Design and Fabrication of Safety Distancing Sensor for Bicycle

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Abstract: Bicycle safety distancing sensor have attracted considerable attention to the fabrication of safety device integrated with the technology. Arduino UNO as programmable microcontroller was used along with ultrasonic sensor and LED strip to produce a functioning and smart alarming device to help the cyclist stay alert during cycling especially at night. The use of safety harness such as fluorescent jacket and lamp torch on the cyclist bicycle itself may not be sufficient for their safety. Hence, the usage of bicycle safety distancing sensor or name as (UNO-Bike) can help the cyclist to ride with more confident. The sensor will detect any upcoming vehicles from behind of the cyclist and warned them by blinking and changing of colour of the LED strip from green to red. There is no invention of safety distancing sensor for bicycle currently, hence our product has an advantage on the novelty, and it is a cost-efficient product as it uses Arduino which is very user-friendly on the cost and the mechanisms.

Keywords: bicycle, safety, distancing sensor, ultrasonic, alarm

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1. Introduction

This way people use bicycles has changed very little since their invention in 1817 [1]. As urban bike shares grow increasingly popular, more cyclists are hitting the streets [2]. Helmet strapped and riding a two-wheeled vehicle that can sometimes is more expensive than the cars that pass them, they go it alone or sometimes ride in packs. While this trend has many advantages, cyclists often struggle with staying safe among automobile traffic [2,3]. Cities are often slow to adapt separate bike lanes, so it is up to the cyclists to ensure that they protect themselves. The unmistakable beacon shows automobile drivers the proper and safe radius between a car and a cyclist [2,3]. 20% of drivers do not honour this distance and cause more than 5,000 otherwise avoidable accidents each year [2].

In addition, cycling at night has become the main choice for the riders nowadays. It is just as enjoyable and convenient as in the daylight, by continuing to be active in the outdoors while the rest of the country choose to stay at home hibernating [4]. However, danger is everywhere. The riders are not exceptional from any incidents that may occur if they did not follow the right way to cycle safely.

To reduce any unwanted events or danger from occur, cyclist will take safety precautions before riding the bicycle at night. The most basic thing is by wearing a fluorescent safety jacket and safety helmet [5]. In addition, they will also place a torch light on the bicycle to tell their presence to other riders and drivers. Nevertheless, apart from telling the other road users about their presence on the road, there is something should be done to give warning to the cyclist if any vehicle is coming from behind or near them. This is because a bicycle does not have a side mirror like a car does and it is not very practical to place a side mirror on the handle of the bike.

To reduce accidents that might occur, researchers come out with a solution to assist the cyclists to ride safely at night which is to invent a sensor that can detect any vehicle from behind and give warning to the cyclist by the blinking of LED light on the handlebar stem of the bike. An ultrasonic sensor is used together with microcontroller, Arduino UNO [6].

Arduino is an open-source microcontroller which can be easily programmed, erased, and reprogrammed at any instant of time [7]. Arduino platform was designed to provide an inexpensive and easy way for students and professionals to create devices that interact with their environment using sensors and actuators. Based on simple microcontroller boards, it is an open-source computing platform that is used for constructing and programming electronic devices [7]. It is also capable of acting as a minicomputer just like other microcontrollers by taking inputs and controlling the outputs for a variety of electronics devices.

Therefore, this safety distancing sensor for bicycle is built using Arduino microcontroller to detect when a vehicle approaches from behind the cyclist the sensor will detect, and LED light will light up to signal the cyclist.

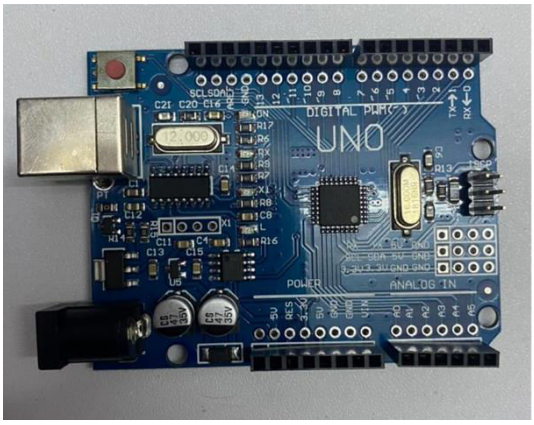


Figure.1. Arduino UNO microcontroller

2.Significance Of The Study

Cycling at night has become the main choice for the cyclists nowadays. It is just as enjoyable and convenientas in the daylight, by continuing to be active in the outdoors while the rest of the countries choose to stay at home hibernating. However, danger is everywhere. The riders are not exceptional from any incidents that may occur if they did not follow the right way to cyclesafely. In addition, the cyclists are commonly referred to as vulnerable road users because the lack of protective features on the bicycle. Bicycle accidents is frequently occurred by police records. Safety helmets itself cannot prevent accidents but only can lower head injuries therefore their wearing need to be emphasized as the only injury prevention method. [8]To reduce any unwanted events or danger from occur, cyclist will take safety precautions before riding the bicycle at night [9]. The most basic thing is by wearing a fluorescent safety jacket and safety helmet. In addition, they will also place a torch light on the bicycle to tell their presence to other riders and drivers [9]. Nevertheless, apart from telling the other road users about their presence on the road, there is something should be done to give warning to the cyclist if any vehicle is coming from behind or near them. This is because a bicycle does not have a side mirror like a car does and it is not very practical to place a side mirror on the handle of the bike.

The main contribution of this study is to reduce accidents that might occur, we come out with a solution to assist the cyclists to ride safely at night which is to invent a sensor [10,11] that can detect any vehicle from behind and give warning to the cyclist by the blinking of LED light on the handlebar stem of the bike. An ultrasonic sensor will be place at the seat post and LED light will be connected to it. Hence, when a vehicle approaches from behind and it came near about 2-3.5 metres distance, the sensor will detect, and LED light will light up to signal thecyclists.

Objectives and contributions:

i. To design a bicycle safety distancing sensor that can help cyclists.
ii. To develop coding for Arduino tofunction
iii. To control the distance that the sensor can detect.

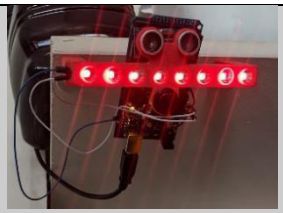
3.Review Of Related Studies

Research on the design of product is for the comparison of product in the market. This comparison is done from different aspects such as design, function, and similarities. Therefore, the innovation of the product is made from the product that going through a lot in significant, characteristics, or problem arises from the product itself. So, there are three comparisons of the product that have similar innovation with our project which are garage distance sensor, eye-fit: light & reading distance keeper and social distance detector [12,13,14].

Hence, the comparison and problem arise from the other products can be used to innovate new product of bicycle safety distancing sensor that will become one of the alternative tools to detect any vehicle that vehicle from behind and give warning to the cyclist by the blinking of LED light on the handlebar stem of the bike.

Diagram below shows the comparison between the products in the market for distancing sensor.

Table.1. Similar Innovation with Bicycle Safety Distancing Sensor

Product Name	**Garage distance sensor**	**Eye-fit: light & reading distance keeper**	**Social distance detector**
Diagram of product			
Similarities	To warn the driver when it is near to the object.	To warn the person when they came near to the objects for example, television, book, and computer.	To warn the person to maintain a distance from each other.
Differences	The sensor stays at one place which is on the back wall of garage instead of attached to the back of the car.	Use small scale of distance and have buzzer to warn the person.	Need to be carry around by a person.
Problem	The person keeps hitting the wall of his garage because he could not estimate when he should stop the car.	People may not notice the consequences of watching television or reading a book very near. They may suffer from poor eyesight due to their action.	Due to this pandemic, it is quite difficult to keep a distance in an open place.
Solution	Hence, he decided to make a gadget to help him to estimate how far he can go before he hit the wall of garage. [12]	This sensor is produced to warn them when they came near the screen or books so that problems such as poor eyesight can be reduced or overcome. [13]	This sensor is invented to help the people to keep distance from other people so that the case of covid-19 can be reduced. [14]

4.Design of RomLIC

This section describes the methodology adopted in this study, which includes systematic organization of different research phases in conjunction with the detailed design and implementation of the UNO-Bike prototype. In addition, the selection of components and their integration are explained to fulfill the design objectives.

The flowchart in Figure 2 illustrates the conceptual framework of this study. The research starts by identifying the problems encountered in Malaysia. Most considerable problems of the available products in the market are their sensor for alerting the cyclists.

The modeling phase focuses on the selection of materials and components [15,16] for building the prototype and developing the UNO-Bike. The UNO-Bike is designed on Arduino software, and the prototype is fabricated using Arduino UNO [17].

The design and implementation of the UNO-Bike are conducted [18]. Wiring and connection between different components (LED, battery, and sensor) in the UNO-Bike are installed and tested.

After the connection of the microcontroller and components, coding is performed to realize the required tasks. Then, the design is rechecked to identify whether any problem exists with the system functionalities. Testing is conducted to validate the system effectiveness.

The system returns to the previous phase, which is enhancement and optimization, when any problem is found. The system is finalized when it exhibits good performance.

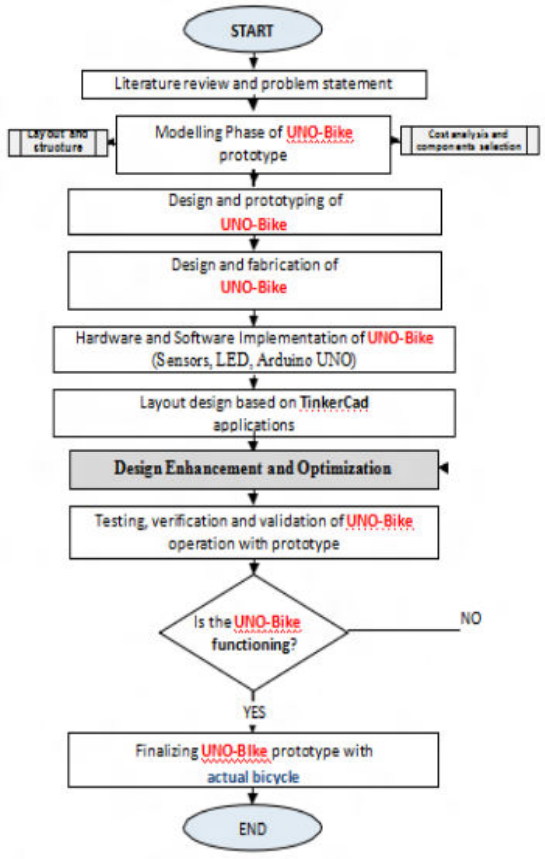


Figure.2. Flowchart of research activities

A design is a plan or specification for the construction of an object or system or for the implementation of an activity or process, or the result of that plan or specification in the form of a prototype, product or process. In order to

develop the best design product, this project has made the circuit, simulation and arrangement of components and tools.

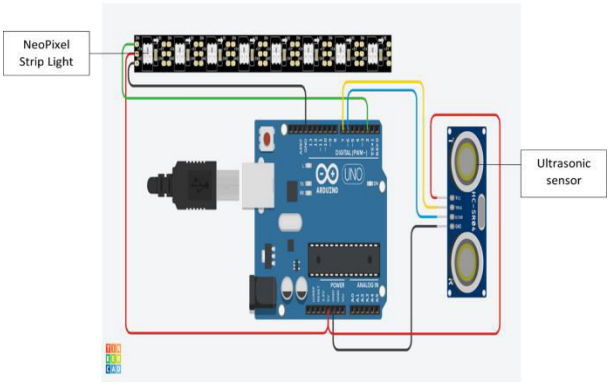


Figure.3. Design of UNO-Bike prototype

The UNO-Bike is designed on TinkerCadsoftware based on the requirements [18]. The prototype design includes Arduino UNO board, battery, NeoPixel LED strip light, and ultrasonic sensor.Anultrasonic sensorisconnectedto the Arduino UNO board to detect vehicles from behind. A NeoPixel LED strip light is placed on the handle of the bicycle to give warning to the cyclists.Overall, the UNO-Bike is implemented with the Arduino UNO booard. Figure 3 shows the overall design and layout of the Arduino UNO prototype.

The circuit project consists of the main components that are combined to form one complete circuit that can function in good condition. This circuit is consisting of Arduino UNO board, ultrasonic distance sensor, RGB LED strip and jumper wires.

The diagrams below show the arrangement of components to build one complete circuit using Tinkercad software that are meant to appear in color, or shades of black/gray. Such figures may include photographs, illustrations, multicolor graphs, and flowcharts.

Figure.4. Overview

Figure.5. Top view

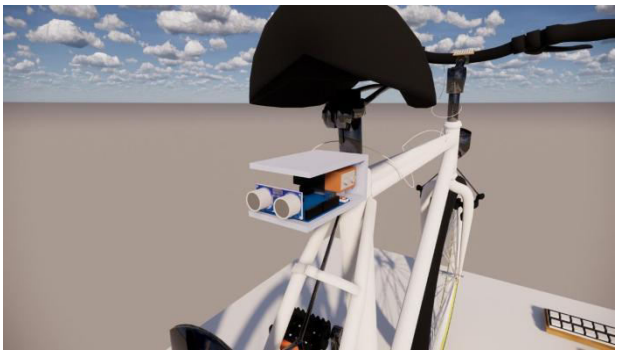


Figure.6. Back view

5.Development of RomLIC

In this phase, the main components in the project are explained in detail. In addition, it explains the benefits in using the components.

The Arduino Uno is an open source microcontroller board based on the Microchip ATmega328P microcontroller microcontroller and developed by Arduino.cc [19]. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is similar to the Arduino Nano and Leonardo. The hardware reference design is distributed under a Creative Commons Attribution Share-Alike 2.5 license and is available on the Arduino website. Layout and production files for some versions of the hardware are alsoavailable.

A jump wire (also known as jumper wire, or jumper) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering [20]. Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment.

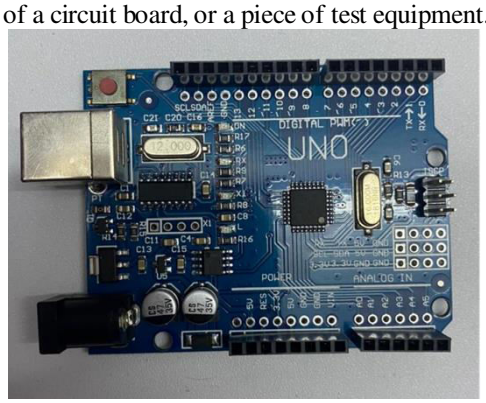


Figure.7. Arduino UNO microcontroller

Figure.8. Jump wire

Ultrasonic distance sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves and converts the reflected sound intoan electrical signal [21]. Ultrasonic waves travel faster than the speed of audible sound (i.e., the sound that humans can hear). Ultrasonic sensors have two main components: the transmitter (which emits the sound using piezoelectric crystals) and the receiver (which encounters thesound after it has travelled to and from the target) [22].

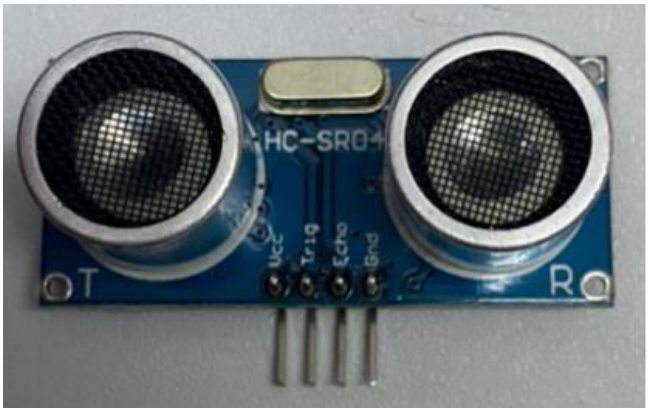


Figure.9. Ultrasonic distancing sensor

An LED strip light (also known as an LED tape or ribbon light) is a flexible circuit board populated by surface mounted light-emitting diodes (SMD LEDs) and other components that usually comes with an adhesive backing [23]. Traditionally, strip lights had been used solely in accent lighting, backlighting, task lighting, and decorative lighting applications. Increased luminous efficacy and higher-power SMDs have allowed LED strip lights to be used in applications such as high brightness task lighting, fluorescent and halogen lighting fixture replacements, indirect lighting applications, Ultra Violet inspection during manufacturing processes, set and costume design, and even growing plants.

Figure.10. LED strip

A battery is a device consisting of one or moreelectrochemicalcellswithexternalconnectionsforphones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode. The terminal marked negative is the source of electrons that will flow through an external electric circuit to the positiveterminal.

When a battery is connected to an external electric load, a redox reaction converts high-energy reactants to lower-energy products, and the free-energy difference is delivered to the external circuit as electrical energy. Historically the term "battery" specifically referred to a device composed of multiple cells. However, the usage has evolved to include devices composed of a single cell.

Figure.11. Dry cell

The connector is a device that joins electric circuits together. Most battery packs require more than one connector. The main battery connector is both mechanical and electrical part that interfaces the battery to the PDA or other electronic device [24].

Figure.12. Connector

Using the information gathered in the analysis and design phase, the performance solution is created. The output forms the design phase is going to be the output of the development phase and will be tested consistently to get accurate result.

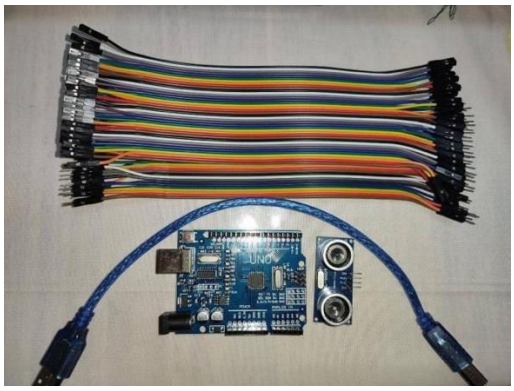


Figure.13. Components for prototype

Flowchart below shows how the bicycle safety distancing sensor works [26]. When the vehicles approaching the bicycle, the ultrasonic distance sensor will detect and collect information. If the distance between vehicles and bicycle is less than 3 metres, 2 metres and 1 metre, it will give signal to RGB LED strip to emit red colour to give warning to the cyclists. However, if the distance is more than 3 metres, the RGB LED strip will remain green colour.

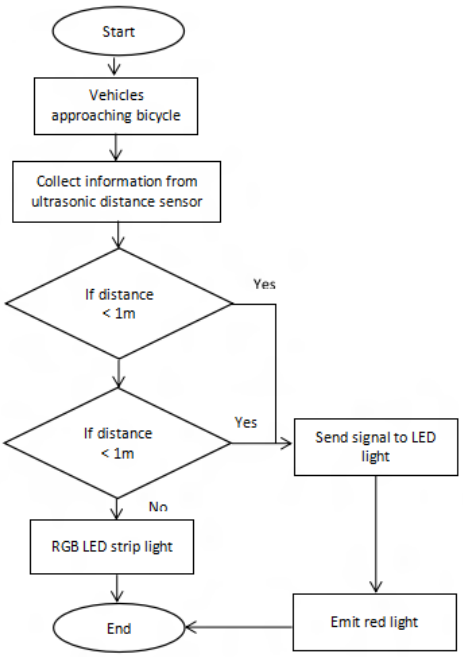


Figure.14. Flowchart on how prototype function

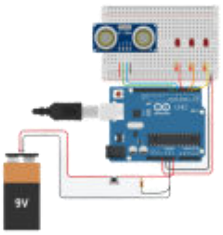


Figure.15. First design of prototype

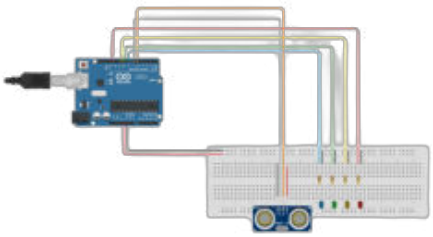


Figure.16. Second design of prototype

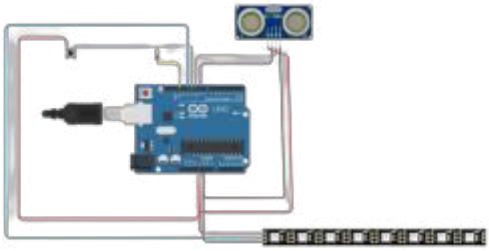


Figure.17. Third design of prototype

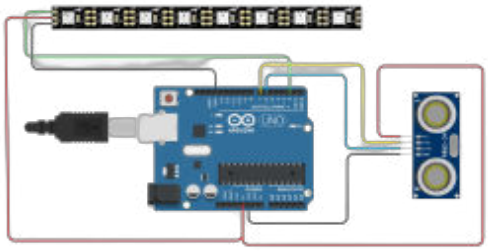


Figure.18. Fourth design of prototype

6.Implementation

The implemented hardware system in the UNO-Bike prototype is evaluated, and the design is enhanced and optimized when anyerrorexistsuntilthesystemcanperformwell.Thisphase is important to improve the system performance and detect errors. Thus, the problems encountered during the previous phases are identified and fixed. This step is repeated until a successful implementation is achieved. For example, before starting the real implementation of our product, NeoPixel LED strip light are used as replacements for RGB LED strip light to give warning to the cyclists. After compiling all the programming codes into Arduino UNO, all the componentsare used for the real testing.

As shown in Figure 19, the LED strip will turn to green when object is far while on figure 20, LED turn to red when object is near. All the installed wiring connections are checked. The wires are marked and named to help the user to clearly verify every part of the system connection. Furthermore, the wires are isolated and covered with black tape for protection and organization. In this phase, the product is evaluated to prove that all sensors, LED strip light, and Arduino UNO are functioning effectively.

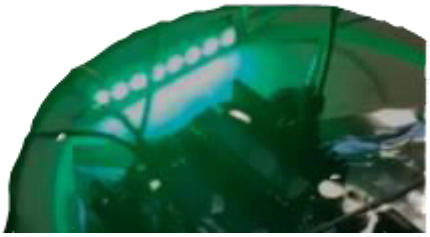


Figure.19. LED strip in green colour

Figure.20. LED strip in red colour

```
Distance = 101.67
Distance = 101.67
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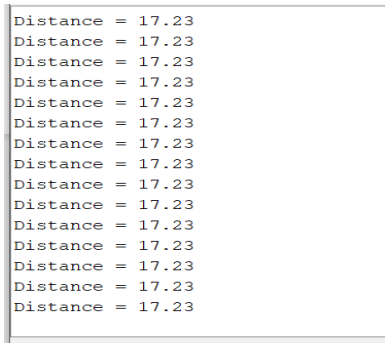

Figure.21. Readings of distance during testing

During this phase, the materials need to be prepared to run the project physically. The product that has been done will be testing to the respondents for identifying the problems that might be occur during the process implementation. If there is a mistake during the testing, an action will be taken to make the improvement.

The product is tested using Algorithm 1 (coding) for the ultrasonic sensor and LED strip testing.

Algorithm 1:

```
#define trigPin 10
#define echoPin 13

#include <Adafruit_NeoPixel.h>
#ifdef __AVR__
#include <avr/power.h> // Required for 16 MHz Adafruit Trinket
#endif

// Which pin on the Arduino is connected to the NeoPixels?
#define PIN        6 // On Trinket or Gemma, suggest changing this to 1
// How many NeoPixels are attached to the Arduino?
#define NUMPIXELS 30 // Popular NeoPixel ring size

Adafruit_NeoPixelpixels(NUMPIXELS, PIN, NEO_GRB + NEO_KHZ800);
#define DELAYVAL 50 // Time (in milliseconds) to pause between pixels
void setup() {
// neopixel

#if defined(__AVR_ATtiny85__) && (F_CPU == 16000000)
clock_prescale_set(clock_div_1);
#endif // END of Trinket-specific code.
pixels.begin(); // INITIALIZE NeoPixel strip object (REQUIRED)
//Distance sensor declare
Serial.begin (9600);
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
}

void loop() {
// distance sensor input output calculation
float duration, distance;

```

```
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);

distance = (duration / 2) * 0.0344;
//Neopixel RGB LED Lighting value
for(inti=0; i<NUMPIXELS; i++) { // For each pixel...
// pixels.Color() takes RGB values, from 0,0,0 up to 255,255,255

// Here we're using a moderately bright green color:
// pixels.setPixelColor(i, pixels.Color(0, 200, 0));
//    pixels.setPixelColor(i, pixels.Color(0, 150, 0));

//Neopixel connecting with distance sensor
if (distance >= 150){
Serial.print("Distance = ");
Serial.println(distance);
pixels.setPixelColor(i, pixels.Color(0, 150, 0));
pixels.show();   // Send the updated pixel colors to the hardware.
pixels.clear(); // Set all pixel colors to 'off'
delay(50);
}

else if (distance <150){
Serial.print("Distance = ");
Serial.println(distance);
pixels.setPixelColor(i, pixels.Color(150, 0, 0));
pixels.show();   // Send the updated pixel colors to the hardware.
pixels.clear(); // Set all pixel colors to 'off'
delay(50);
}

else {
Serial.print("Distance = ");
Serial.print(distance);
Serial.println(" cm");
//    delay(50);
pixels.clear(); // Set all pixel colors to 'off'
}
}
}
```

A block diagram is a graphical representation of a system – it provides a functional view of a system [27]. Block diagrams give us a better understanding of a system's functions and help create interconnections within it. Block diagrams derive their name from the rectangular elements found in this type of diagram. They are used to describe hardware and software systems as well as to represent processes. Block diagrams are described and defined according to their function and structure as well as their relationship with another block.

Diagram below show the block diagram for bicycle safety distancing sensor in this project:

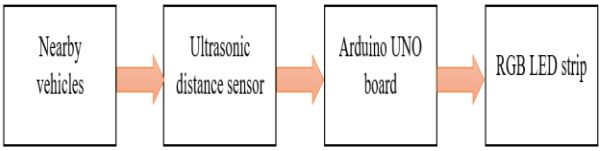

Figure.22. Block diagram

i. Vehicles approaching the bicycle.
ii. Ultrasonic distance sensor detects the vehicle because the distance keeps decreasing.
iii. Arduino board receives the signal form the ultrasonic sensor.
iv. RGB led strip change colour from green to red when the car is quite close to the cyclist and change to green when the vehicle further away from the cyclist.

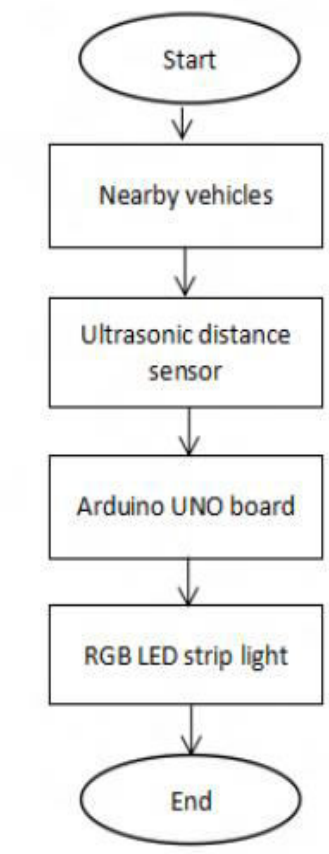

Figure.23. Flowchart of system operation

The hardware functions well for both increasing and decreasing distance. The RGB LED strip gives signal to the cyclist when there is an approaching vehicle. The distance sensor can detect the nearby vehicles without any problems. The project is successful.

Figure.23. Seat of bicycle

Figure.24. Ultrasonic sensor

Figure.25. Arduino UNO microcontroller with battery

Figure.26. Green light when vehicle is far

Figure.27. Red light when vehicle is close

7. Conclusion and Future Works

UNO-Bike is one of the technologies that can help cyclists to ensure their safety on the street. The RGB LED strip can gives signal to the cyclists when there is an approach car. This technology can help to reduce the number of accidents occur that cause by the cyclists and other vehicles.

Nowadays trend of cycling grows increasingly where more cyclists are hitting the streets. While this trend has many advantages, cyclists often struggle with staying safe among automobile traffic. Cities are often slow to adopt separate bike lanes, so it becomes cyclist responsibilities to ensure their safety. So, we are helping in this personal safety efforts with new bike technology called UNO-Bike. Relatively simple in concept, the RGB LED strip is on the handlebars and the sensor is put below the seat of the bicycle along with the Arduino UNO.

We know many innovations in the market for this bicycle safety distancing sensor. However, our project use RGB LED strip to maintain the brightness of the LED. It is used to ensure the cyclists aware about the approaching vehicles behind them. The use of the Arduino UNO gives us low cost in manufacturing them.For the recommendation, we can install the buzzer to the hardware for another signal. If the cyclists do not aware about the RGB LED strip, they can hear the sound form the buzzer [28].

In addition, ultrasonic distancing sensor can be switch to sonar device which can detect 3 foot barrier around cyclists [29]. HC-SR04 can detect nearby vehicles but with new innovation, the bicycle can detect vehicles that are far behind it.

Lastly, position of RGB LED strips light can be changed to handlebar [30]. This position can give warning not only to the cyclists but to the drivers or motorcyclists on the road. Plus, this situation can reduce accidents in Malaysia that has been increasing lately.

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