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An Intelligent Aid for Visually Impaired-Obstacle Detection and Content Recognition System

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Abstract

Across the globe, there are 15 million visually impaired people and they cannot move confidently, independently, and safely in this world. These people are restricted to their neighbourly surroundings. Also, in order to perform their basic tasks they need continual assistance. There are some of the products which are already present in the market, which provides some features that can help in assisting these peoples. However, these features come independently over several products. To overcome the hardship of using these products independently, we have come up with a device which is an absolute set of features that help visually impaired people to perform their basic tasks such as walking through streets, navigation in public places and seeking assistance seamlessly, safely and confidently. Our proposed system consists of features like obstacle detection, voice based interface, navigation and Intelligible Content Recognition (ICR). This system makes use of technologies like CNN (Convolutional Neural Networks), IoT (Internet of Things), various sensors. In addition, the proposed system is designed, by using materials which are of lower cost.

Keywords: *CNN, IoT, Obstacle Detection, ICR, Navigation, Voice based.*

1. Introduction

Eyes are one of the most precious senses that have been gifted by God to us. About 85% of the information is achieved from the surroundings by vision only . Over the past decades it has been noticed that, number of visually impaired people is increasing rapidly. As per the report by WHO, it is estimated globally that around 285 million people have been suffering by vision impairment or blindness. These people are confined to their own surroundings. They can't move confidently, independently and safely in this world. They need supplementary assistance in order to move from one place to another. To overcome the hardships that have been faced by visually impaired people, there is a need to propose an aid or system that can help these people to perform their basic tasks without any supplementary assistance, so that these people will get more confidence in performing their basic tasks like sighted people

Although, through the last decades many assistance systems have already been found which provide some features in assisting visually impaired people. But these systems are available with the independent features and they are too costly also.

In this paper, we are implementing a wearable system for the visually impaired people, which helps them to move feasibly around the familiar or unfamiliar environment without individuals support, it can also help them in detecting and avoiding obstacles.

Our System mainly consists of following features:

1. Obstacle Detection
2. voice based interface
3. Navigation and Intelligible Content Recognition (ICR).

The main aim of this paper is to implement a complete set of features that provide assistance to visually impaired people in performing multi tasks such as walking in their home, navigation in public places , detecting obstacles and in addition along with low cost building . The design of the system uses the raspberry pi 3 B+ board, an earphone to convey information to the user,

May-June 2020
ISSN: 0193-4120 Page No. 4803-4806

a camera, an ultrasonic sensor for detecting obstacles, a TTS and GPS is used in the system which convert images to text and text to speech which help visually impaired people to migrate from one place to another. This system makes use of technologies like CNN (Convolutional Neural Networks), IoT (Internet of Things), various sensors.

Our rest of work in the paper is organized as follows. Section II contains the related works. Section III explains the methodology of the system that has been discussed. Section IV, explains the findings discussed briefly i.e. result. In Section V the design of the product has been modeled and explained. Finally, Section VI contains the conclusion and future works are discussed for the system.

2. Related Works

The visually impaired made use of mobility tools such as white canes for centuries to navigate for the reason that it is portable and cost efficient. It is effective in detecting hurdles like stairs, holes on the ground etc. But it does not achieve its maximum productivity to detect moving objects such as vehicles and revolving doors sometimes and its sensing range is limited to the length of the stick. With the enhancement of technology this paper's purpose is to provide the absolute set of features that makes the visually impaired mobility easier.

[1] Et Al N. Sathya Mala, Et Al S. Sushmi Thushara, and Et Al Sankari Subbaiah in their paper "Navigation Gadget for Visually Impaired based on IoT" proposed a wearable obstacle detection and navigation system. (uses GPS & Ultrasonic sensors)

[2] In a study performed by Et Al Hsieh-Chang Huang, Et Al Ching-Tang Hsieh and Et Al Cheng-Hsiang Yeh, they proposed an obstacle detection method that uses region growth and depth information to detect and avoid obstacles.

[3] Et Al Mohamed AL. Mekhalfi, Et Al Farid Melgani, Et Al Yakoub Bazi, Et Al Naif Alajlan in their paper they introduce a portable camera-based method for helping blind people to recognize indoor objects. (Uses Euclidean distance measure).

[4] Et Al Jae Sung Cha, Et Al Dong Kyun Lim and Et Al Yong-Nyuo Shin proposed an android app that uses TTS for I/O and fetches data from Google Maps API to help the visually impaired navigate to their destination.

[5] Et Al Tao Wang and Et Al David J. Wu provided a system which uses CNN to identify scalable features to recognize text.

[6] Et Al Nobuo Ezaki proposed an OCR (Optical Character Recognition) system in which a camera is mounted on a person's shoulder that automatically captures an image of a signboard, poster, etc. and recognizes text from it.

3. Methodology

The proposed system consists of 3 modules namely Voice based input/output module, Obstacle detection system, and ICR (Intelligible Content Recognition) system. These modules are linked to the Raspberry Pi which is the brain of the system since it controls the entire data flow.

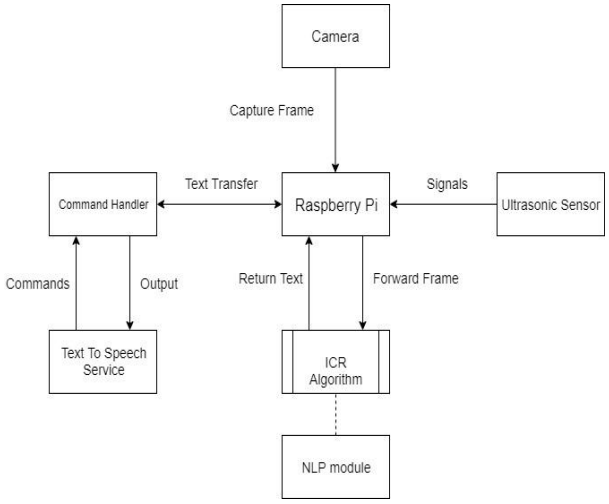

Figure 1: Low level system architecture

As shown in the above diagram, this system is composed of many features that can help the visually impaired. The voice based Input/output system can be developed using any TTS service (Text- To-Speech).

The Obstacle detection system helps the user to detect any obstructions ahead of him/her. Obstructions include anything from large stones to poles/walls. This sub module consists of an ultrasonic sensor which is connected to the Raspberry Pi. The ultrasonic sensor works as an attachable component. The roundtrip time of an ultrasonic wave is the total time taken by the ultrasonic wave to travel till an object and vice versa. If the obstacle is close to the ultrasonic sensor, the roundtrip time will be low and if the obstacle is far away from the ultrasonic sensor, the roundtrip time will be high. Here we will be using an 8 cycle 40 KHz ultrasonic burst to cover a fairly large distance.

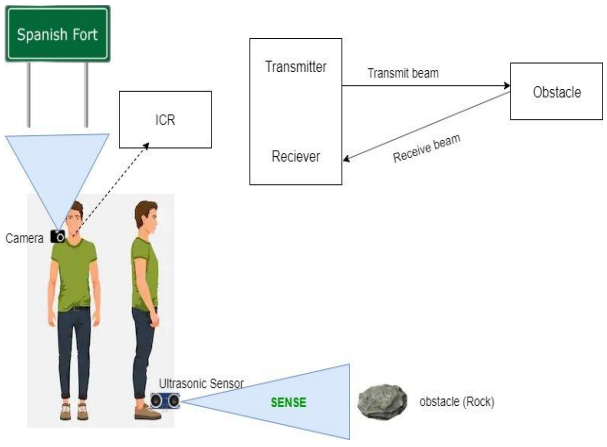

Figure 2: High level system architecture

May-June 2020
ISSN: 0193-4120 Page No. 4803-4806

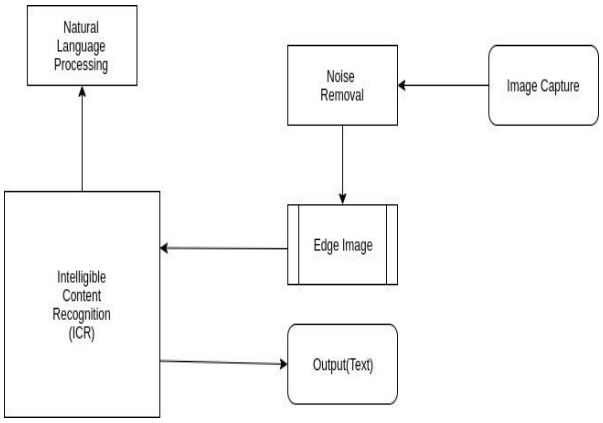

Figure 3: ICR module architecture

The ICR (Intelligible Content Recognition) system captures the image of any signboards, posters, etc. and translates the optical text into computer understandable and human understandable strings. This string will then be converted to audio using a TTS service and the text will be recited to the use. The ICR algorithm first captures all the text/words in the image and makes use of the Natural Language Processing Toolkits like NLTK in order to remove unwanted or irrelevant words/data. This ensures that only the required information reaches the visually impaired person.

The entire system can be seen as an attachable device. a camera for ICR will be placed on the shoulder and can be attached at an optimal location.

The cascading of a HC-SR04 sensor with a Raspberry Pi is shown in the below diagram. GPIO input is provided from the Ultrasonic sensor to the Raspberry Pi through a voltage divider circuit. This is because the ultrasonic sensor operates at 5V whereas the Raspberry Pi's input GPIO pins expect a 3V input. So having a 5V input can actually damage the Raspberry Pi or even fry the circuit.

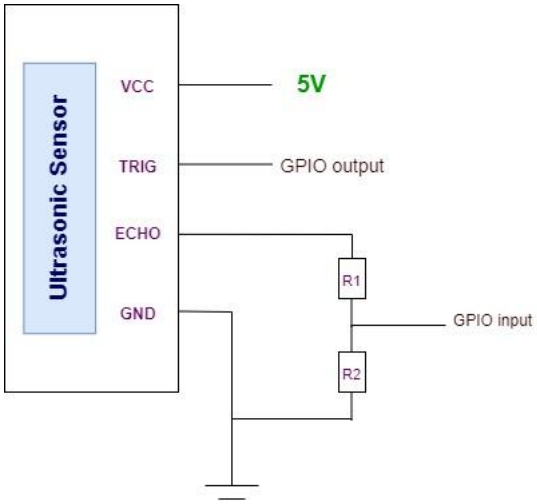

Figure 4: Cascading of HC-SR04 with Raspberry pi

The values for R1 and R2 can be calculated as shown below in equation (1).

4. Results and Discussion

All modules were individually tested a few times and the results were recorded. The results are as follows:

$$V_{out} = V_{in} \quad \frac{R1}{R1+R2}$$

$$3.3 = 5 \times \frac{1000}{R1+1000}$$

$$R1 = 515\Omega$$

- Obstacle Detection:

Position of object	Obtained Output
5cm	8.25cm
10cm	11.65cm
15cm	14.26cm
(away from FOV)	236cm

From this table, it can be inferred that a HC-SR04 ultrasonic sensor can provide a value only as accurate as ±2cm. Hence this bias must be handled in an elegant manner to make the system more reactive.

- Intelligible Content Recognition

Figure 5: Image for detection

The above image was predicted as "Danger High Voltage". This is because the OCR detected all the words present in the image and the NLP algorithm (ICR algorithm) removed the useless words and just retained the words that are crucial to the user's survival.

May-June 2020
ISSN: 0193-4120 Page No. 4803-4806

- Text to speech

Input	**Obtained Output**	**Expected Output**
"Danger move" (text)	"Danger move" (voice)	"Danger move" (voice)
"help" (text)	"help" (voice)	"help" (voice)
"testing 1 2 3" (text)	"testing 1 2 3" (voice)	"testing 1 2 3" (voice)

- Speech to text

Input	**Obtained Output**	**Expected Output**
"Danger move" (voice)	"Danger move" (text)	"Danger move" (text)
"help" (voice)	"help" (text)	"help" (text)
"testing one two three" (voice)	"testing one two three" (text)	"testing one two three" (text)

5. Conclusion and Future Scope

In this paper, we are implementing a wearable system for the visually impaired people, which helps them to move easily around a familiar or unfamiliar environment without an individual's support. It can also help them in detecting and avoiding obstacles. The main aim of this paper is to implement a complete set of features that provide assistance to visually impaired people in performing multi tasks such as walking in their home, navigation in public places , detecting obstacles In addition the system is designed with more reliability and relatively low cost.

Although there are many advantages of commissioning this system, there are a few limitations. Ultrasonic sensors can only detect obstacles that are big, rigid and well defined. There are cases when the obstacles are really small but can cause damage to visually impaired people. An example for this type of obstacle is a signboard's pedestal. The visually impaired person can trip on this obstacle and encounter damage. Moreover, the ICR system can only remove irrelevant words only to an extent. There is a need for a better artificial intelligence that can filter out words or add more words in order to convey important context based information to the visually impaired people based on what the ICR system sees. The HC-SR04 sensor isn't accurate or powerful enough to have a wide FOV (Field of view) and hence, there is a possibility of inaccuracy. In order to prevent this, we can, however, move on to a different distance measuring sensor like the proximity sensor or maybe infrared.

6. Acknowledgment

The success and final outcome of this project required a lot of guidance and assistance from many people and we are extremely privileged to have got this all along the completion of our project.

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