

TAOAID: Pedestrian Assistance Using Car Motion Detection System

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Abstract

This case study intended to propose an assistive pedestrian system using Arduino UNO as the microcontroller and several electronic components for the actuators and sensors of the prototype. For the sensors, ultrasonic sensors will be used as a proximity sensor to detect if there are pedestrians that need to cross the road and a passive infrared (PIR) is used for motion detection of cars on the road. There are three actuators for this proposed system: speakers, LED, and a micro server motor. These actuators produce sound, light, and motor movements respectively, that intended to alert pedestrians and drivers for a safer pedestrian crossing. This system suits to assist a wide variety of pedestrians including the blind, deaf, and children because of the actuators way of alerting through the sense of hearing, sight, and touch. The internet of things technology proposal in this study includes the circuit design, design illustration, and costs of materials. The speakers, LEDs, and micro servo motor served as actuators that alert the sense of hearing, sight, and touch, respectively, making this proposed project assistive to various pedestrians even to those with disabilities.

Keywords

arduino UNO, actuators, passive infrared, internet of things, circuit design

1. Introduction

1.1 Background of the Study

According to the National Center for Health Statistics (NHCS), it has been estimated that 7,668 pedestrians have been killed due to traffic or non-traffic incidents in 2019 (Injuryfacts 2022). Some of the main causes of these incidents are due to pedestrian distractions from texting and calling, poor visibility, darting to the road, and walking in the wrong direction (Laborde Earles 2022).

Visually impaired pedestrians rely on the noise of a combustion engine to gain information on their surroundings when crossing roads. However, due to the innovation of new technologies such as silent vehicle technology, pedestrians with vision impairment/loss may lack awareness of nearby vehicles. Statistics had mentioned that not less than 70 visually impaired individuals are involved in pedestrian-related accidents every year (HG.org 2022). Pedestrians' inattentiveness and lack of awareness of the noise and sound of their environment are one of the causes of pedestrian-related accidents. Therefore, individuals with hearing disabilities rely on gaining information more on visual cues (Arrive 2021). According to the Centers for Disease Control and Prevention regarding Pedestrian Safety, 20% of all pedestrian deaths and 10% of all pedestrian injuries in 2017 are from individuals that are aged 65 and older. Older pedestrians are one of the most at risk due to their speed on crossing roads slower than the average (Arrive 2021).

Internet of Things (IoT) provides the ability to capture and share data through a network of networks. IoT has affected many divisions of organizations and one of its priority areas is asset tracking and management. The usage of IoT sensors attached to assets had allowed organizations to track information through sensors to track and detect the current state of an object such as its position, measure of heat, and motion. This information is tracked and obtained without the participation of humans (Nord et al. 2019). With the use of IoT sensors, smart homes (SH)

could be enabled with an automatic system. Through motion sensors, doors can automatically close and open by detecting motion. Motion sensors could also be used for notifying the homeowners while they are not present in their homes when there is any movement detected (Jabbar, et al. 2019).

1.2 Objective of the Study

The main objective of this study is to provide an assistive pedestrian system using a car motion detection system. Specifically, it aims to:

- a. light an LED through the usage of ultrasonic sensors;
- b. signal drivers regarding the presence of pedestrians through the lighting on a LED;
- c. emit sound and control a gate through the implementation of infrared sensors;
- d. notify pedestrians on incoming vehicles and preventing them from crossing the road through an emitted sound and a dropped gate; and
- e. allow pedestrians to cross the road through a pulled-up gate through data from the infrared sensors.

1.3 Scope and Delimitation

The study will mainly focus on developing an assistive technology system for pedestrians with the usage of specific materials. The developed system will be used on roads where pedestrians are more likely to cross on.

Ultrasonic sensors and infrared sensors will be used for receiving and sending data on the current state of the environment. The usage of LED light, sound emitter, and gate will notify pedestrians and drivers of the information gained from the sensors. The components used for notification will support pedestrians with vision, hearing, and mobility disabilities.

1.4 Significance of the Study

The study aims to develop a system that will provide pedestrian assistance with the usage of a car motion detecting system. The system's objective is to also promote road safety and awareness of the pedestrian's and driver's environment. One of the causes of pedestrian-related incidents is due to distractions which leads to the pedestrian's inattentiveness (Laborde Earles 2022). Through the system's notifiers such as LED light, sound emitter, and gate, the pedestrian will be alerted through the effects of these notifiers. Pedestrians with vision disabilities are at risk when crossing roads (HG.org 2022). Therefore, a sound emitter will be implemented for alerting the pedestrian on an incoming vehicle. Individuals with hearing disabilities rely on visual cues to gain information on their environment (Arrive 2021). To allow them to gain this information, a LED light and gate will allow the individual to know when it is safe or not safe to cross the road. It is common for old pedestrians to have mobility disabilities which makes it risky for them to cross a road without them and the driver being notified of the current state of the environment (Nord et al. 2019). Therefore, the notifiers will be utilized in the system to allow old pedestrians to cross a road safely.

2. Review of Related Literature and Studies

2.1 Internet of Things (IoT)

Concurrently, there are 10 billion connected IoT devices and are predicted to grow by 2025 into 22 billion. Physical objects are called "things" which are usually embedded with various sensors, software, and some technologies for their goal to connect and exchange different information/data to other devices and systems over the internet. Internet of Things is important especially as we are in the 21st century where most of our everyday objects are connected to the internet, like kitchen appliances, cars, baby monitors, etc. Just by connecting to the internet we can communicate easily to various devices anytime, anywhere, and process our needs. A few of the advantages of IoT is that first, the connectivity, which has been made easy to connect sensors to the cloud. We can also have machine learning and analytics, especially in the business industry wherein they could gather a vast amount of data or business insights in the industry (Hwang 2016). In a study entitled, Distansya: an IoT Platform to Physical Distancing Provision.

Notification, the main goal of the project is to build and offer a prototype system that combines inexpensive but effective IoT technology with basic deterrent equipment. This would be accomplished by first examining pertinent related literature and past projects referring to specific components such as ultrasonic sensors, photoresistors, and lidar sensors that do not need to be employed at the same time (Blancaflor et al. 2021).

2.2 Motion and Proximity Sensors

Motion sensors can be in various forms of technology as it detects movement in a designated area. The main theory on how motion sensors work is that they stand as a guard that is ready to react to various situations, specifically, to moving stimuli. One of its applications is for security purposes in homes (Tross 2020).

There are several types of motion sensors that can be used in different projects. First is the Passive Infrared (PIR) Sensor which uses a pyroelectric film that responds to IR radiation by discharging electricity. PIRs are considered economical because it is cheap and uses less energy compared to other sensors (ELPROCUS 2020). Next is the Microwave (MW) Sensor that sends out microwave pulses and measures the bounce back or reflections of the wave from moving objects. MW sensors are more expensive and vulnerable to electrical interferences (Tross 2020). An ultrasonic sensor is another type of motion sensor which measures the distance of an object by emitting ultrasonic sound waves and detect the reflected sound into an electrical signal. The difference between the time of emission and the time the transmitter receives the reflected sound waves is how an ultrasonic sensor detects the distance and proximity of objects within its range (Tross 2020). Its maximum range can be up to 11 meters (Jost, D. 2019). Other types of not commonly used motion sensors are Area Reflective sensors, and vibration motion sensors (Tross 2020).

2.3 Detection System

Detection systems are used to monitor, distinguish, find or identify an object especially when something is being protected or monitored. Detection systems are typically based on extracted features and a learning algorithm to process on its own. There are various ways to detect an object and one of which is an active/passive sensor such as lidar, radar, ultrasonic sensors, camera, etc. (Jost 2019).

There are also many types of detection systems that can be used, one of which is a violence detection system, wherein it can do surveillance jobs more efficiently, and intelligently can do its work on its own (Frenzel, L. 2018). Another can be camera-based lane detection which is widely used and one of the key techniques in advanced driver assistance systems (Jabri, S. 2018). Vehicle detection systems sometimes use a camera, mounted on their cars to detect preceding vehicles. Induction loops can also be used to detect a vehicle and it's been used since the early 1960s, wherein it consisted of a wire and electronic detection unit, and the primary principle is for it to detect metal (Shahzad, K. et al. 2018).

2.4 Pedestrian Systems in the Philippines

Pedestrian Systems requires to be efficient as well as effective for the general public to be used and for their safety in public, especially on the road. It was also said that having pedestrian-friendly facilities promotes and creates a healthier environment for people to live in. It was also said that having those pedestrian-friendly facilities like sidewalks, ramps, curbs, trails do promote individuals to travel by either cycling, walking, and not used motorized modes of transportation which can also help in the environment. In many Asian countries, there are recent findings that show an enormous increase in motorization while having little to no attention to pedestrian and public transport facilities, which results in decreased overall pedestrian mode share. In the Philippines, particularly in Cagayan De Oro, people do prefer to walk especially on small trips to get to their destination. However, many pedestrians were observed that are walking alongside the road which poses some risk to impending dangers on a nearby motorist.

According to statistics by the Department of Transportation and Communication (DOTC), there was an increase of 14.6% on accidents alone in 2013 and it's still increasing each year. Many factors led to these incidents in the Philippines. One study finds that there is a poor facility rating in the Level of Service (LOS) in Cagayan De Oro, and all six intersections that were observed failed in walkability. Additionally, a score of 52.68% which is failed was rated in the collective intersection in terms of walkability and a grade of "F" in LOS was given on sidewalks of intersections. Moreover, the huge volume of pedestrians exceeds the capacity of the sidewalks in most of the city's intersections. There is also a lack of non-existing pavement markings, buffer zones, ramps, and signal lights. These facilities are necessary to help pedestrians to be safe and as said the city lacks many of these (Go 2017).

2.5 Rapid Ground Car Detection on Aerial Infrared Images (Liu et al. 2018)

This research's objective is to detect cars efficiently with accuracy and by reducing problems that a regular car detection system would face. The proposed system that the researchers did is to use an infrared sensor instead of a normal camera which can have many false detections or false alarms. The proposed system removed the false alarms by confidence threshold and are eliminated by Non-Maximum Suppression (NMS). Additionally, instead of detection systems to be installed on the streets or roads, the researchers installed the system in an aerial moving platform or popularly known as Drone. A DJI M-100 UAV with a 640 X 512 resolution was the system it was built

on, having the infrared sensor attached to it. For the data collection and testing, a crossing road was the first flight place which is filled with large traffic and 5 different locations. For the training of the system, the help of a pre-trained classification network on ImageNet was used, and then it was fine-tuned.

Results found that infrared sensors can lessen false detection or alarms on detecting in motion cars and a mean precision of 94.61% was achieved in detecting cars, while the average recall is 97.11%. False detections that were some of the problems in a normal car detection system have been reduced and only a few false detections were detected and not because of some shadows of some trees.

The study has some gaps which were not taken into consideration, like for the long-term detection of in-motion cars where the platform was only powered by a battery which can be drained in a few hours or less (Liu et al. 2018).

2.6 Rash Driving Detection Using a Frontal View Camera in Cars (Jain, H. 2018)

Rash Driving is one of the most common causes that deaths on road occur. In 2016, 90% of the deaths on the road were accounted for rash driving. 1.51 lakh or 151,000 people died on the road and 80.3% of them were the driver's fault. This research aims to propose an in-car visual analysis based on a rash driving monitoring system. Two models were used in this study, the first being the detection motion parameters that use CNN trained video dataset, and the second model is used for detecting rash driving that was trained using rashness dataset. The researchers used their video dataset with the help of PilotGuru, an Android application to record video and sensor (Accelerometer, GPS, and gyroscope) data and it is cost-effective and easy to install, especially on smartphones. They also used a PilotGuru post-processor that cleans, and processes captured sensor data to generate forward speed (in acceleration and braking) and angular velocity (in steering). 30 videos were captured in residential and countryside areas. An android smartphone was used, specifically, the Samsung Galaxy S8 with an in-built video stabilization turned on. The PilotGuru that has a 30fps, 1980x1080 was then converted into 10fps, 960x400 PNG images. The Faster-RCNN is used to detect vehicles and pedestrians only.

In training the system, the rashness detector, a manually annotated rashness dataset was used. Two models were used the SVM and MLP, and because of a very-small data-points, the researchers tried to use cross-validation training with repetition. The vehicle motion detection model and Faster-RCNN were implemented using TensorFlow. For dense optical flow, the OpenCV was implemented. Training of the system was done for 16 epochs and the best model is saved.

On the 30 videos that the researchers have collected 10 videos had instances of mild rashness. Additionally, in the first conducted full test of the model, it showed a bad result since the detected rashness was not close to the ground truth, but after smoothening the predicted output on the motion detection model and scaling of the aw, results showed a better and almost comparable to the ground truth (Jain, H. 2018) .

2.7 Movement Direction and Distance Classification Using a Single PIR Sensor (Gami, H. 2017)

This study utilized a PIR sensor to distinguish spatial and temporal relationships of objects in the sensor's angle of view. The presence, direction, and distance of movements of a person in a hallway in the event that this study focused on to experiment. This study proved the efficiency of PIR sensors with more than 99% and 93% accuracy for classifying direction and distance of the movements, respectively.

One of the strengths of this study is that it used well-known machine learning concepts and computer vision methods to recognize, detect, and classify the movements that are being detected by the PIR sensor. It was also successful in demonstrating how effective a single PIR sensor in terms of motion detection and occupancy or proximity detection in a building, office, or public place. It is also considered as a ubiquitous type of Internet of Things (IoT) system, and not an ordinary electronic project because of the presence of data and utilization of machine learning. This research only focused on movement detection of humans, which makes it a shortcoming of the study. The study could have included an experiment on other objects or living things or test it in other environments outdoor. (Gami 2017)

2.8 Pedestrian-safer IoT-based Smart Crossing System with Object Tracking (Pathak, A. et al. 2020)

The system that was used in the study made use of various sensors to track fast-moving objects such as cars. The study aims to provide a system that aids pedestrians to cross streets. According to the study, there are four main

concerns for pedestrians when crossing the street. Miscalculation of traffic distance, lack of sidewalk space, pedestrians moving out of crosswalks, and pedestrians not following traffic signs.

Their system utilized ultrasonic sensors as well as an IR sensor to measure the distance of an object to a target destination. The Arduino controller that they are attached to then transmits commands on an ISD1820 voice module that outputs audio to warn pedestrians. Results of their study show the number of pedestrians in the main points of concern. They have found that 62.16% of the pedestrians use the overpass, 19.37% use the zebra crossing, and the remaining 18.27% cross illegally. The researchers believe that the numbers are significant since 82% of the pedestrians use legal ways to cross. They have installed the system that they have designed on the zebra crossing and aims to notify the pedestrians of incoming traffic using IR and ultrasonic sensors.

Pathak et. al (2020) system is designed to detect both pedestrian and the driver to avoid casualties when crossing the road. They have incorporated various sensors such as IR sensors and ultrasonic sensors to detect the movement of both pedestrians and vehicles. They have also designed the system to give off an early warning for the pedestrian whenever a car is nearing the pedestrian lane. They have also incorporated a servo motor to act as a gate to prevent dangerous crossing. The design uses ultrasonic sensors to detect nearby pedestrians as a validation method so that the device will not perpetually operate even though there are no pedestrians in the area. The IR sensors were tactically placed at a good distance away from the pedestrian lane to ensure accurate scanning and to provide a window for the reaction for both pedestrian and driver for the early warning devices.

The researchers have used the design developed by Pathak et. al to develop a device in which detects incoming cars that are heading towards the pedestrian lane. The design developed by this study's researchers has also incorporated an early warning device for the drivers to alert themselves when a pedestrian is occupying the pedestrian lane, making a two-way early warning device for both pedestrians and drivers. (Pathak et al. 2020)

3. Project Details

3.1 Design Plan Deliverables

Figure 1 shows the process flowchart for TAOAID. The process starts in the ultrasonic sensors, if either of the ultrasonic sensors detects pedestrians within 10cm the LED will light up to inform the oncoming drivers that there are people in the pedestrian lane. After that, the system will also send data to the IR sensor and checks if there are vehicles within 20cm, if yes, the gate is lowered down, and sounds are emitted to the speakers to alert the pedestrians that they should not cross because there is an upcoming vehicle. If there are no vehicles detected within 20cm, the gate is not lowered, and the pedestrians are allowed to cross.

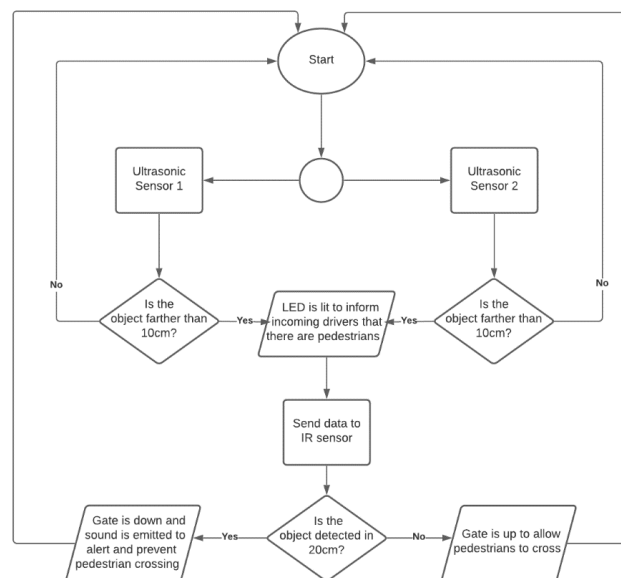


Figure 1. Process Flowchart

As shown in figure 2 is the proposed circuit design of the system. It is composed of the necessary sensors such as the IR sensor and the ultrasonic sensors as detection devices, two servo motors to act as gates, two audio speakers with GROVE to provide audio output, two LED lights to provide visual signals to vehicle drivers and pedestrians. All of these electronic components are connected into pins and digital switches of an Arduino UNO microcontroller. The Arduino UNO is connected into a powersupply to supply the circuit with electrical power and a USB connector to load logic codes into the microcontroller. The electronic sensors and actuators stated above are all interconnected through the breadboard.

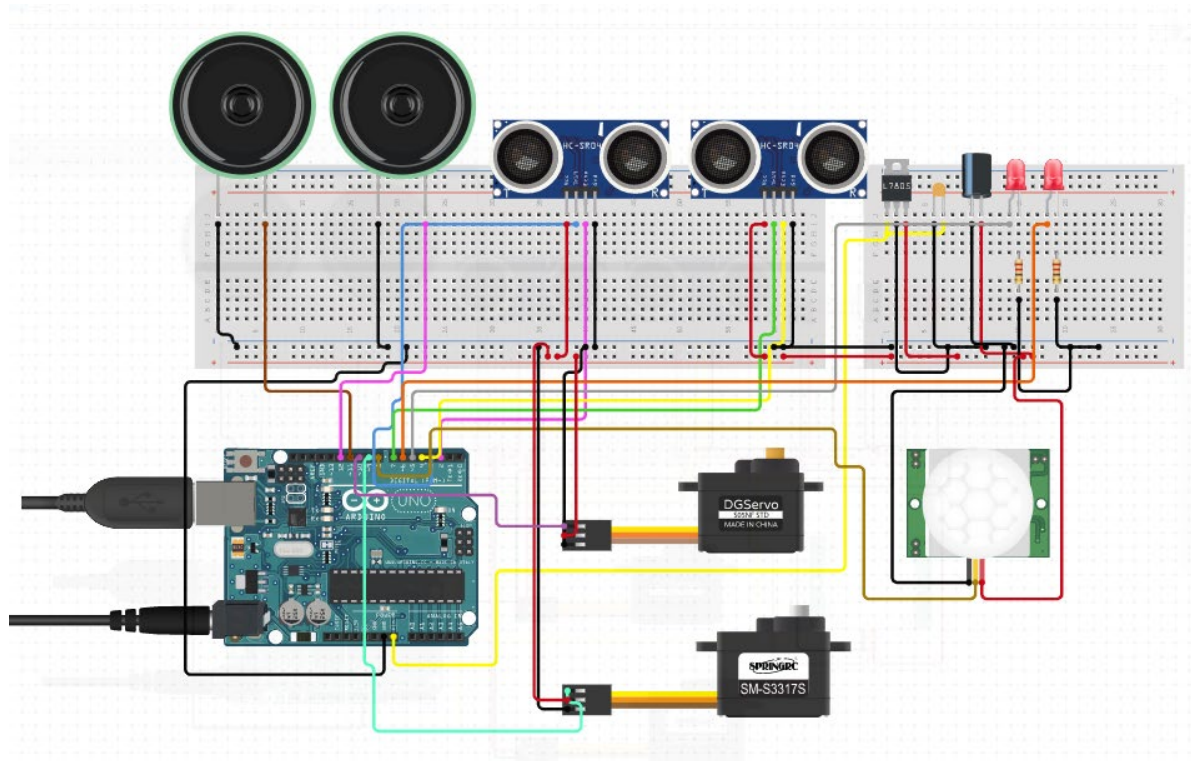


Figure 2. Circuit Design

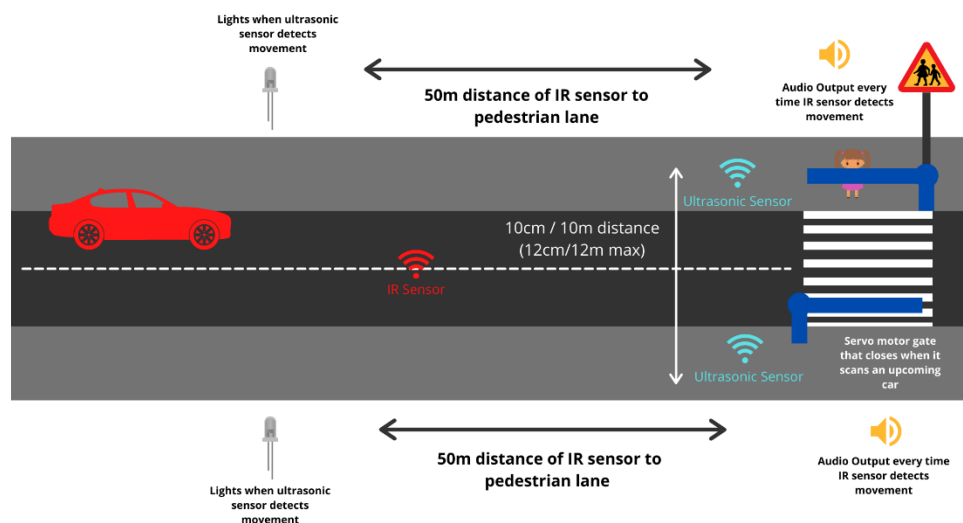


Figure 3. Execution Design Illustration

Figure 3 shows the proposed execution design of the system. Similar to Pathak's group's system, the researchers have opted to place detection devices using ultrasonic sensors to detect if there are any pedestrians in the pedestrian lane. The proposal design also contains an IR sensor in which detects if there is an object that is heading towards the pedestrian lane. If both sensors detect the conditions which in this case are the pedestrian and the car, the warning device in the form of an audio output using speakers is emitted as well as a signal light that informs the incoming car that there is a pedestrian in the pedestrian lane. To ensure the safety of the pedestrians, a gate is placed in the pedestrian lane to prevent passage. The servo motor in the design shall serve as the gate in the model.

The IR sensor will detect upcoming traffic, fulfilling one of the conditions for the warning outputs to emit. If the IR sensor detects upcoming traffic without the ultrasonic sensor detecting movement in the pedestrian lane, the warning devices will not emit audio output as well as the motor being in its' default state. If both the conditions are met (IR sensor and ultrasonic sensor both detects movement), the warning devices shall engage (LED lights up, speakers emit an audio output, servo motor prevents passage in the pedestrian lane).

3.2 Technical Background

The list of the materials that were used in this system are as follows:

- Arduino Uno R3
- Large and Small Breadboard
- IR Sensor
- Ultrasonic Sensor
- Micro Servo Motor
- Speaker with Grove
- Jumper Wires
- Electrolytic Capacitor
- Ceramic Capacitor
- 5V Voltage Regulator
- 220 Ohms Resistor
- 9 Volt Battery

Table 1 presents the components used in the proposed project and its corresponding cost. Total cost of the project is 3223.97 pesos.

Table 1. Bill of Materials and Cost

Part	Price	Quantity	Total Price
Arduino Uno R3	₱249.75	1	₱249.75
Large Breadboard	₱64.75	1	₱64.75
Small Breadboard	₱45.75	1	₱45.75
IR Sensor	₱399.75	1	₱399.75
Ultrasonic Sensor	₱58.75	2	₱117.5
Micro Server Motor	₱274.75	2	₱549.5
Speaker with Grove	₱369.75	2	₱739.5
Jumper Wire	₱49.75	1 set (40 pcs)	₱49.75
5V Voltage Regulator	₱45.95	1	₱45.95

Electrolytic Capacitor	₦4.37	1	₦4.37
220 Ohms Resistor	₦24.18	1 set (10 pcs)	₦24.18
Ceramic Capacitor	₦1.985	2	₦3.97
5mm LED Light	₦59.75	1 set (30 pcs)	₦59.75
9 Volt Rechargeable Battery	₦499.75	1	₦499.75
Total Cost of Arduino Prototype			<u>₦3223.97</u>

4. Conclusion

This project focused on the field of IoT and assistive technology through the use of motion and proximity sensors. The restrictions of this setup due to cost and time constraints forced the researchers to substitute expensive and hard-to-obtain actuators to be substituted by cheaper ones. The speakers, LEDs, and micro servo motor served as actuators that alert the sense of hearing, sight, and touch, respectively, making this proposed project assistive to various pedestrians even to those with disabilities. For the sensors used, the usage of IR sensors makes the project efficient in relation to its effectivity and cost while the ultrasonic sensors are placed for accuracy in proximity detection. Thus, this project is a modest attempt for a pedestrian assistance system and improve the safety of pedestrians with the prototype model using Arduino UNO and several electronic components. Its implementation plan is fairly limited to small pedestrian crossings. However, future researchers in the field of IoT, electronics, IT, and engineering could further improve this by enlarging its scope or involving application integrations.

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Biography

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