JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

INTELLIGENT NAVIGATION APP FOR THE VISUALLY IMPAIRED: A SMARTPHONE-BASED ASSISTIVE TECHNOLOGY

Dr. B. SRINIVASA RAO, PROFESSOR, Department of CSE, TEEGALA KRISHNA REDDY ENGINEERING COLLEGE, Hyderabad – 500097
BOBBILI DISSHAA, B.Tech Student, Department of CSE, TEEGALA KRISHNA REDDY ENGINEERING COLLEGE, Hyderabad – 500097
B. SAHITHI, B.Tech Student, Department of CSE, TEEGALA KRISHNA REDDY ENGINEERING COLLEGE, Hyderabad – 500097
ALAMPALLY RAMYA, B.Tech Student, Department of CSE, TEEGALA KRISHNA REDDY ENGINEERING COLLEGE, Hyderabad – 500097.

Abstract

The World Health Organization (WHO) suggests that, more than 2 billion individuals globally face vision related challenges in varying degrees of severity; out of which 295 million individuals encounter vision impairments. Navigating through the world around them is a significant challenge for them and there is a critical need for tools that aid in improved mobility and provide spatial awareness, safety, and independence for this community. Although traditional assistive technologies like guide dogs, electronic travel aids, and GPS-based solutions offer valuable support, they lack dynamic, real-time spatial awareness. Our "Intelligent Navigation App" proposed in this paper, harnesses the power of smartphones and AI to provide a reliable, cost-effective, comprehensive and user-friendly solution for those with visual impairments. It uses the capabilities of TensorFlow Lite to detect obstacles and hazards and Google ARCore's spatial mapping and depth detection capabilities to provide real time feedback using intuitive audio cues and haptic feedback describing the nature and distance of detected objects, empowering the users to confidently and safely navigate both indoors and outdoors.

1. INTRODUCTION

1.1 Motivation

The difficulties that people with visual impairments encounter are numerous and severe. and go well beyond the mere act of mobility Over 295 million individuals worldwide suffer from mild to severe visual impairment, and over 2 billion people have some form of visual impairment, according to WHO data.

Visual loss has been linked to considerable and well-established impediments to education, employment, and social engagement. Adults with severe visual impairments have high unemployment rates, and children with these problems are frequently excluded from educational institutions. These problems not only restrict individual freedom but also feed a larger cycle of injustice, highlighting the pressing need for creative solutions that could improve safety, independence, and spatial awareness. To solve these challenges, there is an urgent need for tools that

connec t the gap between existing assistive technology and the dynamic, real-time needs of those with visual impairments.

The assistive technology scene has altered dramatically in recent years, owing largely to the rapid increase of mobile computer capability. Mobile phones used to be, for talking to people. Now they are like mini computers that can run all kinds of cool apps that make life easier to manage and navigate through different tasks. The latest technologies, like computer vision and AI are getting added into these gadgets at a pace which could really change the way impaired folks move around and interact with the world around them. When these tools work together seamlessly they can offer individuals personalized insights into their surroundings and helps them navigate their surroundings and vastly improve the quality of their life.

Compared to more conventional mobility aids like guide dogs or white canes, which are useful but constrained by their static, one-dimensional capabilities, this combination of AI and spatial mapping technology marks a substantial advancement. Whereas a cane only signals the presence of an obstacle in direct contact, and a guide dog's training is limited to specific tasks, smartphone-based solutions provide a much more dynamic, comprehensive awareness of one's environment.

1.2 Objective

The recommended Intelligent Navigating App transforms a smartphone into an excellent real-time navigating assistance by detecting barriers' size, shape, and distance in addition to their position. It incorporates object identification, depth estimations, and intuitive feedback mechanisms like haptic feedback and auditory cues to offer a more profound and user-friendly navigation experience.

These solutions are both scalable and economical because of the versatility of mobile phones, which are already possessed by millions of people. By utilising existing infrastructure, these technologies offer a global solution without requiring expensive equipment or specialist training. They can operate without continuous internet connectivity by leveraging edge computing to perform all of the computations on the device itself and are therefore useful in a variety of settings ranging from busy city streets to isolated rural areas.

By using smartphone technology and cutting edge artificial intelligence algorithms, the "Intelligent Navigation App" assists individuals with impairments, in bridging the gap in mobility and enables them to move around with confidence indoors and outdoors.

2. LITERATURE REVIEW

The development and progression of assistive technology used by the blind and the visually impaired is truly inspiring and a good example of human creativity and fight with accessibility. Whether it is the physical world of Braille, or the virtual one of screen readers and voice assistants and other mobility aids, every new development has represented a huge leap forward. But the work these tools do, while great, is still no substitute for the more nuanced, real-time spatial awareness that many visually impaired people want. In recent years, there has been significant progress in enhancing the mobility and independence of individuals with visual impairments. We will review some of these existing tools and technologies in this literature survey.

1. Katz et al. (2012). Wearable Tactile Navigation System for the Visually Impaired. IEEE Transactions on Neural Systems and Rehabilitation Engineering: The authors proposed a wearable device that will provide visually impaired users with tactile feedback to alert them of nearby potential obstacles. The device was intended to supplement traditional tools like white canes. Also, it was useful only if you had a wearable device.

2. Maharana et al. (2018). Services and Applications of Engineering and Navigation Assistance for Visually Impaired Using Smartphones. Proceedings of IEEE International Conference on Mobile Services: This research paper proposed a low-cost navigation assistance system by using smartphones augmented with built-in GPS for location-oriented support. The system was GPS-reliant and allowed neither real-time obstacle avoidance nor depth sensing; consequently, it was limited to outdoor navigation.

3. Patel, W. (2023). Review on LiDAR-Based Navigation Systems for the Visually Impaired: This

article evaluates LiDAR-based systems that map the user's surroundings using light detection. These devices help visually impaired people navigate by offering detailed obstacle detection and environmental mapping. The high cost and the need for specialised hardware make these solutions less accessible.

4. Arxiv Research, 2023, SLAM for Visually Impaired Navigation: A Systematic Literature Review: This study looked at the application of Simultaneous Localisation and Mapping (SLAM) technologies for real-time environmental mapping by visually impaired people. These give great accuracy in obstacle recognition and spatial awareness, but are often computationally demanding, making them unsuitable for smartphone-based applications.

5. MDPI Review, 2024, Advances in Smart Assistive Navigation Systems: In this research, the effectiveness of different available assistive technologies for the visually impaired is evaluated, including orientation aids, position locators, and travel aids. It also examines AI and IoT in enhancing navigation-related technologies. Most of these systems rely on infrastructure of sophisticated complexity making them less portable and less economical.

It is evident from the study of existing literature and systems that there is a pressing need for tools or aids for the visually impaired which are cost effective and user friendly and also do not require the use of complex systems or are computationally intensive. Smart phone based applications offer a cheaper and intuitive alternative to these due to their ubiquity, availability of a range of sensors and processing capabilities and ability to employ latest image processing techniques and machine learning and AI technologies.

3. PROPOSED SYSTEM

The new system called the "Intelligent Navigation App" is a smartphone application designed to enhance the freedom and autonomy of individuals, with impairments by combining real time object recognition technology with depth perception and various input modes (sound and touch). It is an innovative tool that enables navigation and obstacle detection in outdoor environments and uses a modular framework that supports scalability and quick operation. The system uses generally accessible smartphone technology and machine learning models for obstacle identification, resulting in a low-cost, scalable solution that does not require any additional equipment and also works in offline mode.

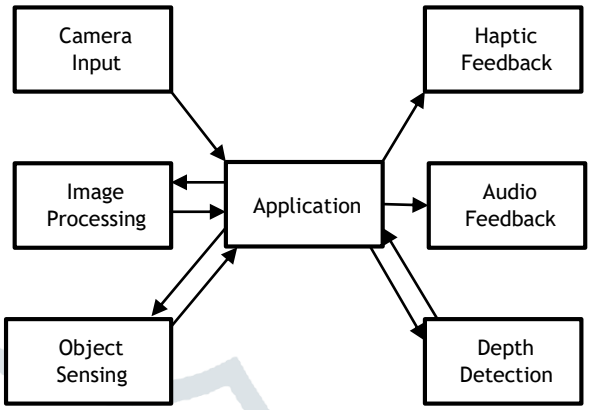

Fig 3.1: System Architecture of Proposed System

3.1 Camera Module

The app's core component, the camera module, handles real-time video capturing using the CameraX library. This module is designed to easily adjust to changing lighting conditions, resulting in consistent performance in a range of settings. The app has a low-light recognition mechanism that leverages CameraX's built-in low-light mode when necessary, as well as automatic exposure and focus adjustments to ensure clear and consistent image quality. It also activates the phone's flash to improve vision in extremely low-light settings.

The video feed from the camera is preprocessed using OpenCV, a popular computer vision library which prepares it for analysis by optimising the data for the Object Detection module. This preprocessing guarantees that the subsequent modules receive clean and well-structured input, which improves the accuracy and efficiency of the system's analysis pipeline.

3.2 Object Detection Module

The Object Detection module, the app's primary component, is responsible for the majority of its functionality. The module provides users with actionable data for safe and informed navigation by detecting things and obstacles such as furniture, vehicles, and pedestrians in real time. The app uses

speech recognition to listen for commands from the user to start/stop object detection.

The app makes use of TensorFlow Lite, a lightweight and extremely efficient machine learning framework that allows the module to run pre-trained machine learning models even on mobile devices with limited processing capacity. This architecture is extremely important since it allows the system to function properly offline, eliminating the need for constant internet connectivity. Users may rely on the module to provide fast and accurate insights regardless of their location or network connection ensuring uninterrupted operation.

The application requires an object detection model that is fast, accurate, operates under various obstacles, and in different environments with varied conditions and can work offline. Some pre-trained open-source Tensor Flow object detection models include: SSD, which is very fast; Faster R-CNN, which is very precise; YOLO, for quick inference; and RetinaNet, which is designed for class imbalance. However, the best choice is EfficientDet, which integrates the light-weight EfficientNet backbone, compound scaling, optimizing depth, width, and resolution so that it can be well-achieved without the overburdening system resources and with minimum latency, making it a perfect choice for building a responsive high-performance navigational tool for the visually impaired.

EfficientDet's performance is improved by using a BiFPN (Bidirectional Feature Pyramid Network), which processes features at various scales to detect objects of varying sizes and distances. This structure enables the model to focus on both fine details and broader settings, making it useful for detecting both adjacent and distant threats. The Weighted feature fusion optimises this process by dynamically prioritising the most critical features thereby ensuring accuracy without losing processing performance.

The module is intended to highlight the most important navigational elements and obstructions. Filtering out less important information reduces cognitive strain and ensures that consumers only receive key insights. The Object Detection Module's combination of offline operability, real-time detection and efficient architecture makes it a reliable tool for increasing users' situational awareness.

3.3 Depth Perception Module

The Depth Perception Module generates detailed depth maps of the user's surroundings with Google ARCore. The app creates depth maps by combining Google ARCore's advanced spatial tracking algorithms with spatial data captured by the camera. By doing this the system is able to recognise the relative locations and distances of objects in real time and develop a three-dimensional understanding of the surroundings.

This module's main job is to determine precise distances to items it has spotted, which aids the app in distinguishing between obstacles that are farther away and nearer dangers. For example, it can recognise a door at the end of a hallway or a chair a few paces ahead. This form of depth awareness is essential for activities like notifying users of things within a specified range or emphasising safe navigation paths. By understanding the spatial relationships between various entities, the system can present users with more significant and valuable data.

The depth-sensing features of ARCore allow the module to dynamically react to the user's motions. The module is constantly adjusting the depth map to accommodate for changes in perspective as the user moves about. This ensures that even if obstacles or routes change while the user is travelling, the app will continue to provide dependable and consistent assistance.

By combining precise depth analysis with object detection, the Depth Perception Module gives users a clear understanding of how objects are positioned relative to them. This ensures that users are aware of their location and surroundings, enabling them to make informed and self-assured decisions in real time.

3.4 Feedback Module

Feedback is an important aspect of the app since it helps users understand their environment using two basic but powerful systems: audio and haptic feedback. This system turns detection data into spoken messages that inform users about objects and their distances. The messages are intended to be concise and straightforward, ensuring that users receive the information they require without feeling

overwhelmed. For example, the system may state, "Table at five feet" or "Car at two feet."

This system uses haptic feedback to alert users about potential hazards in their surroundings. Specific risks are communicated using various vibration patterns and intensities. For example, a loud vibration could signify a nearby obstruction, whereas a milder one could indicate a potential threat further away. This technique is especially useful in noisy locations or for people who have difficulties hearing, as it provides an alternate means to remain aware of their surroundings.

By combining these two approaches, the app gives clear and consistent feedback, allowing users to navigate securely and confidently in a variety of circumstances.

4. METHODOLOGY

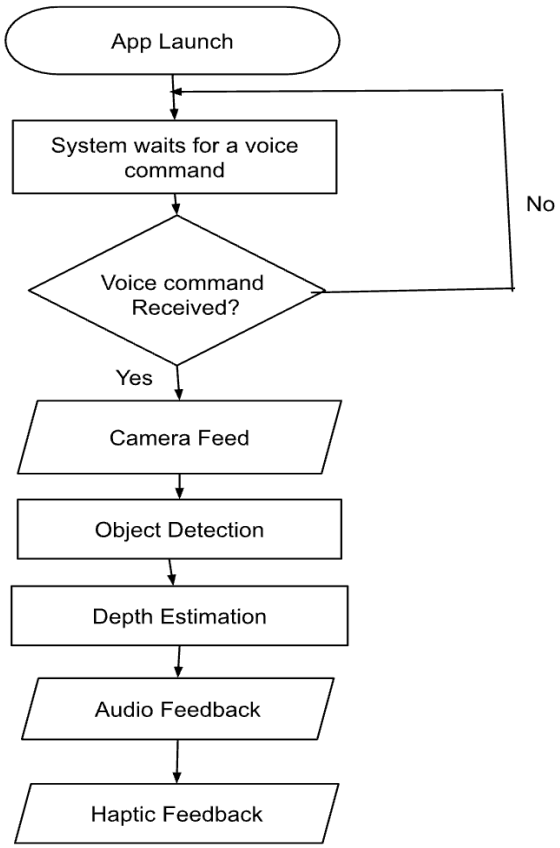

Fig 4.1: Flow Chart

STEP-1: When the app is launched it presents the camera feed in the home screen and waits for the user voice input using the android speech recognition API.

STEP-2: When the start command is given the object detection module is enabled and it analyses the camera feed to detect obstacles ahead of the user.

STEP-3: When the device recognizes objects or barriers it utilizes Google ARCore to create depth maps and calculate the estimated distance of the obstacle from the user.

STEP-4: The app informs the user of any obstacles detected and their respective distances using Android's Text to Speech API and Android's Haptic Feedback API.

STEP-5: When the stop signal is recognized, the obstacle detection. The application goes back, to listening for input, from the user's voice.

5. IMPLEMENTATION

Hardware Requirements

Hardware found in the Smart Navigation App consists of an Android smartphone together with a high-resolution rear camera, additionally, the phone's speaker and vibrating motor. The rear camera would be capturing live video images and this helps it in the recognition of objects and estimation of depth. Autofocus would be required to capture precise images of obstructions. The smartphone's built-in speaker is used for voice feedback with Text-to-Speech (TTS) whereas the vibrating motor gives haptic feedback to alert users to obstructions.

Software Requirements

The software components of the Intelligent Navigation App are crucial to processing the camera data and identifying the existence of any obstructions. It also estimates the depth and provides feedback. They work together in unison to form an accurate and efficient guide in navigation. The development tool used is Android Studio and the Android SDK in Kotlin, the app also uses several APIs and libraries.

The android library, CameraX, is used to improve upon the built-in camera functionality including noise reduction, adjusting the focus and the exposure, and also ensuring performance in low-light conditions.

TensorFlow Lite, an open source machine learning framework, implements the pre-trained EfficientDet

object detection model to detect obstacles in real time from video streams. Google ARCore uses Depth API to measure distances between detected objects so it can avoid obstacles. OpenCV is added for more advanced image processing operations, like object detection and depth sensing. Using the Android TTS API, real-time audio feedback provides information on impairments and their proximity. The Haptic Feedback API issues vibration alerts based on proximity to the obstacle for haptic notification of consumers. Other voice commands like "start detection" and "stop detection" use Android's speech recognition abilities to provide for hands-free control of applications.

6. RESULTS

Fig 6.1

Fig 6.2

Fig 6.3

During testing, the Intelligent Navigation App performed well in various scenarios and effectively identified and categorized common obstacles such as vehicles, trees, people, and stairs with minimal delay, even in difficult environments like busy streets and poorly lit rooms. It consistently delivered accurate proximity measurements using the ARCore Depth API, detecting objects within a range of 5 to 10 meters with a low error margin. Real-time depth calculations were reliable across different lighting conditions, including low light and night-time settings. Clear

audio prompts, along with effective vibration alerts, improved user understanding and confidence. The app successfully executed voice commands like "start detection" and "stop detection" with a 95% success rate. Feedback from visually impaired users during testing highlighted the app's ability to greatly enhance navigation and foster independence, making it a promising solution in the realm of assistive technology.

7. FUTURE SCOPE

Future scope of the intelligent navigation app would encapsulate enhanced object detection through AI to identify more obstacles, better real-time situational awareness through traffic sign recognition, and personal adaptive feedback depending on user habits and preferences. The app can also function as a personal feedback system by adapting to the individual walking patterns of the user through the personalized adapting feature. Location awareness from GPS and incorporation into the mapping platform will enable seamless merging of indoor mapping with outdoor navigation. Voice activation and advanced speech recognition promote passive control during motion. Linguistic and cultural enhancements will attract many other users-for instance, those who cannot speak a single word of English. To reach its full potential really means creating an extremely personal, inclusive, and intuitive navigational experience for visually impaired users.

8. CONCLUSION

The Intelligent Navigation app provides visually impaired people with a dependable way of navigation through their surroundings. Modern technologies like TensorFlow Lite to identify objects and Google ARCore's Depth API for proximity sensing are used by this app along with Android's Text-to-Speech (TTS) and Haptic Feedback API to support quick feedback. This combination helps users stay aware of their surroundings and navigate with confidence.

The app’s modular design incorporates essential components such as Camera Input, Object Detection, Depth Perception, Audio Feedback, Haptic Feedback, and Control Modules, ensuring that it can be easily updated and scaled as new technologies emerge. Each part of the app is carefully designed to be reliable and easy to use, offering both visual and non-visual cues to guide users safely through different spaces.

The application is designed with accessibility at its core. The app has been optimized to ensure optimal performance on mobile devices, using lightweight object detection models that minimize delay in real-time processing of feedback.

The Intelligent Navigation App allows visually impaired to move around their environment more safely and securely. Combining AI with accessibility skills in a practical, user-friendly package improves users’ quality of life while also making public and private spaces more inclusive and accessible.

References

[1] Katz et al. (2012). Wearable Tactile Navigation System for the Visually Impaired. IEEE Transactions on Neural Systems and Rehabilitation Engineering.

[2] Maharana et al. (2018). Navigation Assistance for Visually Impaired Using Smartphones. Proceedings of IEEE International Conference on Mobile Services.

[3] Bhowmick & Hazarika (2017). An Insight into Assistive Technology for the Visually Impaired and Blind People. Journal on Multimodal User Interfaces.

[4] Preece et al. (2017). Designing Audio and Haptic Feedback for Wearable Navigation Aids. Journal of Assistive Technologies.

[5] Patel, W. (2023). Review on LiDAR-Based Navigation Systems for the Visually Impaired.

[6] Okolo, G. I., Althobaiti, T., & Ramzan, N. (2024). Assistive Systems for Visually Impaired Persons: Challenges and Opportunities for Navigation Assistance. Sensors.

[7] Arxiv Research (2023). SLAM for Visually Impaired Navigation: A Systematic Literature Review.

[8] MDPI Review (2024). Advances in Smart Assistive Navigation Systems.

[9] IEEE Xplore (2024). Assistive Navigation System for Visually Impaired and Blind People: A Review.

[10] "Assistive Technology for Visually Impaired and Blind People" by R. M. McDonnough

[11] "Designing and Developing Assistive Technology for People with Disabilities" by Nermin U. O'Connor