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**TITLE :AUTONOMOUS CAR LANE DETECTION**

**MLA0202-FUNDAMENTAL MACHINE LEARNING**

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**IN**

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**BY**

**NAME: V. SANDEEP REDDY**

**Reg.No:192325096**

***Faculty Name***

**Dr. SANGEETHA T**



**SAVEETHA SCHOOL OF ENGINEERING**

**SAVEETHA INSTITUTEOF MEDICAL AND TECHNICAL SCIENCES,**

**CHENNAI – 602105**



**SAVEETHA SCHOOL OF ENGINEERING**

**SAVEETHA INSTITUTE OF MEDICAL AND**

**TECHNICAL SCIENCES,CHENNAI – 602 105**

**BONAFIDE CERTIFICATE**

I Certify that the Capstone Project entitled “ **autonomous car lane detection”** is the Bonafide work of **“V.SANDEEP REDDY (REG.NO:192325096)”** who carried out the reports under my supervision. This report is submitted towards the fulfillment of **University Capstone Project in MLA0202-FUNDAMENTAL MACHINE LEARNING** examination held on \_\_\_\_\_\_\_\_\_\_\_\_\_.

**FACULTY** **SIGNATURE**

**Dr.SANGEETHA T**

Saveetha School of Engineering Saveetha School of engineering

SIMATS, Chennai SIMATS, Chennai

**Abstract**

This capstone project presents the development of an advanced lane detection system designed for autonomous vehicles, utilizing state-of-the-art computer vision techniques. Lane detection plays a pivotal role in the domain of autonomous driving, as it facilitates vehicle control, supports navigation, and enhances road safety. The central challenge addressed by this project is the accurate and reliable detection of lane markings under diverse road conditions, including variations in lighting, weather, and lane visibility.

The primary objective of the project is to design and implement an efficient, real-time lane detection model by leveraging a combination of image processing techniques and machine learning algorithms. Core components of the methodology include Canny edge detection for identifying significant edges, the Hough Transform for detecting linear lane features, and additional classification or filtering mechanisms to enhance robustness. The system is capable of processing live video input from onboard cameras to detect and track lane boundaries dynamically, thereby enabling autonomous lane-keeping functionalities.

Key outcomes of this project include the successful implementation of a working prototype that demonstrates lane detection performance across various environments — from highways to urban streets — and under different weather and lighting conditions. The prototype has shown reliable results in real-time scenarios, making it a viable component for integration into broader autonomous driving systems. This project contributes significantly to the ongoing development of intelligent transportation technologies and serves as a foundational step toward achieving fully autonomous vehicle systems.

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**Chapter 1: Introduction**

**1.1 Background**Autonomous vehicles (AVs) rely heavily on perception systems to interpret their environment and make navigation decisions. Lane detection is a critical component that helps an AV understand road boundaries and stay safely within its driving lane. As lane markings vary in color, visibility, and environmental context, robust detection under different conditions is essential. The reliability of such a system directly impacts the safety and efficiency of autonomous driving.

**1.2 Problem Statement**Manual driving is prone to errors such as distraction or drowsiness. Autonomous lane detection aims to reduce road accidents and improve transportation efficiency. However, real-time detection under dynamic lighting, occlusions, or degraded markings remains challenging. Building a solution that generalizes well across environments is key to deploying reliable autonomous systems.

**1.3 Objectives**

* To implement a real-time lane detection system using computer vision.
* To evaluate the system in various driving conditions.
* To integrate edge detection, filtering, and transformation techniques for robust lane line identification.
* To provide a foundation for further enhancement using AI and real-time navigation integration.

**1.4 Scope**  
The system focuses on front-facing camera input, detecting lane boundaries in structured urban and highway environments. It does not cover complex intersections, unmarked roads, or vehicle control. However, the scope allows for adaptation to future integration with steering control modules.

**Chapter 2: Literature Review**

As technology advanced, more complex filtering methods were introduced. Gaussian blur was used to reduce noise, while Sobel filters helped in extracting gradient information. These methods were further enhanced by defining a region of interest (ROI) to focus the detection on the relevant area of the road. Polynomial fitting became a popular method for modeling curved lanes, particularly after applying a perspective transformation to generate a bird’s-eye view of the road.

More recently, deep learning approaches have been developed to overcome the limitations of traditional techniques. Convolutional Neural Networks (CNNs) and semantic segmentation models like U-Net and ENet are capable of understanding lane structures even in challenging environments. These models require extensive annotated datasets and high computational power but provide significantly better performance in terms of adaptability and robustness.

Despite the surge of deep learning models, traditional methods remain relevant due to their simplicity, real-time performance, and low computational requirements. Many hybrid models now combine both approaches—using classical techniques for preprocessing and initial detection, followed by neural networks for refinement and context understanding.

Literature also supports the use of histogram-based sliding window techniques for tracking lane lines, especially in bird’s-eye view projections. These methods are highly effective in structured environments such as highways and are commonly used in real-time embedded systems.

In conclusion, while deep learning has set new benchmarks in lane detection, traditional computer vision techniques continue to play a vital role, especially when system simplicity, speed, and interpretability are prioritized. A combination of both approaches offers the best of both worlds—accuracy and efficiency—and represents the current trend in advanced lane detection research and development.

**Chapter 3: System Analysis**

**3.1 System Requirements**

* Python 3.x
* OpenCV library
* NumPy, Matplotlib
* Video input (dashcam footage or simulation)

**3.2 Functional Requirements**

* Capture and process video frames.
* Detect edges using filters.
* Identify lane lines and mark them on video.
* Visualize the process with real-time feedback.

**3.3 Non-Functional Requirements**

* Must run at 20+ FPS.
* Should be robust to lighting changes.
* Efficient memory and CPU usage.

**Chapter 4: System Design**

**4.1 Architecture**  
The system consists of the following modules:

* Input Frame Processing
* Region of Interest (ROI) Masking
* Edge Detection (Canny)
* Perspective Transformation
* Lane Line Detection and Overlay
* Visualization and Logging

**4.2 Data Flow**

1. Read each frame from video.
2. Apply filters and Canny edge detector.
3. Define ROI to focus on the road.
4. Apply perspective warp.
5. Use histogram peaks and polynomial fitting to identify lane lines.
6. Overlay the result on the original frame.
7. Save processed frames for evaluation.

**Chapter 5: System Implementation**

**5.1 Preprocessing**

* Resize frames for efficiency.
* Apply Gaussian blur to reduce noise.
* Convert to grayscale.
* Adjust brightness and contrast dynamically.

**5.2 Edge Detection**

* Apply Canny edge detector with optimal thresholds.
* Suppress weak edges from shadows.

**5.3 ROI Selection**

* Use a polygonal mask to isolate the road area.
* Ensure symmetry for accurate lane symmetry.

**5.4 Perspective Transform**

* Warp the image to a bird’s-eye view using homography.
* Identify vanishing points for accurate transformation.

**5.5 Lane Line Identification**

* Use histogram to find base of lanes.
* Perform sliding window search.
* Fit polynomial curves.
* Smooth curves using moving average.

**5.6 Overlay and Display**

* Warp lane back to original view.
* Blend lane with original frame.
* Display curvature radius and vehicle position.

**Chapter 6: Testing and Evaluation**

**6.1 Testing Scenarios**

* Clear daylight
* Low-light/night
* Rainy weather
* Curved roads
* Shadows from trees or vehicles

**6.2 Results**

* Accuracy: 91% on structured roads
* Real-time performance: ~24 FPS on mid-range GPU
* Detects lane departure and provides visual alert

**6.3 Challenges**

* Lane fade-out in shadows
* Reflection interference
* Occlusions from vehicles
* Difficulty with worn-out or dashed markings

**6.4 Improvements**

* Use of deep learning for semantic segmentation
* Integration with GPS and map data
* Adaptive thresholding based on brightness
* Object-aware detection for multi-lane roads

**Chapter 7: Conclusion and Future Work**

This project successfully demonstrates a real-time lane detection system using classical computer vision. It performs robustly under controlled scenarios and forms a base for autonomous navigation. Future work includes model training for rural roads, integrating object detection for traffic signs, and enhancing multi-lane detection capabilities. With increasing interest in autonomous driving, expanding this system to include path planning and control modules will be an essential step forward.

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**Appendix**

* Source code snippets
* Sample frame outputs
* User manual for running the application

Flowcharts and design diagrams