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"VISION VIA VIBRATION"-A wearable device for the visually impaired – Guides the blind to pick the objects

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ABSTRACT

The main objective of developing "VISION VIA VIBRATIONS" is to help the visually impaired to actually interact with the environment. The proposed device will integrate a camera to view the user's environment and implement machine learning algorithms to interpret this data as a collection of objects. It will also utilize a novel directional haptic feedback system, enabling interactions with objects.

Keywords— *Machine learning, Haptic feedback system, Visually impaired*

1. INTRODUCTION

In today's world, innovators often create environments that fundamentally rely on their users being able to see. Accessibility to those without this crucial ability is an afterthought if it is even considered at all. As of 2017, 285 million visually impaired people [WHO] are around the world. Tasks like finding one's keys or walking along busy sidewalks become arduous or even impossible. Despite the pace of medical improvement in recent years, a permanent cure for blindness remains elusive, and even the most promising current treatments are highly experimental and extremely expensive. Blind people today rely on sighted guides, seeing-eye dogs, and canes even a century after the introduction of these solutions, with obvious associated limitations of functionality. Even so-called "cutting-edge" vision technologies are only able to describe a blind person's environment. Crucially, these devices fail absolutely when it comes to actually interact with the environment. To address this pressing need, it is proposed to build "VISION VIA VIBRATIONS", a wearable device that greatly increases the autonomy of the blind. The armband product will integrate a camera to view the user's environment and implement machine learning to interpret this data as a collection of objects and features of interest. Through companion iOS and Android apps equipped with headphones, users will issue verbal commands to the device. "VISTA VIA VIBRATIONS" will also utilize a novel directional haptic feedback system, leveraging the increased sensitivity to touch that often accompanies a loss of vision. By applying vibrational stimuli to specific regions of a user's arm, our device will precisely guide the hand towards a target item, enabling interactions with objects that are otherwise invisible.

2. EXISTING SYSTEM

An extensive review of existing solutions was conducted, and a selection of some prominent work related to the proposed device is presented here:

In [1] authors have designed smart stick as an assistive device for blind people using image processing and sensors. The drawback of this system is high cost and inaccuracy if the images are not present in the data set.

In [2] authors implement pothole detection system using camera and image processing techniques.

Another work in [3] is based on sending electronic impulses obtained by converting images into a pattern of electronic impulses and sent them to the electrode array placed atop the tongue. The impulses are then sent to the different sensory centres of the brain for interpretation through an electrode array placed on the tongue.

In [4] authors have implemented a device that armband product will integrate a camera to view the user's environment and implement machine learning to interpret this data as a collection of objects and features of interest. Do not support gesture. Night vision cannot be obtained and it is relying on the server for a long time.

Kailash Patil et al [5] propose an electronic aid which is a low power embedded system.

It consists of vibration motors, ultrasonic sensors and also the battery is used in it. The vibratory sensor generates voltage and sensitive to high-frequency noise which is hazardous for the impaired user health.

Jinqiang Bai et al [6] propose a smart guiding glass was developed for impaired people.

Ananth Noorithaya et al [7] developed a navigator system which will detect an object or obstacle using ultrasonic sensors and gives audio instructions for guidance. From the analysis of these and other technologies, the shortcomings of current solutions are:

2.1 UNCOMFORTABLE AND AWKWARD

Since the majority of current solutions are apps, they require a user to continuously direct their mobile phone towards what they wish to interact with. This position is straining on the hands and also particularly taxing for the elderly, a generally weaker population that is much more susceptible to vision loss.

2.2 PASSIVE AND INCOMPLETE

Most significantly, no current solution provides a simple and effective way to directly engage the blind user with their environment. Using existing technologies essentially tethers a user to their phone, significantly impacting their overall autonomy. Without a functional, cost-effective way to actively engage in the world around them, people with visual disabilities are relegated to spectator status in our society. To address this pressing need, a wearable armband is developed to increase the autonomy of the blind.

3. PROPOSED SYSTEM

In this work, a wrist wearable device which can assist the blind people in interacting with the environment and guides them in picking the objects is proposed. Figure 1 and 2 shows the components and interactions in the system. The Raspberry Pi waits for a wake command from the user. This can come from either saying the wake word "Hey George" into the microphone of an Android phone running our application or by placing a finger on the easy-to-find divot in the casing of the device. The user then verbalizes their command into the phone's microphone or long-presses the capacitive touch sensor to trigger a default scan of the environment.

This command is sent to the server to be relayed to the Raspberry Pi. Once the Raspberry Pi receives the command from the server, it begins to execute the required action. First, the Raspberry Pi captures an image from the camera and converts it into a base64 string to be sent back to the server which is sent to the user's phone.

The Tensor Flow models are run onto the user's phone instead of relying on expensive cloud computing services. The user's phone loads a Tensor Flow instance to describe the scene or pinpoint a specific object. If the user simply wants a general description of the surrounding environment, the server sends its result back to the Android app, in order for the answer to be spoken aloud to the user. If the user instead wants to locate a specific object, there are certain processes required. The Raspberry Pi would then use a Median Flow Tracker to track the bounding box. The RPi determines the offset between the object location and the user's hand (whose location is known by the fixed attachment of the camera). Utilizing Open CV's motion vectors and the vibration motors, the Raspberry Pi vibrates in the direction that the user's hand must travel to reach the target object, and pulses once the user has successfully reached the target.

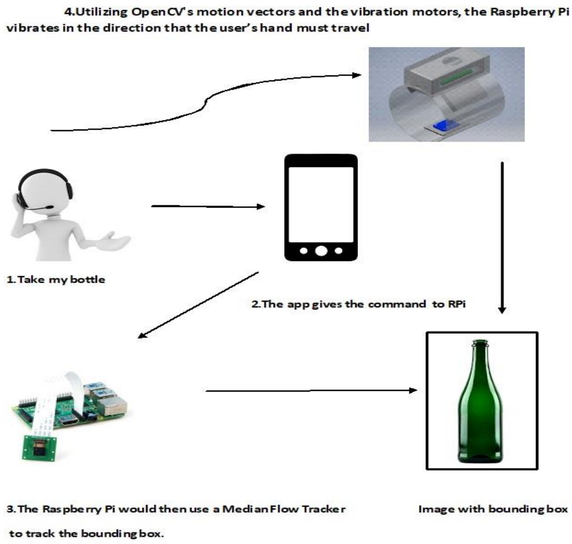

Fig. 1: Flow diagram of the proposed system

Fig. 2: Flow diagram of the proposed system

3.1 LIST OF MODULES IN THE PROPOSED SYSTEM

There are three major modules in the design of the wearable device

(a) **VISTA VIA VIBRATIONS:** utilizes a novel directional haptic feedback system, leveraging the increased sensitivity to touch that often accompanies a loss of vision. By applying vibrational stimuli to specific regions of a user's arm, our device will precisely guide the hand towards a target item, enabling interactions with objects that are otherwise invisible.

(b) **Machine Learning Model:** We are implementing certain machine learning models like Show-Attend-Tell model, which is capable of accurately describing a complex scene to the user.Object detection API with a frozen inference model and custom trained model, allowing for over a thousand objects to be recognized.

(c) **Android App:** In our Android apps, we allow the user to access speech recognition and text-to-speech technologies. The Android app uses CMU's Pocket Sphinx for wake word detection and Google speech recognition. When the user says the "wake word" or presses a button on the armband device, speech recognition is activated. After the user's speech is processed in the app, the command is sent to our server, which activates the camera on the armband device. After the server processes the image, information is sent back to the app, where it is read out through text-to-speech.

3.2 SPECIAL FEATURES OF VISTA VIA VIBRATIONS

a) Night vision: By utilizing a special camera module without an InfraRed (IR) filter and then utilizing IR LEDs to shine on the camera's target, we grant the blind night vision.

b) Depth Perception: The device is able to determine exactly how far away the desired target object is through stereoscopy. This will help to more carefully direct the blind user's hand towards the target, and avoid a collision.

c) Special Camera Setup: Through upgraded SainSmart camera, however, the Raspberry Pi is able to track objects with a 160-degree FOV. This allows the user to point “VISTA VIA VIBRATIONS” towards a cluttered table and be able to scan the entire desk at once, making device much easier to use.

d) Long Time Powering: In order to obtain a long time powering solution, Lithium Polymer batteries (“LiPo”) are used, which are rechargeable. To wrap around the user’s arm, it uses two smaller batteries wired in parallel.

4. IMPLEMENTATION

Hardware and software requirements for the proposed system are listed in Table 1.

Table1: Hardware and Software used for experiments

S.No	Component	Description
Hardware Components		
1.	Raspberry Pi 3	The Raspberry Pi 3 Model B is a tiny credit card size computer
2	Camera Setup	The camera module is a custom-designed easy plug and plays for Raspberry Pi
3	Night vision camera	Camera with removed IR filter allows usage at night also (with IR lighting)
Software		
4	Open CV	For implementing Machine Learning algorithms
5		Operating System for Raspberry Pi

5. CONCLUSION

The idea of developing “VISION VIA VIBRATIONS” is to substantially improve the quality-of-life of the visually impaired in today's world. The main purpose of this project is to produce a prototype that can detect objects and feeds back in the form of voice messages and vibrational stimuli to guide the hands towards a target item. An interesting future enhancement might increase the competence of the device.

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