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Smart Spine: An IoT-Enabled Wearable Posture Monitoring and Correction System

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Abstract: Poor posture is a major cause of spinal disorders, chronic back pain, and reduced quality of life, especially among individuals with sedentary lifestyles such as students and office workers. Continuous monitoring and timely correction of posture can help prevent long-term musculoskeletal complications. This paper presents a wearable posture correction and system using the ESP8266 microcontroller and ADXL335 accelerometer sensor. The ADXL335 continuously measures body orientation and spinal alignment by detecting acceleration changes along three axes (X, Y, and Z). The collected sensor data are processed locally by the ESP8266, where threshold-based posture classification is implemented to identify in correct sitting or standing positions. When poor posture is detected, the system provides immediate feedback to alert the user and encourage posture correction. In addition, the monitored posture data are transmitted wirelessly via Wi-Fi to the Thing Speak cloud platform for real-time visualization, storage, and long- term analysis. Cloud integration enables remote monitoring of posture trends and supports data-driven evaluation of spinal health over time. Experimental results show that the proposed system offers reliable posture detection, low power consumption, and smooth IoT connectivity. The developed solution is lightweight, cost-effective, and scalable, making it suitable for daily posture improvement and early prevention of spinal health issues through continuous wearable monitoring.
Keyword: ESP8266, ADXL335, IoT, Posture Correction, Thing Speak, Wearable Device

I. INTRODUCTION

In recent years, spinal health problems have increased due to lifestyle changes and long hours of sitting while using computers or mobile phones. Poor posture such as slouching and forward head position can cause back pain and long-term musculoskeletal problems. Traditional posture correction methods like physiotherapy and braces are often expensive and do not provide real-time monitoring. To address this issue, this project proposes wearable posture correction and spinal health monitoring system using the ESP8266 microcontroller and ADXL335 accelerometer sensor. The sensor measures body tilt along the X, Y, and Z axes, while the ESP8266 processes the data to detect incorrect posture. When poor posture is identified, the system alerts the user to correct it. Additionally, posture data is transmitted via Wi-Fi to the Thing Speak cloud platform for storage and graphical analysis. The system is low-cost, lightweight, and suitable for continuous posture monitoring and early prevention of spinal disorders.

II. LITEARATURE REVIEW

[1] Human posture recognition has become an important research area in healthcare and ergonomic monitoring systems. J. Su and S. Chen (2025) developed a dynamic sitting posture recognition system using passive RFID tags combined with RSSI and Doppler signal features. The collected data were processed using a ResNet-based deep learning model to classify sitting postures. The system achieved a high recognition accuracy of about 99.17% while maintaining privacy and low implementation cost. However, the system requires proper placement of RFID tags and is mainly limited to sitting posture recognition. [2] A.S.Mahomed and A.K.Saha (2024) presented a comprehensive review of driver posture recognition techniques used for safety monitoring in vehicles.

The study analysed sensor-based, vision-based, and hybrid approaches used for detecting driver posture and fatigue conditions. Although the review provides a detailed comparison of existing technologies, the work does not include experimental implementation or validation.[3] G. Liu et al. (2024) proposed a human posture recognition system using skeletal data captured through depth cameras. The system utilizes Kinect sensors to collect skeletal joint coordinates and applies Graph Convolutional Networks (GCN) for posture classification. This approach provides accurate skeletal modelling and improves posture detection accuracy, but the system requires specialized depth cameras and mainly operates in indoor environments.[4] D. Carneros-Prado et al. (2024) investigated sitting posture recognition using skeleton data extracted from MediaPipe. The study compared two machine learning models, namely Multi-Layer Perceptron (MLP) and Kernel Attention Network (KAN), to evaluate performance. The results showed that both models achieved high classification accuracy with relatively fewer parameters. However, since the method relies on vision-based cameras, it may raise privacy concerns in certain environments.[5] J. Li et al. (2024) developed a multimodal posture recognition system using surface electromyography (sEMG) and accelerometer sensors. The collected data were processed using Convolutional Neural Networks (CNN) and Canonical Correlation Analysis (CCA) for feature fusion and classification. The system demonstrated robust recognition of posture variations, but the use of multiple wearable sensors increases system complexity and user inconvenience.[6] L. Yuan et al. (2025) proposed a smart pressure e-mat system designed to recognize sleeping postures using pressure sensors integrated into a mat structure. Deep learning algorithms were applied to analyse the pressure distribution patterns and classify different sleeping positions. The system provides non-invasive and accurate posture monitoring, but the large size of the mat reduces portability and limits its use to specific environments.[7] E. L. A. Ekmeyen et al. (2025) introduced a posture recognition approach using lightweight transformer models applied to human skeleton data. The method achieved high recognition accuracy with efficient computational performance, making it suitable for real-time applications. However, the approach requires labelled skeleton datasets, which can be difficult and time-consuming to collect.[8] C. Jandaeng et al. (2025) developed the ANYA dataset for ergonomic posture analysis using webcam-based video recordings. Supervised machine learning models were applied to classify posture patterns and evaluate ergonomic conditions. The system provides a scalable and low-cost solution for posture monitoring, although its performance can be affected by lighting conditions and camera positioning.[9] L.Jiang et al. (2025) proposed a cross-subject finger movement recognition system using wearable data gloves. The collected hand motion data were processed using CNN- LSTM networks combined with contrastive learning techniques to improve generalization across users. While the system achieved high recognition accuracy, the application is mainly limited to finger and hand posture recognition.[10] S. Wu et al. (2024) developed a lightweight neural network called Concatenate for sleep posture classification using pressure mat sensor data. The model enables real-time and low-power operation, making it suitable for continuous monitoring systems. However, the system focuses only on sleep posture scenarios and does not address other types of human posture detection.

III. METHODOLOGY

The methodology of the proposed Wearable Posture Correction and Spinal Health Monitoring System focuses on developing a compact and IoT-enabled device that continuously monitors the user's body posture and provides real-time corrective feedback. The system integrates a microcontroller-based processing unit, an accelerometer sensor for posture detection, a feedback alert module, and cloud connectivity for remote monitoring. The methodology includes system design, hardware integration, posture detection algorithm development, IoT communication, and system testing.

A. System Design and Architecture

The proposed system is designed to monitor the user's posture continuously and provide immediate feedback whenever incorrect posture is detected. The overall architecture of the system consists of three main modules: sensing module, processing and control module, and communication and feedback module. The sensing module uses the ADXL335 accelerometer sensor to measure the orientation and tilt of the user's body. The sensor detects acceleration values along the three axes (X,Y,and Z), which represent the posture position of the user. The processing and control module is based on the ESP8266 microcontroller, which acts as the central processing unit of the system. It receives the sensor data from the accelerometer and processes the values using a threshold-based algorithm to determine whether the user's posture is corrector incorrect. The communication and feedback module provides real-time alerts and cloud connectivity. When the detected posture exceeds the predefined threshold values, the system activates an alert mechanism such as a buzzer or vibration motor to notify the user immediately. In addition, the posture data are transmitted to the Thing Speak IoT cloud platform through the Wi-Fi capability of the ESP8266.The system operates in real time where posture data are continuously sensed by the accelerometer, processed by the microcontroller, and analysed to detect posture deviations. When incorrect posture is identified, the feedback module alerts the user, while the IoT platforms to resand visualizes the posture data for long- term monitoring and analysis. This architecture ensures continuous posture monitoring, early correction of improper posture, and improved spinal health awareness for users.

B. Hardware Components

The proposed posture monitoring system uses several hardware components to detect body posture and provide feedback to the user. The main component is the ESP8266, which acts as the central processing unit of the system. It receives data from the sensor, processes posture information, and manages system operations. The ADXL335 accelerometer is used to measure body orientation by detecting acceleration along the X,Y,and Z axes. These values help the system determine whether the user's posture is corrector incorrect.

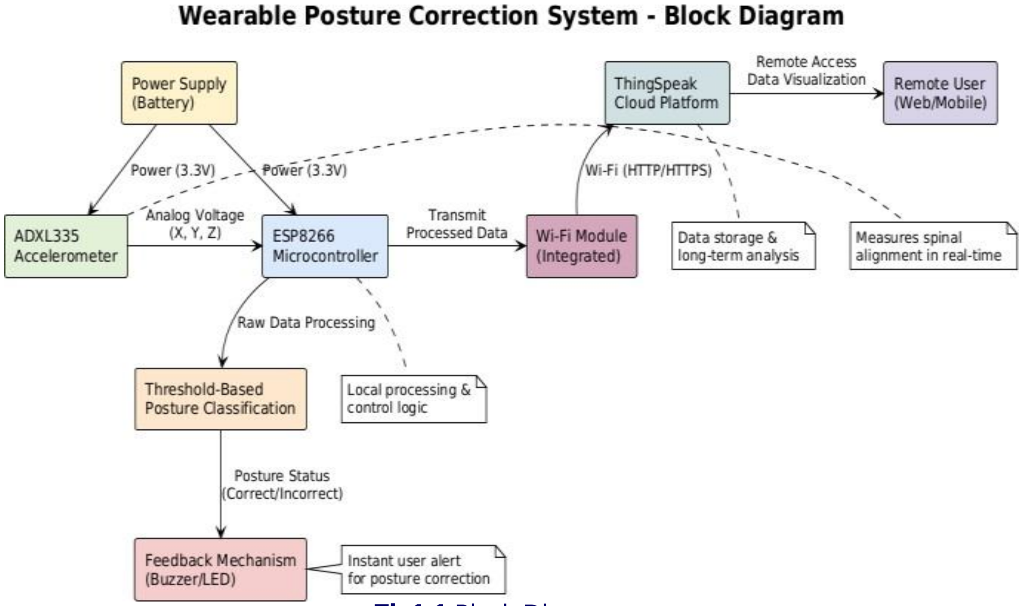

Fig1.1 Block Diagram

A feedback module such as a buzzer or vibration motor is used to alert the user when improper posture is detected. The system also sends posture data to the Thing Speak IoT cloud platform through Wi-Fi for real-time monitoring and data storage. A power supply unit provides the required electrical energy for stable operation of the system Wi-Fi–Based IoT Monitoring System. The proposed system uses the built-in Wi-Fi capability of the ESP8266 to transmit posture data to an IoT cloud platform. The microcontroller connects to the internet through a wireless network and sends the processed posture readings to the Thing Speak cloud server. The uploaded data can be visualized in real time through graphs and charts on the Thing Speak dashboard. This enables continuous monitoring and storage of posture information for further analysis. The IoT connectivity allows users and healthcare professionals to observe posture patterns over time and evaluate improvements in spinal health.

C. Alert and Feedback Mechanism

The alert and feedback mechanism is used to notify the user when in correct posture is detected. The posture data collected from the ADXL335 accelerometer are processed by the ESP8266 to determine whether the user's posture is within the predefined threshold limits. When the detected posture exceeds the allowable range, indicating slouching or excessive bending, the system activates a feedback module such as a buzzer or vibration motor. This immediate alert warns the user and encourages them to correct their posture. This real-time feedback mechanism helps prevent prolonged poor posture, reducing the risk of spinal stress and improving posture awareness during daily activities.

D. System Operation and Testing

The operation of the proposed posture monitoring system begins with the sensing of body orientation using the ADXL335 accelerometer sensor. The sensor continuously measures acceleration values along the X, Y, and Z axes and sends the data to the ESP8266 for processing. The microcontroller analyses these values using predefined threshold limits to determine whether the user's posture is corrector incorrect. When improper posture such as slouching or excessive bending is detected, the system activates an alert through a buzzer or vibration motor to notify the user to correct their posture. At the same time, the posture data are transmitted to the Thing Speak IoT cloud platform through Wi-Fi for real-time monitoring and storage. The system was tested under different posture conditions such as straight sitting, slouching, and bending to evaluate its performance. The testing results showed that the device successfully detects incorrect posture and provides immediate feedback to the user. The system also demonstrated reliable data transmission to the cloud platform for continuous posture monitoring and analysis.

E. User Control Interface

The user control interface allows the user to monitor posture data and observe posture trends through an IoT platform. The proposed system uses the Thing Speak cloud platform as the interfacefordatavisualizationandmonitoring.TheESP8266 sends posture data collected from the ADXL335 accelerometer to the cloud server through Wi-Fi. The uploaded data are displayed in graphical form on the ThingSpeak dashboard, allowing users to easily observe posture variations over time. Through this interface, users can monitor their posture condition in real time and analyse historical data to identify frequent posture issues. This user- friendly interface helps improve posture awareness and supports long-term monitoring of spinal health.

F. Testing and Evaluation

The proposed posture monitoring system was tested to evaluate its performance in detecting different body postures. The ADXL335 accelerometer was used to measure body orientation while the ESP8266 processed the sensor data to determine posture conditions. The system was tested under different scenarios such as correct sitting posture, slouching posture, and excessive bending.

During testing, the sensor values were analysed to verify whether the system could accurately identify incorrect posture based on predefined threshold limits. When improper posture was detected, the alert mechanism such as a buzzer or vibration motor was successfully activated to notify the user. In addition, the posture data were transmitted to the Thing Speak IoT cloud platform through Wi-Fi, where the data were displayed and stored for monitoring and analysis. The evaluation results showed that the system effectively detects posture deviations and provides timely feedback to the user, demonstrating reliable performance for continuous posture monitoring and spinal health awareness.

G. Expected Outcome

The expected outcome of the proposed posture correction and spinal health monitoring system is the accurate detection of improper body posture in real time. By using the ADXL335 accelerometer and the ESP8266, the system is expected to continuously monitor the user's body orientation and identify posture deviations such as slouching or excessive bending. When in correct posture is detected, the system will generate an immediate alert through a buzzer or vibration motor, helping the user correct their posture instantly. This real-time feedback is expected to reduce prolonged poor posture and help prevent spinal stress and back pain. Additionally, posture data will be transmitted to the Thing Speak IoT cloud platform for real-time monitoring and long-term data analysis. The system is expected to provide a lightweight, portable, and cost-effective solution that promotes posture awareness and supports the improvement of spinal health in daily activities.

H. Result

The proposed wearable posture correction and spinal health monitoring system was developed and tested to evaluate its performance in detecting incorrect body posture in real time. The system was tested under different posture conditions to analyze posture detection accuracy, response time, and IoT data transmission reliability. Experimental results show that the system effectively monitors body orientation using the ADXL335 accelerometer sensor and processes the data through the ESP8266 microcontroller. During testing, the accelerometer sensor continuously measured acceleration values along the X, Y, and Z axes to determine the orientation of the user's body. Different posture conditions such as correct sitting posture, slouching posture, and forward bending were tested. The system successfully detected posture deviations when the measured values exceeded the predefined threshold limits. When in correct posture was detected, the feedback module such as a buzzer or vibration motor was activated immediately to alert the user. The response time between posture detection and alert generation was observed to be less than one second, ensuring quick notification and allowing the user to correct posture instantly.

Fig1.2 SmartSpine: An IoT-Enabled Wearable Posture Monitoring and Correction System

The posture data were also successfully transmitted to the ThingSpeak IoT cloud platform through Wi-Fi connectivity. The uploaded data were displayed in graphical format on the cloud dashboard, allowing real-time monitoring and long-term analysis of posture patterns. The experimental results confirmed that the system operates effectively and provides reliable posture detection with real-time feedback and cloud- based monitoring. Overall, the developed system demonstrates improved posture awareness, early detection of poor posture habits, and a practical low-cost solution for promoting spinal health in daily life.

CONCLUSION & FUTURE SCOPE

This project successfully developed a wearable posture correction and spinal health monitoring system using the ESP8266 microcontroller, ADXL335 accelerometer sensor, and Thing Speak IoT cloud platform.

The system continuously monitors the user's body orientation and detects incorrect sitting or standing posture in real time using a threshold-based classification method. Whenever poor posture is identified, an instant alert is generated through a feedback mechanism such as a buzzer or vibration motor, allowing the user to correct posture immediately and reduce stress on the spine. In addition, the system uploads posture data to the ThingSpeak cloud through Wi-Fi connectivity, enabling real-time visualization, storage, and long-term analysis of posture patterns. Experimental testing showed that the system provides reliable posture detection, smooth IoT integration, and low- cost implementation. The device is lightweight, portable, and suitable for students, office workers, and individuals with sedentary lifestyles, making it an effective solution for improving posture awareness and preventing spinal disorders through continuous monitoring. In the future, the system can be further enhanced by integrating machine learning algorithms for more accurate posture classification, developing a dedicated mobile application for real-time notifications and user-friendly monitoring, and incorporating additional sensors such as gyroscopes or flexible posture sensors to improve spinal alignment analysis. These improvements can transform the system into a more intelligent, accurate, and comprehensive posture monitoring solution for healthcare and daily wellness applications.

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