REAL-TIME ROAD ANOMALY DETECTION FROM DASHCAM FOOTAGE ON RASPBERRY PI

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EVENT: BHARAT AI-SOC STUDENT CHALLENGE

PROBLEM STATEMENT

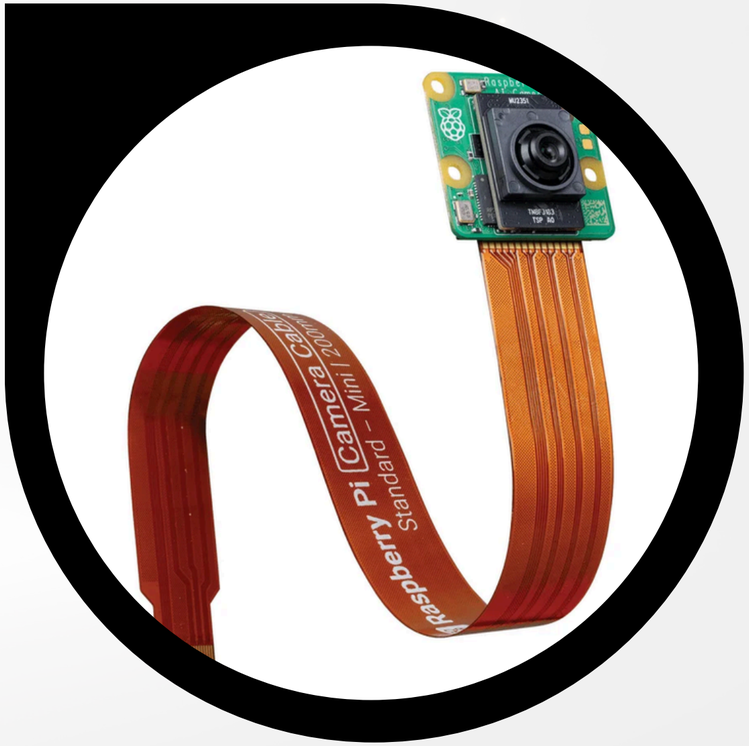
Road anomalies such as potholes, cracks, and unexpected obstacles:

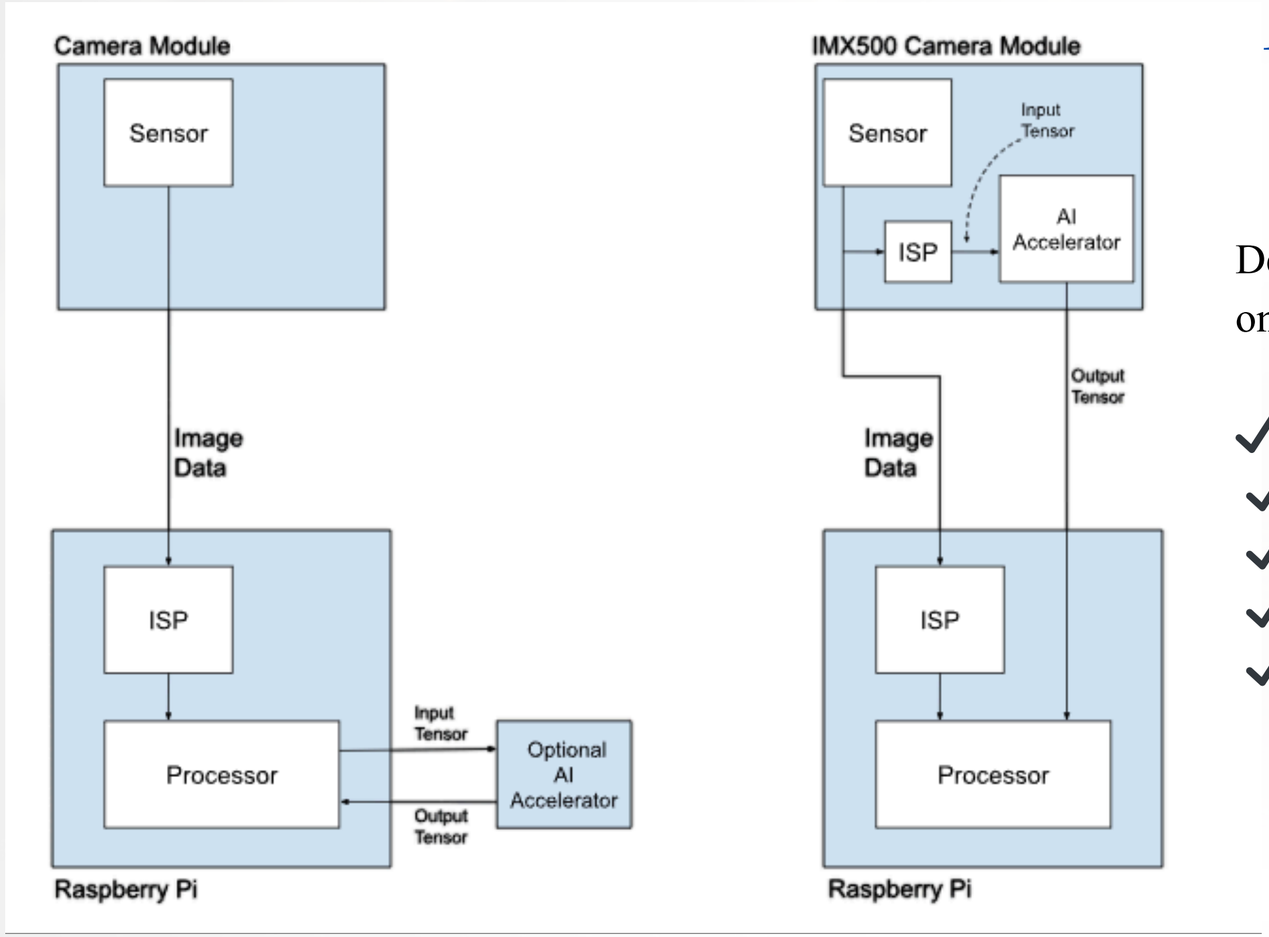
- Cause accidents and safety risks
- Lead to vehicle damage and maintenance costs
- Are difficult to monitor using manual inspection
- Lack real-time detection systems in most regions

NEED FOR A SOLUTION

There is a need for a low-cost, scalable system that can:

- ✓ Automatically monitor road conditions
- ✓ Detect anomalies in real time
- ✓ Operate without internet connectivity
- ✓ Be deployed easily on vehicles or roadside units



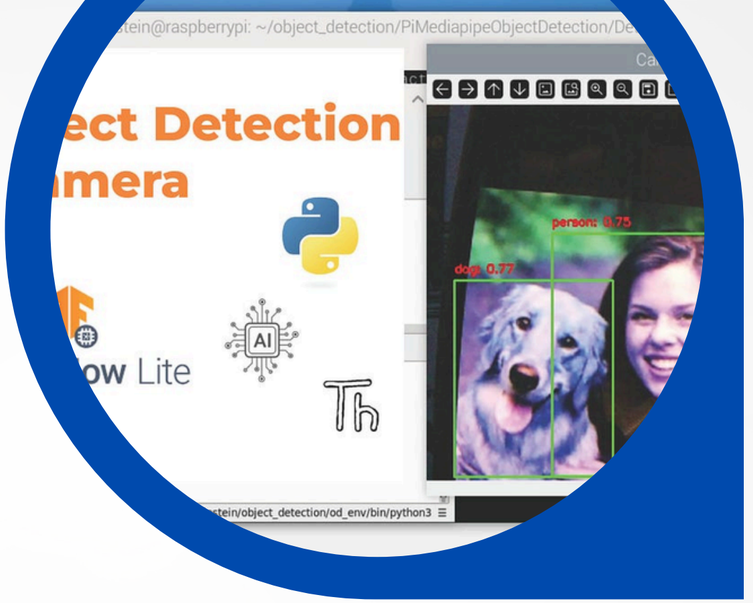


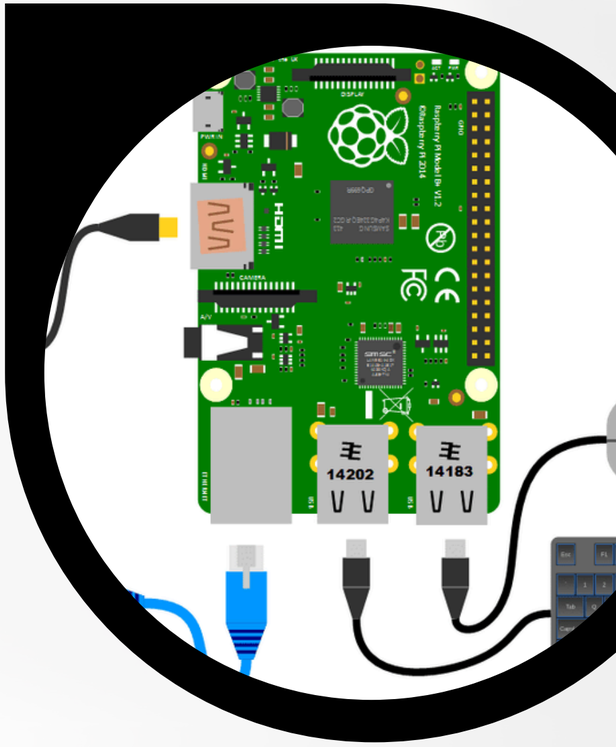
PROJECT OBJECTIVE

Design and implement a Real-Time Edge AI Application on Raspberry Pi that:

- ✓ Captures live dashcam footage
- ✓ Detects potholes and road obstacles using a lightweight AI model
- ✓ Logs anomalies with timestamp and saved frame evidence
- ✓ Runs entirely on Raspberry Pi CPU (No GPU / No accelerator)
- ✓ Works offline for scalable deployment

Key Focus of This Project

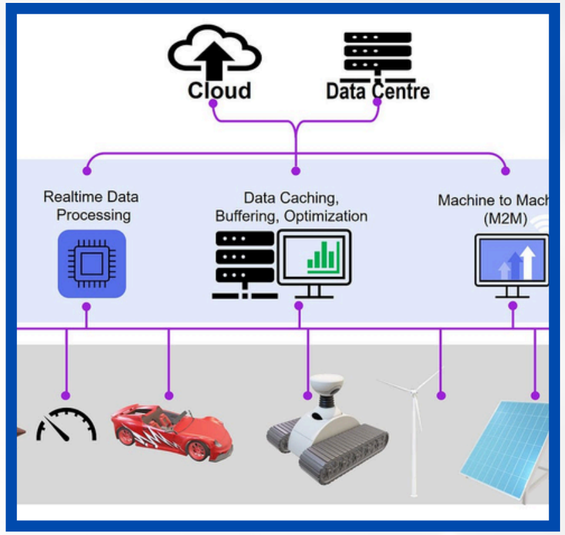


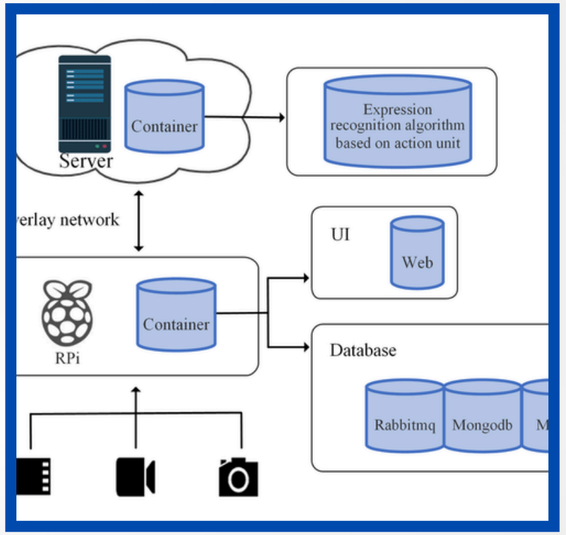


- Efficient AI deployment on constrained hardware
- Achieving near real-time performance (≥5 FPS)
- Optimizing model size, speed, and accuracy
- Building a practical embedded vision pipeline

WHY EDGE AI? (INSTEAD OF CLOUD-BASED DETECTION)

Cloud-Based AI	Edge AI (Our Approach)
Requires Internet	Works Offline
High Latency	Real-Time Detection
Privacy Concerns	Local Processing
Expensive Infrastructure	Low-Cost Deployment
Not Scalable in Rural Areas	Easily Deployable Anywhere





ADVANTAGES OF EDGE AI FOR THIS USE CASE

- ✓ Immediate detection without network delay
- ✓ Suitable for moving vehicles (dashcam scenario)
- ✓ Reduces bandwidth usage
- ✓ Enables large-scale deployment at low cost
- ✓ Reliable even in remote locations

OVERALL SYSTEM ARCHITECTURE

STEP-BY-STEP WORKFLOW:

- Camera captures live road video
- OpenCV reads frames from video stream
- Frames are preprocessed (resize, normalize)
- Optimized AI model performs inference
- Detected anomalies are identified
- System logs timestamp + saves detection frame
- Output can be used for alerts or analysis

HARDWARE COMPONENTS USED

Raspberry Pi 4 / 5

→ Main processing unit running AI inference

Raspberry Pi Camera Module v2 / USB Webcam

→ Captures real-time dashcam footage

High-Speed microSD Card

→ Stores OS, model, and detection logs

Power Supply & Mounting Setup

→ Enables deployment in vehicle-like environment

SOFTWARE TOOLS & FRAMEWORKS

- Raspberry Pi OS
- → Lightweight Linux environment for embedded deployment
- Python
- → Main programming language for pipeline integration
- OpenCV
- → Captures video frames and handles preprocessing
- TensorFlow Lite / ONNX Runtime
- → Runs the optimized deep-learning model efficiently on CPU
- Pre-trained Quantized Detection Model
- → Detects potholes and anomalies in real time

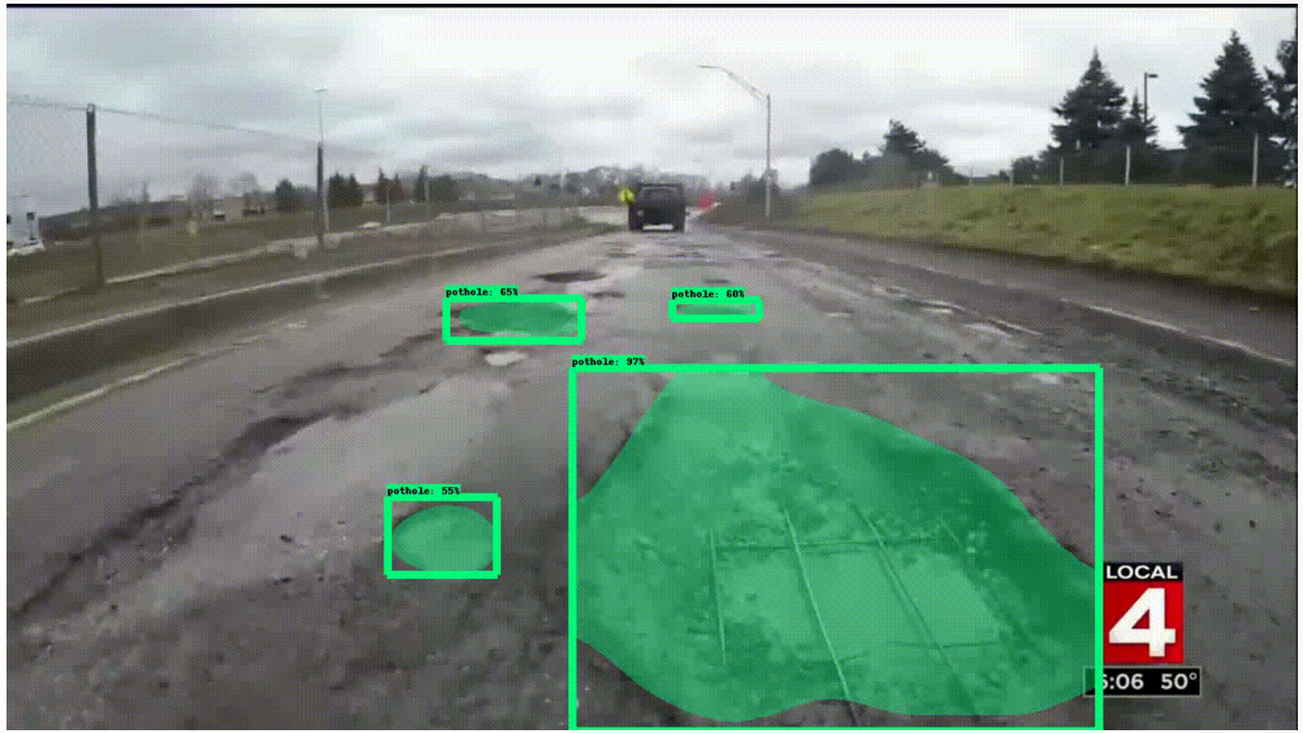
MODEL OPTIMIZATION TECHNIQUES TO ACHIEVE REAL-TIME PERFORMANCE:

- INT8 Quantization → reduces computation
- Reduced image size (e.g., 320×320)
- Frame skipping for speed
- Efficient OpenCV preprocessing

PERFORMANCE TARGETS

1. Metric Target
2. Speed ≥5 FPS
3. Latency <200 ms
4. Accuracy High Precision
5. Mode Fully Offline

System Generates:



- ✓ Bounding box around pothole/obstacle
- ✓ Timestamp log
- ✓ Saved detection image
- ✓ Data for road monitoring

Learning Outcomes

- ✓ Edge AI deployment experience
- ✓ Embedded vision pipeline design
- ✓ Model optimization on ARM CPU
- ✓ Understanding real-world AI constraints

THANK YOU