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AI-Based Smart Posture Monitoring and Muscle Strain Prevention System

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Abstract: In the current digital age of technology, excessive sitting, sustained computer use, and smartphone usage have all greatly contributed to heightening posture-related health problems in students and working individuals today. This increases muscle tension, spinal misalignment and reduced productivity and has triggered chronic musculoskeletal problems as a result. There are now diverse ways to improve users' postures, but they are not affordable, responsive or easy to use in real time with the right posture-monitoring and correction technology. In this paper, researchers discuss an AI-connected smart monitoring system for posture and muscle strain prevention, developed on an ESP32 microcontroller and an MPU9250 inertial measurement unit (IMU) that measures body motion using accelerometer, gyroscope and magnetometer sensors. To reduce noise and improve real-time posture angle estimates, a complementary sensor-fusion technique using filters is used. The estimated tilt angle identifies good, minor deviation, and terrible posture. To avoid misleading perceptions from quick movement, it validates results in real time. LEDs and a buzzer help users improve posture in real time. ESP32 supports a web-based dashboard that dynamically displays posture, angles, and graphical trends without a backend server. Experimental results showed that, with improved stability and performance, this method can detect posture and could be used for health monitoring, physiotherapy, office ergonomics, and daily life improvement.

Keywords: Posture Monitoring; ESP32 and MPU9250; Sensor Fusion; IoT and Inertia Measurement Unit; Wearable Systems; Healthcare Monitoring; Spinal Misalignment; Magnetometer Sensor.

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1. Introduction

Human lifestyles have been profoundly altered during the last few decades by rapid technological progress and the use of electronic devices. Students and working professionals are now sitting up late in front of their computers, laptops and other devices in poor posture, an issue often unrecognized [4]. Such years of exposure to poor postures have led to a high prevalence of posture-related conditions, including neck and back pain, muscle fatigue and chronic musculoskeletal conditions [5]. Recent health research studies have shown that poor posture contributes to spinal misalignment and reduced physical efficiency. Correct posture is absolutely vital for biomechanical function in body health. Still, with normal posture corrections, one needs careful thought, hand observation, self-awareness, and periodic physiotherapy intervention [6]. Unlike regular posture adjustment, these methods do not always deliver satisfactory performance in real time; users often ignore posture correction until discomfort or pain is felt [7]. Also, there are expensive, non-portable technological solutions (camera-based models and high-end health devices) that require extensive engineering, limiting their use in individuals' everyday lives. Wearable posture monitoring systems are vital strategies for overcoming these challenges. Employ inertial measurement units (IMUs) to measure body orientation and speed [8]. However, very few of today's implementations focus on posture estimation, providing only instant corrective responses and no easy-to-use IM interfaces.

However, the systems are not operating fully due to sensor noise, inaccurate measurements and a lack of real-time response. Building a similar design philosophy, researchers propose an AI-based smart posture-monitoring and muscle-strain-prevention system that integrates embedded systems, sensor fusion, and IoT visualization [9]. This system uses an ESP32 microcontroller with an MPU9250 IMU and continuously monitors body orientation in real time [10]. Using accelerometer, gyroscope, and magnetometer data, the system adopted a complementary filter to enhance accuracy and stability in posture estimation [11]. The proposed system is not just for recognizing posture deviations, but also for enabling users to take instant corrective action through real-time feedback, with visual indicators (LEDs) and auditory alerts (buzzer). Unlike conventional systems, this application uses a simple web-centric dashboard hosted directly on the ESP32, without a backend server. This simple approach makes system operation quite easy, with very low latency and can be applied easily. Additionally, the system encourages intelligent posture classification using standard angle thresholds. It validates over time to prevent false notifications caused by sudden body movements. Focusing on cost-in and convenience-of-use efficiency, these devices help students, office workers, and various healthcare applications, such as physiotherapy and rehabilitation monitoring. In contrast, providing real-time, continuous monitoring enables the development of a reliable, cost-effective, and timely posture-monitoring system that encourages healthy posture habits and reduces muscle strain. Thus, the proposed system plays a pivotal role in advancing preventive healthcare technologies by bridging the divide between research–based posture estimation analysis and practical implementation in real-world settings.

2. Literature Survey

Posture monitoring and correction have received significant attention in recent years due to the rise in physically inactive human subjects and the emergence of numerous posture-related diseases. Researchers explored sensor- and vision-based, as well as wearable, approaches to track the corrective effect of a posture modality. Initially, attention was primarily focused on computer-based camera posture-sensing systems that use image processing and computer vision to detect body position. These systems can obtain precise measurements to characterize posture but require fixed settings, a controlled environment and a relatively high computational burden, making them unsuitable for continuous, real-time posture monitoring in real life. To address these limitations, wearable sensor-based systems can be developed to analyze and monitor patients' posture. Yamato [1] conducted an exploratory study to estimate posture using wearable sensors, demonstrating that accelerometer data can also capture posture changes. But research mainly focused on experimental testing and verification. It did not have an interactive feedback and response mechanism for real-time corrections, or interactivity in a real case. Wu et al. [2] described a wearable posture sensor that uses inertial sensors to monitor posture, implemented as an interactive sensor. They proposed a passive system to maintain the posture on sensors as a dynamic measure of sitting posture. To demonstrate how the IMU- based posture tracking works in practice, their system showed. However, the system lacked real-time alerting capabilities, which limited its use when users' postures changed in response to cues. Baldi et al. [3] employed an extensive posture estimation using a wearable inertial sensor and a multiplicative Kalman filter. The approach greatly reduced noise and drift errors in posture estimation and significantly improved measurement precision. The method had an extremely accurate output (to determine the pose) and did not have built-in end-user practical feedback.

Recent research themes have centered around the use of IoT technologies and smart algorithms in posture observatories. IoT-based systems provide remote monitoring, data processing and long-term posture analysis. Some work has already proposed using wearables to transfer posture information to the cloud for healthcare practice. However, these systems often depend on the backend server and network connectivity to perform the tasks, which introduces extra system latency and complexity [4]. Moreover, recent work has likewise covered the application of machine learning and artificial intelligence to posture classification. These offer classification and adaptability at high grades. Most of these solutions depend on big data and expensive computation, and they also involve models that are trained or computationally intensive. So far, researchers know that many of these solutions are not viable for low-cost embedded implementation. However, many problems remain behind these advances [5]. However, most existing systems are insensitive in real time; feedback is not immediate, and corrective action is delayed; they are costly, and deploying such systems is going to be a nightmare. Sensor noise and instability also hinder the reliability of posture detection, especially in cheaper wearable devices. To address such issues, the current system incorporates sensor fusion, embedded processing and time feedback methods on multiple devices in a compact and ec. It includes complementary filtering, which enhances sensors and posture precision with high accuracy, reducing false alarms compared with previous work [6]. It provides instantaneous feedback from LEDs and a buzzer to maintain an optimal posture. Moreover, a lightweight web dashboard is implemented directly on the ESP32 without a backend server, enabling dynamic visualization and facilitating real-time data analysis. Hence, researchers propose to bridge the gap between research-based posture estimation and practical application of wearable health care systems for the preventive healthcare needs [7].

3. Proposed System

Using the human body posture monitoring system that helps prevent muscle strain, researchers designed an artificial intelligence-based monitoring system. This system is being developed based on a global IoT framework that supports wearables with sensing, intelligent classification and web-based visualization, thus providing an integrated system. Goal 1 – Uncovers incorrect posture and notifies the user in real time of long-term-range muscular strain, and any other concerns with the user's health. The system itself consists of four main modules — sensing unit, processing unit, feedback system and visualization interface. Proper posture- detections, real-time responsiveness, and easy user touch are achieved by the components working within one another.

3.1. Sensing Unit

The sensing instruments are an MPU9250 IMU, a 9-axis measuring instrument comprising a 3-axis accelerometer, a 3-axis gyroscope, and a 3-axis magnetometer. The linear acceleration of the body is measured by an accelerometer, which indicates the body's tilt due to gravity. Gyroscope — measures angular velocity and provides rotational motion and immediate orientation changes. The magnetometer provides direction by recording Earth’s magnetic field; thus, the measurement provides a stabilizing orientation estimate. Three sensors are integrated to monitor a body's posture in real life, in 3D, with accuracy! In motion data, the sensor continues to record motion along the X, Y and Z axes, along with the corresponding motion and relay data, through the I2C communication protocol to the computational unit.

3.2. Processing Unit

For the CPU computing unit and CPU core, the ESP32 microcontroller was used. ESP32 was found to be the best in computation size, power utilization, Wi-Fi, and computation speed. MPU9250 raw sensor data are processed to eliminate background noise and instability. In addition to speed, a complementary filter is proposed to integrate accelerometer and gyroscope data, enhancing accuracy and eliminating drift. The filtered data are used to calculate tilt angles— pitch and roll—that indicate body orientation. - It is a processing device for dynamic data processing with dynamic changes every 100 to 200 milliseconds: sensor values are sampled every 100 to 200 milliseconds, processing data is applied, and the time taken to be recorded. - Non-blocking programming systems, including timers, are implemented to prevent interruptions and ensure continuity in operation.

3.3. Posture, Classification Modules

Is the posture. An intelligent posture classification function is applied in the system based on the calculated tilt angles. There are three levels of posture:

- **Good posture:** the tilt angle is less than 10 °.
- **Mild Deviation:** A tilt angle between 10 and 25 degrees is considered a mild deviation.
- **Bad posture:** if the tilt angle exceeds 25 degrees, there is a significant misalignment, leading to a very out-of-proportion stance.

A time-based validation mechanism is provided, which reduces false alarms around abrupt positioning and transient positions. They need to be reported only if the incorrect position continues for a long time, usually from 3 to 5 seconds. This is how classification becomes sound and stable in terms of accuracy. In particular, the feedback system transmits corrective signals to the user instantaneously. It has LED indicators and a buzzer. The LED indicator that visually indicates posture status:

- Green LED signals correct posture.
- A yellow LED indicates a slight deviation.
- Red LED means bad posture.

The buzzer provides auditory feedback in different types in response to the user. For subtle deviations, a short beep is sent; for negative posture, repeated or longer beeps are sent. Note: Since this is online feedback, users can swap positions whenever they want.

3.4. Website Design and Test

The ESP32 directly inspires the proposed system's web-based Dashboard. It does not need a cloud server or backend for the Internet of Things (IoT) systems. Unlike traditional IoT, it uses ESP32 as a server running on the light on the internet. The Dashboard in this paper is available with a web browser and using the ESP32 IP address. Posture status of the client panel, angle value and graph trends are displayed in real-time; a dynamic graph is also displayed using JavaScript libraries like Chart.js, with elements refreshing at different intervals rather than when the page is refreshed. The system's latency and complexity also decline, while its portability increases. This makes it easy to use this system for real-time classroom, office or healthcare monitoring. The full system architecture is presented in Figure 1. This indicates the collaboration of the sensing unit, the processing unit, the feedback system and the web dashboard.

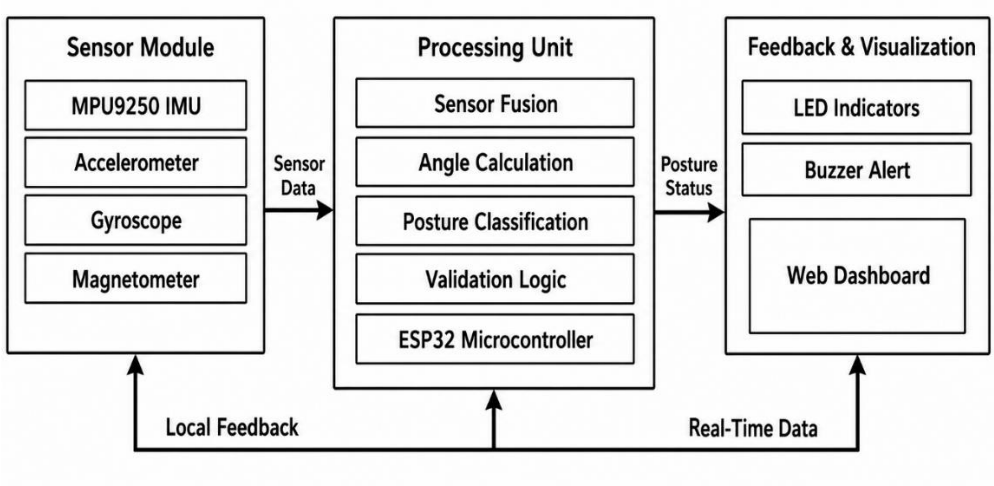

Figure 1: Block diagram of the proposed posture monitoring system

As the architecture proposes an efficient flow of data at this stage by processing, analyzing and using sensor data in real-time, it is one way the system processes the local feedback, which can be processed remotely with complete real-time monitoring and monitored from the system.

3.5. Proposed System Strengths and Highlights

- Immediate posture monitoring and feedback.
- Heightened precision with sensor fusion.
- Constructable and inexpensive enough for a portable build.
- Backend services are not backed up.
- A user-friendly web-side interface is also possible.
- It is applicable in everyday life and the health field.

The previously described system is also applicable to the real-world implementation of pragmatic, efficient posture-monitoring and muscle-strain-prevention methods, thereby lowering the research-level system design requirements and reducing the gap between existing and expected applications.

4. Methodology

This means that the system provides a framework for detecting posture with precision, processing postures from live data, and receiving feedback from any target system to enable real-time system creation. The workflow comprises a sequence of steps taken by users (or observers) for sensor data acquisition, data preprocessing, sensor fusion, angle computation and posture classification, alert generation and in-platform visualization. Every stage is to be consistent, convenient to execute and computationally simple.

4.1. Sensor Data Acquisition

At the outset of the technique, motion and orientation data are continuously acquired in motion using an inertial measurement unit, the MPU9250. These measurements are taken regularly. The sensor provides real measurements of three elements:

- **Accelerometer:** Monitors linear acceleration along X, Y, and Z axes.
- **Gyroscope:** Applies angular velocity around X, Y and Z axes.
- **Magnetometer:** Measuring magnetic field strength for directional indication.

The ESP32 communicates with the MPU9250 via I2C and sends sensor data at a high sampling rate. The dataset is updated in real time every 100-200ms.

4.2. Preprocessing and Noise Reduction

To preserve the integrity of the dataset and reduce noise, offset calibration is set:

- Smoothing with primitive filtering steps.
- Normalizes Accelerometer values.

This procedure ensures the data's reliability for later computation.

4.3. Sensor Fusion Using Complementary Filter

Accurate orientation is achieved by combining accelerometer and gyroscope data using a complementary filter. The accelerometer has a stable long-term orientation but is subject to noise; the gyroscope transitions quickly but drifts over time. The complementary filter offsets these effects using the following equation:

$$\theta = \alpha(\theta_{gyro}) + (1 - \alpha)(\theta_{acc}) \quad (1)$$

Where:

- θ is the estimated angle,
- θ_{gyro} is the angle computed by integrating with the gyroscope.
- θ_{acc} is the angular angle determined by the accelerometer data,
- α is a constant (0.98).

This guarantees a stable and responsive final angle.

4.4. Angle Calculation

Tilt angle (pitch and roll) is calculated from the filtered sensor to determine the user's position. These are the angles of orientation of the body relative to the gravitational axis. The angles are derived from trigonometric relationships:

$$\theta = tan^{-1} \frac{a_y}{a} \quad (2)$$

$$\theta = tan^{-1} \frac{a_x}{a} \quad (3)$$

Where a_x, a_y, and a_z are accelerometer measurements along the relevant axes. The maximum of these angles will be used as the effective posture deviation value.

4.5. Posture Classification Algorithm

Researchers classify posture into three classes using angle:

- **Good posture:** $\theta < 10^\circ$
- **Mild Deviation:** $10^\circ \leq \theta < 25^\circ$
- **Bad posture:** $\theta \geq 25^\circ$

More trustworthy with a new time-based filtering. The system dynamically tracks posture and will not issue an alert if bad posture is detected after a specified measurement. This helps ensure that no alert is issued when sudden or transient movement is detected.

4.6. Real-Time Feedback Mechanism

When posture is properly categorized, the new system returns immediate feedback to users via LEDs and a buzzer:

- The Green LED shows correct posture.
- Yellow LED indicates mild deviation.
- Red LED indicates bad posture.

The buzzer sounds and indicates the severity of the posture:

- Short beep for mild deviation.
- Repeated or continuous beeps for bad posture.

Such a mechanism provides users with immediate feedback for posture adjustment.

4.7. Real-Time Processing and Optimization

The ESP32 uses non-blocking programming techniques in its system operations to ensure smooth operation. By using timing functions, it manages operations with updates rather than running them at a fixed time. Key optimizations include:

- Use of millis() to handle timing control
- Efficient loop execution
- Fast sensor polling

With this setup, researchers can support real-time, very low-latency processing.

4.8. Web Dashboard Data Handling

As a web server, the ESP32 is lightweight and acts as a real-time dashboard. It gives an API endpoint that contains posture data in JSON format:

{" angle": value, "posture": "status" } (4)

This data is periodically pulled and dynamically updated in the Dashboard using a little JavaScript to refresh the interface. Visualization is enabled using Chart.js to display posture data over time.

4.9. Overall Algorithm

The solution can be described as follows:

- Set up the sensor and ESP32
- Read raw sensor data
- Preprocess it and then filter it
- Perform sensor fusion
- Calculate tilt angles
- Classify posture
- Check time threshold
- Trigger alerts if needed
- Update the web dashboard
- Repeat continuously

The method ensures correct posture detection, ease of processing, and real-time user interaction, enabling the practical development of the system (Figure 2).

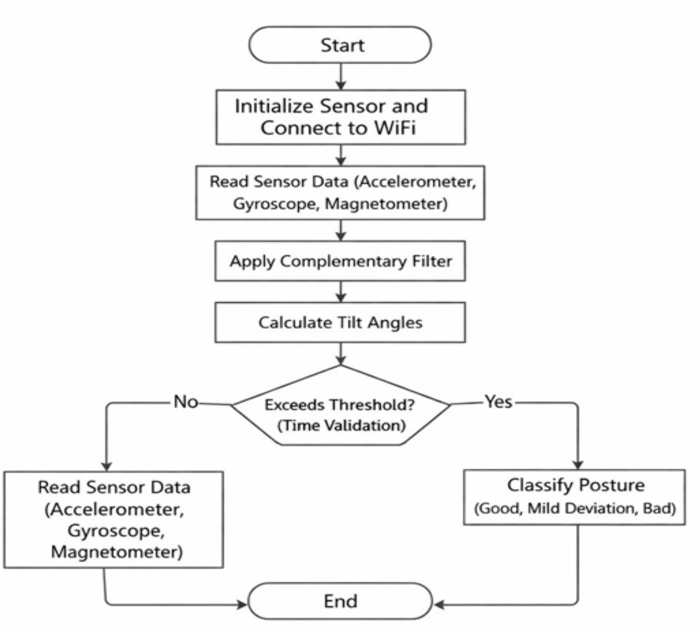

Figure 2: Flowchart of proposed methodology

5. Implementation

Both hardware and software technologies are used to implement the AI-based intelligent posture-monitoring system for positioning. The design of this system is intended to be small, efficient, and up to date. This section discusses the hardware configuration, software design, system integration, and web- based visualization.

5.1. Hardware Implementation

The system's hardware architecture relies on the ESP32 microcontroller and the MPU9250 inertial measurement unit. The ESP32 is the main processing system; the MPU9250 is used for motion and orientation signals. The MPU9250 sensor provides a direct I2C link to the ESP32. GPIO21 and GPIO22 of the ESP32 relay the SDA and SCL pins of the sensor. This allows the sensor to work freely with the ESP32 at 3.3V. There are three LEDs, green, yellow, and red, and a buzzer present in the feedback device. Each LED connects to a GPIO pin via a resistor to limit current. The buzzer itself is also tied to a GPIO pin and controlled using PWM to produce the buzzer signal, which generates the alarm noise of different colors (Figure 3).

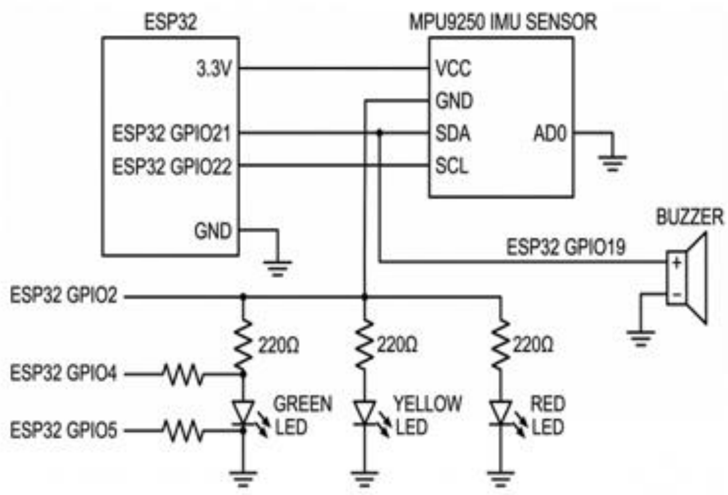

Figure 3: Proposed system hardware circuit diagram and the entire system is wearable; This can be fixed to the upper body for continuous posture monitoring

5.2. Software Implementation

The software is developed using Arduino IDE and C/C++. The firmware handles sensor initialization, data acquisition, processing, classification, alert generation, and web server processing. The implementation is modular in nature, with certain well-defined functions:

- **Sensor Initialization:** Initializes registers for MPU9250 and I2C communication.
- **Data Acquisition:** Regularly reads the parameters from the accelerometer, gyroscope and magnetometer
- **Filtering:** Provides an additional filter to enable sensor fusion.
- **Angle Calculation:** Determines pitch and roll angles
- **Classification:** Assigns posture type
- **Output Control:** Drives LEDs and buzzer
- **Web Server Handling:** The server that serves data to the Dashboard in real-time.

5.3. Real-Time Processing Strategy

The system is guaranteed to run smoothly with little block time. Rather, the application uses the millis() function to time the run. It does not require data to be processed across multiple occasions, such as scanning sensor readings, organizing files, or refreshing page content. At least every 100 to 200 milliseconds, the system updates posture data, making it very dynamic. Optimized and efficient memory management and efficient loop execution are implemented to keep the system stable.

5.4. Posture Detection and Alerts

The filtered angle data is analyzed by a posture-detection algorithm that compares each angle level against predefined thresholds. Posture deviation verification without alarming is performed using time-based verification. Alert operations are defined as:

- **Good Posture:** Green LED ON; buzzer OFF
- **Mild Posture:** Yellow LED ON, short buzzer beep
- **Bad Posture:** Red LED ON, repeated buzzer alert

The multi-level feedback system below enhances a user-friendly and intuitive experience.

5.5. Web Server Implementation

For the web server configuration, the ESP32 is configured with a built-in Wi-Fi module. Once on a local Wi-Fi network, the ESP32 obtains an IP address. The ESP32 can be read on a web browser. At the server, a web page with HTML, CSS and JS components is being placed. It also defines an API endpoint (e.g., /data) that serves real-time posture information in JSON format:

{"angle": 22.5, "posture": "MILD"}

JavaScript refreshes the display dynamically whenever traffic is received from the web page. This data is retrieved continuously from the web page using JavaScript, which dynamically updates the display.

5.6. Web Dashboard Design

The Web Dashboard is both clean and easy to use. It includes:

- Instant posture status view
- Numerical angle representation
- Chart of trends in posture
- Color-coded indicators

Graphs on a webpage using a JavaScript library, such as Chart.js, were created to display real-time plots. With each Dashboard refresh every 1 second (or 1 second), the visualization is continuous, and the web page refresh will not disturb the smooth visualization (Figure 4).

Figure 4: Web dashboard interface

5.7. System Integration

It has an entire hardware and software system that works together seamlessly. The sensor data from MPU9250 is sent to ESP32 for processing and categorization. Results are fed for local feedback (LED and buzzer) and remote visualization (web dashboard). The integration ensures:

- Real-time performance
- Low latency
- High reliability
- Ease of deployment

5.8. Challenges and Solutions to Implement

Many challenges were encountered while implementing the work:

- **Sensor Noise:** Resolved using filtering methods
- **Gyroscope Data Drift:** Supported by a complementary filter
- **False Alerts:** The time-dependent validation checks minimize these effects.
- **Real-Time Performance:** Refined with non-blocking code

This technology combines embedded hardware, real-time processing, and web-based visualization into a single system. This design not only enables accurate posture detection but also provides efficient real-time monitoring, making it well-suited for real-world deployment.

6. Results and Discussion

The realized performance of the proposed AI-based smart posture monitoring system, in terms of accuracy, responsiveness, stability and feasibility, was evaluated under various real-world conditions. Researchers were testing it on a large number of users with different pose types (upright sitting, slightly forward bending and extreme slouching).

6.1. Accuracy of Posture Detection

Its posture classification was stable and involved sensor fusion techniques. Complementary filters result in low noise and stable angle estimation. The classification thresholds resulted in a high level of good, mild, and poor posture. The experimental findings support that:

- A tilt angle as little as 10° was considered good posture.
- Low-risk deviations were determined accurately within the range of 10-25 degrees.

- Any discrepancies in posture above 25-degree marks were considered bad posture.

This increased accuracy is achieved through time-based validation, which reduces false detections caused by transient motion.

6.2. Real-Time Performance Analysis

The system operates in real time, with the sensor recording readings every 100 to 200 milliseconds. Not blocked, run the program without lag or interruptions. For a posture change, the system responded within 1 second, demonstrating very responsive performance. This prompt notification means that when users move position, the system becomes much more useful.

6.3. Evaluation of Alert System

The LED and buzzer-assisted feedback solution is intuitive and does its job. Posture was correctly identified by color and sound signals:

- The green LED verified proper posture.
- The yellow LED and short beep indicated that something was wrong.
- A set of red LEDs and repeated buzzer alerts indicated an incorrect posture.

This multi-step alert system ensured reliable communication without impacting the system.

6.4. Web Dashboards Performance

It successfully displayed real-time posture data on a web-based Dashboard on an ESP32. The Dashboard visually displayed posture status, angle value and a visual trend of posture behavior, providing an overall posture behavior overview (Figure 5).

Figure 5: Real-time posture angle variation

Asynchronous data fetching simplified updates and enabled stateless page refreshes. The angle change graph is the one that allows a user to analyze posture patterns well. It was easy to use and deploy, as the Dashboard was accessible from any web browser on the same network.

6.5. System Stability and Reliability

The system was reliable over an extended period of operation. The complementary filter eliminated sensor reading perturbations, yielding a uniform angle distribution. With the time-based filter, false alarm reductions remained, and the user experience improved. The system worked no matter why, moving and the environment.

6.6. Comparison with Current Systems

The proposed solution has several advantages over such traditional posture monitoring systems:

- Sensor fusion provides higher precision
- Real-time feedback capability
- Dependence is not on the backend server
- Portable and very low cost
- User-friendly web interface

In addition, the system adopted in our work does not require a fixed position or a high computational overhead, as it uses camera-based systems, making it more feasible for daily use. Although convenient, it is a mixed bag in scope:

- The precision may be a little biased by sensor position.
- The system currently uses threshold-based classification rather than advanced machine learning methods.
- There is no data for later use, as it does not include any backend server.

The solution demonstrated that the proposed system successfully addressed posture monitoring and muscle strain prevention through experiments. The fusion of sensors, live processing, and real-time user output enables real-time feedback. This bridges the knowledge gap between research-based posture estimation methods and practical use. Because of its low cost, simplicity, and high working performance, it is common in classrooms, workplaces, and hospitals. Thus, the results indicate that the proposed system is expected to maintain precise, real-time posture monitoring and to make significant contributions to preventive health care services, as the study aims to enable.

7. Applications

Researchers present an AI-based smart posture monitoring and muscle strain prevention system (BPS) for patients, helping mitigate muscle strain with a flexible device suitable for applications such as healthcare, education, workplace ergonomics and personal wellness. Real-time monitoring, mobility and low cost are what have made it a potential user both personally and institutionally.

7.1. Medical Sciences and Physical Therapy

The healthcare industry is one of the system's applications. The system is for physiotherapists and other medical professionals watching the rehabilitation of physical postures to avoid postural disorders like spinal misalignment, cervical pain, or lower back pain. A real-time feedback loop ensures patients maintain good posture whilst improving their recovery exercises, enabling them to perform effectively during treatment. Using the web dashboard, doctors can monitor posture trends and the patient's condition over time to see whether the patient is improving. This is because students often sit in the wrong position for prolonged periods, which can lead to posture problems much earlier. Additionally, the system can be applied in learning institutions to establish healthy posture practices among the learners. It promotes a posture habit during studies and online classes to help students be aware of such changes, delivering alerts on the fly. This helps stave off chronic health problems later on, but it also improves performance, aids your focus and reduces fatigue.

7.2. Office Ergonomics

Workers in today’s workplace have to work for long hours, hunched over computers, often with terrible posture and even some type of musculoskeletal disease. This system is also applicable for monitoring employee posture in the office to achieve ergonomic performance. The alert system provides users with posture correction, while the Dashboard would assist in studying body posture patterns and improving workplace ergonomics. It increases productivity and reduces absenteeism due to health-related issues.

7.3. Remote Health Monitoring

Given the expansion of the telemedicine space and distributed health systems, the proposed system could be implemented for remote posture examinations. This can be used at home by patients, with the health system collecting posture history from the Dashboard and conducting an assessment. This avoids the burden of multiple hospital visits and allows for an opportunity to continue monitoring, especially when patients with chronic illnesses and the elderly are involved.

7.4. Fitness and Lifestyle Applications

The system is also usable for fitness and wellness programs. For example, if you do yoga, strength training and physiotherapy exercises, it must look right; posture has to be correct, with proper alignment. In addition, it helps users not only avoid injury and perform efficient workouts overall, but also maintain proper body alignment, minimizing injuries and time lost, and enhancing exercise effectiveness. It's also used as a daily personal posture assistant. As a daily exercise, it could also serve as a postural aid to enhance everyday lifestyle. Which means it helps users exercise more regularly.

7.5. Elderly Care Systems

Older individuals are prone to posture issues due to weakened muscles and reduced mobility. The implemented system can help keep them aware of the new posture and notify them in time to avoid discomfort and injury. This can also be quite effective in supported living facilities, and caregivers can ensure older people maintain good posture when completing tasks at home. This is to promote accessibility and track progress without requiring additional equipment. This unification may lead to the development of wearables in next-generation medical devices. The industrial working conditions that ensure safe health practices at home and in the workplace are not solely the responsibility of industry. In an industrial setting, improper loading or handling of work may result in impact and injury. This system is applicable when handling workers in certain postures on the factory floor to monitor and observe how they maintain a safe condition during the job. Real-time alerts can help the employee reposition to avoid accidents and thus reduce work-related hazards, as well as protect the individual from them.

In addition, the system can serve as a research platform for studying human posture behavior and developing advanced posture analysis algorithms. Such data can be useful to researchers in developing more effective posture detection methods and in developing machine learning-based solutions. In general, the proposed system is highly versatile and transferable for several applications. It is one of the solutions that provides real-time monitoring, feedback and visualization of all pertinent data to enhance posture awareness and prevent muscle strain across a wider spectrum of real-world scenarios.

8. Conclusion

A smart posture-monitoring and muscle-strain-prevention system powered by AI was successfully applied to the target population to address postural health issues in today's lifestyles. Wearable sensing applications, computer-aided embedded processing, sensor fusion and real-time feedback processes are employed extensively in the solution. Researchers use the MPU9250 inertial measurement unit to keep the device in motion and track body orientation using accelerometer, gyroscope and magnetometer data. And it adds a complementary filter to the sensor fusion process, helping mitigate noise and drift issues introduced during angle estimation, thereby improving accuracy and stability. The postures can be correctly detected using a defined angle threshold and a time-integrated validation algorithm to improve accuracy, helping to avoid false alarms caused by postural deviation. Using LED indicators for real-time feedback or buzzer alerts to adjust posture can help ensure posture and reduce muscle strain from contraction, potentially preventing muscle damage and its associated health consequences.

Furthermore, implementing a web-based dashboard directly on the ESP32 enables the ESP32 itself to be used. Posture data can now be visualized in real time, without a backend server or any other approach. This system adds simplicity, reducing both physical labor and operational complexity, keeping it efficient. The recommended solution results in an analysis that shows how to detect posture deviations and act before any real effects occur. The system operates in a stable, low-latency mode, providing consistent performance across all operating environments. The low price and high portability make it a favorite for a wide range of applications, from healthcare monitoring to student office ergonomics. As a whole, this proposed system addresses the gap between research-level posture estimation methods and practical applications quite well. This also supports preventive health by boosting acceptance and the rapid adoption of good posture. It is a testament to the fact that a simple, inexpensive and smart approach can prompt great change in posture habits and ultimately reduce the onset of musculoskeletal disorders on a day-to-day basis.

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