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Smart Glasses Using Ultrasonic Sensor and AI for Blind Person

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Abstract

Smart glasses has received considerable attention recently from people around the world. This research paper introduces a pioneering project, 'Smart Glasses Using AI and Ultrasonic Sensor,' aimed at revolutionizing the assistive technology landscape for visually impaired individuals. The project seamlessly integrates advanced hardware, including Raspberry Pi and Node MCU, with an array of sensors and state-of-the-art machine learning techniques, notably the YOLOv5 model. This paper presents a new paradigm in assistive technology where the fusion of artificial intelligence and ultrasonic sensor technologies empowers users with enhanced spatial awareness and real-time assistance. The smart glasses introduce novel features such as object recognition, temperature sensing, 'find my glass' functionality, and distance measurement, leveraging a user-centric design, cost-effective solutions, and community-informed development, promising to significantly enhance accessibility, convenience, and independence for visually impaired individuals.

Keywords: Smart glass, ultrasonic sensor, node MCU, raspberry pi, Pi camera, temperature sensor, IR sensor

INTRODUCTION

The realm of technology is undergoing a significant transformation, with a growing emphasis on developing solutions to empower individuals facing distinct obstacles and enrich their lives. Amidst numerous innovative advancements, assistive technologies hold great significance as they have the potential to bridge gaps and foster inclusivity. Artificial intelligence has become a transformative element in the development of assistive devices. AI systems can process vast amounts of data rapidly and make real-time decisions, which are essential for the functionality of assistive technologies. In the context of devices for visually impaired individuals, AI can be utilized for tasks such as object detection, facial recognition, and scene interpretation. These capabilities enable the device to provide immediate feedback and assistance, significantly enhancing the user's ability to navigate and interact with their environment.

A prominent AI technique used in assistive devices is the YOLO (You Only Look Once) model, specifically YOLOv5. Reputable for its effectiveness and precision in real-time object identification is YOLOv5. It processes images in a single pass, allowing for fast and reliable identification of objects. Because of this, it is ideal for incorporation into wearable assistive technology, where instantaneous performance is crucial. YOLOv5, an advanced object detection system, is notable for its accuracy and quickness. It is perfect for applications where prompt replies are required since it can detect objects within picture or

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video frames in real-time. To recognize numerous objects at once, YOLOv5 divides the image into a grid and forecasts bounding boxes and probabilities for each sector. This capability is particularly beneficial for assistive devices that require real-time interpretation of the user's surroundings to provide immediate and actionable feedback.

Ultrasonic sensors are key components in many assistive technologies, particularly those designed to aid individuals with visual impairments. These sensors measure the time it takes for echoes to return after emitting high-frequency sound waves, which allows them to calculate the distance to surrounding objects. This information is crucial for detecting obstacles and providing spatial awareness. In wearable assistive devices, ultrasonic sensors can alert users to the presence of obstacles, helping them navigate safely and confidently in various environment.

The below graph as shown in Figure 1, represents the market for smart glasses is growing, driven by technological advancements and an increasing focus on enhancing the quality of life for visually impaired individuals. The integration of AI and ultrasonic sensors into smart glasses is proving revolutionary, providing users with real-time environmental feedback and improved spatial awareness that foster greater independence and safety.

Figure 1. Market growth of AI glasses [1].

Need for AI in Glasses

The inclusion of Artificial Intelligence (AI) in the "Smart Glasses Using AI and Ultrasonic Sensor" project is paramount for addressing the unique challenges faced by visually impaired individuals. AI serves as the cognitive powerhouse of the smart glasses, enabling them to perceive and comprehend the visual world in real-time. This capability significantly enhances the spatial awareness of users, facilitating the immediate recognition of objects and obstacles, thereby improving their ability to navigate and interact with their surroundings.

AI technologies, particularly machine learning algorithms, allow the smart glasses to process vast amounts of visual data swiftly and accurately. This real- time data processing is crucial for providing visually impaired individuals with instantaneous feedback about their environment, enhancing their safety and independence. By leveraging advanced AI, the smart glasses can offer functionalities such as object detection, facial recognition, and scene interpretation, transforming the way users experience the world around them.

Addressing the Gap in Assistive Technology

The Smart Glasses Using AI and Ultrasonic Sensor project emerges as a direct response to this unmet need in the realm of assistive technology. The initiative aims to bridge the gap in current solutions by incorporating cutting-edge technology like artificial intelligence and ultrasonic sensors. These smart glasses aspire to redefine the user experience for visually impaired individuals by providing real-time object recognition, spatial awareness, and audible alerts. In acknowledging and addressing this specific gap, the project not only aligns with the principles of inclusivity and accessibility but also sets a precedent for the integration of cutting-edge technologies to meet the evolving needs of those with visual impairments.

Approach to Accessibility

It introduces the user-centric design, cost-effectiveness, and adaptability as key elements shaping the project [6]. This section sets the stage for the comprehensive exploration of the project's methodology, advantages, and potential impact, highlighting its commitment to inclusivity and accessibility.

Organisation of the Paper

Section 1 has the introduction of the paper, after that literature review and related work is discussed in Section 2. Section 3 provides further details on the suggested approach, while Section 4 presents the findings and a commentary. Finally, Section 5 presents the findings and directions for further research.

LITERATURE REVIEW

This section reviews various studies by different authors, highlighting advancements in assistive technologies, particularly the integration of AI and ultrasonic sensors in smart glasses for the visually impaired.

- *Tahoun et al.* titled "Smart Assistant for Blind Person," discusses the design and implementation of a smart assistant system tailored for blind individuals [1], It incorporates various sensors and machine learning algorithms to provide real-time feedback and assist with navigation and object detection, thereby enhancing the user's independence and safety.
- *Samuda et al.* presented an innovative approach with their "Arduino based customized smart glasses for blind people" [2]. This study explores the use of Arduino microcontrollers combined with ultrasonic sensors and AI to develop a cost-effective and efficient assistive device. The smart glasses designed in this study provide real-time obstacle detection and navigation assistance through auditory feedback.
- *Babu et al.* titled "Smart Blind Glasses Using OpenCV Python," the authors explored the use of OpenCV combined with Python to develop smart glasses for visually impaired individuals [3]. At the IEEE Wireless Antenna and Microwave Symposium (WAMS) in 2024, this study was presented. The research focused on integrating computer vision techniques with ultrasonic sensors and AI to create a comprehensive assistive device.
- *Gonzalez-Lorence et al.* titled "Smart glasses for blind people," present a comprehensive prototype of smart glasses designed to assist visually impaired users [4]. Published in the Journal of Technological Prototypes, this study explores the integration of various technologies to create an effective assistive device.
- *Nazim et al.* In the paper titled "Smart Glasses: A Visual Assistant for the Blind," presented at the 2022 International Mobile and Embedded Technology Conference (MECON), Nazim et al. explored the development of smart glasses using these advanced technologies [5]. The study focused on integrating AI, computer vision, and ultrasonic sensors to create a comprehensive assistive device for the visually impaired.
- *In their paper "Smart Glasses for Blind People Using Obstacles Detection," which was presented at the International Conference on Sustainable Emerging Innovations in Engineering and Technology (ICSEIET) [6], Sharma et al. address the incorporation of obstacle detection systems in smart glasses for the visually impaired. In order to improve mobility and independence, their work focuses on the employment of ultrasonic sensors and computer vision algorithms to identify barriers and deliver aural feedback in real time.*
- *Ahmed & Reddy* "Obstacle Avoidance Using Wi-Fi Enabled Smart Ultrasonic Glasses for Visually Blind" Discusses the design and implementation of smart glasses that utilize Wi-Fi-enabled ultrasonic sensors for obstacle detection [7]. Highlights the effectiveness of using ultrasonic waves to detect obstacles and provide real-time audio feedback to the user via Wi-Fi communication, enhancing mobility and safety for visually impaired individuals.

- *Rajput et al.* titled "Smart Obstacle Detector for Blind Person," published in the Journal of Biomedical Engineering and Medical Imaging presents a smart obstecle detection system designed for blind person [8].
- The development and use of smart glasses using ultrasonic sensors and an Arduino-based system is examined in Bollimara et al.'s paper, "Ultrasonic Sensor and Arduino-Based Smart Glasses for Visually Assisting the Blind" [9]. It draws attention to how well these technologies work to identify barriers and give users immediate feedback, enhancing their safety and mobility.
- Rani, T.P. et al. "Visual Information Translator Using Smart Glasses for the Blind." presents a significant advancement in assistive technologies [10]. Their creative strategy has the potential to increase visually impaired people's independence and quality of life.
- *Available Assistive Device:* Over the past decade, the market for assistive devices has experienced significant growth, driven by technological advancements and increased awareness of accessibility needs. The available assistive devices are listed below in tabular form.

Table 1. Comparison between proposed AI glasses and available assistive devices.

Device	Functionality and No. of tasks	Price (INR)	Remarks
eSight 4 [12]	Re-display the live scenes for visually impaired to see (multitask).	1,050,000	Non affordable price and only for people with low vision, but not total blindness
OrCam [13]	Multitask- includes reading	175,000	Non affordable price
Screen reader [14]	Reading digital format (one task)	70,000	Only for digital Content
Proposed	Object	17,000	Affordable
AI glasses	detection,		price, Find
	Temperature		my glasses,
	hazard alert,		Object
	Auditory		detection,
	warning		Type of
	(multitask)		object.

As Table 1, the eSight 4 is a sophisticated device designed to re-display live scenes, catering specifically to individuals with low vision. Priced at 1,050,000 Rs, it falls into the category of high-end assistive technology, rendering it non- affordable for many. It offers multitasking capabilities, allowing users to engage with their surroundings in real-time. However, its limitation lies in its high cost and exclusive focus on those with low vision rather than total blindness, making it inaccessible to a broader user base.

OrCam, another assistive technology, offers multitasking features such as reading and screen reading. Priced at 175,000 Rs, it falls into the non-affordable category. While its reading capabilities are commendable, the device is tailored for those with low vision and does not cater to individuals with total blindness. Additionally, the screen reader variant, priced at 70,000 Rs, focuses on reading digital content only. These price points and limitations position OrCam as a valuable but financially inaccessible option for many potential users.

The "Screen reader" device, priced at Rs 70,000, is designed to perform a single task, which is reading digital content. This makes it specifically suitable only for accessing digital material, indicating its limited functionality compared to other multi-tasking smart glasses. Its singular focus on digital content underscores its role as a specialized tool within assistive technology for the visually impaired.

The proposed AI glasses aim to address these affordability concerns. Priced at 17,000 Rs, these glasses offer multitasking functionalities, including object detection, temperature hazard alerts, and auditory warnings. The emphasis on affordability and the incorporation of multiple tasks makes these

AI glasses a promising solution, widening accessibility to a more diverse user demographic. The proposed glasses bridge the gap by combining functionality, affordability, and inclusivity in their design.

Proposed Design

Considering the above literature review, available devices and the limitations of smart glasses, proposed a new model "Smart Glasses Using Ultrasonic sensor and AI". proposed model incorporates sophisticated machine learning techniques, notably the YOLOv5 model, for real-time object detection. Integrated into the Raspberry Pi, this technology allows the smart glasses to quickly identify and classify objects, enhancing navigation for visually impaired users. This integration of advanced AI, alongside tools like python libraries and Google Text to Speech, provides crucial auditory feedback, significantly enriching the user experience and safety. Block Diagram Proposed model is shown in Figure 2.

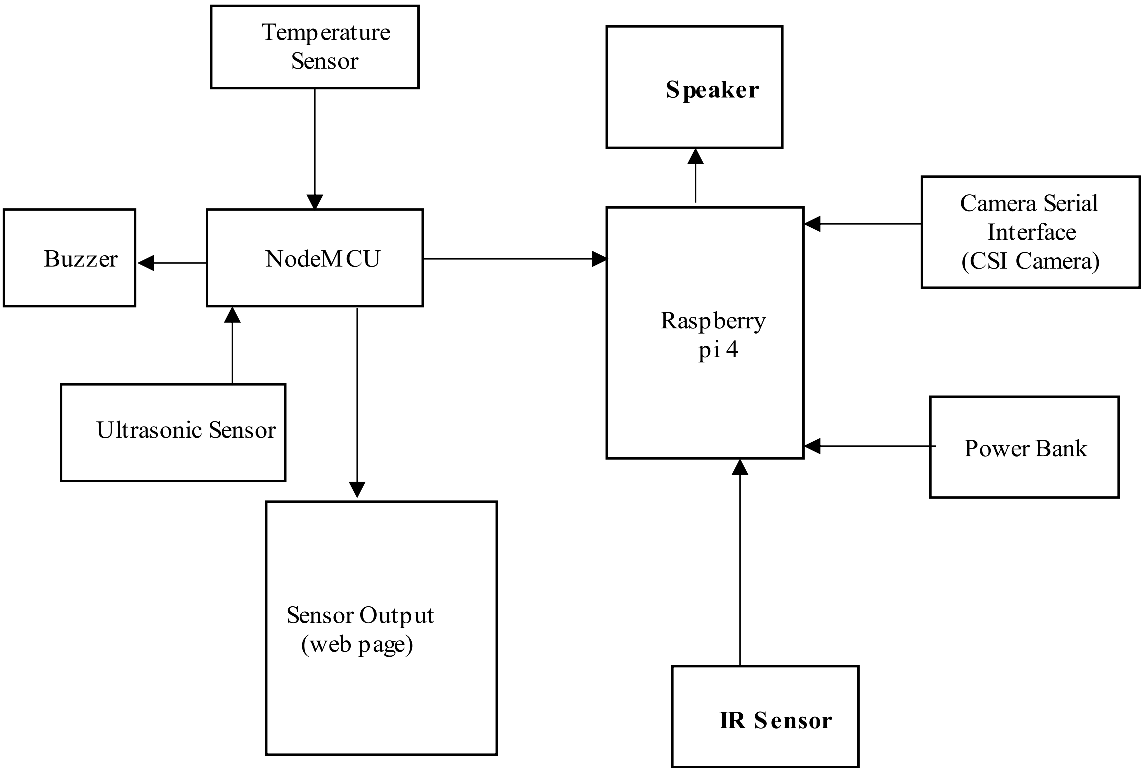

Figure 2. Block diagram proposed model.

Proposed model also utilizes cloud-based platforms like Google Colab for efficient AI model training, which streamlines development and ensures robust performance. Additionally, the inclusion of user-friendly development tools like PyCharm enhances the software's flexibility, making it adaptable to various user needs. The culmination of these technologies results in a comprehensive assistive device that pushes the boundaries of what smart glasses can achieve for the visually impaired community.

Object recognition model with obstacle detection and distance measuring that helps blind people grasp everything in their environment in real time The environment's current temperature and humidity are calculated by a temperature and humidity sensor, which notifies a blind person in case of danger.

Smart glasses that employ sensors to gauge the distance between the wearer and nearby objects are able to detect obstacles. Ultrasonic sensors measure distance using ultrasonic pulses. Its components are an ultrasonic pulse emitter (transmitter) and a time-sensitive receiver (receiver) that detects the reflected waves.

The sensor determines how far away the obstruction is in order for the waves to return. The ultrasonic sensor in the proposed system is equipped with a Node MCU on the front of the glasses, which triggers a buzzer sound when it detects an impediment less than 100 cm in its route. The sound is released by the buzzer to notify the user that the object is close. It is essential to have this instantaneous audio feedback when navigating through crowded or unfamiliar areas.

The proposed model also incorporates sophisticated machine learning techniques, prominently featuring YOLOv5 for real-time object detection. YOLOv5, known for its efficiency and accuracy, is seamlessly integrated into the Raspberry Pi, enabling the smart glasses to identify and classify objects in the user's surroundings. The choice of YOLOv5 reflects a commitment to leveraging advanced AI algorithms for enhancing the perceptual capabilities of the device. This approach not only addresses the immediate needs of visually impaired users but also positions the technology at the forefront of innovation in assistive devices.

Finally, this approach embraces the potential of Python libraries PyCharm Development Tools and cloud-based resources, like Google Colab to train AI models. This collaborative framework simplifies the development process fosters a relationship between different software components. The incorporation of Google Text to Speech (GTTS) adds to the user experience by providing output. In summary this proposed approach envisions an integration of hardware and software that culminates in the creation of "Smart Glasses Using Ultrasonic Sensor and AI" an assistive device that goes beyond traditional boundaries.

“Smart glasses using ultrasonic sensor and ai For Blind Person” reflects a systematic and interdisciplinary approach, combining hardware integration and software implementation to achieve a cohesive, functional system. proposed model hardware foundation comprises the Raspberry Pi, Node MCU, ultrasonic sensor, and additional peripherals, strategically interconnected on a Zero PCB board. This hardware ensemble forms the backbone of the smart glasses, facilitating distance measurement, temperature monitoring, and user interaction through a meticulously designed circuit. The Zero PCB board, serving as a common platform, streamlines power distribution and signal routing, ensuring stability and accurate readings from the sensors.

As Figure 2's block diagram illustrates, the system architecture is designed to facilitate a decision-making process based on sensory input from a camera and microphone. At the top, two separate inputs, "Camera Input" and "Microphone Input," feed into their respective processing blocks. The "Camera Process" block likely handles image analysis, while the "Sound Process" block processes audio signals.

These processed inputs convert into a "Central AI," the core decision-making unit, which evaluates the processed data to make context-aware decisions. This AI may use algorithms for object detection, hazard awareness, and auditory cues interpretation, as indicated by the labels surrounding the AI block: "Object Detection," "Temperature Alert," and "Auditory Warning."

Post-processing, the outputs are directed towards a "Decision" block, symbolized by a rectangular shape, indicating a branching decision point. Depending on the decision made, the system can either interact with the user through the "Display" block, which might provide visual feedback, or through an "Audio Output" block, offering auditory information or alerts.

Furthermore, there are peripheral interactions with "Memory" and "Processor" blocks, suggesting that the system uses storage for data retention and a processor for managing tasks, enhancing the system's efficiency and responsiveness.

RESULTS & DISCUSSION

The implementation of the "Smart Glasses Using Ultrasonic Sensor and AI For Blind Person" proposed model yielded promising outcomes in terms of functionality, affordability, and user-centric design. The YOLOv5 model-powered object identification module showed strong real-time detection performance, giving users improved spatial awareness. The integration of ultrasonic sensors for proximity detection and temperature sensors for ambient monitoring contributed to a comprehensive system capable of addressing diverse environmental challenges. In Figure 3. auditory warning system, utilizing a buzzer or speaker, successfully delivered immediate alerts based on the analyzed data, ensuring users were promptly informed of potential hazards. In terms of affordability, the proposed AI glasses presented a cost-effective solution, priced at 17,000 (INR). This stark contrast with existing devices, such as eSight 4 and OrCam, positioned the proposed model as a more accessible option for a wider demographic. The affordability factor combined with multitasking capabilities, marked a significant achievement in making advanced assistive technologies available to a broader audience. The multitasking capabilities of the proposed model, including object detection, temperature hazard alerts, and auditory warnings, represent a comprehensive approach to enhancing environmental awareness. This functionality aligns with the varied needs of users, allowing them to navigate and interact with their surroundings more confidently. The successful execution of these tasks validates the effectiveness of the chosen hardware components and software algorithms. The affordability of the proposed model addresses a significant barrier in the adoption of assistive technologies. While devices like eSight 4 and OrCam provide valuable functionalities, their high costs limit accessibility. The proposed glasses aim to bridge this gap, ensuring that individuals with visual impairments, regardless of economic status, can benefit from advanced assistive technologies.

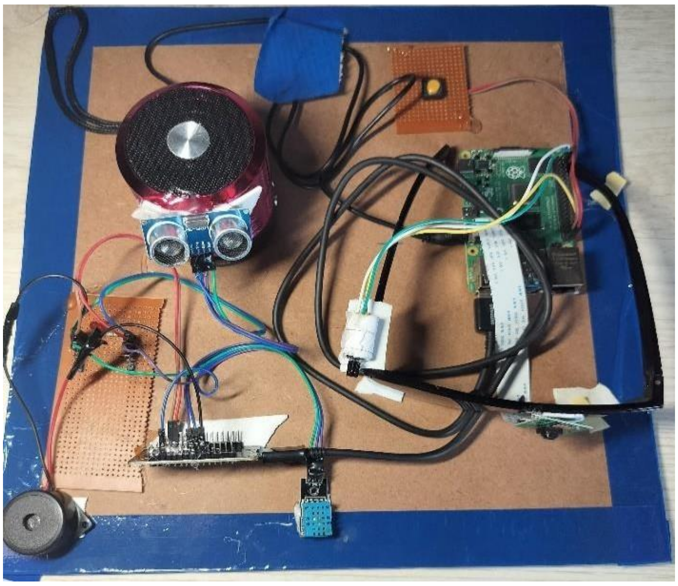

Figure 3. Smart AI glasses.

The following latency Table 2. provides a detailed breakdown of the time each process consumes, including image capture, processing, inference by the YOLOv5 model, and the delivery of spoken output to the user.

Table 2. Latency table

Example No.	Image Capture(s)	Processing Time (s)	Yolov5 Interferences(s)	Speaker Output (s)	Total Latency(s)
1.	0.8	1.2	2.5	0.3	4.8
2.	0.85	1.25	2.6	0.35	5.05
3.	0.75	1.1	2.4	0.25	4.5
4.	0.9	1.3	2.7	0.4	5.3
5.	0.82	1.15	2.55	0.32	4.84

6.	0.78	1.05	2.45	0.28	4.56
7.	0.83	1.22	2.52	0.33	4.9
8.	0.77	1.18	2.48	0.29	4.72
9.	0.86	1.27	2.63	0.36	5.12
10.	0.79	1.12	2.5	0.31	4.72
Average	0.815	1.184	2.533	0.319	4.851

Additionally, the graph as shown in Figure 4 visually illustrates these latencies, allowing for an at-a-glance comparison of the system's responsiveness across multiple trials. These metrics are indispensable for understanding the system's efficiency and for informing further optimization to ensure that the smart glasses operate seamlessly, offering a virtually instantaneous aid to visually impaired users.

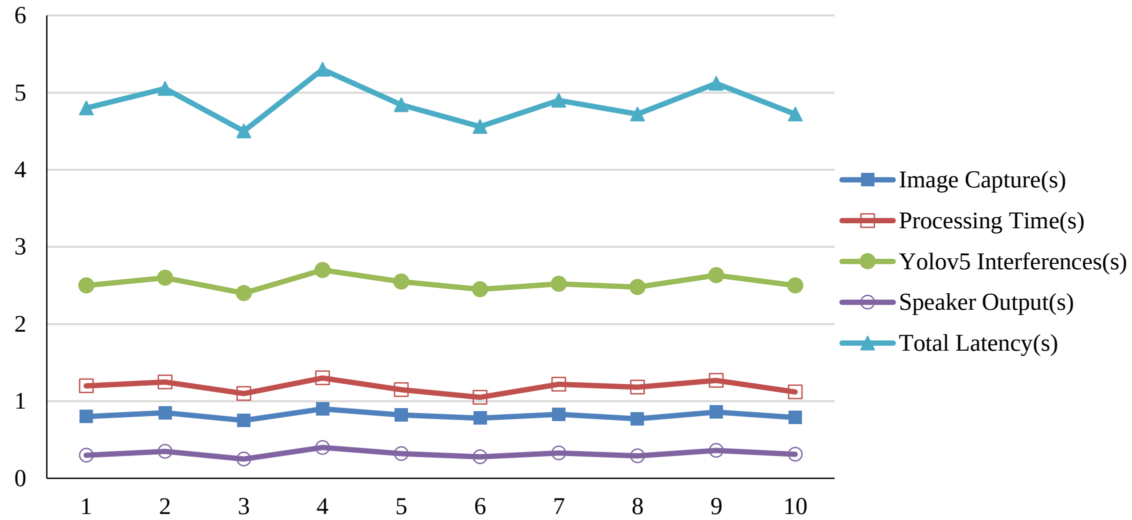

Figure 4. Latency graph.

CONCLUSION & FUTURE WORK

- In this paper, we analyze the implementation and outcomes of the "Smart Glasses Using Ultrasonic Sensor and AI For Blind Person" proposed model designed to assist visually impaired individuals. The multifaceted functionalities, including object detection, temperature hazard alerts, and auditory warnings, demonstrated the project's capability to enhance spatial awareness and provide real-time environmental feedback. Moreover, the affordability of the proposed model, priced at 17,000 (INR), represents a crucial step towards democratizing advanced assistive technologies. Through a user- centric design approach and community involvement, the project emphasizes the importance of tailoring solutions to meet the specific needs of the visually impaired. The success of this endeavor signifies a significant stride in making inclusive and accessible technologies that empower users and contribute to their independence and safety in daily life.
- In future work, critical enhancements will be pursued to fortify the "Smart Glasses Using Ultrasonic Sensor and AI For Blind Person" proposed model. In order to secure user data and allay worries about the device's customization options, password protection procedures will be put in place. Improvements in the accuracy of object detection algorithms will be a focal point, with the exploration of advanced machine learning techniques and continuous model training to enhance recognition capabilities. Fine-tuning the ultrasonic sensor's precision in measuring the distance to objects will be prioritized, refining the glasses' spatial awareness and obstacle detection capabilities. Additionally, the integration of Bluetooth technology will be explored, enabling seamless connectivity with other devices and expanding the functionality of the smart glasses.

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