Radar Belt for the Visually Impaired

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Abstract A person who is partially blind finds it difficult to maintain daily activity, and many challenges arise when they are moving from one location to another. The most crucial one is recognizing obstructions while they are moving. They frequently run into poles, walls, cars, and other road users because they are unable to see, which can cause severe injuries. Therefore, it is crucial to introduce portable devices to assist this group by being able to provide the appropriate information, at the appropriate location, in the appropriate manner. Electronic travel aids (ETAs) have become more common and have excelled at helping the sight handicapped navigate. The methodology used to implement an ultrasonic sensor system that helps visually impaired people navigate unfamiliar environments safely is presented in this research. The aim of this study is to develop a more efficient tool for visually impaired person. The system reacts to nearby obstacles by using ultrasonic sensors and generates vibration using a vibrating motor belt to achieve high performance, low power consumption, and portability. In the final section, reports the experimental findings from fifteen (15) person under situations with various barriers. These outcomes demonstrate good performance and participant acceptance, emphasizing the simplicity of following instructions and the brief training period.

Keywords: Visually impaired, Ultrasonic sensor, Electronic Travel Aid (ETA)

1. Introduction

Globally, 2.2 billion people have vision impairment or blindness, according to the World Health Organization [1][2]. Blindness is divided into two categories: full blindness and partial blindness. People who are partially blind can see partially or have other eye conditions that cause visual problems. Partial blindness is caused by weakened optical nerves, while full blindness is caused by persistent eyesight impairment. Nothing could be seen in that state, and it was difficult to move. A blind person or assistive device is required to walk them through the directions. Blind persons commonly utilize the

cane as a guiding aid. The cane usually suffices in a familiar travelling area and atmosphere. In an unfamiliar situation, the person may become confused and require additional assistance.

Numerous persons who have vision issues have found it difficult to travel freely. Many tools are available to assist people in their mobility, depending on their needs. One method is to have an expert coach child to walk independently [3]-[5]. However, the training is very expensive, and not everyone can afford it. Another option is to train a dog to assist humans in navigating the trail. However, training the dog is an expensive endeavor in and of itself. Furthermore, the added responsibility of caring for a dog will make it a difficult task [6]-[8]. The lifespan of a dog is restricted to only ten years.

All of this adds to the methods complexity and cost. Many innovative technologies have recently been invented to help blind individuals move around. Electronic devices, sensors, and signal processors are the most common [9]. Electronic Travel Aid (ETA) gadgets is the name used for it. Many studies have divided ETAs into two categories: 1) sensor input and 2) camera input. These devices work in the same way that a radar system does, using ultrasonic or similar rays to identify the object's height, direction, and speed. The time it takes for the wave to travel can be used to calculate the distance between objects and obstacles.

Sensors collect all reflecting signals and, if an object is present, it will analyze its distance using an Arduino microcontroller. If anything is detected in the vicinity of the sensors, the microcontroller will trigger the coin vibration motor to inform the visually impaired person. Furthermore, a cane or other expensive tools are not required. The individual only needs to wear the belt. It's low-cost and ideal for real-time applications.

2. Methodology

2.1 Radar belt system

The developed radar belt system's overall flowchart, which incorporates an ultrasonic sensor, is shown in Figure 1. This straightforward circuit, which is attached to an Arduino nano microcontroller, begins by initializing the port that has already been declared using the Arduino IDE. The radar belt's body is then configured to accommodate an ultrasonic sensor at a specific angle. The ultrasonic sensor's job is to find obstacles within its line of sight. The coin vibration motor will activate when the ultrasonic sensor detects an object between 60 cm and 80 cm away, acting as an alarm warning that an obstruction is ahead. The user will then move in response to the vibration motor's warning.

The project's most crucial phase is hardware development. For the development of this device, there are three main elements that are crucial. In this project, the ultrasonic sensor serves as an input component. It is used to calculate the distance to obstacles. The Arduino nano microcontroller, which serves as the project's brain, comes in second. The microcontroller contains all the programming. The final component of this system that produces output is the coin vibration motor. The user will then be informed of any impending barriers by all these outputs.

In a variety of environments, the adaptable HC-SR04 ultrasonic sensor can measure distances without the need for human intervention. It can only measure distances to within 3 mm between 2 and 80 cm [10]. The ultrasonic sensor is employed in this system to find approaching obstacles. The basic speed, distance, and time formula is used to calculate the distance and is as follows:

$$Distance = Speed \times Time \qquad\qquad (Eq.1)$$

The Arduino nano is a compact, comprehensive, versatile, and breadboard friendly Microcontroller board based on the ATmega328p. It was designed by Arduino.cc in Italy in 2008 and includes 30 male I/O headers set in the DIP30 manner. There are 14 digital pins, 8 analogue pins, 2 reset pins, and 6 power pins on the Arduino nano. The Arduino IDE, which can be downloaded from the Arduino website, is used to program it. The Arduino nano is a smaller version of the Arduino UNO, and the two boards have nearly identical functionality. It has a 5V operational voltage, however the input voltage

can be anywhere between 7 and 12V. The maximum current rating of the Arduino nano is 40mA, so the load connected to its pins should not drain more than that [11]. This system uses a Linear vibration motor (LRA) provides faster response time and longer usage life when compared with ERMs. As such, linear vibration motor (LRA) is more commonly used in handsets, wearable vibration, mobile phone vibration. Moreover, linear vibration motors (LRA) are capable of vibrating at a steadier frequency with less power drain, delivering better quality for the handset haptics experience [12]. Figure 2 shows the project flow of radar belt system.
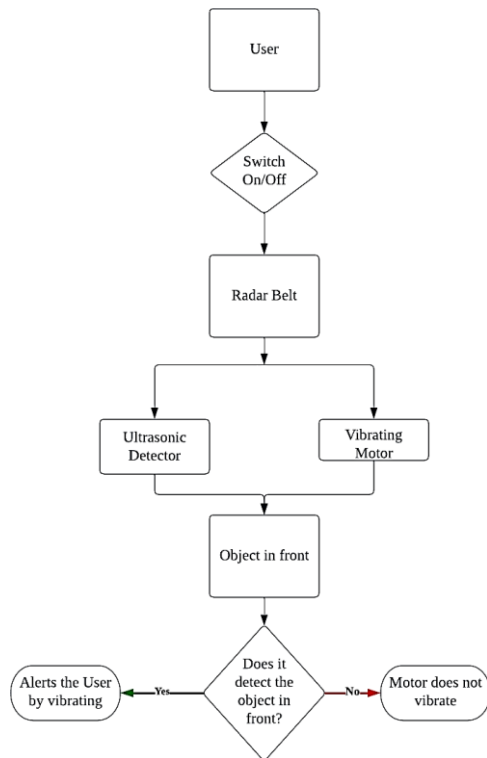

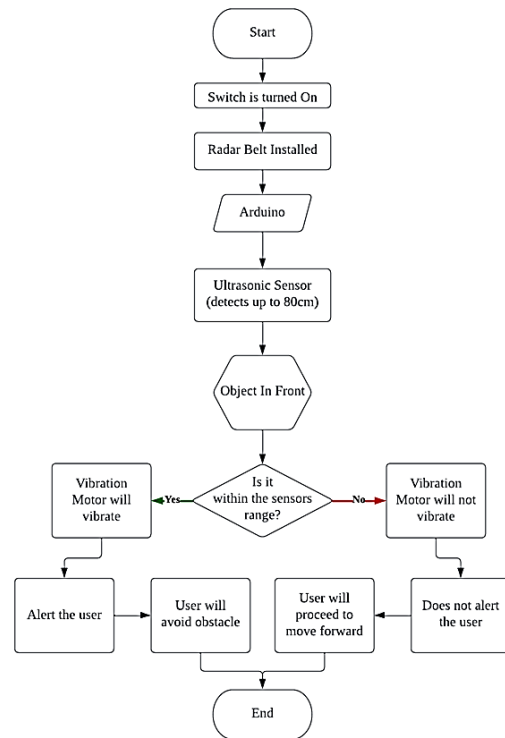**Figure 1: Block Diagram of radar belt application**

Figure 2: Project flow of radar belt system

2.2 Materials and method

The hardware and software development components of the radar belt system project can be separated into two main categories. All the hardware elements used in this project are included in the hardware development section. An ultrasonic sensor, Arduino nano microcontroller, coin vibration motor, and battery/power supply are a few of the parts. Software for designing circuit layouts is created using Proteus as in Figure 3, and programming is done using the Arduino IDE. Figure 4 shows the hardware connection of the system.
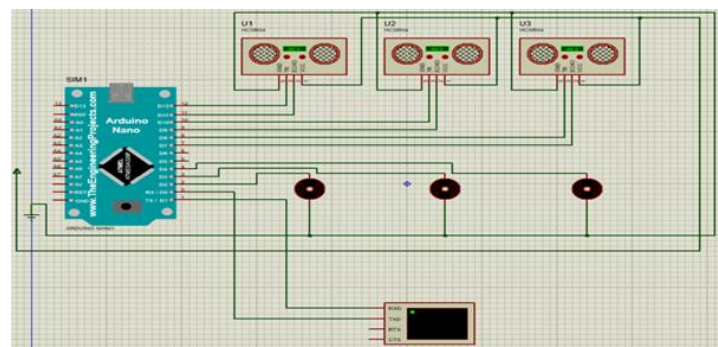

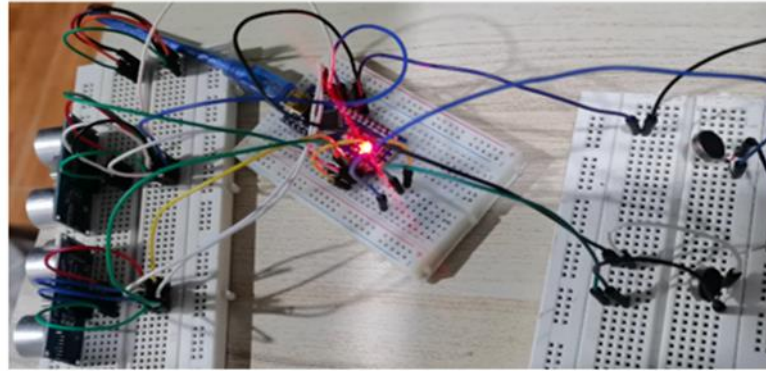**Figure 3: Proteus design of radar belt system**

Figure 4: Hardware connection radar belt system

2.3 System performance evaluation

2.3.1 System sensitivity and response time

The same experiment is repeated three times using battery- and USB-powered devices to test the ultrasonic sensor's sensitivity. The object in front is set to be detected at 60 cm for Sensors 1 and 3, and 80 cm for Sensor 2. As a result, the experiment is run a total of six times consecutively to evaluate the sensor's sensitivity. The experiment was repeated numerous times to check that the radar belt operates as predicted, just like in the computer simulation, and to test the transmission time for the receiver to detect an object and the coin vibration motor to trigger. In addition, fifteen (15) examinees were asked to test the radar to determine if the radar belt can be used successfully.

3.   Results and Discussion

The radar belt system is expected to fulfil all necessary goals and requirements. At the conclusion of this project, a set of data will be generated by testing the radar belt on the examinee using various types of obstacles, and the examinee will demonstrate whether the sensor can detect objects within its detection range. The usage of the radar belt, which is intended for one standard height, may be impacted if volunteers are higher or lower than that height.

3.1 System overview

A few factors involving system stability and test subject feedback affect the system's outcomes. To better understand how the system detects an object in its environment, it also includes a prototype design of the system. The primary goal of this portable, automated prototype is to help visually impaired people move through their environment without running into nearby objects. According to the prototype's design, three sensors are positioned 180 degrees apart on the belt. While sensor 2 is angled downward at a 65° placement, sensors 1 and 3 have a 60cm range and are placed in a straight line to detect obstacles that are in front of the user. This will guarantee that the sensor will be able to detect objects at the front and ground level. The prototype designs are shown in the Figures 5 and 6. Only three sensors were used for this project because more would have resulted in inadequate power for the sensor, which would have prevented it from detecting objects in front and caused the vibrating motor to vibrate slowly.
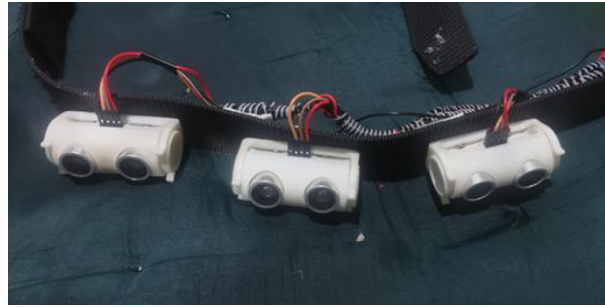
Figure 5: System front view

Figure 6: Complete product of radar belt

3.2 System performance

3.2.1 The sensitivity of the ultrasonic sensor in detecting object.

The most important step in this system is to measure the suitable range for the user from the object in front. This experiment is carried out in various places to test the radar belt's efficiency on detecting various object in everyday lives. As the sensor detects an object and passes the acquired value, in our case, 60 cm and 80 cm, the coin vibration motor would emit a vibration to alert the user.

The calibration of the ultrasonic sensor is checked by running the same experiment to see if there is any error occurred in detecting the range of an object which has been set to 60 cm for sensor 1 and sensor 3, and 80 cm for sensor 2. Therefore, the experiment is repeated in a total of six times with battery powered and USB powered in a row to determine the sensitivity of the sensor. Table 1 shows how the sensitivity of the ultrasonic sensor is tested.

Table 1: The sensitivity of the ultrasonic sensor in detecting obstacle.

		Distance detected by the ultrasonic sensor, (cm)		
USB Powered	Sensor 1	64.5cm	64.5cm	64.4cm
	Sensor 2	86.5cm	87.1cm	85.8cm
	Sensor 3	64.4cm	64.3cm	64.2cm
Battery Powered	Sensor 1	64.0cm	63.5cm	64.5cm
	Sensor 2	82.0cm	83.1cm	83.6cm
	Sensor 3	64.4cm	63.5cm	64.0cm

3.2.2 Obstacle detection setting.

Table 2 shows the result of participants testing the radar belt using different type of obstacles and the trial shows if the sensor can detect objects in the sensor's range. While Figure 7 shows five different types of area used to test if the radar belt can detect objects in the sensor's range. This shows that the area in Field has the highest percentage of 90% detection accuracy compared to the others. Trees and common things can be detected more clearly than sewage drains or other impediments.

Table 2: Obstacle Used for the experiment.

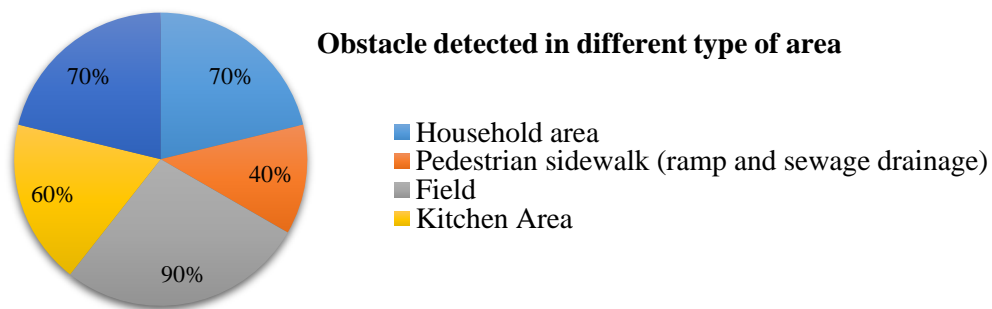| Type of obstacle	Trial										Percent of success
Household area	✓	✓	✕	✓	✕	✓	✓	✓	✕	✓	70%
Pedestrian sidewalk (ramp and sewage drainage)	✕	✓	✓	✕	✕	✓	✕	✕	✓	✕	40%
Field	✓	✓	✓	✓	✓	✓	✓	✓	✓	✕	90%
Kitchen Area	✓	✓	✓	✓	✓	✕	✓	✕	✕	✕	60%
Pedestrian sidewalk (Lamp Pole)	✓	✓	✕	✓	✕	✕	✓	✓	✓	✓	70%

Figure 7: Percentage of obstacle detected in different type area.

3.3 Obstacle detection setting

Table 3 highlights the participants response and feedback when using the radar belt. Using the feedbacks given, the radar belt was tweaked and improved to fix the incomplete product. Figure 8 shows the way on how to wear the device correctly.

Figure 8: How to properly wear radar belt.

Table 3: Feedback from participants during radar belt test.

Name	Gender	Height	Weight	Feedback
Person 1	Male	161cm	78kg	Works ok
Person 2	Male	175cm	90kg	Feels like the distance of the sensor needs to be increased.
Person 3	Male	163cm	50kg	Even in the absence of an obstacle, the left sensor continues to vibrate.
Person 4	Male	163cm	66kg	There is a delay before the left sensor stops vibrating.
Person 5	Male	163cm	55kg	For a brief second, all three sensor vibrates
Person 6	Male	168cm	58kg	The middle sensor tends to vibrate suddenly.
Person 7	Male	184cm	57kg	The left sensor keeps vibrating.
Person 8	Male	152cm	57kg	All okay, but sometime the vibration is weak.
Person 9	Male	162cm	63kg	The hand position is awkward due to the position of the sensor.
Person 10	Female	159cm	48kg	The sensor cannot detect far away object, the middle vibration motor is not as strong as the left/right motor.
Person 11	Female	148cm	44kg	The sensor cannot detect far away object, the sensor cannot detect ground surface.
Person 12	Female	167cm	53kg	Sensor needs to be stronger since they are wearing thick clothing.
Person 13	Female	168cm	48kg	All three sensors vibrate when the object is too close, which causes them to become disoriented and anxious.
Person 14	Female	157cm	45kg	If the object is suspended (notice board) the middle sensor cannot detect, sensor needs to be stronger since they are wearing thick clothing.
Person 15	Female	163cm	85kg	For a brief second, all three sensor vibrates even if the object is far.

4. Conclusion

Based on the results of studies that have been done on the radar belt system, all objectives of the project have been achieved regardless of any errors. Each part of this system functioned properly. The ultrasonic sensor was able to detect the distance of the object perfectly which was set at a value of 60 cm for sensor 1 and sensor 3, and 80 cm for sensor 2. If an object passed the value of 60-80 cm, the coin vibration motor would vibrate and if the object was less than 60-80 cm, the coin vibration motor would not vibrate. The limitation of this prototype is that since the creator was responsible for troubleshoot, the sensor's coding and range were best suited for the wearer's height and weight. Therefore, the detection range of the sensor will likely be impacted by the height of the participant. The issue might be resolved by modifying the coding and including a potentiometer, which would allow testers to change the sensor distance range at any moment by adjusting the potentiometer. Finally,

regular wear while using a battery can seriously drain the battery. Only hours can be spent using the radar belt before the battery needs to be changed. Finding a rechargeable battery is advised so that the device is always ready to use.

These functions provided a reliable delivery with a short response time and produced a trustable output for its users. It was able to detect nearby object by using an ultrasonic sensor placed on a belt. Finally, it brilliantly became a pre-warning system for oncoming object when the user is using it to navigate the surrounding area.

Acknowledgement

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