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Real-Time Detection of Poor Posture Using MPU6050 and Arduino with Haptic Feedback Mechanism

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ABSTRACT —

Poor posture is a common issue that can lead to long-term back and neck problems if not addressed early. In this project, we developed a simple, wearable device aimed at helping users maintain better posture throughout the day. The system uses an MPU6050 sensor, combined with an Arduino Uno, to monitor the angle of the upper back in real time. When the user slouches beyond a certain threshold, the device triggers a buzzer to remind them to sit or stand upright. Designed to be comfortable, the device offers a practical solution for improving daily posture habits without the need for constant self-awareness. Future improvements could include a mobile app support to track posture trends over time.

Keywords— Posture correction, Wearable device, Haptic feedback, Real-time system, Prototyping

INTRODUCTION

The prevalence of poor posture has become a significant concern in modern society, often attributed to the increasing adoption of technology and the rise in sedentary behaviors. According to the American Chiropractic Association, as much as 80% of the population experiences back pain. It has been found out that the major reason for back pain is poor posture.

Maintaining correct posture is crucial for overall health and well-being, it not only influences musculoskeletal health but also increases energy levels and stabilizes mental state. Some studies explain good body postures by measuring head incline angles – the true horizontal angle in conjunction with any of the following lines: the Ear-Eye line (from the tragus to the canthus), the Frankfurt line (from the tragus to the bottom of the eye socket), the tragus-to-nasion line, the tragus-to-infraorbital-notch line, and more.

The downside of using head tilt angles is that they only refer to one aspect of the complex geometry involved in head and neck posture.

Studies show that for every 15 degrees of forward neck tilt, as much as 10-20 lbs. A comfortable head/neck angle is about 30° in a normal sitting posture and about 40° in using a computer. A posture below 25°or beyond 50° is considered poor and needs to be corrected.

The objective of this paper is to present the design, implementation, and potential benefits of this innovative posture corrector, supported by a comprehensive review of relevant academic literature.

A REVIEW OF EXISTING POSTURE CORRECTING SYSTEMS

Back pain is a common medical condition that usually requires medical intervention. Patients with chronic pain are mostly advised to undergo surgery or use external devices such as dynamic joint braces. While these braces are designed to correct spinal alignment, they are typically cumbersome, uncomfortable, and too expensive to use repeatedly.

Operative correction, although at times performed by minimally invasive techniques, generally necessitates a prolonged recovery period of six to twelve months. Additionally, the outcome is not always guaranteed, and many patients still have limitations after the operation.

Non-surgical interventions, including the application of heat and cold packs or acupuncture therapy, are also typical recommendations. Although such interventions do give pain relief, they never offer a solution to the biomechanical abnormalities underlying the pain.

Spinal disk replacement is reserved for very extreme cases only. This involves a rubber pad inserted between vertebrae for the single purpose of restoring movement and relieving pressure on the spine. The surgery has great risks involved, including post-operative pain and complications, which greatly impact the patient's lifestyle.

Wearable posture correction belts are another alternative available. They feel when one is slouching and provide vibrational cues to transition to better posture. Tracking of posture is even included using smartphone technology on some models. But extended usage will be discomforting, and the relatively costly nature of high-quality models is still a point preventing mass application.

System Design

The real-time posture detection system is designed as a wearable device to address the limitations of existing posture correction methods. This section describes the overall architecture of the system, the hardware components used, and the overall connected circuit

Overall Architecture

The real-time posture detection system is implemented in a wearable, modular manner that attempts to detect and correct poor posture. The system consists of sensing, processing, feedback, and power modules, enabling it to function in an autonomous manner.

The major pieces of the system include an MPU6050 inertial measurement unit (IMU) to detect, an Arduino Uno microcontroller to compute, and a buzzer used to provide haptic feedback. The MPU6050 is oriented in a manner that its X-axis will be parallel to gravity if on the top portion of the back or neck of the user, thereby allowing precise measurement of the angle.

The power is sourced from a 3.7V battery that is boosted by a booster circuit to provide the necessary voltage to the Arduino and the sensor. The system power is regulated via a switch, and the battery is automatically charged. The Arduino computes the posture angle from the data received from the MPU6050 and compares it to a set threshold of 15 degrees. When the threshold is exceeded, the Arduino triggers the buzzer to inform the user.

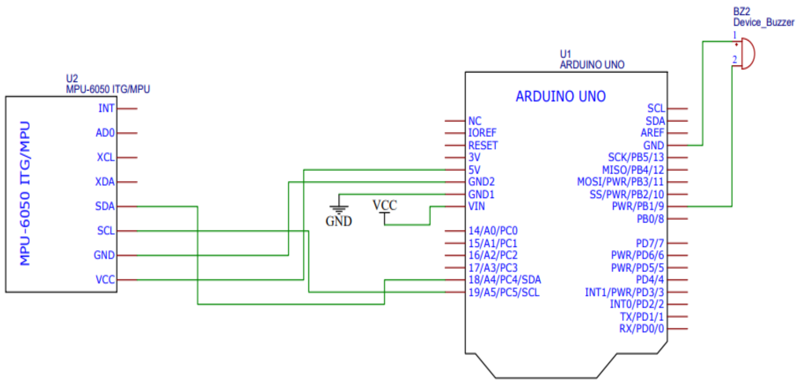

Fig. 1. Overall system architecture

Hardware components

Real-time posture detection system contains some necessary hardware elements that allow it to perform its sensing, processing, feedback, and power management operations. The elements used were selected under the project limitations of wearability, real-time, and power usage.

The system's central processing unit is the Arduino Uno microcontroller board. The open-source platform was chosen because of the simplicity of coding, small size, and sufficient processing capability to perform sensor data acquisition and posture detection algorithm.

Fig 2. Arduino Uno microcontroller board.

Posture information is recorded by the MPU6050 inertial measurement unit. It has an on-chip 3-axis gyroscope and 3-axis accelerometer to record movement and orientation. Raw MPU6050 data can be used to compute the angle of the user's upper back in real time.

Fig 3. MPU6050 inertial measurement unit (IMU).

Portability of the system is provided by a 3.7V Lithium-ion battery, which is employed as the primary power source.

Fig. 4. 3.7V Lithium-ion battery.

To provide the required operating voltage to the Arduino Uno and other circuits, an XL6009 booster circuit is used to amplify the voltage level of the battery from 6V-7V.

Fig. 5. XL6009 booster circuit module.

A combined BQ001A recharging module is included for easy recharging of 3.7V battery to make powering of the unit for long-term use easy.

Fig. 6. BQ001A battery charging module.

There is a simple switch in the power supply circuit so that the user can easily turn on or off the device and control the power supply from the boosted battery to the system.

For haptic feedback, a buzzer is also present in the Arduino Uno. The buzzer will be triggered by the microcontroller if it senses poor posture, alerting the user to correct it immediately.

Fig. 7. Buzzer used for haptic feedback.

Circuitry and Connections

This sub-section demonstrates the electrical connection of the hardware devices to complete the overall circuit of the real-time posture detection system. The circuit connection diagram is shown in Fig. 1.

MPU6050 inertial measurement unit (U2) is connected to Arduino Uno (U1) with the I2C protocol. The SDA pin of MPU6050 is connected to the SDA pin (A4) of Arduino, and SCL pin of MPU6050 is connected to SCL pin (A5) of Arduino. MPU6050 is powered by connecting VCC and GND pins of MPU6050 with 5V and GND pins of Arduino, respectively.

Buzzer (BZ2) is also connected to Arduino Uno's digital pin 9 (PD9). This enables the microcontroller to trigger the buzzer to provide haptic feedback to the user. Buzzer is connected to digital pin 9 at one end and GND at another end.

The system's power supply, which is a 3.7V battery, XL6009 booster circuit, switch, and BQ001A charging module, supplies the board with the voltage it needs through the Arduino Uno. The switch output of the booster circuit is connected to the Vin pin of the Arduino Uno to supply the board. The connections are attached below in fig. 8

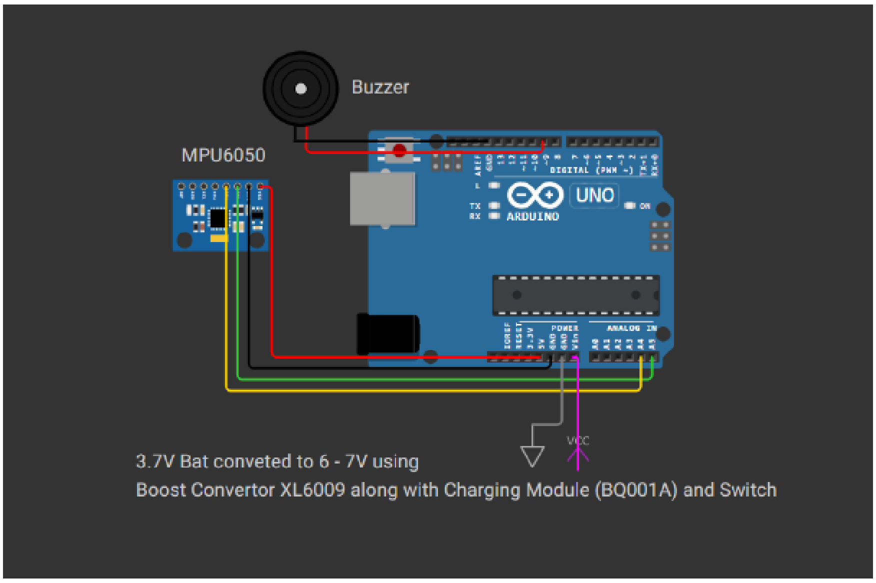

Fig. 8 Physical wiring diagram

Working

The operation of the real-time posture detection system is a chain of processes that begin from initialization and continue until continuous sensing, data analysis, and feedback provision. The system is designed to function autonomously once it is switched on, with real-time detection and alert.

Once powered on via the power switch, the system goes ahead to boot up, which involves the calibration of the MPU6050 sensor. Calibration is a procedure that establishes a reference point for the first correct posture angle, to which subsequent measurements will be adjusted.

After the initialization phase is completed, the Arduino Uno goes on to read data from the MPU6050 sensor. Using the MPU6050 Light library, the raw data from both the accelerometer and gyroscope are processed through filtering techniques to calculate the current orientation and evaluate the posture angle of the user in real time.

The current posture angle is then computed and compared to the initially calibrated angle. If the absolute difference between the original and current angles is more than a pre-set threshold of 15 degrees, the system identifies it as a poor posture indicator.

When suboptimal posture is sensed, particularly once the 15-degree value has been crossed, the buzzer is turned on by the Arduino. The audio signal serves as immediate touch feedback for the user to guide them into correctly positioning their posture.

The entire cycle of sensing, processing, and feedback is continuously repeated in the system's main loop, thus ensuring that the user's posture is continuously monitored in real time with corrective feedback provided when required.

Results

Thus, we successfully developed a wearable device to identify and signal instances of poor posture in users. The device used an MPU6050 inertial measurement unit and an Arduino Uno microcontroller to measure when the user departs from a calibrated correct posture.

The device adequately identifies when a user assumes inappropriate posture. The MPU6050 sensor data taken through the processing by the Arduino Uno, the device makes the buzzer trigger giving instantaneous feedback once the angle of the posture varies more than a threshold of 15 degrees from the original calibrated posture angle. Once detected, the response time for buzzer is nearly instant, thus offers timely remainder to user to correct the posture.
The 15-degree threshold for activating the feedback was validated by checking the activation of buzzer at different angles of deviation from original position. The buzzer activated consistently when the posture angle crossed this threshold, confirming the system's compliance with the specified parameter for detecting poor posture.

Conclusion

In terms of functionality, our device worked exactly as expected. The design (in terms of placement of the sensor on back/shirt) worked well too. This means that whenever a poor posture was detected by MPU6050's X-axis (when it crossed threshold angle of 15-degrees) , Arduino will trigger the buzzer giving user a remainder to correct the posture.

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