Hardware Design for Smart Walking Stick Supporting Neural Networks

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Abstract—This paper aims to bring out the efficient hardware system design to be used in walking stick by the visually impaired people especially to support the cutting edge software technologies to assist in their mobility. It is designed in such a way that it is convenient to handle and also to perform heavier programs without any degradation in accuracy. Hardware design uses Rasberry pi3 Model B for finding the obstacle and to find the distance of the obstacle. Pi camera is used to capture the video frames and feed each frame for processing. For real time object detection, the proposed system uses neural network to train the images.

Keywords—raspberry pi3, pi camera, walking stick, real time object detection, neural network.

I. INTRODUCTION

Visually challenged people have constraints in mobility especially outdoors. They always seek for other people help for their daily routine and the surrounding becomes highly dangerous as they are unaware of the dynamic changes happening around them. They cannot distinguish

Traditionally, visually challenged people use white cane for their navigation in outdoors which provides them limited utility and mobility. It aims at providing support to walking and not much to help them to see what is in front of them. Mere walking support is not adequate in comparison with the technology what we have today. Researchers and developers have been working decades on improving the living standards of the visually challenged.

In order to improve its effectiveness, a smart system is required to ensure safety and to make the individual highly aware about his surroundings. Instead of adopting conventional sensor technology for bettering the smartness, recently evolved cutting edge technologies has been used to develop device that uses cloud computing and neural networks. With cloud computing becoming easy to use and the developers are creating neural networks to train them for object detection in the cloud itself, usage of processor with minimal support is sufficient. Neural networks is blooming in the field of real-time object detection and recognition. There are many algorithms like genetic algorithms [7] are used to detect objects but neural networks give optimized result in identifying objects. With its ability to be pre-trained in the cloud with millions of images for each and every object, the detection accuracy is atmost. So to balance this advancement in software it is extremely important to choose the perfect hardware of required specification that has the ability to run with these heavier programs in it. The overall framework of hardware is considered in such a way that it is light, moderate cost and efficient for these kinds of software modules that doesn't over run the processor and is only semi-dependent on the processing part of the program.

The main objective is to develop a system for detection and avoidance of obstacles that assists visually impaired/disabled persons in their movement in real time. In order to develop the proposed system, this paper will focus on the design of hardware module that is effective, convenient and compatible to work with pre-trained neural networks.

II. EXISTING DEVICES

Vast variety of handheld devices have been developed and introduced in the market to assist the visually challenged people which helps them in different requirements like guiding them with voice, detecting objects through sensors and intimating them vibration etc.

An electronic strolling guide which is built with four ultrasonic sensors [1]. Out of these four sensors, three sensors are utilized for obstacle detection which is set in favor of the stick. The fourth sensor is mainly in charge of pothole identification which is attached beneath the smart stick. The range of these ultrasonic sensors go from 2-250 cms. A camera is utilized to distinguish between objects and text. A flip switch is kept which is worked by the client to utilize other key options available in the stick. At last the final output of the stick is through a voice command.

[2] Sonic pathfinder is an ultrasonic sonar gadget intended to give object detection in and to the side of one's way of movement for visually impaired people. It has 2 transmitting, and 3 receiving, transducers, fitted in a headband. The transmitting transducers flood the field before the user with ultrasonic beam. The receiving transducers distinguish the signs that are echoed back from items in its way. These are prepared by a microcomputer and converted into melodic notes over smaller than normal speakers for the user. The minute beeps that alarms the explorer to objects in the way similar to notes on the melodic scale closely resembling the distance. Items recognized at the most extreme range (2.76-3.06 m) are distinguished by the most astounding note and those at the

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base range (0.0-0.75 m) the least. While the gadget recognizes objects both in front and to the side of the voyager, it reacts specifically to those articles that are nearer and increasingly vital to the line of movement. Moreover, the SP will just illuminate the user of those articles shutting in range while disregarding those at a steady or expanding range.

Mowat sensor [3] is a device which emits a beam of ultrasonic sound and detects its reflection from objects and obstacles. The Mowat vibrates when it detects objects within its range of detection. The amount of vibration suggests the distance of the obstacle from the user. It is highly compact and can be carried in pockets when needed.

In [4] the system is made up of the Ultrasonic sensor which is connected to the microcontroller, codes are written with the Arduino sketch and the physical sensor was connected to the microcontroller. The Moisture sensor has two wire probes which rely on the specific resistance of water to sense its presence when there is a contact. The RF transmitter was interfaced with the microcontroller as codes were written with Arduino sketch and the RF receiver was connected to the microcontroller. The LCD was interfaced with the microcontroller connected to pin and all codes written with the Arduino sketch. The system have the capacity to detect obstacles that exist on the ground during walks indoor and outdoor navigation. The smart stick is basically an embedded system integrating the following: pair of ultrasonic sensors to detect obstacles in front of the blind from ground level height to head level height in the range of 400 cm a head. Ultrasonic sensors and water sensors take real time data and send it to the microcontroller. After processing this data, the microcontroller activates the buzzer. The water sensor detect water on the ground, and battery is used to power the circuits.

Authors [5] proposed a Smart Walking Stick which is an Electronic Approach to Assist Visually Disabled Persons. Their device is a microcontroller based automated hardware that can assist a blind to detect obstacles in front of him/her promptly. The hardware consists of a microcontroller PIC16F690 incorporated with ping sonar sensor, proximity sensor, wet detector, a GH311 Ultrasonic obstacle sensor, a micro pager motor and additional equipment. The design has an added vibratory feedback mechanism necessary for creating vibratory signal for multiple disable persons to get precise information from the output. Wet, muddy or possibly slippery terrain can be detected by a pair of electrodes. Apart from others blind guidance systems; it has a fingernail controller.

Authors [6] proposed Smart Electronic Stick for Visually Impaired. Their proposed framework is a hypothetical model and a framework idea to give a shrewd electronic guide to blind individuals. The framework is proposed to give counterfeit vision, object discovery and crisis informing facility. Ultrasonic sensors compute the distance of the hindrances around the visually impaired individual to direct the person towards the accessible way. Output is as signals which the visually impaired individual can hear. GPS and GSM are utilized to obtain the precise area of the visually impaired individual on occasion of emergency and send the coordinates to his/her relatives. The equipment comprises of Arduino Uno board ATmega2560, ultrasonic sensor, Infrared sensor, GPS, GSM, Keypad and two speakers. The sensors utilized in the stick proposed are exceedingly precise and delicate. They give definite readings of obstructions and distance to be crossed. The GPS and GSM modules gives the area of the patient and accordingly help the patient in critical moment by sending a crisis informing. The speaker helps in human-machine interface by sending the signs to the patient about deterrents and path to be travelled. Likewise, running this coordinated arrangement of equipment requires an option in contrast to the battery.

With the above mentioned hardware specifications used widely in the development of smart sticks, underutilization of the processor is observed. The sensor technology and the other detecting technologies have been used along with high end-processors which doesn't fully utilize the computation.

III. PROPOSED SYSTEM

The proposed system consists of raspberry pi3 model B which acts as the main controller, a camera to get visual input from the environment and a speaker to give the auditory output. The hardware module is powered by battery and made to operate stand-alone as and when powered on by the user. It is fixed on the upper part of the stick near the handle so as to get full coverage of the outer environment. The overall processing is when the pi is booted, camera captures the video frames and is processed by the program residing in the controller. After processing, the distance of the closest object detected is measured and if it's proximity is much closer to the user, the distance is then converted as a voice signal and is sent through the speaker to give alarm to the person about the obstacle to the user in his/her path. Figure 1 shows the overall hardware description of the system.

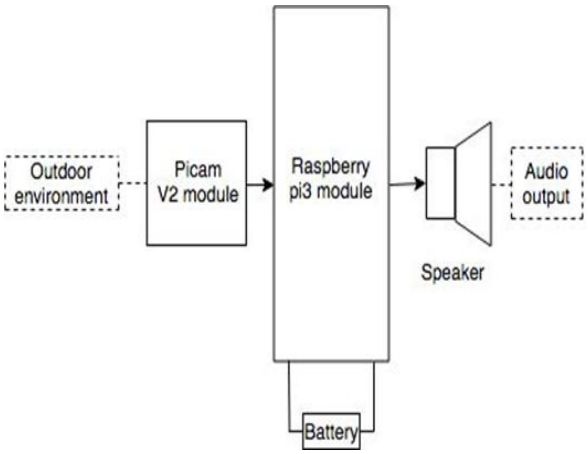

Figure1. Overall view of hardware module

A. Raspberry pi 3 Model B

The most important part is choosing the correct microcontroller which can handle the program load and also to be affordable. Raspberry pi3, a single board computer with inbuilt WLAN connectivity, is used as the controlling unit. It is a low cost computer which can be plugged and played in TV's and laptop and can be worked remotely. It

uses Raspbian Stretch as its OS which is light-weighted and has all the libraries inbuilt in it that are essential for image processing and object detection. With Quad Core 1.2GHz Broadcom BCM2837 64bit CPU, it is sufficient to process image calculations and processing. Model B is preferred over model A because of higher RAM and better GPU support. It is powered by battery so as to make it standalone.

B. Pi Camera module V2

Camera is used to capture the real-time environment and to detect obstacles. It has a quality of 8MP which gives quality video frames that can be processed precisely by the software. Picamera offers much performance than the webcam or any other camera when used with raspberry pi as it is directly connected to the board rather a USB cable. This fastens the transmission rate of captured frames to the processor and hence greater performance.

C. Speaker

Speaker is used to alert the user with auditory information which is basically the distance of the closest object from the user. Usage of speaker claims to be more efficient rather than alerts ,as the users can be more aware about their proximity to the obstacle.

D. Battery

A battery of 2500mAh is used to power up the pi and it is made to run run standalone. The raspberry pi 3 draws 700-800 mAh in idle state whereas it runs at 2.1mAh when connected with other peripherals. The battery is sufficient to run the system for several hours. It comes with a switch which toggles the power when needed.

IV. IMPLEMENTATION AND FLOW CHART & RESULTS

The system consists of smart walking stick embedded with raspberry pi3 powered by battery, camera and a speaker. The picam draws power from the raspberry pi itself. The camera is controlled by the pi. Figure 2 represents the workflow of the system.

When the raspberry pi is powered on by an externally connected battery, it boots and the peripherals are powered on. The object detecting pre-trained caffe model neural network is made to auto run when the pi boots up.

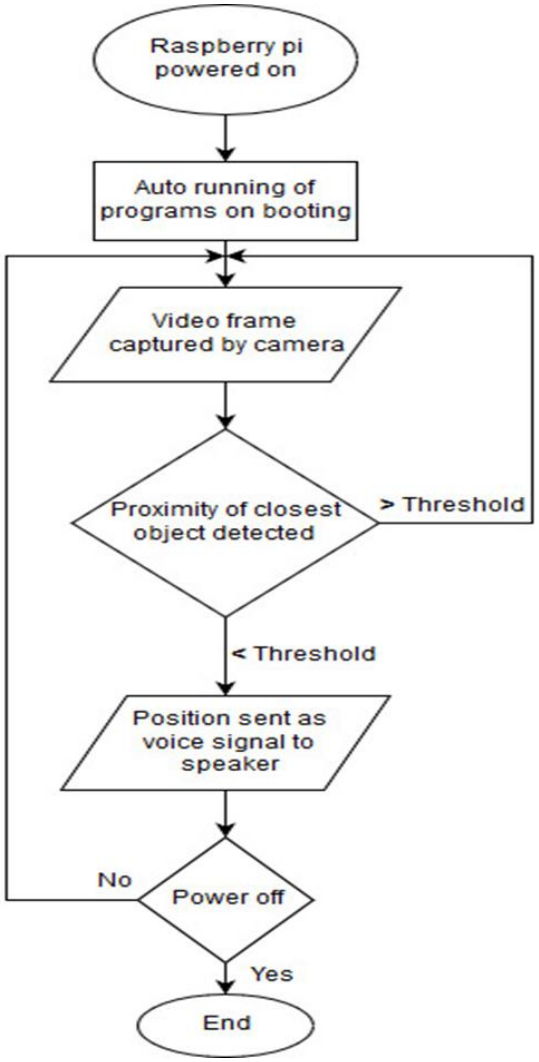

Figure 2. Flow chart of working system

So as soon as the pi is powered on, the program runs which will switch on the camera. The camera starts capturing video frames with a minimal time delay so as to reduce the load on processing. Each frame is sent to the pre-trained neural network which is the main part in detecting the objects in the frame.

We have a pre-trained neural network that is a convolutional neural network of caffe model framework. The Mobile Net has already trained objects with which when an image is sent to it, it is able to detect and localize the object with feature mapping. Since multiple-object can be detected in the same frame, the proximity of the closest object is detected by measuring its height and width within the frame.

So when an object of closer proximity is detected, the program sends a command to the speaker. The command is translated into a voice signal through text-to-speech api, which is read out by the speaker. The command consists of the name of the object and also the nearness of the object to the stick.

Only the closest object is considered because that is the nearest obstruction in the user's path. As the voice signal

also says the name of the object , it is highly helpful to the user so as to make decision whether to walk over it or take a detour and take a new path. This will run continuously as long as the user needs it.

V. SIGNIFICANCE

The main advantage of the system is its ability to run a neural network at a faster rate comparatively with other controllers. The gpu provides quality video frames that is sufficient for object detection. This setup is suitable for any kind of deep learning networks with minimal hidden layers that is ultimately used for object detection.

VI. CONCLUSION

The proposed hardware architecture is very much suited to support all kinds of pre-trained neural networks. This system forms a basic foundation for all kinds of softwares involving deep learning networks.

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