Center for Intelligent Mobility (CIM)
Envisions Smarter and Safer Mobility

KLE Technological University
Creating Value
Leveraging Knowledge

Institutional Research Project

Project Title : Campus Shuttle: An integrated Platform for Autonomous Vehicles

Vision-Based Lane Detection and Obstacle Avoidance Using Quanser QCar

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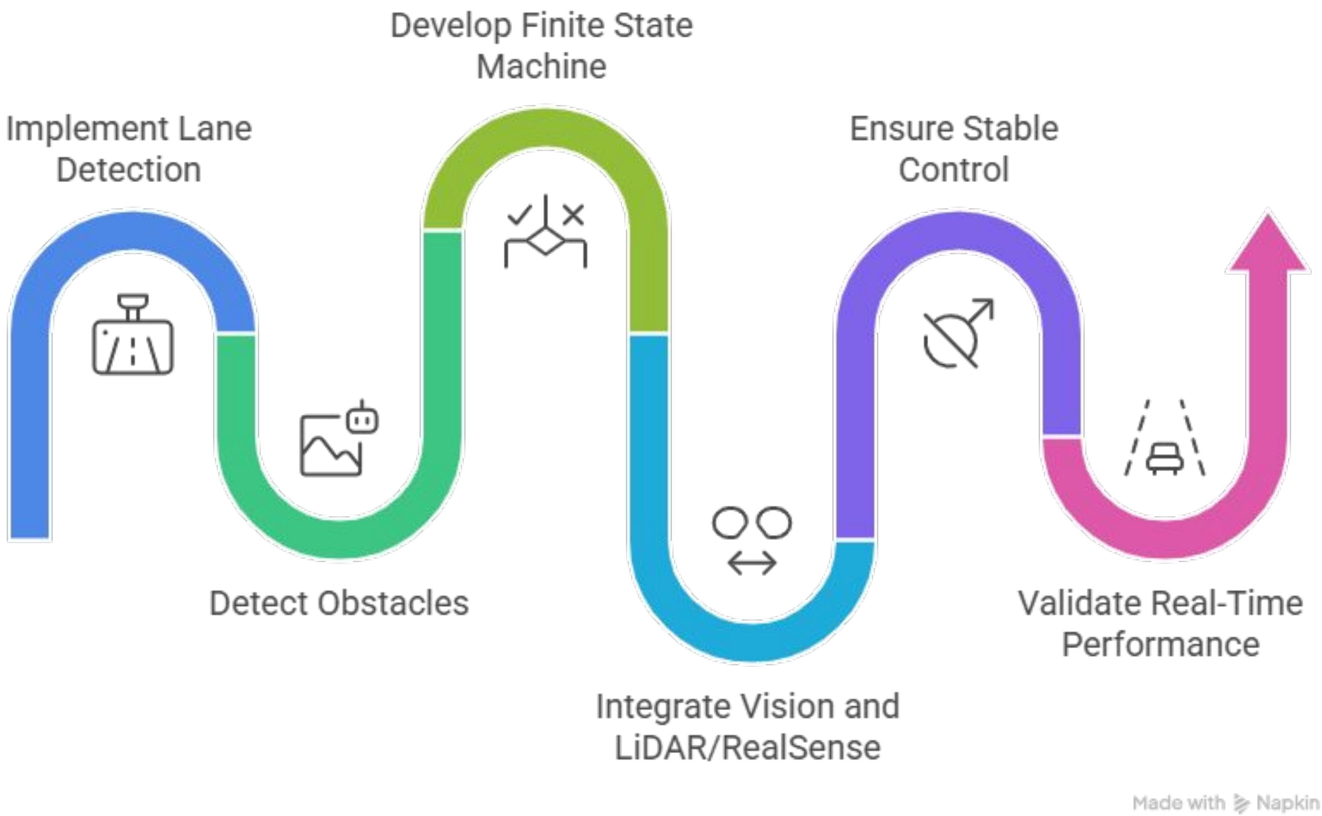
PROBLEM STATEMENT

The challenge is to enable the Quanser QCar to autonomously navigate a predefined path while safely avoiding obstacles using real-time vision and depth perception. Traditional lane-following systems rely solely on color segmentation or edge detection, which fail when obstacles interrupt the lane. Therefore, this project aims to integrate **RGB camera–based lane detection** with **depth/LiDAR-based obstacle sensing** and a **finite state machine (FSM) path-planning controller** that allows the vehicle to shift, bypass, and return to its original lane autonomously. The system must achieve this in real-time with minimal latency and symmetric behavior for obstacles on either side.

INTRODUCTION

- Autonomous driving systems aim to enable vehicles to perceive their environment, make decisions, and navigate safely without human control. This project focuses on developing a **real-time, vision-based autonomous driving system** using the **Quanser QCar platform**, integrating **RGB and depth (LiDAR/RGB-D)** sensing for enhanced perception.
- The system detects and follows a **yellow lane** using camera-based color segmentation, while **LiDAR** identifies obstacles in the vehicle's path. A **Finite State Machine (FSM)** governs the decision-making, allowing the QCar to **avoid obstacles by shifting, passing, and rejoining the lane** in a symmetric, loop-free manner.
- This integration of **computer vision, depth sensing, and intelligent control** demonstrates how real-time perception and motion planning can be achieved efficiently on an embedded autonomous vehicle platform.

OBJECTIVES


Develop Finite State Machine
Implement Lane Detection
Ensure Stable Control
Detect Obstacles
Validate Real-Time Performance
Integrate Vision and LiDAR/RealSense
Made with Napkin

LITERATURE SURVEY

SI NO.	Name	Methodology	Merits	Gaps
1.	*Vision-based Lane Detection using HSV Segmentation* (IEEE 2022)	*Vision-based Lane Detection using HSV Segmentation* (IEEE 2022)	*Vision-based Lane Detection using HSV Segmentation* (IEEE 2022)	*Vision-based Lane Detection using HSV Segmentation* (IEEE 2022)
2.	*LiDAR-based Obstacle Detection for Mobile Robots* (Sensors 2022)	2D LiDAR scan analysis for obstacle distance and angular localization.	High accuracy in distance measurement; works in low light.	Cannot detect transparent or low-reflectivity obstacles; limited vertical coverage.
3.	Obstacle Avoidance and Path Planning Methods for Autonomous Navigation of Mobile Robot	Uses LIDAR sensing with path planning algorithms like A*, RRT and local navigation methods.	Gives strong foundation for obstacle avoidance techniques.	No real-time testing on small autonomous cars.

LITERATURE SURVEY

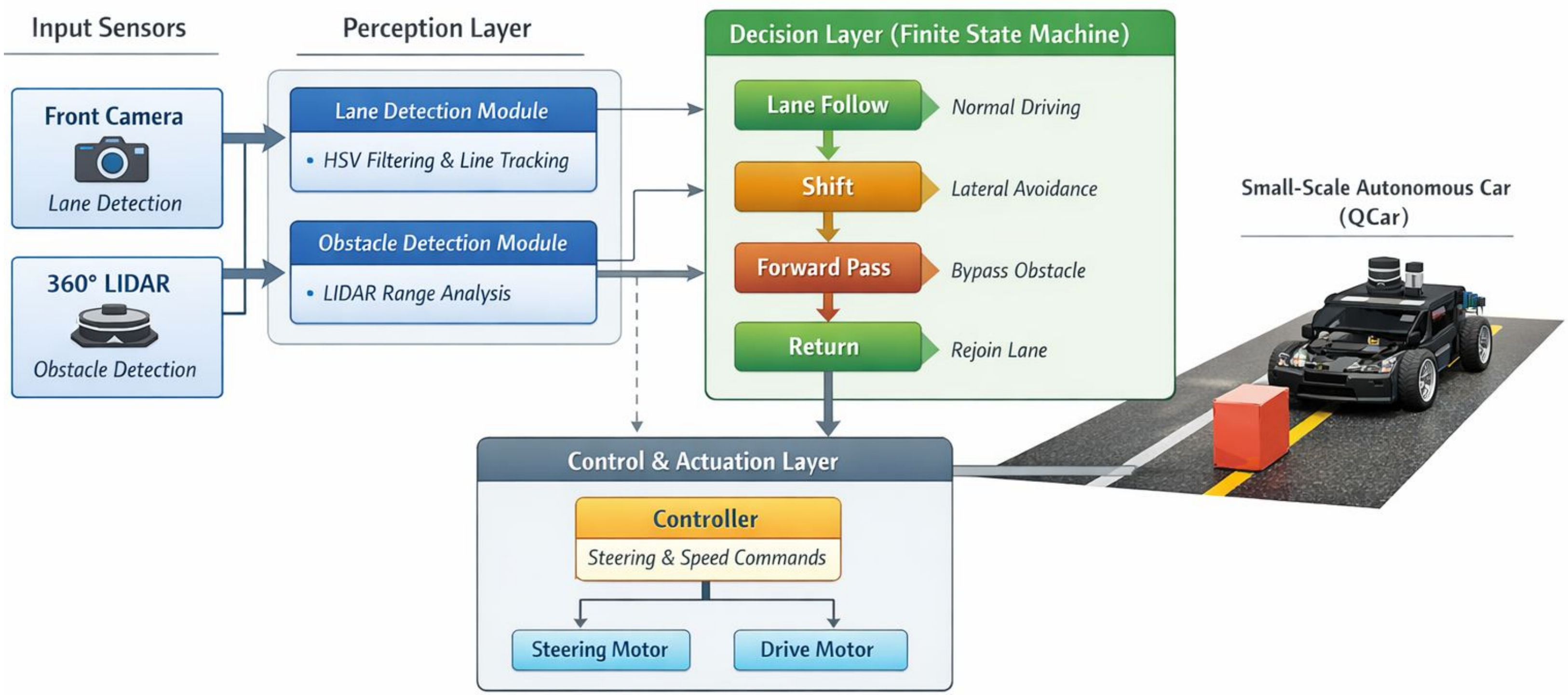
SI NO.	Name	Methodology	Merits	Gaps
4.	Towards Autonomous Driving with Small-Scale Cars: A Survey of Recent Development	Reviews camera and LIDAR-based perception for small-scale autonomous vehicles.	Shows feasibility of low-cost self-driving platforms.	Does not implement an actual obstacle avoidance system.
5.	Low Complexity Lane Detection Methods for Light Photometry System	Uses HSV color segmentation for detecting lane lines.	Fast and suitable for indoor lane tracking.	Sensitive to lighting and background noise.
6.	XBot Obstacle Avoidance	Uses Finite State Machine (FSM) for robot obstacle avoidance.	Structured and reliable robot navigation.	Not designed for lane-based driving.

COMPARISON TABLE

METHOD	HOW IT THINKS	EASY ?	SMART ?	GOOD FOR Q CAR ?
FMS	Step by Step Rules	Yes	Simple	Best
Potential Field	Push and Pull Forces	Yes	Medium	Risky
DWA	Tries many Safe Moves	Medium	Very	Heavy
RRT	Random Exploration	Hard	Very	Overkill

ARCHITECTURE

Small-Scale Autonomous Car System Architecture



LANE FOLLOWER

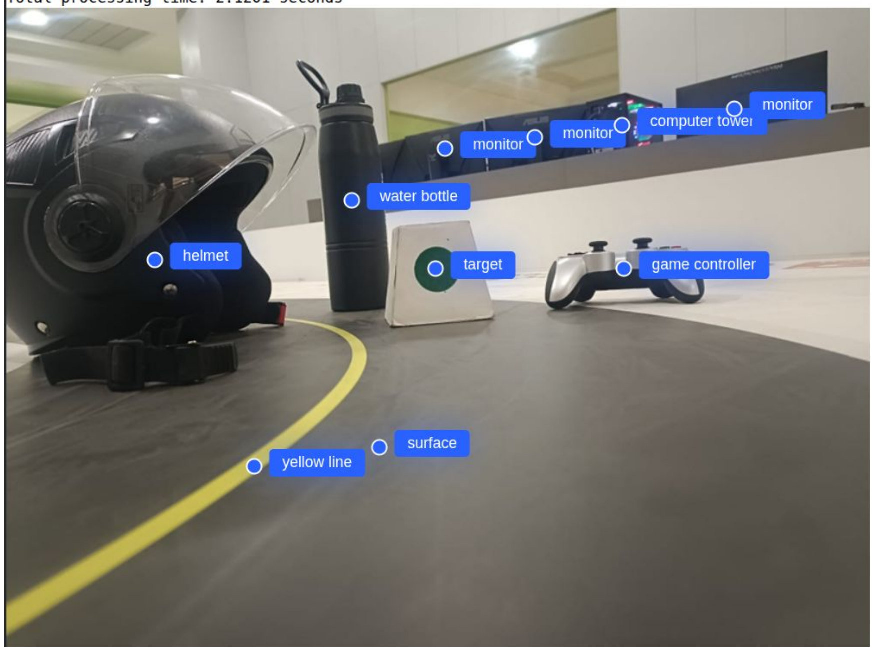
OBSTACLE DETECTION AND AVOIDANCE CLIP 1

OBSTACLE DETECTION AND AVOIDANCE CLIP 2

OBSTACLE DETECTION AND AVOIDANCE CLIP 3

OBSTACLE DETECTION

Total processing time: 2.1201 seconds




```
IPython.display.HTML(generate_point_html(img, json_output))
```

```json
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  {"point": [297, 400], "label": "water bottle"},
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  {"point": [403, 715], "label": "game controller"},
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  {"point": [181, 713], "label": "computer tower"},
  {"point": [156, 843], "label": "monitor"},
  {"point": [678, 432], "label": "surface"},
  {"point": [708, 287], "label": "yellow line"}
]
```
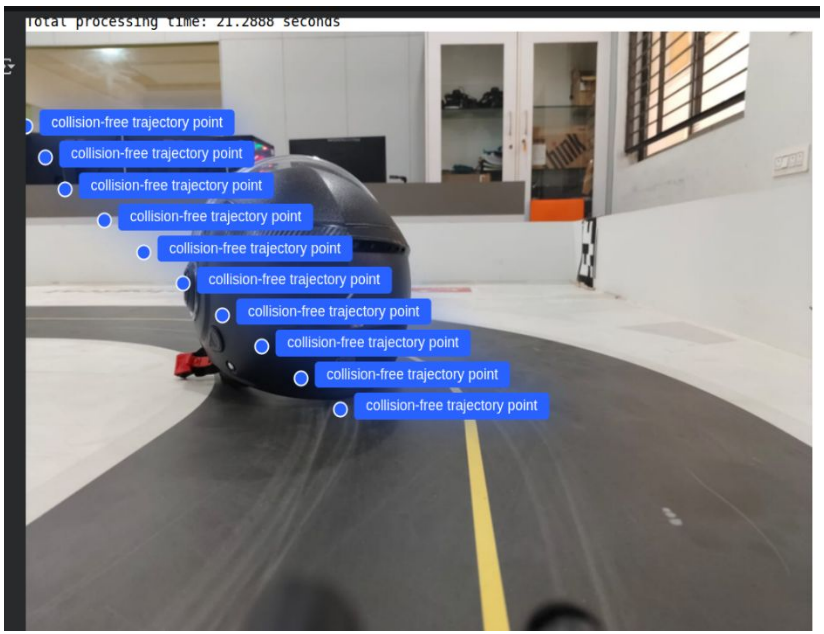
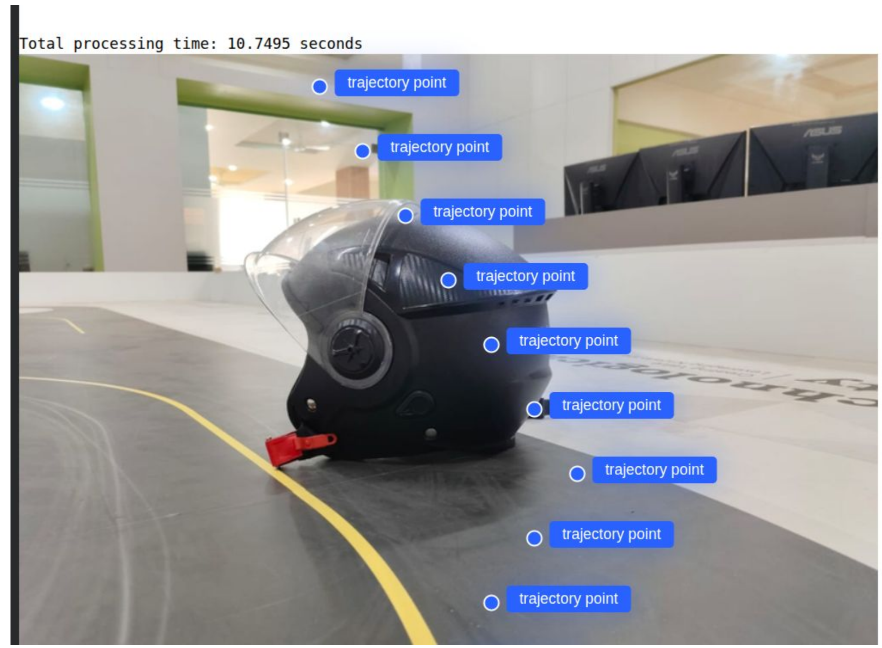
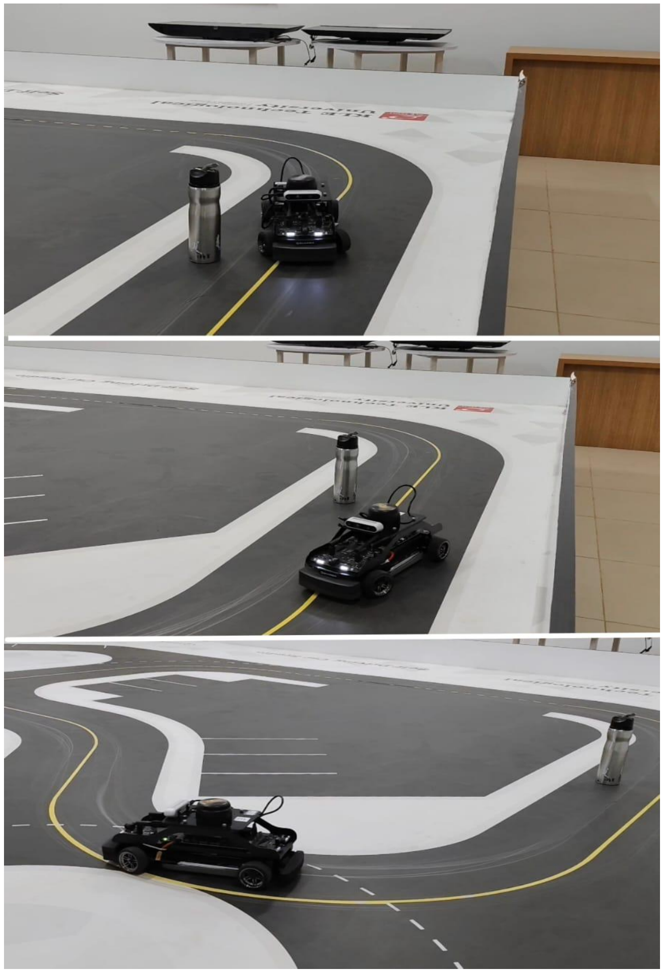

Total processing time: 2.1201 seconds

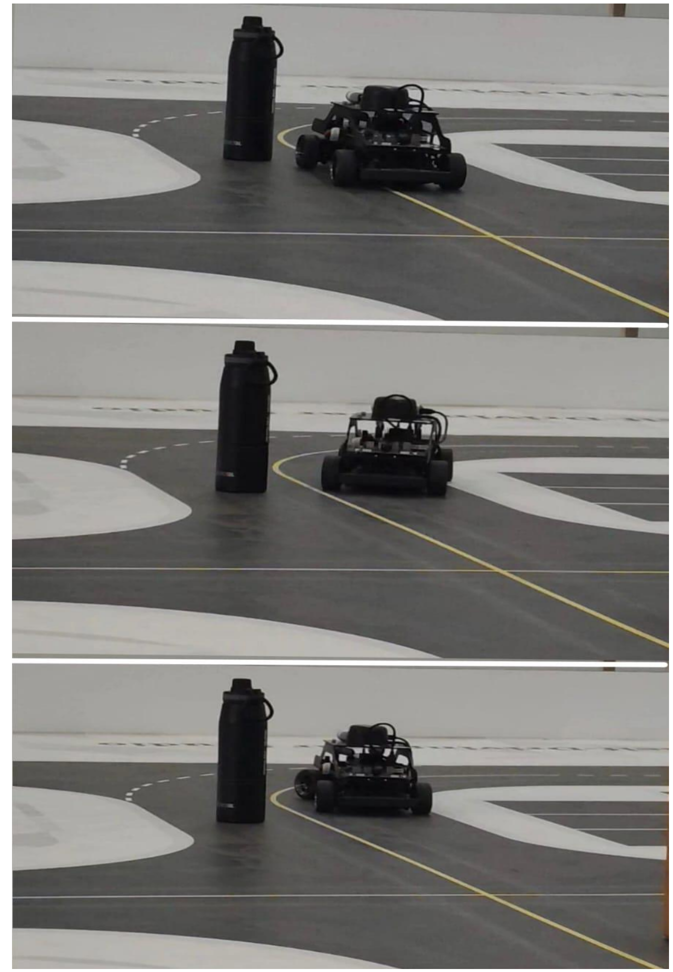
AVOIDANCE PATH





RESULTS





THANK YOU