SMART BLIND STICK FOR DETECTION AND AVOIDANCE OF OBSTACLE

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ABSTRACT

Eye sight plays a major role in collecting most of the information from the real world and that information will be processed by brain. Blindness or visual impairment is a condition that affects many people around the world. Visually impaired people suffer inconveniences in their daily and social life with respect to challenges during commuting. This condition leads to the loss of the valuable sense of vision. Worldwide, there are millions of people who are visually impaired, where many of them are blind. The need for assistive devices was and will be continuous. There is a wide range of navigation systems and tools existing for visually impaired individuals. The blind person truly requires an aid in identifying objects. Smart Blind Stick is an interactive device which mainly aims at helping the blind to navigate easily and in a safer manner. In a normal day to day situation a blind person waves the blind stick ahead of them in order to check for any objects or obstacles. The smart stick helps them in this by detecting if any obstacle is blocking the path being taken by the subject. The device detects the obstacle with the help of a camera attached to the front of the stick. On detection of the obstacle, it is identified and appropriate instructions are provided to the user. The instructions to the blind person are sent over earphones. Thus, using the various technologies, the stick provides a safer and a better navigation experience for the visually challenged.

Keywords: Image Processing, Machine Learning, IoT, Computer Vision.

INTRODUCTION

In computer science, digital image processing is the use of computer algorithms to perform image processing on digital images. As a subcategory or field of digital signal processing, digital image processing has many advantages over analog image processing. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing. Since images are defined over two dimensions (perhaps more) digital image processing may be modeled in the form of multidimensional systems.

Blind stick or white cane is introduced to blind people after the First World War as a mobility tool to detect the obstacles in the path of the user. This paper proposes a smart obstacle finding stick for visually-impaired people, which helps a blind person by detecting the obstacles using Ultrasonic sensors, a camera and a Raspberry pi. The main objective of this is to help a blind people to move more freely by informing the blind person about the circumstances & present condition of the path where he/she is walking using a reliable stick.

PROBLEM STATEMENT

Existing System: Majority of them are using a conventional white cane to aid in navigation. The limitation in white cane is that the information's are gained by touching the objects by the tip of the cane. The traditional length of a white cane depends on the height of user and it extends from the floor to the person's sternum.

Limitations of Existing System

Existing systems have the following limitations.

- Very Expensive
- Difficulty to identify the object
- No security of the stick

Proposed System

The proposed system architecture (Fig 2.a) will utilize the features of microcontrollers, machine learning and IoT for its core functionalities.

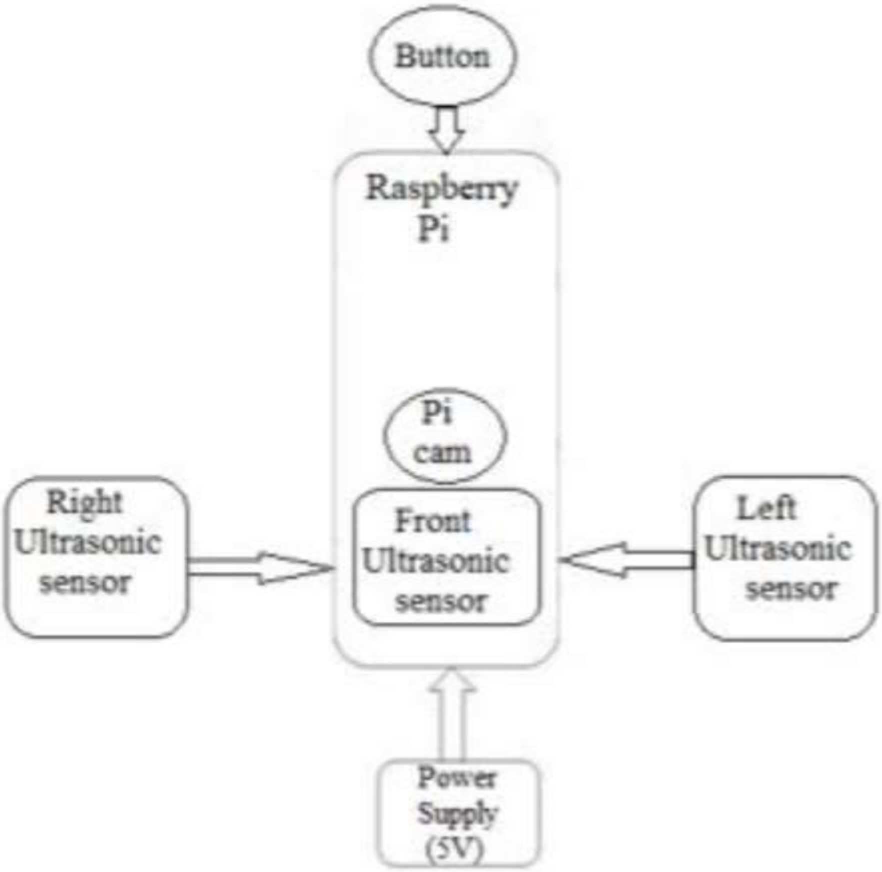

Figure 1: Proposed System Architecture.

Advantages of the Proposed System

The proposed system has the following advantages over the existing systems.

- Low Cost
- Very Handy
- Instruction is passed on through earphones
- Camera to detect the obstacle ahead
- Easy Navigation

SYSTEM DESIGN

The use case of the Smart Blind Stick is as shown in Figure 2. The stick is used by the blind person to navigate around in an environment by avoiding the obstacles. The stick is mounted with a Raspberry Pi setup. Once the obstacle is recognized, audio instruction over earphones is given to the user and asking him to slow down the two ultrasonic sensors on either side of the stick are triggered on detection of an obstacle.

These are used mainly for re-directing the user. An obstacle detection approach based on Cascaded Convolution Neural Network will be designed. The approach will achieve a better performance by cascading three different Convolution Neural Networks with high accuracy.

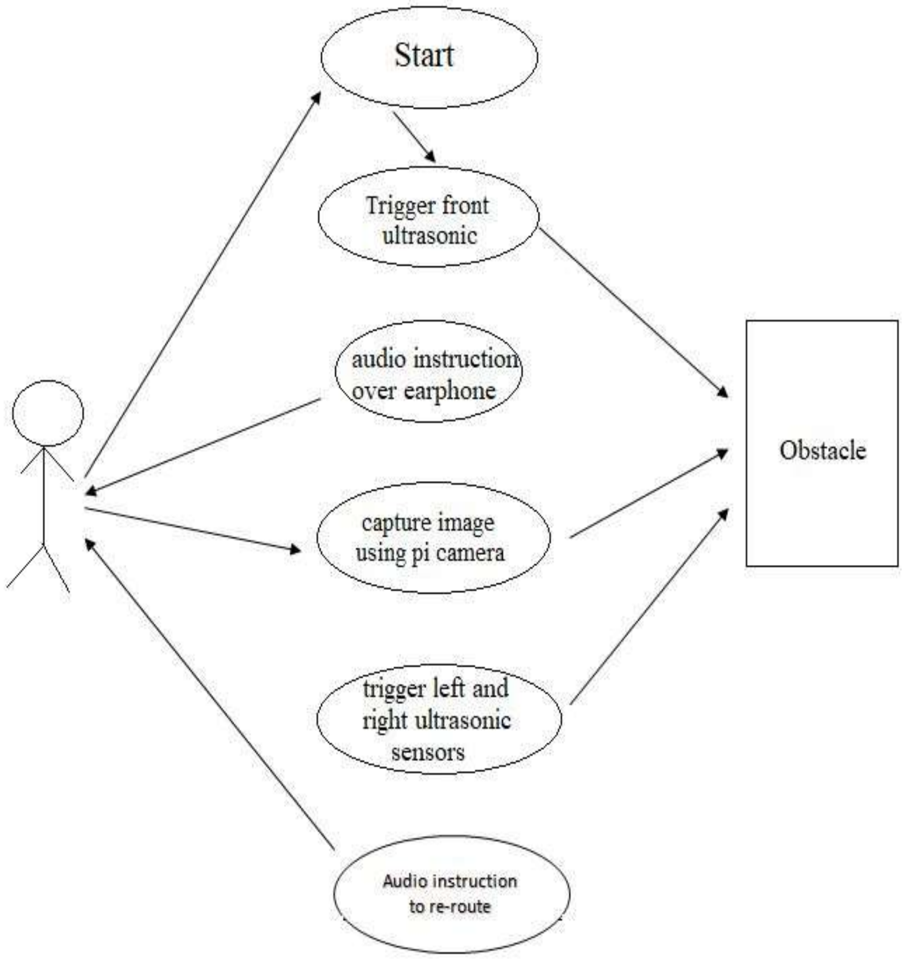

Figure 2: Use Case of a Smart Blind Stick

REQUIREMENTS

Hardware Requirements

- Raspberry Pi
- Pi camera
- Three Ultrasonic sensors
- Bread board
- Power bank

Software Requirements

- OpenCV
- Tensorflow
- PuTTY
- VNC Viewer

IMPLEMENTATION

The camera is attached in the middle part of the stick and is connected to the microprocessor. It captures the images at regular time intervals and converts the rgb (red, green, blue) frame into a grayscale frame. The ultrasonic sensors judge the distance of the obstacle by the time taken by the ultrasonic signal to strike the obstacle and return. An obstacle detection approach based on Cascaded Convolution Neural

Network will be designed. The approach will achieve a better performance by cascading three different Convolution Neural Networks with high accuracy. The data flow is as shown in the Figure 3.

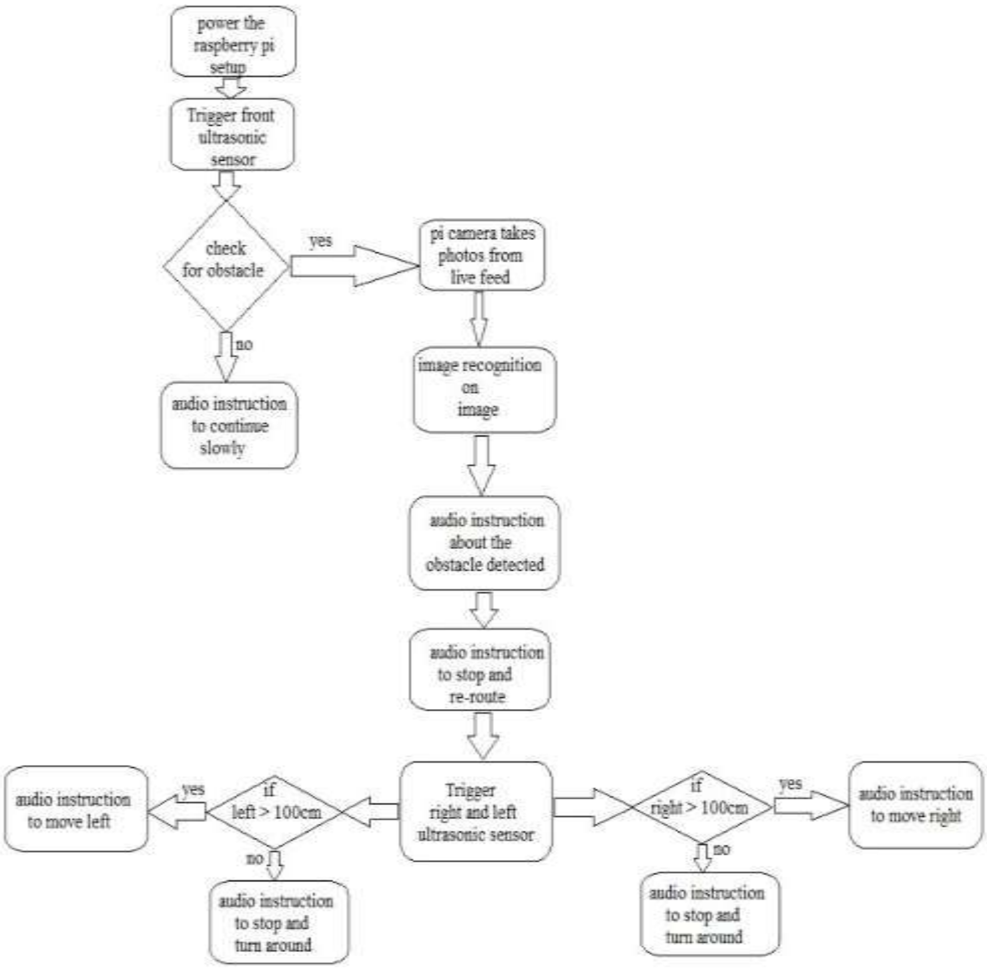

Figure 3: Data Flow Diagram of Smart Blind Stick

The Convolution Neural Network will have a certain robustness to the obstacle and illumination. At the backend, a Python IDE will be used to run the Machine Learning applications. The Keras API, using the TensorFlow library as a backend, will be used to design the Convolution Neural Network (CNN) that will be trained in obstacle recognition.

Pseudocode 1

```
prot= "MobileNetSSD_deploy.prototxt.txt"
mod= "MobileNetSSD_deploy.caffemodel"
os.system("--prototxt "+ prot +" --model " + mod)
```

The captured image is passed to the MobileNetSSD model for detection of obstacle.

Pseudocode 2

```
GPIO.setmode(GPIO.BOARD)
GPIO.setup(PIN_TRIGGER, GPIO.OUT)
GPIO.setup(PIN_ECHO, GPIO.IN)
```

Once an obstacle is detected in the captured image, the ultrasonic sensors are triggered to find the distance to the detected obstacle. This information is utilized to then provide information to the user to avoid the obstacle.

Pseudocode 3

```
text='Checking for obstacle'
tts=gTTS( text , lang='en')
```

The Google Text To Speech(gTTS) package is used to convert the text msg to audio which is conveyed to the blind person over earphones.

RESULT/ TESTING ANALYSIS

Unit Testing

This test case checks if the three ultrasonic sensors being used are working accurately, as shown in Table 1.

Table 1: Unit testing results for ultrasonic sensors

Sl.No	Name of test	Item being tested	Sample Input	Expected output	Actual output	Remarks
1	Proximity sensing test	Ultrasonic sensor	Place the obstacle ahead	Respective distances (16.2,21.8,35.6)	16.2,21.8,35.6	Pass

These below test cases check as to whether the object detection module is working accurately as shown in Table 2.

Table 2: Unit testing results to check Object Detection

Sl.No	Name of test	Feature being tested	Sample Input	Expected output	Actual output	Remarks
1	Object detection	Image processing	Person as obstacle	Person ahead	Person ahead	Pass
2	Object detection	Image processing	Chair as obstacle	Chair ahead	Chair ahead	Pass
3	Object detection	Image processing	Bottle as obstacle	Bottle ahead	Bottle ahead	Pass

Validation Testing

These below test cases are for the various possibilities possible on detection of an obstacle shown in Table 3.

Table 3: Validation Test Cases

Sl.No	Name of test	Feature being tested	Sample Input	Expected output	Actual output	Remarks
1	Validation test	Re-routing directions	Obstacle to the left of the blind person	Instruction to re-route to the right	Instruction to re-route to the right	Pass
2	Validation test	Re-routing directions	Obstacle to the right of the blind person	Instruction to re-route to the left	Instruction to re-route to the left	Pass
3	Validation test	Re-routing directions	Obstacle to the either side of the blind person	Instruction to re-route by taking two steps to the back	Instruction to re-route by taking two steps to the back	Pass

CONCLUSION

This project is designed to create a system using ultrasonic sensors and providing voice command through headphone to the blind people. It would help a visually impaired person navigate through a public place independently. The proposed system tries to eliminate the faults in the previous system. It aims to solve the problems faced by the blind people in their daily life. The system also takes measures to ensure their safety. The design Smart Blind Stick using ultrasonic sensors and with voice output is of great benefit to blind people when it comes to independent mobility. The advantage of the system lies in the fact that it can prove to be very low-cost solution to millions of blind persons worldwide. Text-to-Speech conversion is used to provide voice command as output. The blind person can easily navigate from one place to another as we are providing voice message.

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