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Design, Construction and Performance Test of Sensor-Based Assistive Walking Stick for the Visually-Impaired

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Abstract

The purpose of this paper is to design, construct and do performance test of a smart walking stick with object detection, recognition and location tracking. It has an ultrasonic sensor for object detection from a variable distance. A vibrator actuator is connected to the sonic sensor which gives the signal about how far the object is. There is a camera integrated too that does image processing and can detect up to 80 different objects. A headphone is connected that says what the object is and also states the scenario within the range of camera. A GPS system is also added to pinpoint the location of the user. A raspberry pi integrates all of these sensors & a 9V battery powers it up. All of these is in an attachment which is connected to the walking stick. This smart device can help the visually impaired be self-sufficient to a large extent.

Keywords: Visually impaired, Obstacle Detection, Scenery Description, Location Tracking.

1. Introduction

Visual impairment refers to the term of not being able to use the eye sight properly. It includes complete and partial blindness. The visually impaired people suffer a lot due to their inability to detect objects ahead of them which they cannot touch. So, navigation for them is really difficult without any help from others. The idea of being self-reliant seems like a tough ask. Even if they could somehow, detect an object ahead of them there is no way they can say what the object is or har far the object is located.

Over the last decades some researches have been done in this field. The researchers tried to accomplish easier ways for navigation of the visually impaired. Some really good work has been done and walking aid devices for the blind have been made. But there is still much work that needs to be done to make the devices more feasible and cheaper.

The smart walking stick that is going to be proposed here consists of some sensors, obstacle detection, recognition devices and location tracking system. Ultra-sonic sensors detect obstacles within the range of 0 to 13 feet from the stick. Through image processing with Pi Camera, the stick can detect what the object is and describe the scenario ahead. With the help of GPS module any guardian of the visually impaired can track his location. A raspberry pi processes all these components and a 9-volt battery powers up the whole system. For the complete integration of all the components with in a single stick, much design consideration needs to be done. That is one of the main aspects of this paper. Here the complete design model of the stick and attachment for the integration of all the necessary components with complete dimension will be given. Furthermore, the working result of the smart stick is also going to be discussed with scopes of future modifications. Another important aspect of the design model is that it is going to be portable, light weight, easy to use and cheap than any other conventional devices present today.

Quite a bit of work has been done on this topic for the last decades. There has been work on wearable assistive devices like SVETA [1]. It consists of a computing device, stereo headphones, cameras. A stereo matching is performed over the transformed images to calculate dense disparity image. Low texture filter and left/right consistency check are carried out to remove the noises and to highlight the obstacles. A sonification procedure is used to know the situation in front of the user.

Fig. 1. SVETA

Shashank Chaurasia et al., (2014), presents a conceptual model of an electronic walking stick for the blind, where two ultrasonic sensors, two infrared sensors are used to detect an object in front of the blind person. A vibration actuator and buzzer has been used to convey the message of the detected obstacle to the user. GSM module was used to send a pre prepared message text to a specific number [2].

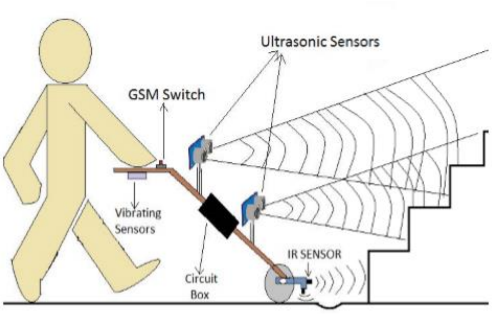


Fig. 2. Walking stick conceptual model with sensors.

Kher Chaitrali S et al., (2015), introduces a model of walking stick based on Radio-frequency identification (RFID). There is a RFID sensor placed on the stick. When that walking stick comes with in the range of a RFID receiver, the sensor gets activated and it is connected to an android application system. The application then searches the database for the entry corresponding to the RFID tags and gives speech output about the location information stored. The application also updates the user's location on the cloud [3].

Ayat A. Nada et al., (2015), implemented a smart stick model that can detect obstacles based on IR sensors. Stair detection experiment and obstacle detection experiment were done with good results. The IR sensors were inclined at a certain angle to be able to detect obstacles situated at different heights. After detection it gives warning messages based on how far the object is [4].

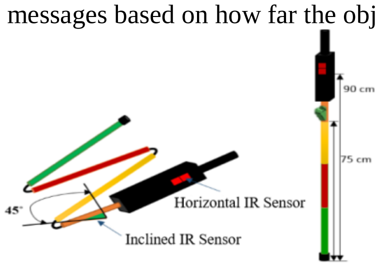


Fig. 3. walking stick with IR sensor

D.Sathya et al., (2018), presents an integrated smart stick with ultra-sonic sensor, camera, water sensor as input and voice synthesizer, Rf receiver, buzzer, microphone as output. A Raspberry works as the processor of all these and a 9-volt DC battery powers up the system. A model diagram was given without any real-life model or any design consideration of the stick [5].

G.J. Pauline Jothi Kiruba et al., (2018), describes about a smart walking stick with ultrasonic sensor to measure obstacles in front, GSM & GPS system to track location. Arduino Uno is showed as the controlling unit. The addition in this model was integrating temperature and heartbeat sensor to know the health condition of the blind person. A circuit connecting all these components was designed and simulated. But o real life model was done of the circuit or the stick to implement in real life scenario [6].

Quite a lot of work has been done in this field. But there are still room for improvements. In this research a proposed model with some selected sensors have been used because of certain advantages over the others. In this proposed model there will be ultrasonic sensor, raspberry pi cam, GPS module will be used as input. Vibration actuator and Head-phone will be used as output of the system. A Raspberry pi will work as the controlling unit. A battery will power up the whole system.

Certain considerations were in mind while choosing these components. Firstly, Ultrasonic sensor was chosen instead of IR sensors because Ultrasonic sensors are, for the most part, completely insensitive to hindering factors like light, dust, smoke, mist, vapor, lint. But IR sensors might get affected by these factors while using in outdoor environments.

Vibration actuator will be used instead of headphone in case of ultrasonic sensor because it is easier to know instantaneously about the obstacles ahead. There will be a switch when the user wants to activate the pi cam. It will then take a picture, process it and then describe the scenario through head phone. GPS module will be added to track the location of the user. A proper design model will be added to integrate all the components in a single unit.

2. Model and Design

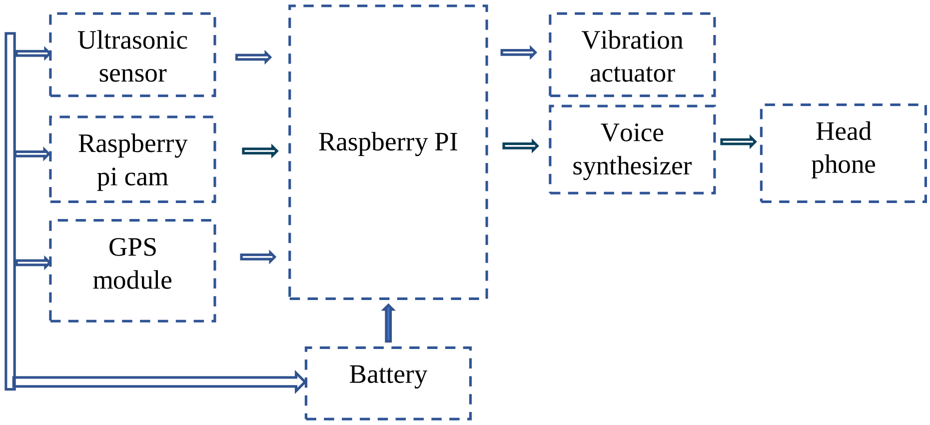
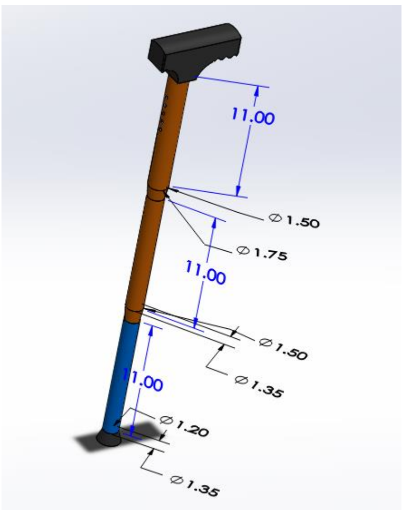
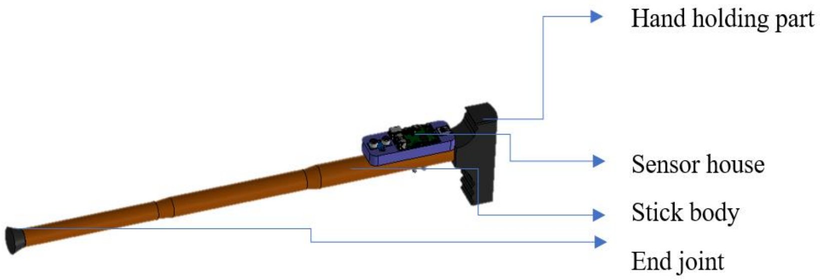


Fig. 4. Operation Method diagram of the sensors with stick.

(a)



(b)



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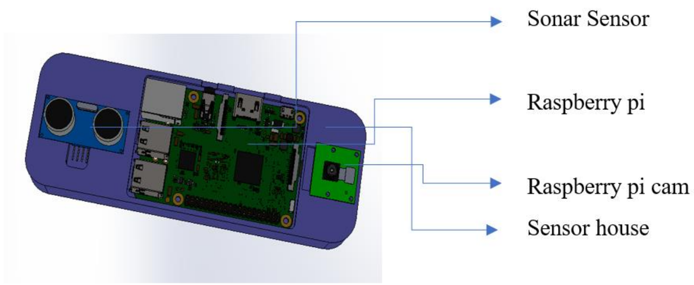

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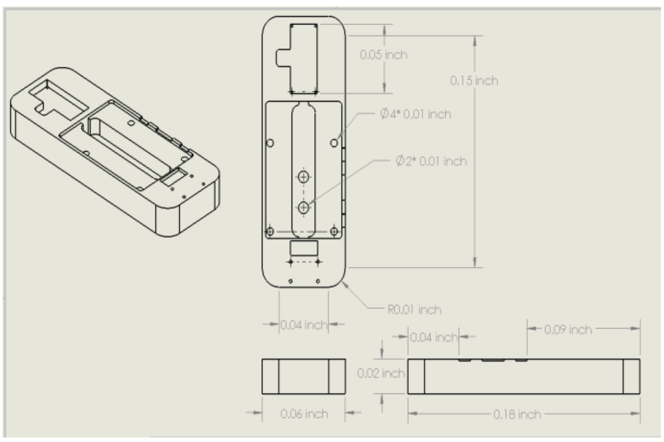
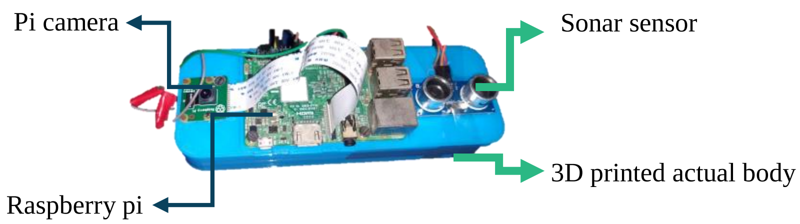


(e)

(f)

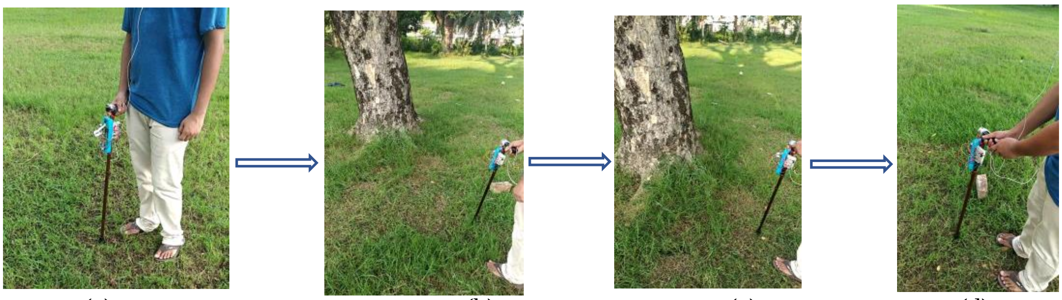


(g)

Fig. 5. (a)Solid works design of the walking stick with attachment for housing the sensors (b)walking stick with dimensions(in inch) (c) identification of parts in stick (d) solid work design of sensor house (e) dimension of sensor house (in inch) (f) Actual sensor house integrated with circuit (g) identified part of the 3D printed sensor house.

3. Results and Discussion

The actual model based on design had been made and some performance test was done. At first the performance test for ultra-sonic sensor was done.

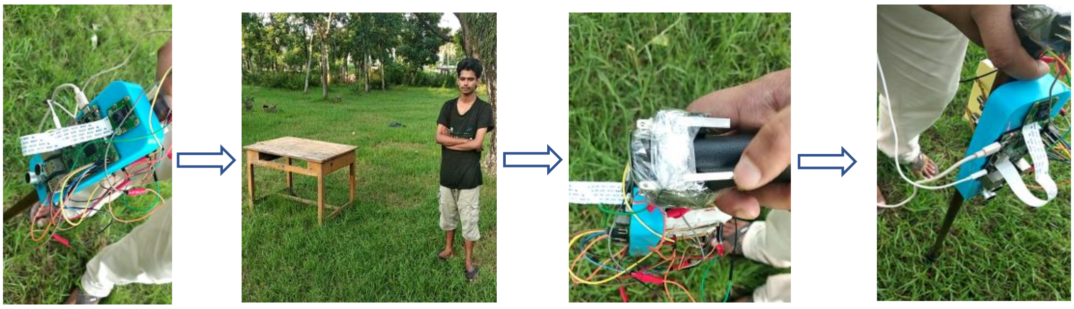


(a) (b) (c) (d)

Fig. 6. (a) random person walking with stick (b) the stick comes with in the range of sonar sensor (c) the vibration actuator starts vibrating letting the person know there is an obstacle (d) the person changes the direction of the stick and there is no vibration because there is no obstacle.

The sonar sensor senses any obstacle within the range of 1 to 13 feet. Based on how far the obstacle is it gives vibration feedback which gives the user an idea about the distance between the user and the obstacle. If the obstacle is very close to the user then it gives the vibration actuator generates intense vibration with higher frequency. As the distance between the user and obstacle keeps increasing the vibration intensity decreases.

Then the performance test of pi camera was done.



(a) (b) (c) (d)

Fig. 7. (a) a person with stick and pi cam (b) There is a table and another person in front of the blind person (c) The blind person pushes left side analyze button and it describes the front scenario (d) From the audio jack a headphone is going out and says, "There is a person in front and a table on the right"

The camera captures the image based on what is in front of the user. It describes the front scenario. About 80 objects have been updated in the database. If there comes any object amongst the pre-determined 80 objects then it can identify it and describe the scenario. If there is any unknown object then it says there is an unknown object in front. There has been given about 17 languages in which the voice output can be given.

4. Conclusion

In this paper a solution has been proposed for the easier movement of the visually impaired. A design model of the stick with integration of all the sensors have been shown. The ultrasonic sensor is able to detect obstacle within the range of 0 to 13 feet and gives a signal to the vibration actuator. The actuator vibrates intensely if the obstacle is close and less intensely if the object is far away. Pi cam can say what the object is in front of the blind person by describing the scenario. Location of the blind person can be tracked with GPS system. All these are integrated in a single place and can easily help the visually impaired move around easily. All these have been done maintaining the whole system cheap, light weight and portable.

5. References

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