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Technology for SMS-based assistive device for the visually impaired

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ABSTRACT

The term "tunanetra" is used to refer to someone who experiences total blindness or visual impairment. Such visual limitations result in visually impaired individuals facing difficulties in accessing information quickly and performing daily activities like walking, driving, and more. Walking is one of the crucial activities for visually impaired individuals because it is one way to explore the world and engage in daily activities. Based on this issue, an assistive device for the visually impaired was designed using embedded system technology. In 2022, Serly Juliana Taneo, Jonshon Tarigan, Frederika Rambu Ngana, and Andreas Ch. Louk developed a mobility aid device for individuals with visual impairments using ultrasonic sensors for distance detection and Arduino as the microcontroller. However, the device primarily focused on mobility, and there is a need to add new features, such as emergency information using SMS technology that can send messages with the press of a button. The research results indicate that the ultrasonic sensor successfully triggers vibrations within a range of 1-100 cm, and the button can send emergency notifications via SMS when pressed. Therefore, it can be concluded that all connected components can function as intended. By combining SMS technology and ultrasonic sensors, this assistive device is expected to enhance the safety and independence of individuals with visual impairments as they navigate their surroundings.

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1. INTRODUCTION

As science advances, technological progress is one of the inevitable outcomes because technological advancements proceed in line with the progress of science[1]–[3]. Every technological innovation is designed to simplify and provide benefits to human life, thus offering solutions to many problems, including assisting the daily lives of visually impaired individuals with limited physical capabilities.

Tunanetra is a term used to refer to someone who experiences total blindness or visual impairment [4]–[6]. This blindness can be caused by genetic factors, accidents, or specific diseases. Visual limitations like these result in tunanetra individuals facing difficulties in accessing information quickly and performing daily activities such as walking, driving, and more. One of the crucial activities for tunanetra individuals is walking because it is one way to explore the world and engage in daily activities. To perceive their environment, individuals with visual impairments can rely on their remaining senses or use a cane as a directional aid [7]–[9].

To assist individuals with visual impairments in walking, they use aids such as a cane. However, conventional aids like these provide only limited and less specific information, making them unreliable. One solution that can aid visually impaired individuals is the use of SMS technology. This technology is a wireless short message service accessible by almost all types of mobile phones, allowing communication with others without the need for internet access or social media [10]–[12]. By harnessing this technology, visually impaired individuals can send emergency text messages by simply pressing one button, allowing the recipient to take further action.

In addition to SMS features, ultrasonic sensors can also be used to assist visually impaired individuals in detecting objects in front of them. Ultrasonic sensors are electronic devices that use ultrasonic waves (sounds above the human hearing range) to detect the distance or presence of objects [13], [14]. The working principle of ultrasonic sensors is similar to sonar or radar. These sensors generate ultrasonic sound waves and measure the time it takes for the waves to bounce back after hitting an object [15], [16]. Based on the sound wave's travel time, ultrasonic sensors can calculate the object's distance from the sensor. Furthermore, the SMS-based emergency button feature is a key component of this assistive device. By pressing the emergency button, users can quickly send SMS messages to parties that can provide assistance or emergency notifications. This is crucial in emergency situations or when users feel unsafe.

In 2022, Serly Juliana Taneo, Jonshon Tarigan, Frederika Rambu Ngana, and Andreas Ch. Louk developed a mobility aid for individuals with visual impairments using ultrasonic sensors for distance detection and Arduino as the microcontroller. The results of their research indicated that the visually impaired cane worked effectively in detecting objects by providing alerts to the user when objects were within a range of 2 to 100 cm in front of them. However, the device primarily focused on mobility, and there is a need to add new features, such as emergency information using SMS technology that can send messages with the press of a button. By combining SMS technology and ultrasonic sensors, this assistive device is expected to enhance the safety and independence of individuals with visual impairments as they navigate their surroundings.

Based on this issue, the author will design and build a prototype assistive device for visually impaired individuals to access necessary information easily and quickly. This will be achieved by utilizing ultrasonic sensors and a buzzer as directional guidance, as well as SMS and GPS features to provide location coordinates if visually impaired individuals become lost, which can be activated by pressing a button on the mobility aid. This assistive device will be designed with user-friendliness in mind to ensure that it can be used by visually impaired individuals with ease and comfort. With the presence of this assistive device, it is hoped that it will enhance the quality of life for visually impaired individuals and assist them in accessing information more easily and quickly.

2. METHOD

In this section, we will discuss the research planning related to the development of an innovative mobility aid for the visually impaired. It will outline the steps to be taken, including the research phases, component selection, and system algorithms.

2.1 Research Phases

The research phases are divided into four sections: Problem, Designing, Data Processing, and Conclusion, in accordance with the order displayed in Figure 1 as follows.

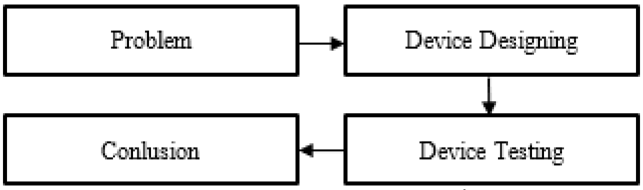

Figure 1. Research phases

Here is a brief explanation of each of these stages:

1) Problem: In this initial stage, the research begins by identifying the issue to be investigated. This involves selecting a relevant research topic and developing a strong theoretical foundation. The primary focus at this stage is to have a clear understanding of the research problem that needs to be addressed.
2) Device Designing: Once the research problem is identified, the next step is to design the device or instrument that will be used in the research. This includes material selection and planning the operation of the device. The design of this device is crucial as it will impact the success of the experiment.
3) Device Testing: After the device is designed, the next stage is to conduct testing. This involves testing the functionality of the designed device.
4) Conclusion: The final stage of this research involves analyzing the testing results. This conclusion will provide an overview of the strengths or weaknesses of the created device.

2.2 Components

The research components include the hardware used to build the system. The system components can be seen in table 1.’

Table 1. System components

No	Hardware Name	Function	Quantity of Items
1	Mikrocontroller Arduino Nano	The microcontroller that will control all the operations of the mobility aid.	1
2	*Ultrasonic* HC-SR04	Detecting objects around the user	1
3	SIM800L V2.0	Used for cellular communication.	1
4	Button	Used as an emergency button in the system	1
5	Vibration	As a component that will provide haptic feedback to the user.	1

2.3 Flowchart

A flowchart is a visual representation or diagram used to depict the sequence of steps or processes in a system, algorithm, or task [17], [18]. Below is the flowchart for the single-axis solar tracker, which can be seen in figure 2:

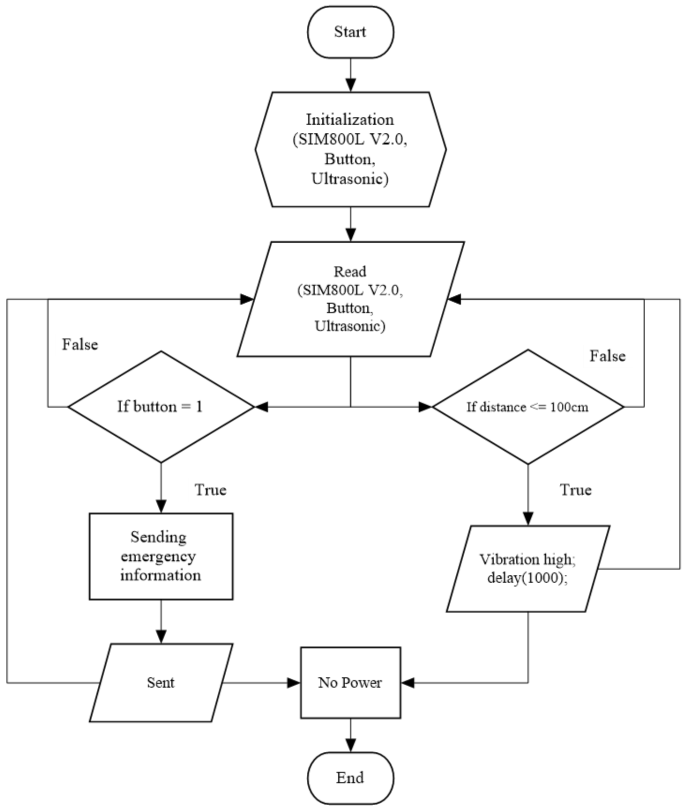

Figure 2. Flowchart

Here is the description of the flowchart in Figure 2:

1) Initialization: The system starts with initialization and initial setup. This includes configuring the pins on the microcontroller, such as pin settings for buttons, sim800L V2.0, ultrasonic sensor, and vibration.
2) Reading Buttons: The system continuously monitors the button's status. If a button is pressed, the next steps will be executed.
3) Sending Emergency Notification via SMS: After a button press, the system sends an emergency notification message to family or friends integrated into the system for assistance.
4) Measuring Ultrasonic Distance: While the system waits for a button press, the ultrasonic sensor continues to measure the distance to the nearest object. This distance data will be used for further decision-making.
5) Distance Checking: The system checks the distance value measured by the ultrasonic sensor. If the distance is <= 100 cm, the vibration will be activated with a 1-second delay.
6) Stopping Vibration: After the appropriate action is taken based on the distance measurement results, the system turns off the buzzer.

Back to Reading Buttons: The system returns to the initial step of monitoring the button's status. This process continues continuously and stops when it no longer has power.
With this flowchart, the system will continuously monitor buttons and the ultrasonic sensor. When a button is pressed, it will send an emergency notification via SMS, and the ultrasonic sensor will trigger vibration sound based on the predefined distance limit.

2.4 Block Diagram

A block diagram is a visualization used to illustrate the main components in a system or process [19], [20]. Each component has its specific role, and with the help of a pre-made block diagram, the design process can be initiated. Below is a block diagram representation for this system, available in Figure 3 as follows.

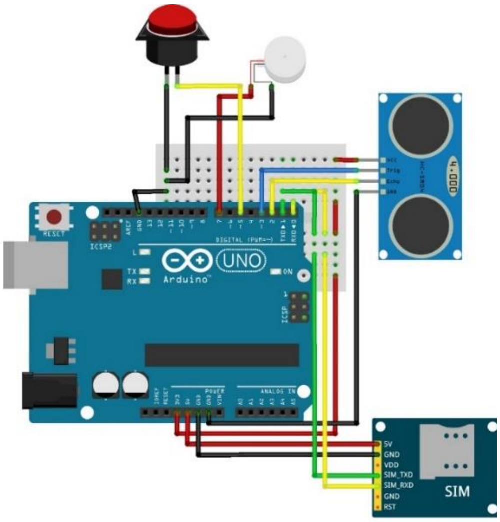

Figure 3. Block diagram

The explanation of pin allocation in the circuit of Figure 3 can be seen in Table 2 below.

Table **Error! No text of specified style in document.**. Pin assignment

Microcontroller	Pin		Components
Arduino Nano	D3	Trig	Sensor *Ultrasonic* HC-SR04
	D2	Echo	
	3.3V	Vcc	
	Gnd	Gnd	
Arduino Nano	D4	*Signal/Vin*	*Buzzer*
	Gnd	Gnd	
Arduino Nano	D7	*Signal/Vin*	*Vibration*
	Gnd	Gnd	
Arduino Nano	Rx	Rx	SIM800LV2
	Tx	Tx	
	5V	Vcc	
	Gnd	Gnd	

2.5 Testing Plan

The testing will be carried out by conducting a series of experiments to assess the functionality and performance of the mobility aid for the visually impaired. The process involves validating the ultrasonic sensor's ability to detect objects, ensuring the appropriate response when the emergency button is pressed, and calibrating the sensor for accurate distance measurement. The results of these tests will serve as the basis for ensuring that the mobility aid functions reliably and provides the expected benefits to the users.

3. RESULTS AND DISCUSSIONS

In this section, the research findings are explored by conducting tests on the designed system. The research tool can be seen in Figure 4.

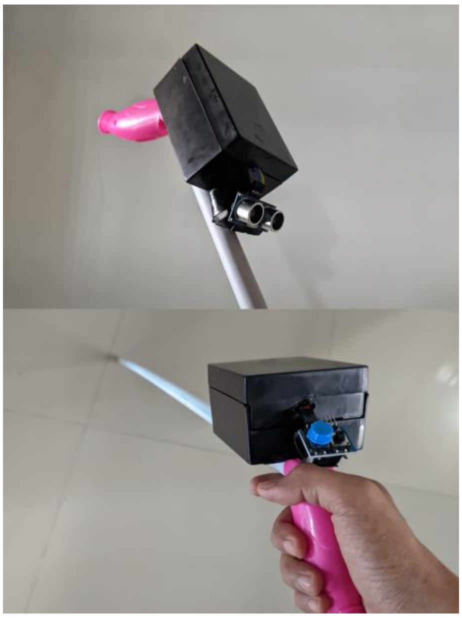

Figure 4. Prototype device

The prototype device has a pole made of polyvinyl chloride (PVC), a plastic cover for the electronic circuitry, and a plastic handle on the pole. The handle on the pole is used to facilitate the user's grip and ensure they hold the device correctly.

3.1 Testing

The first test is conducted by calibrating the sensor's distance measurement to determine if there is any error in the distance measurement. The calibration process is done by comparing distance measurements using ultrasonic and conventional measuring tools. The calibration process can be seen in Figure 5 below..

Figure 5. The distance calibration process

The calibration process is carried out from a distance of 1cm to 100cm by comparing distance measurements using the ultrasonic sensor and a conventional measuring tool like a ruler. The purpose of this calibration is to determine whether the distance values generated by the ultrasonic sensor align with manual measurements or not. The distance calibration table can be seen in Table 3 below.

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Table **Error! No text of specified style in document.**. Calibration distance data

No	Distance (cm)		Error (%)
	Conventional Measuring Tool	*Ultrasonic* HC-SR04	
1	1 - 10cm	1 - 10cm	0%
2	11 - 20cm	11 - 20cm	0%
3	21 - 30cm	21 - 30cm	0%
4	31 - 40cm	31 - 40cm	0%
5	41 - 50cm	41 - 50cm	0%
6	51 - 60cm	51 - 60cm	0%
7	61 - 70cm	61 - 70cm	0%
8	71 - 80cm	71 - 80cm	0%
9	81 - 90cm	81 - 90cm	0%
10	91 - 100cm	91 - 100cm	0%

After calibrating the sensor for distance measurement, the next step is to test the emergency short message service (SMS) delivery to determine whether the button can trigger the SIM800L to send an emergency SMS message. The notification of the emergency message being sent can be seen in Figure 6

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Figure 4. Emergency message

In Figure 6, it is evident that the message was successfully sent when the button was pressed, accompanied by the message sound, “SOS! Saya memerlukan bantuan darurat segera hubungi saya!”.

After testing the emergency message, a test is conducted on the vibration actuator to determine whether the actuator can activate according to the given command or not. The process is carried out by testing at distances ranging from 1-150cm. The vibration actuator test results can be seen in Table 4 below.

Table 4. Vibration test

No	Distance	*Vibration*
1	1 - 10cm	Active
2	11 - 20cm	Active
3	21 - 30cm	Active
4	31 - 40cm	Active
5	41 - 50cm	Active
6	51 - 60cm	Active
7	61 - 70cm	Active
8	71 - 80cm	Active
9	81 - 90cm	Active
10	91 - 100cm	Active
11	101 - 120cm	Inactive
12	121 - 130cm	Inactive
13	131 - 140cm	Inactive
14	141 - 150cm	Inactive

In Table 4, it is evident that the Vibration actuator can work according to the given command. Next, a functional table is created to show the success of each component's operation. The functional table for this testing can be seen in Table 5.

Table 5. Functional test

No	Components Name	Components Function	Identification	Input Voltage
1	Arduino Nano	Giving commands to the system so that it can dry coffee beans.	Successful	5V
2	Sensor *Ultrasonic* HC-SR04	Detecting the distance of an object.	Successful	5V
3	SIM800LV2	Sending emergency notifications in the form of short messages.	Successful	5V
4	Vibration	Vibration actuator.	Successful	5V
5	Button	Sending a message when the button is pressed.	Successful	3.3V

The table indicates that all components connected to the electronic circuit have been successfully used according to their functions. All system components involve verifying the function of each element involved in the mobility aid device. First, the Arduino was evaluated to ensure that it functions as the main microcontroller capable of coordinating the overall system operation. The ultrasonic sensor was then tested to check its ability to accurately measure distances, which is crucial for detecting objects around the user. Next, the SIM800LV2 module was tested to ensure its ability to effectively send emergency SMS messages. The vibration actuator was tested to ensure that the user would receive appropriate haptic feedback when objects approached. Finally, the button, which serves as the emergency information trigger, was tested to ensure its responsiveness when pressed, allowing users to easily utilize the emergency feature.

4. CONCLUSION

In this research, we have successfully designed and integrated all components of the mobility aid system for the visually impaired. All components, including the Arduino Uno, HC-SR04 Ultrasonic Sensor, SIM800L V2.0 GSM Module, and vibration actuator, have functioned well in functional testing. The ultrasonic sensor can detect objects up to 100cm with adequate accuracy, and the vibration actuator responds well when objects are detected, or the emergency button is pressed. The GSM module can successfully send emergency SMS messages to the designated recipients. Testing also included the calibration of the ultrasonic sensor's distance measurement to ensure accuracy. Based on the device created in this research, it is expected to provide a positive contribution in improving the mobility and quality of life for individuals with visual impairments.

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