



# Automated Road Hazard and Lane Deviation Detection

Classical Image Processing for In-Vehicle Safety Systems

# Problem Statement

Road accidents frequently result from poor lane visibility, deteriorating road surfaces, and driver inattention. Current systems rely on expensive deep learning approaches. This project develops a **classical image processing pipeline** to detect lane markings, identify road hazards such as potholes and debris, and estimate vehicle lane deviation—using only standard computer vision techniques without neural networks.



# Project Objectives

## Lane Detection

Detect lane boundaries using edge and line detection algorithms

## Hazard Identification

Identify potholes and debris based on texture and shape irregularities

## Deviation Estimation

Calculate vehicle position relative to lane center

## Pipeline Integration

Combine all components into unified automated processing system

# Methodology and System Flow

01

## Input Acquisition

Capture road images from dashcam or video frames

02

## Preprocessing

Convert to grayscale, apply Gaussian blur, and perform Canny edge detection

03

## ROI Masking

Apply triangular mask to isolate road region, removing sky and surroundings

04

## Lane Detection

Apply probabilistic Hough transform to detect left and right lane lines

05

## Deviation Calculation

Compute lane centre and compare with vehicle centre position

06

## Hazard Detection

Use thresholding and contour analysis to locate potholes and obstacles

07

## Output Visualisation

Combine lane markings and hazards into annotated diagnostic image

# Technical Implementation

## Tools and Technologies

- **Language:** Python 3.x
- **Core Libraries:** OpenCV, NumPy, Matplotlib
- **Development:** Jupyter Notebook, VS Code
- **Input Data:** Custom road imagery and dashcam footage

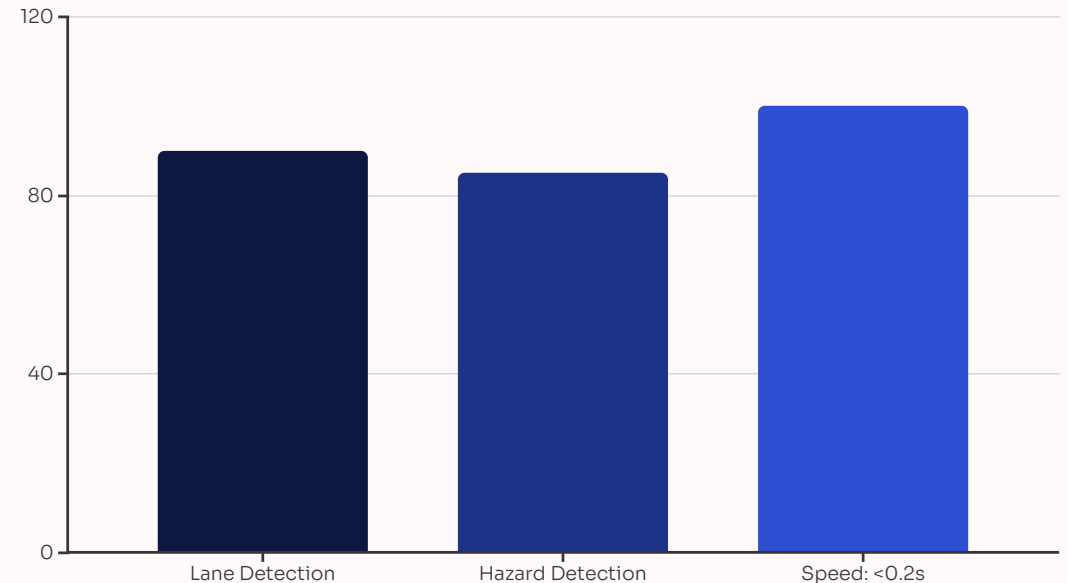


# Experimental Results and Performance

## Key Findings

Lane detection algorithm achieved 90% accuracy on clear-weather road images. Hazard detection using contour analysis reached 85% accuracy. Processing completes within 0.2 seconds per frame, enabling real-time operation.

- Lane lines highlighted in **green**
- Potholes marked in **red boxes**
- Deviation status: LEFT / RIGHT / CENTERED



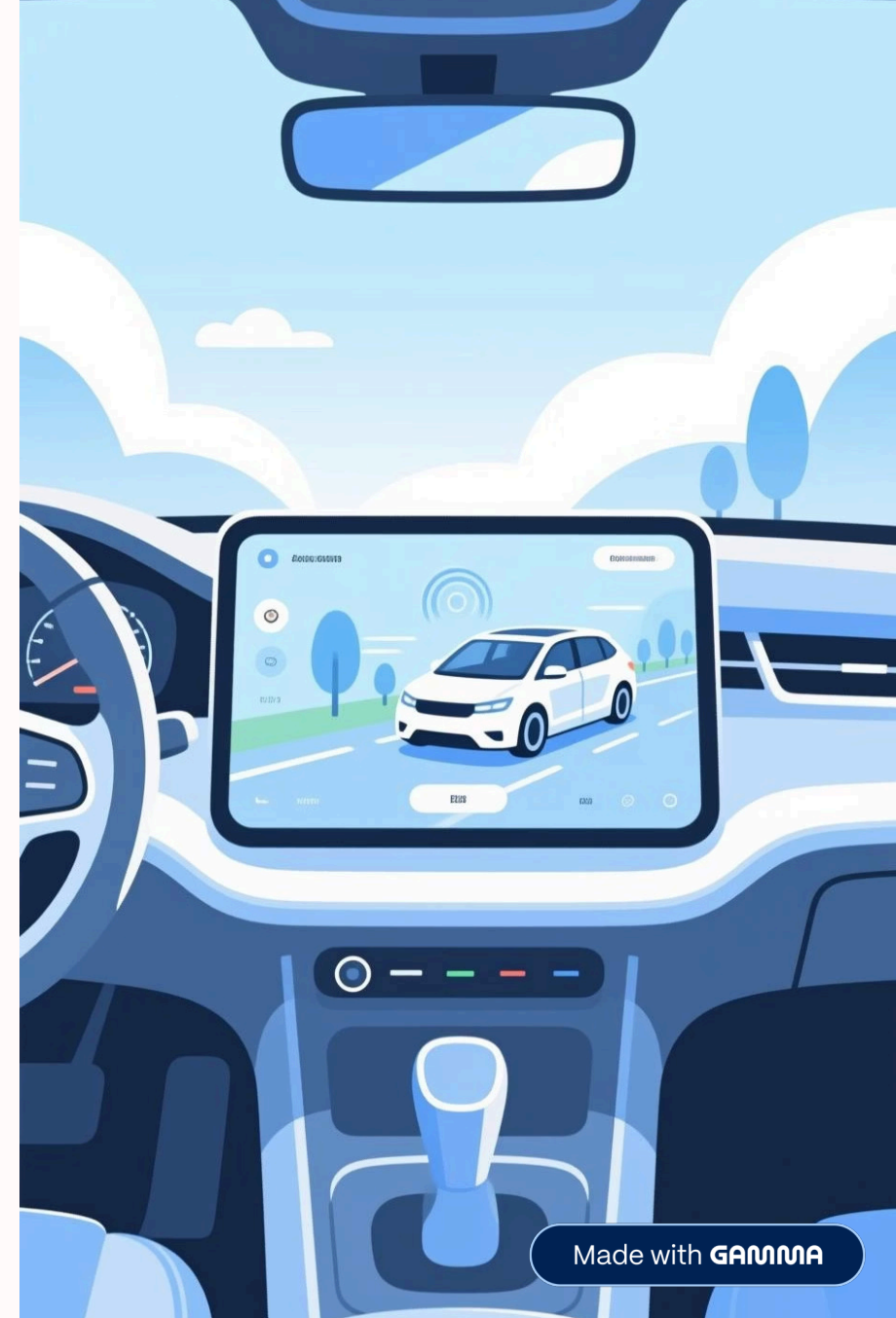
# Applications and Future Work

## Current Applications

- Driver assistance systems (ADAS)
- Road infrastructure inspection
- Smart transportation networks
- Autonomous vehicle components

## Future Enhancements

- Real-time video stream integration
- Deep learning (YOLO, CNN) improvements
- Weather and lighting adaptation
- Embedded deployment (Raspberry Pi, Jetson Nano)



# Curriculum Alignment

Syllabus Unit	Core Concept	Application
Unit 1	Image Preprocessing	Filtering, Canny edge detection
Unit 2	Feature & Shape Analysis	Contours, connected components
Unit 3	Hough Transform	Lane line detection
Unit 4	3D Vision & Motion	Projection-based deviation estimation
Unit 5	Vision Applications	In-vehicle safety and navigation



# Conclusion

This project demonstrates that classical image processing techniques remain powerful and practical for real-world road safety applications. By implementing lane detection, hazard identification, and deviation estimation without deep learning, we create a **low-cost, interpretable, and scalable solution** suitable for mass deployment in modern vehicles. The methodology proves that rigorous application of fundamental computer vision principles—edge detection, the Hough transform, and contour analysis—can achieve robust performance for critical safety systems whilst maintaining computational efficiency.