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A Survey on Mobile Applications for the Assistance of the Visually Impaired

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Abstract: According to statistics released by WHO, 16.6% of the world population is suffering from vision impairment. In the past years, many endeavours have been done to develop several devices to provide support to the visually blind and enhance the quality of their lives by making them capable.

This paper discusses various applications being used in assistive technologies for the visually impaired. These applications focus on using different deep learning algorithms, various sensors and text-to-speech output to the users and are available for various platforms such as Android, iOS. The idea of writing this paper is to concisely review the recent progress of the technologies being used in this topic and provide a clear understanding to other researchers who wish to develop further applications in this field.

Keywords: Visually impaired, Object detection, Android, Assistive technology, Machine Learning, Neural Networks.

I. INTRODUCTION

As per WHO's report it is estimated that at least 2.2 billion people are suffering from vision impairment around the world and India is home to 62 million of them, out of which 8 million suffer from complete vision impairment.

Unlike a normal sighted person, the visually impaired face a lot of problems in their day to day life with ease of mobility being the most common one. Since they do not have a complete understanding and information about their physical environment, they face difficulty in exploring their surroundings hence mobility is the main issue for the visually impaired. They also use canes to detect various objects and avoid collision but canes cannot help in identifying the type of the object and are unable to detect an object that might be out of reach for the user. They generally rely on their experience and other senses to commute through their surroundings but it may lead to an accident or an injury in case of an unprecedented object in an unfamiliar environment. Modern technology has been developing assistive devices that help the visually impaired.

Assistive Technology [1] (AT) can be any device or software that reduces the effort of the visually impaired people in understanding their surroundings and makes them capable, independent and self-sufficient. These devices help the visually impaired person to be more aware of his or her surroundings so that the risk of hurting themselves or getting hurt by others is reduced. Assistive technology improves their response to a situation by providing them information.

Recent research patterns show a rise in development of mobile application aids rather than wearable and handheld device aids for the visually impaired. Having a single device perform multiple aid operations is preferred over having separate external devices and it is much more cost effective. Increased availability and higher computation capabilities of smartphones gives motivation to develop various applications with increased performance to assist the visually impaired in their day to day life. These applications are trained using deep learning models that help to identify and classify various objects in front of the user.

This paper aims at exploring various such assistive technologies developed on a mobile platform to assist the visually impaired in their day to day life.

This paper is organized as follows:

Background of assistive technologies in Section 2. Existing Technologies are discussed in section 3. Section 4 concludes the paper followed by References.

II. BACKGROUND

A. Visual Substitution Techniques

Visual Substitution[2] can be explained as an alternative for the blind where an image may be captured from a camera, information is processed, and output is provided to the user in non-visual form such as in an auditory mode. Visual Substitution can be further subdivided in three parts i.e.Electronic Orientation Aids[3] (EOA), Electronic Travel Aids[4] (ETA) and Position Locator Devices[5] (PLD). Many advancements have been done in the field of development of ETA which makes them more popular than EOA and PLD in the visually impaired community.

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Electronic Travel Aids retrieve data from the environment and then provides it to users via sensors such as NavBelt , Guide Cane etc. These are the most commonly used aids by the visually impaired. Some functions of the ETA are: Detection of Obstacles in path, locating items near the obstacles, conveying the distance between the user and obstacle, detecting gaps, inconsistencies in the surface. Electronic Orientation Aids guide the person about their path by providing directions or through the path signs such as Wheelesley, Smart Walker [6] etc. These devices help in guiding the user in an unfamiliar environment. Some functions are: Selection of best path, Calculating the approximate location of the user, Guiding the user. Position Locator Devices locate the user by finding the user's location via satellite. This helps a visually impaired person to be aware of his or her location and possibly their surroundings. GPS is the most popular example of Position Locator Devices.

Fig. 1. An example of an ETA

B. Challenges Faced by the Visually Impaired

The visually impaired community face a lot of challenges such as, they have a hard time navigating the outdoor environment. Traveling in crowded places is difficult for them. They seek help from either assistive technology or the people around them. They face difficulties while internet surfing for shopping, etc. A blind person cannot navigate between web pages easily. There are many more challenges blind people face like doing household chores, currency denomination recognition [7], obstacle detection [8], navigation, crossing the road, etc.

C. Assistive Technology

We provide Assistive Technology to help the visually impaired overcome the challenges mentioned in the previous subsection. Over the period of time, the number of smartphone users have increased exponentially. Smartphones have become a necessity for everyone today including the visually impaired community. Reports suggest that there are 190 million smartphone users in India and a majority of these users have smartphones that run on an Android operating system. The features and processing capability have also developed significantly and improved over time. Some aids for the visually impaired consist of hardware separate from the smartphone such as Smart Canes [9], cameras, etc. These devices are effective but costly. With the increased functionality of Smartphones, we can develop applications that do not require external devices, hence reducing the costs and increasing mobility of the person (reduction of external hardware). With the help of deep learning, we can create or implement Object Detection Algorithms. There are a lot of pre-trained models for object detection such as YOLO [10], RCNN [11], Fast RCNN [12], Mask RCNN [13]. With the development of such algorithms, object detection has become easier, faster and much more accurate.

Thus, using smartphone applications has become a better option to be implemented as a Assistive Technology for the Visually Impaired.

Fig.2. An example of AT that helps the user identify the currency and denomination.

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III.EXISTING TECHNOLOGIES

A. Deep Learning Based Solutions

Convolutional Neural Networks (CNN) [14] is conceivably the most popular deep learning architecture. It is mostly due to the colossal popularity and effectiveness of ConvNets . It all started with AlexNet[15] in 2012 and has grown exponentially ever since. In only three years, it advanced from an 8 layer AlexNet to a 152 layer ResNet[16]. The fundamental favourable position of CNN contrasted with its predecessors is that it naturally distinguishes the significant highlights with no human supervision. For instance, given numerous photos of cats and dogs it learns particular highlights for each class without anyone else. There is an information picture that we're working with. We play out an arrangement convolution and pooling operations, trailed by various completely associated layers. In the event that we are performing multiclass characterization the yield is SoftMax.

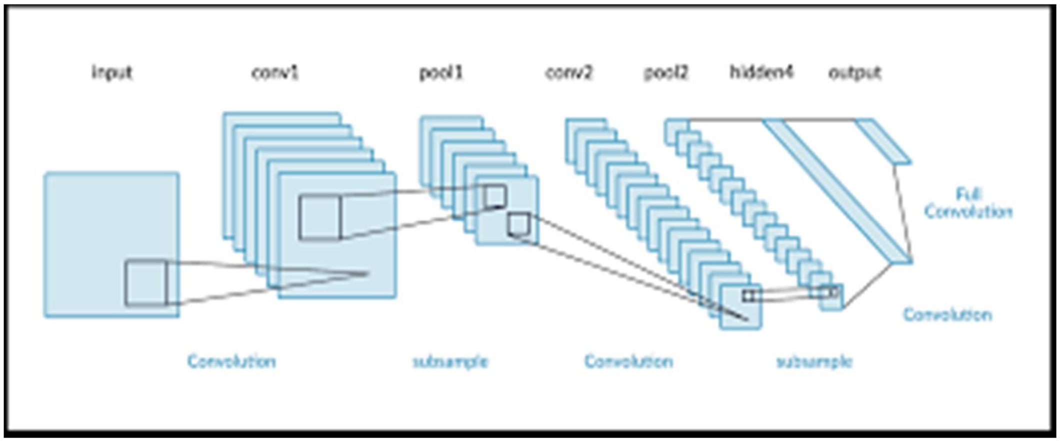

Fig.3. Convolutional Neural Network Architecture

OpenCV [17] is an open sourced library that includes several hundreds of computer vision algorithms, functions aimed at real-time object detection [18]. Through this library we can easily dissect videos and real time data into separate frames for processing and can also convert them into arrays or lists for training the machine learning [19] model for prediction.

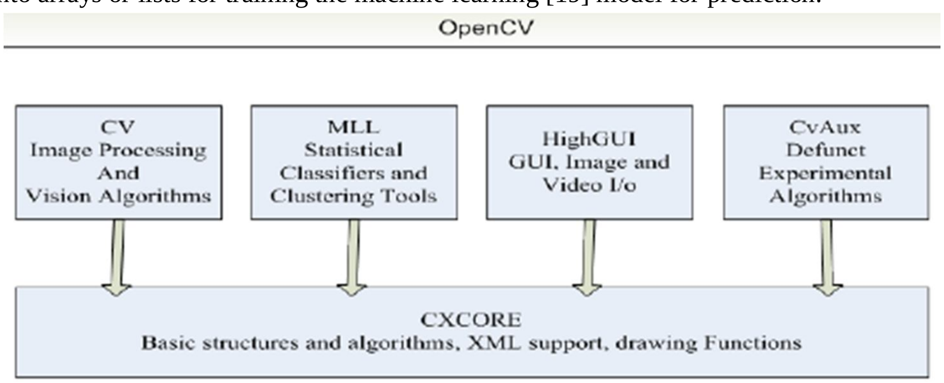

Fig.4. Structure of OpenCV

(2013–2015)

1) *VisualPal: A Mobile App for Object Recognition for the Visually Impaired [20]:* This application is a dedicated image recognition system that runs on an Android platform. This application contains modules for people with complete or partial vision impairment. This object detection module runs image recognition on a hybrid algorithm which is a combination of Artificial Neural Networks and applications of Euclidean distance. The hybrid algorithm requires low computation time and is thus best suited for the development of an application for the visually impaired. It is better than conventional object detection algorithms as it reduces the rate of false-positive results. The second module is best suited for people with partial vision impairment as it also detects colors and maximum brightness is conveyed through the increasing frequency of sound with increasing intensity of brightness.

2) *Real Time Video Processing and Object Detection on Android Smartphone [21]:* In this application, a comparative study is done for real-time video processing efficiency for two applications developed on an Android platform. The comparison is done using applications built using OpenCV and a core library called CamTest. Results show that OpenCV has a higher efficiency of 15fps than cam test with 2.8fps. Next study includes a comparison of the best object detection algorithm support with OpenCV was compared with respect to efficiency. FAST algorithm has the fps value 10 times as that of SIFT, SURF. A system for real-time object detection is built with FAST and BPNN with recognition time of 1ms.
3) *Drishti: A Smartphone Application for Visually Impaired [22]:* The application Drishti, centres around making a platform that can get the job done while fulfilling certain necessities. The significant modules of Drishti incorporate hand gesture authentication, object recognition, currency recognition, emergency calling, current date and time, location tracking, private chat room, phonebook manager, customized keyboard, optical character recognition, shortcuts for navigating to the modules. For object detection, the Algorithm used is YOLO-You Only Look Once whereas for Authentication and simplicity of their activity, Drishti utilizes attracting a gesture to open the modules with the assistance of the GestureLibrary feature from Android and for Speech to text the Google speech API is used.

(2016−2018)

4) *Smart Android Application for Blind People Based on Object Detection [23]:* System built to give directions to an obstacle detected by the camera. using the GPS system in the mobile to prevent collision. The user camera is used to capture a video which will be divided into frames, then the frame will be considered as an image. Objects are detected from this image using Blob detection and ORB algorithms. The key points obtained will be matched to the key points for the various objects present in the server database and if it matches an audio output will be given to the user.
5) *Intelligent Eye: A Mobile Application for Assisting Blind People [24]:* Intelligent eye is a multi-feature app that provides the user-friendly interface specially designed for blind users. It provides various features such as light detection, colour detection, object recognition and banknote recognition. Light intensity output is given to the user by varying frequency of sound depending on the intensity of light to identify colour the user taps on the screen and the RGB values are identified and the matched colour is given to the user as speech output. Object and banknote identification are invoked by capturing an image on the camera. Objects are identified with a dataset present locally on the mobile and currency is verified using the CraftAR database.
6) *Android Smartphone based Visual Object Recognition for Visually Impaired using Deep Learning [25]:* This model primarily focuses on the outdoor navigation of the visually impaired with the requirement of internet connectivity. The user captures video from the smartphone and sends frames over to the server for the identification of objects. The frames are passed through pre-trained models on the servers and the identified objects alert is provided to the user as speech output. The system is capable of identifying 11 outdoor objects where the ResNet50 model has accuracy of 94.78%, the InceptionV3 with 96.4% and the VGG19 with 90.8%.

(2019−2020)

7) *Eye Assistant: Using mobile applications to help the visually impaired [26]:* Eye assistant is a remote application that runs without any remote server. It provides two modules consisting of real time object detection and text detection. The user is required to just open the app and it starts running without any command. It then provides the user the option to detect objects or read text and the output is provided as speech output. Since this application scans objects in real time there is no need to take a picture and fill up the phone's memory.

B. Application Based Solution

1) *Seeing AI by Microsoft [27]:* It is a free iOS application. This application is designed for the visually impaired community. Seeing AI is primarily used to describe short text, documents, products, people, currency scenery, colours, writings and light. The app scans barcodes to describe an item and uses voice outputs to help the user in scanning the barcode properly. The app also recognizes people, describes them, it also estimates the person's age, gender, and their emotions. Seeing AI uses a facial recognition system to identify people by name. While most functions can be run in the offline mode, some of the complex functions require an internet connection.
2) *LookTel by IPPLEX [28]:* It is a money reader application which can detect various currencies and its category, permitting the user to check their cash. Users direct their gadget at the bill, capture a photo and the denomination will be conveyed to the user in real time. This application supports various currencies and operates in multiple languages. This application only exists on the iOS platform.

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3) *VizWiz by ROCHCI [29]:* It is an application that enables the client to capture a picture with their gadgets and post an inquiry about the picture. The inquiries are sent to a web worker via email or Twitter. Responses are received in a couple of minutes or even seconds. This helps the visually impaired user to make better decisions in real time.
4) *SayText by DocScanner [30]:* It is an application for the visually impaired that detects text embedded in a picture and converts the text into speech for the user, for example a sign board, menu, etc. This application reads the content of the image and converts it into audio for the user.
5) *TapTapSee by NetIdeas [31]:* It is an application designed specifically for blind and visually impaired users. It is powered by the CloudSight Image Recognition API. TapTapSee utilizes the smartphone's camera and Voiceover functions to take a picture or video of anything and identify the object in the frame of the camera. After identification the object is described to the user via the smartphone speaker.
6) *CamFind by NetIdeas[32]:* It is a visual search engine application that helps the visually impaired user to find what they're looking for just by taking a picture. After capturing the image CamFind will start the search and return results quickly, along with relevant information about the image. CamFind also acts as a language translator, barcode scanner and QR code scanner and can also perform voice and text searches.
7) *Digit-Eyes [33]:* It is an iPhone and browser app that scans UPC codes and produces audio information about the product. The app is designed for the visually impaired or people otherwise people who have problems identifying products. Digit-Eyes maintains a UPC/EAN database of over 35 million products and items. The database is user-generated. Product information is available in 10 languages.

C. Sensor based

1) *When Ultrasonic Sensors and Computer Vision Join Forces for Efficient Obstacle Detection and Recognition [34]:* The framework exploits two free wellsprings of data- video camera embedded in a regular smartphone and ultrasonic sensors. It can gain information about the environment, semantically decipher it and alert users about conceivable risky circumstances through acoustic feedback. The field of perspective on a video camera is better when thought about than the sonar scope of action. As an outcome, the vision calculations can recognize the quicker moving deterrents arranged at longer distances (extending from ten to twenty meters). For sonars, in the perfect case, the detection distance is limited to five meters.

Fig.5. Combination of Ultrasonic Sensors and Computer Vision for Obstacle Detection

2) *Design, Implementation and Evaluation of an Indoor Navigation System for Visually Impaired People[35]:* This system is designed for an indoor navigation system to the visually impaired through verbal commands and soft beeps through the smartphone. SUGAR which claims a precision of up to 15 cm with a 95% confidence interval is used with UWB based positioning technologies and A* algorithm to calculate the most efficient route between the route and the destination.

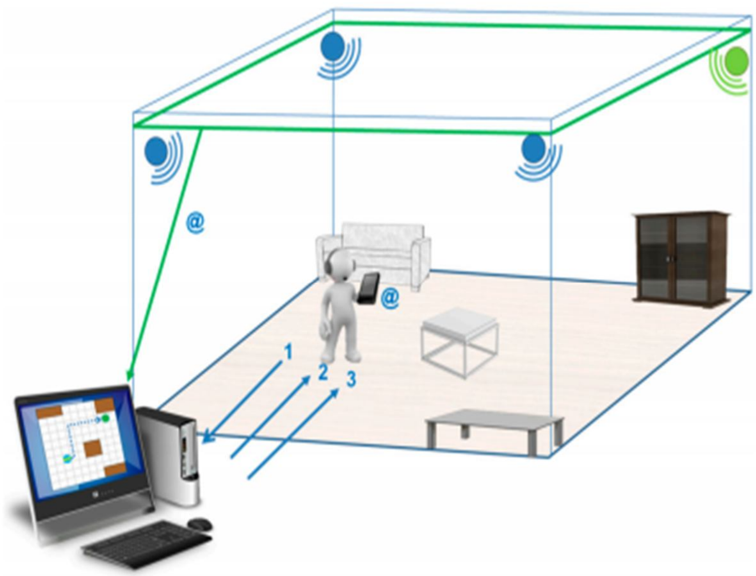

Fig.6. Implementation of Indoor Navigation System

3) *A Wearable Mobility Aid for the Visually Impaired based on embedded 3D Vision and Deep Learning [36]:* A wearable mobility aid for the visually impaired. The system uses a custom RGBD camera which provides dense depth measurements, and has an embedded CPU board in which a vision-based obstacle detection pipeline has been mapped. It also provides categorization of detected obstacles by using a CNN architecture called LeNet since the device cannot support complex architectures like RCNN. RANSAC framework is used to distinguish the ground from the other objects being detected. Kalman filter is used to increase stability and reduce noise. The system is small, lightweight and provides information about the environment through a haptic interface and audio messages. It has an average detection rate of 98% and a categorization accuracy of 72%.
4) *Navigation system for blind person using moving object tracking [37]:* To act as a navigation assistant for the visually impaired using a system with a raspberry pi, camera and an ultrasonic sensor. Moving object analysis and estimation is done by optical flow in MATLAB. The MATLAB coding is converted into the raspberry pi board language. Horn-Schunk method was used for optical flow estimation. Thresholding method was implemented for image segmentation. Blob detection algorithm was used to define the boundary of the object. Video input is given via the camera, the video is converted to grayscale frames which are passed through the optical flow, image segmentation modules. After this, morphological operations are performed to extract features which are then fed into the Blob algorithm. Noise filtering is also performed to remove additive features.
5) *Wearable Object Detection System for the Blind [38]:* RFID, or radio frequency distinguishing proof, is an innovation that can give support for improving the organization and orientation during daylight activities. The device can give to the visually impaired a few bits of data about the separation and streamline the hunt; other than distinguishing the medicines, the device can give the user an acoustic signal so as to discover effectively the ideal item as soon as possible. It gives the visually impaired a few things of information about the separation of a defined object, that is the manner by how close or far it is.

IV. CONCLUSION

This paper provides a survey on assistive technologies that have been developed to aid the identification task for the visually impaired.

The survey indicates that sensors-based devices used to be the only assistive devices available for the visually impaired. sensors are generally integrated either on a cane or a wearable device would be designed. Table I gives the comparison of various sensors used along with their advantages and disadvantages.

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TABLE I
Sensor Based

SENSOR	FEATURES	ADV	DISADV
Ultrasonic Sensor	Depth range: 1 m	Inexpensive	Low Detection Range
RGB-D Camera	Depth range: 0.15 - 4.0 m	Great Detection Range	Expensive
RFID CAMERA	Range: 460 m	Automates data collection	Low detection range than UWB
UWB	Frequency range from 3.1 to 10.6 GHz	Better transmission range than RFID	Expensive

The last few years saw the rise in the number of applications built on smartphones due to the greater computation power of smartphones. These applications are convenient for the visually impaired but require internet connection constantly. Table 2 gives an idea of the various algorithms used to build these applications along with their advantages.

TABLE II
Deep Learning Based

NETWORK TYPE	MODEL	ADVANTAGE
OpenCV	FAST	High computational Efficiency
OpenCV	ORB	Strong Robustness
CNN	YOLOv2	High accuracy,short processing time
CNN	CNNdroid	supports nearly all CNN layer types
CNN	InceptionV3	High Accuracy

Through this survey we have tried to compare the best possible method to build an aid for the visually impaired. Table 3 gives a comparison for the techniques used on different parameters.

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TABLE III
Comparison Between Sensor Based And Deep Learning Based Models

FEATURES	DEEP LEARNING BASED	SENSOR BASED
Cost	Most applications are free of cost	Cost of sensors is higher
Field perspective	Wider (long distances)	Wide
Response time	Adequate	Fast
Computational Time	High	Low
System Complexity	Relatively Simple	Relatively more complex.

Both sensors based and deep learning-based solutions have their own advantages and disadvantages, but due to the increasing computational power and functionality of smartphones, the requirement of sensor-based solutions will go down. Developments in the deep learning algorithms are more frequent than developments in sensors because it has a larger developer community. The efficiency and performance of deep learning solutions is not as good as sensor-based solutions, but in the future with greater processing power of smartphones and better algorithms, deep learning solutions might substitute sensors.

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