Visually Impaired Persons’ Assistance

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Contributor: Alin-Mihai Căilean, Sebastian-Andrei Avătămăniței, Cătălin Beguni, Eduard Zadobrischi, Mihai Dimian, Valentin Popa

The development of new solutions to assist blind people is a major research domain having great potential to enhance the daily lives of such people. These innovative solutions aim to augment the perception of the surrounding environment for the blind and severely visually impaired.

Keywords: blind person assistance ; light dimming ; visually impaired assistance solutions ; visually impaired person

1. Introduction

According to current statistics, there are about 43.3 million blind people worldwide [1], counting for about 0.48% of the total human population. Although in the last two decades, modern medicine had increased success in healing blindness, some of the current studies estimate that in the next 30 years, the number of blind people will increase by up to three times due to the growing and aging population [2]. As one can imagine, blindness has a major impact on a persons’ life, from social integration to an increased susceptibility to accidents. For instance, the unemployment rate among blind individuals is three times higher than the average, whereas the risks associated with navigating sidewalks are at least twice as high [1][2]. Moreover, in the case of young people, blindness restricts the access to normal education and limits personal progress.

If it is to define blindness, one of the most basic and simple definitions would be as an inability to see, caused by an incapacity to discern light from darkness. In this context, blind people “see” the world through their other senses, most often by hearing and touching. Thus, blindness and severe visual impairment disturb a person’s capacity to receive visual information and can have various causes, including congenital conditions, eye injuries, diseases, or degenerative conditions.

The development of new solutions to assist blind people is a major research domain having great potential to enhance the daily lives of such people [3][4][5][6]. These innovative solutions aim to augment the perception of the surrounding environment for the blind and severely visually impaired. Since a Visually Impaired Person (VIP) cannot rely on their sight, these systems must possess the capability to sense the surroundings, identify pertinent information, and convey it to the user through their other senses, with hearing and touch being the most suitable sensory channels for this purpose. To effectively perceive the environment, these devices incorporate various arrays of sensors, including ultrasound sensors, Passive InfraRed (PIR) sensors, Inertial Measurement Unit (IMU) sensors, LiDAR, GPS, and/or cameras. Once the sensory data are collected, a data fusion algorithm is employed to analyze them and provide the user with information that is not only accurate but also relevant, useful, and presented in an appropriate manner. At present, some of the most advanced solutions designed to assist VIPs are based on Artificial Intelligence (AI), specifically using neural networks for tasks like computer vision and data analysis [6]. These AI-driven systems play a crucial role in processing sensory input and providing meaningful insights to help individuals with visual impairments navigate and interact with their surroundings more effectively.

2. Existing Solutions and Approaches in Visually Impaired Persons’ Assistance

The development of assistance solutions for blind and severely visually impaired people implies several challenges. Thus, in order to efficiently guide the VIP, the assistance solution must be able to identify the location of the user. Secondly, the solution must be able to identify the relevant information that should be useful to the user, and thirdly, it should be able to deliver the information in an adequate manner [7].

Generally, users’ location can be established with the help of various wireless communication technologies, such as Bluetooth [8], or Wi-Fi, based on computer vision and inertial sensing [9], or with the help of the smartphone camera [10], while providing positioning errors between 0.4 to 1.5 m. To identify the information from the area, camera-based image navigation solutions are widely used [11][12]. These solutions imply a camera and specialized software that is able to recognize objects from the scene. Recently, various other solutions, such as artificial intelligence and Computer Vision (CV) applications, are swiftly progressing [13][14]. For relative positioning and distance measurement, as well as for obstacle detection, LIDAR, ultrasound and camera recognition systems are also used [15]. Next, once the relevant information is identified, it is transmitted to the user as audio information or by haptic means.

In terms of user solutions, blind assistance solutions are generally integrated into various devices, but most often into smart glasses and smart canes, while also being developed as personal computer or smartphone-compatible applications. These technologies are designed to enhance daily lives of individuals with visual impairments by providing real-time assistance and information. These smart devices and applications offer features like persons and object recognition, navigation aids, and text-to-speech capabilities, allowing users to receive auditory or haptic feedback about their surroundings. Smart canes are frequently equipped with sensors and GPS for obstacle detection and navigation support [16], Computer and smartphone applications offer accessibility features such as voice assistants, screen readers, and GPS-based navigation. These integrated software solutions aim to improve mobility, independence, and overall quality of life for VIPs. The high prevalence of personal computers and smartphones has led to the development of multiple software applications that are meant to assist visually impaired persons.

3. Commercial Software Applications for Blind and Severely Visually Impaired Persons' Assistance

A significant part of software applications designed for individuals with visual impairment is closely related to assistive technology, playing a crucial role in enabling voice-based reading. Their main purpose is to convert text into speech, making it more accessible for the blind and visually impaired and facilitating their access to written information, documents, and websites. Popular software applications like Job Access with Speech (JAWS) [17] and NonVisual Desktop Access (NVDA) [18] are widely used for this purpose. JAWS, developed by Freedom Scientific, is renowned for its ability to provide voice-based reading and enhanced accessibility, converting on-screen text and graphics into speech or Braille. Its features include compatibility with online platforms, the Microsoft Office suite, web browsers, email applications, and social media. NVDA, on the other hand, is an open-source software solution that offers similar functionalities but stands out for its portability and compatibility across various operating systems and digital resources.

Additionally, there are electronic Braille devices, GPS navigation systems integrated with mobile applications like Lazarillo [19] and BlindSquare [20], voice recognition systems like Siri [21] and Google Assistant [22], or VoiceOver [23] for Apple devices, which provide accessibility features and support for users with visual impairment. There are also mobile applications designed to identify colors in the user's surroundings, such as Be My Eyes [24], which allows users to request assistance from volunteers. These assistive technologies, along with handwriting-to-text conversion apps and Braille printers, contribute to creating a more inclusive and accessible environment for individuals with visual impairments.

Considering the important role of education, as well as the fundamental right to education, assistance software solutions for this purpose have been developed. Thus, specialized educational resources, AI assistance in online education, wearable technologies for content recognition and vocal feedback, and Haptic Wearables for urban navigation have been developed to enhance the daily lives and educational experiences of people with visual impairments. The rapid advancement of technology, including Virtual Reality (VR) and Augmented Reality (AR), has revolutionized the field of assistive technologies, providing innovative and intuitive solutions for the visually impaired. The integration of emerging technologies is transforming the way individuals with visual impairments access information and engage in educational processes. Accessibility standards like Web Content Accessibility Guidelines (WCAG) [25] have played a pivotal role in ensuring that digital learning platforms and online courses are inclusive for individuals with disabilities.

While current studies and developments in this field are still in their early stages, the complexity of addressing the needs of VIPs has led to significant advancements, particularly in the medical field. These advancements range from retinal implants to facial recognition, text reading, and audio playback, with the ultimate goal of enhancing the quality of life for individuals with visual impairment.

4. Visible Light Communications and Their Potential in Blind and Severely Visually Impaired Persons' Assistance

Over the past decade, VLC has emerged as an exciting wireless technology that has witnessed significant advancements. As previously mentioned, VLC uses visible light not only for illumination but also as means of transmitting data, thereby enabling pervasive wireless communication. Consequently, VLC has the remarkable capability to transform any LED light source into a data transmission device. Moreover, extensive research efforts have unlocked the potential of VLC for achieving highly precise localization, making it a valuable technology for delivering position-specific data. In contrast to traditional Radio Frequency (RF) communication, where a central device covers a wide area, VLC networks exploit the inherent properties of light. These characteristics allow for the deployment of a multitude of optical access points and the enhancement of overall performance.

Considering that LED lighting systems are an integral part of our daily lives, serving not only to illuminate our surroundings but also to provide essential visual information, it becomes apparent that their ubiquitous presence can be harnessed for a broader spectrum of applications. In this context, VIPs can derive substantial benefits from VLC's extensive coverage and its capacity to offer location-specific data. Thus, one can see that the VLC technology has the intrinsic means to solve a significant part of the tasks, as it has the potential to identify users' locations and to timely deliver location specific data. Furthermore, as the VLC technology is developing on top of a preexisting and widely available lighting network, its potential is very high. On these grounds, VLC empowers users to be constantly aware of their precise location and receive pertinent information relevant to their specific surroundings.

However, despite the promising potential of VLC in assisting visually impaired individuals, there remains a relative lack of relevant research focused on practical demonstrations of these concepts. More concerted efforts in this area are needed to fully explore and use the capabilities of VLC technology for the benefit of those with visual impairments. Examples of preliminary works focused on VLC use in blind persons' assistance can be found in [26][27][28][29]. Although these works emphasize the benefits of VLC and its compliance with visually impaired assistance, their implementation is still at a low Technology Readiness Level (TRL), whereas the experimental results are far from being relevant for real-life utilization. On the other hand, these works have the merit of pushing things forward in the right direction.

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