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Low Budget Smart Glasses for Visually Impaired People

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Abstract: *Smart glasses are designed for all kinds of applications and can be employed in industrial applications, medical and healthcare, consumer, logistics, security, and government, etc. In practice, blind people identify objects or find out walk able paths using a white cane. In spite of a variety of such canes (long cane, guide cane, support cane) available, it doesn't recognize what the actual object is. The guiding sticks give an idea about the objects that lie only in a limited area. Having a camera vision with the support of audio messages for the visually impaired ones gives them a better and more precise sense of their surroundings, especially in an outdoor environment. However, because of the high cost of such devices, the dependency of blind people on common people is consistent. This paper provides a new design of Smart glasses, that the user can wear as normal glasses. These devices are optical head-mounted devices that integrate camera and allow hands-free operations. The fundamental objective of smart glasses for people with normal vision is to blend human vision with the virtual world, producing a kind of ubiquitous computing. But, using this design, the camera placed on the device obtains the video equivalent to the point of view which will be processed for assisting the visually impaired user. There is no need for the user to hold the device in his hands or move it in the necessary position and the vision of the user is not occluded. It will provide a field of view up to 120 degrees.*

Keywords: Computer Vision, Deep Learning, Image Processing, Machine Learning, Object Recognition

I. Introduction

The number of visually impaired people is constantly at a rise over the past few decades. According to the World Health Organization (WHO) [1] around 285 million people are visually impaired, out of which 39 million are completely blind. Irrespective of the cause, the outcome for these visually impaired people turns out to be a constant dependency on other sensory information [2] or people around them in order to avoid obstacles and to navigate. Taking into consideration the variations in their nature, some of them hesitate to ask for help even to the people close to them. Also, there are situations when they are away from their trusted people and surrounded with strangers which gives rise to trust issues.

To overcome these issues, recent advancements in technology have been channelized, leading to the development of wearable smart glasses [3]. These smart glasses have a wide range of applications and provide personal assistance along with guidance along obstacles to the visually impaired people, hence minimizing their dependency on others. The wearable device also facilitates hands-free experience enabling the user to perform multiple tasks simultaneously.

This paper aims at developing such smart guiding glasses but in an extremely cost-effective manner, making it affordable to low-income people as well. It focuses on smoothing the outdoor experience of the visually impaired by efficiently detecting objects and hurdles from the surrounding. The usability can be expanded by adding on more module.

II. Existing Technologies

Realizing the need of the hour, various companies and organizations have also contributed by developing different kinds of smart glasses for these visually impaired people [3]. Some of the existing smart glasses are OrCam, NuEyes, Esight, etc.

OrCam [4], an Israeli start-up company whose mission was to develop a portable, wearable, visual system using artificial intelligence and augmented reality, has designed a device which recognizes text and objects pointed towards it. It also provides assistance through an earpiece but only in English. Also, this device is pretty expensive ($2500).

NuEyes e2 [5] is the most recently developed lightweight, wearable electronic magnifier for low vision. Its main purpose is magnifying the objects it points at, thus enabling a better vision. This again costs $2750 which is expensive.

Esight eyewear [6] uses technology that helps visually impaired people to actually see the world around them, in real time. Advanced, medically-validated algorithms optimize and enhance the footage captured by high speed, high definition camera. It restores their sight and thus is again really expensive ($9,995).

III. Proposed System

In this paper, we provide a solution to overcome the deficits of the above existing methodologies or devices to help the visually impaired people. Smart Glasses not only detect daily objects dynamically but also give out audio outputs to the visually impaired people so as to notify them about their surroundings in real time.

The Smart Glasses developed by the design proposed in this paper is a wearable device which works on the basis of computer vision, machine learning and image processing. These glasses are to be worn by the user, which are connected to a credit card sized processor — Raspberry Pi Zero, speaker and a camera module driven by rechargeable batteries for power requirements. The object detection model must be trained accurately so as to reap the proper benefits of a small microprocessor. Using a fast object detection algorithm such as YOLO v3 [7] makes the model work at a greater speed and thus gives the real-time object or surrounding information to the user. For effective training of model on a large dataset, Microsoft COCO dataset [8] was used.

Training a machine learning model is a time-consuming and tedious job when it comes to such large datasets to train on. As a result, the training part of the model was extended to a GPU with higher capacity to run through the algorithm quicker than the conventional CPUs and then transferring the trained model files to the memory of a micro-controller. YOLO algorithm is then run on the dataset with means of Jetson TK1 GPU which takes much less time to go through the training dataset.

Once the model is trained, the required files are then transferred on to a Raspberry Pi Zero micro-controller which has a handy micro SD card slot capable of holding the memory card. This processor runs at 1 GHz with the ARM instruction set. After the software model is ready and installed on Raspberry Pi then it is connected with a camera module compatible with the processor which is a 5MP shooter with fixed focus. This camera module is mounted on the top middle of the glasses. It gives a better and accurate video of the view the user is trying to get. The camera module operates with 720p @60fps which degraded to about 10-15fps because of the light weighted processor and simultaneous algorithm execution. The video captured by the camera is processed by the Raspberry Pi Zero which runs the YOLO v3 algorithm for every 5^{th} frame it receives.

The model trained and tested for detecting objects in real time i.e. YOLO v3, output the textual format of the intended objects found in that particular frame of the image. As this device is built for the visually impaired people they can be assisted by giving an audio output rather than a non-useful textual format. The recognized objects are thus conveyed out by a speaker which is attached to Raspberry Pi Zero. The audio signals needed are generated using gTTs library compatible with Python2 and above to convert text to speech. The whole device easily works on rechargeable batteries which can provide sufficient power to run a day long. The Raspberry Pi Zero requires 80mA (0.4W) power [9] which is far less than other processors will need. This makes Smart Glasses cost effective and at the same time more accurate and efficient.

3.1 System Architecture

System Architecture of the system describes the important building blocks of the system, one tries to build. Smart Glasses basically has 4 blocks which should be considered while in the architecture. The user interacts with Smart Glasses which in turn triggers the processor which controls the camera, speaker, and memory/database.

Major building blocks of device's architecture include:

a. Processor
b. Speaker
c. Camera
d. Database Memory

The following figure represents the architecture of the smart glasses proposed in this paper. It shows the interaction be- tween the major building blocks and the functions each block performs.

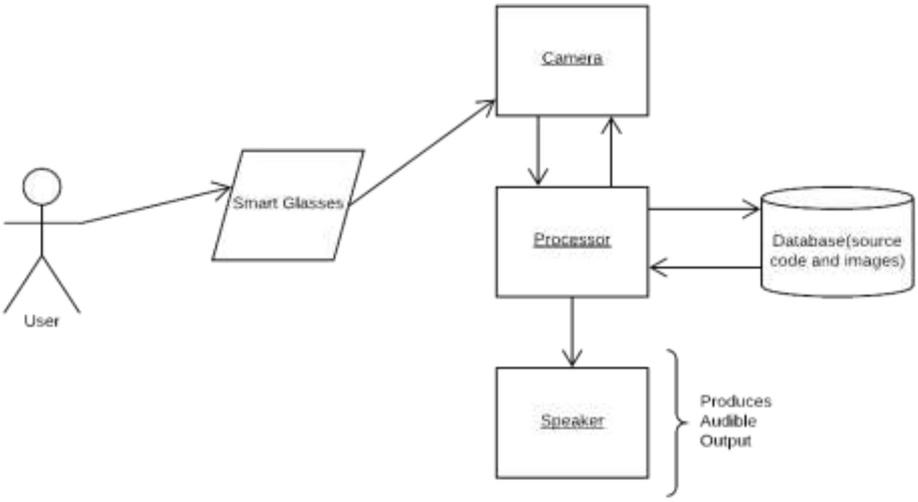

Fig 1. Architecture Diagram

3.2 Working

The main functions carried out by the system are highlighted as we break into its sub processes. The below figure shows the entities and processes they need to follow in order to make the device work according to its functionality. Rectangular boxes define the entities, the rectangular boxes with curved edges represent the processes

a. Turning on the device Switch On
b. Scan video in the angle of vision
c. Detect obstacles Objects
d. Video Analysis

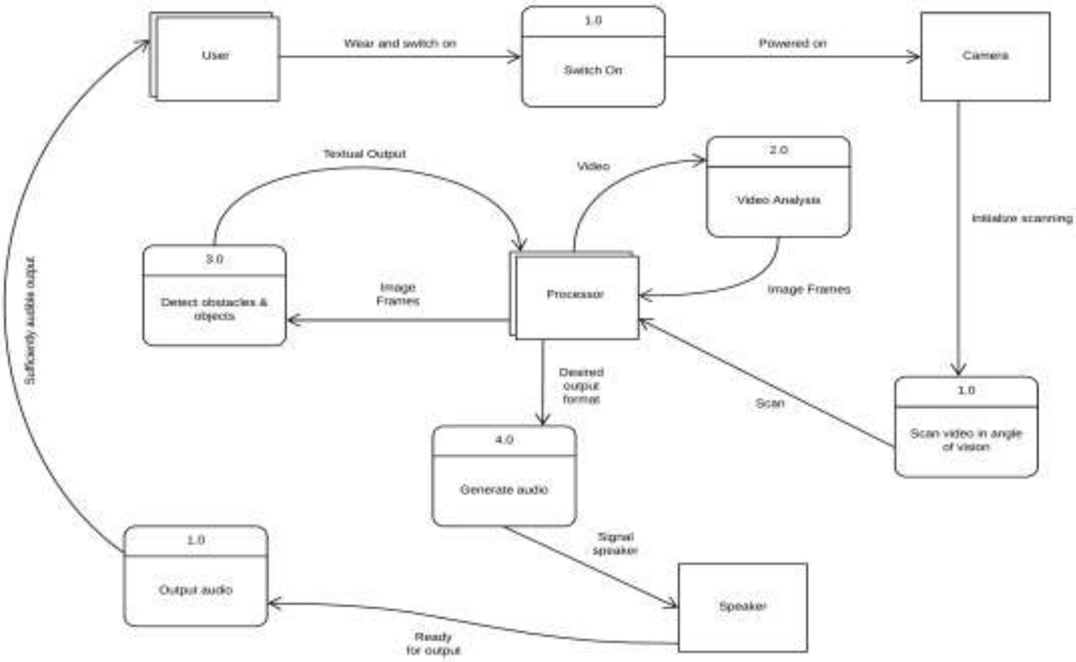

Fig 2. DFD – Working of System

The overall working of the device is shown easily by using data flow diagram given above. Working starts as soon as the user wear and switches on the power supply for Smart Glasses. The first component that initiates in the device system with its job, is the Raspberry Pi Zero processor. It further initiates the camera module attached along with the speaker. The circuit is thus fully running once all the part are operative.

The scanning part is done by the camera module of all the surrounding in its angle of vision. Scanning is possible in only sufficiently well illuminated environments where in the camera easily captures the area circumambient to the user. The video is continuously sent to the processor for processing. Processor performs video analysis by selecting roughly every 3^{rd} to 5^{th} frame from the video so as to not output the same surrounding again.

Subsequently, every selected image frame goes through the trained YOLO model in order to determine the objects at that particular instance. The textual output produced by YOLO algorithm is then converted into speech and speakers are signaled to manufacture its audio version.
Figure 3 describes the process of selecting the frames from live videos and develop the basis for the algorithm to run on.

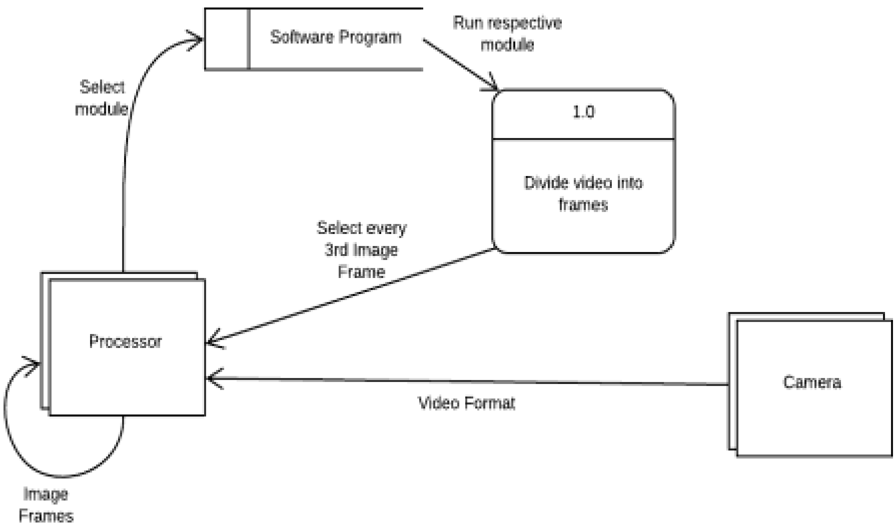

Fig 3. Frame Extraction

Figure 4 sheds light on how the selected frames run through the YOLO algorithm and how finally audio signals are produced for the speakers attached to the device.

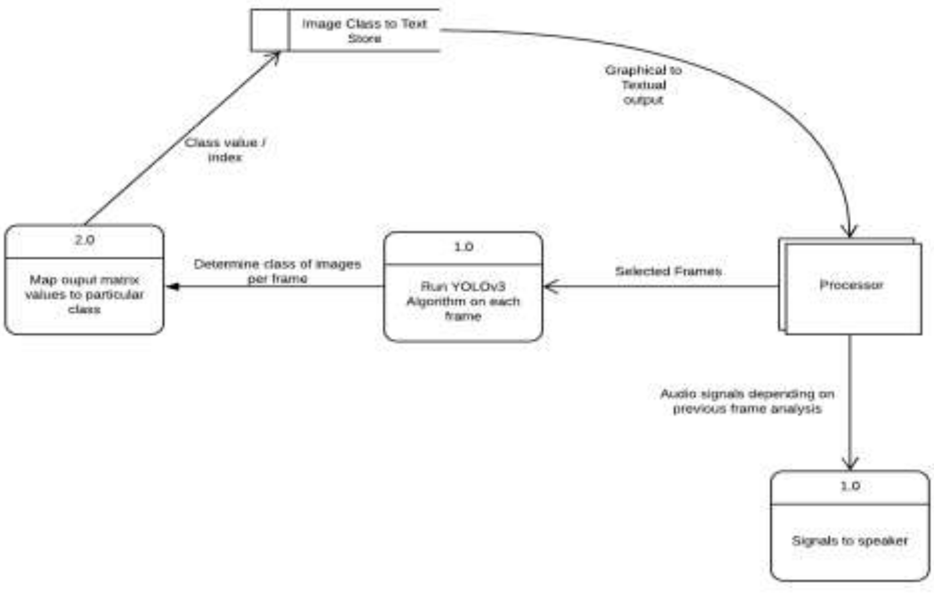

Fig 4. Generation of output Signal

IV. Experimental Setup

The proposed design of smart glasses has a set of hardware and software requirements for the purpose of smooth and efficient working. Table 1 below represents these requirements along with other specification.

4.1 Hardware Requirements

TABLE 1. Hardware Specifications

Hardware Requirements	Specification	Functionalities
Processor 1 : Jetson TK1	DRAM 2GB DDR3L Storage - 16 GB Ports - USB 3.0, USB 2.0, HDMI, RS 232 Camera Ports: 2 fast CSI-2 MIPI camera ports (one 4-lane and one 1-lane) APIs Supported: CUDA 6.0, OpenGL 4.4, OpenCV4Tegra	Being a GPU, this processor has tremendous power for embedded system applications. In this project, Jetson TK1 was used to train the object detection model and to make the computations faster than using a conventional CPU.
Processor 2 : Raspberry Pi Zero	1GHz Single-core CPU 12MB RAM, Mini HDMI and USB On- The-Go ports CSI camera connector Supported Video For- mats: 1080p @ 30fps, 720p @ 60fps and 640x480p 60/90 video	To replace Jetson TK1 once the model is trained and to run real time analysis using the trained object detection model.
Camera : 5MP Raspberry Pi Zero W Cam- era Module	Fully Compatible with Raspberry Pi Zero W. Small and lightweight camera module.	Continuously capture real time videos once the Smart glasses are switched on.
Speaker : Pimoroni pHAT Automatic	3 x 12-bit ADC @ 0-24V (ADS1015) (2% accuracy), 3 x 24V tolerant buffered inputs, 3 x 24V tolerant sinking outputs, Python library available. library	To output the audio corresponding to the textual data generated for objects.

V. Conclusion and Future Work

Smart Glasses for visually impaired people will provide the required assistance to both totally blind as well as partially blind people. Providing real-time object detection capability with audio output will allow users to get an idea of their surroundings with greater precision than using blind man’s cane. People will also be able to find free path along the directions they are walking towards. Using cheap but effective processor such as Raspberry pi Zero will, in turn, reduce the total cost.

The functionality of these glasses can be widened using additional modules. They can also be used for personal navigation by training them over the user’s daily routes. They can also be trained over the user’s family and friend’s faces to help the user recognize who he is talking to or come across.

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