DATS 6501 – Capstone Project Proposal (Condensed Version)

Course: Data Science Capstone (DATS 6501)
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Project Title: ***Lane Detection Using Deep Learning for Driver Assistance Systems***

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1. Project Overview

Lane detection is an essential part of modern driver assistance and self-driving systems. This capstone project aims to create a lane detection system based on deep learning that can identify road lane boundaries from camera images.

Instead of using traditional computer vision methods that depend on manually defined rules, this project takes a data-driven approach using a fully convolutional neural network (FCN). The model predicts lanes at the pixel level and produces lane overlays on road images and videos. The final outputs include a trained model, a complete machine learning pipeline, and visual demonstrations in real-world driving conditions.

This project meets the capstone requirement of creating an end-to-end machine learning proof of concept and serves as a useful addition to a portfolio related to intelligent transportation systems.

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2. Problem Statement and Motivation

Problem Statement
Lane detection is still difficult in real-world situations. Traditional computer vision methods often struggle with changing lighting conditions, shadows, faded lane markings, road curves, and busy traffic. These methods need a lot of manual adjustments and are not reliable in different settings.

Motivation
Human drivers usually recognize lane boundaries, but fatigue and distraction can lead to safety issues. Automated systems, if dependable, can run all the time. A deep learning approach can learn spatial and contextual features directly from data. This reduces reliance on manually created rules and improves performance in various driving conditions. This work shows the practical benefits of deep learning in computer vision and driver safety.

3. Proposed Solution

Approach
This project formulates lane detection as a pixel-wise prediction task using a fully convolutional neural network. The model takes road images as input and outputs segmentation-style lane predictions.

Key features of the solution include:

- End-to-end learning from raw images
- No hard-coded vision rules during inference
- Generalization to unseen driving videos

The trained model will be applied to video streams, where predictions across consecutive frames are aggregated to produce stable lane visualizations.

Why Deep Learning?
Deep learning models excel at visual perception tasks by learning hierarchical spatial features. Compared to classical computer vision pipelines, neural networks adapt more effectively to variations in lighting, perspective, and road geometry without manual configuration.

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4. Data Description

The dataset includes road images taken from various driving videos recorded in different conditions, such as daytime, nighttime, straight roads, curves, construction zones, and intersections. We will use data augmentation techniques like rotations and horizontal flips to improve generalization. Lane labels appear as pixel-level masks or polynomial-based representations created during preprocessing. The dataset is diverse and large enough for effective training and evaluation within a capstone project.

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5. Technical Stack

- Programming Language: Python
- Deep Learning Frameworks: TensorFlow, Keras
- Libraries: OpenCV, NumPy, Matplotlib
- Environment Management: Conda
- Version Control: Git and GitHub

This stack supports model development, evaluation, and reproducibility in line with academic and industry standards.

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6. Evaluation Strategy

Model performance will be evaluated using both quantitative and qualitative metrics, including training and validation loss, visual accuracy of lane overlays, and performance on unseen test videos. Results will be compared against a traditional computer vision baseline, with particular focus on challenging lighting and road curvature conditions.

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7. Expected Outcomes

By the end of the project, the expected deliverables include:

- A trained deep learning model for lane detection
- A complete machine learning pipeline from preprocessing to inference
- Video demonstrations with detected lane overlays
- A well-documented GitHub repository
- A presentation and live demo of the system

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8. Impact and Relevance

This project shows how deep learning can be applied to a real-world, safety-critical problem. It highlights important machine learning concepts like data preparation, model design, evaluation, and deployment. The final system acts as both an academic capstone submission and a professional portfolio piece related to machine learning, computer vision, and autonomous systems.