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Recent Advances in Devices for the Visually Impaired: A Review Article

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Abstract:

Visual impairment which can be partial or total blindness is turning to be a severe health issue. Vision loss not only brings economic burden to a person's life but also brings variety of consequences it affects in all the aspects of life such as social, physiological, and environmental along with the standard of living. Along with dependence it also causes economic burden to a person, their family, and the country. In recent years, new gadgets have been developed with advancement of technologies. However, the integration of such technologies into low vision services has been uneven, with limited evaluation of their effectiveness, usability, and accessibility. There are number of gaps about the practical applications of the devices and lack of information on the user feedback after use, satisfaction level, effectiveness, and practical usability of the devices. In a country like India affordability and accessibility of such devices will be a challenge, particularly the people living in rural areas as well as for the economically backward. By offering an affordable option, these devices can significantly improve the quality of life for those with low vision or blindness This review article analyzes different literatures on the latest technologies which have been developed in recent years such as smart canes, smart shoes, AI based glasses as well as Internet of Things (IOT)- enabled devices.

Keywords: Visual Impairment, Smart Glasses, Smart Cane, IOT, Mobility Devices, Smart Shoes.

INTRODUCTION

Visual impairment is becoming a serious public health threat globally (Thapa et, 2018), with current estimation 285 million people are visually impaired out of which 39 million people are suffering from blindness and 246 million are having low vision across the world (Dilkash et, 2021) (Vishwakarma et al, 2021) (Neurtey et al, 2019) (Rajput et al, 2018) (Wiafe et al, 2015) (He et al, 2020). WHO estimated that India had 8 million blind and 54 million visually impaired persons whereas NPCB estimates 12 million blind and 50 million visually impaired so the blindness prevalence according to both the organizations is 0.67% and 1% respectively (Vashist et al, 2017). As Indian population is growing, ageing population face chronic health conditions and visual impairment is the most challenging health issue (Bharti et al,2022). It has been studied that visual impairment and blindness causes a loss of INR 1158 billion or 0.5% of the total Indian economy which hampers the country's aim of reaching 5 trillion economy (Wong et al, 2022). Not only in India but visual impairment has become a major cause of economic loss globally (Shah et al, 2018). Vision loss not only brings economic burden to a person's

life but also brings variety of consequences it affects in all the aspects of life such as social, physiological, and environmental along with the standard of living (Habib & Irshad, 2018). Daily life activities such as cooking, cleaning, shopping, etc. becomes a challenging task for low vision patients, some patients get embarrassed socially when they are not able to identify people's faces (Jones et al, 2019). This impacts not only the patients but it also has a great impact on family, friends, and society.

Traditionally devices used to rehabilitate visually impaired patients consists of various optical and non-optical devices as well as electronic devices. The optical and non- optical devices were mainly meant for near works while few of the devices helped in distant vision. Few trainings for mobility were provided, the training programs include sighted guided technique in which a sighted person or a dog is trained to guide the visually impaired. The sighted guided technique helps the patient to move around with the help of another person or a dog, which does not provide independence to the visually challenged person. Optical devices include magnifiers, telescopes, contact lenses, spectacles etc. Non-optical devices include- coatings, filters, tints, different environmental and illumination systems, posture and positioning devices, reading guides, writing guides etc. Electronic magnification devices include CCTV which helps in reading. Currently with advancement in technologies, new devices have been developed in recent years which includes wearable devices such as smart canes, smart shoes etc, integrated with augmented reality (AR) or virtual reality (VR), and IoT-enabled solutions. This review aims to explore the recent advancement in device for the visually impaired, evaluate their usability and accessibility, and identify critical gaps to guide future research.

ADVANCED SMART DEVICES FOR MOBILITY AND NAVIGATION:

Various devices with modern technologies have been developed for the visually impaired in past few years. These devices aim to reduce the dependency of the patients which may lead a better quality of life. While some of the devices are already in the market, others are in developmental phases. Available technologies are as follows:

1.WEARABLE DEVICES:

1.1 Smart glasses: With the integration of Artificial Intelligence smart glasses are handy tool for the visually impaired patients. Glasses with advanced microcontroller (Raspberry Pi) which helps in face detection with obstacle identification have been developed (Satani et al, 2020). A pair glasses help the patients in navigation through indoor environments and uses ultrasonic and infrared sensors helping in obstacle detection (Bai et al, 2017). Along with navigation and mobility smart glasses developed by Rajendra et al (2020) are also used for object recognition and reading texts. These glasses use google for data processing helping patients to lead an independent life. The components of smart glasses include a camera, a speaker, Bluetooth microphone attached with a pair of glass. These glasses use AI, machine learning to help the visually impaired. Some of the commercially available smart glasses are – OrCam MyEye, Envision glasses.

Thus, smart glasses are reducing dependency and quality of life by helping patients in reading texts, identifying objects, helping in face detection, mobility with auditory feedback.

1.2 Smart Shoes: Chehade et al (2020) made smart shoe model as a solution for more effective movements with the help of a fall detection sensor with other sensors such as obstacle detection and wet floor detection. Other specifications such as navigation assistance was added. Shoes with

ultrasonic sensors, water level sensors (to detect rain, leakage, and wet floors), flame sensors (to detect high temperatures), GMS/GPS module which connects with IOT (helps patients in navigation and send messages to the caregivers in emergency), humidity sensors (helping patients in moving on extreme weather conditions) are developed to enhance the safety of the patients (Almomani et al, 2023).
Smart shoes with different sensors are a cost-effective solution that will be useful solution in cases of severe visual impairments. Combination of smart glass with shoes is a handy solution for the visually impaired patients. Shoes with ultrasonic sensor providing haptic feedback while the glasses provide voice commands when an object is detected in the front (Chava et. Al, 2021)

1.3 Wearable clip: Wearable clips are very small devices which can be clipped on various parts of the boy depending upon the needs such as they can be worn over shirts or clipped on lower body such as belts.
A wearable smart system was designed known as the IBGS (Xia et al, 2022) which was implemented in the form of a glass clip. The system has speech recognition technology with the help of Conv-transformer transducer. The uniqueness of the device is that it can identify traffic signals with an accuracy of 92.33%. The system connects to a cloud database for information sharing of the patient location with their family. It uses android mobile application for emergency notification with fall detection sensor. With the algorithm known as YOLO, it can detect human figures.

1.4 Smart Bracelets: IOT bracelets designed to help people for indoor navigation (Abusukhon, 2023). The device was designed to help the people in navigation with the help of ultrasonic sensors which guides them by providing feedbacks. The system had fall detection and alert the caregivers during emergency.
The challenges with all the above wearable technologies are the cost which may be on higher side. Other challenges such as accessibility on rural areas, most of the people may find these devices complicated due to their complex designs. Often smart glasses become heavy after incorporation of various sensors. Shoes too will become bulky and cosmetically not preferable after incorporation of various sensors.

2. **HANDHELD TECHNOLOGIES:** One of most common handheld devices for the visually impaired are canes. Canes were used as traditional aids for visual rehabilitation mobility devices. With improvement in newer technologies, canes have been modified by incorporating different sensors. Canes like ‘InWalker’ (Husin & Lim 2020), helping the patients in mobility and navigation by connecting the cane with mobile application via Bluetooth. The sensors present on cane helped the patient in dealing with obstacles both on upper body and lower body levels. The device also sends audio feedback to the user regarding the obstacles. Canes are always best mobility aids since these are simple devices and are affordable gadgets.
A prototype of a smart cane was also developed by the optometry students of Sri Sanakaradeva Nethralaya which included sensors, helping in object detection. Though, smart canes may be useful and affordable still its reliability on varying environments such as crowed places may be inconsistent. Other barrier of smart canes as compared to traditional canes is that, these canes may become bulkier

with incorporation of various sensors which will make the canes heavier. Canes often makes user less confident due to social stigmas, which may not encourage them to use canes.

3. **MOBILITY AND NAVIGATION APPLICATIONS:** With the development in smart phones various applications are developed to assist the visually challenged individuals. BlindNavi (Chen et al, 2015) is one of the prototypes that help people to navigate around places consisting of multisensory navigation messages. By integrating GPS with obstacle detection sensors, BlindNavi provides real-time auditory or haptic feedback to guide users safely through various environments. Commercially available navigation applications such as BlindSquare uses GPS data to identify the user's location and provide detailed information about nearby points of interest (POIs), streets, and intersections. Goodmaps (Palilonis, 2024) is an application supported by Ios and android helping in indoor navigation with the help of mobile camera. The app is designed to help people navigate safely and efficiently with dynamic routing instructions, orientation aids, and landmark recognition. With the help of lidar camera the application creates a detailed map of the environment and helps the patient to navigate around unknown places safely. The advantages of such applications are that they can run even without internet unlike google maps. Apart from navigation, these applications also give details of the environment and obstacles present in front of the users, which will reduce dependency, improving safety and confidence. Some of the disadvantages of such applications are- cost seems to be higher, thus affordability may be an issue, usability for elderly patients is also an area of concern, significant use of camera and GPS may reduce the battery life of the mobile.
Apart from mobility some applications have been developed for object recognition and identification with text to speech ability helping patients in reading. These are discussed in the following section

4. OBJECT RECOGNITION MOBILE APPLICATIOS: Intelligent Eye (Awad et al, 2018) is an application helping in object identification by giving the details of an object such as colour, shape, size etc. Additional it can also be used to identify currency. The patient needs to click the photo of any object and the details will be provided to the user in the form of speech. Blind Reader (Mambu et al, 2019) is an application that helps the users to know details of an object such as reading the labels of a packed product such as name and identifying the colour of similar looking objects. This application also gives the information in the form of sound. Unlike the previous two applications which requires the users to take photograph to identify the objects, Eye Assistant (Shishir et al, 2019) scans the objects directly from the camera of the mobile and gives the details of the object in the form of speech. Many prototypes and commercially available mobile applications have been developed to recognize objects in past few years. The biggest problem with such mobile applications is that the patient is either required to click the photographs of those objects or open the camera to scan them, which may be a troublesome affair, since most patients are partially or completely blind. Since, the patients need to click pictures in most of the applications the phone memory may be soon filled which may lead to drainage of the mobile life. Further, the older generation people are not familiar with such technologies which may be not much useful and easy for them. Thus, usability and efficacy of such applications may be minimal.

3. SMART HOME DEVICES: Voice assistive devices such as Alexa, Google Home and Siri are helping people with their speech recognition abilities these smart devices can provide some amount of

independence to the patients. Thus, by installing Alexa or Google Home, the users can perform end numbers of daily life activities such as – turning on televisions, searching for anything on the internet, listening to songs, closing doors, reading etc. These interactive devices are making the lives of the patients easier. The problem with these devices is- they rely on IOT, not all can purchase these devices, many people may have usability issues with these devices.

4. SMART READDING DEVICES: Most elderly people are interested in reading books; visually impaired people find it difficult to read books and texts. (Harum et al, 2019) developed a book reader which reads out the texts loud with the help of a speaker and a camera records the texts. A prototype which was incorporated with deep learning explains the user even the details of pictures present on the books (Ganesan et al, 2022). Another prototype helped in detecting multiple languages and translate to desired speaking languages with the help of google cloud (Harum et al, 2021). Smart reading devices may be useful and help the people who are interested in reading.

To evaluate the utility, strengths, and limitations of different assistive technologies, a comparative analysis is provided below:

Table: Comparison of the various navigation devices: features, advantages and limitations

DEVICE	FEATURES	ADVANTAGES	LIMITATIONS
Glasses	Object recognition, text-to-speech (TTS), face detection	Enhances navigation and independence; useful for reading and identifying faces	High cost; bulkiness; limited battery life
Shoes	Vibration feedback, GPS navigation, fall detection	Hands-free operation; effective for obstacle detection and route guidance	High cost; short battery life; limited adoption
Bracelets	Helps in mobility with simple sensors	Helpful in severe visual impairments	accessibility
CANES	Ultrasonic sensors, GPS, haptic feedback	Affordable; intuitive; detects obstacles at head and ground levels	Limited detection range; performance issues in crowded spaces
Navigation Apps	GPS-based navigation, real-time audio feedback	Cost-effective; accessible via smartphones; global usability	Requires internet connectivity; accuracy depends on GPS

CONCLUSION: The comparative analysis of assistive technologies reveals that while AI-powered devices enhance mobility and independence. However, there are various challenges and limitations

such as highly relying on internet, complexity of the technologies, reduced accessibility, limited battery life, social stigma to use the devices etc. To overcome such issues newer devices should focus on cost-effectiveness, reduced reliability on internet, real world user feedbacks to understand the usability and acceptance of the devices.

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