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Original Research Paper

Pull-up Counter Device Using Arduino Uno for Fitness Purposes

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Abstract: A pull-up is a type of upper-body exercise that involves the use of both hands. It works by raising the body's head and shoulders and bending the elbows, and extending the shoulders. It can be performed anywhere and is a great way to tone and expand various muscle groups. This study aims to design a device that can count and track the number of pull-up exercises. Pull-Up Counter Device was developed using the Rapid Prototyping model. The product was evaluated by 30 respondents. The result shows that 83.33% of the users strongly agree that the device can display the correct pull-up record on the LCD, and 50% strongly agree that the device can detect pull-up position correctly.

Keywords: Arduino Uno, Infrared Sensor, Pull-Up Counter.

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1. Introduction

We must perform the physical exercise to ensure our body is fit and maintain a healthy lifestyle [1]. Therefore, technology is an essential element in developing competitiveness in the sports industry. The need for technology in the sports sector to support performance enhancements is growing [2]. The technology used in sports has evolved very rapidly. For instance, in the past, video recordings of athletes' motions may have been used to observe their movements. They may now wear body sensors that can also capture action videos.

Many sports have used specialized equipment, such as jump-rope counters, to ensure adequate training. By using this innovation, users can now exercise more efficiently. Many sports equipment have used counters but not in pull-up exercises. The use of modern sports equipment can help provide additional benefits to users [1] [3] [4] [5]. This information can help improve an athlete's performance and reduce the risk of injury [6].

Currently, most sports equipment already has the innovation to make the user do better when exercising. This innovation is hard to see in pull-up bar equipment. The pull-up exercise is important for rock climbing sports, military training or physical test. It is also a well-known exercise to strengthen the upper body; most people perform this exercise at home. To avoid injury, pull-up exercises need to be done with a proper technique [2] [7] [8].

This study aims to promote a healthy lifestyle and ensure users can perform pull-up exercises with the correct techniques. This paper has been organized into 4 parts. Section 2 introduces the related work of the study and the methodology. Section 3 discusses the result and findings, and Section 4 is a conclusion of the study.

2. The Literature Review

2.1. Pull-Up

The pull-up is a form of exercise frequently used in resistance training for various purposes, including building strength and stamina [9] [10]. The biceps brachii muscles are trained and utilized through pull-up training. This is because pull-ups demand that people lift their bodies as much as possible, and the biceps brachii muscle strength increases with the number of repetitions they perform.

The pull-up is a closed kinetic chain upper-body exercise that develops stability of the shoulder and multiple muscles to perform activities like climbing ropes, swimming, rowing and many more. Pull-ups have long been used as a physical fitness assessment method for people who participate in activities requiring a significant amount of upper-body strength to body mass [11].

2.2. Arduino Uno AtMega328

Arduino is a programmable microcontroller and was introduced in 2005 [12]. The Arduino was created for the user who wants to build a device using a sensor and actuator without hassle. It is an open-source computing platform based on basic microcontroller boards for building and programming electrical devices. The main CPU is ATmega328, and it includes 6 analogue inputs, 14 digital input/output lanes (six of which may be used as PWM outputs), 32 KB of flash memory, and 1 KB of EEPROM. When the Arduino UNO ATmega328 sets the bootloader, the Arduino software application can download a programme straight into the UNO [13]. The user can programme the code in IDE before it can be activated by the device.

2.3. Infrared Sensor

An infrared (IR) sensor is a device that produces light to pick up specific details about its surroundings. An IR sensor can measure an object's heat and detect motion. IR sensors are passive and do not emit infrared radiation; instead, they merely measure it. Typically, all objects that use infrared produce thermal radiation. Although these radiations are undetectable to the human eye, but the infrared sensor can detect them. The detector is sensitive to infrared light with the same wavelength as the IR LED. At the same time, the emitter is merely an infrared LED (Light Emitting Diode). The output resistances and voltages change in proportion to the magnitude of the IR light when infrared light hits the photodiode. The infrared sensor has similar functions to the object detection sensor. The sensor contains a photocoupler, a combination of infrared LED and an infrared photodiode. A transmitter that emits infrared energy is an IR LED, and the radiation produced by this sensor cannot be seen with the unaided eye.

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2.4. The Architecture of the Pull-Up Counter Device

The pull-up device consists of several essential components, including software and hardware. IR sensors detect the head and shoulder position, and data will be transferred directly to the processing unit (Arduino Uno AtMega328). Next, the processing unit will store and process all data based on the programming code. When the IR sensor detects movement, the Arduino Uno will record the data using the IR sensor and send it to the LEDs and buzzers. The device used a micro USB connector to ensure a direct power supply to the Arduino Uno. Once the data is processed, the LCD display will display the number of pull-up counters.

2.5. User Requirements

In the prototyping phase, the user requirement for the Pull-Up device was collected. An expert from the Faculty of Sports Science and Coaching, Universiti Pendidikan Sultan Idris, was interviewed to gather the requirement. Table 1 shows the requirement collected for the Pull-Up Counter Device.

Table 1. Requirements Collected for the Pull-Up Counter

No.	User Needs
1	The user doesn't need to download any application to use it.
2	Users just need to turn ON the device to use it.
3	Users can perform correct Pull-Up exercises by using the device.
4	Users can see the number of Pull-Up Counter on LCD
5	Users can reset and OFF the device.

3. Methodology

The Pull-Up Counter Device was developed using the Rapid Prototyping model [14] [15]. Figure 1 shows the process involve in Rapid Prototyping Model. The model contains three phases that must be done iteratively before delivering the product. The first phase is the Prototyping phase, where the Pull-Up Counter model is produced using a paper model. The user reviewed the model, and any improvements and suggestions were recorded and implemented in the review phase. After the prototype was improved, the actual model was produced using the IR sensor and Arduino Uno in the second cycle. The sensor position was revised and tested in the review phase with the user. Finally, the programming code was developed to process the data obtained from the sensor. After the improvement was made, the delivery phase was performed. The final product of the Pull-up Counter Device was tested with the users, and the results were reported in section 4.

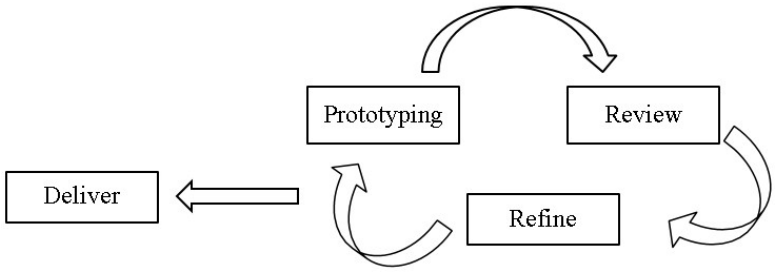

Figure 1. Rapid Prototyping Model

Figure 2 shows the activity diagram for the Pull-Up Counter Device. First, the device needs to be installed on Pull-up Equipment. When it is ready to use, the user can turn on the device by pressing the start button. The IR sensor will start detecting the user's position when the user pull-up their body at a certain height, and the buzzer will sound. Next, the program in Arduino will record the counter

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and display it on the LCD. The program will clear all the records on the counter if the user presses the reset button. Finally, the user can press the stop button to terminate the Pull-Up Device.

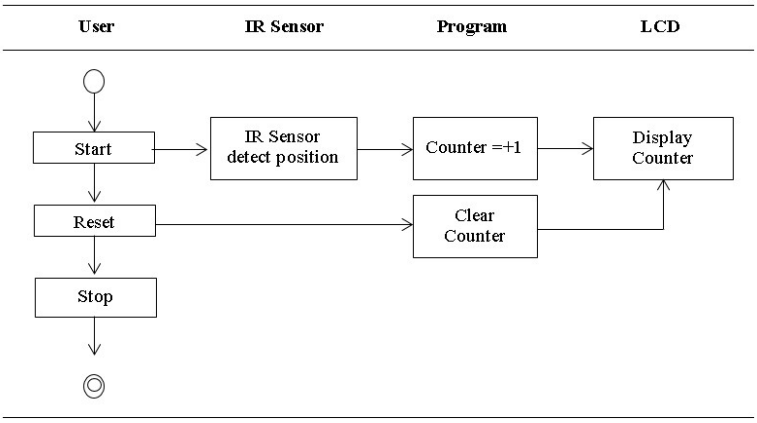

Figure 2. Activity Diagram for Pull-Up Counter

The hardware can be divided into three parts: Sensor Unit, Processor Unit and Output Unit. Figure 3 shows the hardware used in this study. IR sensor detects any movement and automatically counts the number of signals detected by the sensor. The IR sensor will directly connect to the processing unit to transfer the data. LCD Display will be used to display the output.

Figure 3. Sensor Unit, Processor Unit and Output Unit.

4. Finding and Results

4.1. Implementation

Figure 4 shows the connection between Sensor Unit, Processor Unit and Output Unit, while Figure 5 shows the use of libraries, initialization of sensor variables and initialization of data delivery destinations in the Arduino program. Figure 6 shows the final product installed on the Pull-up equipment.

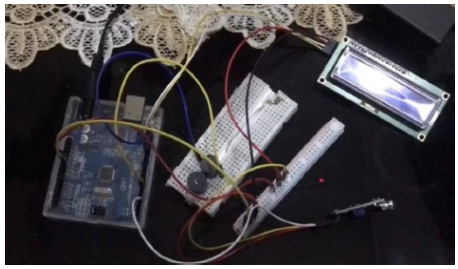

Figure 4. Connection between Sensor Unit, Processor Unit and Output Unit

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Pull-Up_Counter_Device | Arduino 1.8.19

File Edit Sketch Tools Help

Pull-Up_Counter_Device

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

int x = -1;
int counter = 0;
int state = 0;
int buzzer =6;
int led = 13;

LiquidCrystal_I2C lcd(0x27, 16, 2); // set the LCD address to 0x27 for a 16 chars and 2 line display

void setup()
{
  lcd.init(); // initialize the lcd
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("    Welcome   ");
  lcd.setCursor(0, 1);
  lcd.print("   by Ayyadi  ");
  delay(5000);
  lcd.clear();

  pinMode (13, OUTPUT);
  // Print a message to the LCD.
  lcd.init();
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("Pull-Ups Counter");
  lcd.setCursor(0, 1);
  lcd.print(counter);
  lcd.print("   = REPS ");
}
void loop()
{
  int counter = digitalRead(2);
  if (state == 0)
  {
    digitalWrite(13, HIGH);
    digitalWrite(6, HIGH);
    tone(6, 300);
    switch (counter) {

      case 1 : state = 1; lcd.setCursor (0, 1); x = x + 1; lcd.print(x); break;
      case 0 : state = 0; break;

    }
  }
```

Figure 5. Program used for the Counter

Figure 6. Final product install on Pull-up equipment

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4.2. Questionnaire

In the delivery phase, 30 users were identified to test the final product. 20 of the user are Sports Science students, 5 are UPSI Sports Center Staff, and the rest are UPSI students from other faculty. The evaluation was divided into three items which are:

1. User approval
2. Product design and development
3. Product functionalities.

4.2.1. User Approval

Figure 7 shows a graph of user approval that contains three items. From the result, 83.33% of respondents strongly agree to recommend others to use the Pull-Up Counter Device. In addition, 40% strongly agree that Pull-Up Counter Device is easy to use, and 60% agree. Finally, 20% of the respondent strongly agree that Pull-Up Counter Device helps them to track their Pull-Up exercise and 33.33% agree with that statement.

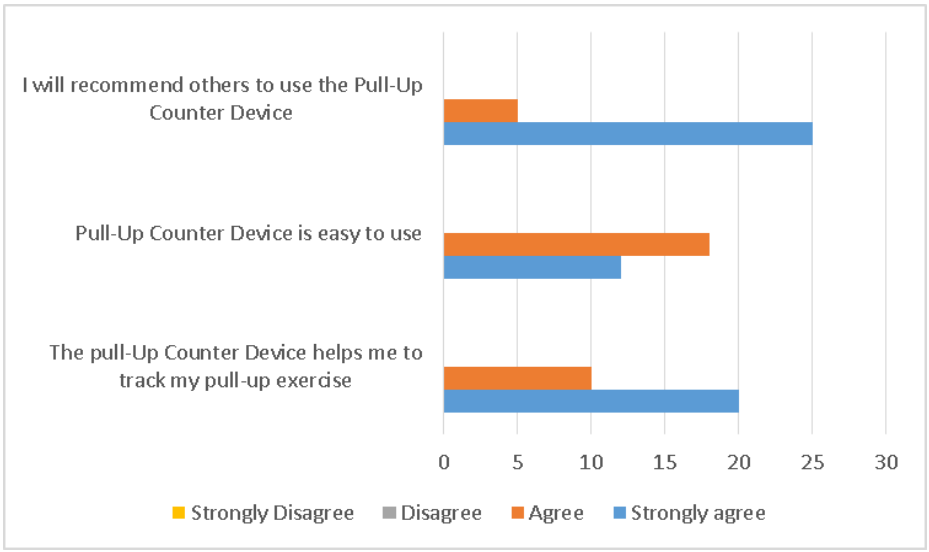

Figure 7. User Approval

4.2.2. Product Design and Development

The Pull-Up Counter Device was evaluated based on product design and development. From the evaluation, 90% of users strongly agree that the Pull-Up Counter Device is useful to help them do pull-up exercises. For the design of the Pull-Up Counter Device, 33.33% of users strongly agree that the design is suitable to be used with the pull-up equipment and 46.67% strongly agree that the design of the Pull-Up Counter Device meets the function. Figure 8 shows the graph of Pull-Up Counter Design and Development

4.2.3. Product Functionality

Figure 9 shows a graph of product functionality. For the Pull-Up Counter Device functionality, 50% of the user strongly agree that the device button functions well as in the functional requirement, 83.33% of the user strongly agree that the device can display the correct number of pull-up records on the LCD and 50% of the user strongly agree that the device can detect pull-up position correctly.

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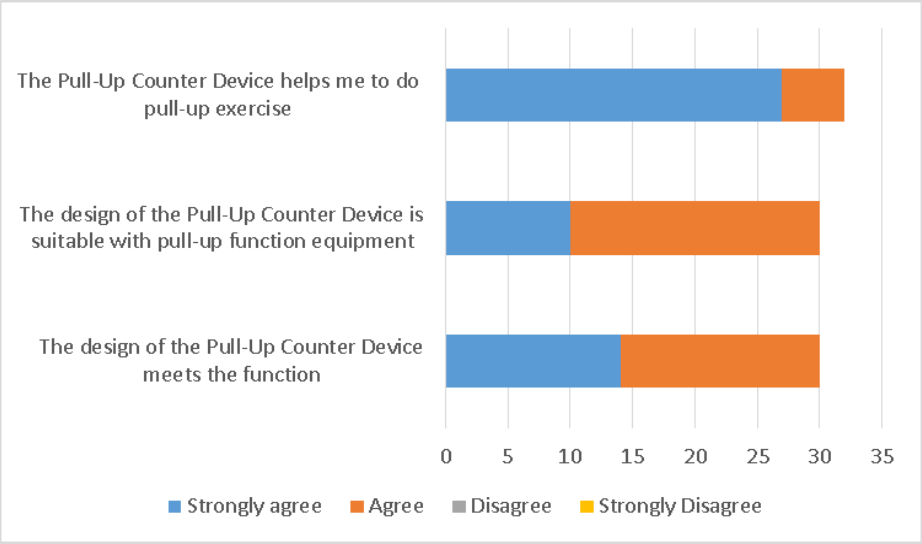

Figure 8. Pull-Up Counter Design and Development

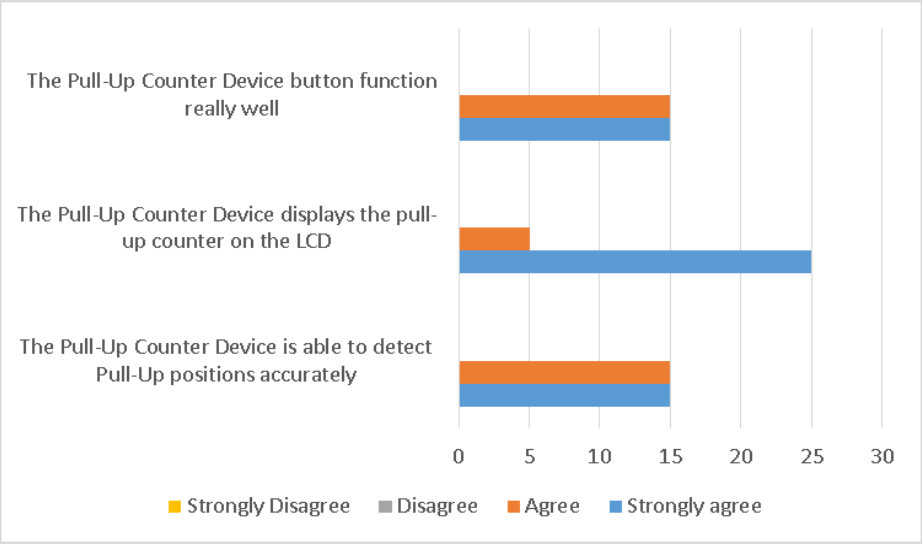

Figure 9. Product Functionality

5. Conclusion

The Pull-Up Counter Device can help a person perform push-up exercises effectively. To begin with, the user will never lose their track count while exercising because the device will record the data. Furthermore, the user can reset the button if they want to perform a new cycle of pull-up exercises. The user also can use the device easily without having to install any application. Finally, the IR sensor that comes together with the device can help detect the correct position of the head and shoulder when the user performs the exercise. Based on the user evaluation, the Pull-Up Counter Device effectively counts the number of pull-up exercises performed by the user. Further research should be conducted to manage and store the data online. The data can be used to calculate the calorie burn of the pull-up exercise. Aside from that, the gadget should run on a direct current to avoid losing power.

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