ACCS DESIGN
CHALLENGE 2024

NAVDRISHTI

"NAV-DRISHTI": Indoor Navigation System for Visually Impaired Individuals.

CONTENTS

INTRODUCTION

- Navigating indoor spaces poses significant challenges for visually impaired individuals due to the absence of reliable and accessible navigation systems.
- There is a need for an affordable, scalable, and accurate indoor navigation system that enables visually impaired individuals to move independently, avoid obstacles, and access real-time navigation assistance.

NAVDRISHTI

INTRODUCTION

WHY IS IT ESSENTIAL?

- Visually impaired individuals face significant challenges navigating large indoor spaces, like malls, hospitals, airports, and offices.
- Statistics based on the 43.3 million visually impaired individuals worldwide, with only 2% using guide dogs and most relying on canes, highlight the critical need for innovative indoor navigation solutions.

CHALLENGES ASSOCIATED WITH CURRENTLY EXISITING SOLUTIONS

- Smart canes help detect objects below waist level, but cannot detect objects above the waist.
- Carry-on-robots are expensive, bulky and have high maintenance cost.

NAVDRISHTI

INTRODUCTION

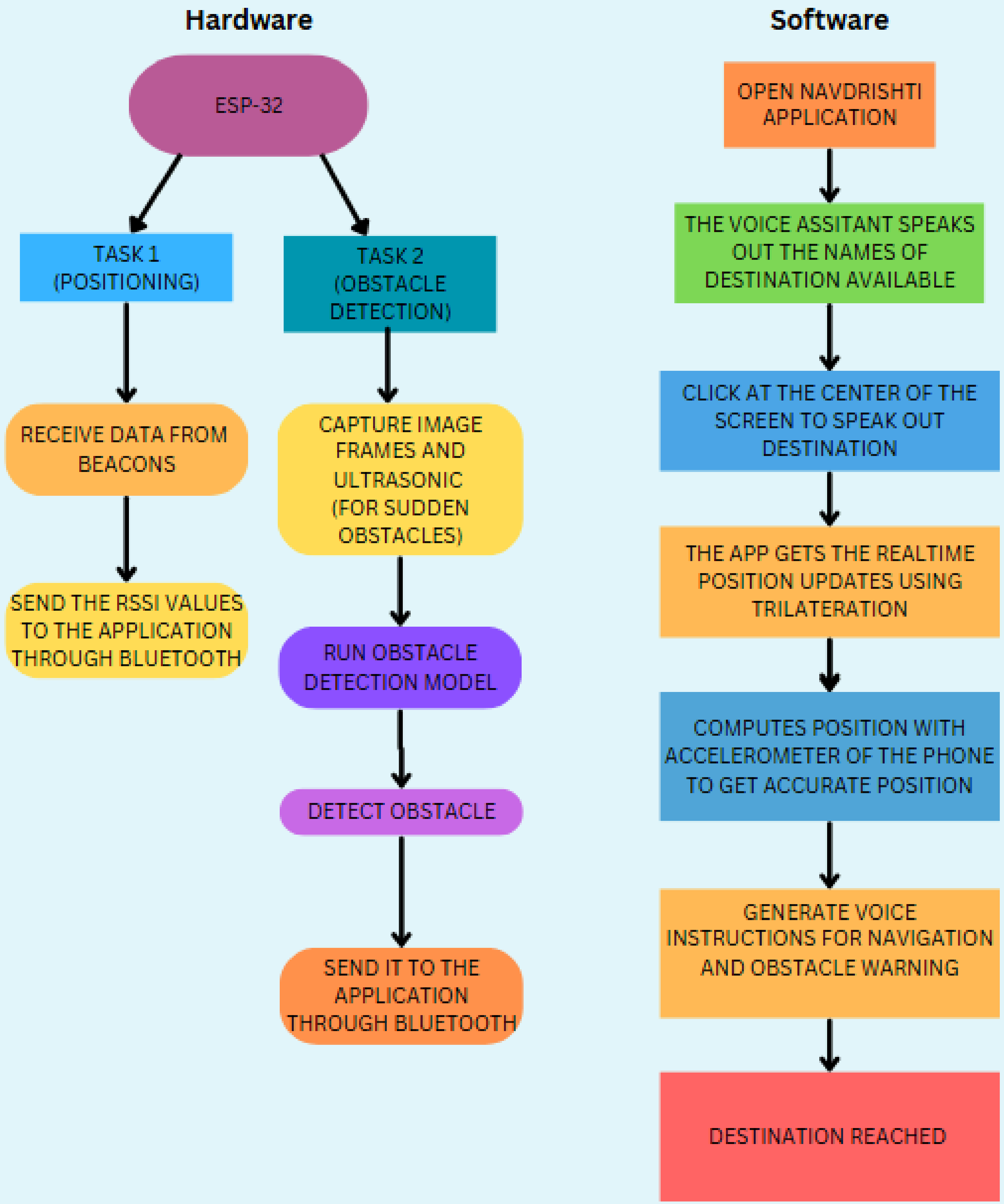
Hence, we introduce "**NAV-DRISHTI**", an innovative indoor navigation system designed specifically for visually impaired individuals.

OBJECTIVES

- Develop an affordable and scalable Indoor Navigation System (INS) for visually impaired individuals.
- Implement IMU and BLE-based trilateration for precise location tracking.
- Provide accurate real-time navigation assistance using voice feedback.
- Integrate object detection for obstacle avoidance.

NAVDRISHTI

SYSTEM ARCHITECTURE



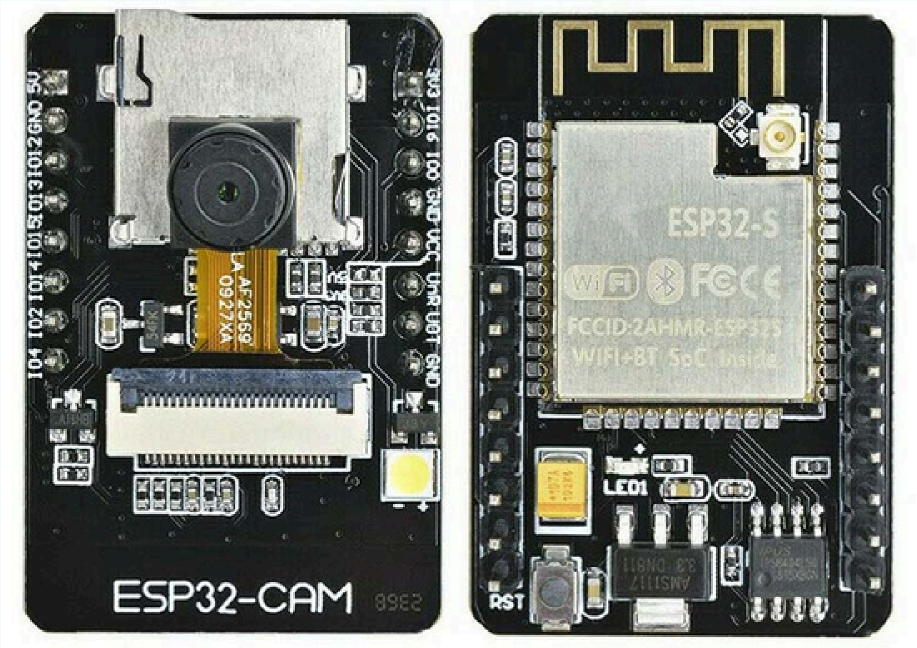
HARDWARE CHOSEN

Hardware Selection

MICROCONTROLLER USED: ESP32 CAM MODULE

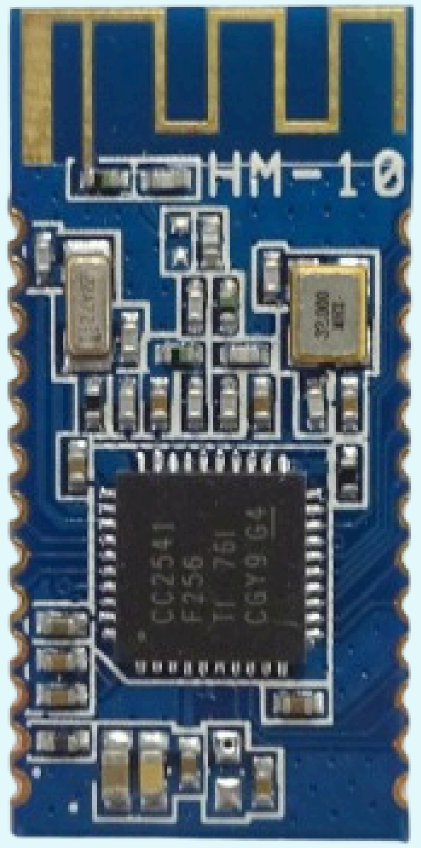
Cost Effective and Compact Size: Highly affordable (₹600 per unit) while providing all the necessary features for real-time BLE scanning.

Camera Connectivity: The OV2640 can be easily connected to the ESP32.Thus facilitating obstacle detection module.



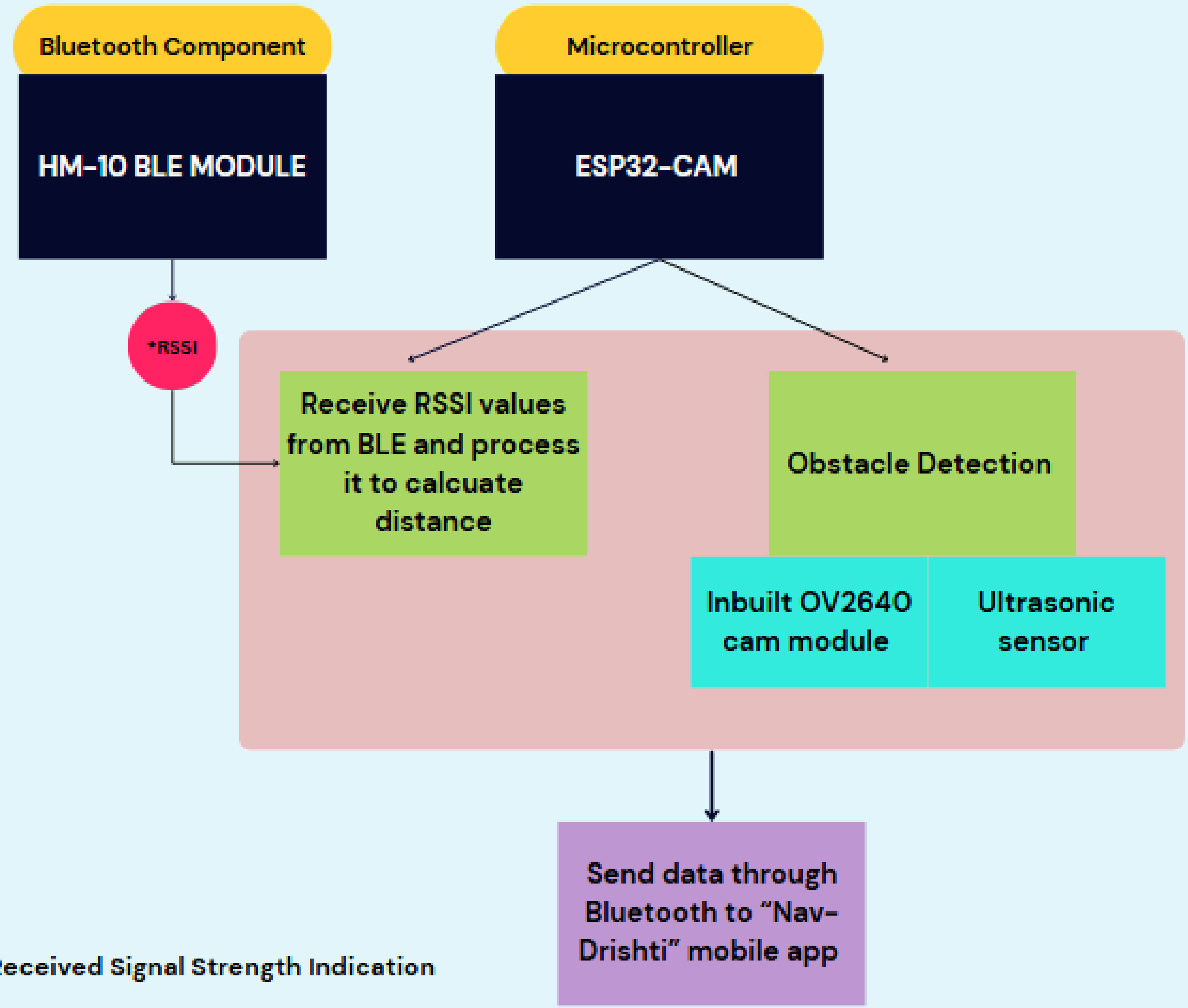
BLUETOOTH BEACON USED: HM10

- **Cost effective:** Compared to other BLE modules (like Nordic nRF series or iBeacon hardware), the HM-10 is relatively inexpensive, making it a good choice for large-scale deployment.
- Provides a reliable range of up to 50 meters in open space and is suitable for indoor positioning without excessive power usage.



NAVDRISHTI

HARDWARE ARCHITECTURE



*Received Signal Strength Indication

NAVDRISHTI

PERFORMANCE ANALYSIS OF OBJECT DETECTION ON ESP32

A lightweight model fomo (faster objects, more objects) mobilenetv2 0.35 trained on esp32 microcontroller for object detection

Classes trained on :1)Standing Human 2)Chair

Latency	Ram Usage	Flash Usage	Accuracy
• **15 ms** for image preprocessing • **833 ms** for object detection • **848 ms** in total	• **4.0 KB** for image preprocessing • **239 KB** for object detection • **243 KB** in total	**79 KB** for storing the model	**71%**

Performance metrics

NAVDRISHTI

ENERGY CONSUMPTIONS

Battery Life Analysis for HM-10 and ESP32-CAM with 3.7V, 2000mAh Li-ion Battery

Power Consumption Overview

- Battery Capacity: 2000mAh
- Voltage: 3.7V

HM-10

- Active Mode Consumption: 20mA for 20ms per second
- Battery Life≈2247 hours(93.6 days)

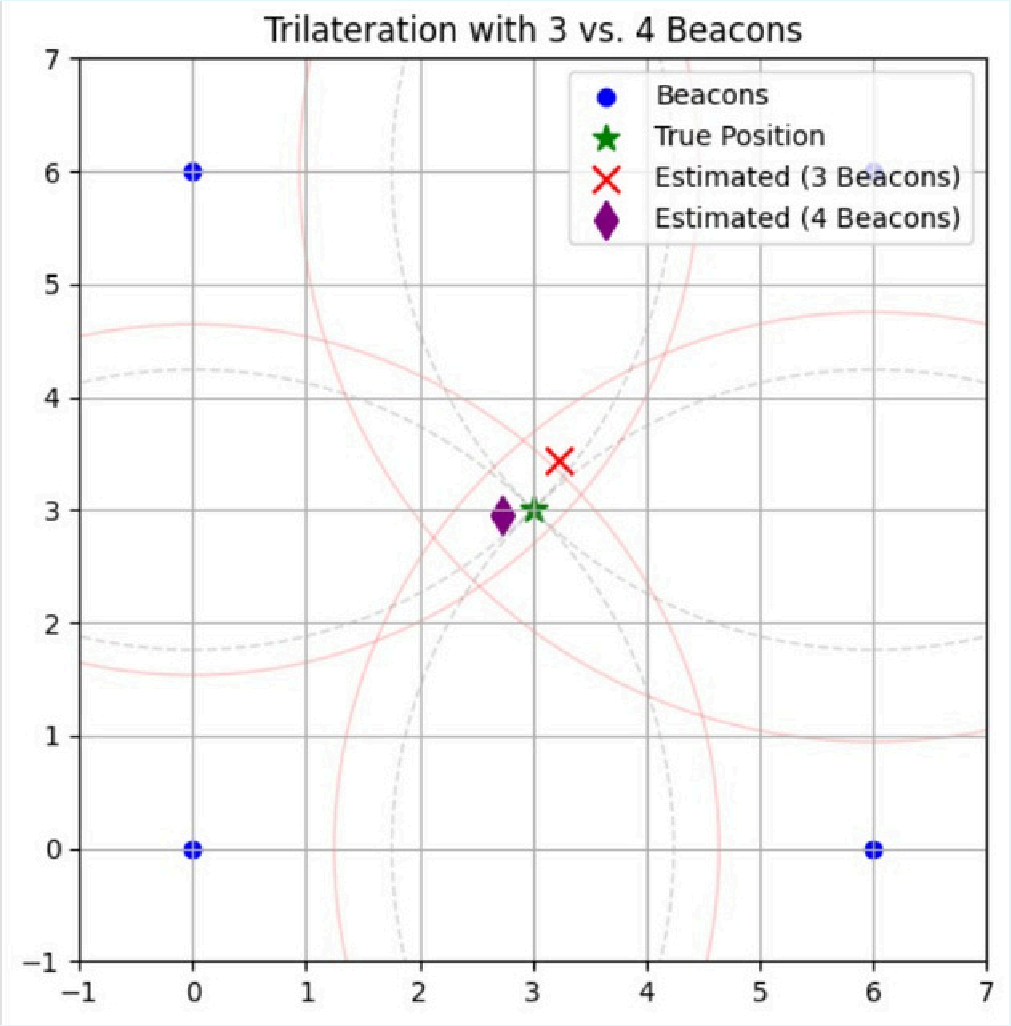
ESP32-CAM

- Active Mode Consumption: ~240mA (CPU at 240 MHz)
- Battery Life : 8.33 hrs

NAVDRISHTI

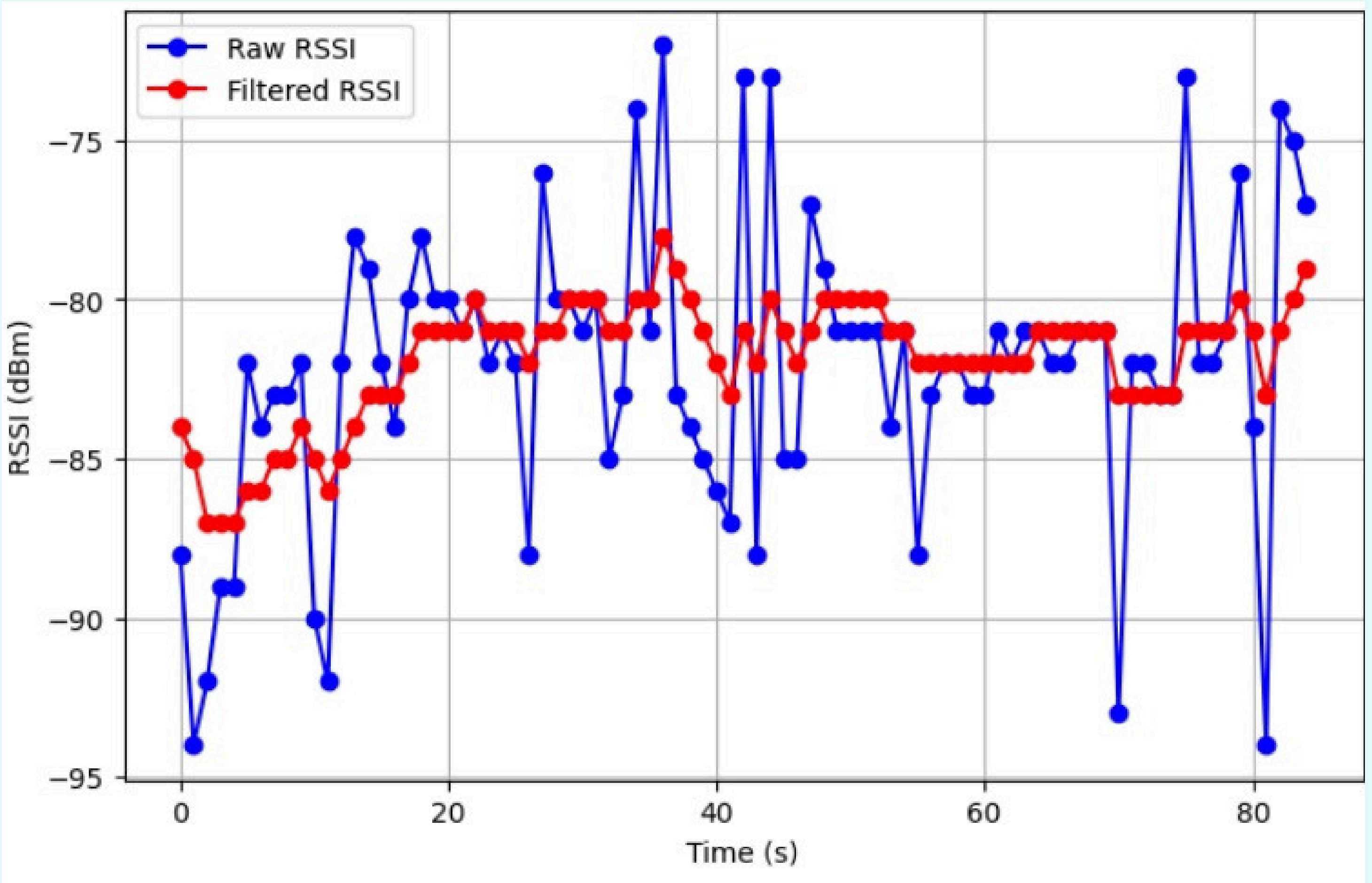
OPTIMIZING HARDWARE RESOURCE UTILIZATION AND IMPROVING ACCURACY

Quantification of beacons



True Position: [3 3]
Estimated Position (3 Beacons): [3.23536358 3.43507727], Error: 0.49
Estimated Position (4 Beacons): [2.72250862 2.95628311], Error: 0.28

Comparative analysis of RSSI with and without Kalman filter



Mean Absolute Error (MAE): 2.68 dB
Mean Error Difference (MED): 0.31 dB
Variance (Raw RSSI): 20.64
Variance (Filtered RSSI): 3.67

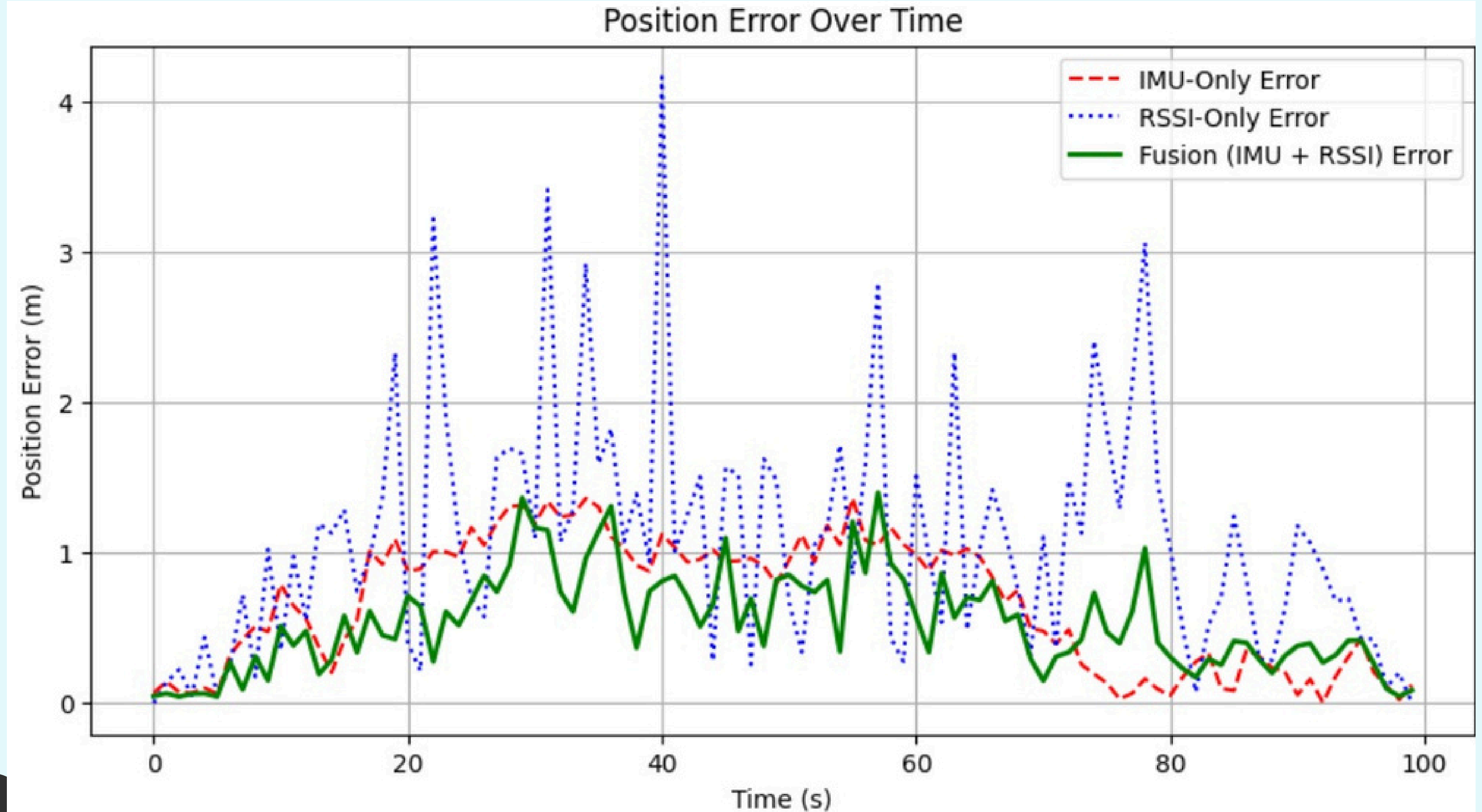
NAVDRISHTI

NAVDRISHTI ALGORITHM

TRILATERATION BASED DELTA X AND DELTA Y CALCULATION

KINEMATIC MOTION MODELLING USING ACCELEROMETER OF THE MOBILE PHONE

$$\Delta x = v_0 \cdot t + \frac{1}{2} a_x \cdot t^2$$



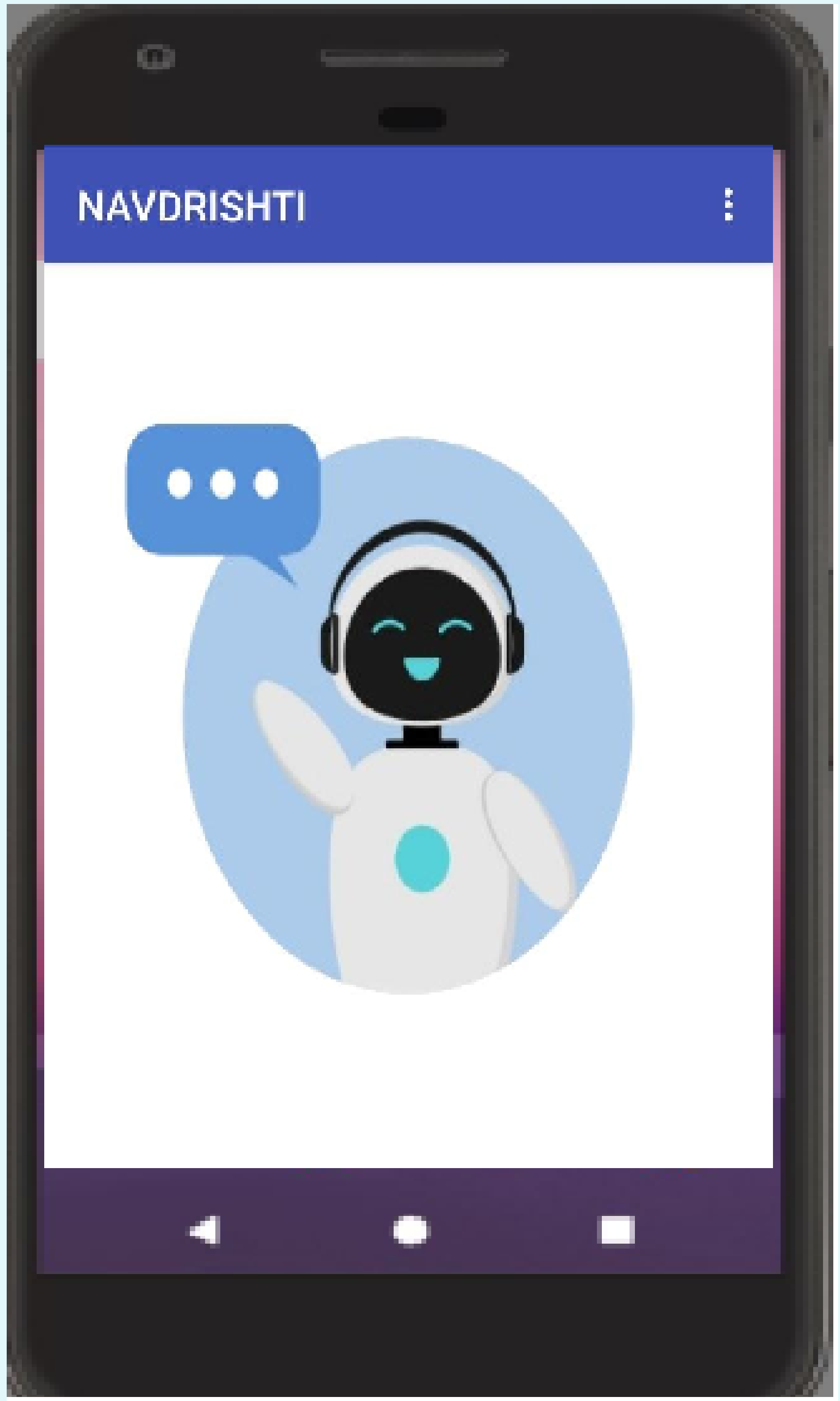
Mean Absolute Error (MAE): IMU = 0.66, RSSI = 1.08, Fusion = 0.54

Root Mean Square Error (RMSE): IMU = 0.79, RSSI = 1.34, Fusion = 0.63

Mean Error Difference: IMU-RSSI = 0.60, Fusion-IMU = 0.25, Fusion-RSSI = 0.64

NAVDRISHTI

SOFTWARE ARCHITECTURE



i)**Bluetooth Communication**

- The app uses Bluetooth to receive data from the ESP32.
- Object detection results and RSSI values data are transmitted via BLE.

ii)**Data Processing**

- The app processes the received data to identify detected objects and calculate user position.
- It applies NavDrishti algorithms for determining the best path.

iii)**Voice Assistance**

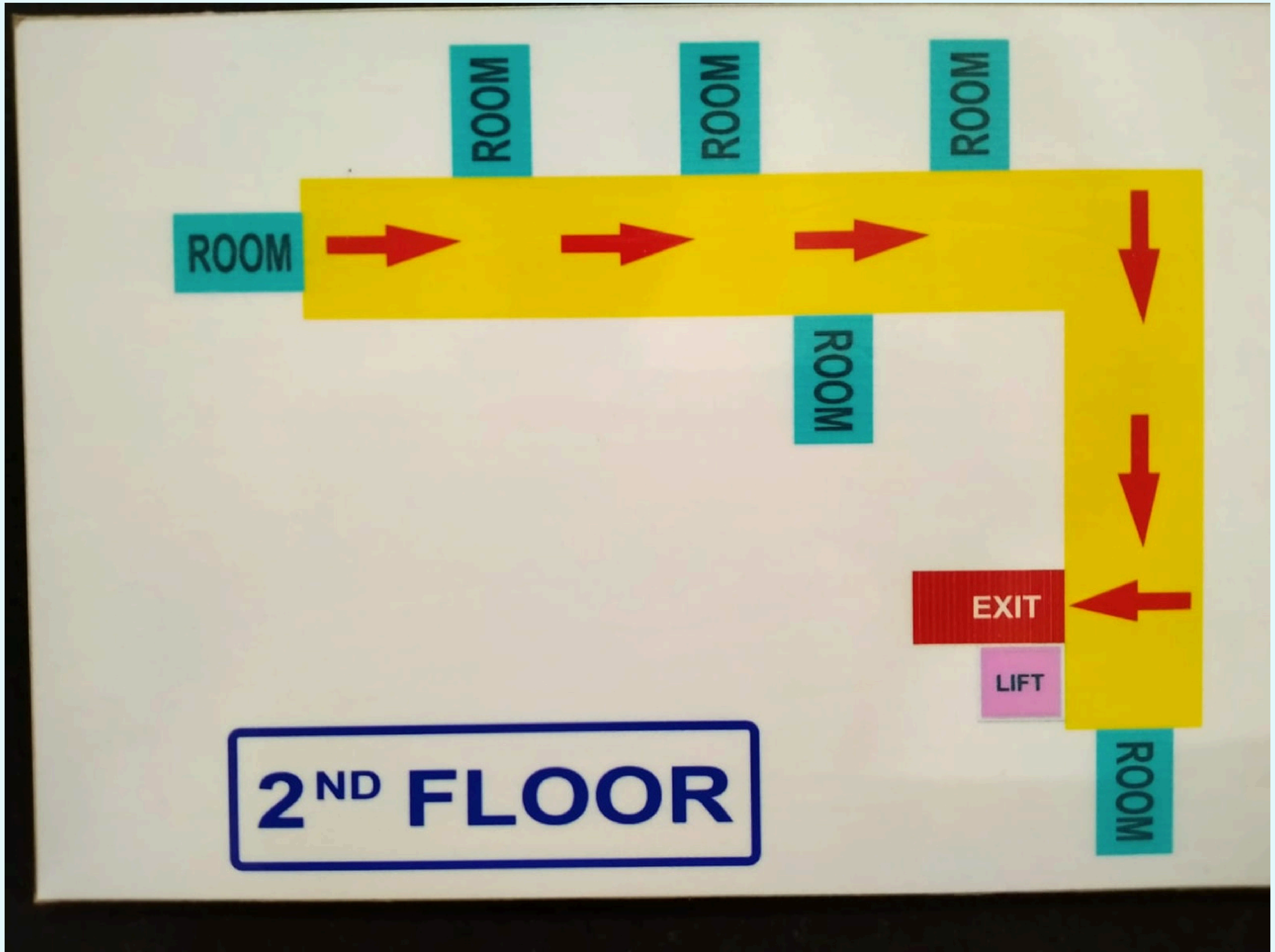
- Text-to-speech (TTS) is used to generate real-time voice commands.
- The app provides clear navigation guidance and obstacle alerts.

The mobile application was developed using MIT App Inventor, providing an intuitive and user-friendly interface for real-time voice assistance and navigation support.

DEMONSTRATION

Basic Path

- From room 1 to elevator



NAVDRISHTI

CONCLUSION

- By leveraging Bluetooth beacons and IMU sensors, the system ensures reliable indoor positioning with minimal drift, enhancing user confidence.
- The lightweight FOMO model on the ESP32 enables real-time identification of obstacles like chairs and humans, while ultrasonic sensors provide additional safety like walls.
- Nav Drishti prioritizes accessibility and independence for visually impaired individuals, offering a scalable and cost-effective solution for safer indoor navigation

FUTURE PLANS

- Smartphone Independence: Enhance the Nav Drishti system by integrating a DSP IC with the ESP32, allowing direct microphone and speaker management. A preloaded map stored on an SD card will enable offline navigation without the need for a smartphone.
- OCR for Vision Assistance: Develop an Optical Character Recognition (OCR) feature to assist visually impaired individuals in reading printed text. This will further empower users to access written information

.

NAVDRISHTI