VIRTUAL EYE FOR VISUALLY IMPAIRED PEOPLE

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***Abstract*— This paper is associated with the development of system to provide an aid to visually impaired people. It involves an implementation of a system which includes a pi camera for detection and recognition of text from image which is possible by using tesseract OCR library of OpenCV in Raspberry pi. This helps to convert the picture of desired page taken by camera into respective text. Finally, this text is converted into speech through headphone using TTS Engine. It also assists visually impaired people to navigate safely and to avoid any accident possible due to obstacles that may be encountered on their way. This paper proposes wearable equipment that consists of ultrasonic sensors to detect obstacles and their distance from the user. The principle used for the detection of obstacle is similar to RADAR except ultrasonic sound wave is used instead of radio wave. This paper describes a system to send an emergency SMS to their guardian if the visually impaired people met any emergency situation. GPS Module is used to extract current location information and GSM Module is used to send SMS to guardian.**

By the use of text to speech utilization, navigation and emergency SMS, it assists them to read printed documents, avoid obstructions while travelling and alert guardian at emergency situation through SMS and hence a visually impaired people can feel not being a visual impaired.

Keywords— Read Printed Documents, Obstacle Detection, Emergency SMS, Sensor Based.

I. INTRODUCTION

Vision allows people to perceive and understand the surrounding world. However, a World Health Organization survey made in 2010, estimated 285.389 million people with visual impairment across the globe. Visually impaired people face different problems because they cannot see any contextual and spatial information around them. So, it is necessary for them to use a Braille reading system or a digital speech synthesizer to read any texts. Most of the printed documents do not include Braille and digital versions. Thus, there is a need to develop a system that can convert text from image to speech. Tesseract is an OCR engine which can be trained to recognize the texts from image. The speech synthesizer, Text to Speech engine converts text in digital format into voice played through an audio system. This paper proposes a system with pi camera interfaced to Raspberry Pi which can take pictures of printed documents and identify text in pictures using image processing and text extraction technique. These identified texts are then converted into speech using speech synthesizer and played through headset connected to audio jack of Raspberry Pi. Visually impaired people also face the problems of mobility in an unknown environment. Many efforts have been made to improve their mobility by use of technology. Many people suffer from serious visual impairments preventing them from traveling independently. Accordingly, they need to use a wide range of tools and techniques to help them in their mobility. One of these techniques to help visually impaired people is to train them to move on their own independently and safely depending on their other remaining senses. Another method is the guide dogs which are trained specially to help visually impaired people on their movement by navigating around obstacles and to alert person to change his or her way. However, this method has some limitations such as difficulty to understand complex direction by dogs and cost of these trained dogs is very expensive. Also it is difficult for many of visually impaired people to provide necessary care for the dog. There is an international tool for visually impaired people like white cane to enhance the movement. The white cane is a simple and purely mechanical device dedicated to detect static obstacles on the ground, uneven surfaces, holes and steps via simple tactile-force feedback. This device is light, portable, but range limited to its own size and it is not usable for dynamic obstacles detection. Recently, many techniques have been developed to enhance the mobility of visually impaired people that rely on signal processing and sensor technology. These are called Electronic Travel Aid (ETA) devices. ETA helps these people to move freely in an environment regardless of its dynamic changes. This project describes an ETA which is composed of ultrasonic sensors. This project operates just like the radar system that uses group of ultrasonic sensors to identify height, the direction, and speed of fixed and moving objects. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. The distance between the person and the obstacles is calculated by measuring time of the wave travel. The information about the presence of an object is given via a voice command through headset. These details help the user

to choose the way without obstacle. This paper also proposes a system that consists of GPS and GSM modules which help a visually impaired person to send emergency SMS containing their location to the contact stored in the system by simply pressing a button.

II. OBJECTIVE

- To detect text from image of printed documents and convert it into voice
- To detect obstacles early and inform user through speech
- To send an emergency SMS to their guardian if visually impaired people met any emergency situation

III. LITERATURE REVIEW

Many attempts related to visually impaired people have been made throughout years. Majority of these attempts includes Object Detection, Global Positioning System, use of Ultrasonic sensor and audio conversion. The paper below has presented brief summaries of different past attempts which include:

M Narendran, et al in their paper proposed a system which is a wearable technology as a band for visually impaired people. This system consists of equipment like Arduino Pro Mini 328- 15/16 MHz board which is a device equipped with ultrasonic sensor, vibrating motor, buzzers for detecting obstacles and letting user know about the obstacle. All the connections are done to the Arduino board. Ultrasonic sensor is used in pair as transceiver. The transmitter emits the ultrasonic sound waves and if obstacles are present in path, wave hits the obstacles and gets reflected back. The reflected wave is received by the receiver. The time interval between sending and receiving of ultrasonic wave is calculated. This time interval is used to calculate the distance between sensor and the obstacle. [2]

V Mahalakshmi, et al in their paper proposed a system that recognizes the characters using OCR. The character code in text files are processed using Raspberry Pi on which characters are recognized using tesseract algorithm, python programming and audio output is listened. To use OCR for pattern recognition and to perform Document Image Analysis (DIA), they had used information in grid format in virtual digital library's design and construction. This work mainly focuses on the OCR based automatic book reader for the visually impaired using Raspberry pi. This proposed OCR dictating system converts the text message to audio speech which is implemented by using raspberry pi with a HD camera and headset. It can read the blur image, low contrast image and over exposed images. [3]

Anush Goel, et al in their paper proposed a system which is connected to ARM microcontroller via USB. After pressing the button, captured image undergoes image processing through OpenCV and text is recognized using OCR. OCR technology allows the conversion of images of printed text or symbols into text or information that can be understood or edited using a computer program. In this system OCR technology uses tesseract library. Using Text-to-speech library data will be converted to audio. Camera acts as main vision in detecting image of the placed document, then image is processed internally and separates label from image by using openCV library and finally identifies the text which is pronounced through voice. Now the text is converted into audio output is listened either by connecting headsets via 3.5 mm audio jack or by connecting speakers via Bluetooth. [4]

Aaron James S, et al in their paper proposed a system that consists of capture button. When button is clicked, it captures the product image placed in front of the camera connected to ARM microcontroller through USB. After pressing the process button, captured image undergoes image processing through OpenCV and text is recognized using OCR. OCR technology allows the conversion of scanned images of printed text or symbols into text or information. In this system for OCR technology, tesseract library had used. Also using Flite library the data will be converted to audio. Finally identified product name is pronounced through voice. Once the identified label name is converted to text and converted text is displayed on display unit connected to controller, then converted text is converted to voice to hear label name through ear phones. [5]

Akhila S, et al in their paper proposed a system which detects object and provides real time assistance via GPS for navigation to specific location by making use of Raspberry Pi. The system consists of ultrasonic sensors, GPS module, and the feedback is received through audio, Espeak is also used for text to speech conversion to provide voice command as output. The aim of the overall system is to provide a low cost, efficient navigation and obstacle detection aid for visually impaired people which gives them sense of artificial vision. [6]

V.S.S Kaushalya, et al in their paper proposed a system named AKSHI which consist of box placed in stick that contains Raspberry pi, GSM, GPS Modules. Below circuit box, sensor is placed towards the direction of 45º where it can detect an obstacle and at bottom of stick, RFID reader is placed to detect pedestrian crossing through RFID tag. The system enables current location and the place details that user wishes to go to be stored in an online web server. The guardian details such as their email address, password will be also stored under the user name. While travelling, in every 10 minutes device sends their location to the server. The guardian need to login with their username and a password. Guardian can access the GPS location which shows where a visually impaired person is currently situated. If the user met an emergency, user will press a button in the circuit and a message will pass to guardian's phone saying that user has met an emergency situation. [7]

D Sekar, et al in their paper proposed a system which is related to smart walking stick that alerts visually impaired people over obstacles, fire and water in front of them. This could help them in walking minimizing accident. It consists of a simple walking stick equipped with sensors to give information about the environment. GPS technology is integrated with pre programmed locations to determine the optimal route to be taken. The user can choose the location from the set of destinations stored in the memory and will lead in the correct direction with the help of stick. In this

system, ultrasonic sensor, temperature sensor, humidity sensor, GPS receiver, vibrator, voice synthesizer, speaker or headphone, PIC controller and battery are used. [8]

Anushree Harsur, et al in their paper proposed a system that provides the route navigation to visually impaired person through Raspberry pi. Here navigation system was developed by the use of sounds in order to provide navigation instruction to the user. The conversion of speech into a text is done by a pocket sphinx and Google API, whereas the text to speech conversion is done by Espeak that converts the speech into an Indian language (Hindi). The route queries of the destination location are geocoded utilizing Geo-coder module and then passed to Espeak (text to speech) module to create a pedestrian route. The user can provide location by microphone connected to raspberry pi. The whole system is mounted to a pack that sits on the client waist. [9]

IV. Problem Statement

For visually impaired people, it is a hard task to read the documents and detect the obstacles present in the surrounding causing them to fall behind in the increasingly complex urban world. However, advances in technology available for visually impaired people are not sufficiently accessible. Therefore, in order to improve the quality of their life, this project focuses on developing new technology which can assist them for the detection and reading of documented text through captured images. It can also help them to detect and provide information about obstacles in the surrounding. In addition to this, they may encounter some emergency situation. In such situation, this project intends to facilitate them to send emergency SMS to their guardian. In this way this project ensures an effective and easy way for providing as much information as possible to visually impaired people, which allows them to live a comfortable life.

V. Working Principle

A. Materials

- Raspberry pi 3B
- Pi Camera
- Arduino Nano
- Ultrasonic Sensor HC-SR04
- SIM808 GSM GPS Module
- Button Panel
- Headset
- Power Supply

B. Methodology

Pi Camera is used to take image of page that visually impaired people want to read. This image is pre-processed using OpenCV. The pre-processing stage consists of seven steps: Resizing, Grayscaling, Gaussian Blurring, Edge Detection, Perspective Transformation, Noise Removal and Adaptive Thresholding. The captured image is resized and grayscaled. For the removal of noise Gaussian Blurring is done. Now, four points of the paper to be processed is determined through canny edge detection and perspective transformation is applied. There are possibilities of the

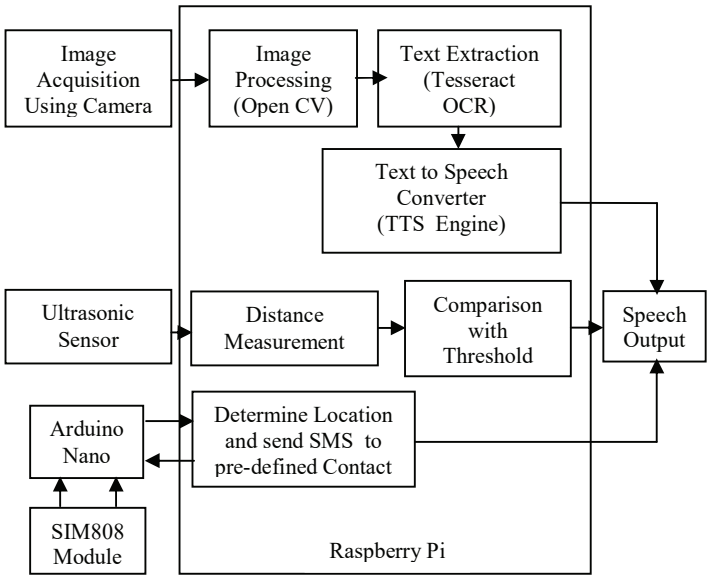

Fig. 1. Block Diagram of Proposed System

image getting skewed with either left or right orientation. So, canny edge detection checks for an angle of orientation and applies perspective transformation till the lines match with the true horizontal axis, which produces a skew corrected image. The noise introduced during capturing or processing of image is cleared by applying morphological transformations. Finally, the image is binarized using adaptive thresholding. The next step is post-processing. It involves segmentation of enhanced image and recognition of characters. The ASCII values of the recognized characters are processed by Raspberry Pi board using Tesseract. Here each of the characters is matched with its corresponding template and saved as normalized text. The recognized text is then converted into speech through headset using TTS Engine. Ultrasonic Sensor is used to determine distance from obstacles. Ultrasonic sound waves are generated by Ultrasonic sensors which are reflected through obstacles. These reflected signals are then received by the module. Calculating the time delay between transmitted and received signal, distance of obstacle is known from the formula.

$$s = \frac{vt}{2} \quad ; v = \text{velocity of sound} = 334\ m/s$$

This distance is compared with threshold distance and warning message is sent to visually impaired people if distance is less than threshold. Distance to his or her right and left side is also calculated parallely. According to distance obtained he or she will be suggested to move in the direction with less or no obstacles. If visually impaired people is lost, he or she can send SMS to his or her relatives by pressing push button. SIM808 module which contains both GPS and GSM module is interfaced to arduino nano. Serial communication is established between arduino nano and raspberry pi. When push button is pressed, data from GPS section is transferred to raspberry pi which extracts data to determine current location and sends it to his or her relative's mobile number (specified in code) using GSM section via arduino nano. Headset is connected to 3.5 mm audio jack provided by Raspberry pi to give voice command to visually impaired people.

VI. Flowchart For Mode Selection

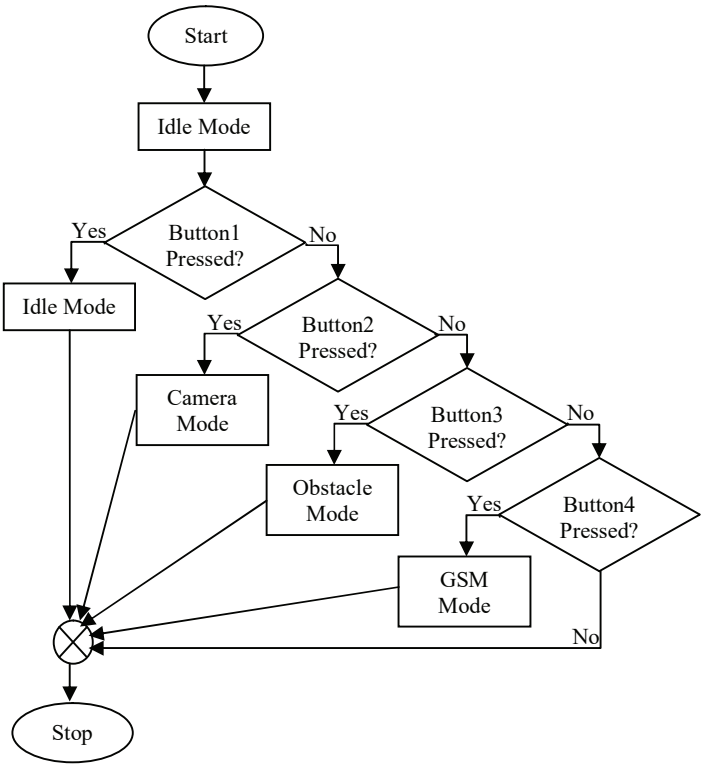

Fig. 2. Flowchart of Mode Selection

VII. Flow Chart For Distance Calibration

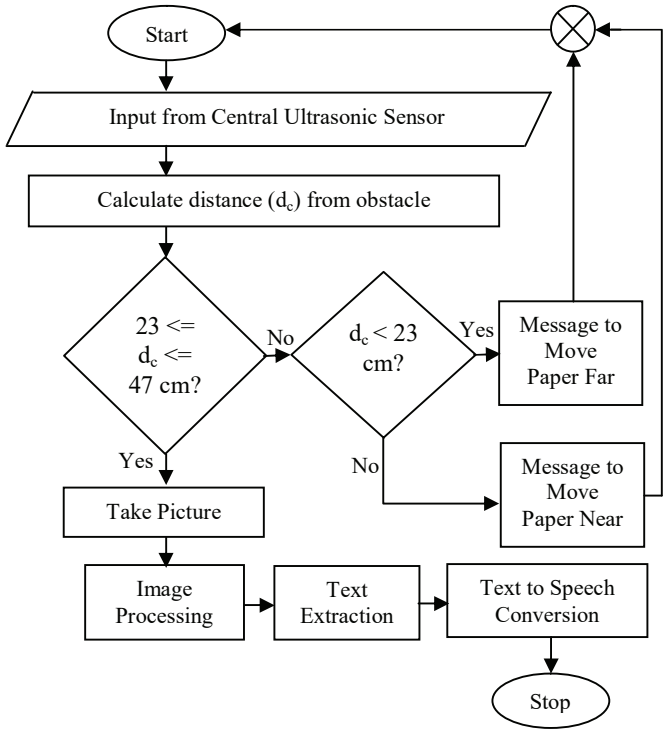

Fig. 3. Flowchart of Distance Calibration

VIII. Flow chart for Obstacle Detection

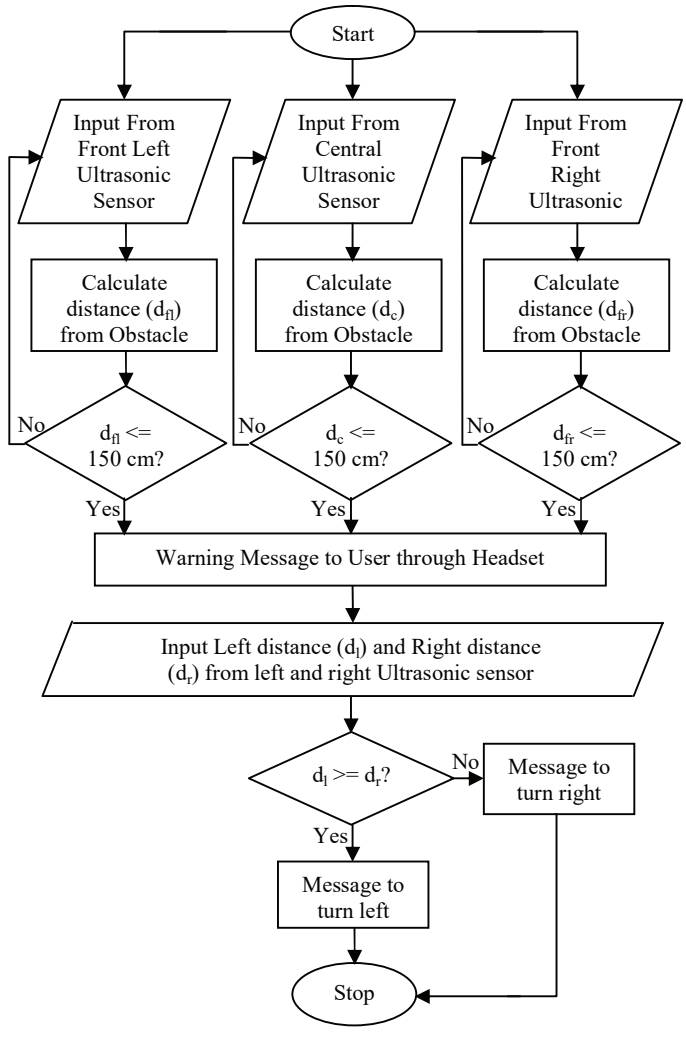

Fig. 4. Flowchart of Obstacle Detection

IX. Flowchart For Emergency SMS

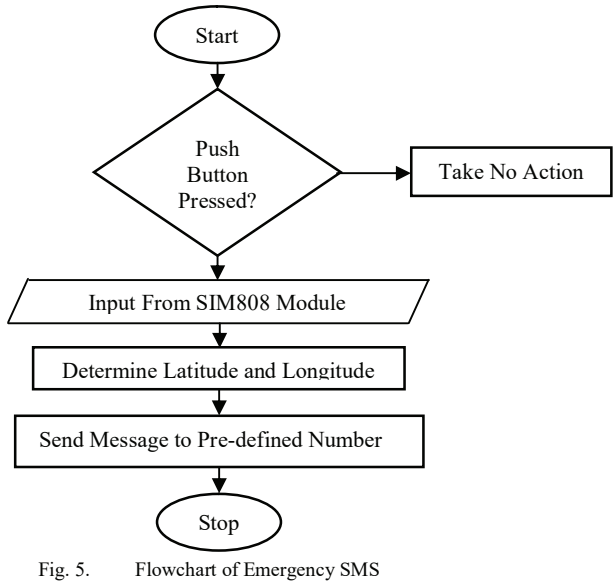

Fig. 5. Flowchart of Emergency SMS

X. FLOWCHART FOR IMAGE PROCESSING

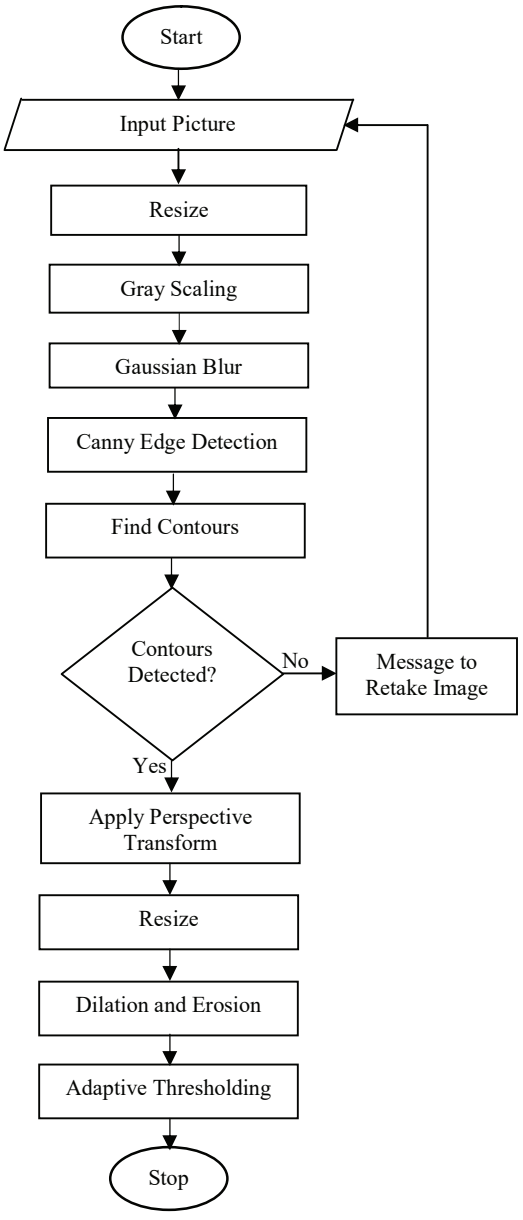

Fig. 6. Flowchart of Image Processing

XI. RESULT AND DISCUSSION

The outcome of this work as estimated to extract the text from image and conversion to voice has been successfully achieved. Thus, it helps visually impaired people to read printed texts easily. This system also makes use of ultrasonic sensors to detect obstacles so that user can navigate safely by providing feedback to user in voice through earphone connected to Raspberry pi. In case of any emergency situations, user can send SMS to their guardians. All works mentioned above deals only with visually impaired people which enable them to read documented texts, navigate safely and send SMS in emergency situation.

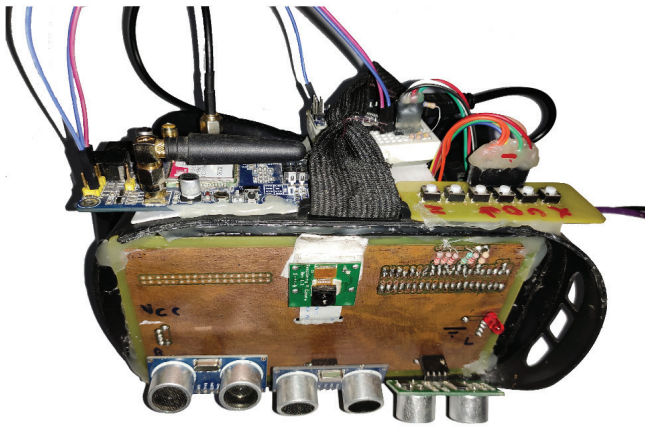

Fig. 7. Snapshot of Hardware of Virtual Eye

For the convenience an output of two different sized papers containing text of different fonts are shown below.

TABLE I. OBSERVATION FOR A4 SIZED PAPER

Distance (cm)	Correctly Detected Words					Accuracy (1024)
	24 pt (11)	16 pt (547)	14 pt (182)	12 pt Bold (202)	12 pt Normal (82)	
37.21	11 100%	541 98.90%	181 99.45%	198 98.01%	77 93.90%	1008 98.43%
41.73	11 100%	532 97.25%	179 98.35%	198 98.01%	75 91.46%	995 97.16%
43.49	11 100%	543 99.26%	179 98.35%	195 96.53%	79 96.34%	1007 98.33%
45.67	11 100%	532 97.25%	177 97.25%	184 91.08%	72 87.80%	976 95.31%
47.34	11 100%	535 97.80%	174 95.60%	133 65.84%	73 89.02%	926 90.42%
49.37	11 100%	517 94.51%	170 93.40%	133 65.84%	71 86.58%	902 88.08%
53.49	11 100%	416 76.05%	104 57.14%	131 64.85%	24 29.26%	686 66.99%

Table I. is the observation table for Times New Roman font taken 10 times. From above table, it can be concluded that for A4 sized paper accuracy lies in between 90 to 98 % for distance ranging from 43 to 47 cm. Also, accuracy was found above 95 % in optimum distance for text size above 14 pt. Hence, optimum distance for A4 sized paper is [43, 47] cm and optimum text-size for A4 sized paper is above 14 pt.

Table II. is the observation table for Arial font taken 10 times. From above table, it can be concluded that for A5 sized paper accuracy lies in between 94 to 99 % for distance ranging from 23 to 43 cm. Also, accuracy was found above 94 % in optimum distance for text size above 12 pt. Hence, optimum distance for A5 sized paper is [23, 43] cm and optimum text-size for A5 sized paper is above 12 pt.

TABLE II. OBSERVATION FOR A5 SIZED PAPER

Distance (cm)	Correctly Detected Words						Accuracy (274)
	24 pt (19)	16 pt (182)	14 pt Bold (14)	14 pt Normal (21)	12 pt Bold (19)	12 pt Normal (19)	
18.78	19 100%	182 100%	14 100%	21 100%	19 100%	18 94.73%	273 99.63%
23.29	19 100%	182 100%	14 100%	21 100%	19 100%	18 94.73%	273 99.63%
27.55	19 100%	182 100%	14 100%	21 100%	19 100%	19 100%	274 100%
32.34	19 100%	182 100%	14 100%	21 100%	19 100%	18 94.73%	273 99.63%
36.74	19 100%	182 100%	14 100%	21 100%	19 100%	19 100%	274 100%
43.29	19 100%	181 99.45%	14 100%	21 100%	18 94.73%	19 100%	272 99.27%

A. *Emergency SMS*

It also facilitates the user to send emergency SMS of current location to their guardian when visually impaired people get lost. The location contained in SMS can be directly viewed in goggle map.

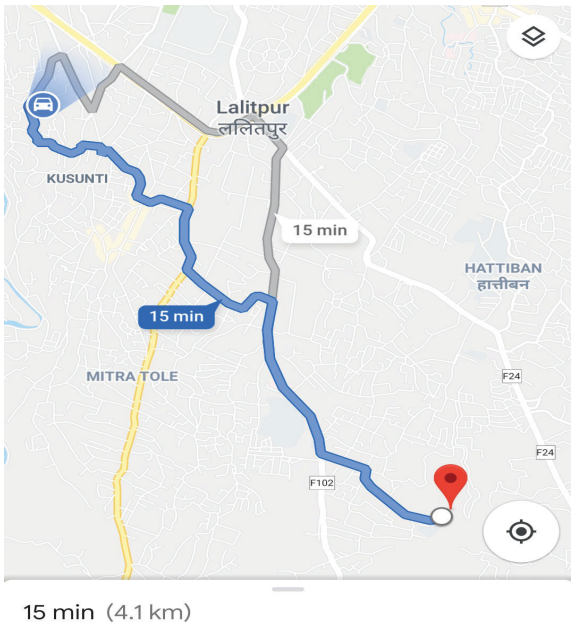

Fig. 8. Google map screenshot with received location

B. *Navigation*

Also simulation has been done in context of GPS based navigation. The simulation was done through an android application which maps an area with predefined route between four points A, B, C and D. The application will ask user for source address and destination address. Google voice-to-text recognizer has been used for this purpose. Then message to aid navigation will be played.

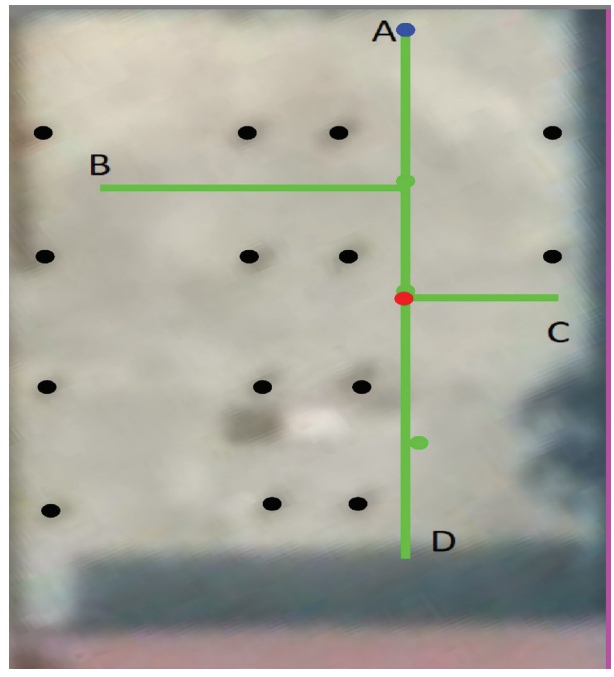

Fig. 9. Simulation of GPS Based Navigation

This project also helps visually impaired person to navigate easily by detecting nearby obstacles in front of him or her and suggest direction without obstacles. For detection of obstacle five ultrasonic sensors have been used. Table III. shows placement of ultrasonic sensors along with detectable height of obstacles.

TABLE III. ULTRASONIC SENSOR PLACEMENT

Ultrasonic Sensors	Angle with Horizontal Axis	Detectable Height of Obstacle, cm
Central	0º	[100, 190]
Left (Front)	46º down	[20, 130]
Right (Front)	17º up	Above 160
Left (Side)	0º	[100, 190]
Right (Side)	0º	[100, 190]

C. *System's Accuracy*

The graph below depicts the distance between camera and paper should lie between 25 cm to 45 cm for efficient text extraction. For distance below 25 cm, all four edges of paper may not be detected due to which there is no information on graph whereas beyond 45 cm accuracy of text drops drastically. Hence for efficient text extraction it is required to maintain optimum distance in between 25 cm to 45 cm.

ACCURACY CURVE WITH CHANGE IN DISTANCE

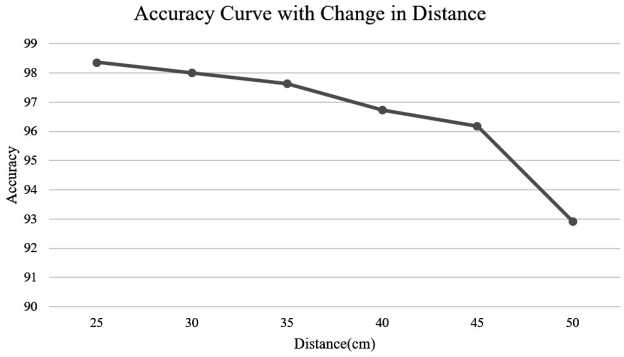

Fig. 10. Accuracy Curve with change in distance

The accuracy of detected text varies with angle between camera and plane of paper. Figure 11. illustrates accuracy with change in angle which was taken at distance of 35 cm for A5 sized paper with Arial font and accuracy above 96 % was obtained for angle ranging from [-30º, 30º].

ACCURACY CURVE WITH CHANGE IN ANGLE

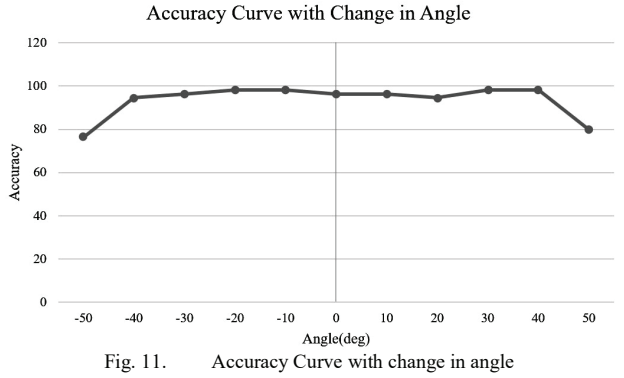

Fig. 11. Accuracy Curve with change in angle

XII. CONCLUSION

The paper proposes a system for visually impaired people using wearable technology which enable them to read printed text documents and inform them about obstacles in their surrounding so that they can navigate easily. Raspberry pi is the processing unit to which all components are interfaced. This device will be a suitable tool not only for the people who have such disability naturally rather it also helps people who got this disability due to diseases and accidental cause. It also helps them to send their location to guardian in case of any emergency situation.

After the implementation of this project, raspberry pi camera which has been used for detection and recognition of text from image and conversion to respective text which is again converted into speech through headphone using TTS Engine has been achieved. The accuracy of the project in A5 size paper above 12 pt font is found to be more than 95%.

A visually impaired people navigate easily, safely and avoid any accident possible due to obstacles that may be encountered on their way with the utilization of wearable equipment that consists of ultrasonic sensors to detect obstacles and their distance from the user. In any emergency situation, SMS to their authorized people can be sent with the help of SIM808 Module.

After the completion of the project, the device that has been made which is useful for a visually impaired people can convert the texts in the form of speech, detect obstacle during navigation and even send emergency SMS about location when in emergency situation.

XIII. SCOPE FOR FUTURE ENHANCEMENT

This work is limited to extracting English text from A4 and A5 size printed document only. But in near future text extraction can be enhanced to detect multiple language and written text as well.

Also obstacle detection using ultrasonic sensor is limited to detecting stationary and slow moving objects. So, in future it can be optimized to detect fast moving object with greater accuracy providing more convenient navigation system.

Also in future, it can be extended to recognize objects and to provide GPS based navigation for visually impaired people.

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