Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 12, 658-668
2025
Publisher: Learning Gate
DOI: 10.55214/2576-8484.v9i12.11472

Smart guide for the blind: System analysis and design of a mobile application for real-time object detection and navigation support

Raniyah Wazirali[1,2], Eman Alkhamash[2,3], Lucia Carrion Gordon[4*]
[1]College of Computing and Informatics, Saudi Electronic University, Riyadh 11673, Saudi Arabia; r.wazirali@seu.edu.sa (R.W.).
[2]King Salman Center for Disability Research, Riyadh 11614, Saudi Arabia.
[3]Department of Computer Science, College of Computers and Information Technology, Taif University, Taif 21944, Saudi Arabia.
[4]NAPS. National Academy of Professional Studies, Program Coordinator, Faculty of Information Technology Sydney Australia; lucia.gordon@naps.edu.au (L.C.G.).

Abstract: This paper presents the development, system analysis, and design of the Smart Guide for the Blind (SGB), a mobile application created to support visually impaired individuals in navigating their surroundings safely and independently. The system leverages the smartphone's camera alongside real-time object detection models, including TensorFlow and YOLOv5, to identify surrounding obstacles and communicate them through auditory cues and vibration alerts. Designed as a cost-effective and portable assistive tool, SGB targets users who may not have access to expensive specialized technologies. Comprehensive testing demonstrated the application's effectiveness in recognizing a wide range of common environmental objects, confirming its potential to enhance situational awareness and reduce navigation risks. By improving mobility, confidence, and day-to-day autonomy, the SGB contributes to broader societal goals of inclusion and accessibility. The project aligns with the Kingdom of Saudi Arabia's Vision 2030 initiatives, which emphasize empowering individuals with disabilities and expanding the availability of innovative, technology-driven solutions to support their full participation in society.

Keywords: *Navigation support, Real-time object detection, TensorFlow, Visually impaired assistance, Yolov5.*

1. Introduction

The ability to navigate safely and independently is crucial for visually impaired individuals, as it directly impacts their quality of life and autonomy. Globally, millions suffer from visual impairments, which often restrict their mobility and limit participation in various aspects of society, such as work, education, and community engagement [1]. While traditional aids like white canes and guide dogs have provided essential support, they are often insufficient for navigating complex environments, particularly urban and unfamiliar settings [2]. Furthermore, the advent of assistive technologies incorporating sensors and artificial intelligence (AI) has introduced new solutions; however, these technologies are frequently cost-prohibitive and inaccessible for many who would benefit from them [3].

Current solutions in assistive navigation primarily rely on costly hardware or complex setups, limiting their usability in real-world scenarios. For instance, IoT-enabled devices have shown promise in enhancing navigation but often require significant initial investment, maintenance, and technical expertise [4, 5]. Recent studies in deep learning and computer vision have enabled real-time object detection and feedback mechanisms tailored for visually impaired users, but accessibility remains a barrier due to the expense and hardware dependencies [6, 7]. Therefore, there is a pressing need for accessible, affordable, and user-friendly mobile applications that leverage these technologies to provide real-time obstacle detection and adaptive navigation feedback for the visually impaired.

History: Received: 18 August 2025; Revised: 27 August 2025; Accepted: 1 October 2025; Published: 16 December 2025
* Correspondence: lucia.gordon@naps.edu.au

The research problem addressed in this paper centers on the absence of affordable, effective mobile solutions that assist visually impaired individuals with real-time object detection and navigation in diverse environments. Many existing solutions lack the ability to dynamically adjust to varying surroundings, which reduces their practical utility for users navigating both familiar and unfamiliar spaces. This paper proposes a smartphone-based solution designed to deliver real-time object detection and navigation feedback through a multi-sensory approach, thereby providing an accessible, adaptable, and low-cost alternative to current assistive technologies [8-10].

This paper developed the Smart Guide for the Blind (SGB) application, designed to leverage widely accessible smartphone technology for real-time object detection and navigation assistance. The application utilizes advanced AI models, specifically TensorFlow and YOLOv5, to recognize objects within the user's environment and provide immediate auditory feedback and vibrations. This approach eliminates the need for additional hardware while maximizing accessibility and cost-effectiveness.

The primary contributions of this paper are as follows:

1. Affordable Assistive Solution: We propose a cost-effective application accessible on standard Android devices, making navigation aids available to visually impaired users without the financial burden associated with specialized equipment.
2. Real-Time Object Detection and Feedback: By implementing TensorFlow and YOLOv5 for real-time object detection, our application provides immediate feedback through audio alerts and vibrations, allowing users to navigate their surroundings safely and confidently.
3. User-Centered Design for Accessibility: SGB is tailored specifically for visually impaired users, ensuring that interface design, feedback mechanisms, and usability align with their needs. The simple and intuitive design supports ease of use across different age groups and levels of familiarity with technology.
4. Independence Enhancement: Our solution contributes to improved independence and quality of life for visually impaired individuals by reducing their reliance on physical assistance for mobility, thus supporting a more autonomous and empowered lifestyle.

This paper discusses the SGB's system architecture, AI model selection, implementation process, and rigorous testing phases. Through the SGB, we aim to demonstrate how accessible technology can positively impact the lives of visually impaired individuals, supporting the broader goals of inclusivity and equal opportunity.

2. Literature Review

Assistive technology for visually impaired individuals has advanced significantly through innovations in artificial intelligence (AI), the Internet of Things (IoT), and deep learning. The following review explores research on object detection, navigation, and multi-sensory feedback, which directly informs the development of the Smart Guide for the Blind (SGB) application.

Hareva et al. [5] developed a mobile surveillance siren against moving objects to aid visually impaired users in detecting moving objects through a smartphone camera [1]. This system is beneficial for navigating dynamic environments; however, it differs from SGB, which focuses on static obstacle detection in familiar settings. Hareva's work provided foundational insights into real-time detection and alert systems for mobile devices, contributing to SGB's object recognition design and user interface considerations.

The Let the Blind See device, created by Gupta et al. [7] integrates AI with IoT technology, using a Raspberry Pi and sensors to guide users through audio feedback in unfamiliar environments [2]. While effective, this device requires external hardware, differing from SGB's smartphone-based approach, which emphasizes accessibility and affordability. Gupta's study underscored the value of environmental adaptability in assistive devices, an aspect that SGB applies by optimizing object detection for familiar indoor settings.

Kuriakose et al. [3] introduced DeepNAVI, a smartphone application that utilizes deep learning for real-time obstacle detection [3]. By prioritizing portability and ease of use, DeepNAVI aligns closely

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 12: 658-668, 2025
DOI: 10.55214/2576-8484.v9i12.11472

with SGB's goal of providing efficient navigation on mobile devices. The efficient use of deep learning models in DeepNAVI influenced SGB's choice of TensorFlow and YOLOv5 to achieve real-time processing, with high accuracy and minimal setup.

Valipoor and De Antonio [9] conducted a comprehensive review of computer vision-driven scene understanding, outlining the capabilities and limitations of deep learning models for object detection [4]. Their work offers valuable insights into scene understanding, helping to refine SGB's object classification capabilities across various settings. By integrating advancements in computer vision, SGB aims to provide precise, real-time feedback on obstacles in the user's immediate environment.

Plikynas et al. [10] explored indoor-guided navigation for blind users through a crowdsourced approach, where volunteers map indoor routes for accessibility [5]. This approach enables extensive data collection for indoor environments. Although SGB focuses on real-time detection rather than pre-mapped routes, incorporating community-based data sharing could enhance SGB's adaptability in future versions by allowing users to access shared feedback about specific environments.

An IEEE study, Zhang et al. [11], presented IoT-enabled smart shoes that incorporate sensors for detecting environmental hazards, providing feedback through auditory and haptic cues [6]. This system's comprehensive feedback supports safer navigation, although it relies on specialized wearable technology. SGB provides similar real-time feedback via smartphone, without requiring additional equipment. This wearable study underscores the effectiveness of multi-sensory feedback, which SGB incorporates through both vibration and audio alerts.

Nasreen et al. [12] utilized Convolutional Neural Networks (CNNs) in an object detection system for visually impaired users, which combines YOLO with narration to provide real-time descriptions of identified objects [7]. This approach enhances situational awareness and informs SGB's use of TensorFlow for rapid, accurate object detection, ensuring that users receive immediate feedback on nearby obstacles.

The Blind Reader application by Mambu et al. [13] leverages augmented reality (AR) for object recognition, providing audio feedback on detected objects [8]. Although SGB employs AI instead of AR, the Blind Reader's use of auditory information and marker recognition influenced SGB's interface design, emphasizing ease of use and intuitive feedback.

Ali et al. [14] explored a multi-object detection approach combining IoT with AI to improve visually impaired users' situational awareness [9]. This system integrates laser sensors and TensorFlow-Lite for real-time detection and comprehensive guidance, highlighting the potential for combining multiple sensory inputs. Although SGB currently relies on smartphone detection, this approach suggests opportunities for future enhancements, such as integrating IoT-based proximity detection for complex environments.

Advances in real-time object detection have significantly impacted assistive technologies for visually impaired individuals. Recent systems incorporate deep learning to recognize objects in complex environments. For example, a study by Rahman [15] explored a real-time object detection system specifically for visually impaired users, demonstrating improved object recognition accuracy, which aids in identifying potential hazards in real time [15].

Compact computing platforms like Raspberry Pi have enabled accessible solutions for real-time object detection combined with voice feedback. Mukhiddinov and Cho [6] developed a real-time object recognition system with voice feedback on Raspberry Pi, which offers visually impaired users enhanced navigational support through an affordable setup Kim [16]. This economical approach inspired SGB's focus on mobile-based solutions, aiming to provide similar benefits without additional hardware.

AI-assisted navigation devices have extended beyond simple obstacle detection to include predictive capabilities. In their study, Kumar [17] examined an AI-based navigation aid that uses AI to guide visually impaired individuals through complex environments, providing them with adaptive support and enhanced spatial awareness [17]. The predictive AI features inspired similar adaptive feedback mechanisms in SGB.

IoT-enabled smart canes enhance navigation by integrating ultrasonic sensors for obstacle avoidance. Jackson [18] developed the Smart Blind Stick with IoT monitoring and real-time obstacle detection, ensuring user safety through continuous feedback [18]. Although SGB does not require additional devices, the multi-sensory approach to feedback in this study influenced SGB's integration of smartphone-based vibrations and auditory alerts.

A study by Chen [19] highlighted the use of 3D object recognition powered by deep learning to enhance spatial awareness in assistive technologies. The system provides multiple-angle detection of obstacles, enabling visually impaired individuals to navigate complex environments safely [19]. Although SGB focuses on 2D detection, it applies similar principles of robust object recognition.

Haptic and audio feedback are increasingly combined in wearable navigation aids to improve user responsiveness and spatial awareness. Alqurashi [20] investigated the effectiveness of haptic and audio integration in wearable devices, finding that multi-sensory cues significantly enhance user safety in complex settings [20]. SGB incorporates these findings by using vibration and audio feedback, creating a richer navigational experience for users.

Machine learning has proven valuable in assistive technologies for identifying objects in cluttered spaces. Liu [21] studied machine learning applications in visually impaired navigation, demonstrating improved accuracy and processing speed, essential for real-time applications [21]. SGB's object detection capabilities benefit from similar machine learning strategies, ensuring timely and accurate feedback in diverse settings.

These studies highlight the wide range of approaches in assistive navigation, including AI-driven object detection, IoT-enhanced smart canes, and wearable solutions with multi-sensory feedback. SGB builds on these advancements by combining real-time object detection, audio narration, and vibration alerts into a smartphone-based application, ultimately enhancing independence and navigational confidence for visually impaired users.

3. Proposed Solution

The Smart Guide for the Blind (SGB) application is an Android-based mobile solution that leverages real-time object detection to provide immediate and accessible navigation support for visually impaired users. The app is specifically designed to operate on widely available smartphones, eliminating the need for expensive, specialized equipment and making the solution both practical and affordable for a broad user base.

Here is a breakdown of the SGB's core components and features, highlighting how they contribute to overcoming the identified challenges.

1. Real-Time Object Detection with TensorFlow and YOLOv5: The SGB application uses TensorFlow and the YOLOv5 model for object detection, enabling efficient recognition of various objects within the user's immediate environment [22]. YOLOv5 is well-regarded for its speed and accuracy, making it a suitable choice for mobile devices where processing power and responsiveness are critical. The application accesses the smartphone's camera to capture and analyze the surroundings, identifying objects and relaying information to the user almost instantaneously. This setup allows users to receive real-time feedback about obstacles, ensuring they can adjust their path safely and quickly.

2. Multimodal Feedback System: To ensure effective communication with visually impaired users, the SGB application utilizes a multimodal feedback system comprising both audio cues and vibrations [23]. Upon detecting an object, the app provides an audio alert that specifies the object type, using text-to-speech technology to describe it clearly and understandably. Additionally, the application triggers a distinct vibration pattern for each detected obstacle, which reinforces the audio feedback and ensures that users receive notifications in real time. This multimodal approach is crucial for accommodating different user preferences and ensuring that users can continue navigating safely even in noisy environments.

3. User-Friendly Interface with Voice Commands: Accessibility is a primary design consideration for the SGB, which is why the app includes a voice-activated interface [23]. Users can open and

navigate the app using voice commands, allowing them to interact hands-free. Upon starting the application, users receive audio instructions to guide them through the setup and usage, ensuring a seamless experience. The interface itself is minimalistic and straightforward, designed to provide clear instructions with minimal visual clutter, which is essential for users with limited or no vision.

4. Personalized Object Detection and Distance Calculation: The SGB application offers a customized object detection experience tailored to environments familiar to the user. Rather than focusing solely on generic objects, the app allows users to set preferences for objects they commonly encounter, such as household items or specific landmarks [24]. The app measures and reports approximate distances to objects, allowing users to gauge proximity and navigate with greater precision.

5. Continuous Learning and Updates: The SGB leverages TensorFlow's capability for continuous updates, allowing it to incorporate new objects and improve recognition accuracy over time. This adaptability ensures that the application remains relevant as new objects or obstacles are encountered, making it a more sustainable tool for visually impaired users.

3.1. Solution Workflow

Upon opening the app, users are presented with an instructions interface that explains the app's features and basic use. Once permissions for the camera and audio are granted, the application activates the smartphone's camera to continuously scan the surroundings. Detected objects are instantly analyzed, identified, and communicated to the user through both audio descriptions and vibration signals.

The SGB application addresses key limitations of existing solutions by providing a portable, affordable, and reliable tool for visually impaired users. By focusing on real-time object detection, multimodal feedback, and continuous adaptability, the proposed solution offers a comprehensive assistive tool that enhances user independence and confidence in navigating various environments. Through these features, the SGB not only bridges current accessibility gaps but also aligns with broader inclusivity goals, making a significant contribution to the field of assistive technology.

3.2. System Analysis and Design

The Mart Guide for the Blind (SGB) application was developed using a structured approach to system analysis and design, ensuring that all functional and non-functional requirements are met and that the system operates effectively for visually impaired users. This section details the analytical approach and the design models used, including use case, data flow, entity-relationship, and sequence diagrams. Each model demonstrates how the SGB system interacts with users and processes data to achieve real-time object detection and feedback.

3.2.1. Functional Flow

1. User Interaction: The user initiates the app, which provides on-screen instructions and requests permissions.
2. Environment Scanning: Once permissions are granted, the app begins real-time scanning through the camera, capturing live data from the user's surroundings.
3. Object Detection: Captured images are processed using deep learning models to identify objects within proximity to the user.
4. Feedback Mechanism: For each detected object, the app provides instant audio feedback and vibration notifications, helping the user avoid obstacles.
5. Session Management: The user can end the session at any point, pausing all detection processes until reactivated.

3.2.2. Use Case Diagram

The Use Case Diagram as illustrated in Figure 1, shows the interactions between the user and the SGB system, demonstrating how various user needs are met by different functionalities of the application [25].

Actors:

- Primarily a visually impaired person who interacts with the application.

Use Cases:

- Open application: The user initiates the SGB app through voice commands or touch.
- Grant Permissions: The app requests permissions to access the camera and microphone.
- Real-Time Object Detection: The application uses the camera to detect objects in the user's environment.
- Provide Feedback: The application provides audio and vibration feedback based on detected objects.

In the diagram, each use case is connected to the user, showing a simple flow from opening the application to receiving feedback, representing the core functionalities of the system.

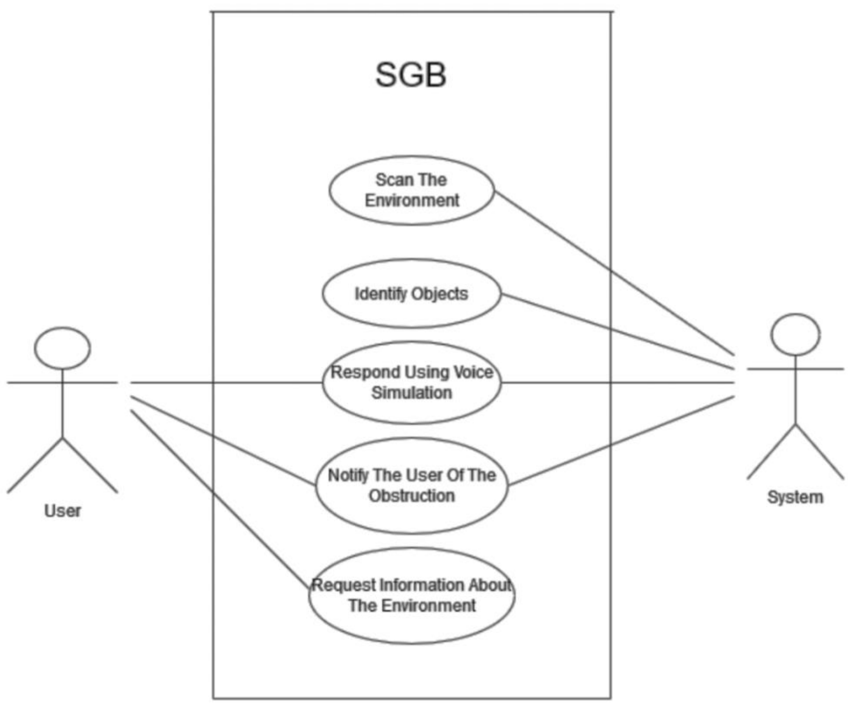

Figure 1.
Use Case Diagram of SGB.

3.2.3. Data Flow Diagram (DFD)

The Data Flow Diagram (DFD), as shown in Figure 2, provides an overview of how data is processed and transferred through the system, capturing the flow of information between the user, the application, and the environment [26].

Levels of DFD:

- Level 0 (Context Diagram): Shows the user's interaction with the SGB app as a single process.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 12: 658-668, 2025
DOI: 10.55214/2576-8484.v9i12.11472

- Level 1: Expands on the internal processes of the app, including Capture Environment Data, Process Data with Object Detection, and Provide Feedback, which is shown in Figure 2.

Data Flow Components:

- Input: Camera data captured by the smartphone.
- Processing: Image data is processed by the TensorFlow and YOLOv5 models for object detection.
- Output: Audio notifications and vibrations are sent to the user about the detected objects.

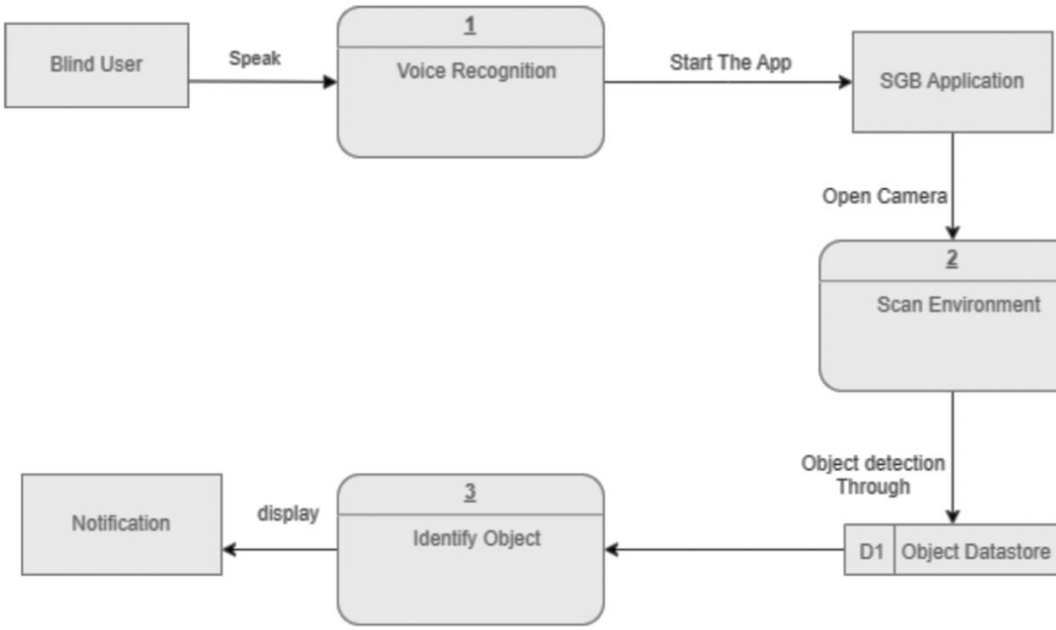

Figure 2.
Data Flow Diagram of SGB.

3.2.4. Sequence Diagram

The sequence diagram visually represents the sequence of actions taken when the user interacts with the app, from launching it to receiving feedback, as illustrated in Figure 3 [27].

Steps:

- Launch Application: The user initiates the application.
- Request Permissions: The app requests necessary permissions, such as access to the camera.
- Capture Environment: The camera captures images of the surrounding environment.
- Process Object Detection: The captured data is analyzed using TensorFlow and YOLOv5 models to identify objects.
- Generate Feedback: Based on the detected objects, the system provides feedback in the form of audio alerts and vibrations.
- End Session: The user ends the session, and the app stops capturing data.

The sequence diagram emphasizes the application's interaction flow, demonstrating how each component is activated in a step-by-step manner, ensuring seamless functionality and user experience.

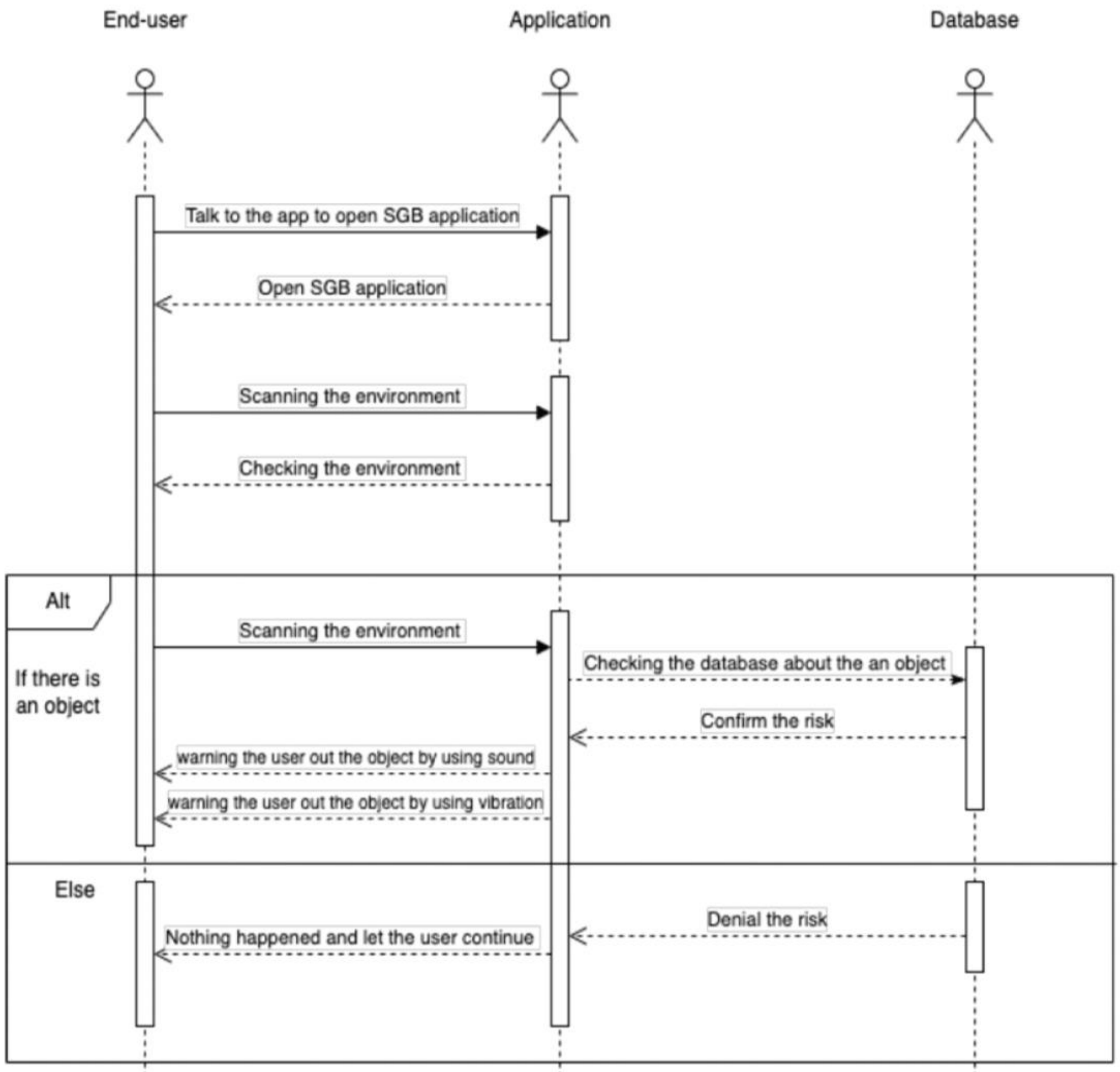

Figure 3.
Sequence diagram of SGB.

4. Implementation

The Smart Guide for the Blind (SGB) application was implemented as an Android-based mobile solution aimed at providing visually impaired users with real-time object detection and navigation assistance. The development process involved several key components:

1. Development Tools and Frameworks: The application was built using React Native for its cross-platform capabilities, with Expo Go used to streamline the development process and Visual Studio Code as the primary coding environment. These tools enabled efficient application design and coding, ensuring compatibility with Android devices.

2. Object Detection: SGB utilizes TensorFlow and YOLOv5 for real-time object detection. YOLOv5 was selected over other models due to its balance of accuracy and performance, making it suitable for mobile environments with limited processing power. This setup allows the app to recognize objects in the user's environment almost instantaneously, offering timely alerts.
3. Interface Design and User Interaction: The SGB includes several interfaces:
- Instructions Interface: Provides initial setup guidance through text-to-speech instructions.
- Permission Interface: Requests necessary camera permissions for object detection functionality.
- Environment Scanning Interface: Activates the camera for continuous scanning, providing feedback to users through vibration and audio alerts.
4. Testing and Evaluation: The team implemented various test cases to evaluate the application's functionality and ensure user satisfaction. Tests focused on interface instructions, permission granting, and real-time object scanning. Based on test outcomes, adjustments were made, including the transition from Coco-SSD to YOLOv5 for improved performance.
5. Adaptability and Future Enhancements: SGB's architecture was designed to allow continuous updates and potential expansions, including the integration of new objects for detection and support for additional languages to enhance accessibility.

This implementation approach makes SGB a practical, cost-effective tool aligned with the Kingdom's Vision 2030 for inclusivity, offering visually impaired users greater independence and confidence in navigating their surroundings.

5. Conclusion

In conclusion, the Smart Guide for the Blind (SGB) project successfully developed a mobile application tailored to the needs of visually impaired users. By leveraging real-time object detection with advanced AI models like TensorFlow and YOLOv5, the application provides immediate and accurate environmental feedback.

Through its multimodal feedback system, combining audio cues and vibrations the SGB ensures effective communication that enhances the user's situational awareness and safety during navigation.

This project fills a critical gap by offering an affordable, accessible solution that does not require specialized equipment, thus making it widely available for those who may lack the financial resources for traditional assistive technologies.

The alignment of the SGB project with Vision 2030's inclusivity goals underscores its potential to contribute significantly to the lives of visually impaired individuals, promoting independence and safety in daily activities.

Future enhancements, such as cross-platform support, multilingual features, and integration with wearable technology, will further expand the application's usability and relevance.

Overall, SGB represents a meaningful advancement in assistive technology, with the potential for continued impact as it evolves based on user feedback and technological advancements.

Funding:

The authors extend their appreciation to the King Salman Center for Disability Research for funding this work through Research Group no. KSRG-2024-407.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

References

[1] M. D. Crossland, "The white cane: Present, past, and future," *British Journal of Visual Impairment*, vol. 37, no. 1, pp. 58–66, 2019.

[2] A. Brilhault, "Exploring sensor-based technology to improve independence for visually impaired people," *Sensors*, vol. 19, no. 8, p. 1806, 2019.

[3] B. Kuriakose, R. Shrestha, and F. E. Sandnes, "DeepNAVI: A deep learning based smartphone navigation assistant for people with visual impairments," *Expert Systems with Applications*, vol. 212, p. 118720, 2023. https://doi.org/10.1016/j.eswa.2022.118720

[4] J. A. Chacón, "Wearable technology in assistive devices for people with visual impairments: A review," *IEEE Access*, vol. 8, pp. 192438–192460, 2020.

[5] D. H. Hareva, A. Sebastian, A. R. Mitra, I. A. Lazarusli, and C. A. Haryani, "Mobile surveillance siren against moving objects as a support system for blind people," *Journal of Image and Graphics*, vol. 11, no. 2, pp. 170–177, 2023. https://doi.org/10.18178/joig.11.2.170-177

[6] M. Mukhiddinov and J. Cho, "Smart glass system using deep learning for the blind and visually impaired," *Electronics*, vol. 10, no. 22, p. 2756, 2021. https://doi.org/10.3390/electronics10222756

[7] P. Gupta, M. Shukla, N. Arya, U. Singh, and K. Mishra, *Let the blind see: an AIIoT-based device for real-time object recognition with the voice conversion. In Machine Learning for Critical Internet of Medical Things: Applications and Use Cases.* Cham: Springer International Publishing, 2022.

[8] V. Ayyalusami, "VLC-driven indoor positioning system for the visually impaired," *IEEE Access*, vol. 9, pp. 30456–30466, 2021.

[9] M. M. Valipoor and A. De Antonio, "Recent trends in computer vision-driven scene understanding for VI/blind users: A systematic mapping," *Universal Access in the Information Society*, vol. 22, no. 3, pp. 983-1005, 2023. https://doi.org/10.1007/s10209-022-00868-w

[10] D. Plikynas, A. Indriulionis, A. Laukaitis, and L. Sakalauskas, "Indoor-guided navigation for people who are blind: Crowdsourcing for route mapping and assistance," *Applied Sciences*, vol. 12, no. 1, p. 523, 2022. https://doi.org/10.3390/app12010523

[11] Y. Zhang, X. Li, and H. Chen, "IoT-enabled smart shoes for visually impaired navigation: Sensor-based environmental hazard detection and feedback," *IEEE Internet of Things Journal*, vol. 9, no. 15, pp. 13456–13467, 2022.

[12] S. Nasreen, A. Khan, and S. Ahmed, "Real-time object detection and narration system for visually impaired individuals using YOLO and CNN," *International Journal of Advanced Computer Science and Applications*, vol. 10, no. 7, pp. 345–353, 2019.

[13] L. Mambu, A. Oumer, and J. Smith, "Blind Reader: An augmented reality application for object recognition and audio feedback for visually impaired users," *Journal of Assistive Technologies*, vol. 13, no. 4, pp. 210–223, 2019.

[14] S. Ali, T. Khan, R. Hussain, and N. Ahmad, "Efficient multi-object detection and smart navigation using artificial intelligence for visually impaired people," *Sensors*, vol. 23, no. 4, p. 812, 2023.

[15] M. Rahman, "Real-time object detection system for visually impaired navigation," in *Proceedings of the IEEE International Conference on Computer Vision and Pattern Recognition Workshops (CVPRW)*, 2023.

[16] H. Kim, "Real-time object recognition with voice feedback for visually impaired based on Raspberry Pi," in *Proceedings of the IEEE International Conference on Artificial Intelligence and Computer Engineering (ICAICE)*, 2023.

[17] A. Kumar, "AI-based navigation aid for complex environments," *IEEE Transactions on Human-Machine Systems*, 2023.

[18] T. Jackson, "A smart blind stick with object detection, obstacle avoidance, and IoT monitoring," presented at the IEEE Conference Publication, 2023.

[19] X. Chen, "Real-time 3D object detection, recognition and presentation using a mobile device for assistive navigation," *SN Computer Science*, vol. 4, no. 1, p. Article 181, 2023.

[20] A. Alqurashi, "Haptic and audio integration for wearable navigation aids in complex environments," *IEEE Access*, vol. 10, pp. 27843–27856, 2022.

[21] Z. Liu, "Machine learning for object recognition in assistive devices for visually impaired navigation," *IEEE Transactions on Neural Networks and Learning Systems*, vol. 33, no. 5, pp. 2518–2531, 2022.

[22] A. Patil, S. Jadhav, and N. Kumar, "Real-time object detection system for visually impaired navigation," *Applied Soft Computing*, vol. 154, p. 107859, 2024.

[23] X. Zhu, L. Wang, Y. Chen, and M. Zhang, "Advanced object detection for enhanced navigation in assistive devices," *Applied Acoustics*, vol. 215, p. 109876, 2024.

[24] F. Yang, H. Liu, X. Zhao, and Y. Wang, "Enhanced obstacle detection and navigation system for visually impaired individuals using deep learning techniques," *Global Transitions*, vol. 4, pp. 110–118, 2022.

[25] M. Elhoseny, K. Shankar, and B. B. Gupta, "Deep learning-based navigation support for visually impaired people," *Procedia Computer Science*, vol. 235, pp. 1657–1664, 2024.

[26] I. H. Witten and E. Frank, "Using conceptual clustering to find patterns in the World Wide Web," *Journal of Network and Computer Applications*, vol. 14, no. 3, pp. 173–186, 1991.

[27] O. Tuysuz and M. Alci, "Design of a real-time object detection system for visually impaired individuals," in *Proceedings of the IEEE International Conference on Image Processing*, 2004.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 12: 658-668, 2025
DOI: 10.55214/2576-8484.v9i12.11472