International Journal of Multidisciplinary Engineering in Current Research - IJMEC
Volume 10, Issue 5, May-2025, http://ijmec.com/, ISSN: 2456-4265

Real Time Object Detection And Audio Feedback For Visually Impaired

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ABSTRACT

This project presents a real-time object detection system integrated with audio feedback designed to assist visually impaired individuals in navigating their environment safely and independently. The system utilizes a combination of computer vision and deep learning algorithms to identify objects in the user's surroundings through a live camera feed. Upon detecting objects, the system provides immediate audio cues describing the identified items and their relative position, enhancing the user's situational awareness. The solution is implemented using technologies such as OpenCV, TensorFlow (or YOLO), and a text-tospeech engine, all optimized for real-time performance on portable hardware like Raspberry Pi or mobile devices. This assistive technology aims to bridge the gap between visual impairment and spatial perception, offering an affordable, effective, and user-friendly aid for daily life navigation.

1- INTRODUCTION

The project titled "Real-time Image Description and Audio Feedback for Visually Impaired Users" aims to enhance the independence and mobility of individuals with visual impairments.

The system is designed to be portable, user-friendly, and adaptable to various environments, enabling users to better understand their surroundings. By offering real-time image descriptions, the project helps visually impaired individuals navigate their environment more effectively, engage with their surroundings, and access information that would otherwise be inaccessible to them.

Here's how it works: A camera captures images in real-time. The software then analyzes these images to recognize objects, people, and text. Once something is identified, the system speaks out loud what it has detected. This gives users an idea of what is around them without needing to see it.

The system is made to be portable (easy to carry), simple to use, and adaptable to different places like homes, streets, or public areas. It helps users understand their environment better, whether they're walking outdoors, reading signs, or identifying people nearby.

By giving real-time voice feedback, the system makes it easier for visually impaired individuals to move around safely, interact with the world, and gain access to important information that would otherwise be difficult or impossible to understand.

Overall, this project brings together smart technologies like AI, image recognition, and speech generation to create a more inclusive and supportive world for people with visual challenges.

2-LITERATURE SURVEY

As a part of research for building our model, a literature review of a handful of IEEE published papers were made. We shall briefly be discussing the review hereunder with appropriate required details.

2.3.1 Real Time Object Detection with Audio Feedback using Yolo vs. Yolo_v3:

The first paper is titled "Real Time Object Detection with Audio Feedback using Yolo vs. Yolo_v3" and was published in the year 2021. This paper uses algorithms and techniques like the OpenCV library, Yolo, Yolo v3. The performance recorded in this paper indicates that it works better for smaller objects with future works mentioned as the expansion of the research on self explored dataset [1]

2.3.2 Reader and Object Detector for Blind:

The next paper is titled "Reader and Object Detector for Blind" which was published in the year 2020. This paper uses algorithms and techniques such as Raspberry pi, OCR, tesseract, and tensorflow for carrying out the project. Text reading and object detection was successful but not for smaller than 16 font size is what was recorded in the performance of the paper. As the objective for future works, making it available for multi languages is recorded as of now [2].

2.3.3 Obstacle Detection for Visually Impaired Patients:

The paper that was studied next is titled "Obstacle Detection for Visually Impaired Patients" which was published in the year 2014. The techniques and algorithms used in this paper are stereoscopic sonar system, sound buzzers, voice IC-APR 9600. Wearable optical detection system is provided that provides full body vibration effect on obstacle detection. However, the device has a very limited range when compared to its own size and is also found difficult for users to comprehend the guidance signals in time [3].

2.3.4 Voice Based Smart Assistive Device for Visually Challenged**:**

The paper that was studied next is titled "Voice Based Smart Assistive Device for Visually Challenged" and was published in the year 2020. The Raspberry Pi, Deep Learning, conversational

ISSN: 2456-4265
IJMEC 2025

Al, speech recognition, Assistive Technology, and algorithms and methodologies were described in the article. After being trained on only 50 photos of each object, the model has an accuracy of 83 percent and detects campus objects that are commonly available. However, because it was trained on 8000 photos from the Flickr 8k dataset, the accuracy drops as the image complexity grows.[4].

2.3.5 A Wearable Assistive Technology for the Visually Impaired with Door Knob Detection and Real-Time Feedback for Hand-to-Handle Manipulation**:**

The next paper is titled "A Wearable Assistive Technology for the Visually Impaired with Door Knob Detection and Real-Time Feedback for Hand-to-Handle Manipulation" and was published in the year 2017. Algorithms and techniques such as YOLOv2, Deep Learning, Neural Network were used. The performance of the device is increased to folds if the hand detection is stable. The biggest difficulty, however, is the consistency of the hand detection performance. More images will be added to the database in the future, and the door knob identification feature will be extended to more general door handles. [5].

2.3.6 VISION- Wearable Speech Based Feedback System for the Visually Impaired using Computer Vision:
The paper is titled as "VISION- Wearable Speech Based Feedback System for the Visually
Impaired using Computer Vision", published in 2020. It is a wearable device based on Raspberry pi, gTTs and YOLO. The text will be read out in English and at a slow speed that is saved as an mp3 file and future work is mentioned as location navigation that works in low-light conditions while remaining cost-effective.[6]

2.3.7 YOLO-Compact: An Efficient YOLO Network for Single Category Real-time Object Detection:
This IEEE paper named, "YOLO-compact:An Efficient YOLO Network for Single Category Real-time Object Detection", published in 2020, is an efficient way for a location navigation that works in low-light conditions while remaining cost-effective.. The model would be more precise if the depth, width and precision is improved. [7].

2.3.8 CPU based YOLO: A Real Time Object Detection Algorithm:
The next 2020 published paper having title "CPU based YOLO: A Real Time Object
Detection Algorithm" is based on Faster R-CNN, YOLO, R-CNN, Fast R-CNN, SSD, Mask R-CNN, R-FCN, OpenCV and RetinaNet. The Model discovers objects from video at a pace of "10.12-16.29 frames per second" on many non-GPU platforms, with an accuracy of 80-99 percent. mAP of 31.05 percent is achieved by CPU Based YOLO with aforementioned future work as increment of FPS and mAP by optimizing the model.[8].

2.3.9 A Novel YOLO-based Real-time People Counting Approach**:**
A 2017 paper titled "A Novel YOLO-based Real-time People Counting Approach" is based on YOLO-PC and CNN. IT provides us an automatic way to count people in a huge crowd and the accuracy states that it works perfectly fine for a huge crowd and for a single person as well. Future Work stated in the paper is to add abnormal behavior detection during counting and children counting.[9]

2.3.10 Edge detection based boundary box construction algorithm for improving the precision of object detection in YOLOv3:
The last paper that we have reviewed is "Edge detection based boundary box construction algorithm for improving the precision of object detection in YOLOv3" published in 2017. YOLOv3, Edge Detection, YOLO, YOLO9000, Boundary Box Prediction, and Object
Detection are all used in this research. The intersection over union for the proposed algorithm and YOLO v3 is determined, and the proposed approach outperforms YOLO v3 in terms of boundary box accuracy. When there are sharp objects in the image or there is too much noise, the model becomes constrained.

3-EVALUATION AND MEASUREMENT OF SOFTWARE PROCESS IMPROVEMENT A-SYSTEMATIC

Software Process Improvement (SPI) is a systematic approach to optimizing the software development process to achieve higher levels of quality, efficiency, and customer satisfaction. In the context of developing real-time assistive systems, such as object detection and audio feedback for visually impaired individuals, SPI is crucial to ensure that the final product is not only effective but also reliable and sustainable.

The primary focus of SPI in this project is on continuous improvement, which involves iterative development, testing, and refinement of the system's components to meet the needs of visually impaired users. Using modern development methodologies, such as Agile, ensures that the software is developed incrementally, allowing for flexibility and adaptability to changing requirements. Furthermore, performance metrics such as accuracy, latency, and frames per second (FPS) are critical in real-time systems, making continuous measurement essential for ensuring that the system operates optimally.

A key aspect of SPI involves using feedback loops to refine the product. The real-time object detection model (YOLO, SSD) undergoes rigorous testing to measure its effectiveness, and the system's responsiveness is evaluated through performance benchmarks. Additionally, integrating continuous integration (CI) and continuous delivery (CD) practices helps maintain software quality, enabling frequent updates and fixes without interrupting the user experience.

By adopting SPI strategies, this project aims to deliver a user-centered solution, optimizing both system performance and user interaction. This ensures the technology can evolve and adapt over time to meet the dynamic challenges faced by visually impaired users.

4-REQUIREMENTS ENGINEERING

This project aims to develop a web-based real-time object detection and audio feedback system for visually impaired users. It uses deep learning models powered by PyTorch and TensorFlow, with OpenCV for image processing and TTS libraries for audio output. The system runs on a browser-accessible platform, using Flask as the backend and JSON for data exchange. It is designed for accuracy, accessibility, and real-time performance, helping users identify objects in their environment through instant audio feedback.

Hardware Requirements

Although the system is web-based, certain hardware components are essential for capturing input and delivering audio feedback. These include a camera for real-time video feed and speakers or headphones for outputting audio cues. A computing device such as a desktop or laptop is required to run the web application through a browser.

S.No.	Component	Specification/Details
1	Camera Module	USB webcam or Pi Camera Module (5MP or higher)
2	Processing Unit	Laptop with GPU support
3	Audio Output Device	Speaker or Earphone (3.5mm jack or Bluetooth supported)
4	Microphone (optional)	For voice commands, if UI supports voice interaction
5	Storage	MicroSD(16GB minimum) or SSD (for local data stotage)

Software Requirements

The system relies heavily on a combination of software libraries and frameworks. Python serves as the main programming language, with Flask used to create a lightweight web server. PyTorch and TensorFlow are used to run deep learning models, and OpenCV handles realtime video processing. For converting text to speech, libraries like gTTS or pyttsx3 are used. JSON is utilized for storing and transferring object metadata efficiently.

S.No.	Software/Library	Purpose/Functionality
1	Operating System	Raspbian OS / Ubuntu / Windows (depending on platform)
2	Python 3.x	Main programming language
3	OpenCV	Image acquisition and preprocessing
4	PyTorch / TensorFlow	Deep learning framework for object detection
5	YOLOv5 / SSD model	Pre-trained object detection model
6	gTTS / pyttsx3 / TTS API	Text-to-Speech for audio feedback
7	Flask	For running a local server or dashboard (optional)
8	JSON	For storing and retrieving detection metadata
9	NumPy, Matplotlib, etc.	Supporting libraries for data processing and visualization
10	Logging module	For performance and error tracking

5-DESIGN

Design Engineering is a critical phase in the software development lifecycle that transforms system requirements into a detailed blueprint for implementation. It involves creating visual models and structured plans that define how the system components interact, behave, and are organized.

Real-Time Object Detection and Audio Feedback for Visually Impaired, design engineering includes a range of diagrams such as use case, data flow, sequence, class, and state diagrams. These diagrams help to represent user interactions, data movement, process flows, and object relationships.

The purpose of this phase is to ensure that the system is well-structured, scalable, and maintainable. By creating a visual representation of both the static and dynamic aspects of the system, we reduce complexity and improve clarity during the coding and testing phases.

Effective design leads to improved software quality, easier debugging, and streamlined development efforts.

DATA FLOW DIAGRAM

A Data Flow Diagram (DFD) provides a visual representation of how data moves through a system, illustrating the processes, data stores, and data interactions. For a system that converts voice to sign language, incorporating linear regression, natural language processing (NLP), and speech recognition, the DFD would illustrate the flow of data from input to final output. Here’s how you might represent this system:

International Journal of Multidisciplinary Engineering in Current Research - IJMEC
Volume 10, Issue 5, May-2025, http://ijmec.com/, ISSN: 2456-4265

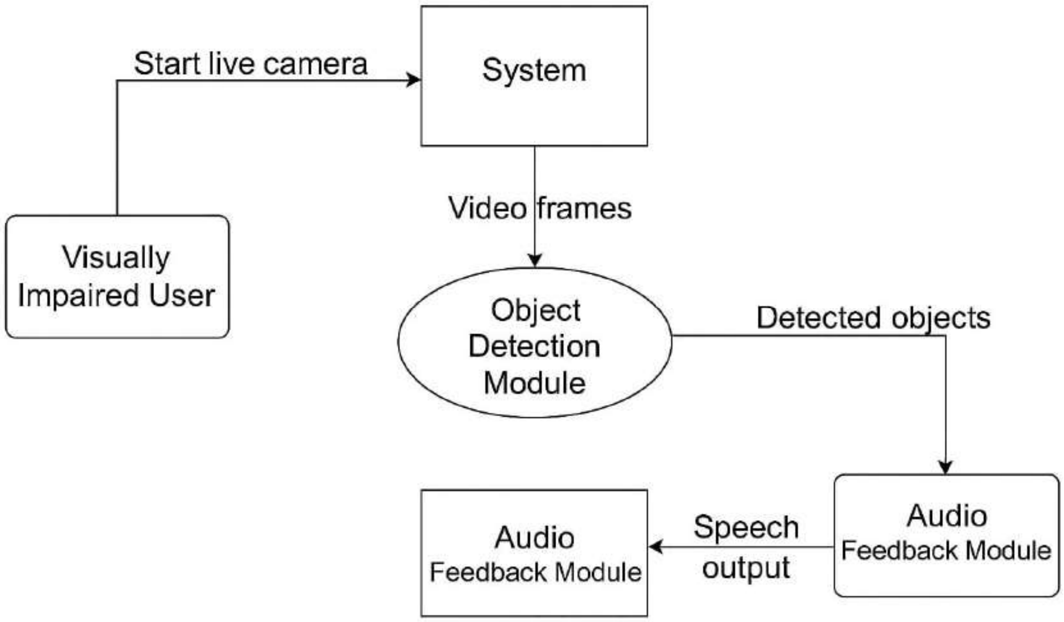

Fig 5.1 Data Flow Diagram

6-SNAPSHOTS

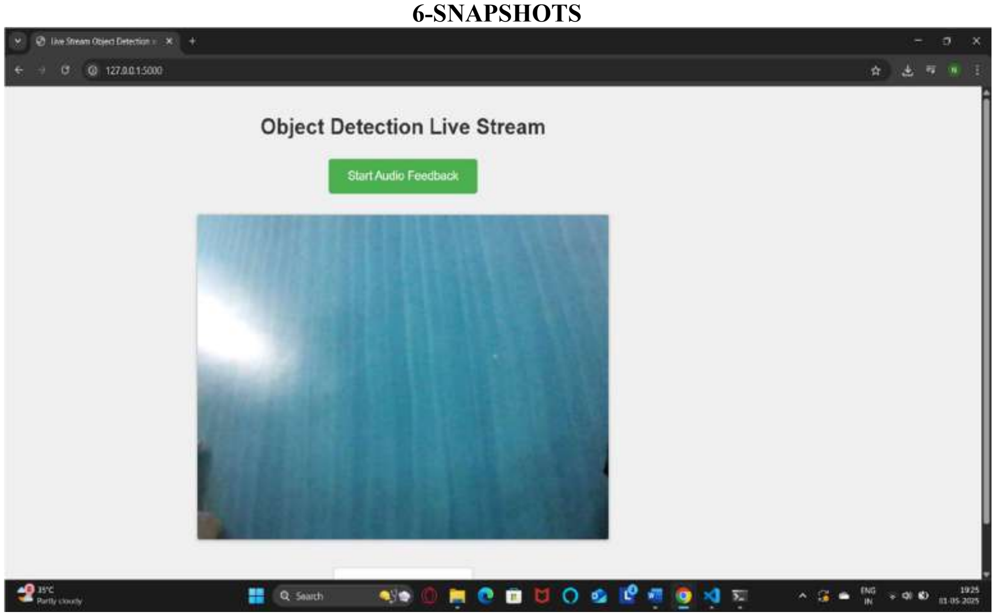

Fig 1 Video Frame Output

ISSN: 2456-4265
IJMEC 2025

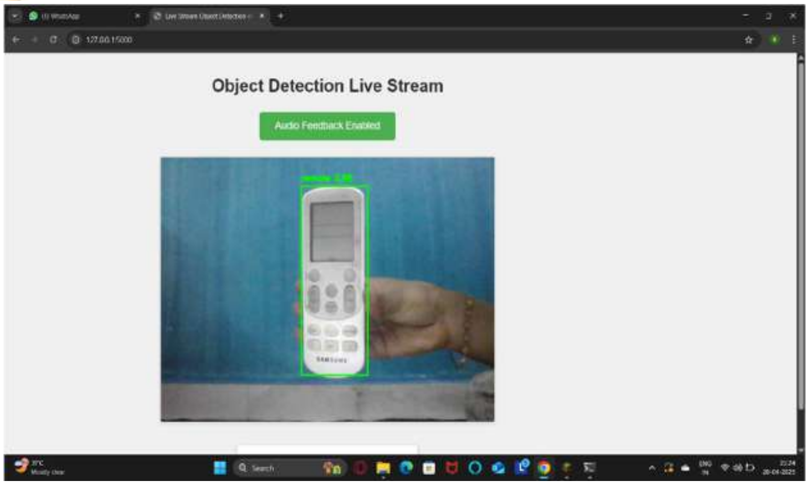

Fig .2 Video Frame Output

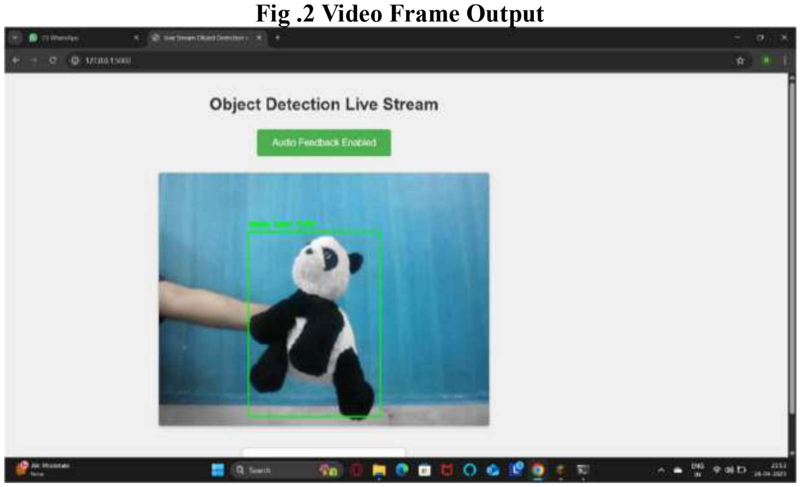

Fig 3 Video Frame Output

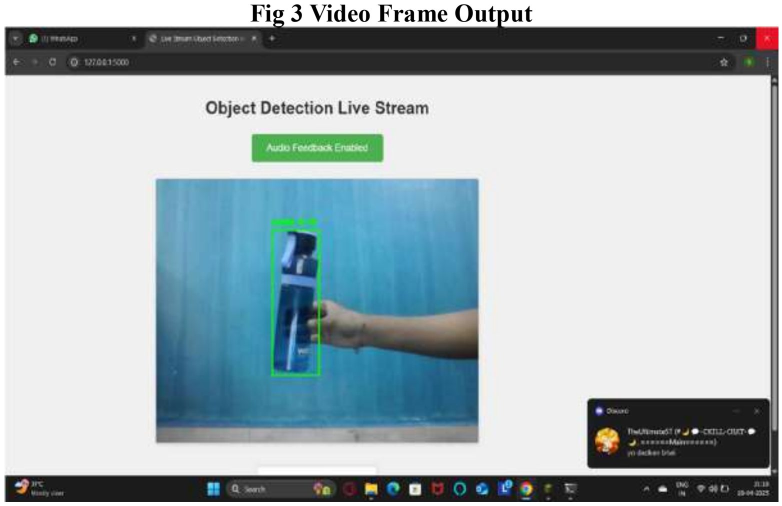

Fig 4 Video Frame Output

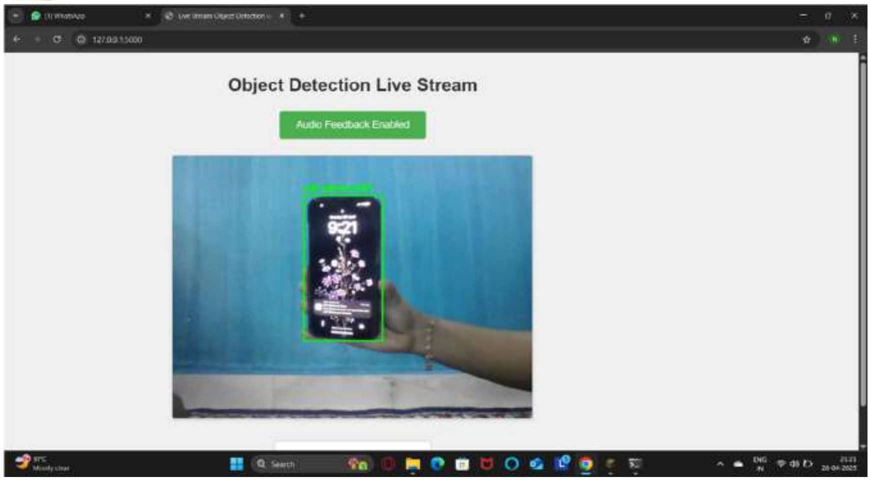

Fig 5 Video Frame Output

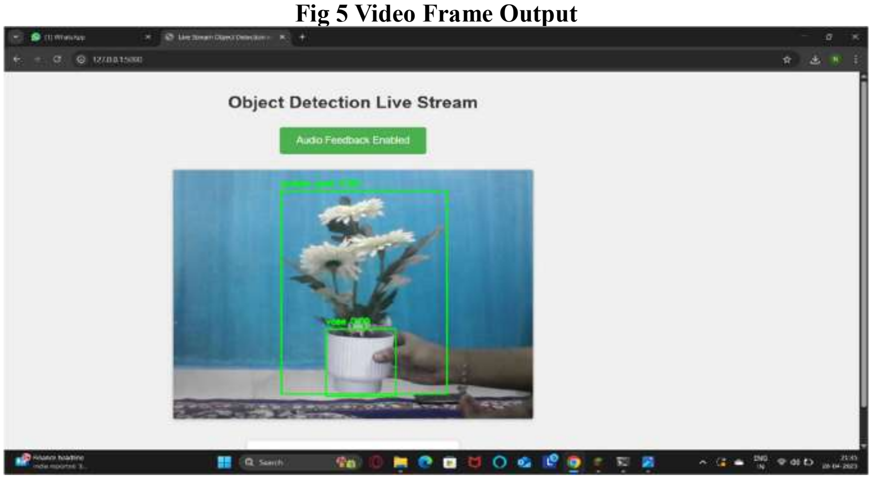

Fig 6 Video Frame Output

7-SOFTWARE TESTING

DEVELOPING METHODOLOGIES

Software testing is an essential phase in the development lifecycle of any software system. For the "real-time object detection and audio feedback system" designed to assist visually impaired users, testing is especially critical to ensure functionality, usability, and performance. Since the system integrates multiple components, including object detection (YOLOv5), web development (Flask), and audio feedback (TTS), testing must cover a wide range of aspects.

The methodologies adopted for testing in this project involve both manual and automated testing techniques. These methodologies are designed to verify that the system meets the specified requirements and performs well across different environments and scenarios.

Unit Testing

Unit testing focuses on testing individual components or units of the system to ensure that they work as expected. For instance:

- YOLOv5 model: Unit tests are written to check the model's ability to correctly detect objects in sample images.
- Flask API: Tests are written to verify that API endpoints return the expected results and status codes.
- Audio Feedback System: Unit tests check if the text-to-speech functionality works correctly for different object labels.

Functional Testing

Functional testing checks whether the system's functionalities work according to the requirements. The tests include:

- Object Detection: Verifying that the YOLOv5 model detects objects correctly from the webcam feed.
- Audio Feedback: Ensuring that detected objects are correctly converted to speech output.
- Web Interface: Testing the Flask application's responsiveness, interactivity, and overall user experience.

System Testing

System testing involves testing the entire system as a whole. This stage focuses on validating that the system works according to the end-user requirements. The system's ability to:
- Handle "real-time webcam streaming" for object detection.
- Provide "real-time audio feedback" based on the detected objects.
- Ensure proper functionality across different web browsers and devices.

8-CONCLUSION

This project, "Real-time Object Detection and Audio Feedback for Visually Impaired", successfully integrates advanced technologies like "YOLOv5", "PyTorch", "Flask", and "Text-to-Speech (TTS)" to create a web-based application that enhances accessibility for visually impaired users. By using "YOLOv5" for object detection, the system identifies objects in real time, while the audio feedback component helps users navigate their environment more effectively. The system is lightweight, cost-effective, and does not require additional hardware like Raspberry Pi, making it accessible on various devices with just a web browser.
The project meets its core objective of providing real-time object detection and auditory cues for visually impaired individuals, helping them to better understand their surroundings and move safely.

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