JNANETRA: AN EDGE-AI-DRIVEN SMARTPHONE FRAMEWORK FOR ASSISTIVE NAVIGATION FOR THE VISUALLY IMPAIRED

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College : Sri Siddhartha Institute of Technology, Tumakuru
Branch : Department Of Information Science Engineering
Guide : Dr. Vani B V
Students : Mr. Hruthik M
Ms. Aishwarya S
Ms. Deepika S
Mr. M M Prateek

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Introduction:

Visually impaired individuals face significant challenges in navigating indoor and semi-outdoor environments due to the lack of real-time spatial awareness and affordable assistive tools. Traditional aids such as canes and guide dogs provide limited support and do not offer information about obstacle distance or optimal path direction. Existing smartphone-based solutions primarily focus on object recognition but fail to integrate depth estimation and navigation planning, while hardware-based systems are often expensive and impractical.

To address these limitations, Jnanetra proposes an intelligent, smartphone-based assistive navigation system powered by Edge AI. The system integrates real-time object detection using YOLO (You Only Look Once), monocular depth estimation using MiDaS, and efficient path planning using the A* Algorithm. By processing all computations locally on the device, the system ensures low latency, offline functionality, and enhanced reliability. It delivers navigation guidance through audio and haptic feedback, enabling users to move safely and independently without the need for additional hardware.

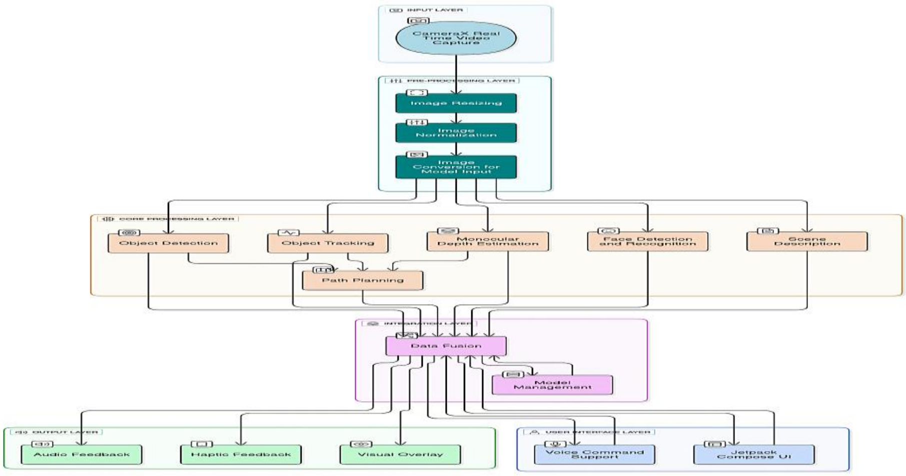

Figure 1: App Workflow

Objectives:

1. To develop a real-time navigation system for visually impaired users.
2. To implement object detection using deep learning techniques.
3. To estimate depth information for obstacle avoidance.
4. To generate a safe navigation path using pathfinding algorithms.
5. To provide audio and haptic feedback for user guidance

Methodology:

1. The proposed system follows a multi-stage Edge-AI pipeline implemented on an Android smartphone. The input is captured through a continuous video stream using the CameraX API, along with sensor data from the accelerometer and gyroscope for motion context.
2. In the perception stage, the captured frames are processed using a lightweight YOLO11 Nano model for real-time object detection. Parallelly, a quantized depth estimation model such as MiDaS or FastDepth generates a depth map to estimate the distance of objects in the scene.
3. The outputs of object detection and depth estimation are fused to create a 2D occupancy grid, which represents the environment as free space and obstacles. This spatial representation enables the system to understand the surroundings in a structured format.
4. The navigation stage uses the A* pathfinding algorithm to compute the safest and shortest path by avoiding obstacles in the occupancy grid. The system continuously updates the path in real time based on incoming frames.
5. Finally, the system provides feedback to the user through Text-to-Speech audio instructions and vibration-based haptic alerts, enabling intuitive and safe navigation. The entire pipeline runs offline using optimized and quantized models to ensure low latency and efficient performance on mid-range smartphones.

Result and Conclusion:

1. The developed system demonstrates effective real-time navigation assistance for visually impaired users by integrating object detection, depth estimation, and path planning on a smartphone platform. The implementation successfully identifies obstacles in the user’s path and estimates their distance with reasonable accuracy under different environmental conditions. The generated occupancy grid and A* pathfinding algorithm ensure that a safe and optimal route is continuously computed. The system operates with low latency due to on-device processing, eliminating the need for constant internet connectivity and making it suitable for practical usage.
2. Audio and haptic feedback mechanisms provide intuitive and immediate guidance to the user, enabling safer movement in both indoor and outdoor environments. The overall performance indicates that the system is reliable, cost-effective, and scalable for real-world applications. In conclusion, the project presents a significant step toward improving independent mobility for visually impaired individuals by leveraging modern AI techniques in an accessible and efficient manner.

References:

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Future Scope:

1. The Jnanetra system can be extended to support outdoor navigation using GPS integration, enabling seamless indoor–outdoor assistance. Future improvements include advanced scene understanding for detecting stairs, doors, and dynamic obstacles, along with voice command interaction for better user control.
2. The system can be optimized using model compression techniques such as TensorFlow Lite and ONNX to ensure efficient deployment on low-end devices. Integration of multi-sensor data (e.g., inertial sensors) can further improve accuracy and reliability.
3. Additionally, the solution can be deployed in public spaces like hospitals, malls, and institutions, and extended to smart city and assistive robotics applications. Further research can focus on improving depth estimation, reducing latency, and enhancing performance in complex real-world environments.