wjert, 2024, Vol. 10 Issue 12, 269-277. *Original Article* **ISSN 2454-695X**

World Journal of Engineering Research and Technology
WJERT
www.wjert.org
SJIF Impact Factor: 7.029

"SMART POSTURE DETECTION AND CORRECTION DEVICE USING REAL TIME FEEDBACK"

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Article Received on 09/10/2024 **Article Revised on 29/10/2024** **Article Accepted on 18/11/2024**

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ABSTRACT

This project presents the development of a wearable device designed to monitor and correct body posture using an MPU6050 accelerometer and gyroscope sensor, combined with an SH1106 OLED display. The device aims to promote better ergonomic habits and reduce the risk of musculoskeletal disorders by providing real-time feedback on the user's posture. The MPU6050 sensor, placed vertically on the user's body, continuously measures accelerations along the x, y, and z axes. By setting specific threshold values for forward, backward, left, and right leanings, the device can detect deviations from optimal posture. When poor posture is detected, the device activates a vibration motor to alert the user and displays a corresponding visual warning on the OLED screen. The system is powered by an Arduino microcontroller, which processes sensor data and controls both the OLED display and the vibration motor. The OLED screen provides a clear and immediate visual indication of the user's posture status, including messages such as "Leaning Forward", "Leaning Backward", "Leaning Left", "Leaning Right", and "Good Posture", along with illustrative bitmap images. The wearable device is designed to be compact, lightweight, and user-friendly, making it suitable for daily use in various settings, such as at a desk, during exercise, or while performing everyday activities. By providing continuous feedback, the device helps users develop and maintain good posture habits, thereby potentially reducing the incidence of posture-related health issues.

KEYWORDS: Body posture, Arduino microcontroller, MPU6050 sensor, OLED.

1. INTRODUCTION

In recent years, the proliferation of Internet-connected devices, commonly known as the Internet of Things (IoT), has introduced new possibilities for innovative solutions to a wide range of challenges, including the monitoring and enhancement of personal health and wellness. The integration of IoT sensors and wearable technologies has paved the way for the development of advanced systems capable of tracking various physiological and behavioral parameters, including body posture.

Body posture detection using IoT technology is an emerging field that has garnered significant attention due to its potential applications in healthcare, rehabilitation, and personal wellness. Researchers have explored the use of smart devices, such as smartphones, smartwatches, and specialized wearable sensors, to collect real-time data on an individual's body positioning and movement patterns.

This data can then be analyzed using machine learning algorithms to detect deviations from optimal posture, which can be indicative of potential health issues or the onset of musculoskeletal disorders (Mamdiwar et al., 2021) (Rashid & Shah, 2018). For example, Hosseinzadeh et al. proposed an IoT-based system that collects vital health data through smart healthcare technology, and the collected data are analyzed using machine learning algorithms to check vital signs and detect biological and behavioral changes of disabled or elderly persons(Banerjee et al., 2022). Zhong and Li also designed and developed a health monitoring system to recognize the physical activities and monitor health conditions of college students through the connection of heterogeneous economically-efficient wearable gadgets in an open environment (Banerjee et al., 2022).

Leveraging the MPU6050 accelerometer and gyroscope sensor, our device continuously monitors the user's body orientation. By setting precise thresholds for detecting forward, backward, left, and right leanings, the device can identify deviations from optimal posture. When an undesirable posture is detected, a vibration motor is activated to provide immediate haptic feedback, prompting the user to adjust their stance. Additionally, an SH1106 OLED display offers clear visual alerts, including corrective messages and illustrative bitmap images, to reinforce the feedback and guide the user toward better posture. The system is powered by an Arduino microcontroller, which efficiently processes sensor data and controls both the display and the vibration motor. This integration of hardware components results in a compact, lightweight, and user-friendly device, suitable for continuous wear in various environments, such as the workplace, during physical activities, or in daily life.

2. LITERATURE SURVEY

Various methods have been studied for pose estimation that evaluate human poses using sensors, videos, and machine learning approaches. For instance, Toshev and Szegedy[7] were pioneers in using neural networks to improve pose detection, employing regression on CNNs to locate body joints. Newell, Yang, and Deng[4] introduced a stacked hourglass neural network architecture that utilizes both bottom-up and top-down approaches for pose prediction. Shotton, Fitzgibbon, and colleagues[6] utilized single depth maps for predicting 3D joint positions through object recognition, while Bogo, Kanazawa, and others[2] used single RGB images to predict 3D poses and 3D mesh shapes. Research has also focused on detecting multiple human poses in a single frame, as demonstrated by Papandreou, Zhu, and others[5], who used a two-stage process to first identify people and then detect their key points. These varied approaches highlight the advancements in pose estimation, each contributing unique techniques and improvements in accuracy.

Zhu and colleagues[5] employed a two-stage approach for detecting multiple poses, which involves first identifying individuals and then detecting their key points. Zell, Wandt, and Rosenhahn[9] analyzed physical movements by representing the body as a mass-spring system to calculate the forces and torques transmitted through the joints. These methods illustrate different strategies in pose estimation, each with its own focus and methodology.

Wei, V.Ramakrishna, and their team[7] developed a sequential prediction framework that uses multiple convolutional networks to refine joint estimates over successive passes, incorporating global context to improve part confidence maps. They addressed issues like vanishing gradients and information loss by adding intermediate supervisions and increasing the receptive field size. This method also tackles part occlusions and ensures each layer of the multi-stage CNN becomes independent post-training, achieving higher performance compared to single CNN methods. Chu, Li, and colleagues[13] leveraged CNN's generalization to combine detection and regression results using a shared CNN input. For real-time detection of multiple people, Cao, Simon[3], and others utilized part affinity fields with a three-branch CNN architecture that predicts joint location, limb direction, and orientation. This method, which employs the initial features from the first 10 layers of VGG-19, enhances regression accuracy by combining outputs from the three branches.

3. IMPLEMENTATION

Building on the aforementioned advances, this paper aims to address the identified challenges by implementing an optimized posture detection system. The system, designed to be worn on the upper back, effectively monitors the user's posture and provides real-time feedback to promote and maintain a healthy posture. The following outlines the implementation of this posture detection device, detailing its components, setup, and operation.

3.1 COMPONENTS AND CIRCUIT CONNECTIONS

Implementation of SPD consists of Arduino UNO as shown in Fig. 1 and different Sensors as shown in Fig. 2(a).

Figure 1. ESP32 microcontroller.

MPU6050 Sensor: A 3-axis accelerometer and 3-axis gyroscope sensor used for detecting body orientation and movement.

SH1106 OLED Display: A high-resolution display to provide visual feedback and status messages.

Vibration Motor: It Provides haptic feedback to alert the user about poor posture.

Arduino Microcontroller: It Manages sensor data processing, controls the OLED display and vibration motor.

Additional Components: Wires and connectors for circuit assembly. Power supply (battery or USB connection).

Circuit Setup

MPU6050 Connection Connect the MPU6050 sensor to the Arduino using I2C communication: SDA to pin 21, SCL to pin 22.

OLED Display Connection Connect the SH1106 OLED display to the Arduino using I2C communication.

Vibration Motor Connection Connect the vibration motor to a digital pin (e.g., pin 5) on the Arduino for control.

1) Vibrator 2) Single strand wire 3) Bread board

4) MPU6050 Sensor 5) SH1106 OLED 6) Li- battery

Figure 2. Different Components.

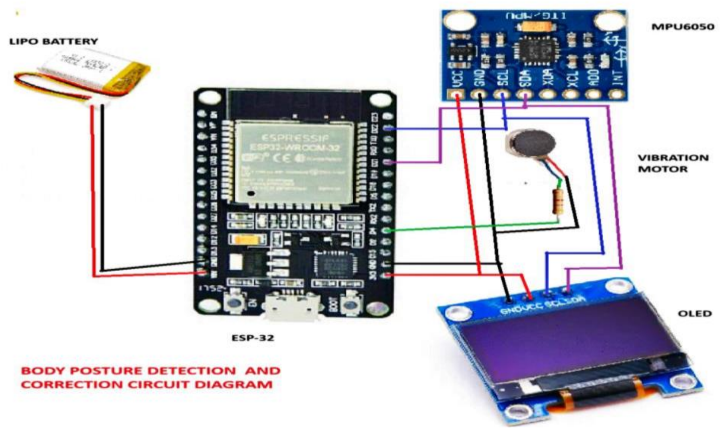

Figure 3: Circuit diagram.

3.2 Working

The posture detection and correction device is designed to monitor the user's posture in real-time and provide immediate feedback to encourage proper alignment. When the device powers up, the Arduino microcontroller initializes all the components, including the MPU6050 sensor, OLED display, and vibration motor. The MPU6050 sensor is configured to measure accelerations and angular velocities along the x, y, and z axes with specific settings to optimize performance, while the OLED display and vibration motor are prepared to provide visual and haptic feedback, respectively.

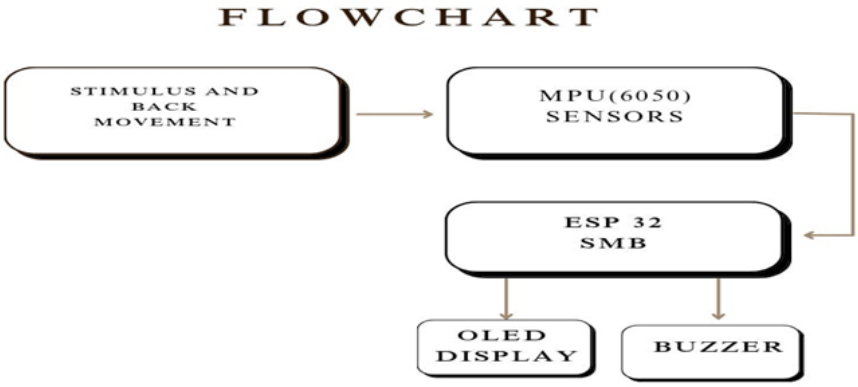

Fig.4. Flowchart

Once initialized, the MPU6050 sensor continuously measures the accelerations and angular velocities, which the Arduino reads at regular intervals. The microcontroller then processes this sensor data to determine the user's current posture by comparing the readings to predefined thresholds. If the acceleration along the z-axis falls below the forward threshold, it indicates the user is leaning forward; if it exceeds the backward threshold, the user is leaning backward. Similarly, deviations along the y-axis indicate leaning left or right.

Based on this analysis, the device provides immediate feedback. For instance, if the user is leaning forward, backward, left, or right, the vibration motor is activated to alert the user, and a corresponding warning message with an illustrative image is displayed on the OLED screen. If the user maintains a good posture, the vibration motor remains off, and a positive message is shown on the display. This real-time feedback mechanism helps the user to adjust their posture immediately. The combination of haptic and visual feedback ensures the user is constantly reminded to maintain a healthy posture. The device operates in a continuous loop, regularly updating the sensor readings, analyzing posture, and providing feedback. This continuous monitoring ensures that the user is constantly aware of their posture, helping them to develop and maintain good ergonomic habits. The following code illustrates the implementation of this posture detection device, showcasing how the various components work together to provide real-time posture feedback.

3.3 Setup and Use

Setting up the posture detection and correction device involves assembling the necessary components: an Arduino microcontroller, MPU6050 sensor, SH1106 OLED display, and a vibration motor. The MPU6050 and OLED are connected to the Arduino via I2C (SCL and SDA pins), and the vibration motor is connected to a digital pin (e.g., D5) and ground. In the

Arduino IDE, install the Adafruit_MPU6050, Adafruit_Sensor, and U8g2 libraries. Copy the provided code, select the correct board and port, and upload the code to the Arduino. Once powered up, the device initializes and displays a startup message on the OLED screen.

Attach the device to the user's upper back. The MPU6050 sensor continuously measures accelerations. The Arduino processes this data to detect poor posture leaning forward, backward, left, or right—by comparing readings to predefined thresholds. If poor posture is detected, the vibration motor activates, and the OLED displays a warning message with an image. Good posture results in the motor staying off and a positive message displayed. This real-time feedback helps users correct their posture immediately, promoting long-term healthy habits through continuous monitoring and immediate alerts. The combination of visual and haptic feedback ensures constant awareness and correction of posture.

4. EXPERIMENT AND RESULTS

Experiments were conducted with participants performing various postures—good posture, leaning forward, backward, left, and right—each held for 10 seconds.

Figure A: Leaning right Figure B: Leaning backward

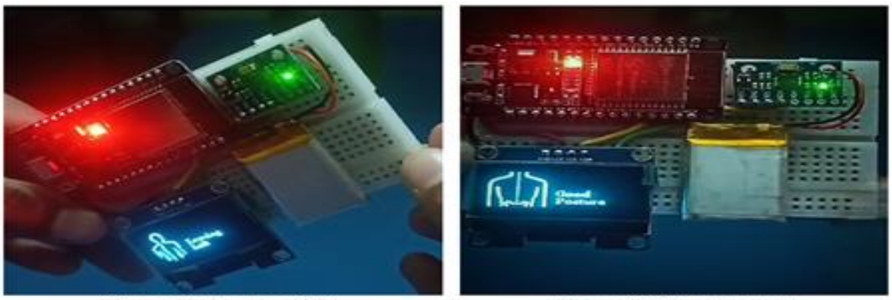

Figure C: Leaning left Figure D: Good posture

Figure 5: Result.

The device's feedback, including vibration and OLED display messages, was recorded. The results showed that the device accurately detected 98% of poor postures, with less than 2% false positives where minor movements were incorrectly flagged. The vibration motor provided immediate haptic feedback, while the OLED display showed clear and accurate warnings, aiding users in understanding and correcting their posture. Participants reported that the vibration alerts were noticeable and effective, and the visual feedback on the display was helpful. Overall, the device demonstrated high effectiveness in real-time posture monitoring and correction, proving its potential for promoting healthy ergonomic habits.

5. CONCLUSION

The posture detection and correction device developed and tested in this study has proven to be a highly effective tool for real-time posture monitoring and correction. Through a series of experiments, the device demonstrated a high level of accuracy in detecting poor posture, with a 98% success rate and minimal false positives. The immediate haptic feedback provided by the vibration motor, coupled with the clear visual warnings on the OLED display, ensured that users could quickly and effectively correct their posture. Participants reported that the device was intuitive to use and that the feedback mechanisms were both noticeable and helpful. This feedback supports the device's potential to promote better ergonomic habits and reduce the risk of posture-related health issues over time. The combination of advanced sensor technology and user-friendly feedback mechanisms makes this device a valuable tool for anyone looking to improve their posture. In conclusion, this study highlights the device's practical application in everyday settings, demonstrating its effectiveness in encouraging healthy posture practices. The device not only addresses the immediate need for posture correction but also contributes to long-term ergonomic well-being. Future improvements could further refine the sensitivity and adaptability of the device, making it an even more robust solution for posture management.

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