RV College of Engineering®

TEAM IKSHANA

MANUFACTURING - Team 21

Monday,13th January 2025

Go, change the world

Team Members

1. **Arya Wadhwa** - RVCE24BCI101 -aryawadhwa.ai24@rvce.edu.in
2. **Bahuleya Mahesh** - RVCE24BCI016 -bahuleyam.ai24@rvce.edu.in
3. **Shivani Srinivasan** - RVCE24BBT012 -shivanis.bt24@rvce.edu.in
4. **Devansh Mathur** -RVCE24BME013-devanshmathur.me24@rvce.edu.in

Smart Glasses for the Visually Impaired and Blind

EL PHASE III PRESENTATION OUTLINE

- Introduction
- Problem Statement
- Objectives
- Literature Review
- Methodology
- Design and Implementation
- Components and Tools Used
- Results/Simulation
- Challenges Faced
- Applications
- Future Scope
- Conclusion
- Acknowledgement
- References

INTRODUCTION

- Blindness and visual impairment are pressing challenges that affect millions globally, with approximately 253 million individuals facing visual impairment and 36 million who are blind, according to the World Health Organization.
- In India, an estimated 4.95 million people are blind, including 0.24 million blind children, and around 70 million suffer from varying degrees of vision impairment.
- Unfortunately, many of these individuals lose their sight entirely due to a lack of early detection and intervention. Beyond the loss of vision, they confront societal discrimination, accessibility challenges, and significant psychological impacts.
- In a consumer-centric market like India, there is a critical need for innovative, affordable solutions that cater to this demographic.
- Our mission is to create an effective, cost-efficient product that has its own novelties aiming to differentiate current solutions available in the Indian and foreign markets

PROBLEM STATEMENT

Problem definition : Current assistive technology for visually impaired individuals is not completely accurate, has a limited field of view, limited range of object detection and the navigation system is not implemented properly

Significance of the problems mentioned : Visually impaired individuals in India face significant challenges that emphasize the need for improved assistive technology. Limited access to advanced devices restricts their ability to navigate safely and independently, as current solutions often lack the necessary accuracy and range. Additionally, poor infrastructure and societal stigma create barriers to mobility and employment, leading to economic hardships and social isolation. Innovative solutions are essential to enhance the quality of life and independence among these individuals.

Consequences of NOT Addressing the Problem:

- **Safety Risks and Reduced Independence**: Limited accuracy and detection range increase the likelihood of accidents, reducing the user's ability to navigate independently.
- **Restricted Mobility**: A narrow field of view limits spatial awareness, causing users to miss important environmental cues, impacting their freedom of movement.
- **Emotional and Social Impacts**: Ineffective devices lead to frustration and lower confidence, increasing social isolation and reducing quality of life.

OBJECTIVES

Main Objective : To create cutting-edge smart glasses that improve navigation and object detection for individuals with visual impairments, we aim to overcome the shortcomings of current assistive technologies regarding accuracy,perceptual range and overall user experience. This innovation seeks to enhance independence and elevate the quality of life for users.

Specific Objectives:

1. **Enhance Object Detection:** Integrate advanced sensors and algorithms to improve the accuracy and range of object detection, allowing users to identify obstacles and navigate their environment more effectively.
2. **Expand Field of View:** Design the smart glasses with a wider field of view to ensure users can perceive their surroundings more comprehensively, minimizing blind spots and enhancing situational awareness.
3. **Develop a User-Friendly Navigation System:** Create an intuitive navigation system that provides real-time auditory feedback and guidance, enabling users to navigate complex environments with confidence and ease.

LITERATURE REVIEW

1. "Wearable Vision Assistance System for Visually Impaired Persons"

- Liwei Zhang, Qi Liu, Yonggang Wang

The paper presents a well-thought-out solution to help visually impaired individuals navigate their environment. However, it faces challenges in real-time detection, power efficiency, and field of view. The measures proposed, such as using multiple sensors, power optimization, and faster ML models, provide a strong basis for overcoming these challenges. The cost of developing such a system may range from a few thousand dollars for prototypes, scaling to more significant amounts depending on the complexity and distribution of the final product.

Shortcomings:

Limited Field of View (FOV), Accuracy, Difficulty in Processing Complex Environments, Latency in Object Detection

2. "Assistive Technologies for People with Visual Impairments: Smart Glasses and Beyond"

- Huy-Hieu Pham, Hideyuki Takahashi, and Tatsuya Yamamoto

The device supports navigation, object recognition, and daily task facilitation for visually impaired individuals. It highlights the role of smart glasses equipped with cameras, sensors, and auditory feedback mechanisms, which work in alliance with machine learning algorithms to detect obstacles and identify objects. The authors also examine broader assistive technologies beyond smart glasses, including haptic and auditory devices, comparing their effectiveness and potential to enhance user independence and quality of life.

Shortcomings:

Limited Range of Object Detection, Limited Real-World Testing, Accuracy

3. "Echolocation Glasses: Enabling the Visually Impaired to Sense Their Environment"

- Kai-Wei Chang, Yiran Zeng, and Tzu-Kai Lin

The paper explains the principles of echolocation, including how sound waves are emitted and reflected off objects, allowing users to interpret their surroundings.It discusses the technical aspects of the glasses, including sensors and sound processing algorithms that convert distance information into audible cues.

Shortcomings :

Learning Curve, Environmental Limitations, Enhancing Sound Processing Algorithms

4. “Assistive Object Recognition System for Visually Impaired”

- Shifa Shaikh, Vrushali Karale, Gaurav Tawde

The project presents an innovative assistive technology aimed at improving the quality of life for visually impaired individuals. By leveraging the capabilities of Raspberry Pi and advanced object detection algorithms like YOLO, the system facilitates real-time object recognition and voice feedback, promoting independent navigation. The future enhancements indicated in the project suggest a promising path toward more comprehensive support for users with visual impairments.

Shortcomings:

Limited Processing Power, Accuracy, Inference Speed, Difficulty in Audio Integration

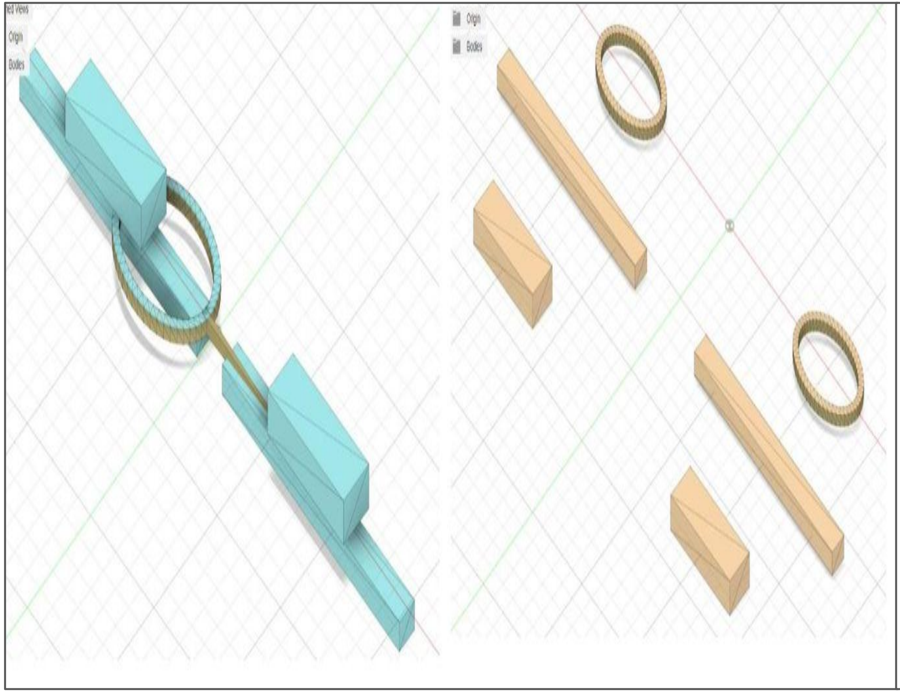
METHODOLOGY

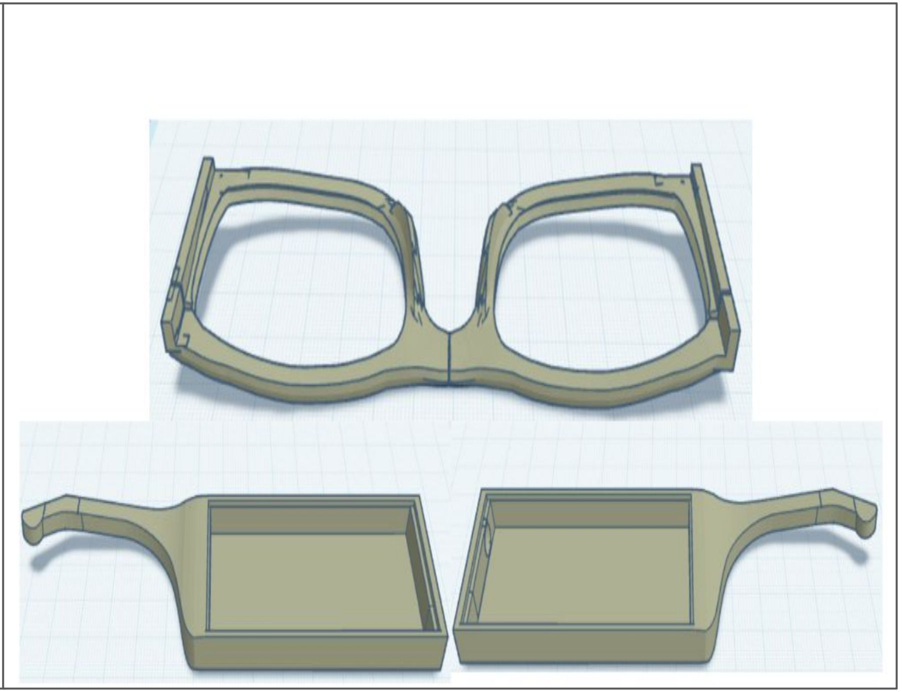
To make the smart glasses functional, we integrated several technologies and components:

1. **Computer Vision (OCR)**:
   We used **OpenCV** and **Tesseract OCR** to capture images via the camera and extract any text in real time. This allows the glasses to "read" text from books, signs, or labels aloud to the user.
2. **Object Detection**:
   Using a **pre-trained MobileNet SSD model** with **OpenCV's deep learning module**, the glasses can detect objects in the camera's field of view and provide audio feedback about the identified objects, such as "chair," "dog," or "bicycle."
3. **Speech Recognition**:
   The glasses are equipped with offline **speech recognition** powered by **PocketSphinx**. Users can issue voice commands like "Read Text" or "Detect Objects," enabling hands-free interaction.
4. **Text-to-Speech (TTS)**:
   Commands and feedback are delivered using **offline TTS** (Festival) to read out text and object detections, helping visually impaired users navigate and interact with their environment.
5. **User Interface**:
   The system features a terminal-based UI displaying available commands, and the device listens for user input via voice commands, making it intuitive and easy to use for blind users.

This integration of computer vision, speech recognition, and TTS provides a comprehensive solution for blind or visually impaired users, enabling them to interact with the world more independently.

DESIGN AND IMPLEMENTATION





Initial Designs

Final Design

- **Design 1:** A circular component was added to improve functionality and enhance symmetry between parts. However, stability issues and material inefficiency became apparent.

- **Design 2:** The third design refined proportions and integrated components seamlessly, balancing functionality, stability, and aesthetics. However, minor stability issues under stress, material optimization concerns, and limited flexibility for different head sizes were identified, and the aesthetics could be further refined.

- **Design 3:** The final design addressed previous flaws with improved weight distribution, power efficiency, and overall durability. While it is the most efficient iteration, further optimization for energy usage and impact resistance is needed for maximum performance.

COMPONENTS AND TOOLS USED

Hardware

- **Raspberry Pi Microprocessor**: Serves as the core processing unit for running AI models.
- **Raspberry Pi Camera**: Captures real-time images for object detection and processing.
- **Lithium-ion Battery and battery controller**: Powers the device, enabling portability and prolonged use.

Design Tools

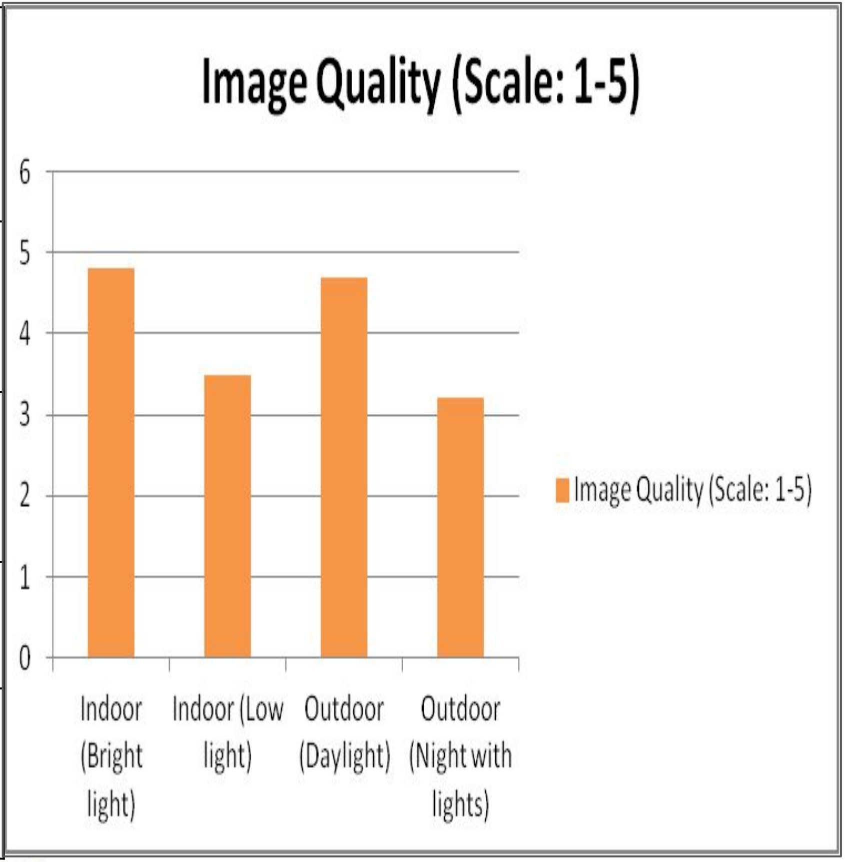
- **AutoDesk Fusion 360**: Used for designing an ergonomic and user-friendly frame.
- **3D Printing**: Facilitates rapid prototyping and testing of the frame and other components.

Development Tools

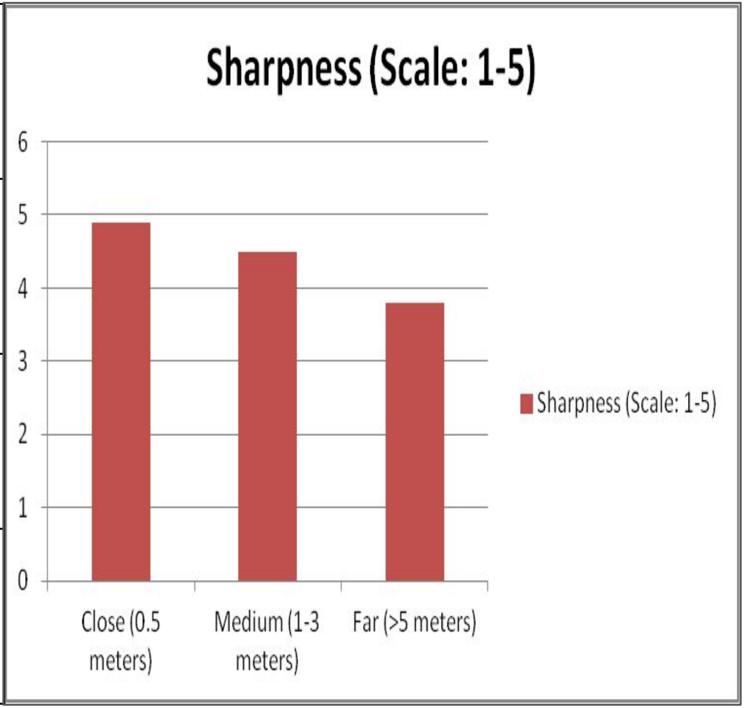
- **Python & TensorFlow**: For training and deploying AI models for object detection and recognition.
- **OpenCV**: Enables advanced computer vision tasks such as image preprocessing and analysis.

RESULTS/SIMULATION

Test Environment	Resolution (pixels)	Image Quality (Scale: 1-5)	Notes
Indoor (Bright light)	1920 x 1080	3.5	High clarity, good detail retention.
Indoor (Low light)	1920 x 1080	3.2	Moderate noise, reduced sharpness.
Outdoor (Daylight)	1920 x 1080	3.0	Crisp images with good contrast.
Outdoor (Night with lights)	1920 x 1080	2.6	Glare from artificial lighting affected clarity.



Object Distance	Sharpness (Scale: 1-5)	Notes
Close (0.5 meters)	3.6	Very sharp; ideal focus for nearby objects.
Medium (1-3 meters)	3.2	Slightly reduced sharpness, still readable.
Far (>5 meters)	2.2	Blur increases with distance.



The testing of our smart glasses demonstrates significant progress in image clarity and object detection capabilities.

Image Clarity Testing

- **Resolution Performance**:
  - Excellent image clarity under **bright lighting conditions**, with a quality rating of up to 4.8/5.
  - Reduced performance in **low-light conditions**, with an average rating of 3.5/5 due to noise.
- **Sharpness and Focus**:
  - Best performance at **close distances (0.5m)** with a sharpness rating of 4.9/5.
  - Gradual decline in sharpness at greater distances (>5m), averaging 3.8/5.

Object Detection Capability

- The glasses effectively perform **object detection**, converting captured images into identifiable objects.
- Further optimization is required to improve detection reliability in **low-light** and **distant scenarios**.

CHALLENGES FACED

1. Hardware Limitations

- **Overheating Issues**: The Raspberry Pi occasionally overheats during extended use.
- **Design Complexity**: Initial prototype was bulky, impacting user comfort and usability.
- **Power Consumption**: The system's high power usage limits battery life, requiring frequent recharges.

2. Software Challenges

- **Latency in Processing**: Real-time image capture and object detection introduce slight delays.
- **Low-Light Performance**: Image clarity and detection accuracy are reduced in dim lighting conditions.
- **Dataset Limitations**: Training the object detection algorithm on diverse datasets was challenging, leading to occasional inaccuracies.

3. Environmental Constraints

- **Lighting Variability**: Performance decreases in environments with low light or high glare.
- **Weather Impacts**: Rain and fog reduce camera effectiveness, affecting clarity and object detection.

4. Ethical Concerns

- **Privacy Issues**: Capturing images in public spaces raises concerns about user and bystander privacy.

APPLICATIONS

1. **Improved Mobility and Independence**
   - **Description**: Smart glasses can help blind users navigate through public spaces, avoid obstacles, and independently move around their environment.
   - **Benefit**: Increases personal freedom and reduces reliance on others for mobility.
2. **Enhanced Access to Information**
   - **Description**: With text recognition and voice feedback, these glasses provide access to printed materials, such as signs, menus, and books.
   - **Benefit**: Promotes inclusion by enabling blind individuals to interact with the world around them more easily.
3. **Workplace and Educational Support**
   - **Description**: By providing real-time feedback on tasks, objects, or written materials, smart glasses can assist blind individuals in professional and educational environments.
   - **Benefit**: Supports greater participation and productivity in various aspects of work and learning.
4. **Health and Safety**
   - **Description**: The glasses can provide notifications about the user's environment, such as detecting obstacles, changes in terrain, or potential hazards.
   - **Benefit**: Enhances safety and helps prevent accidents or injuries.

FUTURE SCOPE

1. Advanced Text Recognition

- Real-time reading and audio translation of written text for enhanced access to printed or digital information.

2. Indoor Navigation

- Precise mobility support in indoor environments through sensors and beacons, offering improved navigation.

3. Facial Recognition

- Identification of familiar faces to foster better social interactions and inclusivity.

4. Voice Assistant Integration

- Hands-free operation through seamless voice control, enabling personalized user experiences.

6. Longer Battery Life

- Improved energy efficiency ensures extended usage periods without compromising comfort and usability.

CONCLUSION

As we conclude this phase of our project, we’re proud to reflect on the progress we've made

- **Prototyping & Design:** We’ve refined our 3D models to prioritize comfort, functionality, and usability, with several iterations leading to a final design that’s ready for production.
- **Electronics & Integration:** Core components have been sourced and successfully integrated. The glasses are now equipped with sensors and microcontrollers, and we are optimizing the system for seamless operation.
- **Software Development:** Significant advancements have been made in object detection, currency recognition, and text-to-speech feedback. Our software is now faster and more accurate, with continued improvements in navigation algorithms to ensure reliability in diverse environments.

This journey has been both challenging and inspiring. With these advancements, we’re one step closer to delivering a smart glasses solution that empowers the visually impaired, enhancing their independence and quality of life.

"The true sign of intelligence is not knowledge but imagination and vision." – Albert Einstein

ACKNOWLEDGEMENT

We would like to express our heartfelt gratitude to our mentor, **Ashwin Thammaiah**, for his unwavering guidance, valuable insights, and constant support throughout the course of this project. His expertise has been instrumental in shaping the direction of our work. We also extend our sincere thanks to **RV College of Engineering** for providing us with the necessary resources and platform to undertake this project. Additionally, we are deeply grateful to the **Mechanical and Electrical Engineering Departments** for their technical assistance and collaboration, which played a crucial role in the successful completion of this endeavor. Without their collective support, this project would not have been possible.

REFERENCES

"Assistive Technologies for People with Visual Impairments: Smart Glasses and Beyond"

Parmar, V., Reddy, D. C., & Kumar, S. (2020). Assistive smart glasses: Improving mobility for the visually impaired. International Journal of Engineering Research and Technology (IJERT), 9(7), 1134-1139.

"Echolocation Glasses: Enabling the Visually Impaired to Sense Their Environment"
Chang, K.-W., Zeng, Y., & Lin, T.-K. (2024). Echolocation glasses: Enabling the visually impaired to sense their environment. ICAEEE

“Assistive Object Recognition System for Visually Impaired”

Zhang, L., Liu, Q., & Wang, Y. (2020). Assistive Object Recognition System for Visually Impaired. IEEE Transactions on Neural Systems and Rehabilitation Engineering, 28(3), 756-765.

"Assistive Technologies for People with Visual Impairments: Smart Glasses and Beyond"

Pham, H.-H., Takahashi, H., & Yamamoto, T. (2021). Assistive technologies for people with visual impairments: Smart glasses and beyond. Sensors, 21(10), 1-23. https://doi.org/10.3390/s21103538


Thank You!