DEVELOPMENT OF SMART NAVIGATION SYSTEM FOR THE VISUALLY IMPAIRED

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DEVELOPMENT OF SMART NAVIGATION SYSTEM FOR THE VISUALLY IMPAIRED

by

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LIST OF ABBREVIATIONS

WHO	World Health Organization
USA	United States of America
ETA	Electronic Travel Aid
ITS	Pedestrian Intelligent System
GPS	Global Positioning System
GSM	Global System for Mobile Communication
GPRS	General Packet Radio Service
SMS	Short Message Service
USB	Universal Serial Bus
PC	Personal Computer
SPS	Standard Positioning Service
PPS	Precise Positioning Service
IDE	Integrated Development Environment
TX	Transmit
RX	Receive
TXD	Transmit Data
RXD	Receive Data
RST	Reset
PWM	Pulse Width Modulation
SRAM	Static Random Access Memory
EEPROM	Electrically Erasable Programmable Read-only Memory

ABSTRAK

Sistem navigasi yang bijak bagi mereka yang cacat penglihatan adalah sangat penting bagi mereka untuk bergerak dari satu tempat ke tempat yang lain. Berbanding dengan peranti mudah didapati seperti “white cane”, membimbing anjing dan lain-lain, yang memakan masa, kos yang agak mahal, potensi untuk kecederaan yang tinggi, manakala projek ini menyajikan cara yang lebih baik dalam mengurangkan potensi kesilapan. Sensor ultrasonik akan dilampirkan di hadapan, sebelah kanan dan ke sebelah kiri. Sensor ultrasonik di hadapan untuk mengesan apa-apa halangan supaya cacat penglihatan boleh mengelaknya. Sensor sampingan bertindak sebagai anti-veering untuk memastikan penginapan yang cacat penglihatan sentiasa berada di trek. Modul GPS serta modul GSM juga digunakan dalam projek ini, untuk mengesan lokasi cacat penglihatan tersebut. Dengan sistem ini mereka yang cacat penglihatan boleh pergi ke mana sahaja kerana lokasi mereka dapat dikesan oleh penjaga. Penyiasatan ke atas sensor semasa berjalan dijalankan. Prestasi GPS dengan GSM juga dianalisis. Hasilnya, sistem ini boleh digunakan sebagai sistem navigasi untuk meningkatkan prestasi dalam berjalan oleh mereka yang cacat penglihatan untuk memastikan mereka berjalan dengan selamat dengan memahami persekitaran.

ABSTRACT

Smart navigation system for the visually impaired is very important for them to travel from one place to another. Compared to readily available devices such as white cane, guide dog and others, which are time consuming, expensive and potential injuries for the visually impaired, this project serves way better in reducing error potential. Ultrasonic sensors will be attached to the front, right side and to the left side. The front ultrasonic sensor is to detect any obstacle so that visually impaired can avoid it. The side sensors act as anti-veering to ensure the visually impaired stay on the track. GPS module with GSM module also used in this project, which is to trace the location of the visually impaired. With this, the visually impaired can go anywhere since their location can be traced by the guardian. Investigation on the ultrasonic sensors during walking is carried out. The performance of the GPS with GSM also analyzed. As a result, this system can be used as a navigation system to increase the performance in walking of the visually impaired to ensure they walk safely by understanding the surrounding environment.

Chapter 1

Introduction

1.1 Background

Visual impaired is vision disaster enough to qualify as a critical requirement of visual capacities occurring in light of contamination, harm, natural or degenerative conditions that cannot be corrected by routine means, for instance, refractive change or medicines. Most recent reviews by the World Health Organization (WHO) demonstrates that, there is an expected 285 million individuals who are outwardly impeded around the world [1]. Visually impaired people unable to do most of the day to day tasks as normal human being. The white cane is one of the most used items by the visually impaired. This is due to low cost and portable which can be folded and slipped into pocket. Hence this will be easy for the visually impaired to carry it with them wherever they go. But there is a problem in this, because in order for the user to use it they need to practice using it for 100 hours. Obviously, to get this training they need to pay extra money and it is expensive. On the other hand, guide dog is also used by the visually impaired. Concerning the guide dog, an additional speculation is required for unique preparing. On top of that, these guide dogs additionally will cost amongst $12,000 and $20,000, and they are valuable for around five years. Moreover, if the outwardly hindered are elderly individuals, then dealing with another living being will be as an additional weight for them. Therefore, just 1% of the evaluated two million outwardly debilitated individuals in the U.S. have guide dogs [2]. Furthermore, Japan has built up a more easy to use extend. The name of this venture is Pedestrian Intelligent Transport System(ITS). This

venture was acquainted with build up a framework that permits sheltered, secure, and smooth go by all walkers, including the elderly, the visually impaired, and wheelchair clients, and in addition cyclists. The administration and nearby experts have assembled a unique person on foot path with "dimpled" asphalt to help them when strolling with their stick. Be that as it may, this office is not accessible all around, generally just amidst the city and rural area [1].

Throughout time researches and development has been made to help the blind and the visually impaired community. There are many navigation systems for visually impaired people but only few can provide dynamic interactions and adaptability to changes. The rapid evolution of technologies has widely influenced the development of this system. One of the most beneficial technology that mankind has developed is the development of smart navigation system for the visually impaired. Smart navigation system for the visually impaired can also be described as an electronic travel aid(ETA), where the visually impaired can use as an assistance to perform their daily life activities [3]. By having this device as an assistance, the life of the visually impaired community will be easier. For example if they want to travel from one place to another, they no longer need anyone to guide them or to follow them to make it happen. By having this system, they can make it by themselves. Besides, they can live their life as a normal human being without being isolated from the community.

The using of Global Positioning System(GPS) module will help in locating the location of the visually impaired. The connection between the GPS module and the guardian’s smartphone will be through Global System for Mobile Communication(GSM) module. In this project, the

coordinate of the visually impaired will be taken and send to the smartphone through the GSM module. In which Short Message Service(SMS) system is used.

1.2 Problem Statement

Independent travel and interacting with the wider world is the biggest problem to perform in daily life activities of the visually impaired [4]. On top of that, the most common issue confronted by visually impaired people is moving around in their condition without chancing upon unforeseen deterrents. Obstruction recognition is hence one of the significant issues to be unraveled to guarantee safe route [5]. In this past two centuries many devices has been introduced in order to help the visually impaired community to overcome the problems they face in daily life [3].

In this project, ultrasonic sensors used to detect obstacle to be implement because it is simple and play crucial role in helping the visually impaired to move around. By having this device it will help the visually impaired to better understand the environment and to move around freely without worrying about involvement in any type of accident. This is because all three sensors will act as alarm to alert the visually impaired whenever they come across any obstacles. For the front and sides ultrasonic sensors different distances been set and each distance have different frequency of sound and vibration been produced. This is to let the user know the difference in distance between them and the obstacle before. The location of the visually impaired can be known by using the GPS module. The use of GPS together with the GSM module will help to locate the coordinate of the visually impaired so it will be easier to trace them.

1.3 Objectives

The aim of this project is to build a smart navigation system for the visually impaired. Therefore, the objectives are:

i. To detect obstacle/s on the ground and produce appropriate indicator to alert the visually impaired

ii. To create an anti-veering system so that the visually impaired can stay on the track.

iii. To create a monitoring system that can trace the location of the visually impaired.

1.4 Scope of the Project

The scope of this project is to build a smart navigation system using Arduino board for the visually impaired. This system focuses on outdoor navigation system and is built with three main functions; (i) it can detect obstacle and produce sound or vibrate to alert the user; (ii) the visually impaired will always stay on track and (iii) it will send the location of the visually impaired through SMS to the guardian. In this project, three ultrasonic sensors are used to detect obstacle on the ground level. A GPS module used to detect the location of the visually impaired. A GSM module act as an interface between the GPS module and the smartphone.

1.5 Outline of Report

This project consists of five main chapters that describes the full information starting from introduction till conclusion of this project. Chapter 1 is about the introduction of this project. It

provides the project overview, problem statement, objectives, project scope and outline of the report.

Chapter 2 presents literature review of previous work related to this project. Previous work related to smart navigation system for the visually impaired has been elaborated in this chapter. Information of GPS and GSM also explained in this chapter.

Chapter 3 covers the methodology of this project. Methodology is one of the main part for this whole project. In this chapter the software implementation and hardware implementation of this project is explained in detail.

In chapter 4, the results and discussion is presented. This chapter shows, the behavior of the smart navigation system for the visually impaired. This will be the technical part for this project and the hardest part as well. This is because, it involves investigations and testing on the system in order to check the performance of the smart navigation system for the visually impaired.

Finally, Chapter 5 presents the conclusion of this project. Summary on, the project implementation is covered. This chapter also includes the limitations of smart navigation system for visually impaired and future works to improve it.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There are number of papers written on obstacle detection, obstacle avoidance and anti-veering system. These papers emphasize on detecting obstacle and avoid them for the visually impaired. With the use of this system, it results in efficiency in the movement of visually impaired from one point to another. Therefore, this system enable the visually impaired to travel independently as well as without colliding with any obstacle throughout the way.

On top of that, the anti-veering system helps the visually impaired to stay on track. Without this system, once the visually impaired move away from the obstacle then they will not be able to come back to the track and this will result they be in kind of lost. This may result for them to end up in different destination from the intended destination. The anti-veering system is a crucial part in maintaining the visually impaired to stay in track.

The GPS with GSM is important for tracking the visually impaired. This system will always track the visually impaired and their position will always be updated to the guardian. The location of the visually impaired will be send to the guardian through SMS. Hence, with this system the visually impaired can go anywhere they want with no worries since their location can be traced by the guardian.

2.2 Obstacle Detection

The outwardly disabled individuals need visual data to understand the hindrances and obstructions in their way in this way making it troublesome for them to play out their everyday undertakings easily and, proficiently. Advanced help procedures have turned out to be an aid for these outwardly tested areas of the general public. Recognition of a hindrance free-way for a less demanding and smooth route of outwardly disabled individuals has been a theme of enthusiasm for specialists throughout the years [6].

Sensors permit perception of the earth in a more then again less solid path contrasted with the human eye. Diverse fields require the utilization of various sensors to help the client in settling on a choice. As needs be, we recognize passive and active sensors. A passive sensor is a sensor that measures a full vitality given by a physical marvel. Thus, all in all terms, the sensors that utilization outer vitality sources to watch a protest are called aloof sensors. Monocular cameras are the most utilized sensors in the mechanical world. They are modest and effective as far as range, precision and measure of usable information. An active sensor gives some sort of vitality (microwave, sound, light, etc.) into the earth keeping in mind the end goal to recognize the changes that happen on the transmitted vitality. That would not joke about this transmits and distinguishes in the meantime [7].

Ultrasonic sensor is the proposed electronic guide which detects the obstructions in its way by consistently transmitting the ultrasonic waves. At the point when an impediment shows up in its region then the ultrasonic waves gets reflected to the framework instantly and alarms the

visually impaired people on foot through voice message [8]. Ultrasonic sensor can likewise give the message that portrays the separation of the question from the client and message is passed on through headphone [9]. K-Sonar is a stick that can recognize a deterrent at 5 meters ahead of time. This propelled identification not just empowers clients to stay away from deterrents, however gives spatial data to perceive points of interest in the earth [10]. Smart Guide Cane can track the course of development of the client and recognize the separation to and width of the hindrances exhibits on the path. Purpose of this sensor stage is to detect the client way to recognize nearness of a snag [11].

The determination must consider the zone of operation of every sensor and its execution. Likewise, it relies on upon a few components: cost, kind of scene, sort of obstruction to be identified, location extend and coveted exactness of the estimations. Our application must meet the imperatives of registering time. Without a doubt, planning to encourage the development of visually impaired individuals, the running time of our framework must be as short as would be prudent, the best being to outline a constant framework [7].

2.3 Obstacle Avoidance

Guide Cane, as shown in Figure 1, is a robot stick intended to help outwardly weakened voyagers to explore securely and rapidly among deterrents and different dangers. It contains a sensor head (Ultrasonic sensor cluster) mounted on a steerable yet unpowered two-wheeled directing hub. Amid operation, the client pushes the Guide Cane while the sensor head constantly distinguishes deterrents and cows the gadget around it. The client feels the guiding summon as an

exceptionally detectable physical drive through the handle and can take after the way of the Guide Cane [2].

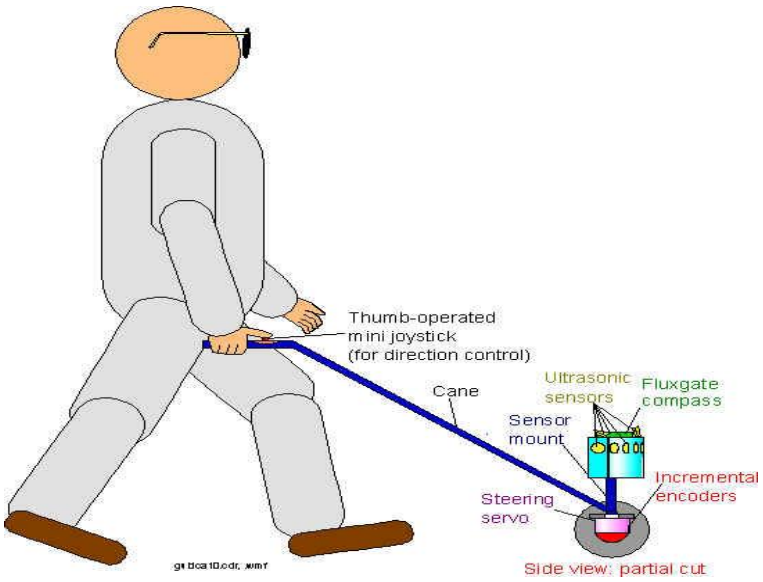

Figure 1 Guide Cane [2]

2.4 Anti-Veering System

A standout amongst the latest research done with respect to veering issue was Walking Straight portable application which was created taking points of interest of the implicit sensors of an advanced cell. Spinner estimations of the advanced mobile phone are utilized to recognize the client's strolling period and his current course of development. Assessments have indicated effective comes about. In any case, the advanced cell introduction must be settled to a particular course and client will most likely be unable to make utilize of the telephone for some other errand while strolling. So far this framework has demonstrated precise execution just for even mounting

of the advanced mobile phone. In this way this can further be enhanced and reached out to a framework that consolidates with a stick to explore the client [12].

Wiicane is a preparation framework to prepare individuals to walk straight utilizing an overhead infrared(IR) lighting track. It tracks the clients position and the introduction of the stick utilizing Wii equipment. This is the main framework that handles the veering issue, yet still it is restricted to indoor condition with reasonable altered framework [13].

Wearable Personnel Guidance System is another instrument which offers path indicate way-point route and additionally a capable of being heard cautioning signal, beginning from the closest point on the first way, to keep the client from veering outside the limits of a characterized hallway. Be that as it may they require numerous parts to be worn, including a versatile personal computer(PC), a sound processor, sound introduction equipment, material information gadgets, and position and introduction following innovations. This makes it awkward to wear out in the open amid day to day work [14].

2.5 Microcontroller

The microcontroller utilized is Arduino UNO. Arduino is an open-source hardware prototyping stage in light of adaptable, simple to-utilize equipment and programming where it can detect the condition by accepting contribution from an assortment of sensors and can influence its environment. Arduino tasks can be remain solitary, or they can speak with programming running on a PC [15]. Arduino additionally utilized for building computerized gadgets and intelligent objects that can detect and control protests in the physical world. Arduino had utilized the Atmel

Atmega AVR arrangement of chips, particularly the ATmega8, ATmega168, ATmega328, ATmega1280, and ATmega2560 [16].

2.6 GPS Module

GPS was at first produced by Department of Defense of the USA, in the 1970's for military utilize. Yet is presently broadly utilized for regular citizen applications including timing, mapping, route, and so forth. This system nominally consists of a fleet of 24 operational satellite, although computationally a minimum of 3 satellites are required for a triangulation. GPS consist of two levels of operation service namely SPS (Standard Positioning Service) for civilian uses and PPS (Precise Positioning Service) for exclusive military use with high level of encryption. As for SPS, GPS provides longitudinal, latitudinal, altitude and speed information [17].

2.7 GSM Module

GPRS is a data transmission technology built on the GSM foundation and widely used because of low costs for a connection [18]. The using of GSM-SMS technologies as a communication technique is far more efficient as it take into consideration both the fully developed area as well as in urban area [19].

2.8 Summary

Based on the literature review, it can be seen that many researches on the smart navigation system for the visually impaired have been carried out. Although there are number of researches and projects have been done but still there are room for improvement. As for obstacle detection, from previous work we can observe that the visually impaired will only be alerted once they have reached very close to the obstacle. The advantage of the smart navigation system that will be built

is that the visually impaired will be alerted twice once reach the obstacle. Hence, they will be more conscious once they reached the obstacle and will have time to decide to move in which direction. Next, Guide Cane is used for obstacle avoidance. Even though this device improve the movement of the visually impaired by taking into consideration the veering issue and obstacle avoidance, however, the user feel uncomfortable using it due to the size as user want to appear normal in public. Hence, taking this into consideration, a suitable cane with normal size and appearance will be built. For the anti-veering system a suitable technique is needed. The size, cost and availability are some of the parts that need to consider to create an anti-veering system. Lastly, the application of GPS and GSM is studied which inspired to implement in this project for tracking the visually impaired.

Chapter 3

Methodology

3.1 Introduction

This project comprises of two main parts, which are software implementation and hardware implementation. The hardware implementation explains in detail on list of components used in this project. This is as described in Section 3.3. For the software implementation, the complete program will be done in Arduino software. The software implementation covers the obstacle detection and tracking system, which describe in Section 3.4. Lastly, a summary of this chapter is presented in Section 3.5. Figure 2 shows the connection between the Arduino Uno with all the hardware involved.

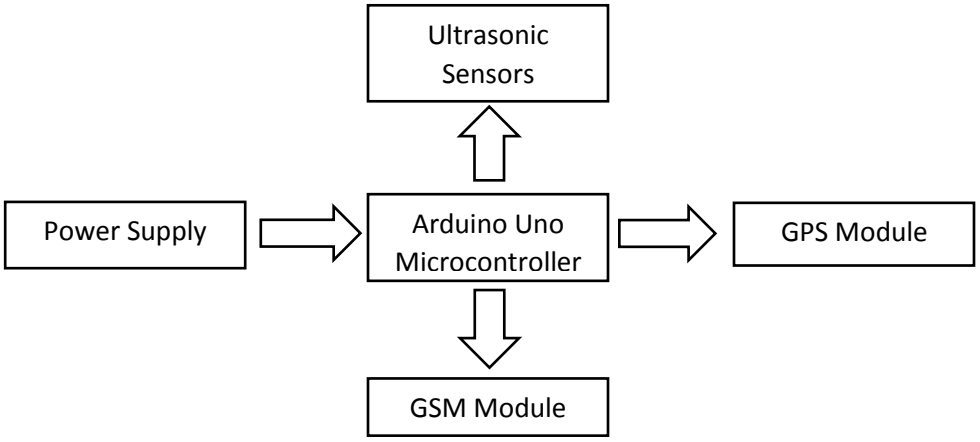

Figure 2 Block Diagram of Smart Navigation System

3.2 Project Overall Work Flow

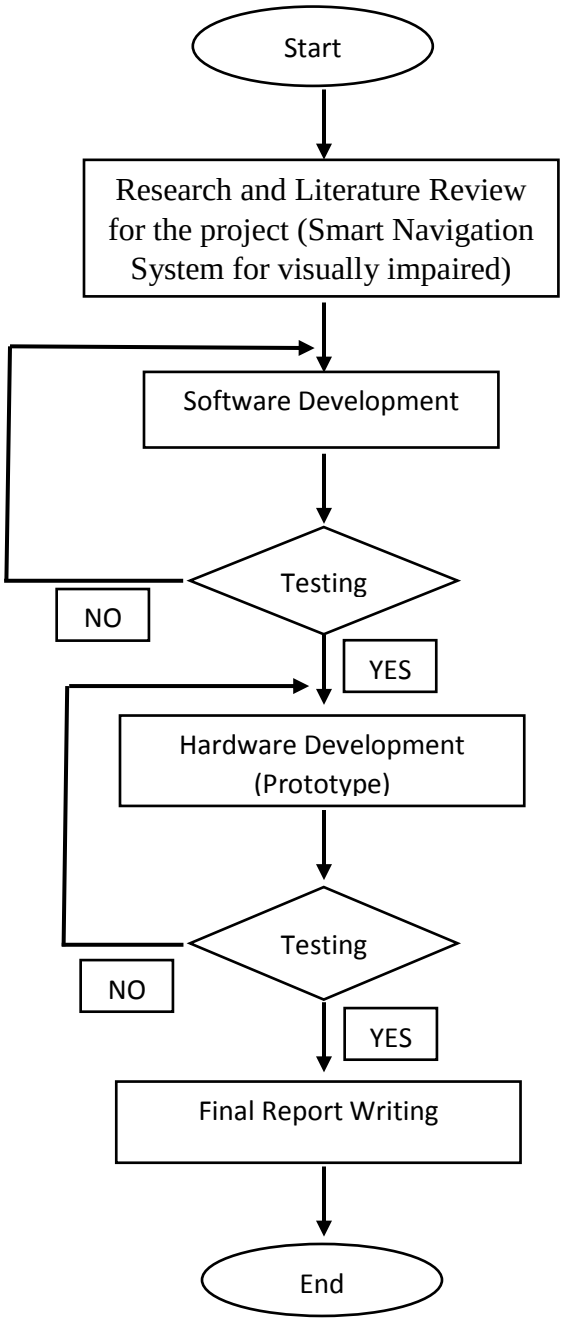

Figure 3 Project Flow Chart

3.3 Hardware Implementation

In this sub-section, the areas of interest is the electrical related items and equipment to develop a smart navigation system for the visually impaired. Figure 4 shows the image of the system. The vibrators that been used are as shown in Figure 5. All the basic parts and devices for the endeavor this project are recorded down underneath:

a) Arduino Uno

b) Ultrasonic sensors

c) GPS Module

d) GSM module

e) Buzzer

f) Vibrators

g) 9 volts Rechargeable Battery

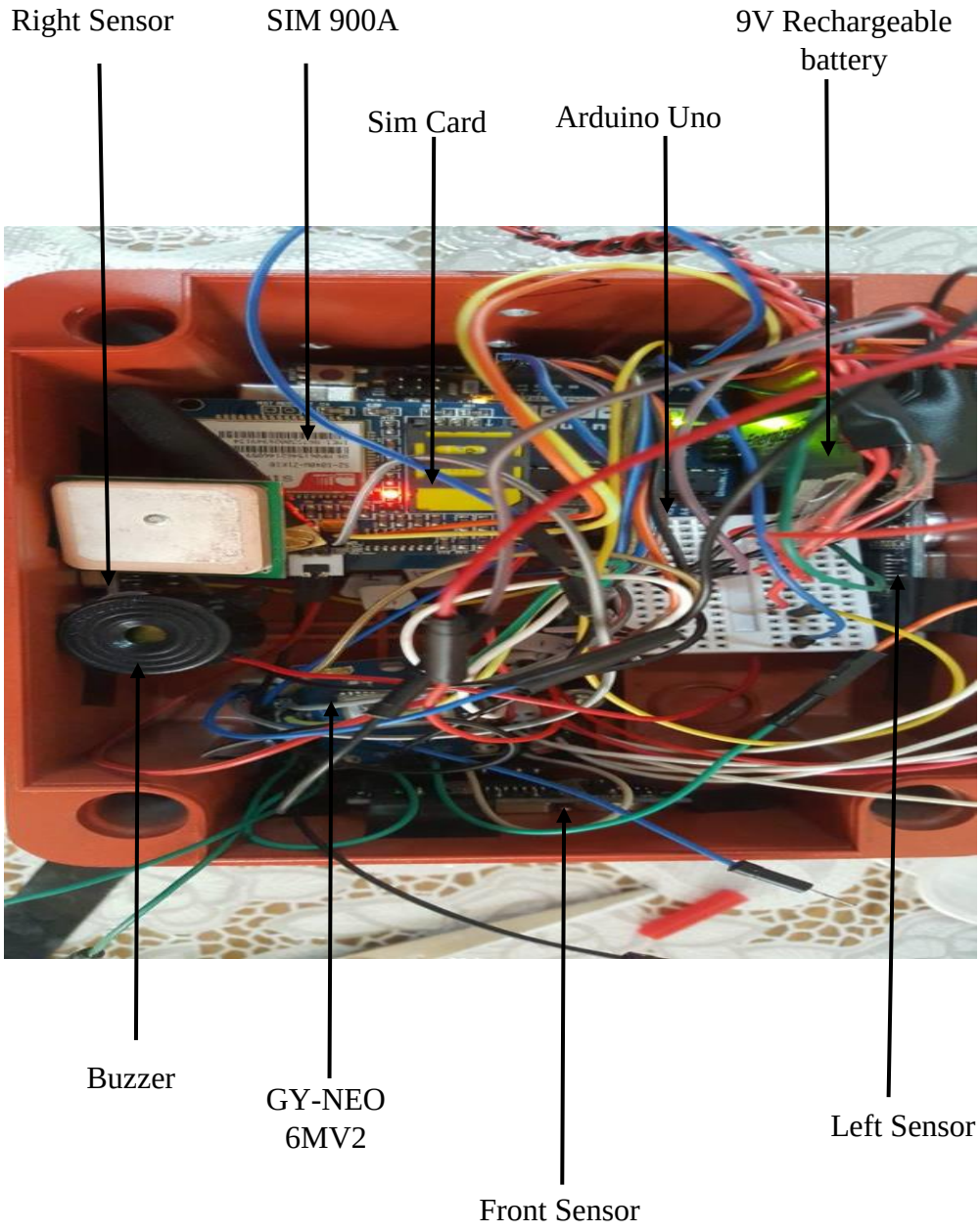

Figure 4 Image of the system

Figure 5 Vibrators

3.3.1 Arduino Uno

Arduino is portrayed out as open-source gadgets prototyping stage giving schematics and adaptable progress packs for enthusiastic clients who mean to pass on regular things or conditions. Arduino can be utilized to detect surroundings by using different transducers to take a gander at and unravel contributions with a specific choosing goal to make reactions for event through the controlling of engines or exchanging of information.

As a touch of equipment, the Arduino can work either uninhibitedly (like in a robot), related particularly with a PC (as requirements be giving your PC access to sensor information from the outside world and giving data), or joined with different Arduino's, or other electronic contraptions and controller chips. Anything can be connected and is compelled just by imaginative limit, status

to put at last and exertion into discovering some new information, and the openness of parts. Figure 6 demonstrates the Arduino Uno board. Table 1 shows the technical specification of Arduino Uno board.

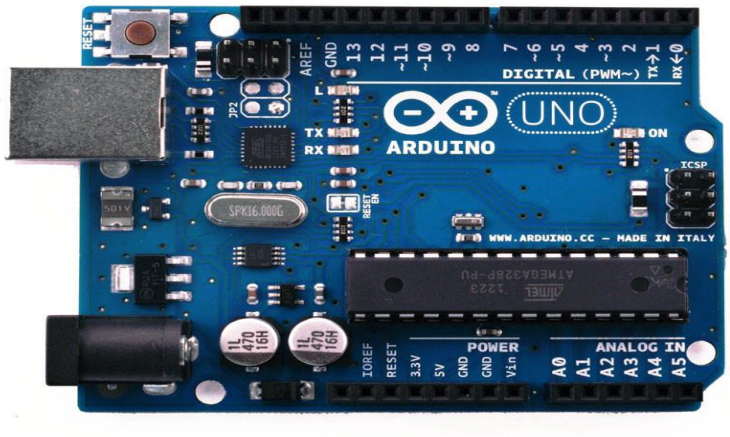

Figure 6 Arduino Uno board

Table 1 Technical specification of Arduino Uno board

Microcontroller	ATmega 328
Operating Voltage	5V
Input Voltage	7-12V
Input Voltage	6-20V
Digital I/O Pins	14(of which provide PWM output)
Analog Input Pins	6
DC Current per I/O	40 mA
DC Current for 3.3V	Pin 50 mA

Flash Memory	32 KB of which 0.5 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz

3.3.2 Ultrasonic Sensor

Ultrasonic sensors utilize sound waves instead of light, making them satisfactory for firm unmistakable confirmation of uneven surfaces, liquids, clear inquiries, and dissents with foul circumstances.

These sorts of sensors work greatly well concerning applications. The thing calls for certifiable estimations among stationary and transporting objects. Table 2 shows the US sensor HC - SR04 purposes of intrigue and Figure 5 exhibits the US sensor.

Table 2 Ultrasonic sensor HC - SR04 details

Working Voltage	DC 5V
Working Current	15mA
Working Frequency	40Hz
Max Range	4m
Min Range	2cm
Measuring Angle	15 degree
Trigger Input Signal	10uS transistor-transistor logic (TTL) pulse
Echo Output Signal	Input TTL lever signal and the range in proportion

Figure 7 Ultrasonic Sensor

3.3.2.1 Timing Diagram

The Timing graph is demonstrated as follows. You just need to supply a short 10uS heartbeat to the trigger contribution to begin the extending, and after that the module will convey 8 cycle burst of ultrasound at 40 kHz and raise its resound. The echo is a remove protest that is heartbeat width and the range in extent .You can compute the range through the time interim between sending trigger flag and accepting reverberation flag. Formula below shows the calculation for the distance in centimeters and inch. The timing diagram is as shown in Figure 8.

Formula:

uS / 58 = centimeters or uS / 148 =inch; or:

range = high level time * velocity (340M/S) / 2

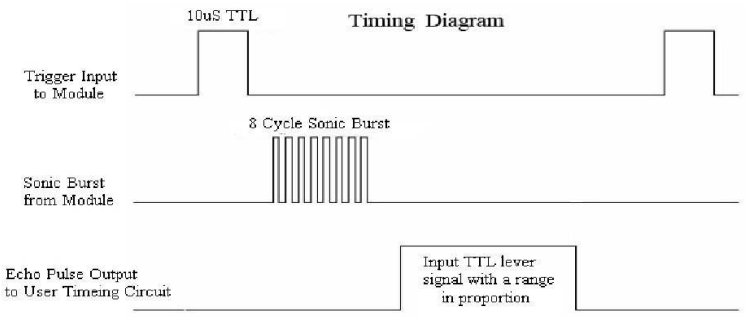

Figure 8 Timing Diagram [22]

3.3.2.2 Working Principle

The genuine HC-SR04 US sensor uses sonar to discover long division to a thing like bats or even dolphin perform. There is incredible non-contact extend exposure with sweeping reliability and high accuracy estimations inside the easy to-utilize deal. Beginning from 2cm to 400cm or even 1 to 13 feet. That technique is not harried by sun bars or even dull shading materials like Razor-sharp rangefinders are generally (but acoustically sensitive resources like material could test to recognize). That comes including ultrasonic transmitter device part. Figure 9 shows the preeminent of perceiving article and measuring the separation of Ultrasonic sensor HC-SR04.

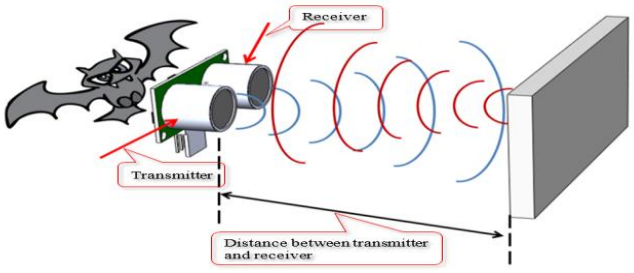

Figure 9 Working Principle HCSR-04 [24]

3.3.3 GPS Module

The GPS beneficiary finds out its position by conclusively timing the signs sent by GPS satellites. Each satellite steadily transmits messages that consolidate the time the message was transmitted, and the satellite position at time of transmission. The recipient utilizes the messages it gets the opportunity to choose the travel time of each message and processes the partition of recipient from each satellite. Each of these divisions and satellites' regions portray a circle. The recipient is on the surface of each of these circles when the divisions and the satellites' regions are correct. These separations and satellites' regions are used to figure the range of the authority using course conditions. The region fuses the longitude and degree which are the GPS bearings of the beneficiary contraption. Figure 10 and 11 demonstrates the GPS module and GPS association with Arduino. Table 3 shows GPS module stick portrayal.

Figure 10 GPS Module

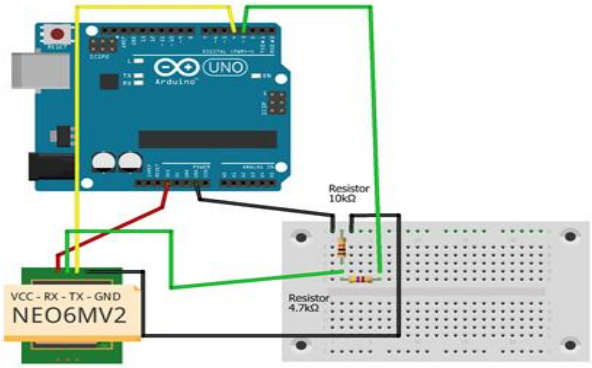

Figure 11 GPS module connection to Arduino

Table 3 GPS Module Pin Description

Pin No.	Pin Name	I/O	Description
1	VCC	Power	Module Power Supply
2	GND	Ground	Module Ground
3	NC	Output	Not Open
4	RST	Input	Module Rest
5	TXD	Input	Connect to Microcontroller's TX Pin
6	RXD	Output	Connect to Microcontroller's RX Pin

3.3.4 GSM Module

GSM/GPRS module is utilized to build up correspondence between a PC and a GSM-GPRS framework. Worldwide System for Mobile correspondence (GSM) is a design utilized for versatile correspondence in the greater part of the nations. Worldwide Packet Radio Service (GPRS) is an augmentation of GSM that empowers higher information transmission rate.

GSM/GPRS module comprises of a GSM/GPRS modem collected together with power supply circuit and correspondence interfaces (like RS-232, USB, and so forth) for PC. The MODEM is the spirit of such modules. The diagram is shown in Figure 10.

In order to let the GSM module to function properly, the pin connection between the GSM module and the Arduino Uno microcontroller must be connected correctly. The VCC pin of the GSM module must be connected to the 5v pin of the microcontroller while the Ground (GND) pins of the GSM module must be connected to the Ground pin of the microcontroller. Same as the GPS module, the RX pin of the GSM module must be connected to the TX pin of the microcontroller while the TX pin of the GSM module must be connected to the RX pin of the microcontroller. Figure 12 shows the GSM module and the schematic diagram is shown in Figure 13.

Figure 12 GSM Module