VisionAid: Assistive Device for the Visually Impaired

Gajanan M. Gambhaire
Vishwakarma Institute of Technology
Pune, India
gajanan.gambhire@vit.edu

Samruddhi D. Khilari
Vishwakarma Institute of Technology
Pune, India
samruddhi.khilari24@vit.edu

Aarya S. Sadawrate
Vishwakarma Institute of Technology
Pune, India
aarya.sadawrate24@vit.edu

Rutuja G. Varpe
Vishwakarma Institute of Technology
Pune, India
rutuja.varpe24@vit.edu

Aman A. Shaikh
Vishwakarma Institute of Technology
Pune, India
aman.shaikh24@vit.edu

Rajvardhan A. Desai
Vishwakarma Institute of Technology
Pune, India
rajvardhan.desai24@vit.edu

Praveen V. Pol
Vishwakarma Institute of Technology
Pune, India
praveen.pol@vit.edu

***Abstract-* For many people who are visually impaired, getting around safely and independently can still be difficult. VisionAid is a smart assistive device designed to make movement easier and safer. It uses a microcontroller, ultrasonic sensors, and a camera to detect obstacles and recognize objects in the surroundings. The system gives real-time feedback using either sound or vibrations, so the user knows what's ahead. It also runs lightweight machine learning models that work even without the internet, making it reliable in any setting. VisionAid Pro is compact, affordable, and simple to use — built to help users move with more confidence and freedom in their daily lives.**

***Keywords*—currency recognition, object detection, smart spectacles**

I. Introduction

Blindness continues to be a major global health challenge, affecting over 39 million people worldwide [1], with more than 246 million others facing severe vision impairment. In India alone, around 9.2 million individuals live with blindness, representing nearly 20% [2] of the global blind population. Data from the National Programme for Control of Blindness and Visual Impairment NPCBVI shows that most of these individuals come from economically weaker communities. A report by the Jyothirgamaya Foundation, an NGO working to empower the blind in India, notes that nearly 75% [3] of blind people in underserved areas still rely on traditional tools like white canes or human assistance. These aids, while helpful, fall short in detecting obstacles that are far away or elevated and cannot interpret dynamic or crowded environments.

With recent advancements in assistive devices, wearable tech and embedded systems, there's a growing opportunity to develop smart, affordable, and user-friendly assistive devices. However, many of the current smart solutions either lack real-time awareness of surroundings or are too bulky, costly, or complex for everyday use. Additionally, many such systems rely on cloud processing, which can introduce delays, raise privacy concerns, and limit accessibility in areas without stable internet.

In response to these challenges, VisionAid is introduced as a smart assistive device designed to help visually impaired individuals navigate more safely and independently.

It brings together a compact microcontroller, ultrasonic sensors, and a camera module to handle obstacle detection and object recognition. By using efficient, on-device machine learning models, the system works in real-time, even without internet connectivity.

The user experience is carefully designed with accessibility in mind. Notifications are delivered through gentle vibrations or audio messages, depending on the user's preference. These messages can be conveyed through bone conduction headphones or a small speaker, ensuring that users remain aware of surrounding sounds, an essential aspect of safe navigation for the blind.

What sets VisionAid apart is its multi-functional approach and affordability. While many existing products offer just one feature, like either obstacle detection or navigation, this system combines both in a single unit. It helps users avoid obstacles while also providing environmental context through smart alerts and object identification.

The broader aim of VisionAid goes beyond building a functional prototype. It's about creating inclusive technology that can make a real difference in people's lives. Built to be scalable, the system is open to future upgrades like GPS-based navigation, voice commands, and smart city integrations. Through real-world testing and continuous improvements, VisionAid aspires to be a trusted aid for visually impaired individuals, empowering them to move independently, confidently, and safely.

I. Literature Survey

To study the existing literature and technological solutions for assisting the visually impaired, we conducted reviews using keywords such as "assistive smart glasses for the blind", "navigation aids for the visually impaired", "object detection for blind users" and "wearable devices for visual impairment" on platforms like Google Scholar, IEEE Xplore, and ResearchGate. From the search results, we shortlisted 30 open-access research papers. These papers, published between 2010 and 2024, were analyzed based on key parameters such as study objectives, hardware components, software tools and models, features provided, and limitations. This structured evaluation helped in identifying technological trends, recurring challenges, and gaps in affordability and real-time functionality, thereby laying the foundation for developing an improved, cost-effective assistive solution through our VisionAid project.

Numerous studies have focused on the advancement of smart glasses aimed at improving the quality of life for individuals with visual impairments. These technologies harness developments in computer vision, sensor integration, and embedded systems to deliver real-time assistance for navigation and environmental awareness. Key functionalities such as obstacle detection, object recognition, and text reading have become central to many of these solutions. Modern approaches often incorporate ultrasonic sensors, LiDAR, and deep learning models executed on edge devices to reduce latency and enhance responsiveness. Despite advancements, widespread adoption remains limited due to issues related to cost, complexity, and dependency on cloud connectivity.

Early initiatives in assistive technologies for the blind focused on basic obstacle detection, using ultrasonic sensors, like iGlasses [5], EyeCane [8], and Arduino-based prototypes [21]. They conveyed the proximity information using tactile feedback, thus providing limited support.

As time passed, the objectives expanded to include outdoor GPS navigation [6], object recognition [7], text reading [9] and [20], and semantic mapping [18]. Several systems [6] and [10] tried to integrate multiple functionalities but faced limitations like poor obstacle detection and limited indoor effectiveness.

A broad range of hardware was used depending on the project's application and cost. Low-cost microcontrollers such as Arduino offered portability and affordability [21] but lacked processing power for high-level tasks. Raspberry Pi became a common choice for most mid-level applications [7] and [14], enabling integration with sensors and camera modules.

More powerful systems, such Jetson Nano [25] and LiDAR-enabled glasses [18], allowed high-accuracy detection, but came with a high cost, which was not affordable to many visually challenged people.

On the software side, early systems relied on sensor-based decision-making using ultrasonic inputs. Many systems used deep learning algorithms, such as YOLOV3 [12], CNNs with Tensorflow [13], and COCO-trained models [25], improving object detection accuracy. Recent approaches have explored semantic segmentation as well [28]. Brain-computer interfaces were also used for intent detection [19], but remained in the experimental phase. Offline AI models, particularly those using TensorFlow Lite [29], provided real-time processing but less accuracy due to limited hardware interaction.

In terms of user interaction, audio feedback remained the most useful mode, as seen in iGlasses [5], Smart Cap [16], and ORCAM MyEye [9]. However, it presents usability issues in noisy surroundings. To overcome this, some systems used haptic feedback through vibrations such as EyeCane [8], VibroVision [15], and BlindEye [10]. A few advanced solutions combined both audio and haptic feedback [11] and [30] to provide a more reliable solution.

In terms of features provided, early devices offered simple vibrations or obstacle awareness [5] and [8]. With the integration of camera and computing units, features have advanced to face recognition [13], text-to-speech conversion [9], and voice-based guidance [30]. Some systems incorporated dual-mode functionality [26] and [30]. Despite this progress, no single system has fully integrated all desired features, often requiring trade-offs between capability, cost, and accuracy.

Across all developments, several limitations emerged consistently. Many systems showed reduced performance in indoor spaces, especially those relying heavily on GPS [6] and [10]. Others faced recognition failures in low light with 20% accuracy [13] and 40% accuracy [28]. Processors consuming high power, such as those in Jetson Nano systems [25], suffered from overheating and short battery life. High cost and reliance on cloud services made systems inaccessible to many due to continuous internet connectivity [9], high power consumption [18] and higher reliability for processing on cloud [15].

In summary, while many innovations have advanced assistive technologies for the visually impaired, a gap remains between high functionality and real-world usability. Many systems either remain too costly or limited in their capabilities. The literature review highlights the critical need for the development of an assistive device that is not only cost-effective but also intelligent and should provide the basic functionalities needed to visually impaired users.

II. METHODOLOGY

The approach used to create VisionAid focuses on combining artificial intelligence with a variety of sensing methods to give visually impaired users real-time environmental awareness. With the help of the Raspberry Pi 4 Model B microcontroller, the system integrates haptic feedback, GPS localization, distance measurement, and computer vision into a single solution. Continuous visual input is captured by the onboard OV5647 camera and processed by edge computing-optimized, lightweight deep learning models. Ultrasonic and GPS sensors offer spatial data that improves contextual awareness in addition to vision-based insights.

In order to meet different user needs and environmental situations, the methodology is built with an emphasis on reliability, low latency, and simultaneous feedback. It uses haptic warnings by vibration motor and auditory via TTS and earbuds . To guarantee dependable performance and a smooth user experience, every functional module—such as obstacle detection, face recognition, and emergency communication—has been separately created, tested, and included into the system design. This section describes the hardware components used, the logic controlling their interaction, and the technical implementation of each of VisionAid's major features.

A. Object Detection System

At the core of the system's ability to recognize and interpret the surroundings is the YOLO (You Only Look Once) model, specifically the Ultralytics implementation. The system captures frames using either a USB or PiCamera, adjusts the size of each frame for optimal processing, and then runs them through the YOLO model. The detected objects are filtered by a confidence threshold, and a tracking algorithm ensures that objects are consistently identified across multiple frames. This process helps eliminate false detections and ensures stable performance in dynamic environments.

B. Distance Sensing System

For measuring distances to nearby objects, the system uses the HC-SR04 ultrasonic sensor, which works by emitting a 10μs pulse from the TRIG pin and measuring the time it takes for the signal to return to the ECHO pin. This time-of-flight principle allows for accurate distance calculations. To prevent errors, the system has built-in safeguards, including timeout protection and retry mechanisms. The TRIG and ECHO pins are connected via GPIO 23 and 24, with an additional level conversion on the ECHO line for safe operation.

C. Vibration Feedback System

To alert users of nearby objects, the system uses a DC vibration motor. The motor's activation pattern changes based on how close the object is, with continuous or pulsed vibrations indicating different levels of proximity. To ensure that the motor does not wear out prematurely, the system has limits on continuous use and includes cooldown periods to maintain both user comfort and the hardware's lifespan.

D. Audio Announcement System

The system also provides auditory cues, using eSpeak to convert detected objects into spoken descriptions. These verbal alerts include not just the object name but also spatial details (e.g., left, right, or center) and proximity information (e.g., nearby, very close). The system prioritizes important alerts, such as warnings about dangerous objects or familiar faces. Audio can be played through headphones, speakers, or bone-conduction devices, depending on the user's preference.

E. Face Recognition System

To help users recognize familiar people, the system combines YOLO-based person detection with HOG (Histogram of Oriented Gradients) face recognition. The faces of known individuals are stored in a database, and the system continuously compares incoming faces to this database. If a match is found, the user is alerted. For faces that are not recognized, the system offers a fallback option. New faces can be added to the database either via keyboard input or voice activation.

F. Voice Command System

To make the system more hands-free, it includes a voice command feature powered by the Vosk offline speech recognition engine. The system listens for a wake word ("assistant") and processes voice commands to perform actions like muting alerts, fetching a list of detected objects, saving new faces, or triggering an emergency alert. High-priority commands require confirmation to prevent accidental actions.

G. Emergency Alert System

In emergency situations, the user can activate the system via voice or a button press. Once triggered, the system collects GPS data and a snapshot of the current environment. This information is then compiled into an emergency email and sent via SMTP to alert pre-configured contacts. The GPS module, like NEO-6M or BN-180, provides accurate location data, ensuring that the alert is contextually relevant.

H. Currency Detection Mode

The system also includes a specialized mode for currency detection. When activated, a YOLO model specifically trained to recognize different currency denominations is loaded. The system announces the detected notes and includes confidence scores to let the user know how certain the detection is. This mode is meant for short-term use and automatically reverts to normal operation after a timeout, with enhanced detection thresholds to minimize errors.

III. System Design

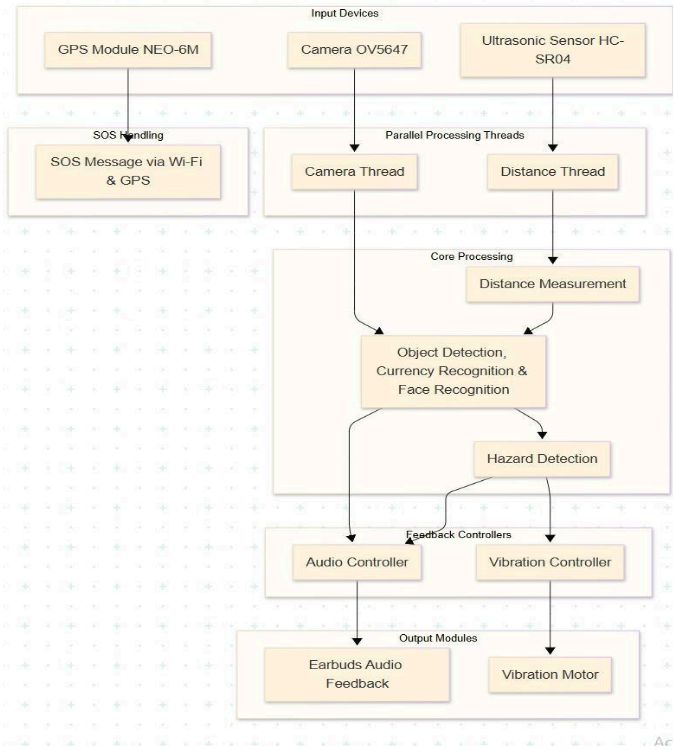

Fig 1. System Architecture

The main objective of the suggested system's architecture is to assist those who are blind or visually impaired by allowing them to see their surroundings more securely and autonomously. From sensing and processing to providing feedback that the user can readily comprehend and act upon, the entire system functions as a pipeline of interrelated components, each of which plays a critical role.

The input devices, which act as the system's senses, are located at the front end. Continuous location tracking using a GPS module NEO-6M is a function that becomes especially crucial in emergency situations. The SOS handling mechanism is immediately activated when the user presses an emergency button if they feel uncomfortable or confused. This module ensures that aid reaches the user promptly by using both GPS and Wi-Fi to send an alert to pre-designated contacts along with the user's current location.

The system uses an OV5647 camera module to record a live video feed of the user's surroundings in order to visually interpret the environment. Simultaneously, an HC-SR04 ultrasonic sensor is in charge of determining the distance to surrounding objects. This sensor provides spatial awareness by identifying obstacles that the camera would not be able to see, such low-hanging items or transparent surfaces.
The system uses parallel processing to make sure that all incoming data is processed quickly. Real-time image capture and distance calculation are made possible by the camera and ultrasonic sensor running on different threads, which eliminates any delays or interference. The system's responsiveness is enhanced by this parallel design, which is crucial while users are navigating dynamic settings.

The core processing unit is the central component of the system. Here is where unprocessed data is turned into useful information. The distance measuring module serves as an early warning system for potential hazards by interpreting ultrasonic readings to estimate how close things are. A YOLO You Only Look Once model, a deep learning-based object recognition system selected for its speed and accuracy in real-time scenarios, analyzes camera images concurrently. The hazard detection module combines these two data streams—spatial proximity and visual recognition—to determine if the things it has discovered are dangerous to the user. To cut down on pointless notifications and maintain user focus, only items that are relevant or threatening are highlighted.

The system moves from analysis to communication as soon as a possible hazard is discovered. The user's alerting is controlled by several feedback controllers. The detecting results are transformed by the audio controller into audible messages that are played through headphones. A vibration controller turns on a motor to provide tactile indications in circumstances where sound would not be optimal, such as noisy settings or for people who are hard of hearing. Different kinds of notifications, including urgency or direction, can be communicated by each vibration pattern. Output modules make up the system's last layer, which provides the user with this feedback. Haptic feedback is provided by a tiny vibration motor, while audio signals are sent through earbuds. All things considered, this architecture combines user-centric input, clever processing, and affordable components to produce a dependable assistive technology platform. It is especially made to work in real time, adjust to a variety of settings, and—above all—enable visually impaired people to move around the world more securely and confidently.

IV. Results

To evaluate the effectiveness of the VisionAid system in real-world scenarios, several tests were conducted focusing on object detection, hazard identification, face recognition, and distance estimation. The system performed consistently well, offering accurate visual and audio feedback to assist visually impaired users. Below are the key observations from our testing sessions.

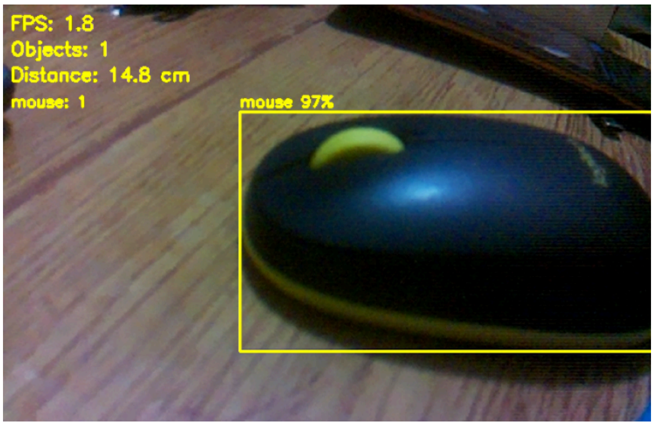

Fig.2 Object Detection

At a distance of roughly 14.8 cm, the system detected a non-harmful object a computer mouse with a 97% confidence score, as shown in Fig. 2. No warning was sent, confirming the object's accurate identification and harmless classification.

Fig.3 Harmful Object Detection

The second scenario (Fig. 3) demonstrates the system's ability to detect and classify potentially hazardous objects. The image showcases the detection of a **knife (74%)** and **scissors (95%)**, both identified from a distance of **43.2 cm**. The system triggered an audio-visual warning that flagged these objects as "Harmful" and displayed a prominent **WARNING!** message on the output screen. These alerts were also linked to a vibration motor to give tactile feedback to visually impaired users, enhancing the awareness of imminent risks.

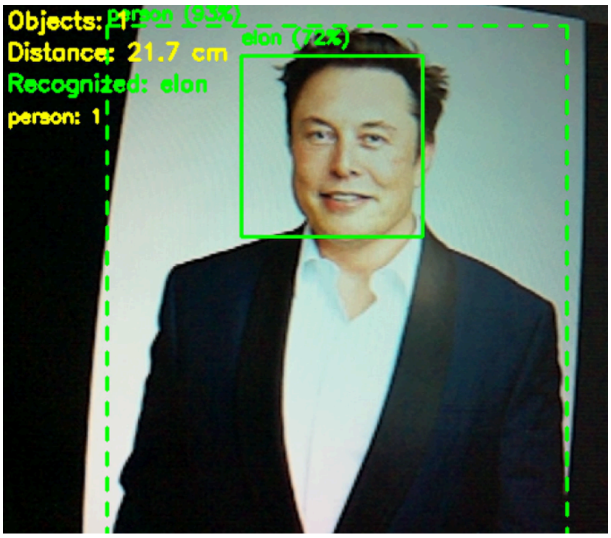

Fig.4. Face Recognition

In this (Fig. 4), the system successfully detected a human subject using the YOLO object detection model and accurately estimated the distance as 21.7 cm from the device. In addition to object detection, the system identified the individual using the integrated face recognition module and recognized the person as "elon" with 72% confidence. This indicates that the model is capable of operating multiple parallel tasks such as object recognition and face matching with high precision.

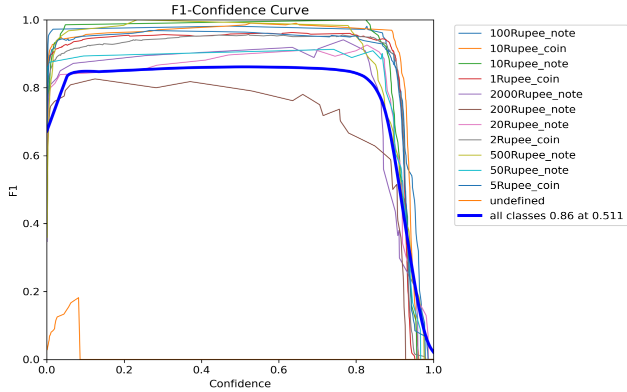

Fig 5. F1-Confidence Curve

To measure how well our system recognizes different Indian currencies, we used an F1-Confidence Curve (Fig. 8). This graph helps visualize how confident the model is in its predictions and how accurate those predictions are. The model was trained to detect various coins and notes—from ₹1 coins up to ₹2000 notes—along with an "undefined" class for unrecognized items.

As shown in the graph, the overall F1-score reaches a peak value of 0.86 when the model's confidence is set to 0.511. This means the system achieves its best balance between correctly identifying currencies (precision) and not missing them (recall) when it's about 51% confident. In simpler terms, this is the sweet spot where the model is both accurate and consistent.

Most of the currency types, such as ₹10 notes and ₹100 notes, show very high F1-scores throughout a wide range of confidence values—especially between 0.5 and 0.9. This indicates the model is quite reliable when it's moderately or highly confident.

However, a few currency classes, like the ₹10 coin and the ₹200 note, showed slightly lower performance. This could be due to visual similarities with other denominations or limited training examples for these classes. Still, the overall results suggest that the system is effective and dependable for helping visually impaired users distinguish between Indian currency denominations in real time.

V. Conclusion

The creation and implementation of the smart spectacles system that helps visually impaired people navigate their daily lives and become independent is presented in this paper. Using a small hardware configuration centered around the Raspberry Pi 4 Model B, together with a camera module ,ultrasonic sensor, voice feedback and vibration alerts, the suggested solution combines real-time object detection and currency recognition.

This research introduced VisionAid, a smart assistive device aimed at improving the quality of life for individuals with visual impairments. By combining computer vision and machine learning, the system successfully identifies objects, estimates distances, recognizes familiar faces, detects potentially harmful items, and even reads currency—all in real time.

Through practical implementation and testing, the device demonstrated the ability to accurately detect people and objects in various settings, warn users of nearby threats using vibration and audio cues, and correctly identify currency notes and coins used in India. The system's currency recognition module, in particular, achieved an F1-score of 0.86 at a confidence threshold of 0.511, showcasing its reliability in handling real-world variations.The project was developed using low-cost components such as the Raspberry Pi and camera modules, ensuring affordability and portability. With its compact design and clear voice feedback via eSpeak, VisionAid offers an intuitive and effective tool for users to better perceive their surroundings and navigate daily life with increased safety and independence.

VI. Future Scope & Limitation

While VisionAid has shown considerable promise in assisting visually impaired individuals through object detection, face recognition, and currency identification, it does face a few limitations. The system's performance is noticeably affected by challenging lighting conditions, such as low light or intense glare, which can reduce detection accuracy. Furthermore, the hardware capabilities of the Raspberry Pi place limits on real-time processing, resulting in lower frame rates when multiple modules are active simultaneously. The face recognition system may also struggle when faces are partially visible, occluded, or not directly facing the camera. Similarly, coins and notes with similar visual features or wear and tear can lead to misclassification. Additionally, the device's reliance on battery power makes it less suitable for prolonged use without regular charging.

Looking ahead, there are several opportunities for enhancement. Integrating GPS and voice-guided navigation could make the system more useful for outdoor mobility. Incorporating natural language processing (NLP) could allow the system to describe scenes in more detail, offering richer contextual information (e.g., "a person sitting on a bench"). Future versions may also benefit from adopting more powerful edge AI hardware like NVIDIA Jetson Nano or Google Coral, enabling faster and more accurate performance. To reach a broader audience, multilingual audio support could be introduced, offering voice feedback in various regional languages. Finally, miniaturizing the device into a lightweight, glasses-mounted or fully wearable form factor would improve usability and comfort, enabling a more seamless, hands-free experience. These advancements would help transform VisionAid into a more robust and inclusive assistive technology for everyday use.

References

[1] World Health Organization, "Blindness and vision impairment," 2023. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment

[2] International Agency for the Prevention of Blindness (IAPB), "India - Vision Atlas," 2023. [Online]. Available: https://www.iapb.org/learn/vision-atlas/magnitude-and-projections/countries/india

[3] Jyothirgamaya Foundation, "Empowering the blind through mobility and technology," 2023. [Online]. Available: https://jyothirgamayafoundation.org/ [Accessed: Apr. 13, 2025].

[4] R. Shoval, I. Ulrich, and J. Borenstein, "NavBelt and the GuideCane: obstacle-avoidance systems for the blind and visually impaired," IEEE Robotics & Automation Magazine, vol. 10, no. 1, pp. 9–20, Mar. 2003.

[5] Orcam Technologies Ltd., "OrCam MyEye – Artificial Vision for the Blind," [Online]. Available: https://www.orcam.com/

[6] A. J. Almazaydeh, F. Aloul, and A. Sagahyroon, "BlindEye: A wearable system for visually impaired navigation," in Proc. IEEE Int. Conf. on Biomedical Engineering (ICoBE), Penang, Malaysia, 2012, pp. 314–318.

[7] A. Kaczmarek, J. Petryk, and J. Grabowski, "Enactive Eyewear: Navigation support for visually impaired using ultrasonic sensors and spatial audio feedback," Journal of Rehabilitation and Assistive Technologies Engineering, vol. 6, pp. 1–10, 2019.

[8] Y. Li, M. Zhang, and J. Liu, "Smart Glasses for Object Detection Using YOLOv3 and Raspberry Pi," in Proc. 2021 Int. Conf. on Artificial Intelligence and Computer Science (AICS), China, 2021, pp. 108–112.

[9] N. Sharma and A. Singh, "Assistive Glasses for the Visually Impaired Using CNN-Based Object Detection," in Proc. Int. Conf. on Smart Technologies in Computing, Electrical and Electronics (ICSTCEE), 2020, pp. 329–334.

[10] M. Al-Ammary and A. Al-Sammarraie, "Intelligent Navigation System for the Visually Impaired Using Multi-Sensor Fusion," International Journal of Advanced Computer Science and Applications, vol. 10, no. 3, pp. 123–129, 2019.

[11] A. Rahman et al., "VibroVision: A Haptic-Based Assistive Device for Visually Impaired," IEEE Access, vol. 9, pp. 47821–47831, 2021.

[12] K. P. Patel and M. D. Bhavsar, "Smart Cap: Object Recognition and Notification Cap for the Blind," International Journal of Computer Applications, vol. 180, no. 12, pp. 1–5, 2018.

[13] S. Jain, P. Verma, and A. Joshi, "Android-Based Object Detection and Navigation System for Visually Impaired," International Journal of Innovative Research in Computer and Communication Engineering, vol. 6, no. 3, pp. 3331–3335, 2018.

[14] M. Fukuda et al., "LiDAR-Based Indoor Navigation for the Visually Impaired," Sensors, vol. 20, no. 18, pp. 5268, 2020.

[15] T. R. Lopes, C. S. Lopes, and A. P. Oliveira, "Smart Glasses with EEG-Based Intent Detection for the Visually Impaired," in Proc. 2019 IEEE Int. Conf. on Bioinformatics and Biomedicine (BIBM), San Diego, CA, USA, 2019, pp. 2553–2557.

[16] A. H. Khan and S. A. Ansari, "Text Recognition Glasses for the Visually Impaired Using Tesseract OCR," International Journal of Scientific & Technology Research, vol. 8, no. 10, pp. 2646–2649, Oct. 2019.

[17] P. R. Nikam, S. S. Patil, and S. R. Kamble, "Low-Cost Wearable Navigation System for the Blind Using Arduino," International Research Journal of Engineering and Technology (IRJET), vol. 6, no. 4, pp. 2578–2582, Apr. 2019.

[18] V. Hicks et al., "SmartSpecs: Design and Evaluation of a Smart Glasses System for Visually Impaired People," in Proc. 2018 ACM Int. Joint Conf. on Pervasive and Ubiquitous Computing and Wearable Computers, Singapore, 2018, pp. 345–348.

[19] T. R. Singhal, R. Verma, and M. K. Gupta, "Offline Object Detection Using Raspberry Pi for Visually Impaired People," International Journal of Engineering Research and Applications, vol. 10, no. 5, pp. 56–60, May 2020.

[20] J. H. Lee and S. H. Kim, "Gesture Controlled Smart Glasses for Blind People Using CNN," in Proc. Int. Conf. on Consumer Electronics (ICCE), Las Vegas, NV, USA, 2021, pp. 1–3.

[21] K. Y. Gupta and A. Yadav, "AI-Based Smart Glasses Using Jetson Nano and COCO Dataset," International Journal of Scientific Research in Engineering and Management (IJSREM), vol. 5, no. 7, pp. 75–80, July 2021.

[22] S. P. Raut and R. A. Patil, "Dual Mode Smart Glasses for Visual Assistance Based on Ambient Conditions," in Proc. IEEE Bombay Section Signature Conference (IBSSC), 2022, pp. 102–106.

[23] H. T. Lam and N. V. Nguyen, "Indoor Navigation System for the Visually Impaired Using QR Codes and Smart Glasses," International Journal of Interactive Mobile Technologies (iJIM), vol. 14, no. 12, pp. 105–116, 2020.

[24] A. M. Sharma, R. Kumar, and D. D. Sharma, "Semantic Segmentation Based Environmental Hazard Detection for the Visually Impaired," Procedia Computer Science, vol. 172, pp. 682–687, 2020.

[25] K. Deshmukh, A. Jadhav, and S. Patil, "Real-Time Object Detection Smart Glasses for the Blind Using TensorFlow Lite on Android,"

International Journal of Innovative Research in Technology (IJIRT), vol. 8, no. 9, pp. 321–325, 2022.