Smart Fitness Suit

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Abstract. Wearable and persuasive computing technology has sparked a lot of interest in fitness and sports. Physical activities play a crucial role in maintaining fitness levels. Even though, during intense and commanding workouts, physical fitness is seriously influenced by both younger and older people, so the problem is while maintaining the physical fitness, the posture should be maintained while performing the exercise, if the posture is improper during workouts may lead to temporary or permanent disabilities such as muscle fatigue, ligament sprains, muscle, and tendon strains. Given the importance of this issue, the system which is proposed is fully portable smart fitness suit for the household to use for exercises without the need of physical gym trainer. The proposed solution is done for bicep curl exercise, and a smart fitness suit that detects posture while performing the exercise, and can easily carried from place to place.

Keywords: Smart Fitness Suit · Accelerometer · Gyroscope · Smart gym · Posture detection

1 Introduction

EMG (Electromyography) is a technique used to examine the health of muscles and the nerve cells that control them. Motor neurons are nerve cells located in muscles that provide electrical impulses that cause the muscles to contract and relax. These impulses are converted by electromyography into graphs or data that doctors can use for diagnosis. When a patient exhibits symptoms of a muscle or nerve disorder such as tingling, numbness, muscle weakness, muscle pain or cramping etc., the doctor orders an EMG test, based on the results, the doctor can easily diagnose the patient's condition.

Surface electrodes used on the surface of the skin and more often, needle electrodes are placed directly into the muscle are used to record EMG. Basically, surface electrodes are available in disposable and reusable varieties. Surface electrodes can be placed on the muscular area in contact with adhesive material, so that no noise is interfered in between the electrode and skin. A ground electrode is placed to provide a common reference measurement. These electrodes will be able to detect potentials produced by muscle fiber contraction and relaxation.

Muscle contraction and relaxation is a muscle mechanism that begins when the nervous system is used to transmit and receive signals from the muscles via the brain and spinal cord. An action potential is generated and passes through motor neuron. A

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neuro-muscular junction is a connection between a motor neuron and a muscle cell. As a signal from the nervous system reaches the neuromuscular junction, the motor neuron delivers a chemical message (Acetylcholine), a neurotransmitter that binds to receptors on the exterior of the muscle fiber. This results in a chemical reaction within the muscle.

2 Literature Survey

The IOT revolution is influencing many aspects of our daily lives [1]. Well-being is quickly becoming one of the most popular IoT application domains, with the goal of providing new services such as smart fitness. This study focuses on smart fitness, which includes IoT-based solutions, AI, and social-IoT effects.

The article describes the development of a physical health smart management system that utilizes cloud computing, big data, mobile internet, and other advanced technologies [2].

IOT technology has scientific, advanced and practical characteristics in wearable fitness equipment and artificial intelligence health management [3]. This paper discusses the intelligent health management system based on IOT technology.

This paper predominantly describes the design direction and the product interaction of intelligent fitness system [4]. The main theme of this paper is to establish a fitness system integrates with online fitness intelligent experience.

The purpose of this paper is the user obtains physical fitness data via the body measurement module, and the huge exercise prescription database is designed and a mobile application is designed for exercise prescription according to the user's fitness environment [5].

In recent years, people pay more and more attention to physical health [6]. After analyzing the advantages and disadvantages of intelligent fitness products at the present stage, there is no trainer to participate in home fitness in real time, the standardization, consistency is to be maintained with the help of technology.

3 Proposed System

Physical fitness has an impact on the quality of life for millions of people worldwide. There are 6 sets of exercises that need to be followed on weekly basis: back-bicep combination, chest-triceps combination, and shoulder-legs combination, and each of these combinations needs to be done twice a week. These exercises should be followed with three sets, with the weight increasing for each set.

While performing bicep curl exercise, the primary muscles that are activated are the biceps brachii, located in the front of the upper arm, as well as the brachialis muscle and brachioradialis muscle, located underneath the biceps brachii and in the forearm, respectively.

People with no knowledge of the correct posture to maintain while exercising may be at risk of serious injuries such as muscle fatigue, ligament sprain, muscle and tendon strains. To detect whether a person is maintaining the correct posture or not, a smart fitness suit with an Inertial Measurement Unit sensor has been introduced. This technique allows for the reading of sensor values of the gyroscope at different posture movements.

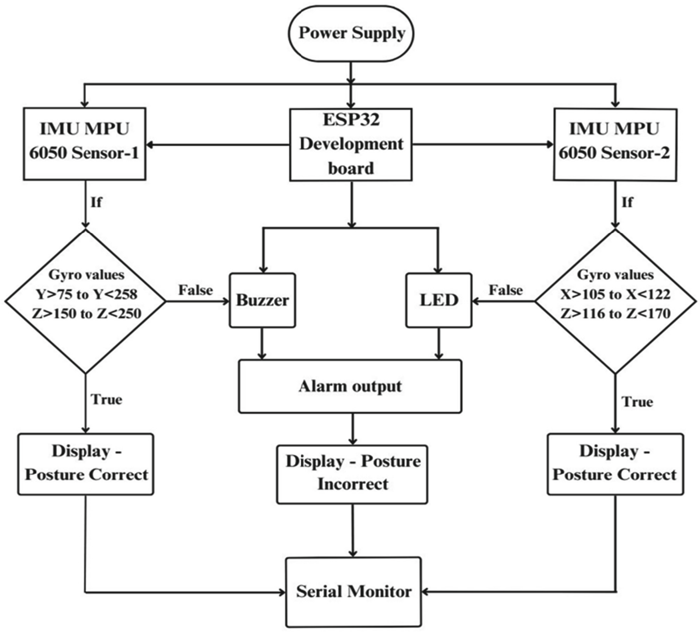


Fig. 1. System Block diagram

The values detected are then analyzed by the micro-controller. Based on the correct and incorrect posture values, a buzzer is connected that gives an alarm to the person and alerts them when they are performing the wrong posture (Fig. 1).

This block diagram illustrates a system where a power supply is connected to an ESP32 development board and two IMU MPU 6050 sensors. These sensors are placed on the forearm and back side of the upper arm to detect X, Y, and Z values while the person is exercising. Based on these values, the system detects whether the person's posture is correct or incorrect. If the forearm position is incorrect, the buzzer will give an alert to the person. If the upper arm position is wrong, the LED light will light up and alert the person. The serial monitor displays the sensor values and whether the posture is correct or incorrect during the exercise. This system can help the person maintain the correct posture while exercising and prevent muscle injuries.

4 System Components

The components used in the System are:

- ESP32 Development board
- MPU 6050 IMU sensor
- Arduino IDE

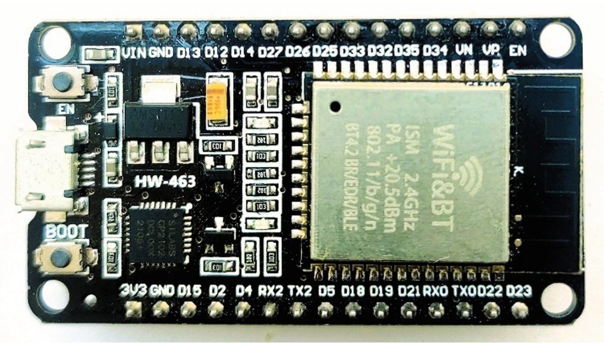


Fig. 2. ESP32 development board

4.1 ESP32 Development Board

The ESP32 is a microcontroller board based on the Xtensa dual-core 32-bit LX6 microprocessor, and it is a popular development board for creating digital devices and interactive projects. The ESP 32 board includes 320 KiB RAM, 448 KiB ROM memory, 34 programmable GPIOs, 18 channels 12-bit SAR A-D convertor and 2 8-bit D-A convertors, as well as USB connection and a power jack. The ESP32's high processing power makes it suitable for handling complex tasks and executing them quickly, while also providing better power management. In addition, the ESP32 has built-in Wi-Fi and Bluetooth capabilities, which make wireless communication easier for transferring data between devices over the internet. Furthermore, the ESP32's abundant memory capacity allows it to store large amounts of data, making it more efficient compared to other micro-controllers. Therefore, the ESP32 was used in this smart fitness suit due to its superior performance capabilities (Fig. 2).

4.2 MPU 6050

The MPU 6050 sensor is a Micro Electro Mechanical Systems (MEMS) device that includes a 3-axis accelerometer and 3-axis gyroscope. The sensor has various pins embedded on it, including GND, VCC, SDA, SCL, XCL, XDA, INT, and AD0. VCC provides power for the module, with a range of 3V to 5V. SCL and SDA are used for serial clock and serial data, respectively, and are used for providing clock pulses and transferring data through I2C communication. XDA and XCL are auxilary serial data and auxilary serial clock, respectively, and are used for interfacing other I2C modules with the MPU 6050. AD0 is used for varying the address, in case more than one MPU 6050 is used. Finally, INT is the interrupt pin used to indicate the availability of data for the MCU to read. Overall, the MPU 6050 is a versatile sensor that provides accurate measurements of motion and orientation through its various pins and I2C communication. Therefore, the MPU 6050 was used in this smart fitness suit due to its accuracy, low power consumption, and high sensitivity capabilities (Fig. 3).

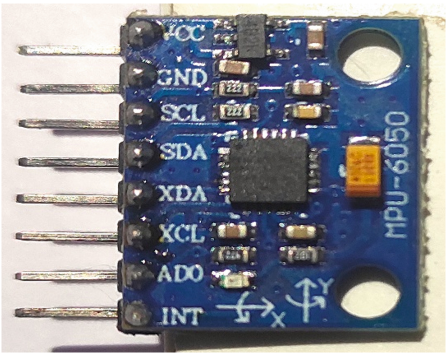


Fig. 3. MPU 6050 IMU Sensor

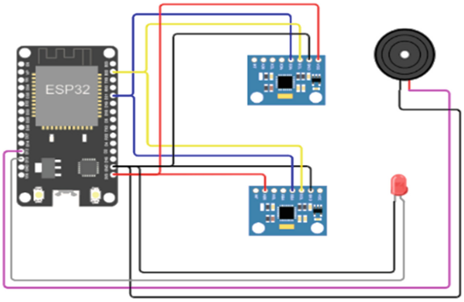


Fig. 4. Circuit Diagram

4.3 Arduino IDE

The Arduino integrated development environment (IDE) is a cross-platform application created by Arduino.cc that can be used to write, compile, and upload code to all Arduino modules. Arduino hardware can be written in any programming language which produces binary machine code for the processor. This software is suitable for all kinds of operating systems: Microsoft windows, macOS, Linux.

5 Circuit Construction

See Fig. 4.

6 Results

To monitor the posture of the bicep curl exercise, two MPU 6050 IMU sensors are utilized. Each sensor is positioned on the backside of forearm and upper arm. The setup includes a breadboard, to which a buzzer and an LED are connected, as shown in Fig. 5, During the Bicep curl exercise, a series of gyro values of X, Y, Z are displayed in the serial plotter. The range of gyro values for sensor-1 is between $Y > 75$ to $Y < 258$, Z > 150 to Z < 250 and the range of gyro values for sensor-2 is between X > 105 to X < 122, Z > 116 to Z < 170 as shown in Tables 1 and 2. By analyzing the data, the posture can be easily detected as correct or incorrect, if the forearm posture is incorrect, the buzzer will alert the person. Similarly, if the upper arm posture is incorrect, the LED will signal an alert. This setup can help maintain proper posture during the exercise, which can enhance its effectiveness and minimize the risk of muscle injuries (Figs. 5 and 6).

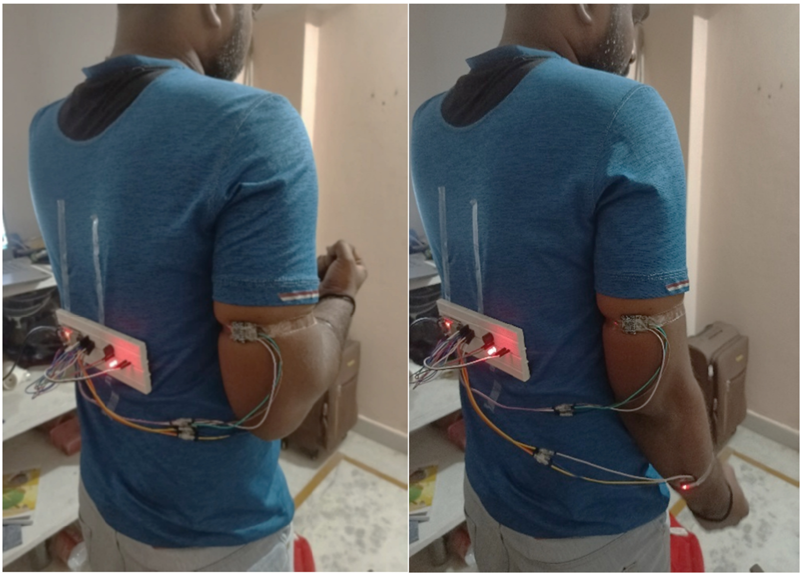
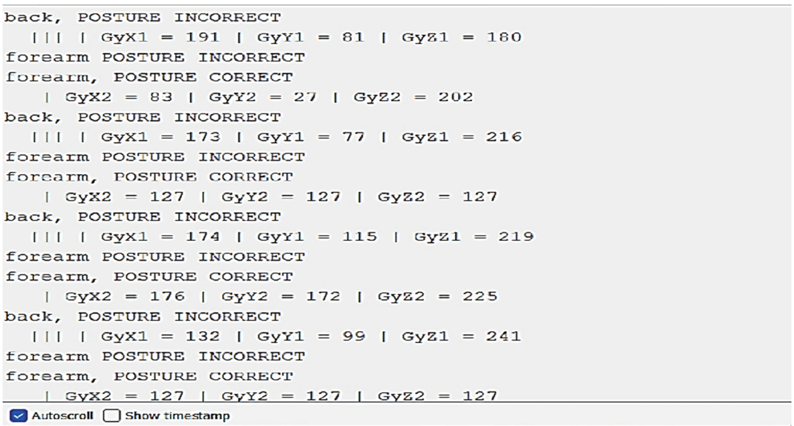


Fig. 5. Prototype



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back, POSTURE INCORRECT
 ||| | GyX1 = 191 | GyY1 = 81 | GyZ1 = 180
forearm POSTURE INCORRECT
forearm, POSTURE CORRECT
  | GyX2 = 83 | GyY2 = 27 | GyZ2 = 202
back, POSTURE INCORRECT
 ||| | GyX1 = 173 | GyY1 = 77 | GyZ1 = 216
forearm POSTURE INCORRECT
forearm, POSTURE CORRECT
  | GyX2 = 127 | GyY2 = 127 | GyZ2 = 127
back, POSTURE INCORRECT
 ||| | GyX1 = 174 | GyY1 = 115 | GyZ1 = 219
forearm POSTURE INCORRECT
forearm, POSTURE CORRECT
  | GyX2 = 176 | GyY2 = 172 | GyZ2 = 225
back, POSTURE INCORRECT
 ||| | GyX1 = 132 | GyY1 = 99 | GyZ1 = 241
forearm POSTURE INCORRECT
forearm, POSTURE CORRECT
  | GyX2 = 127 | GyY2 = 127 | GyZ2 = 127
Autoscroll  Show timestamp
```

Fig. 6. Gyro-1 & Gyro-2 sensor values with Posture detection in Serial monitor

Table 1. Gyro-1 sensor values: upper-arm posture detection

S.NO	X	Y	Z	Posture Status
1	141	13	71	Incorrect posture
2	191	85	190	Correct posture
3	173	90	223	Correct posture
4	138	10	66	Incorrect posture

Table 2. Gyro-2 sensor values: forearm posture detection

S.NO	X	Y	Z	Posture Status
1	100	21	183	Incorrect posture
2	83	27	202	Incorrect posture
3	110	15	165	Correct posture
4	176	172	169	Correct posture

Table 1 and 2 explain the posture detection while performing the bicep exercise. Table 1 shows that the gyro sensor values must range from $Y > 75$ to $Y < 258$ and $Z > 150$ to $Z < 250$ in order for the person to maintain the correct posture. On the other hand, Table 2 indicates that the gyro sensor values must range from $X > 105$ to $X < 122$ and $Z > 116$ to $Z < 170$ for the person to maintain the correct posture.

7 Conclusion

This project aims to develop a posture detection system using an MPU 6050 IMU sensor. It offers a superior technique for individuals who wish to do physical fitness without assistance, and it is user-friendly. This project is highly beneficial for gym trainers and individuals interested in physical fitness. It outperforms existing solutions because they tend to be costly. In the future, machine learning can be utilized to share data through the cloud, enabling trainers to keep track of the exercises performed and postures maintained by the individuals.

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