management (IRPETM)*, 5(4), 7106-7110.
43. **Poornima, G., & Anand, L. (2024, April).** Effective Machine Learning Methods for the Detection of Pulmonary Carcinoma. In *2024 Ninth International Conference on Science Technology Engineering and Mathematics (ICONSTEM)* (pp. 1-7). IEEE.
44. **Garg, V. K., Soundappan, S. J., & Kaur, E. M. (2020).**



Enhancement in intrusion detection system for WLAN using genetic algorithms. *South Asian Research Journal of Engineering and Technology*, 2(6), 62–64.

44. Rengarajan, A., Jayakumar, C., & Sugumar, R. (2012). Optimization Of Recent Attacks Using Internet Protocol. *National Journal of System and Information Technology*, 5(1), 8.
45. Mathew, A. (2024). AI TRiSM: Trust, Risk, and Security Management in Cybersecurity. *Cybersecurity*, 4(3), 84-90.
46. Mathew, A. (2025). Deep seek vs. ChatGPT: A deep dive into AI Language mastery. *Int J Multidisciplinary Res*, 7(1), 1-5.