A Comparative Analysis of Assistive Technologies for Blind Navigation and Daily Interaction

ARTIFICIAL INTELLIGENCE, ASSISTIVE TECHNOLOGY, COMPUTER VISION, OBJECT DETECTION, FACE RECOGNITION, AUDIO GUIDANCE SYSTEMS, ACCESSIBILITY ENGINEERING, HUMAN–COMPUTER INTERACTION, GENERATIVE AI IN ACCESSIBILITY, ETHICAL AI DESIGN

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Cite as: vvennix lu. *A Comparative Analysis of Assistive Technologies for Blind Navigation and Daily Interaction*. Authorea.
DOI: Pending approval

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Date: 2025

Abstract

This work provides an analytical overview of modern AI-driven assistive technologies designed to support blind and visually impaired individuals. The study focuses on four areas of functional relevance: navigation systems, object detection models, face recognition tools, and utility-service functions such as shopping assistance, product identification, and currency recognition. The goal is to compare technical approaches, evaluate usability, and examine the integration of machine learning pipelines within real-world accessibility applications. The review synthesizes findings from recent research to highlight progress and remaining challenges in the development of intelligent assistive systems.

1. Introduction

Advancements in artificial intelligence and computer vision have significantly improved technological support for blind individuals. Traditional mobility tools such as white canes and guide dogs, while effective, are limited in scope. Modern AI systems extend these capabilities by providing real-time spatial understanding, environmental awareness, and contextual assistance.

This study examines four core components of assistive systems for the visually impaired:

- **Navigation** technologies offering path planning and obstacle avoidance
- **Object detection** solutions enhancing environmental awareness
- **Face recognition** systems enabling social identification
- **Utility services**, including shopping support, product detail extraction, and currency recognition

Together, these technologies aim to increase independence, mobility confidence, and overall quality of life.

2. Related Work

Recent developments in AI-powered navigation systems demonstrate the potential of multimodal sensory fusion—combining GPS, LiDAR, inertial sensors, and vision models—to generate safe, accessible paths for blind users. Studies show significant improvements in route stability and hazard detection accuracy.

Research on object detection for blind assistance focuses on lightweight models optimized for mobile devices. Systems built on YOLO variants, MobileNet, and transformer-based detectors deliver high accuracy while maintaining real-time performance.

Face recognition applications highlight the social value of identifying acquaintances, caregivers, or staff members. New approaches reduce false positives while ensuring privacy-preserving data handling.

Utility-service research introduces tools capable of reading product information, detecting shelf labels, scanning barcodes, and recognizing currency to assist in daily economic interactions.

3. Navigation Technologies

3.1 Overview

Navigation systems for blind users rely on a combination of computer vision, audio guidance, and spatial mapping. These tools provide path instructions, hazard alerts, and contextual environment descriptions.

3.2 Key Contributions

- Real-time obstacle avoidance using vision-based models
- Indoor and outdoor navigation through GPS and SLAM
- Audio-based directional feedback for hands-free mobility

3.3 Limitations

- High computational demands for real-time mapping
- Reduced accuracy in low-light or GPS-denied environments

4. Object Detection for Environmental Awareness

4.1 Overview

Object detection assists users by identifying items such as doors, vehicles, steps, traffic lights, and household objects. Modern models enable quick scene interpretation with minimal latency.

4.2 Key Contributions

- Fast detection enabled by optimized CNNs and transformers
- Support for multiple environments—street, home, stores
- Strong generalization across object categories

4.3 Limitations

- Difficulty detecting small or partially occluded objects
- Dependence on camera quality and ambient lighting

5. Face Recognition for Social Interaction

5.1 Overview

Face recognition allows users to identify familiar individuals, supporting social navigation, communication, and personal safety.

5.2 Key Contributions

- High recognition accuracy through deep embedding models
- Ability to store personalized face libraries
- Audio-based identity announcement in real time

5.3 Limitations

- Privacy concerns and storage of biometric data
- Performance degradation under motion blur or occlusion

6. Utility-Service Actions

6.1 Overview

These tools enhance everyday independence by automating common tasks such as shopping, reading product information, and identifying currency.

6.2 Key Contributions

- Barcode/QR scanning for instant product identification
- OCR-based extraction of labels, expiration dates, and pricing
- Currency recognition models trained on diverse datasets

6.3 Limitations

- Variability in label design and text quality
- Differences in currency appearance across regions

7. Conclusion

Advances in navigation, object detection, face recognition, and utility-service technologies collectively support a more inclusive and independent lifestyle for blind individuals. AI-powered systems improve environmental awareness, mobility safety, and access to essential daily activities. Although challenges remain in computation, privacy, and reliability, the integration of modern machine learning techniques continues to significantly enhance the usability and effectiveness of assistive tools. Together, these innovations form a robust technological ecosystem that expands accessibility and empowers visually impaired users in real-world environments.

References

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