Proceedings of the Fifth International Conference on Communication and Electronics Systems (ICCES 2020)
IEEE Conference Record # 48766; IEEE Xplore ISBN: 978-1-7281-5371-1

Multi-Functional Blind Stick for Visually Impaired People

Vanitha Kunta
Dept. of Information Technology
Chaitanya Bharathi Institute of Technology
Hyderabad, India
vanithakunta2406@gmail.com

Charitha Tuniki
Dept. of Information Technology
Chaitanya Bharathi Institute of Technology
Hyderabad, India
charithathuniki@gmail.com

U. Sairam
Assistant Professor,
Dept. of Information Technology
Chaitanya Bharathi Institute of Technology
Hyderabad, India
usairam_it@cbit.ac.in

***Abstract*— One of the biggest problems faced by the visually impaired is navigating from place to place, be it indoors or outdoors. Further, the adverse conditions of the roads make it even more difficult for them to walk outdoors. They have to be alert at all times to avoid consequences like colliding with stable or moving obstacles, ascending or descending staircases, slipping down wet terrain. Also, at times they may be in distress and might want to send an alert message to their relatives or friends about their whereabouts. These problems of blind people can be addressed with the intervention of technology. The proposed solution employs the Internet of Things (IoT) paradigm to provide a medium between the blind and the environment. Several sensors can be used to detect anomalies like obstacles, staircases and wet terrains respectively. The prototype discussed here is a simple, sophisticated and affordable smart blind stick equipped with various IoT sensors and modules. Also, this solution provides a way to send a message about the whereabouts of the user to the concerned people. Adding to the above, a software application is designed to help the acquaintances of the blind to manage the stick's configuration ex: add or delete phone numbers to which alert messages have to be sent. Misplacing the stick indoors can also be a substantial issue. This solution also addresses this problem.**

Keywords*— *smart blind stick using IoT, obstacle detection, wet terrain detection, alert messages, finding misplaced stick.

I. INTRODUCTION

According to the World Health Organization, there are nearly 285 million people with some form of visual impairment out of which 86% people have low vision and 14% people are blind. Vision is one of the most important senses to humans to survive. Vision helps to connect with the surroundings. People deprived of vision rely on other dependencies like a simple walking cane or other people. In familiar places like the interiors of a house, they memorize the site directions, obstacles on their way and navigate according to them. However, it is not always safe for the blind to rely on their memory to move from one place to another. Especially when they are out-doors. Not all the times blind people are offered help from others and hence there is a need for a device, such as a stick, which can assist the visually impaired people in all forms of life.

The main characteristics for the stick to be useful to every visually impaired per-son is for it to be efficient and cost effective. The obstacles such as people, vehicles, stones in the outdoors and stairs, walls, furniture in the indoors hinder the way of the blind. The blind stick developed, alerts the user about various obstacles through a vocal sound from a speaker on the stick. The stick can also detect wet and damp surfaces and raise a vibratory alert to the user.

To a person who is visually impaired, a mobile phone doesn't effectively serve the purpose to send a panic message whenever the person ends up at a location unknown to him. A simple button on the stick will do the job of sending a message to the acquaintances of the blind person. A software application is designed to let the acquaintances change, add or delete the phone numbers. The user can also set up the phone numbers with the help of the supplier, who has admin access to change the phone numbers. To assist the user if a stick is misplaced, a remote with button is provided, which when pressed, makes a buzzer sound on the stick.

II. RELATED WORK

Smart blind stick is an innovative stick which is designed for visually impaired people for improved navigation. The smart stick proposed by M. P. Agrawal [1] can identify all obstacles in the path using a water sensor, ultrasonic sensor, RF module and GPS-GSM module installed in it and pass it on as vibrations to notify the user about hurdles on the way. A blind stick named iWalk by R. F. Olanrewaju [2] has a water sensor integrated therein that activates a distinct buzzer if it detects water. The system also has a wireless RF remote control that produces a sound when pressed, which helps in locating the stick. A stick guide model was proposed by K. B. Swain [3] which consists of GPS and GSM which sends SMS whenever the person needs help. It uses an ultra-sonic sensor to detect obstacles and an infrared sensor for level detection. Nadia Nowshin [4] proposed an Arduino Nano based stick which detects the obstacles using Ultrasonic sensors and an android mobile application to help a blind person. Radhika R [5] developed a model which can detect obstacles within the distance of about 3m with the help of infrared, ultrasonic and water sensors sensors. The blind person can also communicate his location to his guardian using GPS and GSM modules. A blind stick by Manikanta K [6] is integrated with an ultrasonic sensor along with light and water sensing. It sends a signal to sound a buzzer if an obstacle detected is close enough. O.B. Al-Barrm [7] proposed a 3D ultrasonic walking stick in which buzzer and vibration motors are activated when any obstacle is detected. The stick is also equipped with GPS and GSM to communicate the location of blind people. The main component of P. Sharma [8] is the ultrasonic sensor which is used to scan a predetermined area around blind by

emitting- reflecting waves. The microcontroller then communicates the status of a given device back to the earphones using SD Card Technology. A mobile application developed by T.A. Ueda [9] uses the smartphone's camera to alert them about obstacles along the path. The other invention by V. Patel [10], includes a wearable glove to ensure the blind can navigate alone safely. The main component of this system is an ultrasonic sensor which is used to scan direction by emitting-reflecting waves.

III. EXISTING SYSTEM

Existing systems like canes can guide blind people by helping them detect the obstacles in their path through

touching/poking. Alternative to the above method some other
aids include smart belts, smart rings, smart canes etc., which can assist them by detecting obstacles using ultrasonic or laser sensors. These systems produce either an audio or vibration in response w.r.t the detected obstacles to warn them. The limitations of existing systems are as follows:

- Expensive
- Not very effective and reliable
- Have very limited features and usability.

IV. PROPOSED SYSTEM

The proposed model consists of the following units which monitor the situation and act accordingly.

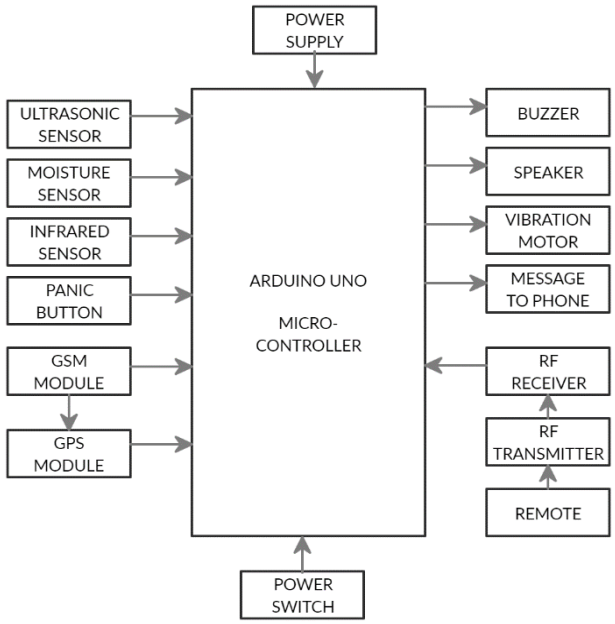

Fig. 1. Block diagram of proposed system.

A. Components

Ultrasonic sensor: An ultrasonic sensor (see Fig. 2) can be used to measure the distance to the target, by using sound waves. It emits a sound wave at a particular frequency and listens for that wave to return. By calculating the elapsed time between these two events, it can measure distance. There are two ultrasonic sensors placed on the stick in order to detect different obstacles like people, vehicles, stones in the outdoors and walls, furniture in the indoors. A HC-SR04 ultrasonic sensor is used in the proposed system which has a theoretical measuring distance of 2cm to 450cm.

Soil moisture sensor: A soil moisture sensor (see Fig. 3) is used to detect the presence of water in the path of blind people. The two probes on the sensor act as variable resistors. When they are placed on a surface, electricity conducts more easily on a wet surface, thus offering a low resistance. While on dry surfaces, more resistance is offered, since electricity conducts poorly. To get the moisture level, the sensor uses these two probes to read the resistance between them.

Fig. 2. Ultrasonic sensor

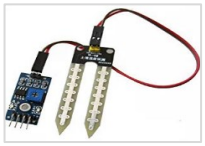

Fig. 3. Moisture sensor

Infrared sensor: It consists of an IR LED and a Photodiode (see Fig. 4) and can be used to generate and detect infrared radiation. LED is used to transmit IR waves
and the reflected IR waves are received by the photodiode. In this project an IR sensor is used with a theoretical detection distance of 2 - 30cm and a detection angle of 35°.

RF module: An RF module (see Fig. 5) consists of an RF transmitter and receiver. This module can be used to locate a misplaced stick. The RF transmitter can transmit serial data. Similarly this transmitted data can be received by an RF receiver. In this project the transmitter is mounted on a simple remote control. The receiver is mounted on the stick.

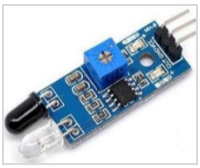

Fig. 4. IR sensor

Fig. 5. RF module

GPS-GSM module: GPS module (NEO-6m) (see Fig. 7) is used to track the current location of the blind person by fetching the GPS coordinates of the person. GSM module (SIM 900A) (see Fig. 6) is used to send these coordinates of the blind person to concerned contacts.

Fig. 6. GSM module

Fig. 7. GPS module

Buzzer and vibration motor: A buzzer (see Fig. 8) is a device that is often used to produce sound. The buzzer is triggered when the button on the RF remote is pressed in case the stick is misplaced. Vibration motor, a mechanical device, (see Fig. 9) is used to generate vibrations. It is triggered when the moisture sensor detects presence of water in the path of blind people.

Push button: A push button (see Fig. 10) is to the user as an emergency/distress signal which when pressed can communicate the users location in the form of a message to the concerned contacts in case of an emergency.

Speaker: A speaker (see Fig. 11) is used to provide alerts to the blind person when an obstacle is detected. It is integrated with a voice recorder to provide custom voice alerts for different types of obstacles.

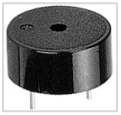

Fig. 8. Buzzer

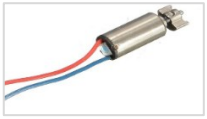

Fig. 9. Vibration motor

Fig. 10. Push button

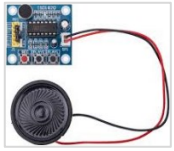

Fig. 11. Speaker

Microcontroller: For communicating different sensors, switches, modules, an Arduino Uno (see Fig. 12) microcontroller is used. It works as a decision-making controller by obtaining various signals from the different sensors and triggering output sensors appropriately.

Switch: A switch (see Fig. 13) is used to disconnect or connect the conducting path in an electrical circuit, interrupting the electric current. It is used to turn off or on the stick when not in use so as to save the battery.

Power supply: A 12 V rechargeable Li-ion battery (see Fig. 14) is used to provide the power supply to the controller which in turn feeds the required power to all the sensors and modules connected to it.

Fig. 12. Arduino Uno

Fig. 13. Switch

Fig. 14. 12V battery

V. METHODOLOGY

The proposed system consists of all the above mentioned components in the IV Section. These components are connected to the Arduino digital and analog pins via jumper wires. The proposed system operates on input voltage of 9V/12V and has the following features. It can scan the surroundings for various obstacles of different sizes and raise appropriate auditory and vibratory alerts. It can detect both damp and wet surfaces and can alert the user. Also, it is able to send the user's location to their acquaintances via SMS in case of an emergency or distress and it can be locatable when misplaced via a RF remote control. The Algorithm running on Arduino polls for input from each of sensors and follows flow as depicted in the below flow chart (see Fig. 15).

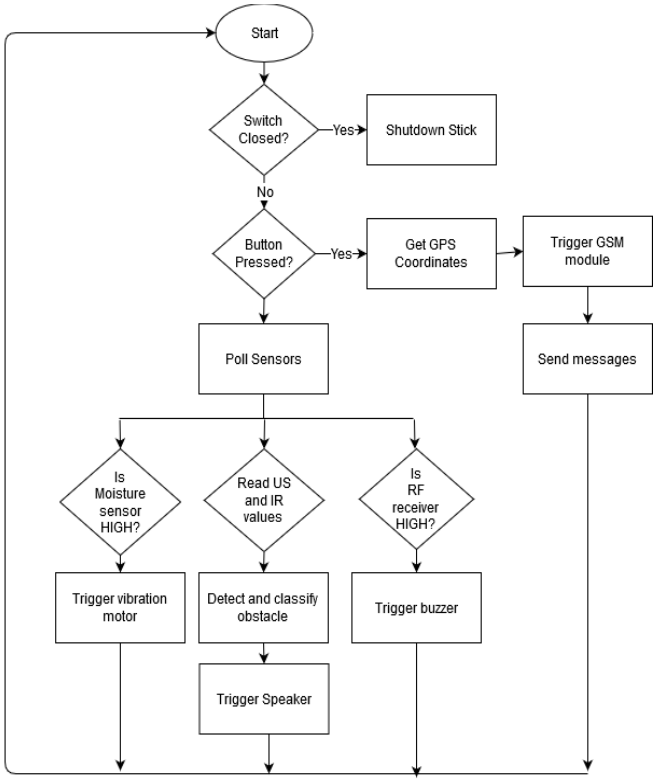

Fig. 15. Flow chart of working mechanism

Each of states corresponds to following:

1. With respect to detecting obstacles the algorithm makes use of two ultrasonic sensors: one mounted closed to the bottom of the stick and the other mounted at 2/3rds of the length from the bottom end of the stick. This setup can detect obstacles of various shapes and sizes. After processing the input from these sensors, the type of obstacle is determined by the logic in the below 'Table 1' and the appropriate pre-recorded audio response or vibration pattern is played to the user using the speaker module or vibration motor.
2. The IR sensor is mounted at the bottom of the stick in order to support detection of stair and small obstacles on the ground.
3. The working of the moisture sensor is simple: the sensor gives a boolean output after scanning the surface using which the algorithm raises a vibratory alert to the user using the vibration motor mounted at the top end of the stick.
4. On detecting a button press from the user the GPS module is polled for the user's coordinates. These coordinates are formatted as a google maps link i.e "http://maps.google.com/maps?q=loc:<latitude>,<longitude>". Then the link is prepended with an appropriate message such as "I'm in danger please find me here" and this processed message is sent to the User's caretakers using the GSM module.
5. Also the algorithm keeps polling the RF receiver mounted on the stick for RF signal, from an RF transmitter mounted on a simple remote controller. This remote controller also has a simple push button along with the RF transmitter, which when pressed transmits a

RF Signal via the RF transmitter on the remote, which can be detected by the RF receiver on the blind stick (see Fig. 16). The algorithm, upon receiving the signal, raises a buzzer alert for a few seconds thus helping the user to locate it.

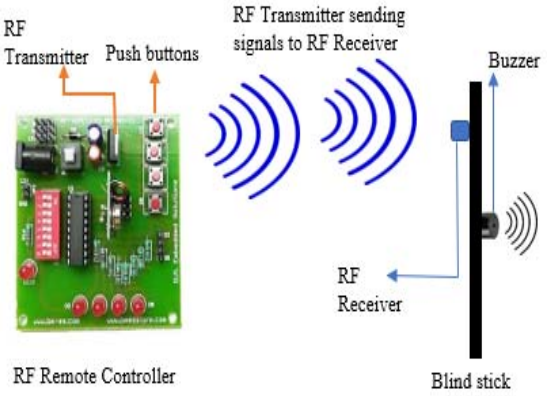

Fig. 16. Flow chart of working mechanism

TABLE I. CLASSIFICATION OF OBSTACLES BASED ON SENSOR READINGS

Type of obstacle	Type of alert	Sensors (Proximity and Distance readings)		
		IR Sensor	Ultrasonic- 1	Ultrasonic- 2
Stairs	Voice1	HIGH	< 20 cm	>50cm & <100cm
Small Obstacles	Voice2	HIGH / LOW	< 100 cm	>400 cm
Large Obstacles	Voice2	HIGH / LOW	< 100 cm	>150cm & <200cm

VI. RESULTS

The proposed prototype has been effective at spotting various obstacles of different sizes lying in the path of the user with great consistency, it was able to send SMS to his acquaintances with accurate coordinates of the user. Also, it has been quickly locatable when misplaced using the RF remote control. The RF module (Transmitter and Receiver) are able to communicate effectively with-in a range of 100m.

The components are mounted on the prototype (see Fig. 17) which is a PVC pipe having a diameter of 2cm and length of 96 cm.

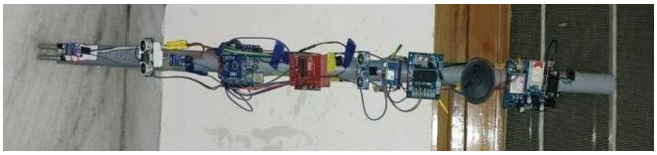

Fig. 17. Prototype

The GPS Module and GSM Module are functional and are able to send messages(see Fig. 18) and give out accurate location of the user. However, the Neo-6M GPS module takes a variable amount of time (30s to 1m) on startup to get a satellite lock. The soil moisture sensor use is able to effectively determine whether the surface is damp. Finally using the IR and the ultrasonic sensors and are able to detect the obstacles as mentioned in Table I and raise appropriate alerts using the speaker module and vibration motor.

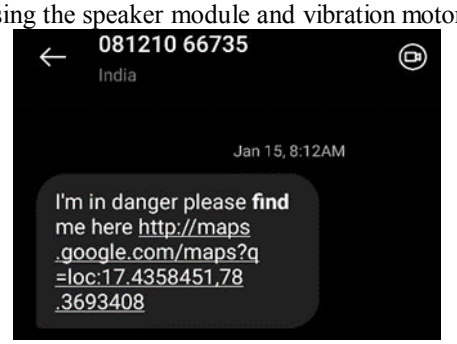

Fig. 18. Message sent to the user

A simple signUp-login-logout software application (see Fig. 19, 20) is developed to assist the users to modify phone numbers, to which alert messages could be sent. Each user's blind stick is characterized by a unique stick ID. The user's acquaintances can use this application on behalf of the user. The supplier of the stick, having an admin access, can modify the numbers of the user too.

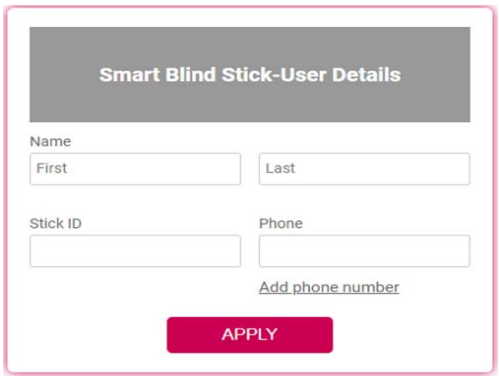

Fig. 19. User UI

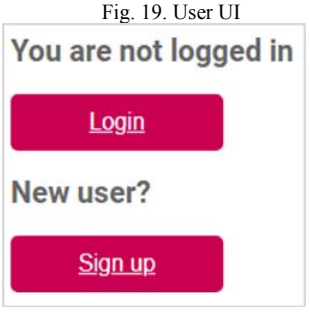

Fig. 20. Login-SignUp UI

VII. CONCLUSION AND FUTURE SCOPE

The blind stick proposed in this paper can aid the visually impaired user by helping him/her navigate through different terrains and obstacles. The stick is also able to inform the user's location to their caretakers in case of an emergency or distress. Also, the stick has the capability to be located using a RF remote control. This can be further enhanced by adding small scale and high performing sensors thus improving the de-sign and reducing the space being occupied on the stick. Few improvements can be made to the sensor angle placement to make them adjust according to the angle of the stick w.r.t to the ground so that they always point straight instead of mounting them at a static angle. Also, it can be further enhanced by using a better material such as carbon fiber for the body of the stick to make it lightweight and flexible to use.

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