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# Towards assisting visually impaired individuals: A review on current status and future prospects

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ABSTRACT

Visually impaired people require support with regular tasks including navigating, detecting obstacles, and maintaining safety, especially in both indoor and outdoor environments. As a result of the advancement of assistive technology, their lives have become substantially more convenient. Here, cutting-edge assistive devices and technologies for the visually impaired are reviewed, along with a chronology of their evolution. These methodologies are classified according to their intended applications. The taxonomy is combined with a description of the tests and experiments that can be used to examine the characteristics and assessments of assistive technology. In addition, the algorithms used in assistive devices are examined. This paper looks at solar industry innovations and promotes using renewable energy sources to create assistive devices, as well as, addresses the sudden advent of COVID-19 and the shift in the development of assistive devices. This review can serve as a stepping stone for further research on the topic.

## 1. Introduction

The term “visual impairment” encompasses both partial and total vision loss. Globally, at least 2.2 billion people have a near or distance vision impairment (W. H. Organization, 2022). The International Classification of Diseases 11 (2018) classifies vision impairment into two groups, distance and near vision impairment (d90 vision impairment including blindness, 1103), whose range of visual acuity is entitled in Fig. 1. All of these individuals must be treated regularly. Regardless of therapy, the total number of visually impaired individuals is escalating as the population grows. All of these assistance devices evolved from the original white cane. Even during the pandemic, assistive technology has continued to help visually impaired people. The gradual improvement of these visual impairment devices has made them a topic of conversation. This study examines contemporary assistive devices and technologies for the visually handicapped. These techniques are classified according to their functions and objectives. These are the key contributions:

- A thorough division of assistive technology into categories
- A detailed evaluation of every category of assistive devices
- A profound understanding of the features of assistive technology
- An exploration of the necessary tests and experiments on the development of assistive devices
- A discussion of the benefits of assistive devices powered by renewable energy sources
- An analysis of how the development of assistive equipment has changed throughout time, comparing the pre and post-pandemic periods of COVID 19
- An overview of the creation of assistive technology for visually impaired people

In this paper, an in-depth investigation of each of the aforementioned topics is presented. On the basis of the topics that have been examined, it illustrates its significant contribution to previous review papers in Table 1.

## 2. Assistive devices

The term “assistive device” is a catch-all phrase that refers to both hardware and software that helps people with disabilities to use technology in a way that improves their quality of life. It is feasible to preserve a person’s degree of functional competence by making use of this

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technology. Many persons who have impairments use assistive technology in order to carry out their daily responsibilities and participate fully in society. Assistive technologies can assist the blind as well as visually impaired people with obstacle detection, visualization, navigation, and recognition as well as tracking their presence or movement in a real-world scenario like Fig. 2. These devices each have a sensor that collects data, which is then processed by a central processing unit (CPU) or a microcontroller. Depending on the device, the user could perceive either sound or vibration, or both of these sensations.

## 3. Evolution of assistive devices throughout years

Assisting visually impaired has a long and storied history, which is shown in Fig. 3. They were once helped in their walking by others. However, independent navigation is always given utmost importance when supporting them. Since the mid-1600s, service animals have been used by visually impaired people. The Germans created the guide dog program during World War I, but Mr. Humphrey trained the first ser-vice dogs in the United States for visually impaired people (Guide dog, 2022). Yet another incredible incident accompanied the promotional white cane for the blind. The white cane faced a new birth to help visually impaired individuals during the Second World War, from James Biggs to Richard E. Hoover (White cane, 2022). Hoover. Louis Braille invented the braille used for reading in 1824 (Louis braille, 2022), but the braille block for easy navigation was created in 1965 by Mr Seiichi Miyake (Introduction for braille block, 2022). This innovation made it much easier for blind persons to go on the road. When the white cane breaks in the sand or snow, Hoople was created in 1990 (Hoople, 2022). Like Hoople, many assistive technology improvements occurred, and thanks to technological innovation, the wooden cane has changed into a smart cane controlled by a microcontroller. There are several wearable technologies available nowadays, especially after 2000, the amount of assistive devices is increasing. In this basic evolution figure, a smart cane represents assistive devices of the new generation. Scientists have advanced significantly by being given solar panels to make eco-friendly devices. The devices can now adapt to emergency adjustments, such as the COVID-19 human tracing for those with vision impairments. It appears like the days are improving.

## 4. Taxonomy of assistive devices

Based on different functionalities, working principles, modalities, and uses, the current assistive devices can be classified into the four categories below:

1 Based on portability
2 Based on navigation
3 Based on detection
4 Based on smartphone assistance

This article focuses on the most important and cutting-edge devices that offer key features including portability, navigation, detection and mobile support to those who are visually impaired. The four primary categories have been segmented further based on their functions. The first topic covered is the classification of assistive technology based on portability. Two sections examining the portability of wearable and non-wearable devices are devoted to wearable and non-wearable devices, respectively. Other technology, such as those worn by blind or visually impaired people on their heads, ears, belts, feet, and hands, are wearable. These tools collect and process information from the environment for visually impaired people, then provide feedback via vibration, sound, or echo waves. The navigation category is shown here. These devices calculate the distance between a user and an impediment using non-vision sensors in order to direct the user to follow a secure path. In general, all indoor, outdoor, indoor and outdoor, and audio-tactile map navigation techniques fall under this category. A full smart city may be navigated via outdoor navigation, including the streets of the city, the airport, shopping malls, and pedestrians. Now it's time to classify things according to detection. The device may need to detect any impediments, such as a car, a staircase, a pedestrian, or an everyday object. However, this category also covers the recognition of gestures and additional items like characters, faces, emotions, and money.

In addition to voice search, voice navigation, interactive games, and blind carts, the fourth category consists of apps for smartphones and virtual assistants. In reality, navigational systems can be portable or equipped with road obstruction detection. They are interrelated. In order to simplify the description, classification was performed. Various types of assistive devices are described in published articles. We have tried to categorise the all the papers read from Google Scholar, PubMed, IEEEXplore and ScienceDirect on this topic, focusing on especially 2013–2022, and come to a conclusion chart with the number of research papers on devices used for navigation and detection, portability and connected with mobile phone in Fig. 4.

In Table 2, portable devices are categorised. The mobility of a

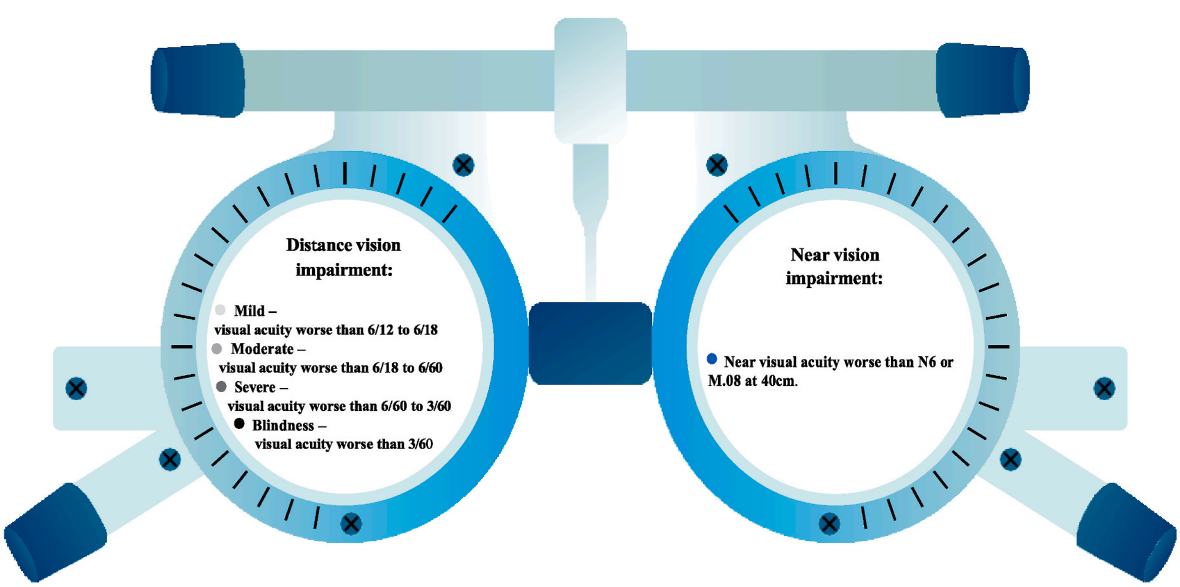


**Fig. 1.** Visual acuity of distance and near vision impairment.

person's devices must be known because detection and navigation aren't enough if they can't be worn or carried. In Table 3, navigation devices are categorised. These identify the best route, trace it, and then instruct the client to ensure safety and mobility for visually impaired people. In Table 4, devices used for detection are categorised. Detection devices gather data from the surroundings where visually impaired people are present, process it, and provide user feedback by vibration, sound, or both. Emotion recognition and gesture recognition is classified as object detection since they detect the face and fingertips, respectively, in order to determine the demand. In Table 5, examples of assistive devices based on smartphone assistance are described. Besides, smartphones employ applications or virtual assistants to aid visually impaired people and make their life easy.

## 5. Features of assistive devices

The factors that are essential for evaluating the utility and dependability of visual impairment assistive devices are referred to as features. This paper's features help users choose a suitable device. The performance of a device depends on:

1. Capturing Devices
2. Working hours
3. Response time
4. Coverage area
5. Feedback
6. Working range
7. Weight
8. Robustness
9. Cost

The capturing devices are mainly two kinds: video cameras and sensors. Here, working hours refer to the choice of working in the daytime or at night; some devices can accommodate both. Response time may or may not be real. An indoor, outdoor, or combined overage area is possible. Feedback must be provided, whether in the form of sound, vibration, or echos. Working range, which might be more significant than or less than 1 meter, is crucial. Light and heavy suggest portability. Robustness, or the ability to withstand stress, can be high, low, or moderate. Costs vary based on the equipment's production process. We have tried categorizing all the papers read from Google Scholar, PubMed, IEEEXplore and ScienceDirect on this topic, focusing on mainly 2013–2022, studied their existing features and represented in Fig. 5. Description of each features given below:

### 5.1. Capturing devices

Different types of sensors measure the object's distance from the visually impaired individual, and cameras capture the object's image for processing. Both of them are classified as capturing devices. The primary sensors used widely in making assistive devices are: Ultrasonic, RFID, GPS, BLE Beacon, IR, GSM, and LIDAR. Silva and Wimalaratne. (2017) have proposed a system with heterogenous sensors; among them, the ultrasonic sensor plays a vital role. Madrigal et al. quote Madrigal et al. (2018) have proposed passive radio frequency identifica-tion (RFID) tags in the hallways of the buildings. Chaccour and Badr. (2016) have proposed a system with GPS (Global Positioning System) system. Nair et al. (2018) have proposed a design with BLE Beacon. Jafri et al. (2017) have presented an obstacle detection system with an IR sensor. Rizvi et al. (2017) have suggested a system using a haptic and voice system with GSM (Global System for Mobile Communication). Ton et al. (2018) have presented a proof-of-concept light detection and ranging (LIDAR) assist spatial sensing (LASS) system in circumventing these limits by acquiring spatial information of the user's surroundings using a LIDAR sensor and translating it into the stereo sound of different pitches. The video cameras used widely in assistive devices are Stereo, RGB-D, Monocular, Kinect, IP cameras, and Webcam. For example, Schwarze et al. (2016) have presented the fundamental principles of scene interpretation, head tracking, and sonification in a stereo camera-based urban navigation system. Using an on-board RGB-D camera, Li et al. (2019a) have created a TSM-KF obstacle detection and avoidance algorithm where a multi-modal human-machine interface (HMI) uses speech-audio and haptic interaction via an electronic Smart Cane. Croce et al. (2016) have shown how to improve Arianna's tracking performance, a low-cost augmented reality system meant for those with orientation challenges, sight impairments, and blindness using a monocular camera. Saputra Santosa et al. (2014) have created a visually challenged obstacle avoidance system using Kinect's depth camera. Chaccour and Badr. (2015) have a system architecture with IP cameras for visually impaired people. Sivan and Darsan. (2016) have discussed a webcam-based detection system for visually impaired people.

### 5.2. Working hours

Working hours denote the suitable working time for the assistive system. Daytime operating hours are common for the vast majority of the devices that we've encountered like Martinez-Sala et al. (2015) have proposed an assistive system with an Ultra-Wide-band (UWB) real-life working indoor positioning system, which is suitable for daytime. Mariya et al. (2019) have proposed a system with Li-fi which uses VLC communication, using LED lights, making it more convenient to use at night. On the other hand, Mancini et al. (2018) have suggested the idea of a mechatronic system for outdoor walking/running with a monocular vision camera.

### 5.3. Response time

The ability to respond in real-time is an important function that should be included in all types of assistive technology designed for people who have visual problems. Nearly all of the devices have the

**Table 1**
Discussed topics in available review papers.

| Authors(year) | Classification of various types of devices | Discussion on features and performance analysis | Discussion on trials and tests on assistive tools | Discussion on renewable energy-powered assistive tools | New Inventions in devices after COVID 19 | Recommendations for making assistive devices with all steps |
|---|---|---|---|---|---|---|
| Zafar et al. (2022) | ✓ | ✓ | - | - | - | - |
| Romlay et al. (2021) | ✓ | ✓ | ✓ | - | - | - |
| Calabrese et al. (2020) | - | | ✓ | ✓ | - | - |
| Islam et al. (2019) | ✓ | ✓ | - | - | - | - |
| Current Study (2022) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

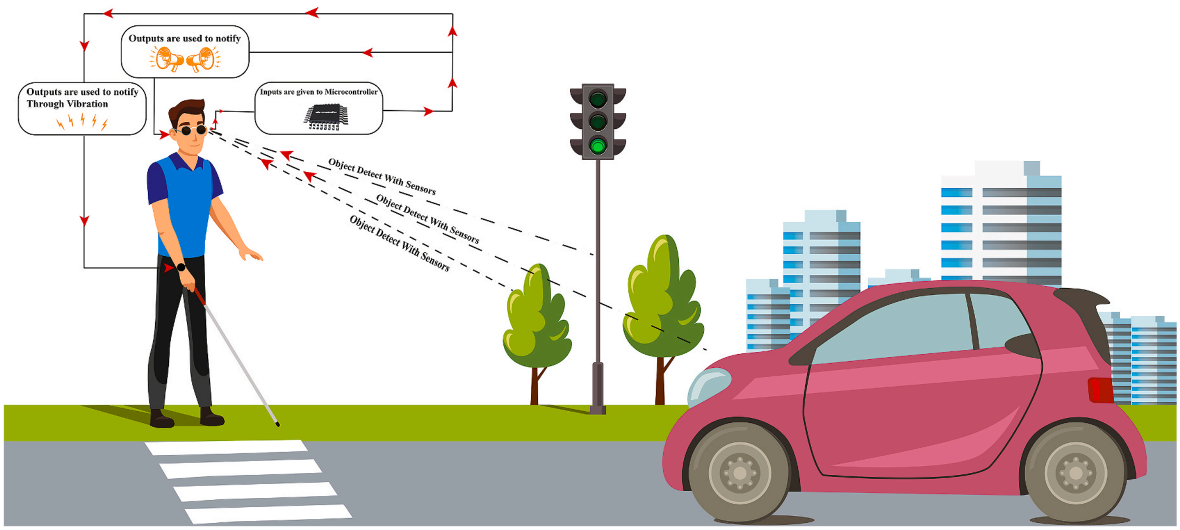


**Fig. 2.** Application of smart glass and smart cane in real life.

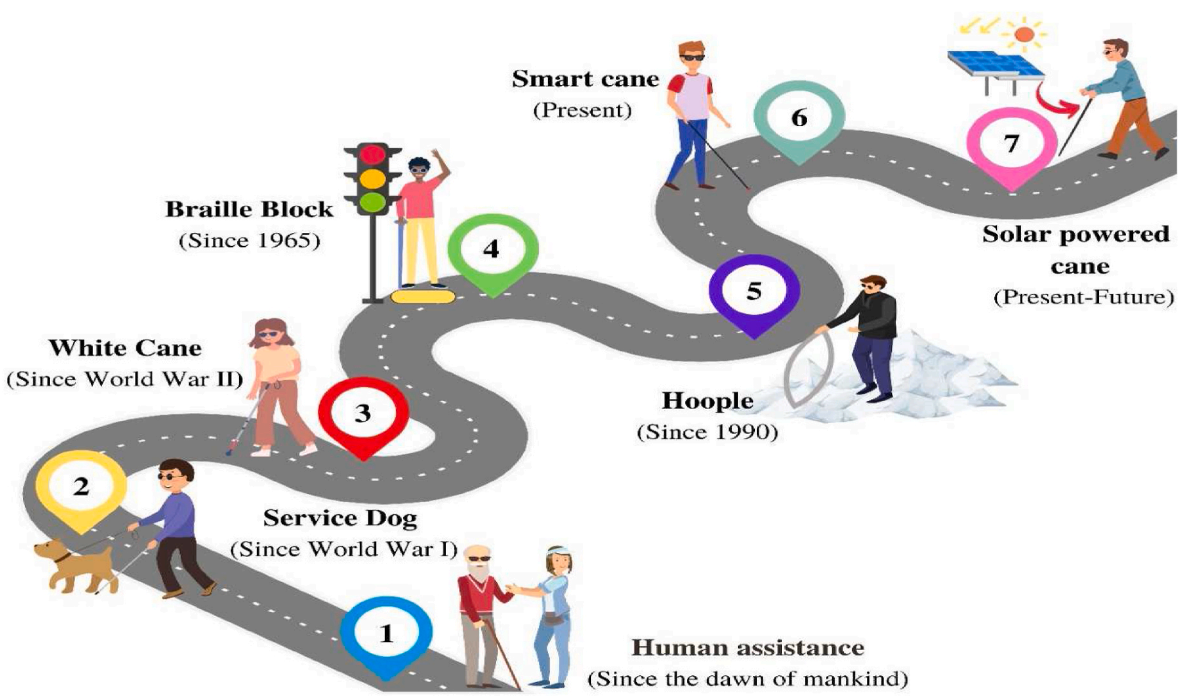


**Fig. 3.** Evolution of assistive devices throughout years.

capability to react in real-time to any obstructions. On the other hand, there is always the possibility of an exception. For instance, Prudhvi and Bagani. (2013) developed a system in which a braille capacitive touch keypad may be used in order to request assistance with a phone number by providing the currently held position. This particular real response type device differs slightly from others.

### 5.4. Coverage area

Occasionally, assistive devices are developed for indoor use, while other devices are created specifically for outdoor use. For example, Akilandeswari et al. (2022) have proposed a CNN-based indoor navigation system using an autoencoder. On the other hand, Meliones et al. (2022) have presented a system with an ultrasonic sensor and GPS module to make a wearable device for outdoor navigation especially. Smart cane can be designed for indoor-outdoor use. When working outside, the environment should also be taken into account, just as Hoople (2022) was initially developed to travel effortlessly in the snow. On cloudy and rainy days, batteries are utilized for assistance equipment, while on sunny days, solar energy is employed. When it is excessively raining or snowing, everyone finds it difficult to navigate. An assistive device with a stereo camera may not perform well in severe weather like snow or rain, but the accuracy of the device is significantly increased by adding an additional IR sensor (Rizzo et al., 2017). Slipping when working on a wet floor happens frequently, especially on rainy days. To overcome this, Patil et al., (2018) have proposed a NavGuide system that detects wet floors with the help of a wet floor detector sensor.

### 5.5. Feedback

It is essential to provide feedback to warn visually im-paired persons

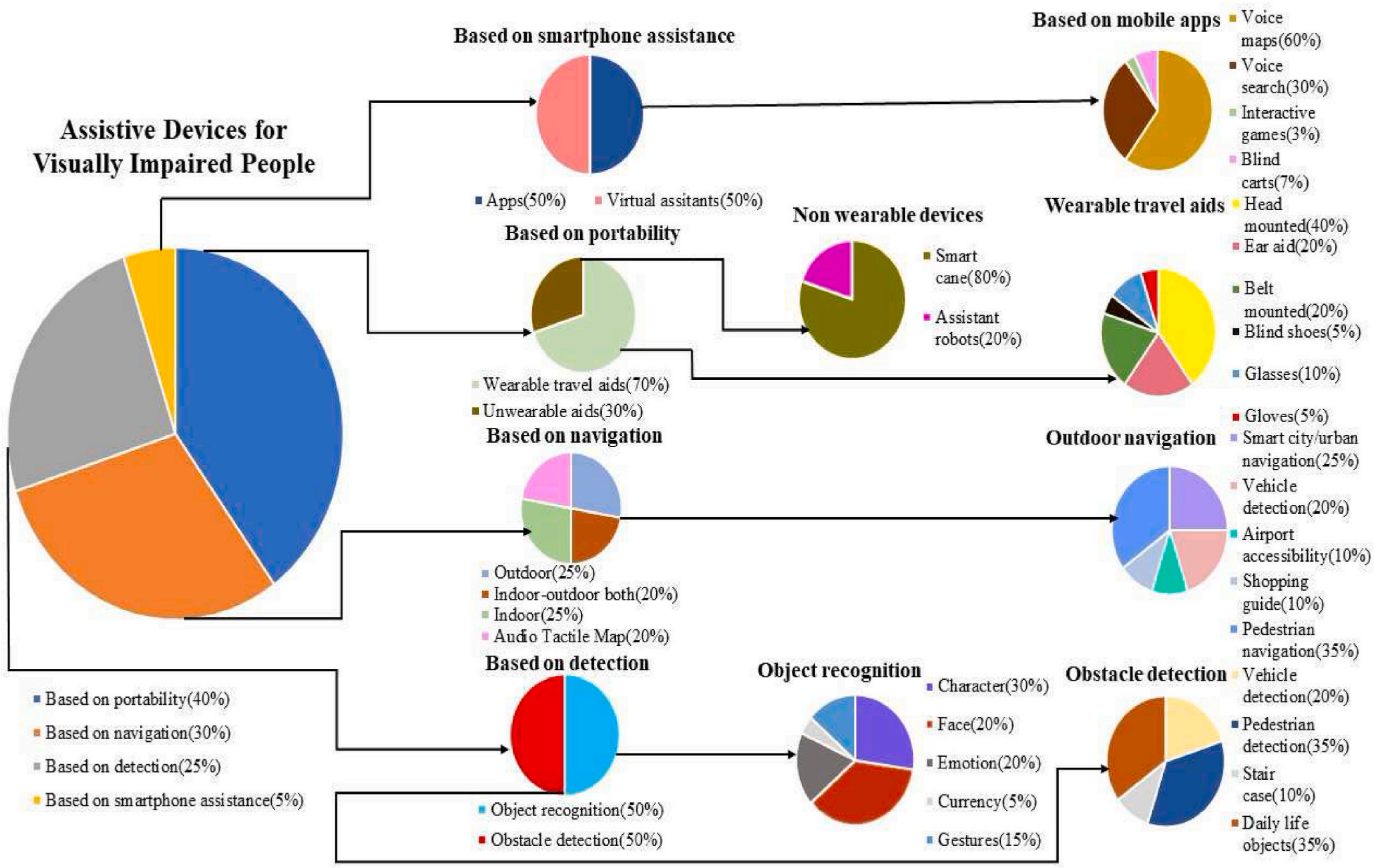


**Fig. 4.** Record of existing papers for visually impaired people.

about the identification of obstacles. Feedback can be in many forms: vibration, audio, and echo wave. Feltner et al. (2019) have discussed a system with vibration feedback. Vera et al. (2017) have provided a system with an audible alert. Besides, Patel et al. (2018) proposed a system with echo waves as feedback.

### 5.6. Working range

The term “working range” refers to the region that is covered by the sensors that are utilized in assistive devices. It is essential for the sensors to have a broad area of coverage in order to identify any obstruction that may be in the vicinity of the person who is visually impaired. For example, Everding et al. (2016) have come up with a device with a high range of coverage area.

### 5.7. Weight

When it comes to wearable devices, one of the most important things to think about is how to keep the devices from being unnecessarily bulky. This is one of the most important aspects to keep in mind. If it is cumbersome or large in size, a person would have an extremely difficult time handling it. Consequently, reducing the amount of weight that the user is required to carry should be the major objective in the process of making the device wearable. This is because it is more comfortable for the user.

### 5.8. Robustness

When creating a piece of assistive equipment, particularly wearable devices, one must keep in mind the need for durability. It is imperative that a person’s assistive devices work faultlessly in the event that they trip or have any other unforeseen challenges. In this context, the robustness of a system is typically evaluated simply by examining the building proposal; nonetheless, this is something that every designer ought to take into consideration.

### 5.9. Cost

When constructing assistive devices for people who live in developing countries, one of the considerations that need to be taken into account is cost. In recent years, renewable energy sources have replaced dangerous, obsolete batteries. Solar energy is a renewable and sustainable energy source. Any device that utilizes solar panels as an alternative to or in addition to batteries is commendable. In order to keep costs down, it is necessary to make use of renewable energy sources such as sunlight rather than batteries.

## 6. Most commonly employed algorithm for the fabrication of assistive devices

Previously, we went over all the aspects that can be directly related to assistive devices and provided a summary of how to choose an assistive device based on its features if a particular circumstance arises. In addition, most of the features of assistive devices are directly related to the components of the device’s hardware. However, the physical details of assistive devices do not make up the full of the devices themselves; software plays a vital role in selecting how to develop assistive devices for a particular circum-stance, cause the term “assistive device” is a catch-all phrase that refers to both hardware and software. Algorithms that are used for object detection, image classification, image segmentation, character recognition, feature extraction, and edge detection play an important role in making an assistive device used for fulfilling

**Table 2**
Examples of assistive devices based on portability.

| Author (Year) | Name/ Description of System | Wearable Devices | Unwearable Devices | Specialties of System |
|---|---|---|---|---|
| Martinez-Sala et al. (2015) | SUGAR system | ✓ | – | headphone navigation system |
| ABI ZEID DAOU et al. (2020) | smart wearable shoes | ✓ | – | predict fall, wet floor, obstacle detect |
| Karmel et al. (2019) | IoT assistive device | ✓ | – | cost-effective, deaf users object detection with ultra-friendly |
| Ahmed et al. (2022) | cost optimized smart cane | – | ✓ | object detection with ultrasonic sensor, microcontroller water sensor |
| Mahmud et al. (2020) | personal assistant robot | – | ✓ | room identification, google voice assistant, |
| Nada et al. (2015) | earphone connected smart stick | ✓ | – | object detection with infrared smart stick |
| Kumar et al. (2022) | smart glass | ✓ | – | Raspberry pi based face recognition obstacle detection with two nition |
| Argüello Prada and Santacruz Forero. (2022) | belt like | ✓ | – | obstacle detection with two ultrasonic sensors |
| Vivek et al., 2022 | gloves based system | ✓ | – | Arduino based detection system |

particular purposes (Anthony and Kusnadi, 2021). Generally, for edge detection, Canny Edge Detector and Line Segment Detector are widely used. The Canny edge detector is an edge detection operator that employs an algorithm to detect a wide variety of image edges, on the other hand, the line segment detector is very useful for 3D line segment detection. Character recognition is a must for assistive devices made for visually impaired people and optical character recognition, OCR, makes it possible by converting text to digital images. Detecting obstacles and objects for visually impaired people is a must, to do this, CNN is used which is beneficial to pattern recognition, image processing as well as voice analysis. YOLOv1 and YOLOv3 are two versions of "You Only Look Once" that are used to detect objects. sometimes features extraction is needed to guide visually impaired people, SURF, BRISK and ORB are used to do that. For image classification, KNN and SVM are widely used, for image segmentation, KMeans Clustering and FRRN are used. All of the algorithms are widely used to help visually impaired people by making assistive devices. Name of the algorithms that are used for object detection, image classification, image segmentation, character recognition, feature extraction, and edge detection are described here: Joshi et al. (2020) have done Char-acter Recognition with Optical with Character Recognition. Sivan and Darsan, (2016) have done Edge Detection (Indoors) with Optical with Canny Edge Detector. Li et al. (2019b) have done Object (Traffic Light) Detection with Optical with CNN. Talebi et al. (2018) have done Edge Detection (Indoors) with Optical with Line Segment Detector. Tapu et al. (2017) have done All object/obstacle detection with Optical with YOLOv1. Dahiya et al. (2018) have done.

Feature extraction with Optical with SURF. Elmannai and Elleithy. (2018) have done have done Image Segmentation with Optical with K-Means Clustering. Zientara et al. (2017) have done Image Classification with Optical with SVM. Afif et al. (2020) have done all objects/obstacle detection with Optical with YOLOv3.

## 7. Tests and experiments on assistive devices

We follow the maturity stages of tests on assistive devices of Romlay et al. (2021) methodologies, thus they test in three categories: simulation, blindfolded-sighted, and visually impaired. We claim that most of the effort goes into coding and simulation process (nearly 70 percent). The second and third tests encompass 15 percent of the work. User testing identifies real-world difficulties for solutions. When conducting experiments with individuals who are blind or have visual impairments, there is a need for additional safety procedures and requirements. After testing, assistive devices can be manufactured commercially. Types of tests include:

1 Simulation
2 Test on Blind-sighted People
3 Test on Visually Impaired People
4 Commercial Production

There is a detailed description of these tests given below:

### 7.1. Simulation

In general, all the assistive devices will require coding, which will initially be validated by the simulation. However, there are times when we come across papers that contain simple simulations but are nevertheless really significant. For instance, Nandini and Seeja. (2019) have proposed a greedy path planning algorithm for guiding a visually impaired indi-vidual through an ideal obstacle-free route across supermarket corridors.

### 7.2. Test on Blindfolded-sighted people

Following the coding and modeling phase, the device is typically

**Table 3**
Examples of assistive devices based on navigation.

| Author (Year) | Name/Description of System | Indoor | Out-door | Indoor-outdoor both | Audio tactile map | Specialties of system |
|---|---|---|---|---|---|---|
| Rachburee and Punlumjeak. (2021) | eSpeak synthesizer | ✓ | ✓ | ✓ | – | high speed and high detection |
| Giudice et al. (2019) | MagNav, a speech-based, infrastructure-free indoor navigation system | ✓ | – | – | – | navigation in shopping mall |
| Li et al. (2022) | TDCP-based Pedestrian Navigation | – | ✓ | – | – | pedestrian navigation in urban regions |
| Md Akanda et al. (2020) | Voice-Controlled Smart Assistant | – | ✓ | – | – | real-time vehicle detection with GPS |
| Guerreiro et al. (2019) | Bluetooth Low Energy (BLE) beacon-based navigation system | ✓ | – | – | – | airport navigation system |
| Götzelmann. (2016) | 3D printed tactile maps | ✓ | ✓ | ✓ | ✓ | capacitive touch inputs and the human tactile sense |

**Table 4**
Examples of assistive devices based on detection.

| Author (Year) | Name/ Description of the system | Object recognition | Obstacle recognition | Specialties of system |
|---|---|---|---|---|
| See et al. (2022) | smartphone based object obstacle detection | ✓ | ✓ | voice command, comfortable, daily life object obstacle detection |
| Meliones et al. (2022) | MANTO project | – | ✓ | obstacle motion sensing, wearable |
| Theodorou et al. (2022) | high precision and safety in outdoor navigation | – | ✓ | detects pedestrian mobility, voice interface |
| Sousa Britto Neto et al. (2015) | face recognition | ✓ | – | Samsung Galaxy Gear smartwatch |
| Semary et al. (2015) | currency detection | ✓ | – | image foreground segmentation, histogram enhancement, region of interest (ROI) extraction |
| Lutfallah et al. (2022) | emotion recognition | ✓ | – | extracting emotional states while leveraging the temporal information from videos |
| Perez-Yus et al. (2017) | staircase detection | – | ✓ | wearable RGB-D camera, position and dimension of stair detection |
| Sharma Jain et al. (2019) | hand gesture and face recognition | ✓ | – | 95.2 percent accuracy in gesture detection, for face it is 92 per cent |
| Rani et al. (2022) | SMS reader, character recognition | ✓ | – | text converts into voice, made of a Raspberry Pi |

tested on sighted persons while they have their blindfolds on. For instance, Zheng et al. (2017) have discussed their 'Abaid' and tried it with blindfolded-sighted people.

### 7.3. Test on Visually Impaired People

Visually impaired individuals also take part in the testing process with blindfolded-sighted individuals. For instance, Pissaloux et al. (2017) have discussed a mobility device tested on visually impaired people.

### 7.4. Commercial Production

After all other tests, production begins. Only one unique product was successfully marketed out of 70 relevant research articles. Sales of pre-production units of GUIDO (Lacey and Rodriguez-Losada, 2008), a smart walker for the blind, have been profitable for the U.S. Depart-ment of Veterans Affairs. So, it is an example of a commercial product made for visually impaired people. The development of various assistive devices is, nonetheless, a continuing process. The first big obstacle to the commercialization of assistive devices is the market's embrace of new technologies. Sometimes, only prototypes are made without thinking about the final outcome of the products and the chances of their acceptance as a whole, so many of them do not get a practical shape. On the other hand, the blind community is nevertheless plagued with worries and safety difficulties. It is possible to remove the skepticism against robotic technology that is impeding the advancement of navigation technology, but it will take a lot of effort, and encouragement in using an assistive device and building trust is a must (Lacey and Rodriguez-Losada, 2008).

**Table 5**
Examples of assistive devices based on smartphone assistance.

| Author (Year) | Name/ Description of the system | Mobile apps | Virtual assistants | Specialties |
|---|---|---|---|---|
| Sohan et al. (2022) | banknote detection | ✓ | – | multi-note detection, audio feedback, torch |
| Patil et al. (2022) | mobile application to assist visually impaired peo- | ✓ | – | obstacle detection, bill payment, regional language converter |
| Chinnasamy et al. (2022) | medicine pill reminder | ✓ | – | helpful to people dealing with deafness and mental health issues |
| Mocanu et al. (2018) | DEEP-SEE FACE | ✓ | ✓ | face recognition system for mobile |
| Calancea et al. (2019) | iAssistMe | ✓ | ✓ | ensure security, accessibility, availability and efficiency of information |
| Götzelmann and Winkler. (2015) | SmartTactMaps | ✓ | – | smartphone based tactile maps |
| Carvalho et al. (2012) | audio games | ✓ | – | audio puzzle games for entertainment |
| López-de Ipiña et al. (2011) | BlindShopping | – | ✓ | an RFID and QR-code based mobile solution, web service |

The examples of tests and experiments to define efficiency is given below in Table 6.

## 8. Assistive devices powered by renewable energy sources

As of late, people tend to use renewable energy sources instead of outdated, hazardous batteries. Such a renewable and sustainable energy source is solar energy. Any device that uses solar panels instead of or in addition to batteries is laudable. Aymaz and Çavdar (2016) have discussed Ultrasonic Assistive Headset with solar panels. Ramadhan (2018) has discussed a wearable smart system with solar panels. (Midi et al., (2021) have discussed a smart cane with solar modules. Calabrese et al. (2020) have discussed a novel low-cost solar-powered wearable assistive technology device whose aim is to provide continuous, real-time object recognition to ease the finding of objects for visually impaired people in daily life. Solar energy can significantly minimize battery replacement costs and aid underdeveloped nations. For instance, Apprey et al. (2022) have explored the blindness problem in Ghana, Africa, and proposed a solar-powered navigation stick for the blind that uses a rechargeable battery to maintain consistent power through solar charging at a low price.

## 9. New inventions in devices after COVID 19

Even during the epidemic, assistive technology has advanced at a sustainable rate, as evidenced by the creation of smart sanitizers for these individuals. Lastovicka-Medin and Vanja. (2021) have discussed a contactless disinfection intelligent hand sanitizer dispenser that uses an RFID tag and RFID reader specially designed for visually impaired people. Martinez et al. (2020) have discussed a real-time semantic segmentation algorithm for maintaining social distance and detecting

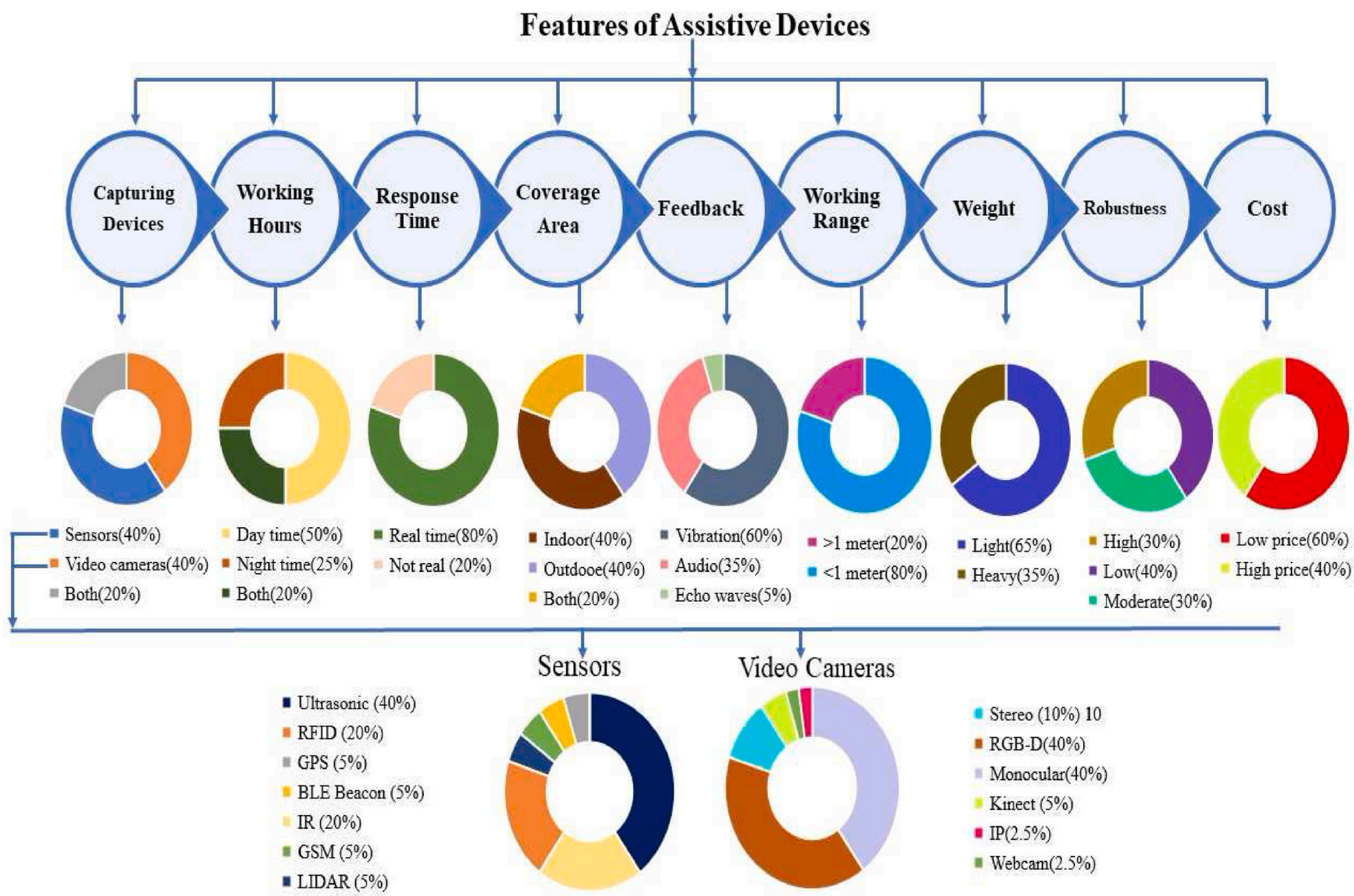


**Fig. 5.** Record of features available in assistive devices.

**Table 6**
Example of tests and experiments to define efficiency.

| Author(Year) | Name/Description of the system | Number of volunteers | Age | Efficiency |
|---|---|---|---|---|
| Busaeed et al. (2022) | LidSonic system | 4(blindfolded) | 18–47 | 92.20% |
| See et al. (2022) | smartphone based object obstacle detection | 5(blindfolded) | 21–26 | – |
| Calancea et al. (2019) | iAssistMe | 6 (vision problem) | 18–23 | – |
| Li et al. (2019a) | mobile assistive device | 4 (vision problem) | 18+ | – |
| Billah et al. (2018) | write-it-yourself | 12 (blind) | 30–60 | 97% |
| Mancini et al. (2018) | mechatronic system to safe navigation | 5 (not specified) | – | 80% |
| Everding et al. (2016) | mobility aid | 11 | 23–33 | approx. 95% |
| Ton et al. (2018) | LASS | 18 (blindfolded) | 18+ | – |
| Croce et al. (2019) | ARIANNA | 1 (not specified) | – | |

obstacles for blind persons with RGB Camera. The evolution of assistive devices is noteworthy even in this crisis.

## 10. Recommendations regarding the direction of subsequent study

Making new assistive devices to help visually impaired people must be going on. Assistive devices are made by researchers who follow a definite work pathway like Fig. 6. Despite developments in technologies and an extensive range of options for assistive devices, their widespread use and user approval remain limited (Gori et al., 2016). In the future, we should continue researching assistive devices. This section offers recommendations for future designers of assistive devices for the visually impaired:

### *10.1. Alternative power sources*

It is recommended to use solar panels or modules either in place of or in addition to the use of batteries. Its affordability will help developing countries. Eco-friendly solar panels replace batteries. Any device that uses solar panels instead of batteries is commendable. The researcher should consider adding renewable sources. There are a lot of examples that directly deal with the solar energy sources, bedsides new researchers should come forward to seek variable alternative sources, like Ramalingam et al. (2021) have come up with an IoT-enabled smart shoe tracking system where energy generated from the footsteps is harvested and utilized further. So, researchers should pick up the idea of working with energy harvesting systems for assistive devices using human motion. Even Kassim et al., (2021) have proposed an energy harvesting method for a wireless charging system in wearable travel aid devices for

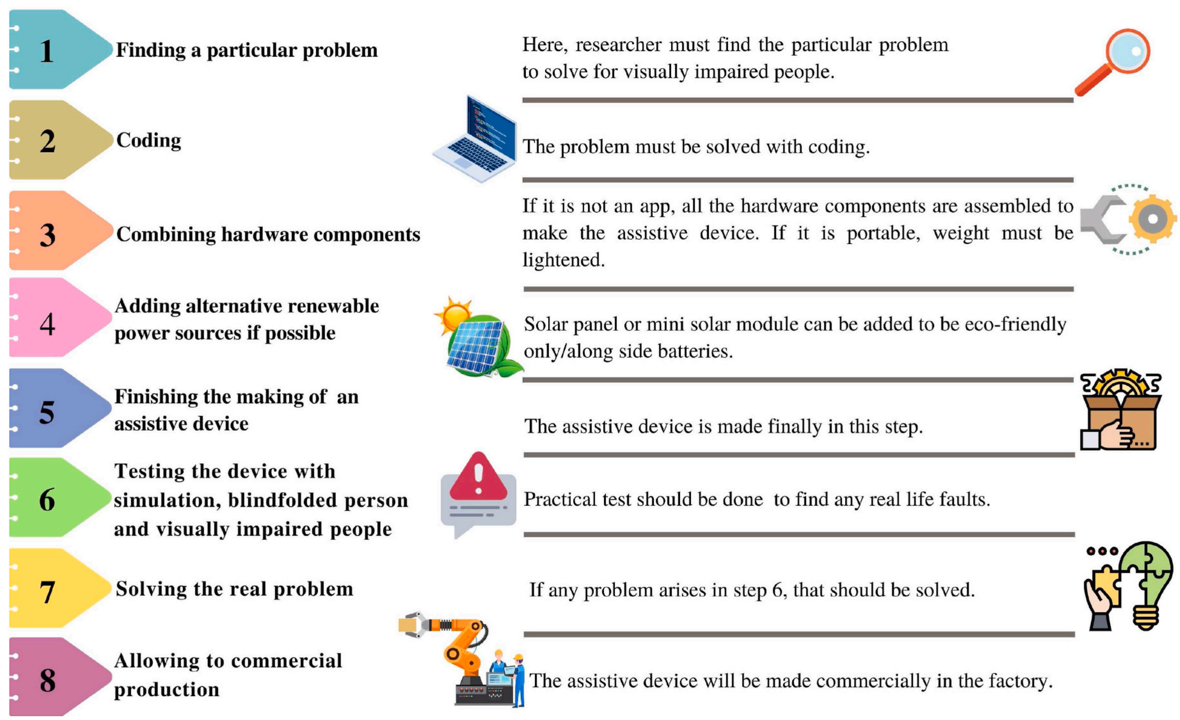


**Fig. 6.** Steps of making assistive devices.

visually impaired people.

### *10.2. Appropriate selection of assistive devices for the particular scenario*

To maximize its effectiveness, assistive technology should be used appropriately across the board. Occasionally, however, the surroundings become apparent since shopping and airport navigation systems are not solely geared for object recognition; they need to double-check the precise path to complete the specified work.

### *10.3. Adapting the functions of assistive technology to meet the demands of the moment*

A smart sanitizer (Lastovicka-Medin and Vanja, 2021) for visually impaired people shows how assistive technology has advanced during the outbreak.

Unexpected COVID 19 outbreaks cause daily mayhem, prompting people to utilize smart sanitizers.

### *10.4. Availability of a variety of alternate choices for feedback (Kuriakose et al., 2022)*

If the system only provides one input type, it can not be helpful in many situations. While some people prefer the aural mode, others prefer the tactile or vibratory mode. However, depending on the circumstance, either of these modes may become applicable. Therefore, if there is a choice between different input modalities, the user will have the freedom to select one depending on the circumstance or setting. This will increase the system's effectiveness in a range of locations.

### *10.5. Accessibility to testing with visually impaired individuals*

Without testing with visually impaired individuals, it is difficult to determine if it is helpful for them and easy to navigate, suppose it is wearable, whether or not it is bulky or cumbersome, and whether or not it can respond at the moment. It is required to obtain clinical or ethical approval to conduct the test before recruiting a volunteer who is blind. It should be a must-step.

### *10.6. Administration and protection of the confidentiality of personal and private information (Kuriakose et al., 2022)*

A blind user should be able to customize the navigation device to use and exchange specific data. This parameter is depending on user preferences and system usage.

## 11. Discussion

Visual impairment affects a sizeable section of the world's population, and those individuals require assistance doing routine tasks. As a result of the use of new technologies, several devices have been developed to assist them with object and obstacle identification as well as navigation in outdoor and indoor surroundings. The functionality and method of operation of these devices determine their classification. This paper focuses on the most important and cutting-edge devices that offer key features, including obstacle detection, portability, navigation, and mobile support to those who are visually impaired. This paper demonstrates the standard operating procedure for various types of assistive technologies. Later, the features of the devices were discussed. Capturing devices, working hours, response time, coverage area, feedback, operating range, weight, robustness, and cost were examined. As there are multiple algorithms for assistive device techniques, this paper presents some of the most commonly used algorithms. Tests and experiments in real-time or simulation determine the efficiency of devices; this paper studies the engagement of blindfolded people and visually impaired people in the testing. Because of the ever-increasing price of batteries, it is essential to ensure that renewable energy is used. Solar energy is a treasure trove. Several studies utilizing solar energy to power assistive devices are summarised in this paper. The sudden emergence of COVID-19 upsets ordinary life and needs the detection of smart sanitizers (Lastovicka-Medin and Vanja, 2021) in addition to commonplace objects; the adapting changes in assistive devices during this pandemic are also covered here. Technology has progressed from the beginning of humanity to the present; this paper examines and contrasts numerous assistive devices for those with vision impairment from the dawn of humanity.

## 12. Conclusion

The conclusion is that no device is regarded to be an optimal device. Therefore, there is a requirement for designing an intelligent system capable of covering essential characteristics for supporting visually impaired people. This paper may help researchers and scientists enthusiastic about developing the device for visually impaired people. Future researchers must step forward to work on this because, as we all know, there aren't many economically successful devices. Additionally, we anticipate that this paper will serve as motivation for future developers to enhance their interactions with medical professionals, their knowledge of the system's medical requirements, and their comprehension of the visually impaired as the product's target market. We propose that future assistive systems employ technological advances to provide a solution that is globally accessible and responds to emergencies. We believe that this paper's analysis of the systems and recommendations can serve as a springboard for further research in the field.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

No data was used for the research described in the article.

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