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Review On Assistive Devices for Visually Impaired for Object Detection & Navigation

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Abstract: *The global population consists of a significant portion of visually impaired people (VIPs). They are present everywhere, all over the world. The technology has been evolved with various innovative devices that assist humans in almost all fields. Similarly, various technologies have arrived to assist visually impaired persons to move around their environment. These devices assist them in day-to-day life in terms of obstacle detection, distance estimation, and navigation. They obtain data from the surroundings through various sensors such as IR, ultrasonic, imagery sensors, etc. Several techniques are followed to process this data and obtain the necessary details. At last, the user is delivered with feedback by means of vibratory or auditory signals. This study provides a comparative review of the visual assistive gadgets for visually impaired people. Furthermore, a study of future advancement of the assistive device is performed, which significantly advances affordable wearable assistive technology, enhancing the freedom, location awareness, safety, and quality of lifestyle of VIPs.*

Keywords: *Visually impaired persons, recognition of objects, distance estimation, location monitoring, navigation, text-to-speech conversion, wearable assistive technology.*

1. INTRODUCTION:

The World Health Organization (WHO) states that 2.2 billion individuals worldwide experience vision issues, making it a significant health concern [1]. About 45 million people are blind in this category. Many others suffer from varying degrees of vision impairment [2,3]. In countries with incomes such as China, India, and sub-Saharan Africa, the incidence of impairment is notably higher. Certain vulnerable groups, like minorities, the elderly, and individuals with disabilities, are disproportionately impacted by this condition [4]. Blindness can greatly impact a person's activities by hindering their navigation skills and social interactions, it poses challenges in developing countries where the majority of visually impaired individuals live. Fig.1 provides the graphical representation of Comparison of Visually Impaired People in Global Population.

According to Courtright et al., retinal disorders, glaucoma, vitamin A deficiency that results in corneal ulcers, cataracts, and neurological difficulties are the main causes of visual impairment in low- and middle-income nations [5]. However, neurological issues are a major contributor in industrialized nations like England, where 75% of blindness is unavoidable. Studies on VI in children from different age groups (like 3–5 years or under 15) and settings (rich and poor countries) have given a lot of info. Still, due to these differences, it’s hard to make global rules or check the impact of current measures [6,7]. Fig.2 shows the comparison chart for Blindness caused by disease and completely blind in Visual Impaired Individuals.

Object detection combined with distance measurement plays a crucial role in the assistive device for visually impaired people. Using advanced models like CNNs [8,9], these systems recognize objects in real time, while ultrasonic sensors help measure how far these objects are. The sensor sends out sound waves and listens for the echo to calculate distance. This blend of technology, with simple feedback like sound or vibration, makes it easy for visually impaired people to understand their surroundings better and navigate safely. It's practical and designed to help users feel more confident in daily life.

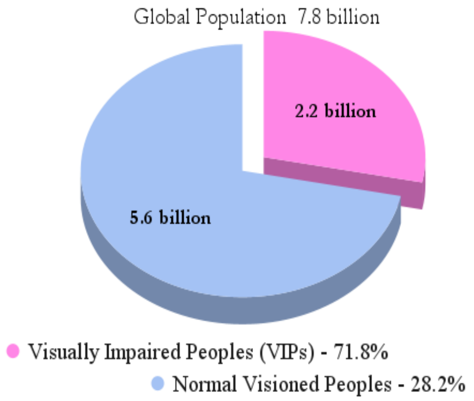

Fig.1: Comparison Chart for Visually Impaired people in Global Population

Distance estimation, an essential component of assistive technology, gives users an easy way to gauge how close objects are to them in their surroundings. One popular technique utilizes the use of ultrasonic sensors, which generate sound waves and measure the time it takes their energy to return after hitting an object. This time is then used for determining the distance between them [10]. To help users stay aware of their surroundings, the system then transforms this into feedback, typically in the form of sound or vibration. This makes navigation more simple and efficient, especially for people who are visually challenged, by giving individuals clear, instantaneous information about what's surrounding.

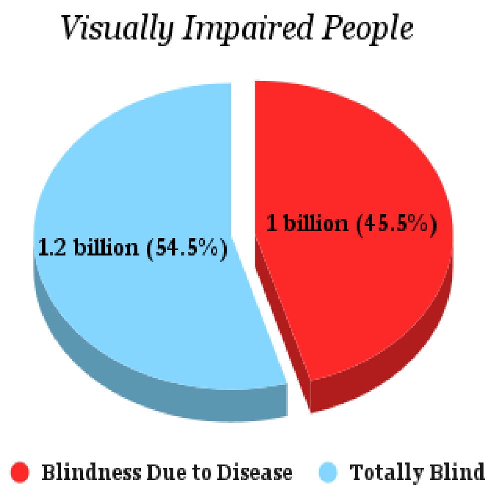

Fig.2: Comparison Graph for Blindness Due to Disease and Totally Blind in Visually Impaired Population

Text-to-Speech (TTS) is the main objective to help visually impaired people to read written content [11]. The technology is important for converting written content to access, especially for people who have trouble in seeing or reading. It converts the text and turns it into natural sounding speech, so users can listen and absorb information without needing to look at a screen. Thanks to improvements in machine learning and language processing, the voices sound more and more real. TTS is found in things like virtual assistants, GPS apps, and online learning platforms, and it can speak in different languages and accents. You can even tweak the speed, pitch, and tone of the voice to make it just right for you. As TTS keeps getting better, it's making tech more accessible and changing the way we interact with devices every day.

The combination google maps API and GPS provide a solid foundation for navigation purposes. By monitoring the time, it takes for signals to reach the gadget, GPS uses satellites to pinpoint your precise location. That location is displayed on a map using the Google Maps API, which also helps you identify neighboring locations, see traffic in real time, and obtain directions. Developers may create apps that track your location, provide turn-by-turn directions, and even display street views by integrating GPS and Google Maps. This greatly simplifies and improves location-based suggestions, delivery tracking, and navigation.

This study involves the development of a smart glass for visually impaired people which will act like an assistive device for obstacle detection and navigation purposes using various components. The system will integrate ultrasonic sensors and GPS technology to provide real-time obstacle detection and navigation systems. Ultrasonic sensors will detect obstacles in the user's path, it will work based on the sound waves transmitted and received back by the ultrasonic sensor and the distance is calculated through the time taken by the transmitted and received sound wave, delivering alerts via feedback or audio to ensure safe navigation. The GPS (Global positioning System) module will enable accurate, turn-by-turn navigation, and guide the user to their route more accurately and safely. This is the main objective of the assistive device. By combining these technologies, the user can more accurately navigate around their surroundings more safely and securely with the help of smart glass.

2. LITERATURE SURVEY:

The most prevalent issue that visually impaired people confront in everyday life is navigating different situations due to their restricted or damaged vision. Resolving this problem is critical for allowing them to move around with ease and pleasantly. While technologies like computer vision have advanced rapidly, offering solutions through deep learning models for object detection, merely identifying objects is not enough. To genuinely aid visually impaired individuals, we want a system that not only identifies items properly but also swiftly enough to deliver real-time information, allowing users to analyze their environment and respond appropriately. Additionally, navigation and position tracking are major challenges that must be solved in order to improve mobility and safety for visually impaired users. Affordability is another critical factor to consider when choosing the right technology, as it ensures accessibility for a broader population. Thus, selecting an appropriate deep learning model is vital for this project, as it must deliver fast, precise, real-time object detection while keeping the solution cost-effective. Table 1 provides the summary of Visual assistive devices.

Review on Previous Work on Visual Assistive Technologies

2.1 Assisitive canes

2.1.1 Ultracane:

The UltraCane, designed by Sound Foresight costing roughly $800, has both frontal and upward-facing ultrasonic detection devices incorporated into the handle that detect objects up to 4 metres distant [12]. The ultracane image is shown in fig.3. It gives precise spatial input via vibrations, showing the object's position. Forward vibrations indicate barriers at the head level, whereas rear sensations detect obstacles from the ground to the chest level, making navigation more effective than traditional canes and aid animals.


Fig.3: Ultracane [12]

Some of the challenges in ultracane are:

(i) High cost may limit accessibility for many users.
(ii) Detection range is limited to 4 metres, which can be insufficient in certain environments.
(iii) Lacks GPS based Navigation and Location Tracking.

2.1.2 WeWalk:

For individuals with vision impairments, YGA developed the WeWalk smart cane, which combines a traditional cane with state-of-the-art features. It uses Bluetooth to receive auditory feedback for navigation and features a touchscreen handle for exploring locations [13]. The model of WeWalk cane is shown in fig.4. Users are alerted by vibration or sound when the integrated ultrasonic sensor detects an obstruction. Additionally, the main usage of the WeWalk app helps users identify local transit options, including bus times, and provides a voice assistant for easier navigation. Users can also find lost devices with a sound alert.


Fig.4: WeWalk Cane [13].

Limitation of WeWalk Device are:

(i) At $500 USD, the device is incredibly multifunctional.

(ii) The smart cane and speaker may malfunction in the event of rain or snow.
(iii) Location Tracking does not exist.

2.2 Supportive Shoes

2.2.1 Embedded Smart Shoes:

Jayanthi Pavan Sathvik et al. introduced the Embedded Smart Shoes project with the goal of improving the protection and freedom of people with vision impairments [14]. The block diagram for Left and Right shoes are shown in fig.5. The project combines servomotors and ultrasonic sensors to identify obstacles and provide immediate assistance via vibration alerts. It is mainly based on the walking energy obtained through the piezoelectric materials. The shoes also consist of a GPS monitoring system, a GSM module for position sharing with guardians, and a panic button for emergencies. The technology uses sensor data to calculate the obstacle's height. The project improves the blind community's quality of life and increases their degree of independence, safety, and navigation by offering them a simple, durable, and flexible solution.

The main disadvantages are:
(i) Limited battery life due to reliance on energy harvested from piezoelectric materials, which may not provide sufficient power for extended use.
(ii) Complexity of the system increases the weight and size of the shoes, potentially reducing comfort for the wearer.
(iii) The reliance on ultrasonic sensors may lead to inaccuracies in detecting certain types of obstacles or those with irregular shapes.

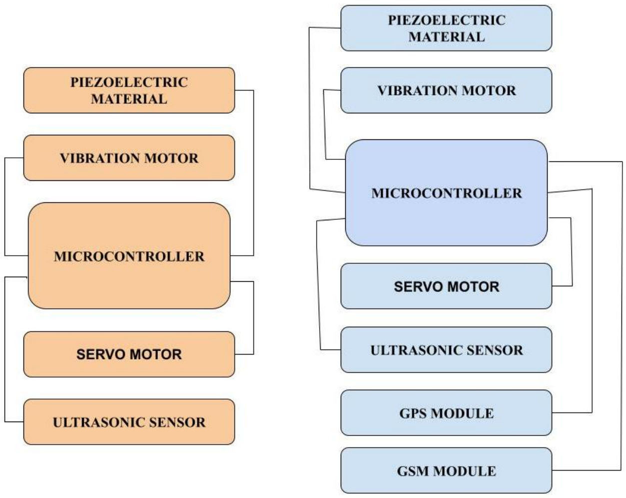

Fig.5: Block diagram for Left and Right shoe

2.2.2 Visual Assistive Shoe:

Chang-Min Yang et al.'s study describes a shoe-type visual assistive device which is equipped with IR sensor, Pressure sensor and vibrating drivers in the shoes [15]. The IR sensor measures the distance between shoes and obstacles of range 20-150 cm. The pressure sensor detects heel strikes during the motion pattern of range 0-20lb. The intensity of the vibrating driver based on the distance between obstacles and shoes. The obstacle detection is by both front and side-mounted sensors continuously. As a result, it reduces the no. of collision compared to conventional white canes.

Some Limitations are:

(i) Inconvenient for daily life.
(ii) Functionality at stairs or slopes is not described.
(iii) Walking speed is lesser than conventional white sticks.
(iv) Lacks GPS based Navigation.

2.3 Head Mounted Technology

2.3.1 A Mobility Aid for VIPs using Cameras:

A portable assisting system for people with low vision is described by Schwarze et al. [16]. Fig.6 shows the prototype model of the device. It uses a stereo camera system to assess the environment and provides the user with clear audio input about barriers and other objects. It is meant to be used in addition to more traditional forms of assistance. The authors explain scene interpretation, sonification, and basic head-tracking techniques. They provide experimental evidence of how these methods improve users' ability to safely traverse unfamiliar urban environments.

Fig.6: Model of Schwarze et al.'s gadget. [16]

Few Constrains of Schwarze et al. model is:

(i) Operable only in an outdoor Environment.
(ii) Location Tracking is not available.

2.4 Visual Assistive Smart Glass

2.4.1 Student-GLASS:

In order to support visually impaired people navigate their environment more efficiently, Azizuddin Khan et al. explained that the Student-GLASS is a portable intelligent camera gadget that provides audio through an earbud [17]. Constructed around a camera and driven by a microprocessor, it can identify traffic signals, obstructions, vehicle and human movement, and objects, letters, numbers, and banknotes. In addition, the gadget acts as a music player and surveillance camera at night. It has a memory card that holds music and picture files, and it pairs with a smartphone via Bluetooth for speech recognition. The device may be operated without a smartphone by means of capacitive touch buttons.

Some restriction of Student-GLASS are:

(i) Depends on a smartphone for voice commands.
(ii) Limited recognition accuracy in complex environments.
(iii) Absence of GPS Based Navigation and Location Tracking.

2.4.2 Smart Glass for Indoor Environment:

Jinqiang Bai et al. introduced a smart glass for guidance and safety of visually impaired people. It utilizes ultrasonic and depth sensors for detecting small and transparent obstacles [18]. An audio system is incorporated for indicating the navigation to completely blind individuals. AR technique, along with a pair of display glasses, helps in the navigation of partially sighted persons.

Certain Drawbacks of Smart Glass for Indoor Environment are:
- (i) AR would not work properly under low-light conditions.
- (ii) AR Enhancement increases power consumption.
- (iii) Outdoor applications not applicable.
- (iv) Location tracking is not present.

2.4.3 Face Recognizable Smart Glass:

Swapna Chaudhary et al. presented an affordable smart glass for visually impaired individuals, which comprises a Raspberry Pi 4, an ultrasonic sensor, and a camera module to capture images and process them through the use of computer vision and language processing [19]. This will enable the people with visual impairments to recognize others and the objects that are present in their surroundings. The device processes the depth of the data and converts it into real-time audio guidance. It is powered by a small 5V supply.

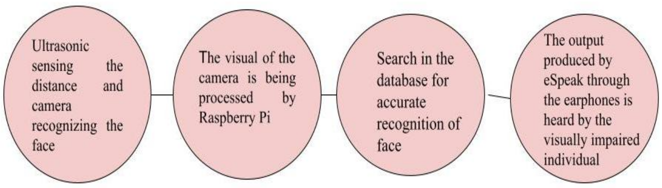

Fig.6: Flowchart of face recognizable smart glass.

Certain Present Challenges of Face Recognizable Smart Glass are:
- (i) Image Processing affects the Battery life.
- (ii) Precision of the system is minimal.
- (iii) Absence of GPS based Navigation system.

Table 1: Summary of Visual Assistive Devices.

AUTHOR/STUDY	SYSTEM TYPE	COVERAGE AREA	RESPONSE TIME	FEEDBACK
Ultracane (Kitchin et al. 2015) [12]	Cane	Indoor/Outdoor	Real-Time	Vibration
WeWALK Smart Cane [13]	Cane	Indoor/Outdoor	Real-Time	Vibration/Sound
Jayanthi Pavan Sathvik et al. [14]	Shoe	Indoor/Outdoor	Real-Time	Vibration
Chang-Min Yang et al. [15]	Shoe	Indoor/Outdoor	Real-Time	Vibration

Schwarze et al. [16]	Head-Mounted	Indoor/Outdoor	Real-Time	Audio
Azizuddin Khan et al. [17]	Spectacles	Indoor/Outdoor	Real-Time	Audio
Jinqiang Bai et al. [18]	Spectacles	Indoor	Real-Time	Audio
Swapna Chaudhary et al. [19]	Spectacles	Indoor/Outdoor	Real-Time	Audio

3. FUTURE DIRECTIONS OF ADVANCEMENT:

In the future, navigation of visually impaired people could be made easier and more efficient through these smart glasses. Real time audio directions through commands to help users could be made possible through integration of the GPS system. Integrating GPS and Google API with other sensors is like a LIDAR or ultrasonic sensor, the glasses could detect obstacles and warn the user of something in their way.

The glasses would give feedback through either sound or vibration. This will be more helpful to them, and they can choose which works best for them. It can be also advanced by allowing them to connect to things like traffic signals or public transport systems to help with live updates or routes or safe crossing. Voice command might make it easier to use. And an SOS button could help in an emergency by sending users' location to others.

Making the glasses with light weight and long lasting material would make it more comfortable. Multi Language options and map updates from users, these glasses could improve the confidence level and lifestyle of visually impaired people.

4. CONCLUSION:

In conclusion, the study highlights the improvements and advancements in assistive technology for visually impaired people. By integrating various sensors and different techniques for data processing, these devices provide necessary feedback to users. It helps to improve the quality of life. Furthermore, the exploration of future advancements improves the potential for affordable and requirement-based wearable solutions that enhance productivity, user safety, freedom, and awareness about the surroundings. Ensuring these devices are affordable and accessible to underserved populations is crucial. These findings help us to understand the importance of ongoing innovation in assistive technology.

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