EZGuide: An Electronic Aid For The Visiually Impaired

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Abstract: Navigating unfamiliar places can be a very challenging task for visually impaired people. The most common method of object detection used by a visually impaired person is the walking cane. The limitations of the cane are that it's based on trial and error, mostly in unknown areas or surroundings. Also, it does not provide the person a complete knowledge of the obstacle. This system proposes the development of an electronic travel aid which will assist visually impaired by specifically informing them of the objects in their surroundings through audio-feedback. We detect the obstacles with the help of image processing and distance sensing using a 25MP USB camera and an ultrasonic sensor respectively. This device is lightweight and easy to use.

Keywords: **Healthcare, Electronic Travel Aid, Image Processing, Object Detection, Blind People, Assistive Technology, Internet of Things.**

I. INTRODUCTION

Vision enables us to perceive objects in their totality and context. Visual impairment makes it strenuous for people to carry out everyday activities. The World Health Organization (WHO) has estimated an approximate number of 285 million people worldwide with low vision and blindness. Blind people traditionally use a walking cane which helps them navigate by detecting obstacles present in their near surrounding. Guide dogs are also used to help the blind explore the environments.

However, there are a few fundamental shortcomings with both the cane and the guide dogs. For instance,

1. The cane can only detect obstacles which are within the range of 1 meter and also it requires the conscious effort and constant activity of the user.
2. It cannot detect objects above knee level and the user is not informed of what and how many objects are present.
3. Trained guide dogs, or the professional trainers for the same, can be unaffordable for some customers.

A blind traveller behaves much like a robot in an unfamiliar environment. Their physical ability depends upon some sensory system to detect and identify obstacles in the surroundings. Considering and analyzing the problems and difficulties faced by blind people in carrying out day to day activities, a few researchers presented Electronic Aids supplied to the visually impaired can greatly benefit them with improved mobility and speed. Handheld devices, wearable devices and smart canes are such ETAs developed to assist visually impaired people. The most globally accepted and widely used ETA is the smart cane [3], which is regular cane with built in laser ranging system. The National Research Council ensures that the visually impaired people are assisted by the ETAs by the detection of objects both, on a floor-level and a head-level to ensure safe movement and better travel surface information. These aids should have minimum interface with the natural sensory channels [2]. These rules are applied by the majority of ETA systems.

This paragraph presents a brief rundown on some of the early existing ETAs. The LaserCane [4], PeopleSensor [5], GuideCane[6] are some of the ETAs based on sensory substitution technique. Sensory substitution allows the visually impaired to make use of auditory or haptic feedback based on natural senses such as hear, touch and feel. The NavBelt [7] is an ETA based on mobile robotics, a portable device with a computer, to assist visually impaired. The CyARM [8] and Sonic Torch [9], are handheld obstacle detection systems based on echolocation. Individuals making use of these systems are required to continuously move his/her hand in many directions to scan the environment actively, detecting all the obstacles.

II. LITERATURE REVIEW

This section focuses on the review of literature on the use of assistive technology for the visually impaired to help them navigate with ease. The main objective is to help blind people go about with their day to day lives without the need to depend on others for their assistance.

Prashant Bhardwaj and Jaspal Singh [10], propose a sensory system that provides haptic feedback to the user. The system consists of an IR sensor, a microcontroller and walking cane with a vibrating motor. The IR sensor detect obstacles and a buzzer is used to alert the user of obstacles present in their path. The use of IR sensors is not very efficient as these need a direct line of sight and do not operate under low light conditions. Buzzers are not the accurate method for determining the presence of obstacle as the user is uninformed of what and where the obstacle is present.

The NavGuide [11] is an Electronic Travel Aid developed by Qailas Patil and other members. This system is developed using various sensors. Its mainly made up of ultrasonic sensors, wet floor detector sensor, microcontroller circuits and four vibration motors. An ultrasonic sensor sends out high frequency sound waves and records the time taken for the reflected sound waves to return. This ETA is developed as a shoe which comes as a wearable device. The main limitation of this system is that it cannot detect obstacles above knee-level and also it cannot give an accurate description of the object in front.

Mr. Ranaweera[12] and members, propose a system that gives our users the ability to travel independently with an automatic, failsafe alert mechanism designed solely for emergencies. This prototype adopts the concept of image processing for obstacle detection and distance sensing using Infrared (IR) sensors. A web based navigation system is developed to assist the users. The system consists of mainly three parts. Camera module and sensor network, Audio acknowledgment system and Navigation system. Two Raspberry Pi cameras, an Infrared (IR) sensor and a GPS module are used in this system.

Jin Liu, Jingbo Liu [17] research on various ETAs present globally. They have divided the paper into two categories, namely sensory based and camera based substitution for the blind. The study on sensory substitution shows the capacity of the brain to adapt the information relayed through an artificial receptor via an auditory or tactile HMI.

III. PROPOSED SYSTEM

The proposed system consists of four important modules.

- Distance calculation
- Object recognition and identification
- Face recognition
- Auditory feedback

Our system makes use of a Raspberry Pi, Ultrasonic sensor and a USB Camera.

A. Distance Calculation

Ultrasonic sensor is used to determine the distance between the user and object. It emits sound waves. The time between the generation of the sound wave and it's reflection off the object is recorded and the distance is enumerated. An ultrasound is emitted at 40kHz that travels through the air and bounces back to the module from the object / obstacle being detected.

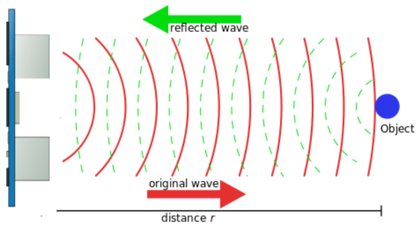

Figure 3.1 Working of Ultrasonic Sensor

The equation for distance calculation is half the speed multiplied by the speed of sound in air that is 340m/s.

Distance=(speed x speed of sound)/2 **(1)**

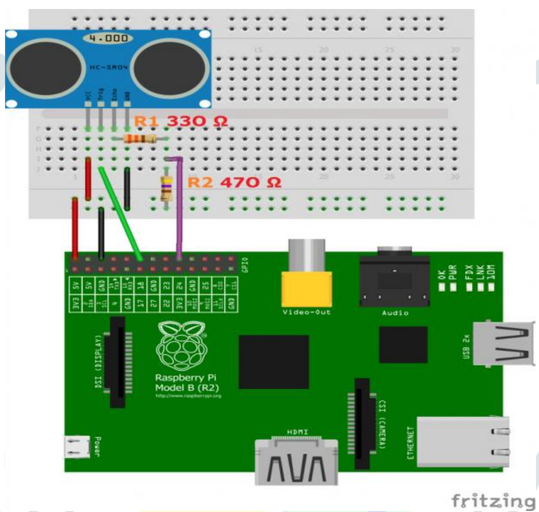

Figure 3.2 Circuit Diagram

B. Object Recognition and Identification

Once the Ultrasonic sensor successfully detects the object, the distance between the user and object is calculated. The USB camera then captures multiple pictures of the surrounding and saves it as an image file. This forms a random dataset which is then used to train the AI model to recognize and display the name of each object present in the surrounding.

C. Face Recognition

This system is also capable of identifying person to person based on their facial features. It recognizes the person and provides the user their name. The system makes use the concept of machine learning to implement feature extraction algorithms.

D. Auditory Feedback

The output generated by this device will then be converted to audio and through external speaker or headphones, the information regarding the users whereabouts is portrayed.

IV. SYSTEM DESIGN AND IMPLEMENTATION

This section of the paper focuses on the detailed design and implementation of the system. The Raspberry Pi is the microcontroller that processes all the inputs gathered by the ultrasonic distance sensor and the USB camera. It provides the output in the form of audio feedback to the user.

Use of Algorithms

- Local Binary Pattern Histogram (LBPH)
- Single Shot Detector (SSD)
- MobileNets
- Caffe Trainer

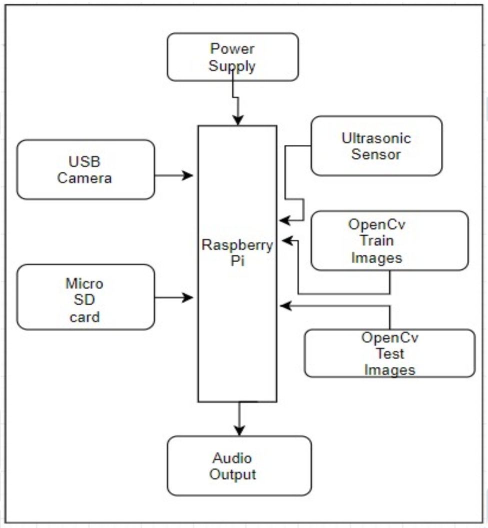

Figure 4.1 Architecture Diagram

A. Object Recognition and Identification

The contribution of Convolutional Neural Network (CNN), a part of Deep Learning, to the field of object identification through feature extraction and image classification has had a huge impact in Artificial Intelligence based object identification systems. CNN image classification takes an input image, processes it and classifies it under certain categories. The input image is taken as an array of pixels depending on the resolution. Each input image will pass through a series of convolutional layers with filters through which feature extraction is done. This image is known as convoluted image. Pooling is responsible to reduce the spatial size of the convoluted image.

Single Shot MultiBox Detector (SSD) [13] is a widely used algorithm in object detection. The specialty of this algorithm is that we only have to take a single shot to detect multiple objects simultaneously within the image.

Working:

- After going through certain layers of convolution for feature extraction, we get a feature map of size **mxn(**location) such as 8x8 or 4x4.
- For each location we get k bounding boxes of varying aspect ratios.
- For each bounding box, we will compute c classes and 4 offsets relative to the original default bounding box shapes.

Along with SSDs we use another class of CNN called MobileNets [15] that helps us perform object detection in a hassle free, fast and accurate environment. On combining both the MobileNets architecture and SSD framework we get an efficient method for object detection based on deep-learning algorithms. This helps us to detect a maximum of 20 objects in one frame.

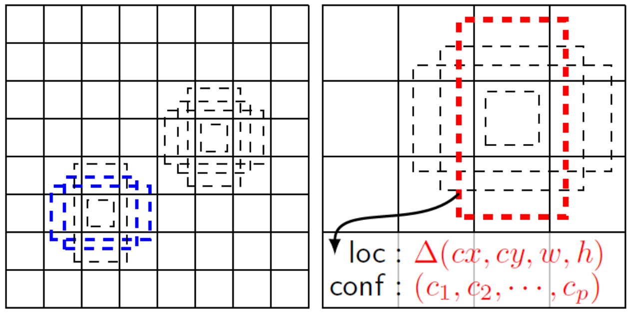

Figure 4.2 MultiBox

We use Caffe [16], which is a deep learning framework, for training our dataset. Caffe helps in speedy image processing thereby providing minimum processing time and maximum efficiency.

B. Face Recognition

Local Binary Patterns Histogram (LBPH) [14] is an algorithm which first converts the scanned image into a matrix sort of image having boxes ,as shown above in the diagram. Then it names the pixels of the image by thresholding its neighboring pixels and stores the result as a binary number. This particular algorithm is trained using a dataset with the facial images. A unique ID is set for each image so that the algorithm will recognize the input image and give the desired output.

- Every image is initially converted to greyscale and a part of the image is taken as a window of 3x3 pixels. The intensity of each pixel can range from 0 to 255.
- The central value of the pixel will be taken as threshold.
- This central value will define the new values from the 8 neighbors.
- For each neighbor of the central value (threshold), a new binary value is set. The values are set 1(one) for values equal or higher than the threshold and 0(zero) for values lower than the threshold.
- Then this generates a binary value which will hence be converted to decimal and set it to central value of the matrix.

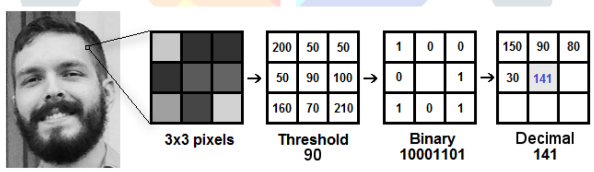

Figure 4.3 LBPH Algorithm

Once a decimal value for each pixel has been generated, a new image with better charecteristics is generated. This image will be divided into grids. Using this we can extract the histogram of each region, thus having one histogram per image. For facial recognition, we compare the picture with the trained dataset. Each histogram created is used to represent each image form the training dataset. Now, by comparing two histograms and returning the image with the closest histogram, we are able to find the image that matches with the input image. To compare the histograms we use the Euclidean Distance.

Based on the algorithm, this system returns a live video feed where in it recognizes the person and returns the name and a confidence value. This will also recognize multiple faces simultaneously in a single frame.

V. CONCLUSION

With the rapid growth and development of technology, people who are visually impaired can easily approach for such a device for their convenience. The features in this device not only meet the user's needs, but are also important from an engineering perspective. Though there's a low probability for this device to be completely error free and efficient, hence the users cannot completely rely and feel confident on using it, though they can use it once the device is evaluated and tested in all possible scenarios.

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