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Smart Blind Stick using Mobile Application and Bluetooth Module

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Abstract : There are many visually challenged people in our world. According to the World Health Organization (WHO), 285 billion people are visually impaired, and 39 million are irreversibly blind. They face many difficulties in daily life. This paper presents the smart blind stick to determine the obstacles such as stairs up/down, walls, sidewalks, holes, and water puddles. In addition, there is a button with pressing, the proposed stick can detect any motion if a user is alone anywhere. There is also a help button for sending the user's location to his friends. The proposed system permits people's attention to blind people walking in the street at night or in dark places by giving warning flashlights. The proposed model comprises four ultrasonic sensors, a PIR sensor, an IR sensor, a rain sensor, and an LDR sensor as inputs for Arduino Mega. Also, a vibration motor, buzzer, and voice messages are used as output for Arduino Mega. Bluetooth Module linked the proposed stick and mobile applications. The mobile application was used to give sound messages for each obstacle, send the user’s location to his friends in the helping case, and know the stick's place by pressing twice on any area on the mobile screen where the stick buzzer is operated. The proposed stick used a Lithium-Ion rechargeable battery with an operation time of 2.30 to 3.30 hours according to use. The proposed stick is safe, low cost, high accuracy, and has low power consumption, as it is easily available to blind people.

Keywords: Smart blind stick, Walking stick, Bluetooth module, Mobile application.

1. INTRODUCTION

A frequent disability among people all around the world is blindness. 285 million people worldwide have visual impairments, including 246 million who have limited vision and 39 million who are blind, according to WHO [1]. Around 90% of those who are blind or visually impaired reside in developing nations. Blindness is a problem for the poor and those who live in isolated rural areas because they require assistance to do all of their everyday tasks, including working outside. Therefore, researchers are constantly trying to create devices to help them and enable them to know obstacles, especially fixed obstacles with high accuracy and low consuming power. In this study, a system is highlighted to free people from the curse of blindness and make them responsible for their daily tasks. For blind people, mobility in unfamiliar places may be difficult. To solve the various problems that appear in front of people with blindness, calculating the distance between the stick and the obstacle is the basis for this project. An integral part of this system is the embedded system. Similar to radar or sonar, ultrasonic sensors assess a target's characteristics by analyzing the echoes of radio or sound waves, respectively [2]. High-frequency sound waves are produced by ultrasonic sensors, which then analyze the echo they hear back. To compute the distance to an object, sensors measure the time between transmitting a signal and getting an echo sending that signal to embedded systems [2]. The research on this topic needs to develop a walking stick substitute for blind people. Thus, smart blind stick developments from 2018 to 2024 are presented in the next section.

2. RELATED WORK

In 2018 an ultrasonic sensing system was created using an Atmega32 controller that detects the object in the right, left, and forward directions. When obstacles are detected, the vibration motor installed on the stick is activated, but

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its disadvantage is 2% accuracy. It can't identify the type of obstacle and recognize obstacles less than 50 cm long. They also installed an emergency button and the time for sending an SMS takes about 6-10 seconds after pressing on the emergency button [3].

In 2019, images of obstacles are captured by a camera and the captured information is sent to a backend application. The backend application then talks to an artificial intelligence system to classify this information and generate a mostly accurate description, as a form of audio file retransmission to Raspberry Pia, and to describe the obstacles to people with visual impairments. Analysis: The time it takes to walk one block is 5 minutes (1 block = 660 feet). The four photos are taken every minute. This stick can detect most obstacles that stand in a person's way with the help of various sensors, but it can only identify specific obstacles. Also, the body must be fixed and it can't detect water. [4].

In 2020, there is an ultrasonic sensing system and this method uses Arduino UNO as a controller. When obstacles are sensed, the sensor passes data to the microcontroller. It can only detect the object but can't determine the type of obstacle. After several experiments with the system on the smart white cane, the following can be concluded: Object detection using ultrasonic sensors works well and is stable with two distance conditions, 1–90 cm, and 90-180 cm. However, its disadvantage was that it could not know the type of obstacle [5].

In 2021, obstacles are detected by the HC-SR04 ultrasonic sensor unit, and all warnings are issued via receive SMS from the patient with location. This system was implemented using an Arduino UNO microcontroller. However, its flaws cannot determine the type of obstacles and structure [6].

In 2022, an ultrasonic sensor system was created using a control unit Raspberry and Arduino UNO. In this system, a water detector is used, and a GSM with a controller for sending location. Also, it has a long battery life but the type of obstruction can't be determined [7].

In 2023, the blind stick was presented to detect a few obstacles using (Arduino Nano), Ultrasonic, and LDR. Some of its drawbacks are not suitable for up and downstairs and didn't know the types of obstacles [8].

In April 2023, Arduino, an ultrasonic sensor, camera, and IVR System were used to find some obstacle types but it was not suitable for stairs, did not use GPS, and couldn't detect smoke [9].

Another cane in 2023 was designed to detect obstacle detection, define stairs, and send emergency SMS by using Arduino Mega, Three Ultrasonic sensors, and a Bluetooth module. However, it is also not suitable for water puddles, Undefined obstacle types, can't detect smoke, and does not send emergency SMS [10].

In 2024, two ultrasonic sensors, one IR flame sensor, water sensor, PIR sensor, GSM and GPS Module are used for object detection, and staircase detection using Arduino UNO with an average performance rate of 90%. This stick can't differentiate between stairs up or down, and detect any hole [11].

Another stick in 2024, one ultrasonic sensor, LDR sensor, water sensor, GSM and GPS module are used for object detection, water detection, dark detection, and voice guidance using Arduino Nano with an average performance rate of 86.78%. From its drawbacks, obstacles types are undefined, and this stick isn't suitable for stairs and holes detection [12].

It is noticeable that researchers' main and common problem isn't to differentiate between fixed obstacle types, in particular, the stairs up and stairs down. Therefore, our focus in this paper was to differentiate between the stairs up/down, the sidewalk, holes, and the wall. In addition, the proposed model is completely automated, inexpensive, simple to maintain, quite comfortable to use, low power consumption, and simple to operate. These are presented in the next sections.

3. THE PROPOSED SYSTEM

The proposed smart blind stick will work to make it easy for everyone who is blind to walk anywhere they like. Also, the voice commands provided by the navigation system are helpful. It will identify the impediments that blind individuals face. The gadget's panic button, which sends the blind person's position to a predetermined person in case of an emergency or stranded situation, is expected to be its most crucial function.

Figure 1 presents the block diagram of the proposed blind stick model. Arduino Mega represents the key feature of the proposed model, four ultrasonic sensors HC-SR04 are used to detect obstacles' distance (stairs up/down, walls, sidewalks, and holes), and a raindrop sensor is used to detect water puddles. Also, LDR is used to detect dark places and give flashlights to normal people to prevent their collision with the blind. IR sensor represents the proposed stick operation switch, i.e., ultrasonic sensors operated when the stick stands perpendicular to the ground for

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increasing distance measurement accuracy of ultrasonic sensors. The system outputs are a buzzer, DC vibration motor, and voice messages for each case using the mobile application with Bluetooth Module HC-05.
Figure 2 displays the prototype of the proposed stick which contains 3 switches (the stick power switch, PIR switch, emergency or help switch). The four ultrasonic sensor heights on the stick are 85cm, 75cm, 22cm, and 15cm, respectively. Also, the four ultrasonic sensors fixed with angles on the stick are 0˚, 45˚, 0˚, and 90˚, respectively.
For the proposed stick power supply, rechargeable lithium batteries with Li Power – Boost converter are used for a highly reactive substance and are light in weight, which leads to an increase in its energy.

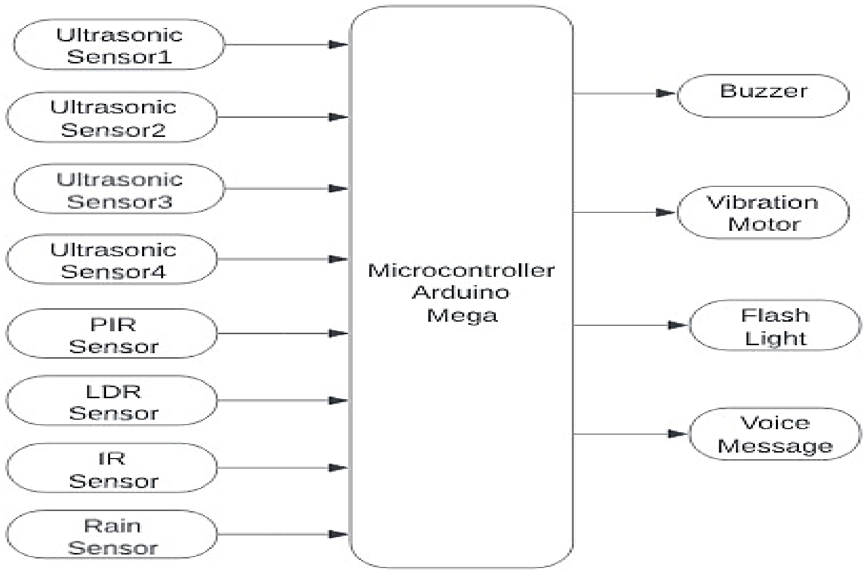

Figure 1: The block diagram of the proposed stick model.

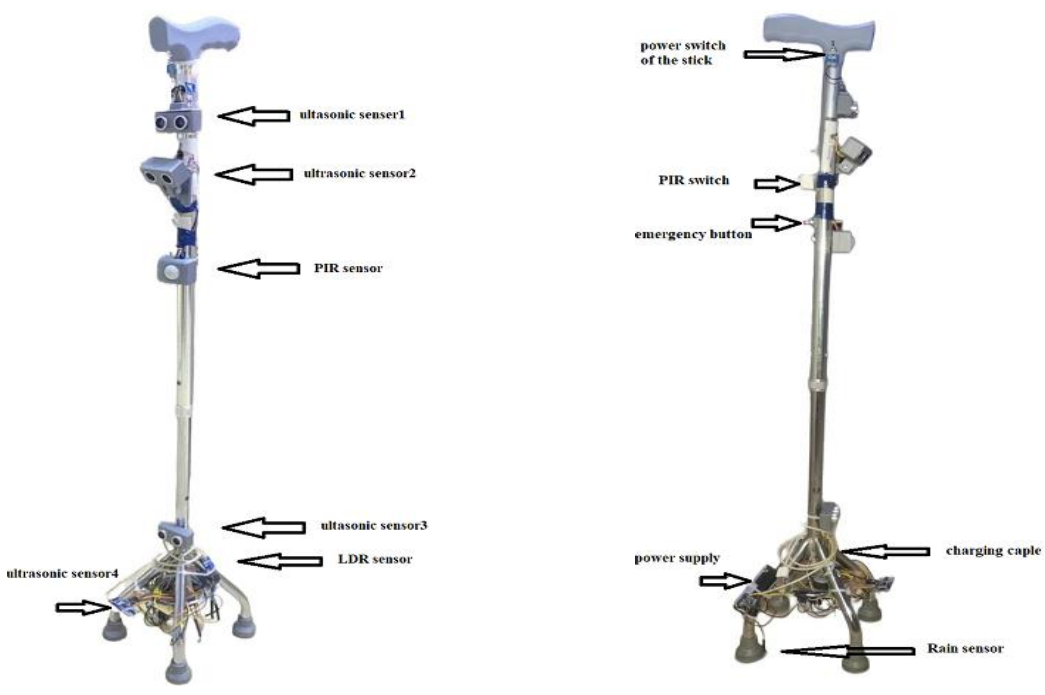

Figure 2: The prototype of the proposed smart blind stick.

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The online Tinkercad simulation program is used to design the circuit diagram of the proposed system as shown in Figure 3.

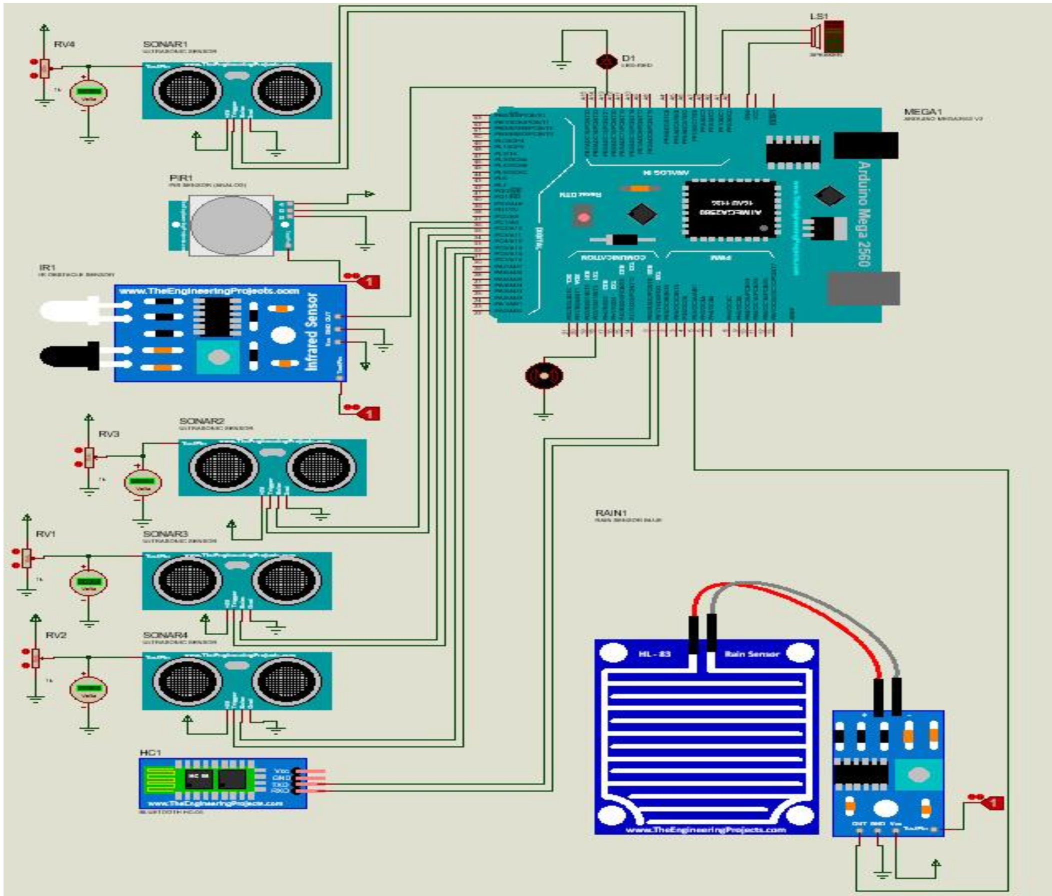

Figure 3: The circuit diagram of the proposed model.

A. how to work the proposed model

A smart blind stick is designed to assist visually impaired individuals in navigating their surroundings. The microcontroller processes the data from the all sensors, interprets the information which is detected by the sensors, and decides to give the correct output to warn the blind man to take care of the obstacles detected.

The Four ultrasonic are input to the microcontroller to detect the different obstacles in the blind man's path like walls, sidewalk, and upstairs by emitting a wave at a speed of sound (340.29 m/s). When the wave collides with an obstacle, it bounces, and the time taken by that wave is calculated from the time of transmission to the time of reception, thus the distance between the blind person and that obstacle is calculated. This sensor provides excellent non-contact range detection from 2 cm to 4 m with a measuring angle of 30º [13, 14].

A passive infrared (PIR) sensor is an input to the microcontroller and is an electronic sensor that measures infrared (IR) from the objects. It is used to detect any motion in front of it, to enable the blind man to know whether there are people around him or not.

Light-dependent resistor (LDR) known as a photoresist is an input of the microcontroller that depends on the amount of light around it as its resistance decreases as the light intensity increases. In the dark and at low light levels, the resistance of an LDR is high, and little current can flow through it. When it detects dark areas, the microcontroller (Arduino Mega) gives the order for operating the flashlight.

The rain sensor is an input to the microcontroller, the principle of operation of the rain sensor is when the water reaches its two ends it causes a short circuit and the circuit is closed, and the current reaches the sensor and gives

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information to the microcontroller to give the command to the vibration motor to work and to the phone to send a voice message to the blind man to alert him that there is water in front of him on the road.

The Bluetooth module enables communication between the smart blind stick and a mobile device (such as a smartphone). It allows for additional functionalities, such as connecting to a smartphone app for more detailed navigation assistance.

The vibration motor is active when any sensor detects any obstacles in the bind man path. It provides haptic feedback to the user to alarm the blind man from the obstacles which is detected by sensors.

The flashlight is a light depending on the LDR sensor when the blind man passes in a dark area and the flash will alarm any person passing around him so as not to crash him.

The voice message is the output of a mobile application which is connected to the microcontroller by Bluetooth module, to allow the blind man to be able to identify the type of obstacle he faces more easily through voice messages that specify to him the type of obstacle in front of him. The buzzer is an output of the microcontroller that works as a sound alarm with different tones when the sensors detect any obstacles in front of the blind man. Figure 4 presents the flow chart of the proposed model.

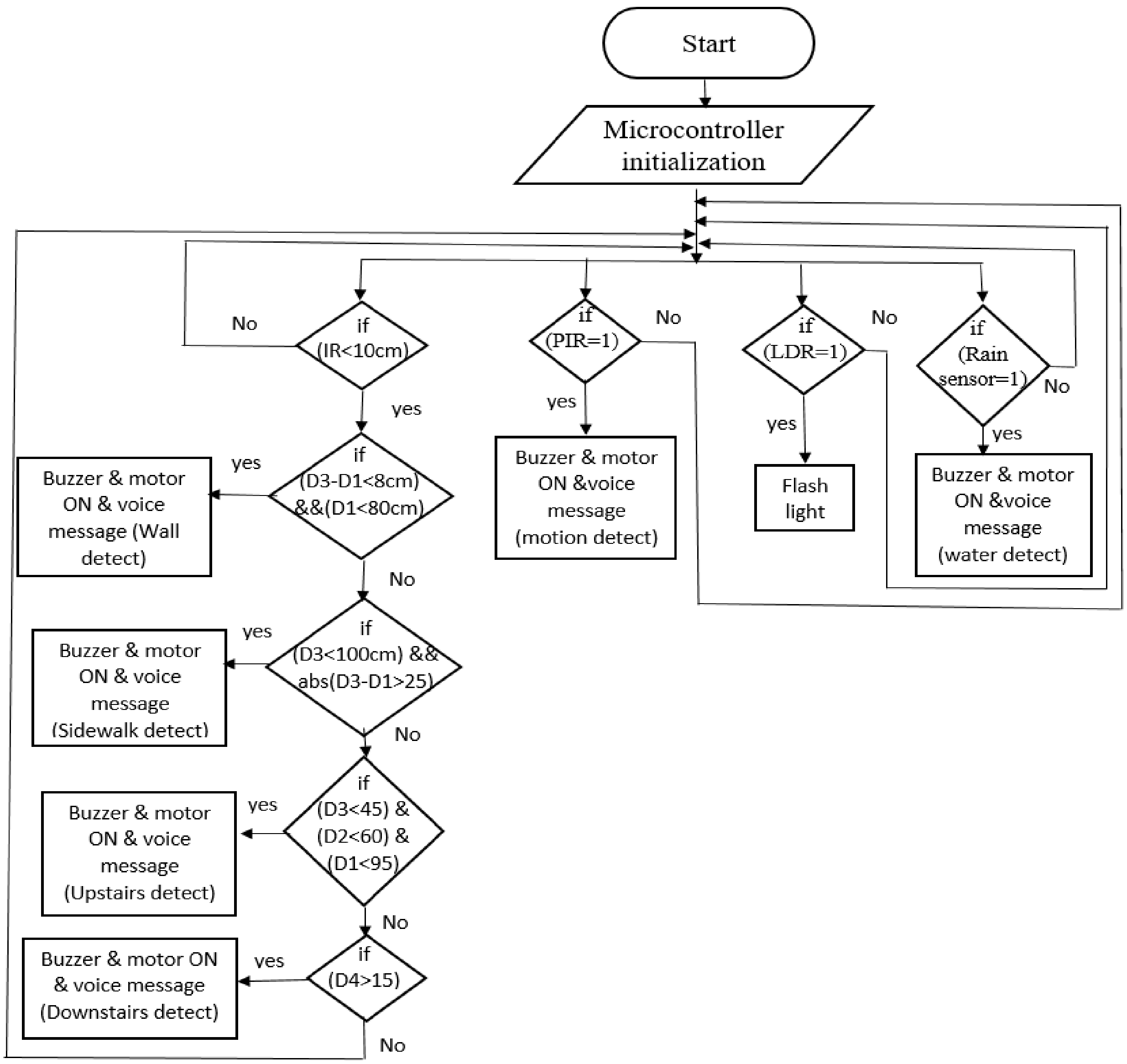

Figure 4: The flow chart of the proposed model.

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From Figure 4, four conditions are used to detect the obstacles:
The first condition is the detection of the wall it happens when the difference between the distance of ultrasonic 3 and the distance of ultarsonic1 is less than 8 centimeters. Also, the distance of ultrasonic1 to detect the wall is less than 80 cm will be enough to enable the blind person to recognize the obstacle (wall) at a sufficient distance to avoid it, (D3-D1< 8 cm) && (D1< 80 cm). This detection output will be shaped in a buzzer, vibration motor, and voice message (beware wall in front of you).
The second condition is the detection of the sidewalk it happens when the distance of ultrasonic3 is less than 100 centimeters and the absolute difference between the distance of ultasonic3 and the distance of ultarsonic1 is greater than 25 centimeters. This difference will be enough to enable the blind person to recognize the obstacle (sidewalk) at a sufficient distance to avoid it, (D3 < 25 cm) && (D3-D1 > 25 cm). This detection output will be shaped in a buzzer, vibration motor, and voice message (beware sidewalk in front of you).
The third condition is the detection of the upstairs it will happen when the distance of ultrasonic3 is less than 45 centimeters, the distance of ultrasonic2 is less than 60 centimeters, and the distance of ultrasonic1 is less than 95 centimeters as the height of the step of the stairs is 15 cm. This detection output will be shaped in a buzzer, vibration motor, and voice message (beware upstairs in front of you).
The fourth condition is the detection of the downstairs or hole it will happen when the distance of ultrasonic4 is larger than 15 centimeters. The distance of ultarsonic4 is greater than 15 centimeters will be enough to enable the blind person to recognize the obstacle (downstairs) at a sufficient distance to avoid it, (D4 > 15 cm). This detection output will be shaped in a buzzer, vibration motor, and voice message (beware downstairs in front of you). We are differentiated between the buzzer tone, and the motor vibrating for each obstacle for attention to the blind man quickly if found any obstacle in front of him.
In addition, using a PIR sensor as a motion detector, If the PIR sensor detects any motions around him, it will give a high value (1) to the microcontroller it will send a voice message to him that a person or an animal is near him. This detection output will be shaped in a buzzer, vibration motor, and voice message (beware of a person nearby you). If the PIR sensor doesn't detect any motions around it, it will give a low value (0) to the microcontroller. Then using the LDR sensor as a light alarm in dark areas, if LDR does not detect any light it will give a high value (1) to the microcontroller and the flashlight will be ON to warn people passing by him that a blind person is passing. If the LDR sensor detects any lights around it, it will give a low value (0) to the microcontroller. In addition, using a rain sensor as a detector of water bulk, If the Rain sensor detects any water in the road, it will give a high value (1) to the microcontroller and it will warn him by sending a warning voice message to him, the buzzer output high, and the vibration motor. If the rain sensor does not detect any water, it will give a low value (0) to the microcontroller. Using an IR sensor as a switch of four ultrasonic, if the distance between the ground and the IR sensor is greater than 10 centimeters, the four ultrasonic will not be operated. If the distance is less than 10 centimeters, means that the stick is in the right position to work then the four ultrasonic will be in active mode to detect. The IR sensor condition is a novelty contribution to the proposed stick, which increases the system's accuracy of ultrasonic threshold selection values.

B. mobile application

A software programmer created to operate on mobile devices like smartphones and tablets is known as a mobile application, or simply just a mobile application with a variety of features and services available to users, these applications are designed to capitalize on the special qualities and powers of mobile devices.
There are several categories into which mobile applications may be divided, such as applications for social networking, productivity, entertainment, gaming, utilities, and much more. Usually, online app shops tailored to each mobile platform such as Google Play for Android devices and the Apple App Store for iOS devices are where you may download and install them. The need for portable and convenient solutions has led to an enormous boom in the creation of mobile apps in recent years, as smartphones have become more and more common.
Mobile applications, which provide answers to a wide range of requirements and interests, have become an essential part of our everyday lives. The ability to use the hardware components of the device, such as the camera, GPS, and sensors, as well as their connection with internet services and cloud-based storage, are essential elements of mobile apps. They frequently have touchscreen-optimized user interfaces that guarantee a fluid and simple user experience.

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Each platform-specific programming language, framework, and tool used in the creation of mobile applications is different (iOS, Android, etc.). Programmers use languages like Java or Kotlin for Android, Swift or Objective-C for iOS, and other web technologies for cross-platform development to create apps.

The potential and capabilities of mobile apps are growing as mobile technology develops, resulting in creative solutions that improve user experience, productivity, communication, and entertainment. The ever-evolving demands and tastes of consumers are met by the frequent release of new applications and updates, which are made possible by the dynamic nature of the mobile app ecosystem.

The mobile application in the smart blind stick plays an important role in enhancing the functionality and usability of an advanced assistive device to help blind people detect the obstacles they face.

The mobile application serves as a control system to give the right detect sound messages to the blind man to make him able to avoid obstacles.

The main features of mobile applications for the smart blind stick such as,

- Connectivity: the application provides a smooth and facile connection with the smart blind stick through a Bluetooth module.
- Navigation Assistance: the application guides the blind man through voice messages putting them in the app store and calling the right voice message for the right obstacles.
- Location information and Emergency Assistance: The application uses GPS to determine the location of the blind person to determine his location if he encounters any difficulties, and the location is sent to the number of another person who identifies him via an SMS message.
- The customization: Users can alter settings according to their preferences. This includes changing the feedback systems, sensitivity levels, and overall user experience.
- Battery Status: The application can display the battery status and age to inform the blind person of its condition and the need to recharge it.

4. RESULTS AND DISCUSSION

Firstly, click on any place on the mobile screen to open the mobile application and link it with the proposed stick, and the stick buzzer operates as a working indication as shown in Figure 5.

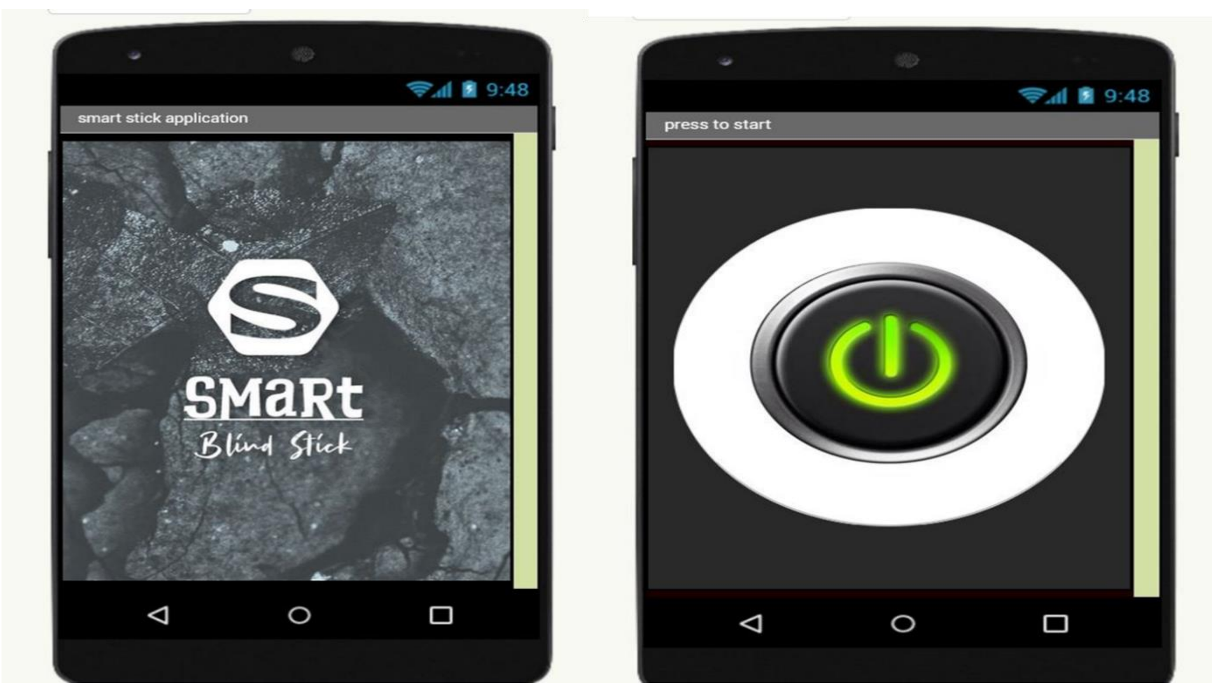

Figure 5: Mobile application.

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We can use the terminal application to save the results detected in a previous time. To show us the obstacles that have been discovered a previous time, to know what happens if the blind person collides, or if the stick helped him to discover obstacles. Also, all the results are shown on the screen, as shown in Figure 6.

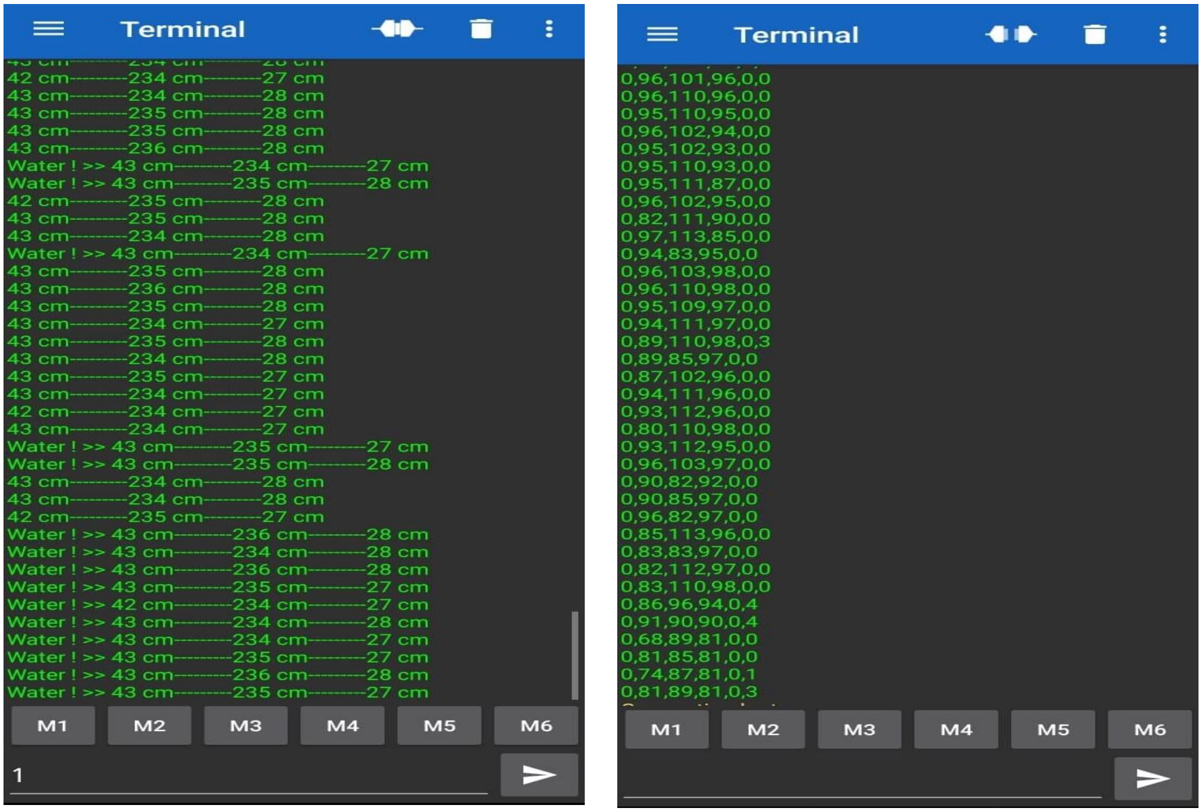

Figure 6: Bluetooth terminal application

- The number on the left represents the discovery of the water puddle, so if the number 1 means that water was discovered, and if it is not discovered, it will be given No. 0.
- The second number from the left represents the distance of the first sensor.
- The next number represents the distance that the second sensor measures.
- The next number represents the distance that the third sensor measures.
- The number that follows represents the discovery of the PIR sensor.
- The last number is on the right, as it shows us the script number or the delicacy that was discovered, it is registered with numbers to send it to the phone application, and through the number it determines the correct voice message based on the record number of the registered, so the blind person warns so that it can avoid it.

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Table 1: Comparison between our prototype and the previous works of 2023 and 2024.

References	Obstacle type	Sensor types	Controller	Output notification	Drawbacks
[8]	Undefined obstacles types	2 Ultrasonic sensors, 1 IR sensor, water sensor, Bluetooth module.	Arduino Nano	Voice module playback, and LCD.	-Undefined obstacles types -Not suitable for stairs. -No using GPS. -No emergency SMS.
[10]	Object detection, emergency SMS	Ultrasonic sensor, RF transmitter and receiver, Location detector, Water detector, GSM and GPS Module	Arduino Mega	Buzzer, Vibration motor, and Voice playback.	-Not suitable for stairs.
[11]	Object detection, Staircase detection, With an average performance rate of 90%	2Ultrasonic sensor, 1 IR flame sensor, water sensor, PIR sensor, GSM and GPS Module	Arduino UNO	LCD, buzzer, vibration motor, and Voice feedback.	- Not differentiate between stairs up or down. - No hole detection.
[12]	Object detection, Water detection, Dark detection, Voice guidance, With an average performance rate of 86.78%	1 Ultrasonic sensor, LDR sensor, Water sensor, GSM and GPS Module	Arduino Nano	Vibration motor, and voice alerts.	-Undefined obstacles types -Not suitable for stairs. - No hole detection.
The proposed model	Walls, Sidewalk, Stairs down, Stairs up, Hole, Motion, Light, and Water detection. With an average performance rate of 98%	Three ultrasonic sensors, an LDR sensor, a PIR sensor, an IR sensor, a Rain sensor, and a Bluetooth module.	Arduino Mega 2560	Buzzer, vibration motor, voice alerts, and Mobile Application. In the help case, there is a switch on the proposed stick for sending SMS messages about the user's location to his friends.	Not differentiate between stairs down and hole.

The smart blind stick prototype has been built and tested in this paper effectively. Tests are conducted on a blind prototype stick at different obstacles such as up/down stairs, walls, sidewalks, light, motion, and water puddles. Also, it was able to send SMS to his acquaintances with accurate coordinates of the blind stick when an emergency button is pressed. As shown in Table 1, the proposed model is compared with recent related work in 2023 and 2024

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with the whole obstacle types, sensors used, controller, drawbacks, and output notification. Observation of sensor trials based on different obstacles and locations is shown in Table 2. The proposed model is effective in the whole described obstacle detection with an average performance rate of 98%. This is the highest average performance rate percentage compared to previous works. Also, the Lithium-Ion rechargeable battery of the proposed model operates from 2:30 to 3:30 hours according to use.

Table 2: Observation of sensors trials based on different obstacles and locations.

Type of obstacles	Trial (15 times)	Percentage of success
Wall	15	100 %
Upstairs	14	93 %
Downstairs/ holes	15	100 %
Sidewalk	15	100 %
Motion	14	93%
Light	15	100 %
Water	15	100 %

5. CONCLUSION

The smart stick acts as a basic platform for the coming generation of more aiding devices to help the visually impaired to be safer. With the aid of the proposed smart stick, visually impaired individuals may maintain their connection to their surroundings. Therefore, they can move about freely and without risk of injury from the surrounding barriers. It is employed to identify impediments in the blind person's route such as walls, sidewalks, stairs up/down, hole detection, motion, light, and water detection. It is a straightforward, effective, portable, easily adjustable, and manageable electronic guiding system. It leads to good results in detecting the obstacles lying ahead of the user in a range of accepted meters and detecting up/down stairs and walls. The proposed stick offers a low-cost, reliable, portable, and low power consumption. Despite the multiple sensors and other components, it is still lightweight. In future work, we will differentiate between stairs down and holes using additional ultrasonic or adjust ultrasonic distances. Also, the stick will be experimented on blind people to evaluate it.

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