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THE USE OF SENSOR-EQUIPPED GLASSES TO ENHANCE MOBILITY INDEPENDENCE FOR PEOPLE WITH VISUAL IMPAIRMENTS

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Abstract

People with visual impairments face mobility challenges, particularly in detecting obstacles in their surroundings. Assistive technology, such as sensor glasses, offers a solution to increase user independence and safety. This article aims to examine the use of sensor glasses technology to improve the mobility independence of people with visual impairments. The method used was a literature review, collecting and analyzing various relevant scientific sources. The study results indicate that sensor glasses use ultrasonic sensors to detect obstacles in front of, to the right, and to the left of the user, then provide feedback in the form of sound or vibration via a microcontroller. This technology offers significant benefits in terms of real-time obstacle detection, increased safety, and user independence during activities. Integration with IoT and GPS-based systems also allows for remote location monitoring. However, sensor glasses still have limitations in optimal ground detection. Overall, sensor glasses have the potential to be an effective mobility aid for people with visual impairments, especially when combined with a traditional cane.

Keywords: sensor glasses; visual impairment; mobility; independence; assistive technology

1. Introduction

The development of science and technology makes a significant contribution to various aspects of life, including the development of assistive technology for individuals with disabilities. Visual impairment is a general term referring to a condition in which an individual experiences impairment or limitations in visual function, thereby requiring assistance in performing daily activities (Atika et al., 2023). This condition demands more innovative strategies and assistive devices, considering that technological advancements have been proven to foster more adaptive learning and support approaches for individuals with visual impairments (Rahmayani & Selian, 2025).

The utilization of technology not only plays a role in increasing the efficiency of general public activities but also functions to expand accessibility for people with visual impairments, namely by providing facilities aimed at creating equal opportunities in all aspects of life (Rama & Trustisari, 2024). One form of such development is demonstrated through the presence of sensor-based assistive technology designed to support independent orientation and mobility processes.

In carrying out daily activities, visually impaired individuals often face major challenges related to mobility and safety, particularly in public spaces that are not yet fully friendly to disability needs (Dava et al., 2025). One of the main issues that frequently arises is the

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limitation in recognizing obstacles in the surrounding environment, determining travel directions, and obtaining spatial information quickly and accurately. Conventionally, the traditional white cane remains the primary assistive tool; however, its use has limitations because it can only detect objects in specific areas at the lower ground level, thus falling short of providing comprehensive, real-time environmental information.

These conditions indicate a clear need for the development of assistive devices capable of presenting broader and more responsive environmental information. Along with advancements in microcontroller and sensor technology, various innovations have been developed, one of which is smart sensor glasses. Operating through integrated ultrasonic sensors controlled by a microcontroller system, these glasses can perform various functions, including estimating object distance (Yanti et al., 2022). Sensor glasses can detect objects in front, to the right, and to the left of the user via frame-mounted sensors, subsequently providing feedback in the form of sound or vibration as a warning indicator.

Furthermore, trends in assistive technology also point toward utilizing Internet of Things (IoT)-based systems to support mobility safety for the visually impaired. The integration of IoT systems with GPS modules has been proven to enable real-time location monitoring via applications such as Telegram, allowing remote monitoring of the user's position to enhance safety during mobility (Azmi et al., 2026).

Although various innovations have been developed, several studies indicate that sensor glasses technology still has limitations, such as suboptimal detection under certain conditions and the incomplete integration of all user needs into a single compact and comfortable system (Taneo et al., 2022). This highlights the necessity for further development of assistive technology that focuses not only on obstacle detection but also on comprehensively improving user independence and safety.

Based on this background, this article aims to examine the utilization of sensor glasses technology in enhancing the mobility independence of visually impaired individuals through a literature review of relevant studies.

Research Questions

Based on the background study regarding the development map of assistive technology, this literature review article focuses on answering several research questions as follows:

1. How is the current development of assistive technology supporting navigation accessibility for visually impaired individuals?
2. What are the basic principles and working mechanisms of sensor glasses technology in identifying environmental obstacles?
3. What are the concrete benefits of integrating sensor glasses technology and IoT-based systems for user mobility independence?
4. What technical advantages and limitations are identified in current sensor glasses development?

2. Method

2.1 Research Type and Approach

This study uses a literature review (library research) approach, which aims to examine and analyze various scientific sources to answer research questions without directly collecting field data.

2.2 Data Sources and Collection Techniques

Data in this study were obtained through searches of journals, research articles, and books that discuss assistive technology for individuals with visual impairments, specifically sensor glasses as mobility and independence tools for users. The sources used were selected based on thematic alignment and the relevance of the publication year to the study topic.

2.3 Data Analysis Techniques

The collected data were analyzed descriptively to identify the benefits, working mechanisms, as well as the potential and limitations of implementing sensor glasses technology for individuals with visual impairments. As part of the review, the literature search also included a general overview of the development stages of sensor glasses as reported in previous studies, including designing the glasses to be comfortable to wear, installing ultrasonic sensors on the front of the glasses to detect surrounding objects, integrating Arduino Nano as the main controller for processing sensor data, adding a buzzer as an audio warning output, and testing the device to ensure all components function as designed.

3. Results and Discussion

As a basis for analysis, Table 1 summarizes several studies that serve as the main references in this article.

Table 1. Literature Review

No	Penulis (Tahun)	Fokus Kajian	Temuan Utama
1	Yanti et al. (2022)	Design of smart glasses using the brainstorming method	Smart glasses are capable of estimating object distance and supporting navigation functions for visually impaired individuals
2	Muzawi et al. (2020)	Guide glasses prototype for the visually impaired	Ultrasonic sensors and microcontrollers are effective in detecting objects and producing responsive warnings

3	Shiddiq et al. (2020)	Obstacle detection system using ultrasonic and infrared sensors	The system is capable of distinguishing object conditions in the lower area (< 73 cm) and potholes (> 89 cm)
4	Widianto et al. (2021)	HC-SR04 multisensor vest for the visually impaired	Wearable devices enhance user comfort, utility, and safety
5	Rizky et al. (2024)	GPS-based navigation for the visually impaired	The combination of GPS and ultrasonic sensors increases the sense of security and mobility independence
6	Azmi et al. (2026)	IoT-based assistive device with voice guidance and location monitoring	IoT-GPS integration enables remote location monitoring via the Telegram application
7	Taneo et al. (2022)	Walking aid based on Arduino and ultrasonic sensors	Technology is still limited in consistently detecting lower surface area conditions

3.1 Development of Assistive Technology for Visually Impaired Individuals

The development of technology has provided many conveniences in human activities, including in the field of mobility and accessibility for visually impaired individuals. For the general public, navigation technologies such as Global Positioning System (GPS), automatic sensors, and digital applications help users obtain location information quickly and accurately, while for visually impaired individuals, assistive technology is developed to help increase safety and independence in daily activities (Arifin et al., 2024).

One form of developing assistive technology is the use of ultrasonic sensors on mobility aids, which work by detecting obstacles around the user and providing information in the form of sound or vibration so that visually impaired individuals can recognize objects or obstacles when walking more safely (Idhartono et al., 2024). In addition, technological innovations based on smart glasses are also starting to be developed to help visually impaired individuals obtain information from the surrounding environment.

Another development can also be seen in the use of devices based on Raspberry Pi, GPS, and navigation sensors that provide user location information and detect obstacles in the vicinity, thereby increasing the sense of security and independence during activities (Rizky et al., 2024). From these various developments, sensor glasses have become one of the innovations with great potential in assisting the mobility of visually impaired individuals, as they are designed to detect surrounding obstacles in real-time and convey this information in

the form of sound or vibration, enabling users to determine directions and avoid obstacles more easily when walking.

3.2 Working Principles and Mechanisms of Sensor Glasses

Sensor glasses are designed to help visually impaired users recognize the presence of objects or obstacles around them through three main components: distance sensors, processing units, and output devices.

Ultrasonic sensors, according to Chandra and Pratama (2023), are electronic devices that utilize the principle of high-frequency sound wave propagation to measure distance and detect the presence of objects. This sensor consists of a transmitter unit that generates ultrasonic waves and a receiver unit that captures reflected waves. Based on the time of flight method, the distance between the sensor and the object is calculated from the time difference between wave emission and reflection reception, in accordance with the propagation speed of sound waves in the air.

Distance data obtained by the sensor is then sent to a processing unit in the form of a microcontroller such as Arduino, which has been programmed with a specific distance threshold, for example 1 meter or 50 centimeters, as implemented in object detection devices for the visually impaired developed by Muzawi et al. (2020). If the detected object distance is less than the threshold, the processing unit immediately sends a command signal to the output device.

Signals from the processing unit are subsequently converted into alerts felt by the user, through two output options: sound via earphones, in the form of beeps or voice messages that become faster or louder as obstacles get closer; and vibration via small motors on the glasses frame, whose intensity increases as the distance to obstacles decreases. Both forms of warning provide early alerts so users can stop or change direction to avoid collisions.

Through this mechanism, the glasses are capable of detecting obstacles such as walls, chairs, doors, or other people in the user's path. This device does not eliminate the function of traditional canes, but serves as a complement that enhances the sense of security and independence, especially in familiar environments such as schools or homes.

3.3 Benefits of Sensor Glasses for Visually Impaired Mobility Independence

Developments in science and technology in the field of microcontrollers have driven the creation of sensor glasses as a more adaptive technological alternative in supporting spatial navigation needs of users, as they are able to provide broader environmental information compared to conventional tools such as passive guide canes (Muzawi et al., 2020).

3.3.1 Benefits to Mobility

Technically, sensor glasses work by integrating ultrasonic sensors that detect objects around the user in real-time, mapping environmental conditions in the front, right, and left areas, so that the information obtained is not limited only to lower areas as with guide canes. Based on research by Shiddiq et al. (2020), there are two main conditions in this detection mechanism: the first condition occurs when the sensor detects an object or obstacle in the lower area, indicated by a slope distance reading of less than 73 cm, while the second

condition occurs when the sensor detects potholes, indicated by a slope distance reading exceeding 89 cm. The detection results are then processed by the microcontroller to generate feedback in the form of sound or vibration as a warning of obstacles.

In the aspect of orientation and mobility (OM), which is a fundamental skill for visually impaired children to recognize and understand their surrounding environment so they can move with confidence (Astuti, 2025), this technology makes a significant contribution because the system's ability to detect objects from various directions allows users to obtain a more complete picture of the environment when walking in public spaces. Furthermore, the integration of an IoT-based GPS module connected to applications such as Telegram enables real-time location monitoring by companions (Azmi et al., 2026), allowing users to remain independently active under remote supervision.

3.3.2 Benefits to User Safety

The safety aspect is one of the main objectives in developing sensor glasses, as an effort to increase comfort, utility, and safety for users (Widianto et al., 2021). This device is designed as a prevention system that provides early warnings before users come into direct contact with surrounding objects, thereby minimizing the risk of accidents during independent mobility. Testing results reported by Muzawi et al. (2020) show that ultrasonic sensors on glasses have responsive performance in detecting objects and sending warnings in a short time; sensors placed at the lower part of the glasses frame also function to identify road surface conditions such as potholes, elevation drops, or depressions, thereby providing additional protection for users. With this early warning system, user awareness increases, significantly reducing the risk of injury due to collisions or tripping.

3.3.3 Benefits to Independence of Visually Impaired Individuals

Through the combination of ultrasonic sensors and microcontrollers, this device is able to provide environmental information automatically without requiring direct assistance from others. When the system detects an object within a certain distance, the device sends a sound signal as an indicator of an obstacle in the path of movement (Azmi et al., 2026), helping users make independent decisions while moving around the environment, thus increasing the sense of security and confidence. Furthermore, IoT-based development allows remote user location monitoring via GPS modules connected to companion applications such as Telegram, allowing families or companions to monitor user locations (Azmi et al., 2026); this feature not only improves safety aspects but also expands user mobility space to act more independently, effectively, and efficiently.

3.4 Advantages and Limitations of Sensor Glasses

Sensor glasses technology has advantages in detecting the presence of obstacles from various directions, including front, right, and left of the user. When ultrasonic sensors successfully identify an obstacle, signals are immediately sent to activate warnings in the form of buzzer sounds as object indicators, allowing users to obtain real-time warnings for objects that are too close in distance (Taneo et al., 2022). The audio system serves as a medium for conveying information in the form of voice guidance, and according to test results conducted by Azmi et al. (2026), voice messages issued by the system can be heard clearly and delivered

in a timely manner, contributing to increased safety, independence, and a sense of security for visually impaired individuals in carrying out daily activities.

On the other hand, the drawback of sensor glasses technology lies in the suboptimal ability of the device to detect surface conditions in lower areas, such as holes, depressions, or road elevation drops, so potential hazards from that direction cannot yet be fully anticipated (Taneo et al., 2022). In addition, the accuracy of ultrasonic sensors can also decline under certain environmental conditions, especially when dealing with object surfaces that do not optimally reflect sound waves, meaning consistency of detection results cannot yet be fully guaranteed in various field situations. These various limitations indicate that sensor glasses technology still requires further study and development to present a more comprehensive and reliable assistive solution for visually impaired individuals.

4. Conclusion

Based on the results of the literature review that has been conducted, it can be concluded that the development of assistive technology, specifically sensor glasses, makes a significant contribution to supporting the mobility independence of visually impaired individuals. The presence of this technology is a response to the limitations of conventional assistive tools, such as traditional white canes, which are only capable of detecting objects in specific lower areas, thus failing to provide comprehensive and real-time environmental information.

Sensor glasses work by utilizing ultrasonic sensors integrated with microcontrollers to detect obstacles in the user's front, right, and left areas in real-time. The distance data obtained is then processed by the microcontroller to generate feedback in the form of sound or vibration as an early warning to the user. This mechanism allows users to obtain a broader and more responsive picture of the environment compared to conventional assistive tools currently in use.

Nevertheless, sensor glasses technology still has several limitations that require attention, particularly regarding the ability to detect lower surface conditions such as potholes, depressions, or road elevation drops, as well as the accuracy of ultrasonic sensors which can decline under certain environmental conditions. These conditions indicate that sensor glasses cannot yet fully replace the function of traditional canes, but are more appropriately positioned as complementary assistive tools used concurrently. Overall, sensor glasses have the potential to become an effective assistive solution for visually impaired individuals if developed continuously, so further development and studies are still needed so that this technology can serve as a more comprehensive, reliable solution aligned with user needs in various environmental conditions.

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