Navigation Aid for Visually Impaired

A project report for end term evaluation

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AN INSTITUTE OF NATIONAL IMPORTANCE ESTABLISHED BY THE MINISTRY OF HOME AND RESOURCE MANAGEMENT

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UNDER THE GUIDANCE OF

Dr. Dinesh Kumar V.

ACKNOWLEDGMENT

We would like to express our deep gratitude towards ***Dr. Dinesh Kumar V.,*** Associate Professor, Department of Mechanical Engineering, Pandit Dwarka Prasad Mishra Indian Institute of Information Technology, Design and Manufacturing, Jabalpur, for their guidance with unsurpassed knowledge and immense encouragement.

Lastly, we would like to thank our parents, friends, and classmates for their immense support and encouragement during our project. We would like to thank everyone who supported us directly or indirectly during this time.

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1. Introduction

1.1 NAVIGATION AID FOR VISUALLY IMPAIRED

- **Objective**:

  This project aims to create a hands-free, wearable navigation aid for visually impaired users using haptic feedback and audio cues. It utilizes LiDAR-based depth sensing for real-time obstacle detection and spatial awareness in various environments. The device is designed to be lightweight, efficient, and comfortable, promoting long-term independent mobility.

- **Key Features**:

  - LiDAR-based depth sensing
  - Haptic feedback and air conduction audio cues
  - Lightweight, hands-free, and energy-efficient design

1.2 BACKGROUND AND NEED

- Traditional aids like white canes and guide dogs have limitations in obstacle detection, cost, and convenience.
- Visually impaired individuals lack a comprehensive, hands-free tool that provides real-time spatial awareness without blocking environmental sounds.
- Smartphone apps are unreliable in indoor or low-signal areas due to dependence on GPS.

1.3 MOTIVATION

- To enhance independent mobility and safety through a wearable device offering haptic and audio feedback.
- To leverage LiDAR and real-time environmental analysis for accurate navigation in all settings.
- To provide a lightweight, energy-efficient solution that works effectively both indoors and outdoors, day or night.

2. User/Field Study

2.1 Potential Use Case

The Navigation Aid has a wide range of applications across multiple parameters in visually impaired India, particularly in environments which is not much adaptive.

- **Independent Daily Navigation:** Assisting visually impaired individuals in safely navigating homes, offices, streets, malls, and public transport.
- **Object and Person Identification:** Helping users recognize static and dynamic obstacles, household items, and familiar faces in both familiar and unfamiliar environments.
- **Situational Awareness:** Providing real-time feedback for crossing roads, avoiding moving vehicles, and identifying doorways or signboards.
- **Indoor and Outdoor Mobility:** Supporting users in transitioning seamlessly between indoor and outdoor spaces without relying on sighted assistance

2.2 Targeted Users

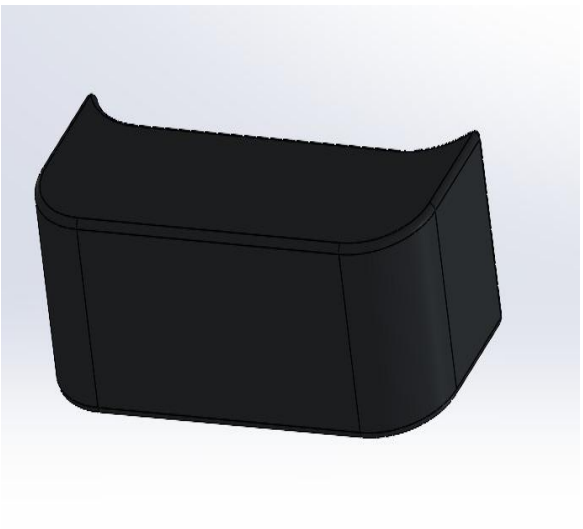
- **Students and working professionals** seeking independence in daily tasks and commuting.
- **Rural and semi-urban residents** with limited access to high-tech assistive devices.
- **Middle- and low-income groups** looking for cost-effective, multifunctional solutions.
- **Non-tech-savvy users** needing easy-to-use, intuitive interfaces

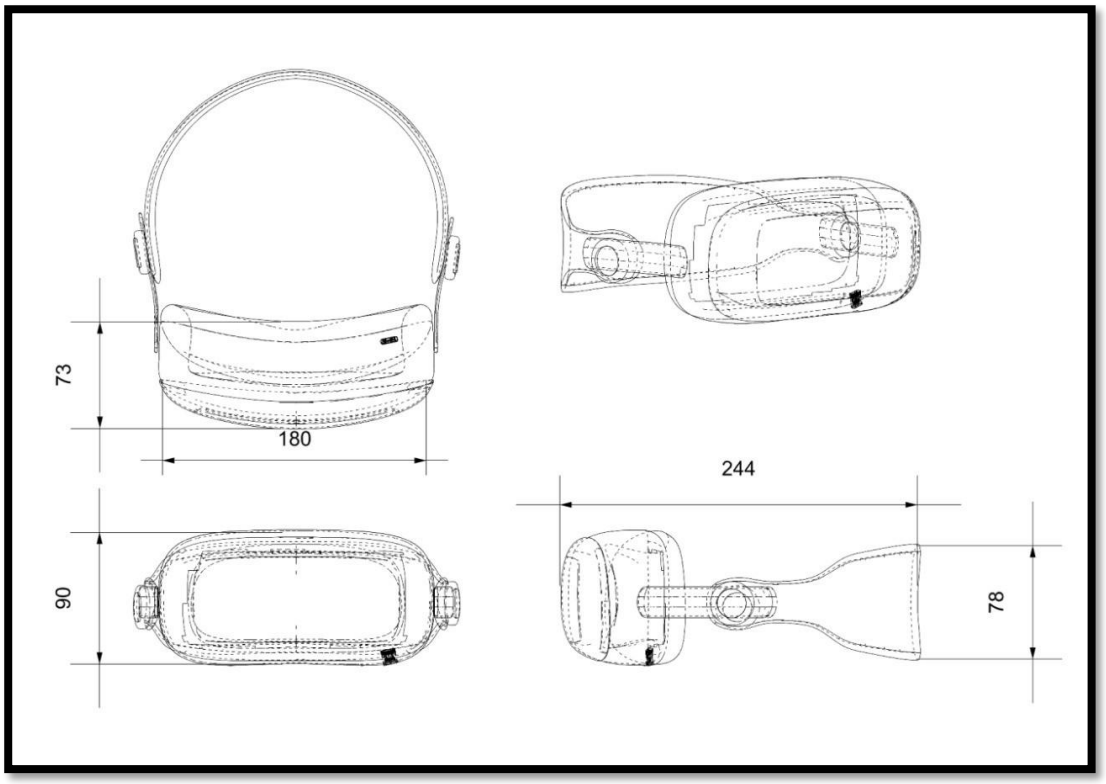
2.3 Stakeholder Requirements

- **Essential Functionalities:**
  - Obstacle and moving object detection (including bicycles, cars, overhead signs).
  - Face and object recognition capabilities.
  - Real-time voice guidance and haptic feedback.
- **Design Preferences:**
  - Lightweight, compact, and discreet design suitable for public use.
  - Comfortable and hands-free operation.
- **Cost and Accessibility:**
  - Affordable pricing (₹5,000–₹20,000).
  - Availability in regional languages and compatibility with Indian environments.
  - Low learning curve with simple operation suitable for varying tech-literacy levels.

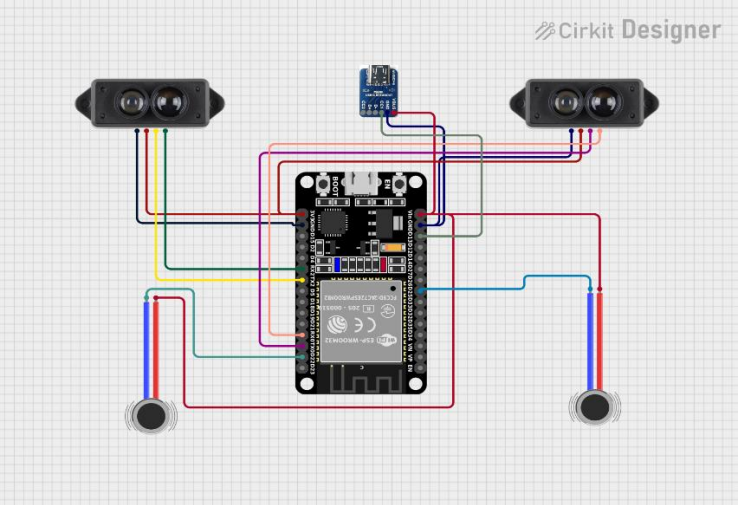
3. TECHNICAL/PRODUCT SPECIFICATIONS

3.1 Mechanical Design

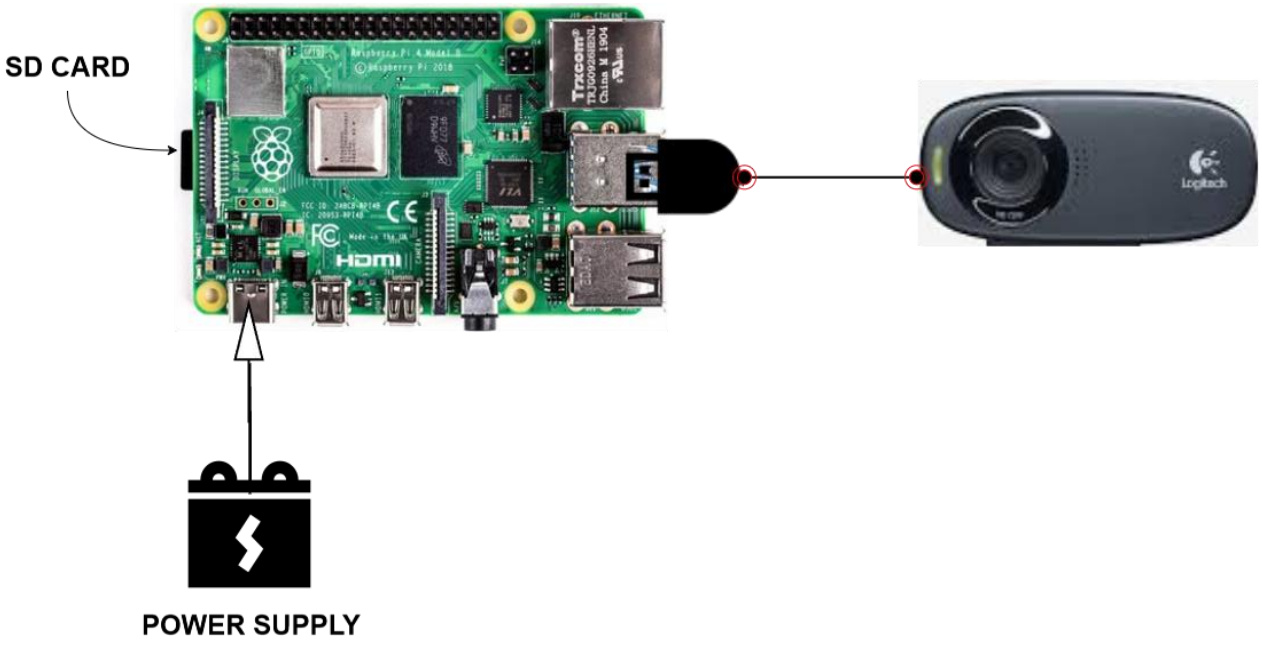




3.2 Electronics and Detection Systems



- **ESP32 WROOM-32 Controller**
- **LIDAR and Vibration motor sensors.**
- **Raspberry Pi-5 with Logi-Tech Camera**



3.3 Fabrication Architecture:

A. Hardware Layout:

- **Central Controller:** Raspberry Pi 5 (32GB RAM)
- **Vision System:** USB Webcam or Pi Camera Module for capturing live feed
- **Sensors:**
    - a. **Ultrasonic Sensor (HC-SR04):** Measures distance to nearby obstacles
    - b. **Vibration Motor Module:** Provides haptic feedback based on proximity
- **Audio Feedback:** Bluetooth Earphones for real-time object name announcements
- **Power Supply:** 20000 mAh Li-ion Power Bank with USB output

B. Software Layout:

- **Object Detection Engine:** YOLOv8 (Ultralytics) running on PyTorch
- **Programming Language**: Python 3.10
- **Key Libraries:**
    - OpenCV for video stream handling
    - Pyttsx3 for offline Text-to-Speech (TTS)
    - RPi-GPIO for sensor and motor control
- **Data Handling:** XML-labeled datasets used for object recognition classes

4.Concept Generation

The concept of the *Smart Navigation Aid for Visually Impaired Individuals* emerged through a structured idea development process focused on solving real-world mobility challenges faced by people with visual impairments. Key steps and inspirations in the concept generation phase included:

1. Problem Identification:

- Recognized the limitations of traditional aids like white canes and guide dogs.
- Observed difficulty in detecting obstacles beyond ground level or moving objects**.**

2. User-Centric Approach:

- Considered feedback from visually impaired users about their daily navigation struggles.
- Focused on hands-free operation and real-time awareness**.**

3. Technology Research:

- Explored affordable and compact AI solutions like YOLOv8 for object detection.
- Evaluated sensors suitable for distance measurement and obstacle awareness (e.g., LiDAR, ultrasonic).

4. Feasibility Assessment:

- Chose Raspberry Pi and ESP32 for their GPIO capabilities and processing power.
- Ensured the entire system could run offline to suit varied environments**.**

5. Multi-Modal Feedback Design:

- Combined vibration motors for haptic alerts with Bluetooth earphones for audio guidance.
- Designed to cater to both mild and fully blind users with flexible feedback modes.

6. Simplicity & Portability:

- Conceptualized a wearable device that is lightweight, unobtrusive, and easy to power.

7. Prototyping Goals:

- Set goals for a modular, scalable, and user-friendly system that could be improved or extended in future iterations.

8. Scalability & Future Readiness:

- Envisioned integration with GPS, mobile apps, and cloud services for next-gen enhancements.

5.Cost of Fabrication

S.No.	Item Description	Vendor Details (including Bill No. & Date)	No of Components	Rate	Amount (INR)
1.	Realtek AMB82-Mini IoT AI Camera Arduino Dev. Board	Robu.in (INV2425/357147 & 09.03.2025)	1	₹ 2,600.00	₹ 2,600.00
2.	ERM Coin Vibration Motor, 8 mm Dia.,2 mm Width	Robu.in (INV2425/357147 & 09.03.2025)	6	₹ 58.00	₹ 348.00
3.	Benewake TFMini-S Micro LiDAR Distance Sensor	Robu.in (INV2425/357147 & 09.03.2025)	4	₹ 3245.00	₹ 12,980.00
4.	GPS NEO-6M Satellite Positioning Module Development Board	Robu.in (INV2425/357147 & 09.03.2025)	1	₹ 538.00	₹ 538.00
5.	SanDisk Micro SD 32GB Class 10 Memory Card	Robu.in (INV2425/357147 & 09.03.2025)	1	₹ 419.00	₹ 419.00
6.	Digital Sensor TTP223B Capacitive Touch Switch	Robu.in (INV2425/357147 & 09.03.2025)	1	₹ 24.00	₹ 24.00

7.	Male to Male Jumper Wires 40 Pin 30cm	Robu.in (INV2425/357147 & 09.03.2025)	1	₹ 67.00	₹ 67.00
8.	e to Female Jumper Wires 40 Pin 30cm	Robu.in (INV2425/357147 & 09.03.2025)	1	₹ 53.00	₹ 53.00
9.	USB A Type to Micro USB B Type -100cm	Robu.in (INV2425/357147 & 09.03.2025)	1	₹ 41.00	₹ 41.00
10.	ESP32 WROOM32 38 PIN	Createshala Learning Sol. (003 & 19.04.2025)	2	₹ 714.00	₹ 1428.00
11.	3D PRINTING WITH MATERIAL - 28 GRAM	Createshala Learning Sol. (003 & 19.04.2025)	1	₹ 800.00	₹ 800.00
12.	TYPE-C BRAKOUT BOARD	Createshala Learning Sol. (003 & 19.04.2025)	1	₹ 87.00	₹ 87.00
13.	22 AWGSILICON WIRE	Createshala Learning Sol. (003 & 19.04.2025)	1	₹ 76.00	₹ 76.00
14.	COD & Miscellaneous				₹ 500.00
			Total (in Figures)		**₹ 19,961.00**
	Total (in Words): Nineteen Thousand Nine Hundred and Sixty-One Only				

6.CONCLUSION

6.1 Current Status

- **Real-time Object Detection using YOLOv8** – capable of classifying over 30 common objects with no local training.
- **LiDAR Sensor Integration** – provides accurate proximity sensing for dynamic and static obstacles.
- **Bluetooth Audio Feedback** – hands-free object announcements using offline text-to-speech.
- **Haptic Feedback System** – vibration motor intensity varies based on object distance.

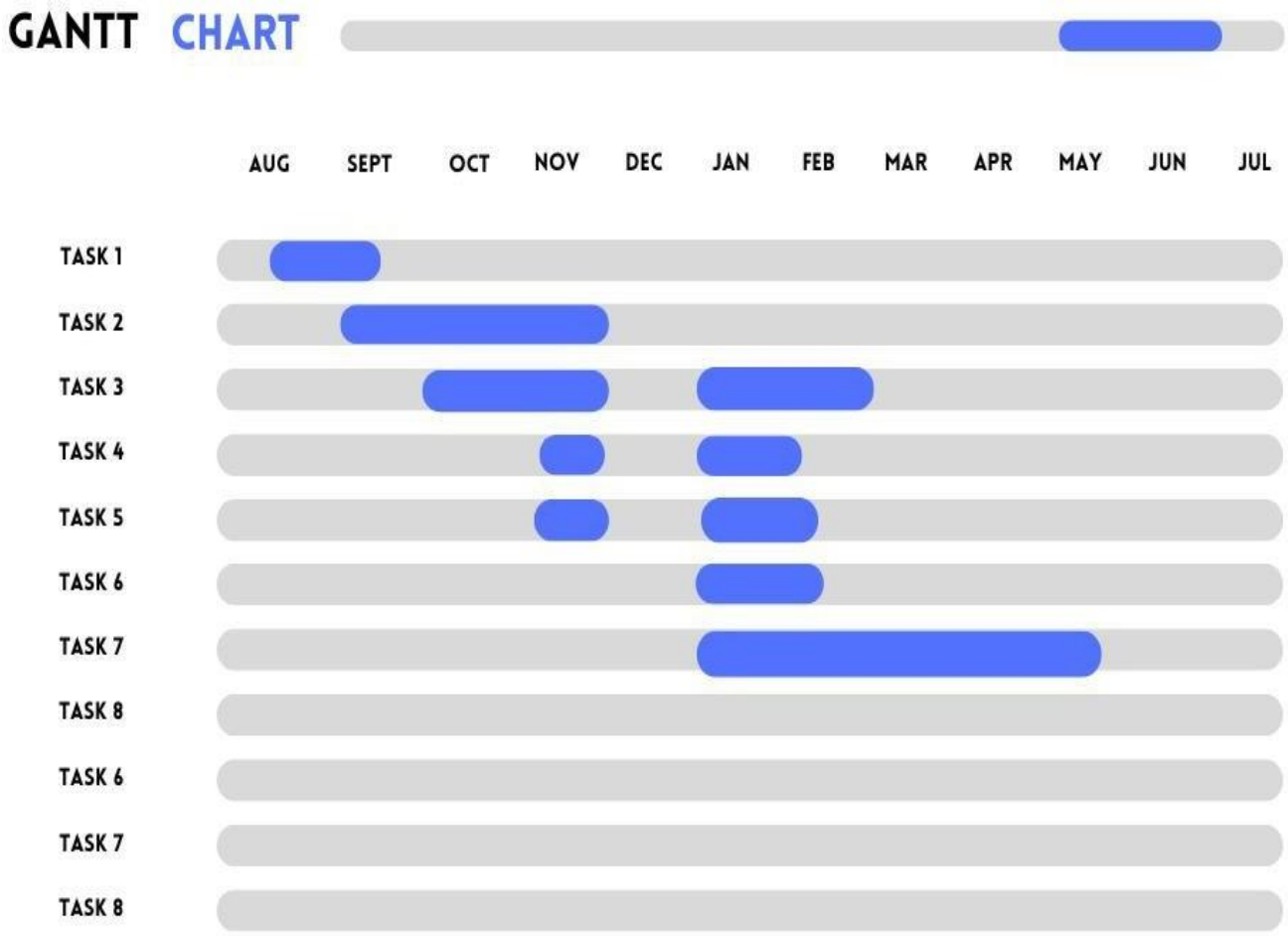
6.2 Future Work

- **GPS-Based Navigation Integration** – enabling guided routing and landmark-based instructions.
- **Mobile App Pairing** – for route customization, system updates, and health tracking.

6.3 Expected Outcomes

- **Scalable Personalization and Smarter Assistance** Advanced mapping and telecommunication capabilities.
- **Integration into Smart Infrastructure and Public Systems**

6.4 Gantt Chart/Time Estimates



Task1: Project Ideation.
Task2: Project Conceptualisation according to latest research and advancements.
Task3: Study of existing technologies and solutions based on that
Task4: Finalizing our product specification
Task5: CAD Model preparation.
Task6: Fabrication of Low fidelity prototype.
Task7: Fabrication of final product.

7.REFERENCES

Video Link:

Best Hands-Free Navigational Aid for the Blind and Visually Impaired

Watch on YouTube

Navigation Companion for the Blind and Visually Impaired

Watch the demonstrationYouTube+1YouTube+1

Oko: The Genius Navigation Tool for the Blind:

View the videoYouTube

Articles:

a) **A Comprehensive Review of Navigation Systems for Visually Impaired**

Read the full paper

b) **Navigation Framework for Blind and Visually Impaired Persons Based on Sensor Fusion**

View the researcharXiv

Web Sources: Google Scholar, IEEE, AnalogDevices, ChatGPT, Wikipedia.