International Journal of Engineering Applied Sciences and Technology, 2023
Vol. 8, Issue 02, ISSN No. 2455-2143, Pages 147-153
Published Online June 2023 in IJEAST (http://www.ijeast.com)

ASSISTIVE WALKING STICK FOR VISUALLY IMPAIRED

Samridhi Bhandari, Neha Bansal, Sami Noor Saifi
HMR Institute of Technology and Management, New Delhi, India

Abstract: **This paper presents the smart walking cane based on ultrasonic sensors, Arduino UNO and concepts of Machine Learning and CNN for visually impaired people. There are approximately 37 million people across the globe who are blind according to the World Health Organization (WHO). People with visual disabilities are often dependent on external assistance which can be provided by Humans, trained dogs, or special aid devices. Thus we are motivated to develop a smart walking stick which not only detects object but also detect the floor, surrounding along with collision detection and raises an alarm in case of any mishap. The system was designed, programmed using C language and tested for accuracy. Our devise can detect objects within 5m of distance**

Keyword- **ultrasonic senso visually impaired, Arduino UNO, Mobility aid, Alarm system, CNN**

I. INTRODUCTION

According to the World Health Organization (WHO), globally, at least 2.2 billion people have a near or distance vision impairment. The leading causes of vision impairment and blindness are uncorrected refractive errors and cataracts. The majority of people with vision impairment and blindness are over the age of 50 years; however, vision loss can affect people of all ages. People with vision impairment often have lower rates of workforce participation and productivity along with walking difficulties as they grow older. The very common dangerous walking situations include:

1) Collision with aerial obstacles in front According to a survey, 15% of visually impaired people hit obstacles every month on an average, and 40 % of visually impaired people fall down every year because they hit obstacles. The aerial objects such as tree branches cannot be detected using walking stick.

2) Falling and causing serious injuries A visually impaired person's chance of falling is 1.7 times that of the average person.

3) Inability to recognize the object in front of them

Till now very few devices have been made and sold in market which are not that accurate to help the visually impaired person to recognize the object lying in front of him. Since the object kept in front of him could be a giant rock or a pithole or even worse a slippery surface. Since the existing devices in marketplace are unable to recognize the depth, structure and composition of objects and surface of floor lying in front of such people, it ultimately increases the risk of them getting seriously injured.

There are many guidance systems for visually impaired people to navigate quickly and safely against obstacles and hazardous surfaces .Generally a visually impaired person uses white cane walking sticks, a constant companion with the, and voice guidance devices (built-in A-GPS) to provide directions in their day to day life. However, these types of tools have a short range of sensing which limits the information that can be perceived from a distance. The most critical shortcomings of these aids include: essential skills and training phase, range of motion, and very insignificant information communicated been communicated. Here, the idea is to recognize an object which is located in the path or trajectory of a user and provide an alert in order to avoid a collision and a potential fall. Our approach modified this cane with some electronics components and sensors, the electronic aiding devices are designed to solve such issues. The ultrasonic sensors, water sensor, buzzer, and RF transmitter/Receiver are used to record information about the presence of obstacles on the road. Ultrasonic sensor have the capacity to detect any obstacle within the distance range of 2cm-450cm. Therefore whenever there is an obstacle in this range it will alert the user. Water sensor is used to detect if there is water in path of the user. This type of solution is usually based on the idea of edge detection, object detection, fall detection, object recognition, line detection and floor boundary detection. The main aim of this project is to develop a simple guidance system for the visually impaired people.

In this paper, we approach the problem of floor detection in indoor as well as outdoor environments. By using Neural networks it has become possible to collect huge amounts of data and we avoid the extraction of edges common in computer vision and Assistive Walking Stick for Visually Impaired feature engineering approaches needed in traditional machine learning models. The objects present in the user trajectory the exact pixels in the image are required to be known and to avoid the inconsistency in shapes. This problem is tackled using semantic segmentation which performs pixel grouping on the image then determines what class the group of pixels belong to. Mask R-CNN is one of the examples of such neural networks.

International Journal of Engineering Applied Sciences and Technology, 2023
Vol. 8, Issue 02, ISSN No. 2455-2143, Pages 147-153
Published Online June 2023 in IJEAST (http://www.ijeast.com)

The rest of the paper is organized as follows

II. RELATED WORK

Many related studies were read to find out previous attempts to assist the visually impaired population. The present development status of sensor-based assistive aids provide some possible future development trends including state of art wearable devices/headsets prior to 2018.Mobile based assistive devices, thin client-based concept of smart city assistive infrastructure for blind and visually impaired people are some of the prominent works.

A generic classification of existing fall-related systems from fall detection and prevention have been addressed in the past, which suggested some future development directions for assistive devices for visually impaired people.

Generally walking sticks have become a basic aid for visually impaired people, our project revolves around modifying and improving the range and nature of detection of objects coming in path of the visually impaired population. Other related works include HALO, intelligent walking sticks which assisted visually impaired people in safely moving around hoes, water, obstacles and stairs.. Furthermore, electromagnetic sensor-based system that was mounted on conventional white stick to assist with the autonomous walking of visually impaired people. An active optical-based electronic travel assistive device that used a photodiode and a LED was also studied.

Few of the current works have applied popular deep learning techniques such as object detection and semantic segmentation for navigation assistance and obstacle avoidance. However these work still lack feasibility for the current lightweight microprocessors and battery-life conditions of such devices including high power consumption by these devices for performing deep learning techniques. Floor detection is one of the prominent issue since it represents a large number of applications in robotics, navigation, healthcare and more.

Completely reliable and feasible solution is still lacking and needs to be provided for the assistance of visually impaired. This paper proposes an intelligent walking stick device for visually impaired people to achieve the goals of obstacle avoidance, fall detection and object recognition.

III. PROPOSED SYSTEM

This section deals with theory of some of the components used in this project including the design and implementation of an intelligent walking stick for the visually impaired.

Our attempt to use Machine learning includes the detection of all types of objects that are present. It is however impossible to take every potential object into consideration and misidentification of objects could be a common error in such cases. In this project we not only detect the object, we find the desirable walking space radius that is safe to walk on.

Fig.1 shows a cane , wherein two ultrasonic sensors are mounted on to the stick having range from 20- 350cms.Two Infrared sensors are implemented on the lower side of the cane for avoiding small obstacles ranging from 2-10 cms. A camera to capture surrounding. Our mechanism works in such a way that the ultrasonic sensor transmitter generates signals and transmits them in a particular direction which will then be reflected back when they are approaching any possible obstacle(s). Then the ultrasonic sensor receiver receives it and sends it to the microcontroller which will trigger/switch ON the buzzer.

I. Design Architecture

Our proposed system consists of Ultrasonic sensor interfaced to the microcontroller, encoded with the code written in Arduino Sketch along with the physical sensor connected to the microcontroller. We have used Arduino UNO which is a microcontroller board based on the ATmega328p9datasheet).It has 14 digital outputs and input pins of which 6 can be used as PMW outputs,6 analog inputs, a16MHz quartz crystal, a USB connection, a power jack . We have used a moisture sensor consisting of two wire probe which rely on specific resistance of water Assistive Walking Stick for Visually Impaired to sense its presence when there is a contact with its surface. RF transmitter was interfaced with the microcontroller as codes were written on Arduino Sketch and the RF receiver was connected to the microcontroller. A LCD screen is interfaced with the microcontroller connected to pin and all codes written in Arduino sketch. The cooperation between Ultrasonic and IR sensors are utilized to create a complementary system that is able to give reliable distance measurement.

The smart stick as shown in Fig 2 is basically an embedded system integrating the following:

An ultrasonic sensors to detect obstacles in front of the visually impaired from ground level height to head level height in the range of 1 m upto 5.5m.Ultrasonic Sensors and water sensors take real time data and send it to the microcontroller. After processing the data, the microcontroller activates the buzzer. The water sensor detect water on the ground, and battery is used to power the circuit. A USB- A is also used.

A detailed description of Equipments/gear used:

A. Arduino UNO

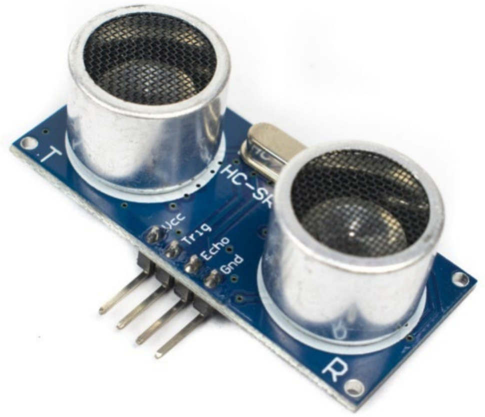
Arduino UNO is a microcontroller board – Atmega328P which contains everything need to support the microcontroller.14 digit input/output pins (6 PWJ outputs) along with 6 analog inputs and 16 MHz ceramic resonator.

International Journal of Engineering Applied Sciences and Technology, 2023
Vol. 8, Issue 02, ISSN No. 2455-2143, Pages 147-153
Published Online June 2023 in IJEAST (http://www.ijeast.com)

Arduino UNO r3

B. Ultrasonic Sensor

Ultrasonic sensors also known as transducers is a type of sensor that uses sound waves to detect an object. It works on similar principle of radar or SONAR which generates high frequency sound waves and evaluates the echo which is received back by the ultrasonic sensors. Sensors then calculate the time interval between sending the signal and receiving the echo to determine the distance to an object present in the path.



Ultrasonic sensors

C. Infrared Sensor

An IR sensor is an electronic device that emits and/or detect infrared radiations in order to sense some aspect of the surroundings. When an object is close to the sensor, it automatically bounces alight from the object and it is received by the receiver LED.

Infrared sensor

D. ATmega328

ATmega328 is a microcontroller which can be used in Arduino board, as it is an open-source physical computing platform based on Atmel microcontrollers and a development environment for writing software for the board. It can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling other physical outputs. Assistive Walking Stick for Visually Impaired

Proposed solution

A.) Infrared(IR) Trans receiver Sensor Module

Most popular sensors for measuring distance available in the market, can be used as they are inexpensive. We can use IR trans receiver (SHARP GP2Y0A710K0F) that can measure distance between 1 and 5.5 meters. Fig 3 shows the output voltage of the adopted IP transceiver sensor module corresponding to the detection change. We can use the change in voltage to determine the distance. The induction distance we set is 0.5 to 3 meters and represents the distance to an object(obstacle) when the corresponding voltage is more than 1.5 Volts. The size of IR transceiver is that of 22mm x 8mm x 7.2 mm (length x width x height), which is very much feasible. The IR transceiver doesn't have much load and its power consumption is also low. Fig 4 shows a relationship between the output voltage and the measured distance is nearly linear within the range that the IR transceiver sensor module can measure.

B.) Calculation of distance detection of objects with more height than the visually impaired person module.

As shown in Fig 5 we use an assumption based method where the reference points with known coordinates can form a triangle. Two known coordinates are those of IR emitting diode (TX) and the position IR sensor diode (RX) on the IR transceiver sensor module, and the measurement target point is an obstacle. As a result, we can calculate the length of the reference side of the two reference points and the target point to find the distance and coordinates of the target point.

C.) Motion Sensor for tracking movements (Fall recognition module)

A motion tracking sensor module placed near the palm of user (an MPU6050 is adopted) is used as a component to detect the movement and posture of visually blind person. The motion sensing tracking sensor module (6-axis sensor module) contains a 3- axis acceleration sensor and a 3-axis gyroscope sensor so that these two sensing components can be used to analyse five postures of human body. The five steps involved in fall recognition module are:

1) Feature acquisition and analysis

The accelerator and gyro signals of the motion tracking sensor module can obtain the vertical angle (θAcc) between the walking stick and the ground (g) during movement, as shown in Fig 6, we can produce an equation (1),

$$\theta Acc = \arctan (Ax/ g) / (Az/g) \quad (1)$$

The Y-axis data of the accelerometer in the motion sensor module are continuously sampled to determine the current position state of the proposed walking stick from the angle judgement.If the angle measured by the motion sensor module approaches “0” , then the current walking stick position is lying flat on ground.

Hence the verticle angle (θAcc) is added to the gyro sensor of the motion tracking sensor module to measure the value of the angle, θgyro, which is calculated using the multisensory data fusion Kalman filtering model to obtain the corrected upper human behaviour tilt angle θ value, as shown in equation (2) and (3).

The Kalman filtering model is used to filter noise from the accelerometer. Here uk means the input data and bias means the bias of gyro measurement.

$$\Theta = \int u \, dt \quad (2)$$

$$(\Theta bias)k+1 = (0\ 1\ -dt\ 1)\ (\Theta bias)k + (dt\ 0)\ uk \quad (3)$$

2) Action Model Recognition

The fourth-order Runge - Kutta integral equation is used to calculate the vertical velocity x(tk+1) of the upper human body in past k samples, and the two parameters of the tilt angle Θ and x(tk+1) of human body to recognise 6 human postures like standing, running, walking , falling, lying, sitting .

$$x\ (tk+1) \approx x(tk) + (\Delta x1 + 2\ \Delta x2 + 2\ \Delta x3 + \Delta x4)/6 \quad (4)$$

3) Fall detection / Fall posture

We integrate the centre of human torso with the posture changes for standing, sitting, lying, running and walking to determine the fall posture as shown in Fig 7. Through this recognition it is known that if accelaration of the motion sensor module configured in the walking stick is greater than a certain present Assistive Walking Stick for Visually Impaired threshold value Dth(i.e. XMaxDiff x >Dth) during the ith sampling period, this means that the walking stick is currently in a state of a rapid change in tilt.

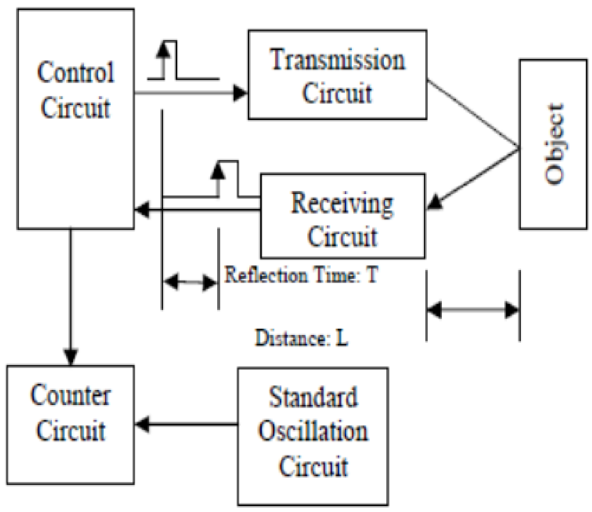
4) Fall Behaviour Recognition

Fall recognition by the proposed cane uses the motion sensor module to detect the posture (motion) of visually impaired and recognize whether it matches a fall event to greatly enhance the accuracy of fall event. When a visually impaired person falls, the position of walking stick will change.

The adjusted human behaviour tilt angle Θ, XMaxDiff, the change in the kth sampled human vertical velocity x (tk+1), and posture conversion recognition are used to develop a high-accuracy fall behaviour algorithm. Finally this fall behaviour algorithm is implemented in firmware in the microcontroller unit (MCU) of the proposed walking stick (cane).

5) Sensitivity and false alarm

To avoid misjudgement by the proposed intelligent assistive system, we fuse fall recognition and Fall detection methods. When the proposed cane recognizes a fall event then it is determined to be a real fall event, raising a buzzer so that any nearby person can help them. Through the fusion of the two fall recognition methods of the proposed walking stick, the fall event recognition rate can be improved and false alarms can be avoided.



Distance calculator

Features of our proposed system are:

- Different types of vibrations for different obstacles
- Automatic (during night time i.e. LDR dependent high intensity (Red color) LEDs.
- A small Torch on the top.
- A user-controlled horn for traffic.
- More efficient and inexpensive than other devices

- Easy to access for blinds.
- Code can be upgrade or changed easily.
- The Arduino UNO would be requiring internet for image processing. This internet connection is given by creating a secured WiFi hotspot on the users smartphone. The WiFi module is already present on Arduino UNO microcontroller and hence establishing a connection is convenient and safe.

Distance (from the stick in cms)	Time (sec)	Type of signal
350	2.0	Very Slow Beeps
300	1.8	
250	1.5	Slow Beeps
200	1.4	
150	1.0	Beeps + Vibrations
130	0.9	
100	0.8	
80	0.5	Fast Beeps +Vibrations
60	0.3	
40-50	0.1	Very Fast Beep + Vibrations
20-30	0.05	
5-10 (due to Infrared Sensor)	-	Continuous Vibrations

Output Signal Algorithm for stick

Software based proposed solution is:

1) Network Architecture

We propose a Convolutional Neural Network (CNN) in a combination of depth image from an RGB-D high-quality camera. This system detects different objects in a scene such as tables, chair, walls and floor. this work presents very good results. It uses naïve Bayes classifier to fuse several visuals cues and features generated by heterogeneous segmentation. A fuzzy system is used to determine which part of the image is an obstacle and which one is part of the floor. The current system uses a monocular camera with a simple image in a combination to a Convolutional Neural Network acting as a process engine for the floor detection. The CNN has been Assistive Walking Stick for Visually Impaired trained with a dataset from openai.com. The first RCNN which uses a process called selective search for proposing regions of interest, all the proposed regions are then fed into CNN individually for classification. Since this whole process takes a lot of computing power we use Fast R-CNN, the use of ROI pooling (Region of Interest) pooling is introduced. The goal of ROI pooling is to reduce the cost of computation by running the regional proposal after running CNN once on entire image.
Ultimately using Mask-CNN combining the concept from faster R-CNN and FCN (Full Convolutional Network), it takes advantage of speed and accuracy of Faster R-CNN with idea of semantic segmentation in FCN to achieve instance-based pixel-wise classification.

2) Data Labelling

The data labelling tool is written in python3 which utilizes a few functions within the modern computer vision libraries such as opens and sci-kit image. It takes in a video file in any format and any length, and split it by frame. After re-sizing the frame to our desired size, the user is able to add, delete and adjust existing points on the frame. A square is created on the existing pints chosen by the user, the square is then filled with everything inside the square representing the floor space and everything outside of it representing the background. The chosen points are saved and tracked in the next frame using the Lucas Kanade Optical Flow method. The purpose of this is to speed up the labelling process, by tracking the points, the user doesn't have to create the points from scratch for every frame.

Implementation

Our proposed smart stick performs different tasks such as image recognition, collision detection and object detection.

1. Image Recognition

Extraction of information from the user captured images, the camera mounted on top of stick captures the images from surroundings, the images are then described by the application's Artificial intelligence, generating captions for every user captured image. Google Talkback identifies the generated captions .Helps in better navigation. Whenever there is a need to analyse an image our system application code invokes a call to Microsoft Cognitive Services (API).Image analysis is done by the API using computer vision, machine learning and neural networks whereas natural language processing is used to generate the caption in a human understandable language.

2. Obstacle Detection

Rasonic sensors generate high frequency sound waves and evaluate the echoes received back by the sensors. For the functioning of obstacle detection, the ultrasonic sensor mounted at stick sends ultrasonic waves towards direction at which the stick is pointing to.

Using the time required by the waves to return back to the sensor, the distance value between the stick and the obstacle is calculated in UNO using formula:

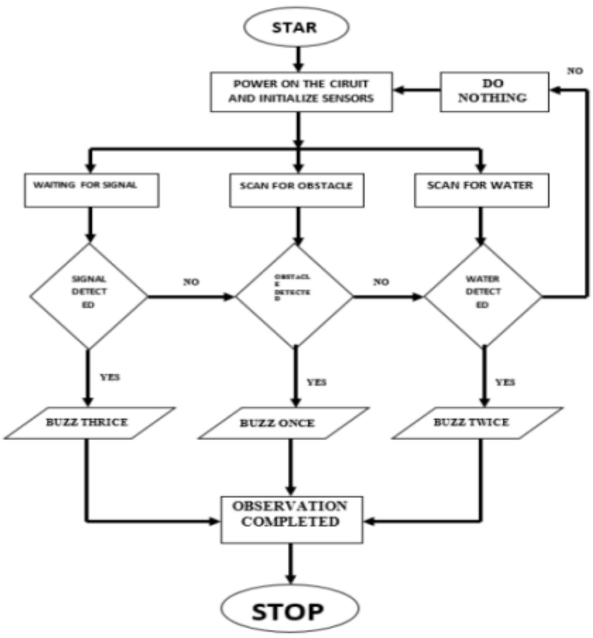
Approx. speed of sound, c=331.5 + [0.6 x (air temperature in degree Celsius)] at 20 degrees

c=331.5+ (0.6 x 20) =343.5 m/s

c=343.5 x 100 / 10^6 cm µS= 0.03435 cm µS / Speed of sound = 1/c=29.1

The time interval between ultrasonic waves sent by the sensor is in µS.

Distance= (duration/2)/29.1



Flowchart of the system

IV. EXPERIMENTAL RESULTS

The electrical circuit design was first assembled on a breadboard. After it was found intact on the breadboard, it was later transferred to a Vero board. The Vero board was divided into sections as such there is a power supply unit, display, transmitter, receiver and microcontroller section. Before soldering the components on the bread board, the strip lines of the Vero board were cleaned with a razor blade to remove any grease, oxidation, oil and dirt. The resistors, capacitors, diodes as well as connecting terminals were carefully connected using soldering iron and soldering flux on the Vero board to avoid damage to integrated circuit IC sockets that were used. In soldering the components on the Vero board, care was taken to minimize component damage due to excessive heat from soldering iron. Also, adequate care was taken to avoid short-circuit between adjacent copper strips on the Vero board during soldering .In order to avoid possible short circuits, discontinuity of the copper strips was created when necessary, this is done by cutting the copper strips where necessary.

Testing of the Ultrasonic Sensor

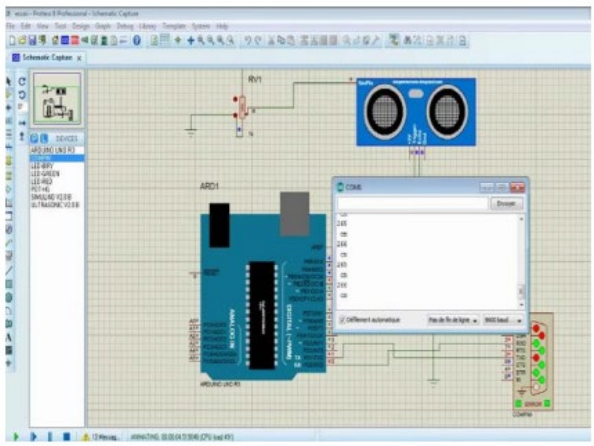
1. The circuit was connected on a bread-board.
2. An object was positioned (fixed at a distance) and the device was taken up to 1m away from the object.
3. Gradually the distance between the device and object was varied until the distance at which the output voltage was logic high (i.e. Buzzer ON)
4. Step 3 and 4 were repeated for different objects of varying size.

Simulation

Several simulations were carried out to ascertain the efficiency of our proposed technique.

Test and reliability check was conducted using each components of the smart stick to validate their efficiency and know if they are working according to specification before soldering.

1. Ultrasonic Sensor: The ultrasonic sensor was tested and the result as presented in Table 1 shows that the system worked according to specification at a distance not too far from the user. The buzzer came ON indicating the presence of obstacle on the way of the user.
2. Water Detection Sensor: A bread-board was used for connecting the circuit. A vessel containing water was placed on the table. The moisture sensor was immersed into the water contained and a beep sound was heard which is different from the beep from the obstacle detection.



V. CONCLUSION

The smart walking stick acts as basic platform for the coming generation of more aiding devices to help the visually impaired to navigate safely both indoor and outdoor. It is feasible and effective. The system Assistive Walking Stick for Visually Impaired offers low-cost, reliable, portable, low power consuming and robust solution for navigation and a short response time. It is light in weight. We trained the machine learning model that can achieve floor detection and object detection. Instead of running object detection on every frame, we decided to only run object detection once every few frames. This system can be applied in straight path, right angle path and curved path. With the help of our smart walking stick, visually impaired people can improve more than 45 % travel speed, reduce minor collision. Further aspects of this system can be improved via wireless connectivity and using GSM module and connecting it with a mobile application. A global positioning method to find the position of the user using GPS and GSM modules to communicate the location to a relative or care giver.

VI. REFERENCES

[1]. Manoj Badoni and Sunil Semwal,"Discrete distance and water pit indicator using Avr Atmega8 in electronics travel aid for blind",Int'l journal for disaster recovery and business continuity, Vol 2 November,2011

[2]. Sung Jae Kang,YoungHo,Kim,InHyukMoon,"Development of an intelligent guide stick for the blind",IEEE Int'l conference on robotics & automation, Seoul,Korea,May 21- 26,2001

[3]. https://www.societyofrobots.com/schematics_ infraredemitdet.shtml

[4]. Clinton R Sanders,The impact of guide dogs on the identity of people with visual impairements,2000

[5]. YinxiaLi,Segmentationoffloor in cooridor images for mobile robot navigation,2011 Suryansh K,M Siva & K Madhava, Markov random field based small obstacle discovery ovr images, 2014 IEEE Int'l Conference on Robotics and Automation,IEEE,2014

[6]. G Prasanthi and P tejaswitha "Sensor assisted stick for blind people",2015