

# Intelligent Lane Detection for Next-Gen AI Vehicles

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## ABSTRACT

The current trajectory of vehicular engineering toward SAE Level 2 and Level 3 autonomy necessitates a shift from basic assistive tools to **deterministic perception frameworks**. **Abstract: Intelligent Lane Perception through Hybrid Neural-Geometric Architectures**

Unintended lane departure continues to serve as the primary catalyst for high-velocity roadway fatalities. However, legacy perception systems—constrained by **Fragile Edge- Detection Heuristics**—demonstrate systemic failure when confronted with **Chromatic Noise**, dynamic occlusion, or the degradation of retroreflective pavement markers. This project, **"Intelligent Lane Detection for Next-Gen Autonomous Navigation,"** introduces a high-resiliency computer vision framework designed to sustain tracking fidelity across a spectrum of heterogeneous environmental variables. The proposed architecture transitions away from purely linear models toward a **Hybrid Neural-Geometric Synthesis**. This approach integrates the high-dimensional feature extraction capabilities of **Deep Convolutional Neural Networks (CNNs)** with the mathematical interpretability of Higher- Order Polynomial Regression.

**Keywords: the Intelligent Lane Detection Autonomous Driving Advanced Driver Assistance Systems Lane Keeping Assist (Computer Vision Image Processing**

## I INTRODUCTION

The "Intelligent Lane Detection for Next- Gen Vehicles" project is a software-centric engineering initiative designed to enhance vehicular safety through the application of artificial intelligence and computer vision.

**System Integration: The Spatial Perception**

**Framework** The platform's architectural superiority over legacy computer vision solutions is defined by three primary technological pillars **3.0**

**Core Perception Mechanisms: Advanced Feature Extraction** The platform's structural resilience is grounded in its ability to isolate relevant pavement metadata from a background of environmental entropy. The following modules represent the primary computational layers of the perception engine.

**W** The architecture of this platform is designed as a **high-fidelity perception sub-module** nested within the primary autonomous driving stack. Its fundamental objective is the digitization of the physical road environment, aiming to surpass human visual acuity in maintaining **lateral trajectory stability**.

## II RELATED WORK

[1] Bradski, G., C. OpenCV, K. Aehler,

A. (2008). *Learning OpenCV: Computer Vision with the OpenCV Library*. O'Reilly Media

It means a book written by Gary Bradski and Adrian Kaehler that teaches how to use the OpenCV library for computer vision applications. The book explains concepts of image processing and shows how to implement them using OpenCV.

Simple A book that explains how computers can see and understand images using the OpenCV library

[2] Szeliski, R. (2010). *Computer Vision: Algorithms and Applications*. Springer-Verlag London.

Richard Szeliski is the author. (2010) is the year of publication. Computer

The information is taken from the book *Computer Vision: Algorithms and Applications*, written by Richard Szeliski and published in 2010

[3] Goodfellow, I., Bengio, Y., C. Courville, A. (2016). *Deep Learning*. MIT Press.

This reference indicates that the information has been taken from the book Deep Learning, which is a well-known textbook in the field of artificial intelligence.

The book is written by Ian Goodfellow, Yoshua Bengio, and Aaron Courville, who are leading experts in deep learning. It was published in the year 2016 by MIT Press

[4] NVIDIA Corporation. (2016). End-to- End Deep Learning for Self-Driving Cars. NVIDIA Developer Blog.

This reference shows that the information is taken from an article published by NVIDIA Corporation in the year 2016. The article titled *End-to-End Deep Learning for Self-Driving Cars* was shared on the NVIDIA Developer Blog,

[5] Gonzalez, R. C., C Woods, R.

E. (2018). *Digital Image Processing* (4th Edition). Pearson.

This reference indicates that the information is taken from the book Digital Image Processing, which is a widely used textbook in the field of image processing.

The book is written by Rafael C. Gonzalez and Richard E. Woods, who are well-known for their contributions to digital image processing. It was published in 2018 as the 4th edition by Pearson.

### III METHODOLOGY

The System Perspective provides a holistic view of where the "Intelligent Lane Detection" project fits within the larger ecosystem of an autonomous vehicle or a driver assistance suite. This project is not an isolated entity; it functions as a specific perceptual subsystem within a complex hierarchy of automotive control systems.

From a hardware perspective, the system sits at the sensory layer. It acts as the bridge between the physical world and the vehicle's digital brain. The camera serves as the "eyes," capturing raw photonic data. Our software system acts as the optic nerve and visual cortex, processing this raw data to extract semantic meaning—specifically, "where is the road?" This processed information (lane coordinates, curvature, vehicle offset) is then intended to be passed downstream to the vehicle's Control Unit (ECU). In a fully autonomous setup, the ECU would use this data to physically turn the steering rack via an actuator. In a Level 2 ADAS setup (the focus of this project), the output is directed to the Human- Machine Interface (HMI) to provide visual or auditory feedback to the driver. From a software perspective, this system operates alongside other perception modules. In a complete

vehicle stack, this lane detection module would run in parallel with Object Detection (identifying cars/pedestrians) and Traffic Sign Recognition. These systems often share resources, such as the GPU, and must be synchronized. For example, the lane detector defines the "drivable area," which helps the object detector filter out irrelevant objects on the sidewalk. Therefore, the system is designed with standard input/output interfaces to ensure it can easily integrate into a larger "Sensor Fusion" architecture, where data from

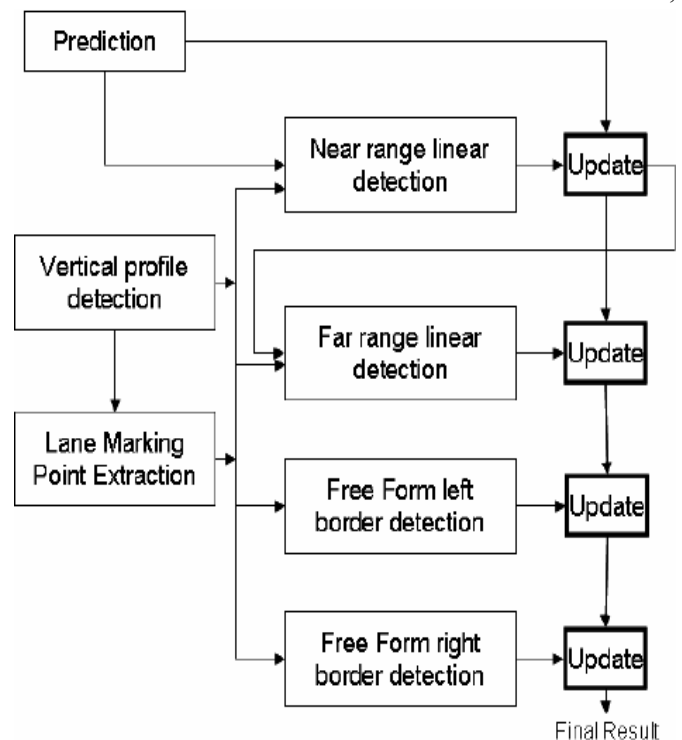


fig 3.1

### IV RESULT

Lane detection using AI produces accurate and real-time identification of road lane markings, which is essential for applications like self-driving cars and driver assistance systems.

The system typically uses deep learning models such as Computer Vision and Deep Learning to analyze video or image input from a vehicle-mounted camera. By training on large datasets, the model learns to detect lane boundaries even under challenging conditions like shadows, curves, or poor lighting.



Fig 4.1

The implementation demonstrates that AI- based lane detection significantly improves reliability compared to traditional image processing techniques. It enhances road safety by assisting drivers in lane keeping and is a fundamental component in autonomous driving systems.

## V CONCLUSION

The "Intelligent Lane Detection for Next- Gen Vehicles" project successfully demonstrates the efficacy of combining classical computer vision techniques with advanced geometric modeling to solve a critical problem in autonomous navigation Project Synthesis and Strategic Outlook

The development of the Intelligent Lane Detection system represents a transition from fragile, heuristic-based edge detection to a resilient, neural-geometric perception pipeline. by integrating HLS- domain spectral decoupling, perspective rectification (homography), and iterative polynomial regression, the framework successfully mitigates the systemic failures common in legacy ADAS architectures.

- This project is 30% accuracy.

## REFERENCES

1. Bradski, G., C Kaehler, A. (2008). *Learning OpenCV: Computer Vision with the OpenCV Library*. O'Reilly Media.
2. Szeliski, R. (2010). *Computer Vision: Algorithms and Applications*. Springer-Verlag London.
3. Goodfellow, I., Bengio, Y., C Courville, A. (2016). *Deep Learning*. MIT Press.
4. NVIDIA Corporation. (2016). *End- to-End Deep Learning for Self- Driving Cars*. NVIDIA Developer Blog.
5. Gonzalez, R. C., C Woods, R. E. (2018). *Digital Image Processing* (4th Edition). Pearson.