Push-Up Counter

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ABSTRACT

A push-up is a common physical exercise that can be done by most people and serves various purposes. To complement this exercise, push up counters have been designed to aid people in their training. However, due to limitations of existing push-up counters, they are unable to determine whether a proper push-up has been performed. In this project, the members design a wearable push-up counter with the appropriate components to resolve this issue. The wearable push-up counter is able to accurately count a proper push-up by making use of sensors which ensure that all the criteria of a proper push-up are met.

INTRODUCTION

A Push-up is a physical exercise performed in a prone position by raising and lowering the body using the arms. It is a basic exercise used to train upper body strength.

A Push-up counter is able to accurately record the number of push-ups done by a person and to help a person monitor the progress of his training. However, most push-ups counters are not accurate due to design flaws.

As such, this project aims to re-design and build a wearable push-up counter, using Arduino, which would be able to mitigate inaccuracies of existing push-up counters.

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino can sense the environment by receiving inputs from connected sensors,. Arduino can be programmed to perform a task by writing codes using the Arduino software. [1]

CASE STUDIES

The group examined several existing push-up counters to identify their inaccuracies in counting push-ups.

IPPT/Fist method:

This method of counting push-ups requires the tester (person recording the push-ups) to place his fist on the ground below of the center of the participant's (person doing the push-ups) chest when doing push-ups. The participant's chest must touch the tester's fist for a push-up to be considered valid. [2]

As the sizes of a fist varies with testers, inaccuracies in results may arise as the distance the participant has to lower his chest changes.

Furthermore, this method requires 2 people (participant & tester). If a person does push-ups alone and counts his push-ups, his results might not be accurate as he might not know if he had done valid push-ups throughout.

Compression-Referenced Push-up counter devices:

Typically, such a device is placed on the ground directly below the prone person's chest. The device will record a push-up count whenever the person's chest compresses the pressure plate of the device.

One shortcoming of this device is that it is not able to validate the posture of the person who is doing the push-ups. Push-ups with unacceptable postures can be counted. For example, a person's back may not be straight when doing push-ups, which might make it easier for the person to do push-ups.

Push-up counter mobile applications:

Push-up counters also come in the form of mobile applications. The mobile applications make use of the infrared proximity sensors on the phone to record push-ups. By constantly sensing the light levels of its surrounding, it can determine if a person has completed a push up. [3]

When placed in different light conditions, its ability to accurately record push-ups is limited as the surrounding light intensity fluctuates and the infrared proximity sensor is unable to pick up push-ups when the distance between the chest and the ground exceed 3cm.

SOLUTION DESIGN

In order to build a push-up counter which only counts a push-up only when the person's chest is descended to a distance of 6-cm off the ground **and** when the person's back is straightened, the group proposed the following design.

Components

Arduino Uno R3	1
Ultrasonic Sensor HC-SR04	1
Passive Buzzer	1
Liquid Crystal Display (LCD)	1
Flex Sensor	1
Light Emitting Diode (LED)	1
Power Source	1
Wire	15

Arduino Uno R3

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards can read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. [1]

Through the Arduino Integrated Design Environment (IDE), users can configure the Arduino board to serve different purposes.

Ultrasonic Sensor HC-SR04

The Ultrasonic Sensor detects the distance of the closest object in front of the sensor (from 3 cm up to 400 cm). It works by sending out a burst of ultrasound and listening for the echo when it bounces off an object. [4] The ultrasonic sensor measures the time it takes for the ultrasound to bounce off the nearest object. Using this information, the distance between the ultrasonic sensor and the ground can be found using the formula,

$$\text{Distance} = \frac{\text{Speed of sound} \times \text{Time duration between the emitted pulse and reflected pulse}}{2}$$

Passive Buzzer

The buzzer produces a sound of varying pitch when a current is passed through it. It is used to indicate when the user can begin push-ups and counts push-ups

Liquid Crystal Display (LCD)

The LCD displays the number of pushups done

Flex Sensor

This flex sensor is a variable resistor like no other. The resistance of the flex sensor increases as the body of the component bends. [5] By measuring the current that flows through the flex sensor, Arduino can measure the degree of how bent the flex sensor is. This is used to check whether the user's back is straightened when doing push ups.

Light Emitting Diode (LED)

Light is emitted when current passes through it in a forward-bias. Photons are given off as electrons move from the n-type to the p-type. As the electrons finish moving, photons are given off. The LED is used to indicate that the user is ready to do push-ups.

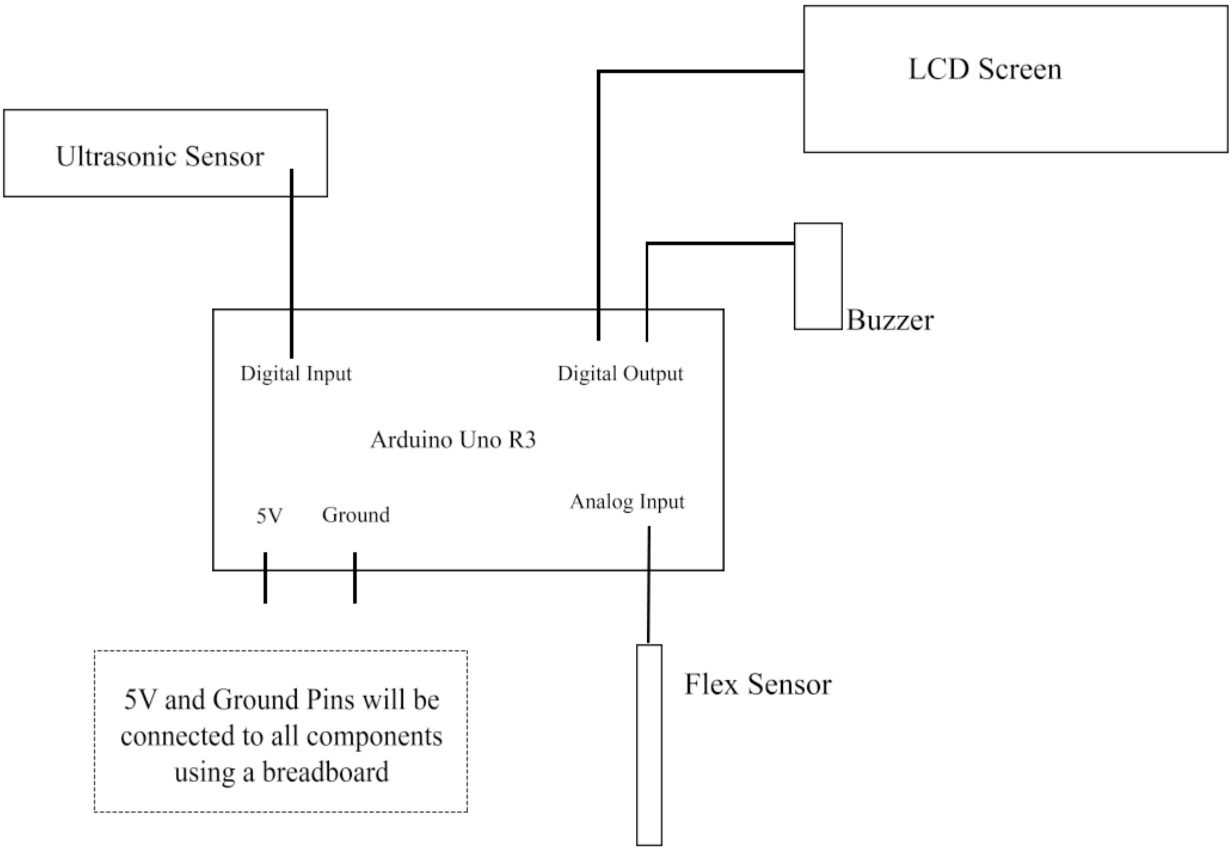

Figure I Circuit Diagram

All the components are connected to the Arduino Uno

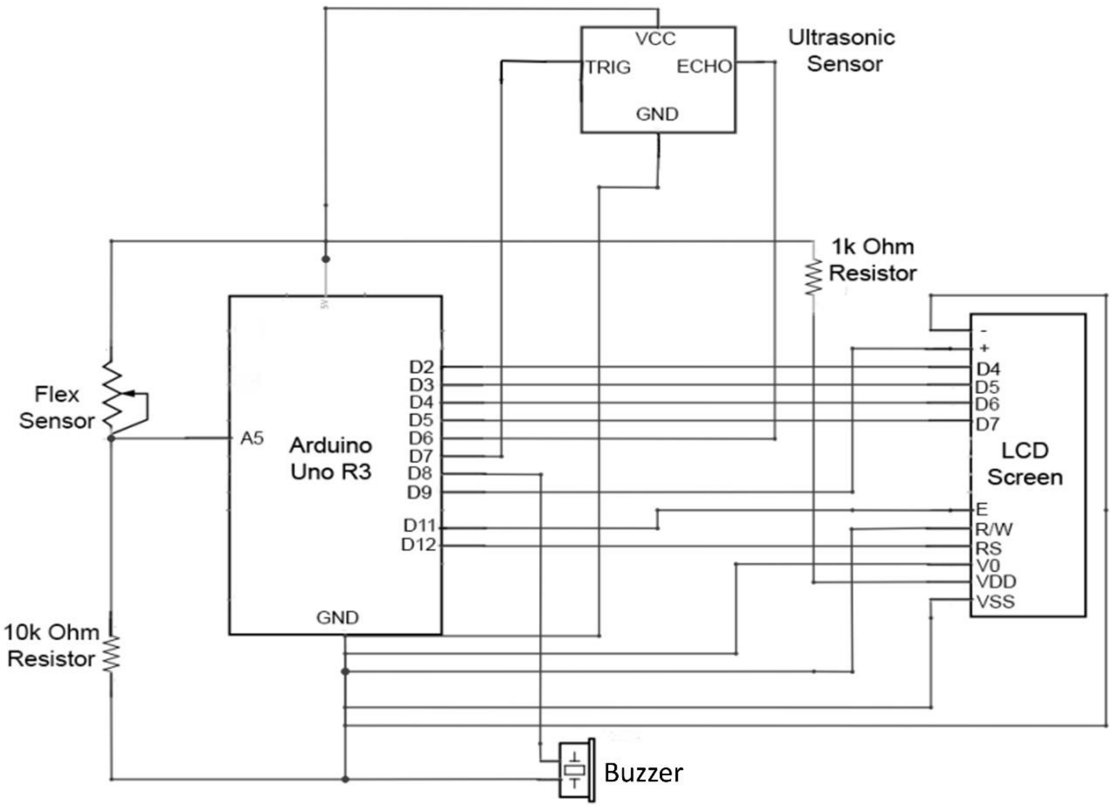

Figure II Schematics of the full diagram

The wiring for the push-up counter is shown above, including input and output pins

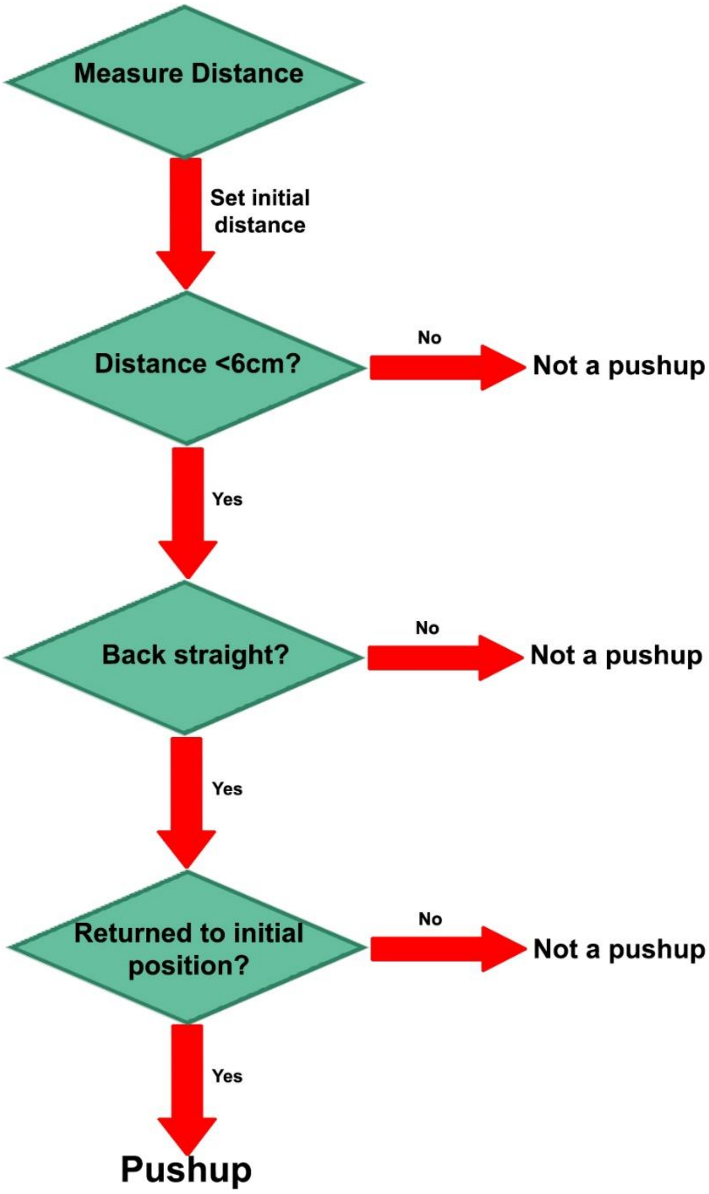

Figure III Logic Tree, a skeleton of the code behind the push-up counter

Arduino Program

The process in which the counter measures a pushup can be divided into 3 stages: Setup, 'Down' Phase, 'Up' Phase.

In the setup phase, the Push-up Exercise Counter has a delay of 5 seconds for the user to get ready. The ultrasonic sensor located on the user's chest will then record the average initial distance (of 99 readings) between the user's chest and the ground. When the initial distance is determined, the buzzer will beep twice, and the LED will light up.

Figure IV Ultrasonic sensor

Used to measure the distance between the chest and the ground

In the ‘Down’ Phase, the Push-up Exercise Counter actively checks for the distance between the user’s chest and the ground. If the distance if measured to be under 6-cm, it will then check whether the user’s back is straight. If both conditions are met, the user is recognized to have his arm bent to a satisfactory extent and should extend his arms next.

Figure V Flex sensor

Used to measure the straightness of the back

In the ‘Up’ Phase, the Push-up Exercise Counter actively checks whether the distance between the user’s chest and the ground has returned to his initial position. If the user has reached the initial position, he/she is considered to have done one successful push-up and the buzzer will beep once. The LCD will update his current Push-ups.

The Push-up Exercise Counter automatically stops when it recognizes that the user is standing up. This is done by recording for consistent high readings from the ultrasonic sensor.

RESULTS & DISCUSSION

Final Product

For our final product, the user can wear it like a pair of suspenders. The user would fasten a belt across his/her hip to secure our push-up counter.

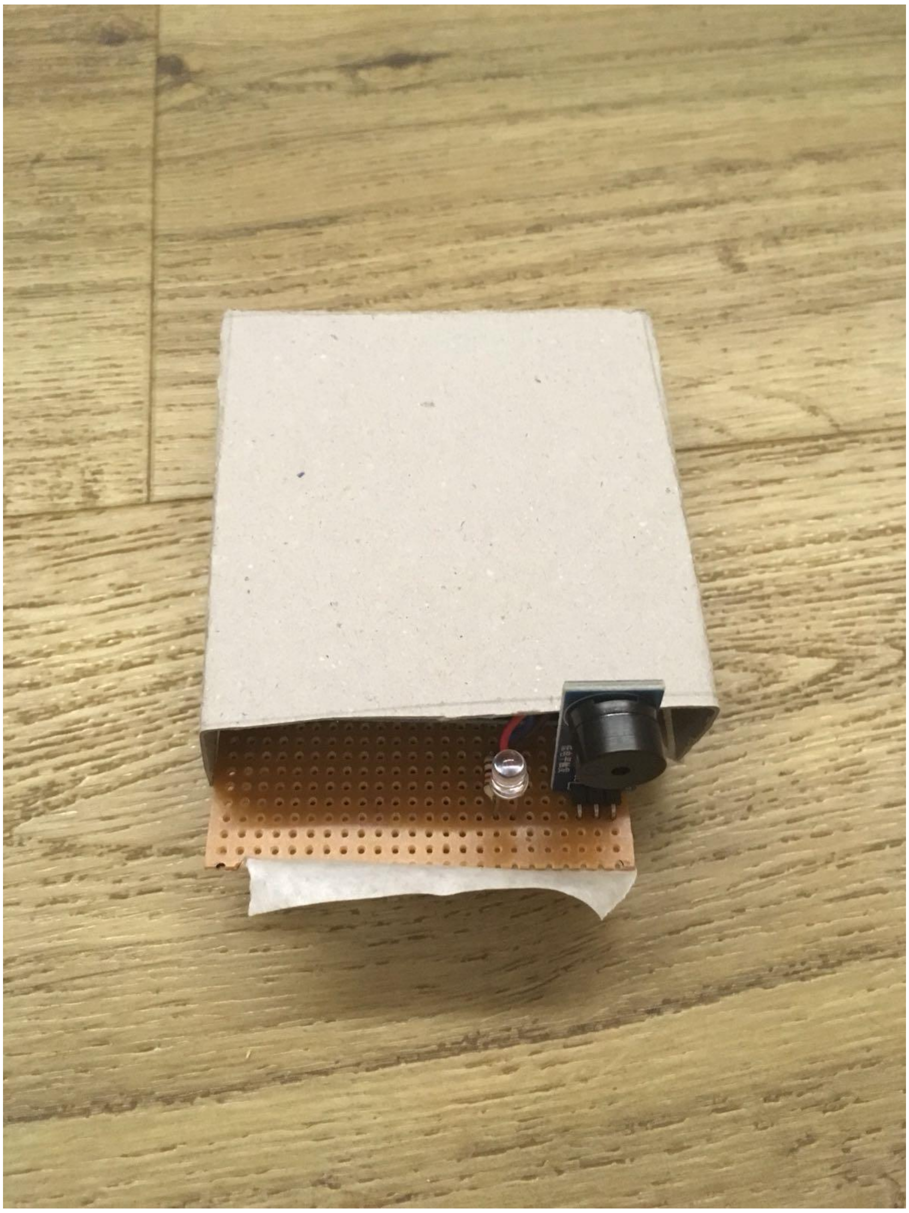

Figure VI Push-up Counter, the LED lights up when the user is ready to do push-ups

The buzzer sounds whenever the user is ready to do push-ups, or that one push-up was done

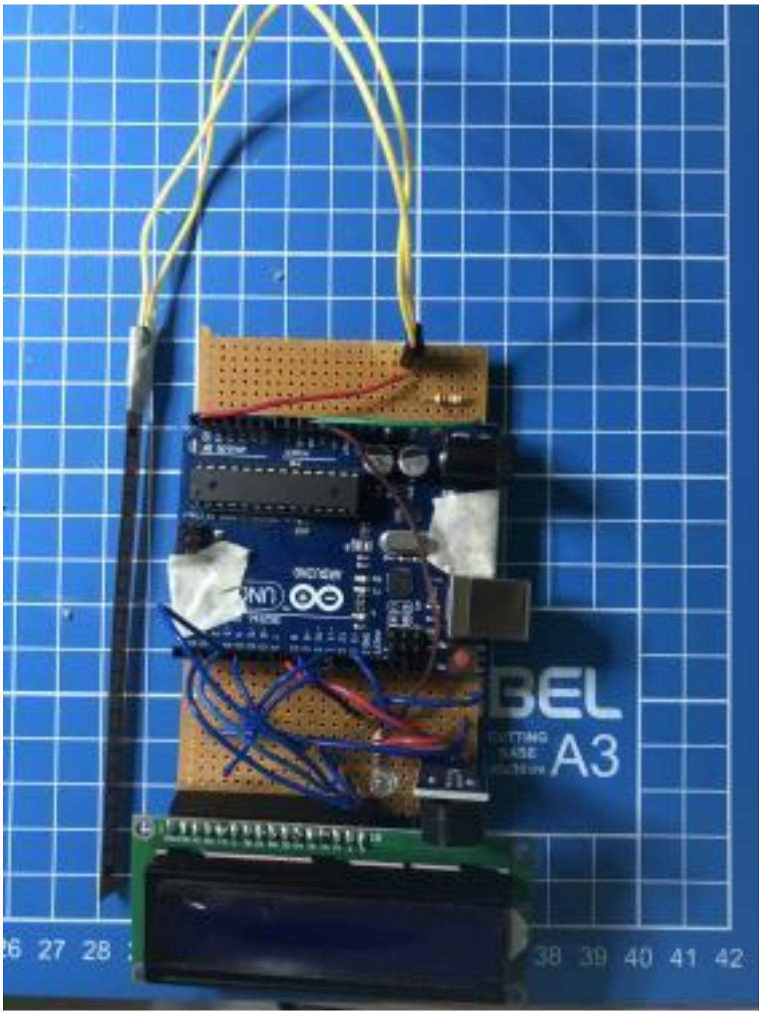

Figure VII Push-up counter (Box removed)

Figure VIII Front View (Worn), only the ultrasound is found on the front of the person's chest, this is to ensure that the ultrasound is as near to the chest as possible, increasing accuracy of ultrasonic sensor.

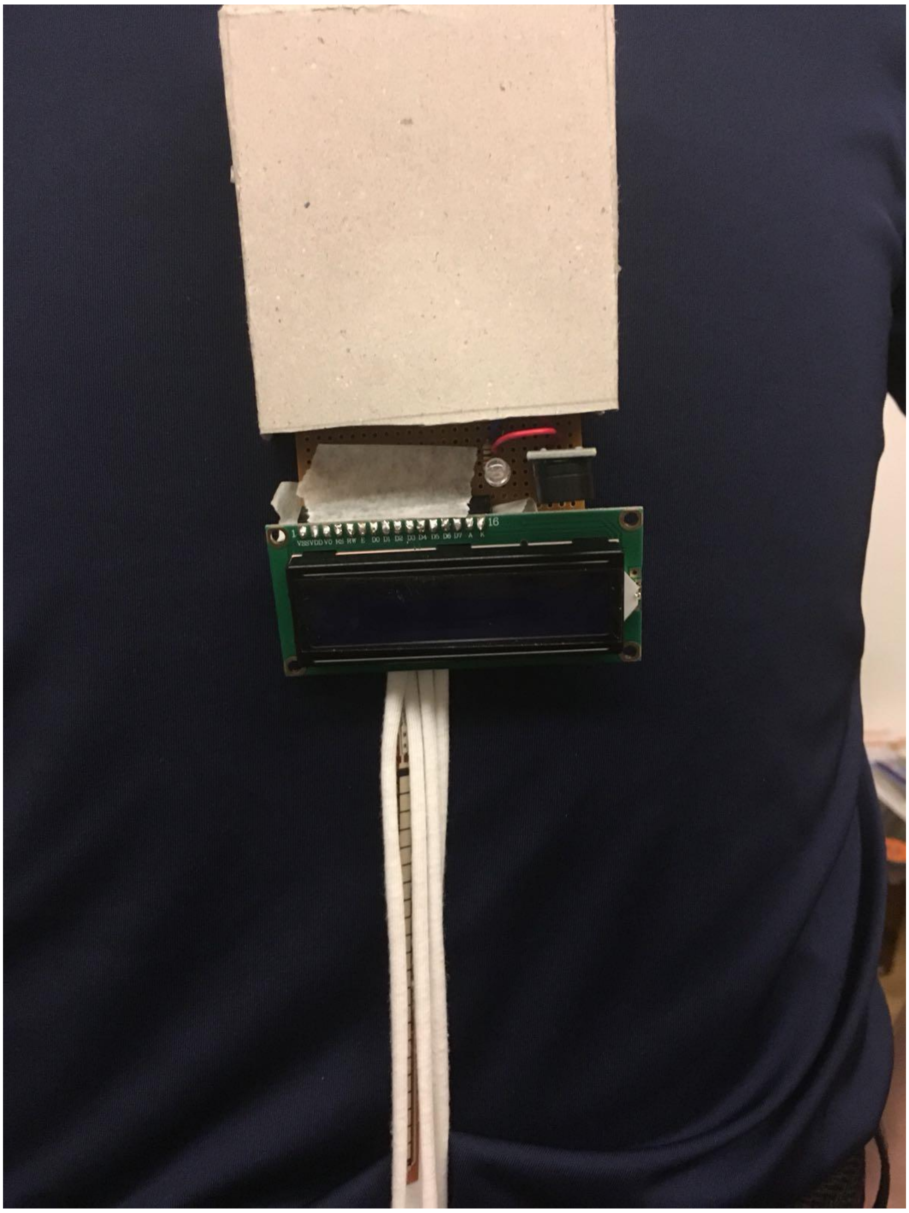

Figure IX Back View (Worn), the flex sensor is located at the lower back while the main circuit is at the upper back of the user, to even the weight of the counter.

CONCLUSION

Extent of success

The project has successfully created a prototype that incorporates the designed solution. The ultrasonic sensor sends and receives around 20 readings per second, allowing the push-up counter to continue recording data accurately even if the user does push-ups at a faster pace. The wearable push-up counter is also adjustable to suit users of different body sizes and is lightweight so that it would not result in too much weight on the user and affect the number of push-ups he can complete.

Future plans

The Push-up Counter can be further developed to record other exercises. The ultrasound sensor and flex sensor can allow it to record sit-ups and "Superman" exercise. Improvements can also be made to send the counter data (using Bluetooth) into an integrated phone application that tracks the user's exercise.

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