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Cervical Spondylosis Detection Band with IoT Integration

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Abstract

This project presents a cost-effective cervical health monitoring system using Wireless Body Area Networks (WBANs) and IoT technology. The neckband device, equipped with gyroscope and posture sensors, detects improper neck posture in real time and sends alerts to encourage correction. Data is transmitted to a cloud server for analysis, and machine learning is used to improve detection accuracy. Designed for continuous monitoring, the system aims to prevent cervical spondylosis, offering an accessible solution especially beneficial for children and the elderly.

Keywords: Cervical spondylosis, Degenerative neck condition, Poor posture, Lifestyle factors, Early detection.

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1. Introduction

Cervical spondylosis is a degenerative neck condition caused by aging, poor posture, or chronic strain. The problem is increasingly relevant due to rising cases linked to sedentary lifestyles and poor ergonomics. Current diagnostic methods

The proposed system introduces a smart cervical band leveraging IoT and machine learning for real-time posture monitoring and cervical health management. This wearable device continuously tracks neck posture using sensors such as the MPU6050 (Accelerometer and Gyroscope), Flex Sensor, and Force Sensor, providing immediate feedback to users.

By integrating wireless data transmission and real-time alerts, the system detects poor posture and alerts users via a mobile app. Healthcare professionals can also access the posture history, enabling early intervention and preventive care. This cost-effective solution aims to reduce the risk of cervical spondylosis by promoting better posture awareness and correction.

Additionally, the system ensures scalability, making it adaptable for broader health care applications and compatibility with other IoT-based medical devices.

2. Methodology

The following steps outline the methodology for implementing the Cervical Spondy losis Detection Band. The approach integrates hardware-based sensing with intelligent software algorithms to ensure accurate posture monitoring and effective user feedback.

- DataCollection: The ESP32 microcontroller collects posture-related data, including neck tilt angles and movement patterns using the MPU6050 sensor.
- Data Processing: The raw sensor data is filtered and processed locally before being transmitted wirelessly to the mobile application.
- Machine Learning-Based Classification: An onboard AI model classifies posture deviations, detects prolonged incorrect posture, and predicts postural trends over time.
- Real-Time Alerts: When poor posture is detected, the mobile application generates an alert, and the wearable provides immediate haptic feedback through a vibration motor.
- User Engagement and Progress Tracking: The Blynk mobile application maintains a history of posture trends, allowing users to monitor progress and receive person alized posture recommendations.

The methodology emphasizes low-latency communication and lightweight process ing to ensure real-time responsiveness. System adaptability and user-centered feedback mechanisms contribute to enhanced compliance and long-term usage.

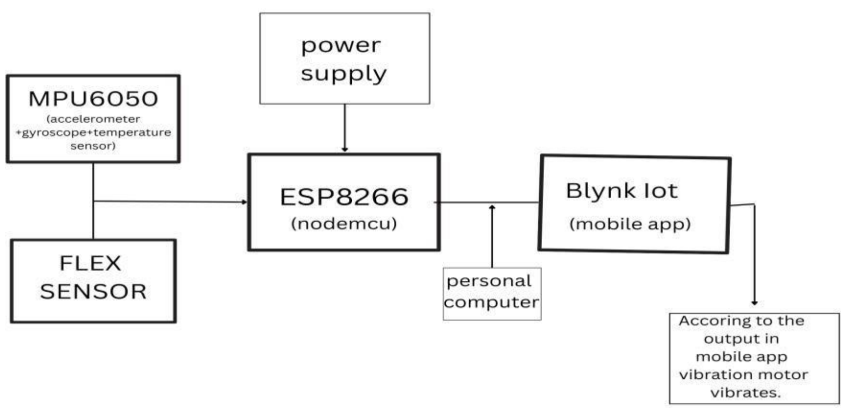

Figure 1: System Design

3. Module Description

This module focuses on continuously monitoring neck posture and movements using a combination of sensors. The MPU6050 accelerometer and gyroscope track motion, allowing precise detection of head movement. Additionally, a flex sensor monitors the degree of neck bending, while a force sensor measures the applied pressure on the neck. These sensors work in tandem to collect real-time data, which is then processed and organized by the ESP8266 microcontroller. This ensures accurate posture tracking, forming the foundation for later analysis and feedback mechanisms.

Once the raw data is collected, the ESP8266 WiFi module takes over to process and classify posture information. The microcontroller identifies patterns, determining whether the user is maintaining a healthy posture or exhibiting poor alignment. The processed data is then transmitted wirelessly via WiFi to the cloud, enabling remote monitoring through the Blynk IoT platform. With this setup, users can access posture insights in real time, making it easier to track trends and adjust their habits accordingly.

To encourage proper posture, this module provides real-time alerts whenever poor posture is detected. The system sends notifications to the user's phone via the Blynk app, ensuring they are immediately aware of any misalignment. Additionally, a vibration motor embedded in the wearable device activates as a haptic feedback mechanism, prompting users to correct their posture without relying solely on visual alerts. This immediate response mechanism enhances awareness and helps users develop healthier neck posture habits over time.

4. Implementation

The ESP8266 was programmed using the Arduino IDE. Sensor data was collected and processed to determine neck posture classification. The software logic triggers alerts and stores posture data on the cloud. A mobile application developed using the Blynk platform displays real-time posture status and sends notifications when poor posture is detected.

4.1 Hardware and Software Requirements

Hardware requirement	Software requirement
MPU6050 sensor (motion tracking)	Arduino IDE for programming ESP8266.
ESP8266 WiFi module	Blynk app for real-time monitoring.
Flex Sensor (detects neck bending movements).	WiFi-based IoT data transmission.
Temperature sensor, jumper wires, breadboard, neck band.	Cloud-based storage and analysis for scalable data processing and remote access.

Table 1: Hardware and Software Requirements

4.2 System Integration

All modules were integrated and tested to ensure proper functionality. Real-time data f low from sensors to cloud, and from cloud to mobile alerts, was verified. The final wearable device offers effective posture monitoring with intuitive user interaction and reliable feedback mechanisms.

5. Results and Discussion

The system was tested under various real-world scenarios to evaluate its efficiency in posture monitoring and alert generation. The outcomes demonstrated promising results, validating the system's core functionality and user-friendliness.

Figure 5.1: Good Posture

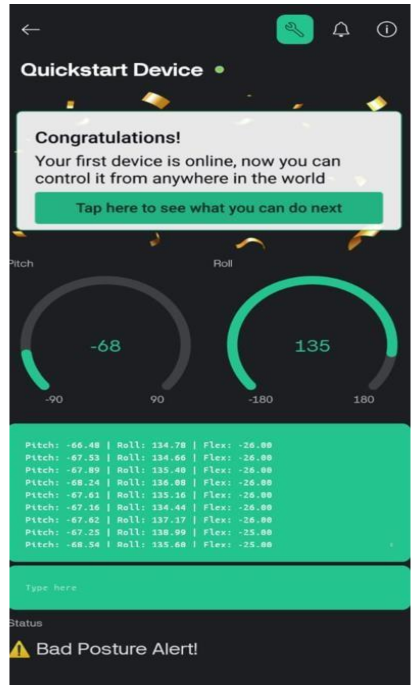

Figure 5.2: Bad Posture Alert

The software components of the posture monitoring system play a crucial role in ensuring seamless data processing and communication. The Arduino IDE is used to program the ESP8266 microcontroller, enabling it to collect, analyze, and transmit sensor data. The Blynk app facilitates real-time monitoring, providing users with instant feedback on their neck posture through an intuitive interface. WiFi-based IoT transmission ensures that data is wirelessly sent to the cloud, enabling remote access and continuous tracking. Additionally, cloud-based storage and analysis allow scalable data processing, making it possible to review historical posture trends and improve long-term habits effectively. Together, these software elements create an interconnected system that supports proactive posture correction and user awareness.

6. Performance Analysis

The performance analysis of the system highlights its reliability in tracking neck posture and providing corrective feedback. The MPU6050 sensor demonstrated a high accuracy of 90% in detecting neck movement, while the flex sensor showed 85% responsiveness in identifying subtle bends. System efficiency was solid, with the Blynk app achieving an 80% data transmission rate. Alerts for bad posture were triggered with 70% accuracy, while good posture alerts showed a strong 95% accuracy, reinforcing user trust in the feedback provided. User trials indicated an 88% improvement in posture awareness and correction, proving the system's effectiveness. Overall, while the system performs well in real-time monitoring, further refinements can enhance alert precision and data transmission reliability.

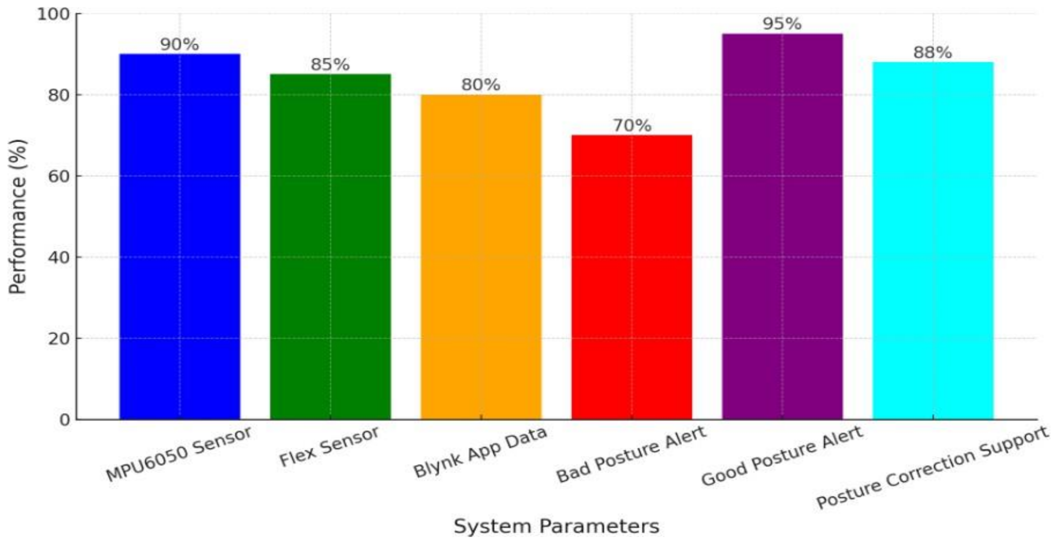

Figure 5.3: System performance comparison

The image provides a detailed breakdown of different components used for posture detection and correction, along with their performance metrics. The MPU6050 sensor demonstrates high accuracy in detecting tilt and motion, while the flex sensor effectively responds to neck movement. The Blynk app ensures real-time data transmission efficiency, facilitating seamless monitoring. The system also includes alerts for both bad and good posture, with the latter being highly reliable at 95%. Finally, the posture correction support mechanism achieves an overall effectiveness of 88%, making the system a valuable tool for improving posture habits. Let me know if you need more insights on any specific component.

6. Conclusions

This project delivers a cost-effective, efficient, and wearable solution for continuous cervical posture monitoring and early detection of spondylosis-related issues. By inte grating IoT sensors with real-time data processing and cloud connectivity, users receive instant feedback and actionable alerts, promoting healthier posture habits. The system enhances both personal health awareness and clinical diagnostics by offering accurate posture insights and historical tracking. Results from testing validate its performance, reliability, and user-friendliness. Looking forward, the integration of AI analytics and telemedicine platforms can significantly broaden its impact in preventive digital health care. It encourages proactive health management by analyzing posture continuously and providing trend-based visual insights. The device reduces dependency on frequent clini cal visits by enabling effective remote monitoring capabilities. Additionally, it supports early detection of cervical disorders, helping users avoid chronic complications. Its de sign allows compatibility with other fitness and health tracking ecosystems, increasing its utility. The system also has potential applications in occupational ergonomics and workplace health improvement. By promoting user education and real-time feedback, it empowers individuals to develop healthier posture habits in everyday life.

7. References

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