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# Electronic Travel Aid for Visually Impaired People based on Computer Vision and Sensor Nodes using Raspberry Pi

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## Abstract

**Objectives:** To make robust, reliable and affordable Electronic Travel Aid (ETA) which is composed of ultrasonic sensor nodes, smart cane stick and object detection device used in synergy used by blind and visually impaired persons for navigation and object recognition in indoor and outdoor environments. **Methods:** For the navigation in indoor environment, four ultrasonic sensor nodes which measure proximity of surrounding obstacles and if any object is too close then vibration feedback is given to the user. Smart cane stick will detect wet floor and stairs and if detected then vibration feedback is given at cane handle. In object recognition device we have used Raspberry pi 3 and camera which will detect defined objects in front of the blind user and describe it using audio feedback via headphones in which we have used computer vision techniques from opencv libraries like SURF extraction and haar cascades used with neural networks for cognitive machine learning which makes object detection and recognition robust. **Findings:** Using ultrasonic sensor nodes at ankles, wrist and waist, yielded better navigation in indoor environment because the ultrasonic sensors are more accurate, fast and distortion less as compared to the other sensors. A simple cane stick gives less information about the environment while smart cane stick gives information about stairs, wet floor and unevenness of floor to the blind user to avoid collision and also better range of detection as compared to simple cane stick. For object recognition, SURF feature extraction and haar cascades are used which is best suited for object detection and recognition of defined objects. And using machine learning increases the accuracy of the object recognition for unknown objects so like this the blind user can understand what kind of object is there infront of him, which was not possible using distance sensors alone. Using the three devices in synergy the blind person can navigate and recognize the objects in indoor and outdoor environments more easily and makes our ETA more accurate, efficient and affordable. **Application:** For visualisation of the surroundings for blind and visually impaired people.

**Keywords:** Computer Vision,Electronic Travel Aid, Haar Cascades, Object Detection and Recognition, OpenCV, Raspberry Pi, Smart Cane Stick, SURF

## 1. Introduction

According to a study by WHO data[1] 285 million people are estimated to be visually impaired worldwide in which 39 million are blind and 246 million have low vision. About 90% of the world's visually impaired live in low-income conditions. And 82% of people living with blindness are aged 50 and above. So to solve this we use Electronic Travel Aids shortly called as ETA's which are for designed and made navigation of the visually impaired and blind people. These can be used by the visually impaired users for sensing the environment. Theymeasure the proximity of the distance between the user and the surrounding objects and the feedback input from the surroundings is sent to the user through vibration feedback or sound feedback by changing intensity of vibration feedback. Well the research work on these devices is going on since many years but still now there is no device came that is commercially viable and user friendly. But we can also use the hand held laser sensor based ETA's, here to measure

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the distance between the sensor the obstacle be we use light. Which is sent and received. And we give output in vibration feedback, but drawback is limited scanning angle and light is distorted. So the best approach is using ultrasonic ETA's these are the best when we want a larger scanning angle and robustness, and here uses ultrasound so there will be no problem because it is not audible to humans. So this device what basically does is give vibration or sound feedback based on the proximity to objects ahead the user. So by further research has concluded that if we make an ETA with ultrasonic sensor nodes, smart cane stick, object recognition device together we will get a better result.

The results of an extensive literature research in the field of Embedded system enhancement with more emphasis on the use of ETA are presented here. Various sensors are also presented. We presented the detail of work undertaken by different scientists and engineers in the field of ETA. The review includes theoretical work undertaken along with the development of the ETA'sfor safety and security of blind and visually impaired people's life.

In[2] Wearable Virtual White Cane an Assistive Technology for Navigating for the visually impaired,they have used multiple ultrasonic sensor nodes to measure the proximity of the obstacles to the user, and give vibration feedback. But the defects in this will be the range and difficulty to use[2].

In [3] Design, Development and Clinical Evaluation of the Electronic Mobility Cane for Vision Rehabilitation here they have given a novel technique to develop a smart cane stick to detect the environment and give feedback according to it to the user. This smart cane stick is different from a normal cane stick since the older cane sticks just give support and less range of detection but this cane stick has bunch of ultrasonic sensors and with normal range and widerange detectors and with wet floor detector, steps detector[3].

In [4] Electronic Travel Aid Based on Multi-Sensor they have given a better way to sense the environment with using the filters which collect the data from the multiple sensors and give feedback according to our configuration[4].

In [5] computer vision based ETA we can use computer vision to detect the environment using image processing and feature extraction algorithms, and sense humans, objects and many more and we can place them on and sticks, which will give audio feedback to us if they detect certain objects[5].

## 2. Devices Used in ETA

Here we have three devices where the first two is ultrasonic obstacle detector based on which proximity of the distance between the user and the surrounding objects is measured and feedback is sent to the user through sound feedback or vibration feedback i.e., by changing intensity of vibration with respect to the distance measured between sensor and obstacles. In the third device we have used object recognition module whichdetect and recognise the surrounding objects and give the audio output to the user if the defined objects are detected.

### 2.1 Ultrasonic Sensor Nodes

Ultrasonic sensor nodes in Figure 1. use ultrasonic sound waves to measure the distance. They do this by sending the sound waves from the trigger and receiving it from the echo and time taken by it will be divided by two, then the duration is converted to distance, so we have many ultrasonic sensors with different measuring capabilities, ranges and angles, they are better than light because light is distorted sometimes and sometimes give error results. But ultrasound is not effected [2].

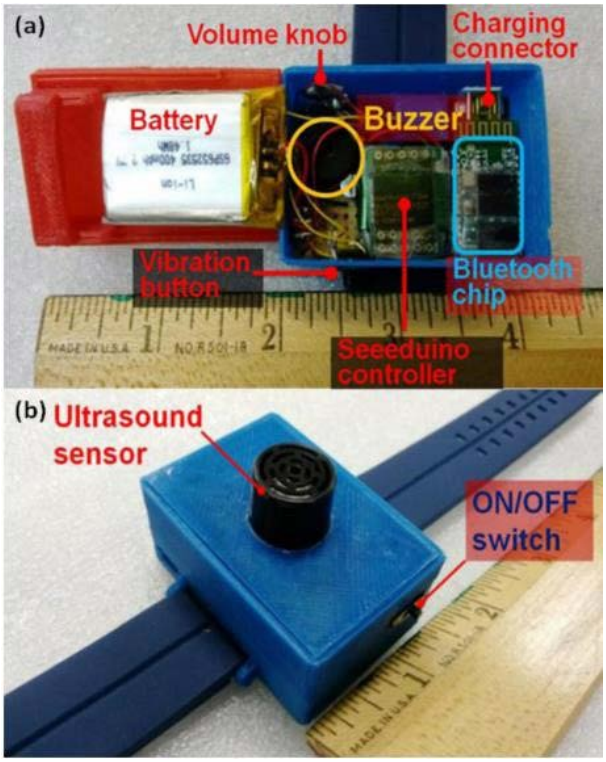


**Figure 1.** a) Internals of ultrasonic sensor node b)outer look of ETA[2].

so here a wearable sensor nodes system is made to estimate the user's position in Figure 2. These nodes are used both for checking the user's motion status and for realizing the relative location. This multi sensors nodes used by the user can find the obstacles in unknown surroundings. This ultrasonic sensor belt can be used as the accurate navigation device in a similar way as the obstacle avoidance system in mobile robots. So all the data for the sensors is given to the raspberry pi for the data fusion of all multi sensor nodes. The uses of this obstacle avoidance ultrasonic sensor system can only be realised in the indoor systems since its range is few meters [4].


**Figure 2.** Ultrasonic sensor nodes belt used by the blind user[2].

## 2.2 Smart Cane Stick

This smart cane stick is different from a normal cane stick since the older cane sticks just give support and less range of detection but this cane stick has bunch of ultrasonic sensors with normal range, wide range detector and also wet floor andstairs detector. In Figure 3. here we have used Atmega 328 microcontroller which takes input from the ultrasonic sensors and processes that information and after that gives a tactile or vibration feedback to the handle of the cane according to the surrounding obstacles, in this we have used bluetooth module which will send the data received by the sensor nodes to the raspberry pi, which will collect data, process it and will give feedback signal to the cane handle to reduce errors. In this stick we have used wet floor sensors which will detect, if the floor is wet and if detected then it will give audio feedback to the user that floor is wet and walk slowly. Further to enhance this we have used the data from different ultrasonic sensors for detection of stairs, and if stairs are detected then it will give audio output as stairs are near to him. Like this we have modified the normal cane stick to smart cane stick which the blind user can use it with more confidence and easily navigate through the indoors, and even through stairs[3].

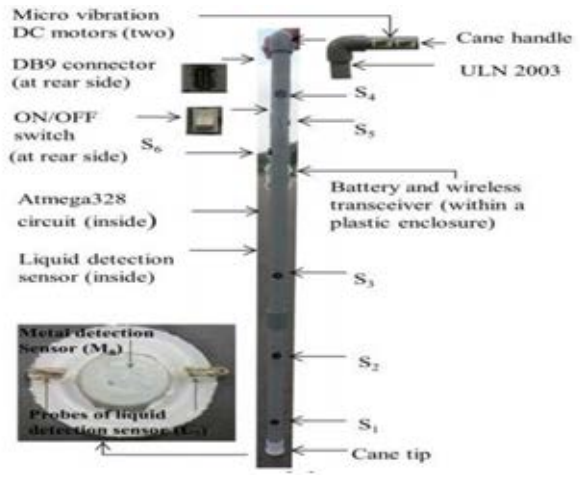


**Figure 3.** A smart Cane Stick[3].

## 2.3 Computer Vision based Object Recognition Device

Here we are implementing object recognition device based on computer vision and this device is mounted on a cap used by the user Figure 4. and the protyping board used is Raspberry pi 3 because it has best support for computer vision applications. and a usb camera is

connected to the Raspberry Pi, and to raspberry pi we will connect ultrasonic sensor nodes, vibration feedback and audio output devices to its gpiopins. Now the working principle is by using Open CV libraries(it is a library which has huge set of functions for image processing and computer vision applications) for computer vision in which we will recognize objects like doors and roads edges and obstacle's like vehicles and walls. So whenever the camera will detect and recognize the object then it will give assigned audio output to the user about that object , so to do this we have to extract features form the image captured from the camera, and apply SURF (Speeded-UP Robust Features) [6] to extract distinctive invariant features that can be used to perform matching individual features of the user asked object to a database of features with different personal items which are saved in advance after this these surf features are sent to the neural networks to make our system learn according to the given input and defined output. So by using supervised machine learning we are getting better results as compared to just using surf. We have also used haar cascades to detect certain objects which will detect that particular object. Here we have used python programming language for more efficient, fast and accurate results. And python has huge support and vast libraries for image processing and it is very light weight as compared to the Matlab.

Further for outdoor navigation we have used Open CV libraries for the roads edge detection in Figure 5., so that the blind user can walk only the road sides, not in the middle of the road, here we have done this using canny edge detection and features extraction based on the edges, it will detect the difference between road and non-road by change in similar pixles will tell the user if he goes to the middle of the road and this is for the outdoor facility. Where the blind user can navigate in the roads.

And for the indoor, for the user to know the indoor objects we have OpenCv libraries for the object recognition where it will recognize the objects and give audio output to the user about the recognized object,but provided the user should mention what kind of object does he want to recognize like in Figure 6. like this the blind user can easily find things which he wants.

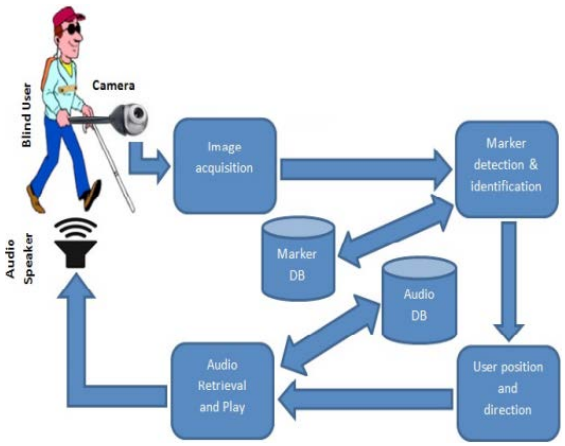


**Figure 4.** Computer vision based ETA[5].

**Figure 5.** Road edge detection[6].

**Figure 6.** Object recognition[6].

## 3. Conclusion

In previous papers they have used ultrasonic sensor nodes through which user can only sense the surrounding in the indoor environment, but using computer vision , smart cane stick and ultrasonic sensor nodes in synergy the user can use them in indoor environment efficiently , and moderately in outdoor environment, since by usage of computer vision the user can determine what kind of object is there infront of him, which was not possible when using ultrasonic sensor alone where maximum range of few meters was not suitable for outdoor environment. And to make computer vision for object recognition more robust, we have used haar cascades, surf and supervised machine learning techniques.

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