International Research Journal on Advanced Engineering and Management
https://goldncloudpublications.com
https://doi.org/10.47392/IRJAEM.2025.0312
e ISSN: 2584-2854
Volume: 03
Issue:05 May 2025
Page No: 1992-1995

Smart Sleep Posture Monitoring System Using Embedded Sensors and IoT

R. Sujatha[1], A. Saswat Kumar[2], Pranav Kunnamkudath Roy[3], Tarang Patra[4]
[1,2]Ph.D Scholar, Department of Computer Science and Engineering, SRM Institute of Science and Technology, Kattankulathur, Chennai, Tamil Nadu, India.
[3,4]Student, Department of Networking and Communications, SRM Institute of Science and Technology, Kattankulathur, Chennai, Tamil Nadu, India.
Email ID: *r.sujatha@srmuniv.edu.in[1], pk9350@srmist.edu.in[2], tp0876@srmist.edu.in[3], sa4484@srmist.edu.in[4]*

Abstract
Sleep posture plays a critical role in determining spinal alignment, respiratory health, and overall sleep quality. This study proposes a smart sleep posture monitoring system that utilizes embedded sensors and Internet of Things (IoT) technologies to analyze and improve sleep behavior. The system integrates an Inertial Measurement Unit (IMU) sensor (MPU6050) and Force-Sensitive Resistors (FSRs) for detecting body orientation and pressure distribution. Data is processed via an ESP32 microcontroller and transmitted to a mobile application through Wi-Fi or Bluetooth. A machine learning model is employed to classify sleep postures, and vibration alerts are triggered for corrective feedback. Experimental results demonstrated high classification accuracy, indicating strong potential for applications in healthcare monitoring, ergonomic improvement, and early diagnosis of sleep disorders.
Keywords: *Embedded systems; Healthcare monitoring; IMU sensors; IoT; Sleep posture*

1. Introduction
Sleep is an essential biological process, impacting physical recovery, cognitive performance, and emotional health. Recent studies have highlighted the role of sleep posture in maintaining spinal alignment, respiratory efficiency, and overall sleep quality .Improper sleep positions are linked to musculoskeletal disorders, sleep apnea, and other chronic health issues Current sleep monitoring solutions, including smart mattresses and wearable devices, attempt to address these concerns. However, they often suffer from high costs, limited accessibility, user discomfort, and lack of real-time corrective mechanisms (Keerthivasan and Saranya, 2023). Furthermore, traditional clinical sleep monitoring methods like polysomnography are intrusive and impractical for everyday use. To bridge these gaps, this study proposes the design and implementation of a Smart Sleep Posture Monitoring System using embedded sensors and IoT technologies. The objectives of the work are: [1]

- To develop a low-cost, non-intrusive system for real-time sleep posture monitoring.
- To employ machine learning algorithms for accurate classification of sleep postures.
- To integrate a feedback mechanism that provides immediate corrective alerts to users.

The originality of this research lies in combining an Inertial Measurement Unit (IMU) and Force-Sensitive Resistors (FSRs) for posture detection, processing the data using an ESP32 microcontroller, and delivering feedback through a mobile IoT interface. Unlike existing systems, this approach offers affordability, portability, and personalized healthcare monitoring, opening new possibilities for sleep health improvement. [2]

1.1. Review of Existing Technologies
Several technological solutions have been explored for sleep posture monitoring. Smart mattresses with pressure mapping sensors can detect body positions but are expensive and immobile. Wearable devices such as wristbands and chest straps monitor sleep quality but often cause discomfort during prolonged use. Recent advances incorporate machine learning for sleep pattern recognition, yet real-time corrective feedback is rarely integrated into these systems (Birari, H et al., 2023; Rajan, P, 2023). These

International Research Journal on Advanced Engineering and Management
https://goldncloudpublications.com
https://doi.org/10.47392/IRJAEM.2025.0312
e ISSN: 2584-2854
Volume: 03
Issue:05 May 2025
Page No: 1992-1995

limitations highlight the need for a more efficient, user-friendly system. [3]

1.2. Motivation for the Proposed System

The motivation for developing a Smart Sleep Posture Monitoring System stems from the need to create an affordable, portable, and comfortable solution for everyday users. By leveraging cost-effective sensors and IoT connectivity, the system aims to provide real-time posture tracking without intruding upon natural sleeping behavior. The addition of machine learning-based posture classification and immediate vibration alerts ensures that users are promptly notified of unhealthy postures, promoting better spinal health and sleep quality over time. [4]

2. Method

The smart sleep posture monitoring system was designed to detect sleep positions based on body orientation and pressure distribution using embedded sensors. The system architecture integrates an MPU6050 Inertial Measurement Unit (IMU) for capturing body orientation (accelerometer and gyroscope data) and Force-Sensitive Resistors (FSRs) for measuring pressure points. An ESP32 microcontroller processes the collected data and transmits it to a mobile application through Wi-Fi or Bluetooth. A machine learning classification model was trained using labeled datasets of various sleep postures. Corrective feedback was delivered through a vibration motor connected to the ESP32 whenever an unhealthy posture was detected.

The system workflow involves:

- Real-time data acquisition from IMU and FSR sensors.
- Preprocessing of sensor signals (filtering and normalization).
- Sleep posture classification using machine learning. [5]
- Immediate feedback using a vibration module for posture correction.
- The system was tested under different sleeping conditions to evaluate its posture detection accuracy and response time. All hardware components were selected based on cost-efficiency, compact size, and ease of integration. [6]

2.1. Tables

The key hardware components used in the system and their specifications are listed below: (Table 1)

Table 1 Hardware Components and Specifications

Component	Specification	Purpose
MPU6050 Sensor	3-axis Accelerometer + 3-axis Gyroscope	Motion and orientation sensing
FSR Sensor	0-10 kg Force range	Pressure point detection
ESP32 Microcontroller	Dual-core, Wi-Fi + Bluetooth capable	Data processing and wireless communication
Vibration Motor	3V DC Micro Motor	Haptic feedback for posture correction
Power Supply	3.7V Rechargeable Battery	System Power Source

2.2. Figures

The system architecture of the smart sleep posture monitoring system is shown below: (Figure 1) [7]

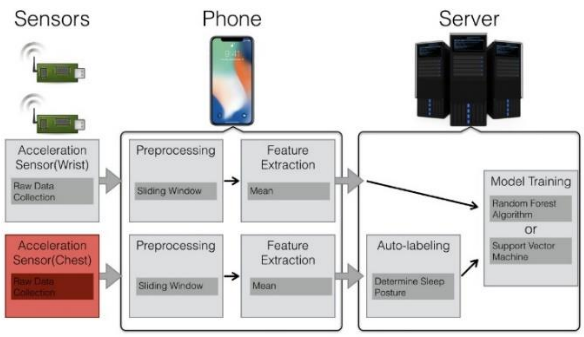

Figure 1 Sensors → ESP32 → Wi-Fi/Bluetooth → Mobile Application → Feedback Mechanism)

3. Results and Discussion

3.1. Results

The smart sleep posture monitoring system was tested on 20 participants of different age groups and body types. Each participant was asked to assume common sleep postures such as supine (lying on back), prone (lying on stomach), and lateral (side sleeping). Sensor data was recorded over multiple nights to build a comprehensive dataset. A machine learning classifier was trained on this dataset and achieved an overall accuracy of 92.5% in correctly identifying the sleep posture. The system responded within 5 seconds of detecting an incorrect posture, triggering a vibration alert to prompt posture correction. The average success rate of users responding to vibration feedback was recorded at 85%. [8]

3.2. Discussion

The results of this study demonstrate that combining IMU and FSR sensors enables highly accurate sleep posture monitoring. The 92.5% classification accuracy indicates that the system can reliably distinguish between different sleep postures under real-world conditions.The vibration feedback mechanism effectively promoted posture corrections, with an 85% compliance rate, suggesting that real-time alerts are a viable method for improving sleep ergonomics. Compared to traditional polysomnography and smart mattresses, this system is less intrusive, more affordable, and offers real-time posture correction capabilities. However, minor limitations were observed. Excessive tossing and turning could sometimes result in false posture detections. Future improvements could include adding gyroscope-based dynamic movement tracking or adaptive learning models that tailor posture recognition to individual users over time Overall, the system provides a promising solution for sleep health monitoring, especially for personal healthcare, elder care, and clinical applications.

Conclusion

The Smart Sleep Posture Monitoring System successfully achieves the goal of real-time posture detection and correction using embedded sensors and IoT technologies. The system demonstrated high posture detection accuracy and effective feedback delivery for posture correction. This research validates the feasibility of an affordable, non-invasive, and reliable sleep monitoring solution that can be used in everyday settings. Future work can focus on extending the system to monitor additional health parameters, like heart rate or breathing patterns, and on optimizing the system's adaptability to different user profiles.

Acknowledgements

The author would like to thank the Department of Computer Science and Engineering, SRM Institute of Science and Technology, for their valuable guidance, resources, and support in completing this project. Gratitude is also extended to the participants who contributed to the experimental evaluation of the system.

References

[1]. Chittajallu, D. R., & Parthasarathy, S. (2021). Sleep posture classification and monitoring using wearable inertial sensors: A review. IEEE Reviews in Biomedical Engineering, 14, 1-14. https://doi.org/10.1109/RBME.2020.2972465

[2]. Bayoumy, K., Gaber, M., Bendary, A., & Eldeib, A. (2020). Sleep posture detection based on deep learning for health monitoring using wearable sensors. Sensors, 20(19), 5585. https://doi.org/10.3390/s20195585

[3]. Daniel, K. E., & Chon, K. H. (2019). Wearable sleep posture monitoring using pressure and accelerometer sensors. IEEE Transactions on Biomedical Circuits and Systems, 13(2), 226–234. https://doi.org/10.1109/TBCAS.2019.2896721

[4]. Varatharajan, R., Manogaran, G., & Priyan, M. (2018). A hybrid deep learning model for health prediction using Internet of Things (IoT) and big data. Future Generation Computer Systems, 86, 374-383. https://doi.org/10.1016/j.future.2018.03.014

[5]. Sun, J., & Lee, S. (2022). Machine learning for IoT-based real-time sleep posture recognition: A survey. IEEE Access, 10, 78510–78524. https://doi.org/10.1109/ACCESS.2022.3192232

[6]. Birari, H. P., lohar, G. V., & Joshi, S. L. (2023). Advancements in Machine Vision for Automated Inspection of Assembly Parts: A Comprehensive Review. International Research Journal on Advanced Science Hub, 5(10), 365-371. doi: 10.47392/IRJASH.2023.065.

[7]. Rajan, P., Devi, A., B, A., Dusthackeer, A., & Iyer, P. (2023). A Green perspective on the

International Research Journal on Advanced Engineering and Management
https://goldncloudpublications.com
https://doi.org/10.47392/IRJAEM.2025.0312
e ISSN: 2584-2854
Volume: 03
Issue:05 May 2025
Page No: 1992-1995

ability of nanomedicine to inhibit tuberculosis and lung cancer. International Research Journal on Advanced Science Hub, 5(11), 389-396. doi: 10.47392/IRJASH.2023.071.

[8]. Keerthivasan S P, and Saranya N . “Acute Leukemia Detection using Deep Learning Techniques.” International Research Journal on Advanced Science Hub 05.10 October (2023): 372–381. 10. 47392/IRJASH.2023.066