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Mobility Assistive Device for the Visually Impaired

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ABSTRACT

The paper is aimed at the design of a mobility assistive device to help the visually impaired. The traditional use of a walking stick proposes its own drawbacks and limitations. Our research is motivated by the inability of the visually impaired people to ambulate and we have made an attempt to restore their independence and reduce the trouble of carrying a stick around. We offer a hands-free wearable glass which finds it utility in real-time navigation. The design of the smart glasses includes the integration of various sensors with raspberry pi. The paper presents a detailed account of the various components and the structural design of the glasses. The novelty of our work lies in providing a complete pipeline for analysis of surroundings in real-time and hence a better solution for navigating during the day to day activities using audio instructions as output.

KEYWORDS: *Navigation, Position Measurement, Obstacle Detection, Mobility Assistive Device, Blind Navigation System*

I. INTRODUCTION

The loss in the ability to see things or inability to become conscious of the surroundings with the help of sight are signs of Visual impairments. Visual impairment can include both the partial as well as complete loss of sight. As per facts laid by the World Health Organization (WHO), there are around 285 million visually impaired people in the world. Among the 285 million people, 39 million people are completely blind and 246 million people have a low vision [1]. Difficulty when it comes to reading, searching for objects around, navigating from place to place is just some of the few day to day problems that they face. These raises the need for external support in the form of an assistive device which helps them by making the environment much more perceivable and their actions interactive.

A. What is assistive technology?

The International Classification of Functioning, Disability and Health (ICF) defines assistive products and technology as any product, instrument, equipment or technology adapted or specially designed for improving the functioning of a person with a disability [2].

When certain technology is designed keeping the environment and usage in mind, they can function as a gamechanger improving independence and participation.

The most basic thought of such a device would be some kind of a walking stick, which has been put to use since ages, which helps to ensure that the walking path is clear of things. There are evident reasons why this is not at all an efficient way of perceiving environment [3]. Everything has had their advances with technology and so has been the walking stick, many of which are now equipped with sensors which make them interactive over their ancestors [4-9]. Though, that still hasn't resulted in solving the physical hindrance and burden of carrying it around, adding to its limited range and perception.

In this paper, we have discussed a device which is designed to help the visually impaired people. We propose a pair of smart glasses which has multiple functionalities. Recent times have seen a considerable improvement in the image processing techniques which have immensely ameliorated the lives of the visually impaired by providing alternatives for their lost senses. Our multifunctional smart glass is integrated with a basic camera which serves as an optical sensing device and a microcontroller to which other sensors for distance measurements are attached. The optical sensor (camera) senses the surrounding and feeds data into the microcontroller for processing. The microcontroller controls the pipeline to process the raw data and provides the user with the desired information. Impaired people cannot localize objects. Our proposed smart glass can detect object distance and can identify commonly occurring objects by classification models. It detects the object and provides the user with audio output.

The proposed design is developed by using simple, cheap sensors. It has many advantages apart from being lightweight and convenient for everyone to use it. Our motive is to make devices which become a part of the user's regular life. Our research focuses on integrating the outputs from the sensors to the visually impaired people to help them in navigation.

III. RELATED WORK

The visually impaired can't sense much of the information in the environment while travelling or moving from place to place. This causes a problem with avoiding obstacles in their way which could have easily been perceived had they been free from their disability. Navigation systems usually consist of three parts to help people travel with a greater degree of psychological comfort and independence: sensing the immediate environment for obstacles and hazards, providing information about location and orientation during travel and providing optimal routes towards the desired destination [10].

The design of the "People sensor" proposed by Sunita Ram and Jennie Sharf [11] makes use of a pyroelectric and ultrasound sensor. They are used to differently identify a human and non-human in the path and measure the distance between the user and the obstacle as well. This in turn helps to avoid hitting the cane at unnecessary places which would have caused an obstruction.

There are different mediums used by people to function as an alerting mechanism. John Zelek [12] makes use of a vibrating glove which alerts the user of terrain fluctuations with the use of cameras. His technology, "the logical extension of the walking cane" works well to provide information about the immediate environment up to 30 feet ahead.

Arjun Pardasani et al. [3] present a complete system where the make use of their smart glasses as well as smart footwear to break the task of object identification and distance measurement. They have demonstrated the same with the use of prototypes.

IV. METHODOLOGY

Figure 1 PROCESS PIPELINE

Over the past few years, noticeable improvements in the image processing techniques have immensely ameliorated the visually impaired. Involvement of computer vision along with other sensors has been essential in many devices [13].

The flow of control for our design can be broadly picturized as shown in Figure 1. As it can be seen that all the sensors work in parallel to assemble the information collected forming a meaningful output. The choice of components is made after extensive research of the use case and discussion with volunteers who are the potential end-user of the product.

The hardware components with their particular use in the system is described as follows:

A. Raspberry Pi:

The Raspberry Pi serves as the development board for the system. The microcontroller is used to connect all the sensors and process the information from them. We need to make full-fledged computations for distance measurement and obstacle identification. So, it comes in handy to serve as the processing unit providing sufficient hardware as a wearable computer to connect all the sensors and assimilate their outputs together.

B. Camera:

Our multifunctional smart glass is integrated with a basic optical sensing device (camera). It senses the surroundings and feeds in information in the form of visual input for processing. One of the features of smart glasses is object detection and identification. This is done by using Tensorflow models. A pre-defined version of Mobilenet network is modified by freezing the last 13 layers of the network and adding a pair of dense layers with softmax and relu activation respectively. The model is then trained using an adam optimizer with a categorical cross-entropy loss. The above hyperparameters are decided considering the objective of building a robust model for detection of commonly found objects in the environment using a small sample dataset.

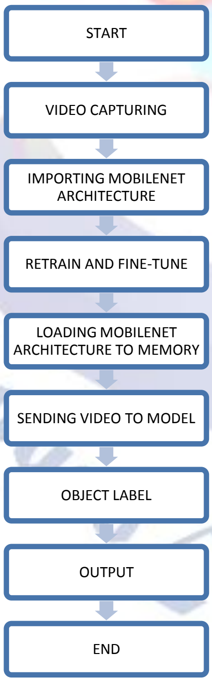

Figure 2 WORKFLOW OF OBJECT DETECTION ALGORITHM

The full functioning of the object detection process can be seen from Figure 2. We would require to further train the model over our own dataset to fine-tune the model for achieving better accuracy. This will help include data as part of the training dataset which could have the objects that are commonly found in one's environment, hence customizing the device as per a user. The purpose of object detection is to give a sense to the user about the objects in his surroundings so that he can get a full idea of his localization among objects and estimate the shape and size of an obstacle.

C. Infrared Sensors:

The Infrared sensors are used to check if an object is in the near proximity. These sensors are placed in such an arrangement which covers all the possible angles around us. This is done to make sure that our walking path is obstacle-free and is clear to move.

D. Ultrasonic Sensors:

These sensors act as the distance measuring unit of our system. A pair of ultrasonic sensors are placed at the exact natural view of human eyes and is used to measure the approaching distance of an object in our motion path. This acts as additional support to decide our path while moving around. Ultrasonic sensors are beneficial in the case of moving objects as well, so we can locate sudden changes caused by moving objects in the environment through them. The input from the ultrasonic sensors is processed to calculate the distance and then guide the user to increase or decrease his speed accordingly via audio commands.

E. Speakers:

The output instructions will be conveyed to the user via small speakers which will be set up for the user to listen the commands.

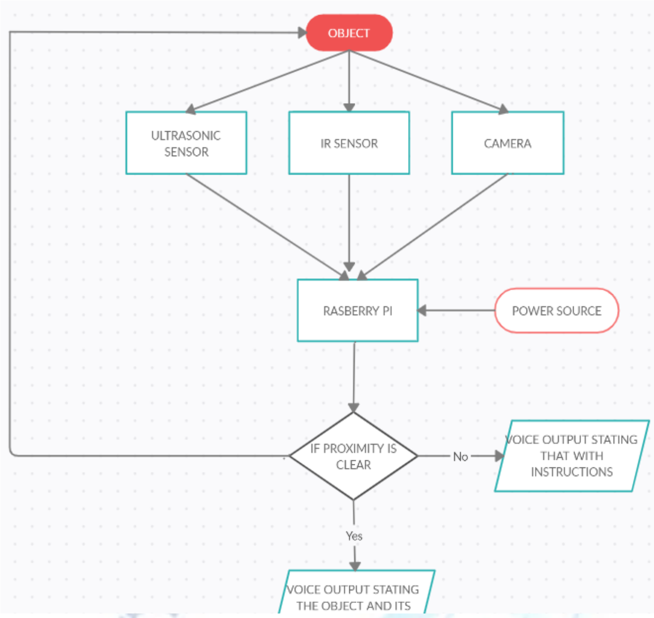

Figure 3 FLOWCHART TO DESCRIBE THE WORKING METHODOLOGY

All the above-stated sensors will be supported by a wearable frame and powered by a 5V battery.

V. CONCLUSION

People suffering from physical disabilities have a tough time performing day to day task without external assistance. It is not always possible to have someone around to help, so using technology can help to solve this problem. Finding yourself in an unknown environment or while commuting from one place to another is a challenging situation that Visually Impaired people face frequently. By proposing the concept of a smart mobility assistive device in the form of a pair of navigational glasses, we have made an effort to make visually impaired people have a feeling of freedom. They can have a sense of their surroundings in real-time. They can get information like the distance of obstacles in their path and identify day to day objects as well. Our design alerts the user with an audio output. Our product promises reliability and is cheaper than the available alternatives in the market. The design can be extended and customized as per a particular user by adding on extra features directly as a supplement to the already existing program easily.

So, with the help of our technology, a visually impaired person can easily detect and avoid an obstacle. The technology like object detection and identification, coupled with the use of distance measuring sensors enhance the information about those particular surroundings in real-time. The concept is targeted at providing end-user with a virtual experience of sensing the environment (which they can't sense due to their loss of sight) and to restore independence and confidence back in their lives.

VI. FUTURE WORK

The project can be extended by adding features to improve the quality of the result. The use of better sensors such as Lidar can improve the depth-sensing of objects. The use of technologies like Bluetooth and WiFi can make room for connection of the device to other devices such as smartphones or laptops to pair up with health or location apps for position tracking. The device can be paired with the GPS system which in turn, if supported with a Google Maps API can create a full ecosystem of path and direction management from a source to destination. The device can be further modified to make it interactive by placing in user input commands via a microphone to instruct the device to perform a certain task or to give certain information. This way the device can function as an assistant providing the features of virtual eyes.

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