Capstone Project Proposal Report
(Individual Report)

Instructions:

This form is to be completed by each student doing Project registration to fulfill their senior design or capstone requirement. It must be completed and submitted to your Guide. Each student must complete this form individually.

This report is to be completed during the starting of the semester, while the project description report will be completed during end of the semester.

Guide Approval (initials/date):		

CAP4001– Capstone Project Proposal Report

Student Name	**Pratik Kumar Jha**
Student Register Number	**22BCE7511**
Course	Computer Science (CORE)
Semester/Year	Fall Sem (25-26)
Guide(s)	Prof. Anurag De
Project Title	SimuDrive: AI-Based Lane and Pedestrian Intent Detection for Autonomous Driving

Team Composition: Provide the information below for each member of the **project team**. Include **all** project team members, not just those in your discipline or those enrolled for Capstone project. Please also include yourself!

Reg. No	Name	Major	Specialization
22BCE7511	Pratik Kumar Jha	Computer Science	CORE
22BCE7090	Aditya Pillai	Computer Science	CORE
22BCE8616	Abhik Das	Computer Science	CORE

Project and Task Description: Provide a brief (one or two page) technical description of the design project and your specific tasks, as outlined below: (use a separate sheet)

(a) Provide a summary of the project, including a description of the project and its requirements, the purpose, specifications, and a summary of the approach. If this is a continuing project, you may use and/or edit the same project description.

(b) Describe the specific role and tasks that **you individually** will be completing as part of the design of the project. What **specific deliverables** will you produce?

(c) Discuss in detail the specific approach that will be used to complete **your** portion of the design.

(d) Describe the phases of the design process that will be incorporated and what work will be accomplished during those phases. (you may attach a Gantt Chart)

Outcome Matrix: Describe your plan to demonstrate each of the outcomes below.

Outcomes:	Plan for demonstrating outcome:
a) an ability to apply knowledge of mathematics, science, and engineering	Implement edge detection, polynomial curve fitting, ML classification using linear algebra, probability, and geometry concepts.

c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Develop a system considering computational efficiency, simulation resource limits, and realistic environmental conditions.
d) an ability to function on multidisciplinary teams	Collaborate with teammates specializing in CV, ML, and simulation
e) an ability to identify, formulate, and solve engineering problems	Optimize lane detection accuracy in poor lighting, improve intent prediction under occlusion.
g) an ability to communicate effectively	Prepare reports, diagrams, and annotated simulation videos.
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Use OpenCV, Porch, YOLOv8, MediaPipe, and CARLA

Realistic Constraints:

- **Economic:** Open-source datasets and tools to minimize cost.
- **Environmental:** Consider variable weather in simulation scenarios.
- **Safety:** Prioritize detection accuracy to avoid false positives/negatives in decision-making.
- **Computational:** Optimize for real-time performance on moderate hardware.

Engineering Standards:

- Follow IEEE standards for software design documentation.
- Use PEP8 for Python coding standards.
- Apply CVPR best practices for dataset preprocessing and evaluation metrics.

Project Summary:

The proposed project, *SimuDrive: AI-Based Lane and Pedestrian Intent Detection for Autonomous Driving*, aims to design and implement an advanced computer vision and machine learning–driven system capable of accurately detecting road lanes and predicting pedestrian intent in real-time. The system will operate in a simulated autonomous driving environment using the CARLA Simulator, allowing controlled testing under varied environmental conditions.

Requirements:

- Detect and track lane markings accurately under normal and adverse conditions (low light, rain, occlusion).
- Recognize pedestrians and classify their intent (e.g., crossing, standing, turning) in real time.
- Integrate both modules into a single decision-making pipeline for simulated autonomous driving.

Purpose:

Enhance the safety and decision-making capability of autonomous vehicles by reducing false detections and improving reaction time to potential hazards.

Specifications:

- Lane detection accuracy target: **≥95%** under standard simulation scenarios.
- Pedestrian intent prediction precision: **≥90%**.
- Real-time performance: **≥20 FPS** on moderate hardware.

Approach Summary:

The project will utilize **OpenCV** for image processing, **YOLOv8** for object detection, **MediaPipe** for pose estimation, and **PyTorch** for model training. Modules will be developed independently and then integrated into CARLA for simulation testing under varied environmental and traffic conditions.

Team Roles and Responsibilities:

1. **Pratik Kumar Jha –** ***Lane Detection Lead & Simulation Integrator***

- **Tasks to be Performed:**
  - Implement lane detection using advanced computer vision algorithms such as Canny edge detection and Hough transform.
  - Apply polynomial curve fitting for smooth lane curvature estimation.
  - Integrate lane detection pipeline with the CARLA Simulator for realistic driving scenarios.
  - Handle adverse simulation conditions like low light, rain, and occlusion.
  - Collaborate with the pedestrian detection module to ensure synchronized decision-making for path planning.

- **Technology Stack:** OpenCV, NumPy, PyTorch, CARLA Simulator, Matplotlib (for visualization).

- **Deliverables:**
  - Fully functional lane detection module with >95% accuracy in controlled simulation tests.
  - Annotated simulation videos demonstrating lane tracking in various conditions.
  - Technical documentation detailing algorithm design, optimization, and integration workflow.

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2. **Aditya Pillai –** ***Data Engineer & Model Optimization Specialist***

- **Tasks to be Performed:**
  - Source, clean, and preprocess datasets from KITTI, BDD100K, and CARLA-generated simulations.
  - Perform data augmentation (brightness adjustment, rotation, scaling) to improve model robustness.
  - Optimize YOLOv8 and other ML models for real-time performance, focusing on hyperparameter tuning.
  - Conduct comparative model evaluations to determine the most efficient architecture for deployment.
  - Maintain version control of datasets and model checkpoints for reproducibility.

- **Technology Stack:** Python, Pandas, Scikit-learn, YOLOv8, PyTorch, Albumentations (for augmentation).

- **Deliverables:**
  - Cleaned and labelled dataset ready for training and validation.
  - Optimized ML models with benchmark reports.
  - Training logs and performance metrics for each iteration.

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3. **Abhik Das –** ***Pedestrian Intent Detection & System Testing Lead***

- **Tasks to be Performed:**
  - Implement pedestrian detection using YOLOv8, coupled with MediaPipe for pose estimation.
  - Develop intent classification logic (e.g., standing, crossing, turning) using temporal and spatial data.
  - Design test cases for both normal and edge scenarios (crowded crossings, partial occlusion).
  - Conduct integration testing between pedestrian intent and lane detection modules in the CARLA environment.
  - Prepare simulation datasets for evaluating pedestrian behavior under varying conditions.

- **Technology Stack:** MediaPipe, YOLOv8, OpenCV, CARLA Simulator, NumPy.

- **Deliverables:**
  - Pedestrian intent detection module with >90% precision in intent classification.
  - Scenario-based testing reports and comparative accuracy charts.
  - Simulation videos showcasing real-time intent prediction.

Phases of the Project:

Phase	*Duration*	*Key Activities*	*Responsible Member(s)*
Phase 1 – Research & Requirements Gathering	Week 1–2	Literature review, tool selection, dataset sourcing	All
Phase 2 – Data Preparation	Week 3–4	Dataset cleaning, labeling, augmentation	Aditya
Phase 3 – Lane Detection Module Development	Week 5–7	Implement edge detection, polynomial curve fitting, lane curvature estimation	Pratik
Phase 4 – Pedestrian Intent Detection	Week 8–10	Implement MediaPipe + YOLOv8 pedestrian module	Abhik
Phase 5 – Module Integration & Simulation	Week 11–12	Integrate both modules in CARLA, simulate various conditions	All
Phase 6 – Testing & Optimization	Week 13–14	Model accuracy tuning, real-time performance testing	Aditya & Abhik
Phase 7 – Documentation & Final Presentation	Week 15–16	Prepare final report, simulation videos, and presentation	All

Project Timeline - Gantt Chart: