# Investigating Existing Support Tools for the Visually Impaired

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**ABSTRACT**
In this paper, we present the current tools existing for the visually impaired. We look closely at how accessible each tool is and we compare the advantages and disadvantages of each one of them. We examine the current non-technical solutions such as the different types of white canes in terms of navigations, orientation and object detection. In addition , we examine the technical solutions which include the GPS, bluetooth beacon, and laser light and how these technologies adapt to the environment.

**Author Keywords**
visually impaired; assistive tools;support tools;

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## INTRODUCTION

The term blindness includes the visually impaired and visually challenged people. Blindness can be defined as the loss of sight either partially or fully. It can be temporary or permanent, either damage to any portion of the eye, the optic nerve, or the area of the brain responsible for vision can lead to blindness [1]. There are numerous causes of blindness. The major blinding eye diseases are: cataracts, age-related macular degeneration, diabetic retinopathy, and glaucoma.

According to world health organization (WHO) estimate of 253 million people live with vision impairment: 36 million are blind and 217 million have moderate to severe vision impairment [2] 81% of people who are blind or have moderate or severe vision impairment are aged 50 years and above [2] .Globally, chronic eye diseases are the main cause of vision loss. The prevalence of infectious eye diseases, such as trachoma and onchocerciasis, have reduced significantly over the last 25 years. Over 80% of all vision impairment can be prevented or cured.

About 65% of the visually impaired are 50 years of age or older in Europe, in particular, about 90% of visually impaired and partially sighted people are over the age of 60.[2] With an increasing population of older people, more people will be at risk of vision impairment due to chronic eye diseases. [3] Children below age 15 an estimated 19 million children are vision impaired. Of these, 12 million children have a vision impairment due to refractive error. Around 1.4 million have irreversible blindness, requiring access to vision rehabilitation services to optimize functioning and reduce disability [3]
These figures are important when considering the population that are visually impaired one major problem that these individuals face in their daily life is mobility and navigation. Moving from one place to another can be quite challenging for them.

The goal of this research paper is to investigate the current existing tools for the visually impaired. We aim to examine the advantages and disadvantages for each tool that is used by visually impaired users. We aim that our research will provide insights when it comes to developing assistive technology for visually impaired people.

## LITERATURE REVIEW

The white cane originated in Europe in 1921 when James Biggs, a photographer who had lost his vision, began to paint his walking cane white to alert others to his presence. [4] When veterans of World War II returned to America with vision impairment and blindness they wanted to have the same level of independence as they had before the war. Because of this, the white walking cane was altered into the long cane form that is still prevalent today. [5]

A white cane is often carried by the blind and visually impaired to give more freedom to the individual. The two main functions of the cane are identification and safety; it should alert the user to obstructions and changes in their path and also notify the seeing pedestrians and drivers that the user has some degree of vision loss. [7]
There are three types of white canes: identification canes, support canes, and long canes. Identification canes are short (reaching only to the user's waist), provide little to no protection, and are generally more popular with the visually impaired who only want to alert others of their impairment.

Support canes have the same purpose as identification canes, except that they provide more support and balance for the legs and body of the user. Long canes, the type of cane chosen to be modified into a Smart Cane, reach the user's sternum and provide the most safety for the user, alerting them of terrain and height changes, walls, doors, and obstacles. They are also the most visible to others. [8]

Many navigation systems for the visually impaired are developing. For example, a navigation system using GPS that supports the independent walking of the visually impaired is being developed [9].

white cane use usually focuses on two major topics: grip and arc.
For outdoor use, where a person's pace is faster and more regular, the proper grip used to hold the white cane is the palm facing up at waist height with the index finger pointing along the cane and the remaining fingers and thumb wrapping around the cane lightly. When indoors or in a more congested environment, such as a crowded city street, the grip changes in such a way that the user holds the cane as if it were a pencil: upright, at sternum height, and closer to the body. With both grips, the elbows are kept tucked close to the body. [9]

The second component, the arc, refers to the sweeping motion of the cane performed by the user. The user sweeps the cane over an area just larger than shoulder width, tapping the ground on the opposite side of the foot currently taking a step in order to prepare for the next step (for example, tapping the ground to the left of the body when stepping forward with the right foot.

Characteristics of the Blind and Visually Impaired is a person who has been clinically determined to have a visual acuity of 20/70 or less in the stronger eye is diagnosed as visually impaired, while a person who is legally blind is defined to have a visual acuity of 20/200 or less in the stronger eye. People whose visual acuity is at either of these levels receive government benefits, such as the right to possess a white cane or own a guide dog [6].

## Current Non-Technical Solutions

In this section, we will discuss advantages and disadvantages of using a white cane in order to gain a baseline for reviewing technological solutions for navigation, orientation, and object detection based on their adopted technologies in terms of serving purposes, usability, affective experience, ethical considerations, and stigmatization. This discussion is focused on both primary aids that are used with a white cane and secondary aids that are used with a white cane [22].

### 1. White Cane

### Advantages and Disadvantages of a White Cane

First, we examine the serving purposes and usability of white canes. There are several types of white canes available for different uses as elaborated in Table 1. Although the white cane was introduced around 1940, only 2% of visually impaired people use white long canes as the navigation tool for performing daily activities independently [23].
Advantageous features that are attributed to different types of white canes are scatteredly distributed, which causes the fact that there is no single cane to meet all sorts of needs in terms of navigation, orientation, and object detection.
Secondly, we take a close look at the user experience that includes effective experience. In order to use the white cane properly, people need to undergo intensive training that is provided by orientation and mobility (O&M) instructors [22]. Walking with the white canes is widely concerned with two techniques: Two-point touch technique and constant contact technique [11].

Although the different walking techniques together with cane properties such as length and weight have influences on walking efficiency [11], the important determinant of the walking efficiency is preview of surroundings. With the preview of the environment provided by a Sonic Pathsounder [20], the visually impaired can walk 18% faster than merely with a white cane [10].
Besides limited mobility provided by a white cane, it is also impossible for the visually impaired to detect objects that are above knee level and gain a preview of object placements in surrounding environment merely with a white cane as a navigation and orientation tool [22], let alone stigmatizations that a white cane may cause. The more serious visual impairment that people have, the lower socioeconomic status they will gain [27]. Many have found it shameful to use a white cane, because normally sighted people do not think a white cane is a normal tool for the visually impaired to gain independence [15].

Further, the condition of an environment also contributes to the efficiency of using the white cane. As a white cane has a certain length, regardless of the cane type, either of two-point touch or constant contact techniques cannot be utilized to its full extent where space is limited in a surrounding environment that may not accommodate the use of a white cane [15]. The aforementioned confidence level will have a negative impact on mobility, as Clark-Carter et al., 1986 [10] discovered.

| White Cane Type | Length | Advantage | Disadvantage |
|---|---|---|---|
| Long cane | It extends from the floor to the user's sternum [28]. The shaft is generally 115 to 165 cm long [28]. | Navigation and object detection | Walking support;<br>Hard to bring when travelling due to its length |
| Folding cane | 70 - 135 cm [29] | Navigation and object detection<br>Easy to bring when travelling due to its length | Walking support |
| Support cane | 80 cm - 105 cm [29] | Walking support | Navigation, object detection, and mobility |
| ID cane | Shorter than long canes | Alerting others of users' visual impairment | Navigation, object detection, and mobility |
| Guide cane | Generally extending from the floor to the user's waist | Navigation and object detection | Walking support |

**Table 1 - Different Types of White Cane**

## 2. Technological Solutions

In order to support people with visual impairments, electronic solutions have been developed to assist or replace the conventional tools for people's mobility, navigation, and object detection [22]. We investigated a few solutions based upon online resources that include contents on their office websites and their product descriptions. As there is no published scientific paper concerned with these specific solutions, the solutions are compared and classified by their adopted technologies. Generally, there are two types of solutions: environmental adaptation-independent solutions that are used individually without support from other systems or facilities in the environment; environmental adaptation-dependent solutions that are used together with other systems and facilities in the environment that are deployed as part of the solutions.

**Table 2 - Different Categories of Solutions**

| Category | Solution |
|---|---|
| Environmental adaptation-dependent | Bluetooth beacons;<br>Internet of Things (IoT) |
| Environmental adaptation-independent | AR4VI;<br>Ultrasound;<br>GPS;<br>Laser light;<br>Infrared |

**GPS**

Global Positioning System is an accurate worldwide navigational and surveying facility based on the reception of signals from an array of orbiting satellites [30]. It is now a standard feature on smartphones that most users take with them everyday. There are a lot of navigation and location tools based on GPS. So far, not a single solution can replace GPS, although GPS has an obvious shortcoming of being unable to use in indoor settings [19].

**Infrared**

Compared to GPS, infrared technology Remote Audible Infrared Signage (RIAS), is an available navigation alternative in indoor environments [19]. Besides usage in navigation, RIAS has also shown ability in object detection. For example, Tom-Pouce, an example of RIAS adoption, emits infrared beams that allow the detection of head-level obstacles [31]. However, as infrared can be disturbed by sunlight and dark objects, the infrared adoptions do not work accurately outdoors [32].

**Laser light**

As an alternative for object detection, the drawback of adopting laser light is a narrow detection range. To overcome this shortcoming, users should continuously use a two-point touch technique with which users tap the tip of the cane side by side [33], which can be energy-consuming.

**Ultrasound**

In contrast to infrared and laser light, ultrasound has the least limitations. It has a wide detection range that can stop users from constantly needing to tap their white canes. Ultrasound sensors detect obstacles up to head-level and at long distances [33]. In the study of [33], all of the test participants who are visually impaired gave the highest rate to the smart cane prototype that uses ultrasound sensors.

**Beacon Technologies**

The employment of beacon technologies enables people to trigger actions on their mobile phones, point-of-sale terminals, digital displays, lighting, or any appliance that is available on the Internet, as they move around in the physical world [24]. Through pre-installed beacons, Wayfindr is an audio-based system that includes a mobile app to give people who have visual impairments instructions about navigation and orientation that are triggered at significant waypoints of their journeys [17]. Installed beacons send small Bluetooth pulses to set intervals that are received by a mobile phone.

The reception of the Bluetooth pulses will trigger an app to instruct the user where and how to proceed in the journey [17]. When Kevin, a blind, participated in the testing of Wayfindr, he described this experience as his first steps into empowered independence and felt Wayfindr were a sighted guide who had walked side by side with him to go through the journey [13]. Based on Wayfindr early testing, it showed that a good coverage of beacon signals plays an important role of independent navigation and orientation of the visually impaired, which requires collective work on environment adaptation that can affect its official rollout plan.

Furthermore, as this solution is merely focused on navigation and orientation but object detection, users with visual impairments will encounter difficulties as when merely using the white cane in detecting objects that are above knee level. If the users  do not use white long canes but other types of white canes, the detection ability will decrease due to its detection radius as discussed previously. Since generally beacon signal strength can reach a 50-meter range [23], theoretically it’s possible to install beacons on objects that are above knee-level in the environment to provide a preview of the surroundings to the blind . However, economic- and time-wise, it’s not possible, as there are many more objects existing in the world other than man-made. Therefore, this solution should be integrated with object detection solutions discussed in the previous sections that do not require environmental adaptations.

### IoT

The Internet of Things (IoT) refers to objects increasingly becoming smart and connected [23]. Handisco is a device that is attached to a white cane used by a blind person. It interoperates elements, such as traffic lights, in an environment that is essential in navigation and object detection as well as orientation on the network [14].

The device uses ultrasonic waves and GPS technology to gather data from traffic lights, bus locations, and crosswalks to provide-real time navigation for the blind. Tagged sensors at different shops and restaurants communicate with the device, telling the user what the shop sells, where the entrance is, and the business hours [16]. Thus, it inherited the features of the host white cane with enhancement of object detection using IoT and addition of support for orientation. However, as discussed about beacon technologies, environmental adaptation requires economic- and time-wise contributions, which is an obstacle to rolling out the solution to the mass public.

With a look at the implementation details, Handisco website claims that the device has a relatively long battery life span of 10 hours per charge, which can satisfy daily use. However, due to the use of GPS [34]. The use scenarios can be limited to outdoor mainly and has a spatial resolution of approximately 10 meters in urban environments when it comes to navigation.

### AR4VI

Augmented Reality for Visual Impairment (AR4VI) is a terminology coined by James M. Coughlan and Joshua Miele, 2017 [19]. With implementation of a gestural interface, AR4VI allows touching or pointing, which is a natural way of interaction, to indicate a location or direction of interest. The AR is realized using additional information or annotation related to objects of interest. The annotation can be any form of audio, tactile, or visual enhancement. However, AR4VI-based solutions are focused primarily on employing text-based information for environment augmentation, which means they are useful for object detection for the visually impaired but are not fully capable of providing environment preview that is important in ensuring safe navigation.

## CONCLUSION

Navigation, object detection, and orientation are very important factors for ensuring safety and independence of the blind. As revealed by the comparisons of the existing solutions, every solution is only focused on one or two of these factors. In the future, as a next step of the study, a more in-depth investigation and study should be done on more scientific grounding, as the resources used in this study are not all from academia. Further work should be placed on the following:

- Finding more academic and scientific resources about the discussed solutions.
- Approaching users to get feedback and conduct studies about the discussed solutions.
- Conducting user testing on the discussed solutions to gain first hand feedback.

In the future, a proposal of a comprehensive solution should be made to cover the three factors in the safety for blind people, based on advantages of each discussed solution as well as resolutions or workaround to their disadvantages. In this paper, the impact of the needs of environmental adaptation is not discussed in detail. However, in order to propose a feasible and practical solution, this impact should be considered and investigated thoroughly in the future work.

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