

REVIEW ARTICLE

Mobility aids for visually impaired persons: Journals reviewed

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ABSTRACT

This paper reviews the literature on mobile assistive devices for visual impaired people, in order to have a clear understanding of the technology and technological progress of helping visual impaired people. In this way, it aims to obtain basic guidelines for analyzing the most relevant equipment to help people with impaired vision and highlight the improvements that can be achieved. The most common device is to integrate different sensors and electronic components into the walking stick to improve their obstacle detection ability. In addition, equipment with cameras, including computer vision algorithms and artificial intelligence technology, has been developed to improve the performance and efficiency of the equipment. Finally, the basic characteristics of the auxiliary system are introduced, and it is found that there is no equipment to meet the needs of users.

Keywords: visual impairment; assistive technology; computer vision; artificial intelligence

1. Introduction

Around the world, 39 million people are completely blind and 246 million have low vision, of which 285 million have visual impairment. More than half of the population is over 50 years old and lives in poverty. Uncorrected ametropia and cataract are the two most common causes of visual impairment, as shown in the **Figure 1**. Percentage of major diseases leading to blindness worldwide^[1].

In a study based on 15 surveys in Latin American countries, 0.9% to 2.2% of the population over the age of 50 had functional visual impairment. The main causes of low vision were age-related macular degeneration (26%), glaucoma (23%), dia-

betic retinopathy (19%), other posterior segment diseases (15%), corneal opacity (7%) and complications of cataract surgery (4%). According to statistics, about 4,000 people per million people need low vision functional services^[2].

Throughout Colombia, an estimated 7,000 people (more than 296,000) are blind for every 1 million people. These figures apply to all the population in the country. Although they have a greater negative impact on children's learning and maladjustment, it is found that about 2% of children aged 6 to 11 have vision less than 20/60, and 75% use special lenses for correction, indicating that the causes of ametropia and visual impairment are the largest and can be corrected in a certain proportion, using

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the appropriate optical equation^[3].

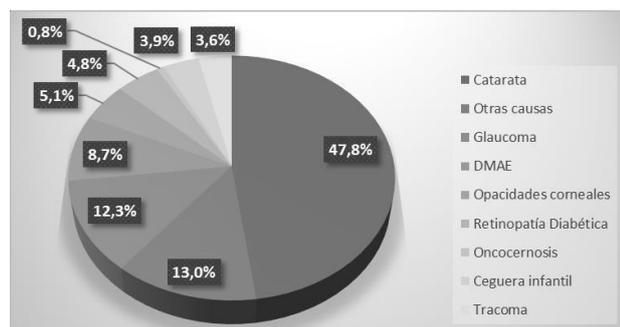


Figure 1. The number of major causes of blindness in the world.

The World Health Organization (WHO) estimates that blindness and severe visual disability will become public health problems worldwide by 2020. This situation will create a general social, economic and cultural burden, especially in low- and middle-income countries^[1]. Although it helps to improve the residual vision of people with mild to moderate visual impairment, they are not suitable for people with severe to severe visual impairment (DVS, DVP) or blindness, who need to develop alternative vision skills^[4]. It is more difficult for them to achieve independence in the basic and instrumental activities of daily life, because other types of disabilities may coexist, further limiting this process.

People with impaired vision rely heavily on others or certain tools to move safely in an unknown environment. In general, they rely on tools such as walking sticks or guide dogs, and each aid has its own limitations. The range of crutches is about 1.5 meters and is not used to detect obstacles above the waist. In the case of guide dogs, it takes a long time to train dogs, and there is also an additional time to adapt to these people and their proper care is difficult visual impairment^[5].

Visual impairment has a great impact on an individual's quality of life, including the ability to work and develop interpersonal relationships. Loss of vision causes individuals to lose about 90% of their spatial perception. Nearly half of the visually impaired feel completely alienated or alienated from the people and things around them. In order for

visually impaired people to truly integrate into society, it is necessary to eliminate the possible physical, technical and mental barriers due to their disabilities, because, like any citizen, they play a social role by developing their personal skills and abilities^[6].

Recent technological advances aim to help and improve the quality of life of visually impaired people and improve their independence in daily activities. Electronic equipment based on various sensors integrated on the walking stick to improve the effectiveness of obstacle detection and spatial perception of the disabled, camera system with computer vision algorithm, and the implementation of artificial intelligence (IA) technology for text reading, face recognition, etc. They are the main technology for visually impaired people^[7,8].

Technological progress is not plain sailing. In a world with the next major development every minute, mainly in the field of software and mobile devices, people with certain visual impairment have been excluded. However, some innovative tools try to take advantage of the potential of new technologies to make their lives easier^[9]. This paper reviews various technical projects developed in recent years to help the visually impaired move and navigate autonomously.

The methodology and structure of this review document include the following steps: Chapter 2 provides a background introduction to the definition of assistance technology, especially for people with visual disabilities. Then, in Chapter 3, academic and research literature sources are searched through special engineering databases (mainly IEEE and science direct) and academic meta search engines (mainly Google scholars and semantic scholars). The latter produced results from various sources and required special consultation. In this step, we only select articles that help or propose innovations, concepts or developments that can be reflected in the impact of visually impaired people on daily activity performance, in order to find the most relevant characteristics that affect such assistance. Subse-

quently, this information is abstracted and divided into different technology affinities in order to deal with topics that can classify the discovered technologies. Chapter 4 summarizes the research results to determine the possible work routes and specific conditions required to develop future equipment for this assistance mission. Finally, the fifth chapter gives the conclusion.

2. Technical assistance

According to the European Council of optometry and optics^[10], low vision refers to abnormal vision, which hinders the ability of daily work. This situation cannot be corrected by optical equation or medical intervention. Typical symptoms of vision abnormalities include loss of vision and field of vision, loss of contrast sensitivity, nocturnal mink, color recognition problems, and increased sensitivity to light (such as glare or photophobia). On the other hand, the international code of diseases (ICD-10) defines blindness as “vision less than 0.05 (20/400, 3/60, 1.3 logmar), or the corresponding visual field loss in the best corrected eye is less than 10 degrees”. Finally, severe visual disabilities include vision less than 20/200, 6/60 and equal to or higher than 20/400 or 3/60, and for mild visual disabilities, vision between 20/60 or 6/18 and 20/200 or 6/60^[11].

Autonomous orientation and autonomous movement are activities directly related to vision. Therefore, the difficulty of movement of people with visual impairment has become the most common problem in their daily activities. That is why it is essential that these people use the equipment and technology to help them develop their daily lives^[12]. The most commonly used tool for people with visual impairment is the white cane, which can guide them to move autonomously in different places. It has three basic characteristics: Uniqueness, protection and information^[13]. Some of the latest efforts in assistive technology for visually impaired people are aimed at providing electronic devices to adapt to mobile and travel tasks to promote them^[14].

2.1. Electronic auxiliary equipment inte-

grated in walking stick

Assistive technology is any improved equipment or system used to improve the functional ability of some people with functional disabilities^[15]. For people with low vision, electronic crutches with ultrasonic sensors have been developed to detect nearby obstacles in advance.

Use the following keywords and equations to query in the database and meta search engine:

- Sugarcane and electronic assistance
- Sugar cane and technical assistance
- Visual impairment and electronic crutches
- Ultrasound and visual impairment
- Smart crutches and electronic help.

According to the emission of ultrasonic pulse and the measurement of the time difference between acoustic emission and echo reception, the distance of obstacles generating acoustic reflection can be determined^[16-18]. These devices provide audible or vibration alarms to prevent users from approaching objects, and similar developments and structural changes have been found in the implementation of proximity sensors^[19], which are adjusted by replacing sensors on walking sticks with elements such as hats and vests under the same principle. Different applications propose to increase the functions of these devices by using a series of technologies, including infrared sensors to detect horizontal changes on irregular ground, GPS (Global Positioning System), GMCS (Global Mobile Communication System), GPRS (General Packet Radio Service) to locate people, locate them in a specific position or guide them to a specific direction, RFID (radio frequency identification) is used to improve navigation in areas with different tags, strategic locations, etc. Finally, according to the needs of the application, various technologies and tools are integrated to improve the action and positioning assistance of people with visual impairment^[20,21].

One of the most important projects related to

the implementation of electronic components and sensors is the intelligent sugarcane product, which is designed to detect objects on the road and generate direction indications^[22]. Smart sugarcane is a portable device with ultrasonic sensor system, humidity sensor, microcontroller, a series of motors and buzzer, which is used to detect obstacles in front of users and provide indication through handheld audio message or vibration alarm. Most electronic devices developed to help visually impaired people rely on information obtained from the environment, and data is transmitted to users through audio devices or vibration alarms. People have different views on what is the best type of feedback, although it is still a discussion topic that can only be solved by end users of different implementation systems.

Mobile enabled electronic devices have not been very successful in business because it is difficult to compete with simple and low-cost walking sticks. What proves this is that many of these devices have been sold on the market and are no longer on the market^[23]. These sensors based mobile auxiliary devices are used to detect nearby obstacles, and there are some design defects. The most important is the communication interface, which sends sparse information to the user without specifying the type of object to be detected, and may represent danger.

2.2. Support of artificial vision algorithm

Artificial vision is a subject that aims to simulate the different processes and elements given to machine vision. These include geometric and other attributes such as color, lighting, texture, and composition. Vision, a person and a computer. This subject mainly includes two stages: Acquiring images and interpreting images. The image acquisition process is carried out by camera. In this way, it only needs subtraction implementation tools to interpret the image, distinguish the objects in the scene, extract information from it, and solve more specific problems as needed^[24,25].

As an alternative to human vision, computer

vision is a key tool to realize the support equipment for visual impairment. Artificial vision is used to support some of the main tasks of visually impaired people, including assisting in movement, orientation, object recognition, obtaining printed information and social interaction. Unlike the technology that combines electronic devices and sensors, artificial vision allows interpretation of the environment and provides a higher degree of realistic representation from more complex information processing. In recent years, the use of artificial vision has been extended to support these^[26,28] laptop based prototypes.

In recent years, the integration of digital cameras into smart phones has created a new generation of tools that enable these people to perform daily tasks, such as obstacle detection^[29], reading printed matter^[30], identifying common objects in supermarkets^[31,32], spatial positioning indoors or outdoors^[33], and social interaction with people around them^[34].

Use the following keywords and formulas to query in the database and meta search engine:

- Computer vision and assistive technology
- Computer vision and visual impairment
- Digital image processing and visual impairment

An example of a real-time obstacle detection system based on artificial vision algorithm is given in^[35], which is used for obstacle detection and movement assistance for indoor and outdoor visual obstacles. The application works with the help of a mobile device with a camera. The device can detect static and dynamic objects in video sequences. The implementation of the system on smart phones has provided great help for the actions of people with visual impairment, because smart phones are more and more portable and have stronger processing ability. However, in places with low illumination and frequent movement, target detection can not be detected effectively. In addition, the results of the

application can vary significantly according to the quality of the video that can be obtained by the camera of the mobile phone.

Although artificial vision has become a widely used tool for developing assistive technology for people with visual disabilities, with the emergence of high-capacity processors and the development of current hardware, the ability to implement algorithms in software has not been brought into full play^[36]. A common problem in the development of new technologies is that in this case, they are not designed according to people's specific needs. Therefore, the real needs of users are unknown, resulting in the failure of the developed equipment to obtain the expected results. Another important problem is that these devices are bulky and difficult to use.

2.3. Computer vision and artificial neural network (RNA) are combined as auxiliary means

The concept of artificial intelligence may have different meanings, depending on its source and viewpoint. Obviously, one of the goals of artificial intelligence is to study the intelligent behavior of machines^[37]. In other words, artificial intelligence studies how to make computers do the best things that human beings do at present.

Neural network is established in the motion research of artificial intelligence.

With the increasing possibility of machines helping human beings' complete daily tasks, some of the most common tasks include: Pattern recognition, character recognition, speech recognition, face recognition, facial expression recognition, planning different tasks, etc. In a 1950 article entitled "computing machines and intelligence", Alan Turing wanted to know whether machines can think^[39]. To get closer to the answer, he proposed a test called Turing test to determine whether machines can simulate human dialogue, "Users who talk through written channels must determine whether their in-

terlocutor is a human or a machine"^[40].

One of the biggest challenges facing mankind is to understand the function of the senses, and then imitate this function through the existing technology, so as to find ways to solve the problems in the real world^[41]. This method uses different computer vision algorithms for image processing, and artificial intelligence technology for data analysis and final results.

Use the following keywords and formulas to query in the database and meta search engine:

- Neural network and auxiliary technology
- Artificial neural network and visual impairment
- Artificial intelligence and visual impairment

Various applications to help visually impaired people integrate the use of RNA trained systems and the use of cameras to obtain images for pattern recognition^[42,43]. Detect different types of objects, such as doors, corners, edges, paths, etc. These objects help to identify obstacles^[44,46] and recognize faces and facial expressions to improve social interaction^[47].

2.4. Use deep learning to assist the image classification process

Machine learning is actually a set of technologies that make artificial intelligence part of algorithm-based learning in large data sets. A very important feature of these algorithms is to predict new cases based on the experience learned from the data set used for training^[48].

Deep learning (DL) is a branch of machine learning. It contains a series of algorithms to simulate the execution process of brain neurons to perform voice, image, word and other applications. These algorithms are processed in layers. Each layer has neurons. They simply process the output of the neurons in the previous layer. However, it is inappropriate to make an analogy with the structure

in the real brain, because artificial neurons are much simpler than natural neurons. It can be assumed that artificial neural networks constitute mathematical models similar to natural networks, and they perform useful functions because they can adapt or learn in a sense^[49]. Deep learning is a concept derived from the idea of using hardware and software to simulate the brain, using hierarchical abstraction capabilities (i.e. Multi-layer representation of input data) to create artificial intelligence^[50]. Since then, the number of structures and training algorithms has increased rapidly^[51].

In order to realize DL, we especially use a structure close to the distribution of biological nervous system, in which a group of artificial neurons are responsible for detecting some features of objects in the image. The application of combined artificial vision algorithm is one of the fields where DL has significant improvement over traditional technology.

Use the following keywords and equations to query in the database and meta search engine:

- In depth learning and technical assistance
- Convolutional neural network and visual impairment
- Object detection and automatic and visual impairment
- Image classification and technical assistance

DL algorithm has become a new choice for developing systems. These systems allow to recognize body expressions, classify images from large databases^[52,53], and realize mobile robot obstacle avoidance. Its algorithm and working principle can be applied to help people with impaired vision move independently. Detection and avoidance of targets^[54,55] and classification and classification of obstacles^[56].

3. Analysis

The number of references found in each topic defined in the previous chapter illustrates the historical development of each topic **Figure 2**. Therefore, it is believed that the fastest-growing theme is 43% of electronic assistive devices, which may be because it is a technology that has existed for decades. For example, compared with artificial vision, it has hardly had any significant development and research in recent decades.

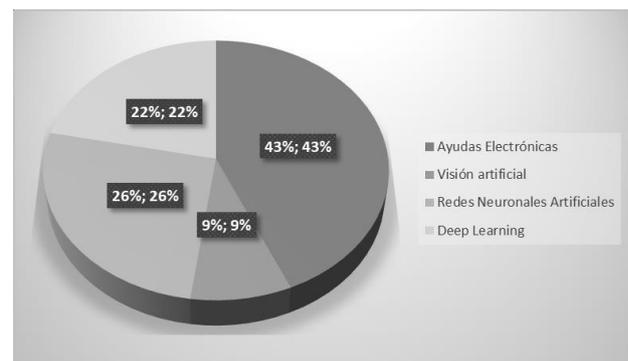


Figure 2. Percentage of references found in each topic.

Various visual impairment AIDS shall provide a series of functions to ensure their user assistance functions. These functions correspond to clear and simple user feedback interface and correct performance under different environments and lighting conditions, it can detect static and dynamic objects to analyze any sudden obstacles on the road, and integrate software and hardware with appropriate performance to process data. These functions are the basic and key to the design and implementation of visual impairment AIDS, because each function will have a significant impact on team performance.

According to the basic characteristics defined and the needs of users for mobile support, no application found shows completely satisfactory performance. It is worth noting that each developed prototype has special functions and may have additional functions, but no prototype supports all necessary functions, which are regarded as comprehensive services to help the visually impaired. This means that it is impossible to regard any development as an ideal device. The main reason for these limitations is that most developers and researchers focus on implementing a different technology to provide a new function, but they don't

notice that their work recognizes the basic functions before adding new functions. The purpose is to create more innovative devices from an academic perspective, rather than as functional elements of user support and services. Another reason for these limitations is that designers do not conduct sufficient research to clearly and concisely determine people's basic views and requirements for a system that will help them in their daily life activities.

4. Conclusions

Countries around the world have made different development and research in solving the problem of visual impairment. Despite efforts, it has not been possible to integrate appropriate tools to provide reliable assistance to meet the main needs of these populations.

In order to develop a device to help people with disabilities move, it is necessary to classify the main needs of people with disabilities, because the environment provides a lot of information and electronic devices have processing capacity. This research is crucial before determining the technical characteristics of auxiliary equipment.

Using artificial intelligence technology and computer vision tools, we must realize the integration of hardware and software to make object classification and obstacle detection possible, analyze it in real-time video, and generate possible auditory alarms for users according to the preset hierarchical order.

Conflict of interest

The authors declare no conflict of interest.

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