Posture detection and Data collection Report

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Title

Posture detection and Data collection using sensors

Abstract

This research looks into human posture detection technologies, new ideas for detection system and how we can use these technologies to help detect and collect data on human posture in sports and exercise.

Posture plays an important role in health and fitness. The most common advice about posture is keep your back straight so the bones and the joints are aligned. This gives our body more energy, less fatigue and it will help us to keep focus and complete our task efficiently (Harvard, 2017). When it comes to sports, energy and how we use muscles in our body in the most efficient way is the most important as it helps to push our bodies to the maximum performance.

To be able to capture and collect data on human or animal posture, there are two main methods found in this research. Using various types of sensors to collect data on our body movement and motion capture technology to detect our posture.

However, understanding the types of sensors to be used and the nature of the device to be built, a thorough look into types of exercises, sports and the most important types of data, athletes, sport scientists, professional players and the general population seek and expect to improve is needed.

Exercises

With the assumption that exercises with an increased amount of body movement requires multiple and different types of sensors, and exercises with less body motion requires one sensor to collect data on fatigue, heart rate, reps, correct motion ...etc., an approach of studying Dynamic exercises and Static exercises was done in this research. By taking this approach, the effectiveness and the functionality of the IoT system can be determined efficiently.

Dynamic Exercises

Dynamic exercises require one body part moving in a certain motion to stress the muscles. Squats, stretches, pull-ups, push-ups, bench press and bicep curls are some examples for these types of exercises. These exercises are practiced

mainly for warmups and muscle building. Focuses on increasing the heart rate while keeping the correct motion in order to build the targeted muscles.

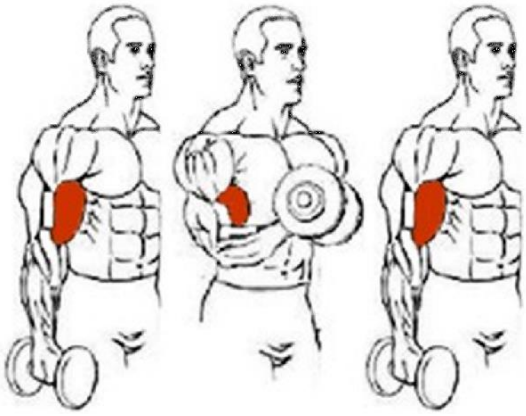


Figure 1 Biceps Curl

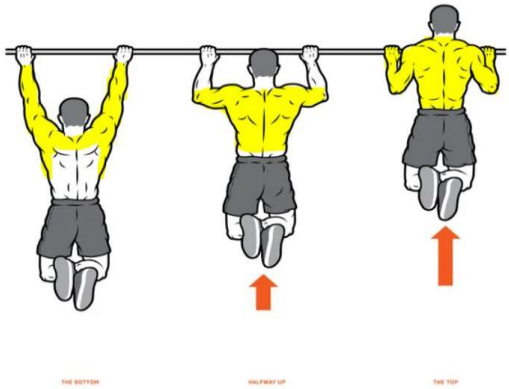


Figure 2 Pull ups

Figure 3 Dynamic Stretches

Heart rate, blood pressure, posture and the weights used are the most important aspects of these exercises. There has been many research done and currently in progress on the effects of dynamic exercises. “The effect of warmups incorporating different volumes of dynamic stretching on 10 and 20m sprint performance in highly trained male athletes” (Olfa Turki, 2011) and “Acute Effects of Dynamic Stretching on Muscle Flexibility and Performance: An Analysis of the Current Literature” (Jules Opplert, 2018), “Heart Rate Variability and Blood Pressure during Dynamic and Static Exercise at Similar Heart Rate Levels” (Maththias Weippert, 2013) are some of the researches done on these activities.

Creating a device collect heart rate, muscle movement and provide rep counts, break periods according to fatigue and posture correction to support ongoing research would be an aspect that will increase the importance of the IoT system.

Static Exercises (Isometric exercises)

Exercises that do not require joint movement and focuses on building strength is categorized as Static or Isometric exercises. Plank, Wall sit and Dead hang are some example activities. Posture is the most important aspect this type of performance in order to target the correct set of muscles. Although the targeted outcome is to build strength, information on heart rate is important to detect fatigue.

Figure 4 Plank

Figure 5 Wall Sit

Figure 6 Dead Hang

As same as dynamic exercises, many research on detecting the effectiveness has been done and currently in progress. However, for isometric activities, the oxygen levels of the body is a critical point that should be considered. Therefore, information on breathing should also be focused when designing the system. The complexity of the device varies on the types of data to be collected and the type of the training and it will be decided towards the end of this project.

Furthermore, wearable devices already in the market such as Apple watch (Apple, 2022) and Fitbit (Fitbit, 2022) lack the ability to provide information on the muscle tension level. According to American Psychological Association muscle tension is important to guard the body against injury and pain as well as a stress relieving method (Association, 2018).

There are devices such as EMS machine (Machines, 2022) already in the market that provide this information. However, the machines are built to be used for medical purposes and is not wearable during exercises. Since, static exercises test the muscles capability to withhold tension as much as possible, it should be given thought to providing information on muscle tension to prevent injuries using a wearable device to compete with the current market.

Sports

Similar to the discussed exercises, wearable devices to measure heart rate, fatigue, muscle tension and posture can be built. While a wearable device like a heartbeat sensor holds accuracy, collecting data on body movement in real time sport activities might result in larger amounts of invalid and inaccurate data. To build muscles, stamina and strength, professional athletes perform the above-mentioned exercises. Even though, the sensors and methods to collect data provides less efficient data, through heavy data cleaning and analyzing, a set of useful information can be gathered using the simple sensors compatible with Arduino. However, there is the motion capture technology (Mocap) that is used widely in game development, movie development, healthcare industry and in robotics development (Chakraborty, 2021).

“Motion capture (mocap) is the process of recording the movement of objects or people” – Vicon (Vicon, 2022). Motion capture records body movement by placing markers in the object or the person to be tracked via infrared cameras. These markers can be LEDs, magnetic or reflective markers which will reflect the light in order to be tracked. Then using software such as Adobe After Effects (Adobe, 2022), 3DS Max (Autodesk, 2022) and Blender (Blender, 2022), the movement is made into a 3D model which will show the tracked movement. This technology is highly accurate and can provide valuable data in activities with fast body motion. Which can be used to provide information mainly on correct posture and fatigue.

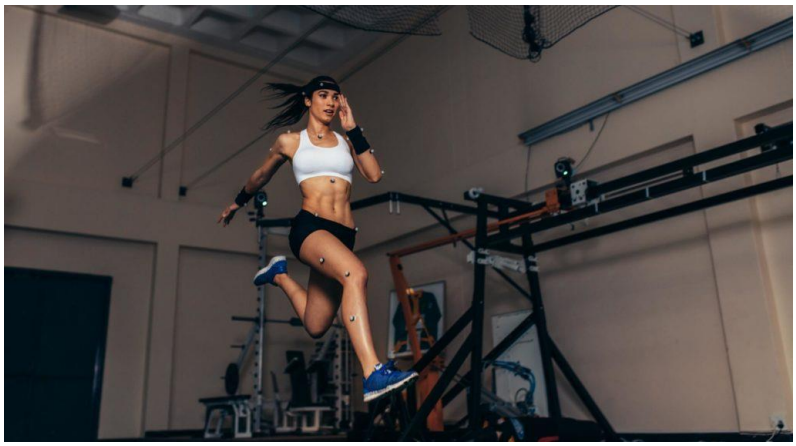


Figure 7 Motion Capture process

Sensors and Devices

The type of sensors, devices and the methods will differ from the type of data targeted and the type of exercise or sport. A set of sensors, motion capture technology and example usages has been identified to build the device.

Flex Sensor

Figure 8 Flex Sensor

Flex sensor which uses resistance as a measurement unit, can be used to collect data on body movement by attaching it to the body.

MPU 6050 3-Axis Accelerometer and Gyro Breakout

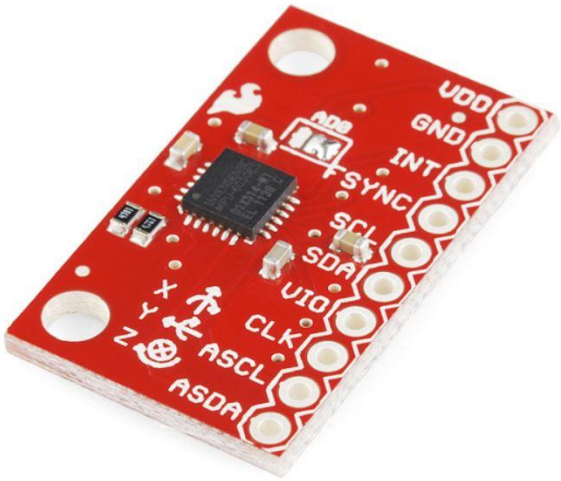


Figure 9 MPU 6050

MPU 6050 sensor is used to measure specific force and turn rate. This can be developed into a wearable device that collects data on the speed of the movement and the posture of dynamic exercises, in some static exercises and sports.

Ultrasonic Distance Sensor HCSR04

Figure 10 HCSR04

This distance sensor emits ultrasonic waves to bounce off the object in front. Then calculates the distance using the time it takes the wave to return. Has the ability to detect objects up to 400cm and 3mm. This can be used in almost every activity to collect data on movement and position. However, if the sensor is not programmed properly according to the activity, sensor tends to be less accurate

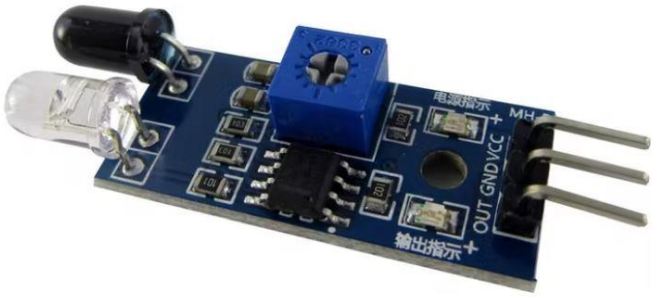
and records invalid data when compared to other sensors that does not require to change the program to be compatible with each exercise.

PIR Motion sensor HCSR501

Figure 11 PIR motion sensor

The passive infrared sensor or the PIR motion sensor objects in front by emitting infrared waves. This sensor does not provide information about the distance as the output is a Boolean value. However, this sensor will be useful to collect data on rep count, fatigue in both static and dynamic exercises.

Infrared Sensor



Ir sensor

Figure 12 Infrared sensor

Mostly mistaken for a different model of the HCSR501 PIR sensor due to the fact that they both has made use of the infrared radiation. This sensor can detect heat and motion. Preventing overheat and informing the user to take breaks during exercise would be an example usage of this sensor.

XD-58C Heartbeat Sensor (Pulse Sensor)

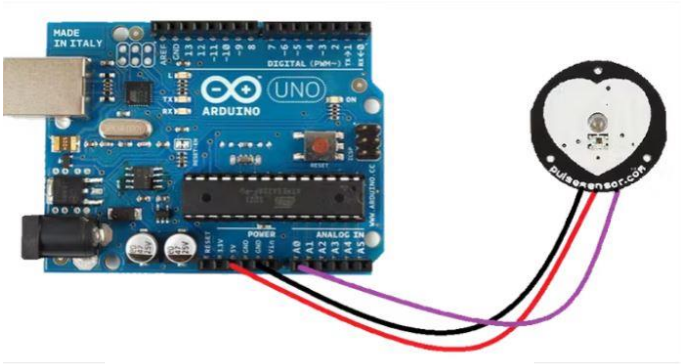


Figure 13 XD-58C Sensor

By placing this on the wrist, neck, ear or in the chest, data on heartbeat can be collected and provide the information to the user similar to Apple watch. However, the success of a new heartbeat sensor is assumed to be low considering the popularity or Fitbit, Garmin, and Apple watch. Combining this with other sensors to create a more complicated device which produce information that the already market dominating devices fail to provide is a major point to be discussed.

Conductive Rubber Cord Stretch Sensor

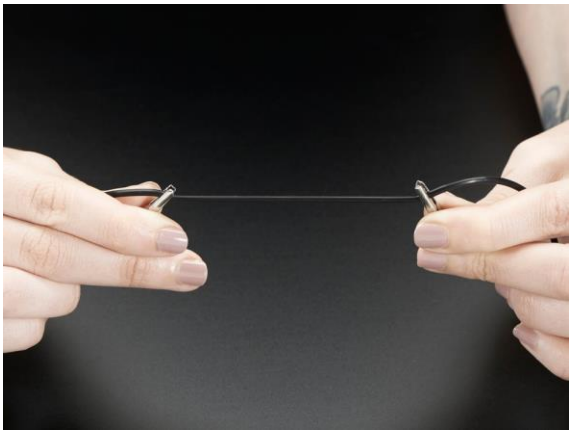


Figure 14 Conductive Rubber Cord

Developed by Adafruit, this rubber cord measures resistance. Understanding the position of the body in stretching exercises would be the main use of this cord for this project. However, since it is a simple cord the durability and accuracy of the data would be arguable.

Data Collection

Heart rate, rep counts, body heat, stretch level and motion are the identified main types of data to be collected. Using this data, conclusions can be made on fatigue, average rep counts per time period, body heat thresholds for each weight class and many more. Before collecting data, deciding which activity to focus on and what is the purpose of collecting data should be discussed. Whether the device is going to be built for research purpose or for everyday use similar to exercise watches available on the market.

In this section, a simple rep count system for push ups has been simulated using Tinkercad (Arampath, 2022). The sensor is assumed to be placed on the floor and the object represents the chest of the user. When the object passes a certain threshold the LED lights up and the buzzer produces a ring noise.

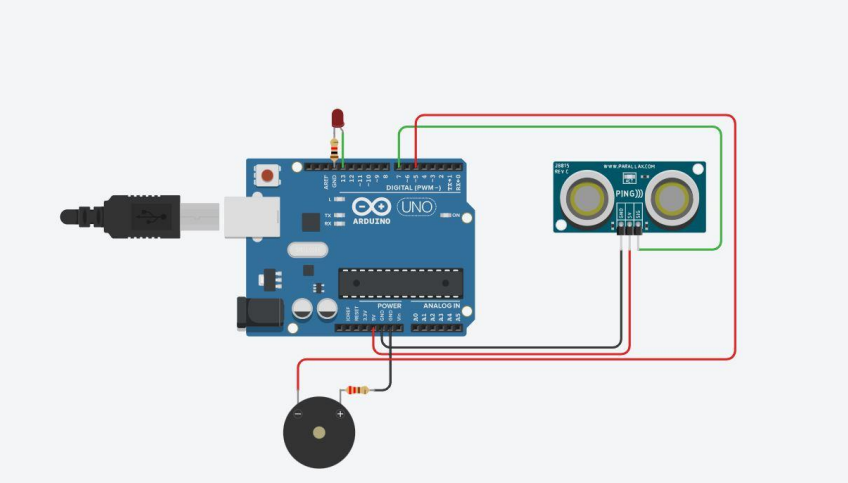


Figure 15 Inactive rep count system

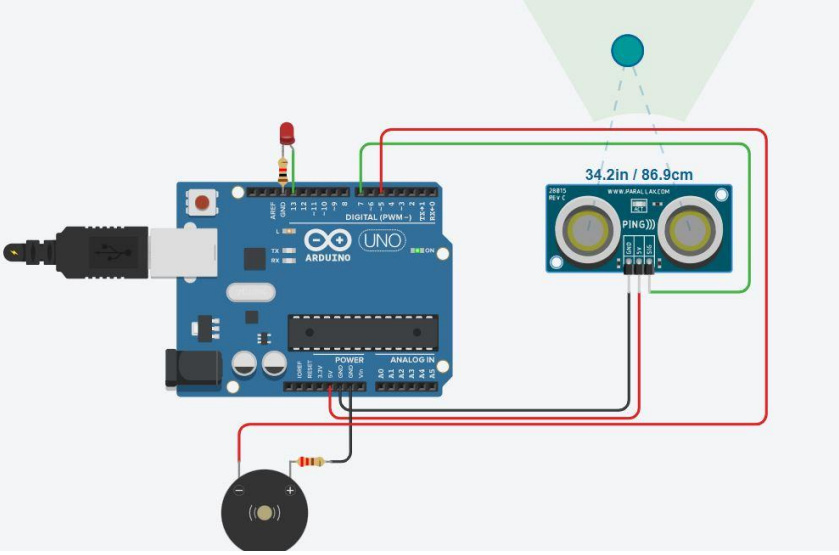


Figure 16 Active rep count system

Figure 15 shows the inactive system with the LED, The buzzer, The ultrasonic distant sensor and the Arduino Uno. In figure 16, an object passes a certain distant threshold triggering the LED and the buzzer to activate. This will let the user learn that one complete push up has been completed.

If the system targets the general market, adding a display to this system to show more information like fatigue, average rep count, rep count history and number of calories burnt that can be concluded using time and rep counts would be an important point to be noticed.

Conclusion

An IoT device to collect data that can help with ongoing research will increase the interest and importance of the device. A device targeted for the general population seems to be difficult with devices like Fitbit, Garmin and Apple Watch already dominating the market. However, it depends on the type of data targeted to be collected.

Heart rate information is important regardless of the activity so it is fair to conclude that the device must have heart rate information if it is targeted for the general population.

A set of sensors has been identified to be used with the Arduino or other Arduino sensor compatible device such as Particle Argon or Photon. These devices will allow to create an early-stage prototype (as in the simulation), under a 50$. The cost depends on the country and the store the sensors and devices will be bought from.

- Default codes for the sensors : https://github.com/ghubk/Redback-IOT.git

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