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A Review on Intelligent Wearable Assistive Systems for Visually Impaired

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ABSTRACT

Assistive wearable technology for visually impaired individuals represents a powerful intersection of intelligence and inclusivity. From smart glasses that interpret surroundings to multi-sensor navigation systems, these digital companions transform how users perceive and interact with the world. Powered by computer vision, artificial intelligence, and embedded systems, these solutions deliver real-time awareness through audio and haptic feedback. Advancements in deep learning–based object detection, ultra-efficient on-device processing, and sensor fusion have enabled greater accuracy, lower latency, and improved energy efficiency. Some systems leverage cloud-assisted intelligence for complex scene understanding, while others operate entirely on edge devices to ensure privacy and continuous operation. These wearables act as silent guides—enhancing mobility, reducing cognitive load, and fostering independence. As research continues to evolve, ethical design and user-centric development remain central, ensuring technology augments human capability rather than replacing it. This review explores recent innovations, compares existing approaches, and envisions a future where intelligent assistive wearables empower visually impaired individuals to navigate the world with confidence and autonomy.

INTRODUCTION

The rapid advancement of computer vision, artificial intelligence, and wearable computing has enabled the development of intelligent assistive systems for visually impaired individuals. Smart wearable devices, particularly vision-enabled glasses, act as digital guides by interpreting the surrounding environment and providing real-time feedback. The integration of these technologies is multifaceted and addresses key challenges in daily navigation and interaction, as outlined below:

Obstacle Detection: Vision-based systems detect nearby objects, pedestrians, and hazards using deep learning models. Real-time alerts through audio or vibration help users avoid collisions in dynamic environments.

Navigation Assistance: Wearable devices combine cameras with GPS, ultrasonic sensors, and inertial units to support indoor and outdoor navigation. Sensor fusion improves accuracy and reliability across varying conditions.

Text and Object Recognition: Optical Character Recognition (OCR) and object recognition techniques enable users to identify signs, labels, and everyday objects, enhancing situational awareness and independence.

On-Device Intelligence: Lightweight neural networks deployed on embedded edge devices allow real-time processing with low latency, reduced power consumption, and improved privacy.

User Feedback Mechanisms: Hands-free interaction using voice guidance and haptic feedback ensures ease of use and minimizes cognitive load during continuous operation.

Through these capabilities, assistive wearable systems demonstrate significant potential to improve safety, autonomy, and quality of life for visually impaired individuals. This review examines recent developments, compares existing solutions, and highlights future research directions.

LITERATURE SURVEY

A Google Glass Based Real-Time Scene Analysis for the Visually Impaired* by Hafeez Ali A., Sanjeev U. Rao, Swaroop Ranganath, T. S. Ashwin, and Guddeti Ram Mohana Reddy, Proposed that an AI-powered wearable assistance system using Google Glass can significantly improve environmental awareness for visually impaired individuals. The system integrates Microsoft Azure Custom Vision for real-time object and scene classification. Detected objects are converted into audio messages and delivered through bone-conduction speakers, enabling hands-free navigation. The study demonstrates high accuracy (84% mAP) and low processing delay, making it suitable for daily use. However, performance may vary in low-light conditions. Overall, the approach shows that real-time wearable vision systems can enhance independence and safety for users.

Smart Guiding Glasses for Visually Impaired People in Indoor Environments* by Jinqiang Bai, Shiguo Lian, Zhaoxiang Liu, Kai Wang, and Dijun Liu, Proposed smart guiding glasses that combine a depth camera with ultrasonic sensors to detect indoor obstacles accurately. The system generates auditory feedback and AR-based visual enhancements (for low-vision users) to support safe indoor navigation. Experimental results show obstacle processing within ~30 ms, enabling fast and reliable collision avoidance. The design is suited for real-world environments such as supermarkets, offices, and homes. This research demonstrates that multi-sensor indoor navigation systems can significantly enhance mobility for visually impaired individuals.

Ultra-Efficient On-Device Object Detection on AI-Integrated Smart Glasses with TinyissimoYOLO* by Julian Moosmann, Pietro Bonazzi, Yawei Li, Sizhen Bian, Philip Mayer, Luca Benini, and Michele Magno, Presents an ultra-lightweight, energy-efficient object detection system optimized for smart glasses. The authors proposed TinyissimoYOLO, a deeply compressed version of YOLO running on a GAP9 RISC-V processor. The system achieves real-time inference (17 ms per frame) with extremely low power consumption (62.9 mW), enabling over 9 hours of continuous wearable operation. Despite its small size, the model maintains good detection accuracy. This work proves that advanced AI models can be effectively deployed on wearable edge devices without cloud dependency.

Cognitive Assisting Aid with Multi-Sensor Fused Navigation for Visually Impaired People* by Myneni Madhu Bala, D.N. Vasundhara, Akkineni Haritha, and CH. V. K. N. S. N. Moorthy, Proposed a multi-sensor wearable system called the “Blind’s Apron” integrating LiDAR, camera vision, GPS, and vibration motors to guide visually impaired users. The system detects slopes, potholes, uneven surfaces, static and moving obstacles using sensor fusion. Real-time vibration feedback alerts the user about potential hazards. Experimental trials show over 200% improvement in walking speed and obstacle detection accuracy. The study demonstrates that combining multiple sensors in a single wearable can provide a safer and more comfortable navigation experience.

Hybrid Navigation System Adapted to Blind Users for Stress-Free Indoor and Outdoor Mobility* by Keryakos Y., Bou Issa Y., Salomon M., and Makhoul A, Presents a hybrid navigation solution that merges QR-code based indoor navigation with voice-guided GPS for outdoor navigation. The system evaluates user stress using biosignals such as EEG, EDA, and BVP, and dynamically selects the “least stress” route. The proposed approach reduces navigation anxiety and improves comfort significantly. This research highlights the importance of considering user emotional state while designing navigation tools for visually impaired users.

Hands-Free Haptic Navigation Devices for Actual Walking* by Ryota Sato, Kaori Fujita, and Hiroshi Kajimoto, proposes a wearable navigation system that guides users through vibration-based cues instead of relying on visual or auditory signals. The study reviews multiple haptic device designs—such as those worn on the arms, head, waist, and legs— and evaluates their usability during real walking tasks. The authors emphasize that GPS-integrated systems demonstrate higher practical readiness, offering autonomous navigation without constant manual input. However, many compact prototypes still require external control or preset paths, limiting their everyday applicability. The paper concludes that hands-free haptic feedback has strong potential to enhance independent mobility, particularly for visually impaired pedestrians or users navigating low-visibility environments. comparable to a commercially available pulse oximeter. The system’s accuracy is enhanced using light- emitting diodes driver circuits and sample and hold circuits, which establish a variable baseline for different skin tones. This makes it adaptable to a wide range of users. The sensor system is designed as a wearable device, making it convenient for continuous health monitoring. It’s a plug-and-play device with Arduino, making it user-friendlyand easy to operate. The system’s high accuracy, with a maximum deviation of 2% compared to a commercially available pulse oximeter, makes it a reliable tool for health monitoring.

Smart Glasses with Voice Assistance and GPS for Independent Mobility of the Blind People* by Lalam Narendra, Bommina Surendra Babu, Bavaraju Venkata Naga Durga Vinay, Gopikanth Tirumani, and Channamolu Manohar

proposes an assistive wearable system that combines AI voice assistance, GPS navigation, object detection, and OCR to support visually impaired users. The device provides real-time audio guidance, obstacle alerts, and text-to-speech reading, enabling safe movement in indoor and outdoor environments. Experimental results demonstrate high accuracy in object detection, reliable GPS-based localization, and fast voice responses, making the system an effective solution for improving independence and situational awareness.

PAPER COMPARISON

RESEARCH PAPERS	*COMPARITIVE STUDY*
1. A Google Glass Based Real-Time Scene Analysis for the Visually Impaired* by Hafeez Ali A., Sanjeev U. Rao, Swaroop Ranganath, T. S. Ashwin, and Guddeti Ram Mohana Reddy	The Google Glass–based system adopts a vision-centric methodology, integrating wearable hardware with cloud-assisted AI processing. The framework utilizes the built-in RGB camera of Google Glass as the primary sensing module, with preprocessing performed on-device to enhance frame quality and reduce transmission load. Cloud connectivity is enabled through lightweight RESTful API communication, ensuring real-time interaction with Microsoft Azure Custom Vision services. The operational workflow emphasizes low-latency inference by offloading computationally intensive tasks to the cloud. User feedback is delivered through bone-conduction audio output, enabling continuous situational awareness without obstructing environmental sound. System reliability is further strengthened through secure HTTPS/TLS encryption and optimized resource handling, ensuring compatibility with dynamic real-world navigation environments.
2. Smart Guiding Glasses for Visually Impaired People in Indoor Environments* by Jinqiang Bai, Shiguo Lian, Zhaoxiang Liu, Kai Wang, and Dijun Liu	This methodology, combining a depth camera and ultrasonic sensors for highly accurate obstacle detection in indoor environments. The device utilizes a dual- output strategy to assist users, providing auditory cues for blind users and AR- based visual enhancement for weak-sighted users. A key focus of the methodology is rapid performance, achieving efficient obstacle processing at approximately 30 milliseconds per frame. Field tests in diverse settings like supermarkets and home environments showed tangible benefits, including improved walking speed and fewer collisions. The authors also highlight the potential for system scalability, noting the possibility of adapting the design to larger, more complex environments.
3. Ultra-Efficient On-Device Object Detection on AI-Integrated Smart Glasses with TinyissimoYOLO* by Julian Moosmann, Pietro Bonazzi, Yawei Li, Sizhen Bian, Philip Mayer, Luca Benini, and Michele Magno	This introduce a methodology centered on achieving Ultra-Efficient On-Device Object Detection specifically for AI-Integrated Smart Glasses, by developing a highly optimized model called TinyissimoYOLO. The research focuses on addressing the power and computational constraints inherent to wearable devices, ensuring high efficiency without compromising detection performance. The methodology involves optimizing both the neural network architecture and its implementation on the device's hardware, allowing the complex task of object detection to run locally on the glasses.
4.Cognitive Assisting Aid with Multi-Sensor Fused Navigation for Visually Impaired People* by Myneni Madhu Bala, D.N. Vasundhara, Akkineni Haritha, and CH. V. K. N. S. N. Moorthy	This utilizes a robust Multi-Sensor Fusion approach for the real-time navigation of blind users. The system integrates a diverse set of sensors including LiDAR, a camera, GPS, and vibration motors to enable comprehensive environmental understanding. The core methodology involves combining sensor-based, vision-based, and cognitive modules to accurately detect a wide range of hazards, such as obstacles, uneven surfaces, slopes, potholes, and hollow objects. The system provides critical safety feedback through both audio and vibration mechanisms. Performance analysis from real-world testing demonstrated significant success, showing more than 200% improvement in walking speed and detection accuracy, while the authors emphasize the system's practical advantages in terms of comfort, portability, and potential for large-scale adoption.

5. Hybrid Navigation System Adapted to Blind Users for Stress-Free Indoor and Outdoor Mobility* by Keryakos Y, Bou Issa Y., Salomon M, and Makhoul A	The paper adopts a mathematical modeling approach using Laplace transform and transfer functions to characterize the dynamics of servomotors. Contro strategies, including Proportional-Integral-Derivative (PID) controllers, AR implemented through MATLAB/Simulink simulations. System identification techniques such as least-squares estimation are employed for accurate mode parameterization. The study prioritizes the Lyapunov stability analysis fo assessing controlsystem stability. Although lacking direct roboticimplementations the methodology serves as a theoretical foundation for the design and control orobotic systems with a focus on safety-criticalapplications.
6. Hands-Free Haptic Navigation Devices for Actual Walking* by Ryota Sato, Kaori Fujita, and Hiroshi Kajimoto	This proposes a hands-free haptic navigation methodology that guides users using vibration-based cues applied through various wearable device designs (arms, head, waist, and legs), specifically for real walking tasks where visual or auditory signals may be insufficient or distracting. The core finding emphasizes the higher practical readiness of GPS-integrated systems for autonomous navigation. In contrast, Lalam Narendra, Bommina Surendra Babu, et al. propose a methodology for Smart Glasses with Voice Assistance and GPS that integrates AI voice assistance, GPS navigation, object detection, and OCR to provide comprehensive assistive support. This system provides real-time audio guidance, obstacle alerts, and text-to-speech reading, demonstrating high accuracy in object detection and reliable localization for enhanced independent mobility and situational awareness in both indoor and outdoor environments.
7.Smart Glasses with Voice Assistance and GPS for Independent Mobility of the Blind People* by Lalam Narendra, Bommina Surendra Babu, Bavaraju Venkata Naga Durga Vinay, Gopikanth Tirumani, and Channamolu Manohar	This introduces a comprehensive assistive wearable system methodology, implemented as Smart Glasses with Voice Assistance and GPS, designed to support the independent mobility of visually impaired users. This system integrates multiple advanced features, specifically combining AI voice assistance, GPS navigation, object detection, and Optical Character Recognition (OCR) into a single platform. The core functionality provides real-time support through audio guidance, immediate obstacle alerts, and text-to-speech reading, enabling safe and informed movement in both indoor and outdoor environments. Experimental results validate the system's effectiveness, demonstrating high accuracy in object detection, reliable GPS-based localization, and fast voice responses, thereby serving as an effective solution for improving user independence and situational awareness.

CONCLUSION

The integration of artificial intelligence, computer vision, and wearable technologies has significantly advanced assistive systems for visually impaired individuals by enhancing navigation, environmental awareness, and independent mobility through real-time perception and feedback. Vision-enabled wearables demonstrate strong potential in obstacle detection, text recognition, and scene understanding, making everyday activities safer and more accessible. However, challenges related to power efficiency, user comfort, system reliability, and data privacy remain and must be addressed to enable widespread adoption. Future research focusing on edge intelligence, sensor fusion, and user-centric design is expected to deliver more efficient, personalized, and accessible assistive solutions that improve the overall quality of life for visually impaired users.

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