

Embedded Assistive Cane for Visually Impaired Persons

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Abstract— The second leading cause of death in the elderly and severe injury for the visually impaired is due to falls. Many studies, reveals that the usage of conventional assistive cane devices is critical in reducing the risk of falls. The conventional aids exhibit serious adverse effects that contribute to falls, even though it provides physical support as well as supplementary sensing feedback to patients. The visually impaired people mostly use white cane or guide dogs to provide directions while walking. In order to enhance the features of existing white cane, a smart assisting cane is designed to achieve the goals of obstacle avoidance and fall detection efficiently. The existing smart cane informs the user whether the obstacle is present or not, but the user have no idea about what type of obstacle it is. Thus, in this work, a system which detects elevated and depressed surface and aids the user while approaching a staircase is designed. This system also detects overhead or hanging obstacles. In addition to that to prevent fall, a moisture sensor is placed at the end of the stick to detect slippery surfaces and an additional ultrasonic sensor is placed for identifying pit. These sensors are interfaced with Arduino. Elevated surface and drop off surfaces are also detected by comparing the difference in delay of signals from the two sensors. The main objective of this work is to design a smart cane which helps the blind user to get aware of what type of obstacle he/she is approaching and alerting them with voice output. The systems also gives alerts the user's relative position by sending the location of the user in case of any abnormal or emergency situations.

Index Terms— Pathhole, obstacle, depressed, slippery, Arduino Uno and Ultrasonic sensor

I. INTRODUCTION AND BACKGROUND

India been home to two third of total world's blind population. According to the World Health Organization, there are 2.2 billion people projected to be visually impaired around the globe. Globally, falls are a major public health problem for both elderly and visually impaired. Researchers predicted that 6,84,000 fatal falls occur each year, making it the second leading cause of unintentional injury death. Ref. [5] Every year, approximately 37.3 million falls are severe enough to require medical attention though it is non-fatal. The conventional smart cane has limitations in tracking the harmful objects in the surroundings of the visually impaired and elderly individuals. Thus to overcome the disadvantages in the conventional cane, a cost efficient smart stick is proposed with voice instruction module is intended and executed to aid blind persons so that they can walk independently without much difficulty. Ref. [6] The proposed white cane is attached with various sensors to detect the drop off surfaces, elevated surfaces and even slippery surfaces and the users are well informed about the same to greatly avoid fatal injury.

The proposed smart cane also attached with a GPS module which provides the relative position of the user in case

of any abnormal or emergency situations. The main objective of the proposed model is to aid visually impaired people to walk independently even in an irregular surface by alerting them with voice output and evacuating them from the fall off location in case of emergency.

II. RELATED WORKS

Some of the major papers referred for the proposed work are summarized below.

Ref. [1] Nur Syazreen Ahmad et. al.(2018) In this a multi-sensor obstacle detection system for a smart cane via model-based state-feedback control strategy has been modelled to regulate the detection angle of the sensors and minimize the false alerts to the user. The effectiveness of the approach has been verified via the designed experiments, and the numerical results have shown that the proposed method can provide significant improvements over the conventional methods in terms of error reductions.

Ref. [2] Mrs. S. Divya et. al.(2019) This system uses an ultrasonic sensor to detect the obstacle for larger distance and an infrared sensor which is used to detect the obstacles which is closer to the stick. The special and improved specifications are GPS and GSM system which shares the user's latitudes and longitudes to their relatives which is used to find the current location of the user. An additional feature to sense moisture is added which will be notified with different pattern of buzzers if user in front of wet surface.

Ref. [3] Malti Bansal et. al.(2020) This arduino based smart walking cane for visually impaired people can detect obstacles and along with it, can sense the water and darkness of the environment in which the blind person is moving. In this work, determining the location is accomplished by the GPS module and GSM module serves as a messenger which to sends the location to the specified mobile number of the family member or guardian.

Ref. [4] Wan-Jung Chang et. al.(2020) In this, an intelligent assistive system has been proposed for visually impaired people for aerial obstacle avoidance and fall detection. The proposed intelligent assistive system comprises wearable smart glasses, an intelligent walking stick, a cloud-based information platform, and a mobile device app. As a result, the experimental results show that the proposed system can efficiently detect aerial obstacles within a distance of 3 meters, and the average accuracy of fall detection reaches up to 98.3% by using the fusion of the two fall recognition methods.

Ref. [8] From the various literature survey papers it can be inferred that ultrasonic sensors are placed at different positions based on the application such as obstacle detection, overhead obstacle detection, elevated surface detection, downfall detection and path hole detection.

III. PROPOSED SYSTEM DESIGN

The proposed system mainly contains five modules namely (i) Obstacle, pathhole and Elevated surface detection (ii) Downfall detection (iii) Overhead obstacle detection (iv) Slippery surface detection and (v) Location detection. The detailed description of all the five modules is discussed below.

A. Obstacle, pathhole and Elevated surface detection

Fig 1 shows the diagram of obstacle, pathhole and elevated surface detection. It has three ultrasonic sensors. The two sensors used are placed on the cane in such a way that one (S1) is placed at 15cm from the bottom of stick and the other ultrasonic sensor (S2) is placed at 35cm from the bottom of stick. Thus the two ultrasonic sensors are separated by a distance of 20cm. When the emitted ultrasonic sound signal reach both the sensors at the same time, then it is an obstacle. When the time taken by ultrasonic signal to reach S2 is higher than the time taken by ultrasonic signal to reach S1, then it is an elevated surface. For pathhole detection an ultrasonic sensor placed at a distance of 2cm from the ground. When the distance determined by the sensor is 2cm then it is a normal surface. When the distance determined by the sensor is above 2cm then it is a pit. The warning for the elevated, pathhole and obstacle detected is given to the user using voice feedback

B. Downfall detection

For downfall detection, the ultrasonic sensor is placed at a distance of 25cm from the bottom of stick, in such a way that it faces the ground and is kept at some angle. The distance from normal surface is kept as L1. Whenever there is a downfall, the distance L1 determined by the ultrasonic sensor is greater than that of L1. Thus the downfall is detected and warning is given to the user with the help of voice feedback. Fig 2 shows that the distance L1 is calibrated between 35cm to 50cm (by taking set of readings before). If the distance is greater than that defined L1, will be detected as depressed surface.

C. Overhead obstacle detection:

For the detection of overhead obstacle, the ultrasonic sensor is placed at the top of the stick in such a way that it is tilted at an angle towards the top. Whenever there is an obstacle in front of the user at his head level, the ultrasonic waves from the sensor are reflected back by the obstacle and the notification about the detected obstacle is given to the user via voice feedback.

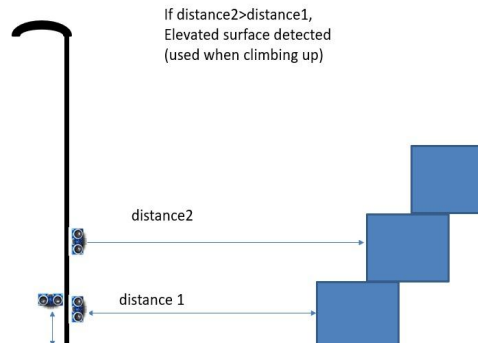


Fig 1. Obstacle, Pathhole and Elevated Surface Detection

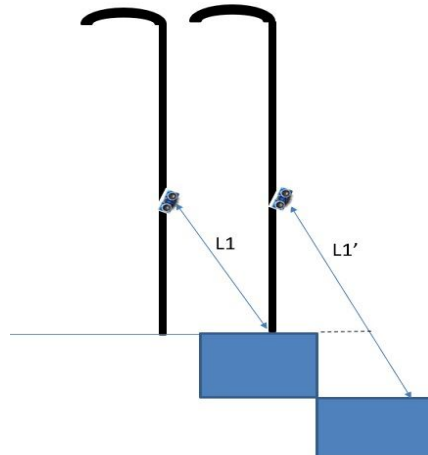


Figure 2. Depressed surface

D. Slippery surface detection:

In this proposed system, the slippery surface is detected by a moisture sensor attached to our white cane. Fig 3 shows the moisture sensor interfaced with Arduino Uno. In this proposed work, the threshold value is set to 200 and it is controlled through the code. The output of the moisture sensor changes in the range of ADC value from 0 to 1023. If the value goes below the threshold value, the buzzer rings and the voice command indicates that the floor is slippery. If the value lies above the threshold value, it indicates that the surface is perfect to walk.

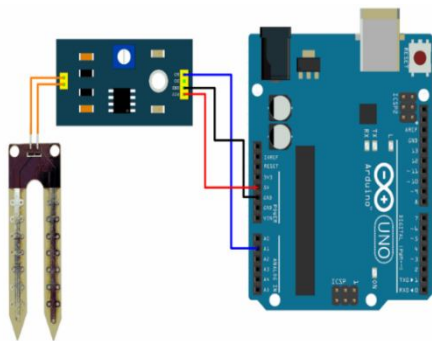


Figure 3. Interfacing moisture sensor with Arduino

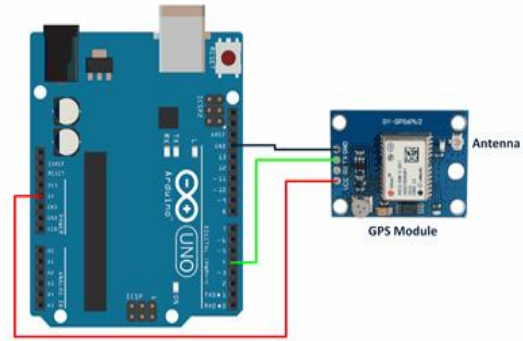


Figure 4. Interfacing NEO-6M GPS Receiver Module with Arduino UNO

E. Location detection

In this proposed work, to evacuate the victim from the fallen location, the geographical coordinates of the victim is obtained with the help of GPS and the location along with an emergency warning signal been shared to the care taker/emergency unit immediately by interfacing the GSM module with the Arduino Uno. Fig 4 shows that interfacing NEO-6M GPS Receiver Module with Arduino UNO. Based on the signals received from the satellite, the GPS module finds the location of the victim. Arduino will read information from the GPS module via serial communication (UART). The location along with the warning signal is sent to any IoT device via a GSM module which is integrated with the Arduino Uno.

In this work, the software programs are written in Arduino IDE. In this section, various modules involved and their use cases in the context of white cane is briefly explained.

IV. RESULTS AND DISCUSSION

The proposed assistant system will help the blind people a lot and guide them to lead a normal life. This section briefly explains the results obtained for all the five modules which are integrated together to implement white cane, the assistant system for visually impaired and elderly population in the world.

Fig 5 shows the hardware setup of the embedded assistive white cane. This white cane has three ultrasonic sensors. The ultrasonic sensor 1 is used to detect obstacle and ultrasonic sensor 2 to detect depressed surface and ultrasonic sensor 3 to detect the elevated surface. The moisture sensor is attached below the white cane, to detect the moisture level in the ground. This set up clearly assistants the visually impaired person to lead a normal life.

Fig 6, depicts how GPS and GSM module are connected for tracking the location of the people and sending alert messages to their peers in need of emergency. In this work, NEO 6M GPS chip is used for finding the latitude and longitudes of the location. The location is sent as SMS through GSM module to the care taker in case of emergency which is invoked with the help of push button.

A. Simulation results

Fig 7 shows that the simulation results for obstacle and elevated surface detection. Based on the distance calibrated, if the distance1 is equal to the distance2, obstacle will be detected. If distance1 is greater than distance2, elevated surface is detected.

Fig 8 shows the simulation results for moisture sensor. The threshold value is fixed as 500 and thus if the sensed analog value is less than 500, then slippery surface is detected and it is displayed in the serial monitor.

Fig 9 shows that serial monitor output location tracking using GPS module. If the value signals go off, "Tracking failed" then acknowledgement will be given to the care taker. In the case of emergency, the victim can use the push button and alert the care taker by providing the latitude and longitude values. This will help the care taker to reach the location and evacuate the victim before any mishappenings occur to the individual.

V. CONCLUSION AND FUTURE SCOPE

This work presents the implementation of a smart embedded stick that assists a visually impaired person in his walking environment. Various sensors were used to detect the obstacles as well as elevated and depressed surface. Buzzer and speaker are used to warn the blind person about the obstacles. Ref. [7] The beep sound will be continuous as the person nears the obstacle which aids him to move aside of the obstacle. Moisture sensor is used to detect the water which aids them to move aside. The GPS module is used to trace the blind person using the data collected by it. GSM Module is used in the case of dangerous circumstances the person whose phone number has been saved is notified that the blind person is at risk, along with the current location of the blind person. All these features are beneficial for the visually impaired people to navigate without the intervention of family members/care takers. The future scope of the existing smart stick is to guide the visually impaired person to navigate independently in an efficient and safe manner.

- The programmable wheels would navigate the stick away from the obstacles and also leading the blind person towards the destination.
- Ref. [8] Internet of Things is a trending concept which increases the benefits of the smart stick by providing fault tolerance to the white cane.
- In order to run this integrated set of hardware, solar panels are used as an alternative to the battery.

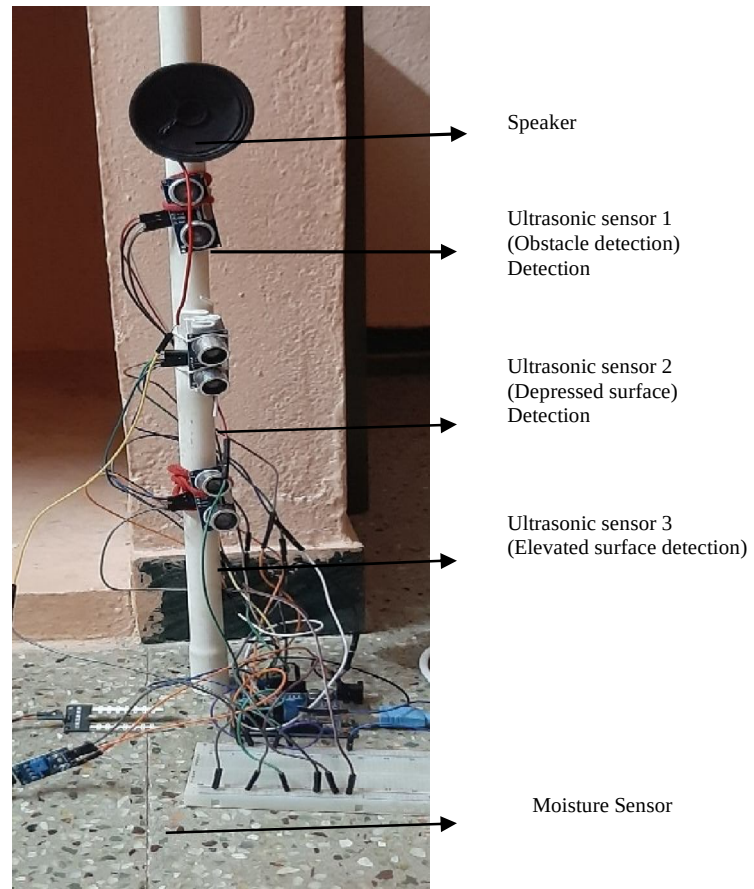


Figure 5. Hardware setup of the Embedded assistive white cane

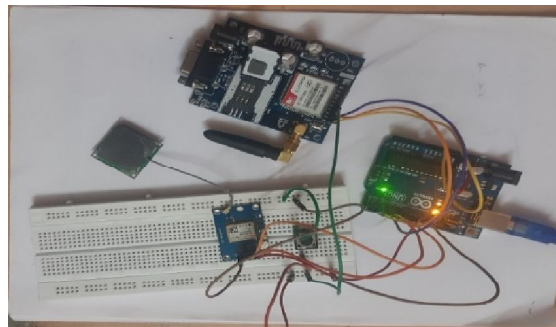


Figure 6. Hardware setup for tracking location using GPS and sending alert message using GSM module

```

// Ca
distance1 = highPulseDuration1 / 29 / 2;
distance2 = highPulseDuration2 / 29 / 2; // Speed
// Di

if(distance1 == distance2){
  Serial.println(" obstacle detected");
  voice.say(mp2_ALERT);
}

else if(distance2 > distance1){
  Serial.println(" Elevated surface detected ");
  voice.say(mp2_DANGER);
}
}

Sketch uses 5826 bytes (18%) of program storage space. Maximum is 32256 bytes.
Global variables use 418 bytes (20%) of dynamic memory, leaving 1630 bytes for local variables. Maximum is 2048 bytes.

```

```

obstacle detected
Elevated surface detected
Elevated surface detected
Elevated surface detected
obstacle detected
obstacle detected
Elevated surface detected
Elevated surface detected
Elevated surface detected
Elevated surface detected
Elevated surface detected
obstacle detected
obstacle detected

```

Figure 7. Serial monitor output for obstacle and elevated surface detection

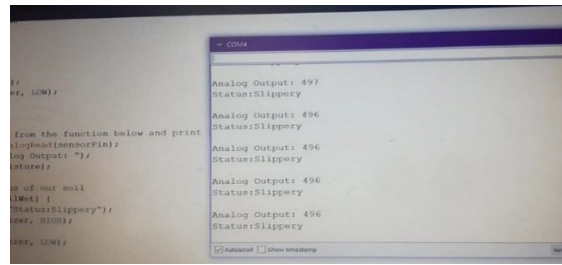


Figure 8. Simulation results for moisture sensor



Figure 9. Serial monitor output for tracking location using GPS module

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