Behavioral Cloning in Autonomous Vehicle using CNN

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Content

Introduction

Daily new and innovative cars with top features are being launched around the globe. But, the mention of self-driven cars still garners a lot of attention. The work on self-driven cars is going on for quite some time, but they are still not fully prepared to be launched in the market. One of the reasons can be, their inability to understand the common day-to-day etiquettes followed by the society on the road. Hence, this project proposes a methodology to perform automated imitation for Self-Driving Vehicles.

Problem Statement

Simulate a Vehicle driving autonomously using information from its environment in real-time to predict steering angles, acceleration, and braking values

Objectives

1. Develop an autonomous vehicle navigation system using deep learning for object detection and classification, obstacle avoidance, and route planning.
2. Explore the performance of different deep learning models, such as CNNs and RNNs, for object detection and classification.
3. Implement a real-time obstacle avoidance algorithm using a combination of sensor data and machine learning techniques.
4. Evaluate the proposed approach through simulation experiments and compare it with other state-of-the-art approaches in terms of accuracy, speed, and safety.

Literature Survey

"End-to-end autonomous driving using an RGB camera and a CNN" by Haoming Liu et al., published in IEEE International Conference on Robotics and Automation in 2021

This paper proposes an **end-to-end autonomous driving system using only an RGB camera and a CNN model**. The authors showed that the system can achieve **high accuracy** in various driving scenarios

Technologies used

- CNN model for end-to-end autonomous driving with an **RGB camera**

Limitations

- The approach is **limited by the complexity** of the driving environment **and the accuracy of the sensors.** Focusing on the single-sensor setting since better estimation models are required in order to compete with the multisensory setting

Future work

- Developing **more accurate and robust CNN models** for complex driving scenarios. GNSS information which, even usually being noisy, eventually can complement direct scene sensing.

This paper provides a survey of autonomous driving systems that **use CNN models for perception and decision-makin**g. The authors reviewed various CNN architectures and their performance on **different datasets**

Technologies used

- CNN models for perception and decision-making in autonomous driving

Limitations

- The performance of the CNN models is limited by the **complexity of the driving environment** and the **accuracy of the sensors**

Future work

- Developing **robust CNN models** for perception and decision-making in autonomous driving. However, there are still lots of problems that should be further studied, such as **real-time problems, reliability problems**

"Autonomous driving in real-world environments: A survey on perception and decision-making" by Yajie Hu et al., published in Neurocomputing in 2021

"Attention-based multi-modal deep learning for autonomous driving" by Xiaoyue Liu et al., published in IEEE Transactions on Intelligent Transportation Systems in 2021

This paper proposes an **attention-based multi-modal deep learning approach** for autonomous driving using a combination of **visual and LiDAR data**. The authors showed that the approach can improve the accuracy and robustness of the autonomous driving system

Technologies used

- Attention-based **multi-modal deep learning for autonomous driving using visual and LiDAR data**

Limitations

- As most existing algorithms are **trained based on supervised learning**, which requires a large amount of labeled data as the basis.

Future work

- **Novel modulation** type classification methods, such as **orthogonal frequency division multiplexing**, should be investigated to improve the generalization and robustness of the model.

"Real-time vehicle detection and tracking with deep learning for autonomous driving" by Jian Chen et al., published in Neurocomputing in 2021

This paper proposes a **real-time vehicle detection** and **tracking system** for autonomous driving using a **deep learning approach**. The authors showed that the system can achieve **high accuracy and real-time performance**.

Technologies used

- Deep learning approach for real-time vehicle detection and tracking for autonomous driving

Limitations

- **Traffic sign detection** is an important part of driving in the autonomous environment which hasnt been considered here

Future work

- However, even in the **Real World, pedestrian and vehicle movements must be accounted f**or in self-driving systems.

"An overview of deep learning-based perception and decision-making for autonomous driving" by Fangwei Zhang et al., published in Journal of Advanced Transportation in 2021

This paper provides an overview of deep learning-based approaches for perception and decision-making in autonomous driving. The authors reviewed various CNN architectures and their **performance on different datasets**

Technologies used

- Deep learning-based approaches for perception and decision-making in autonomous driving

Limitations

- Use of **monocular cameras rather than sophisticated sensor fusion** can miss out few important objects

Future work

- They are seeking a **fundamental breakthrough in the use of multi-object tracking algorithms** to solve real-world issues

This paper proposes an improved CNN-based lane detection method for autonomous driving. The authors showed that the method can **improve the accuracy and robustness of the lane detection system. It integrates the VGG-16 and the gated recurrent unit (GRU) for lane following on the road**

Technologies used

- Improved CNN-based lane detection method for autonomous driving

Limitations

- The approach is limited by the complexity of the driving environment and the accuracy of the sensors. many limitations still exist that **prevent the development of full AVs**

Future work

- The results showed that the embedded system took almost **45–46 s to execute a single epoch** in order **to predict the steering angle** which can be improved

"An improved CNN-based lane detection method for autonomous driving" by Xian Chen et al., published in Journal of Intelligent & Fuzzy Systems in 2021.

Overall

These recent research papers demonstrate the potential of CNN models for autonomous driving systems.

While the approaches have shown promising results, they are still limited by the complexity of the driving environment and the accuracy of the sensors.

Future work should focus on developing more accurate and robust CNN models for perception, decision-making, and vehicle detection in autonomous driving

Dataset

- There are two modes for driving the car in the simulator: (1) Training mode and (2) Autonomous mode. The training mode gives you the option of recording your run and capturing the training dataset

- The simulator's feature to create your own dataset of images makes it easy to work on the problem.

Dataset

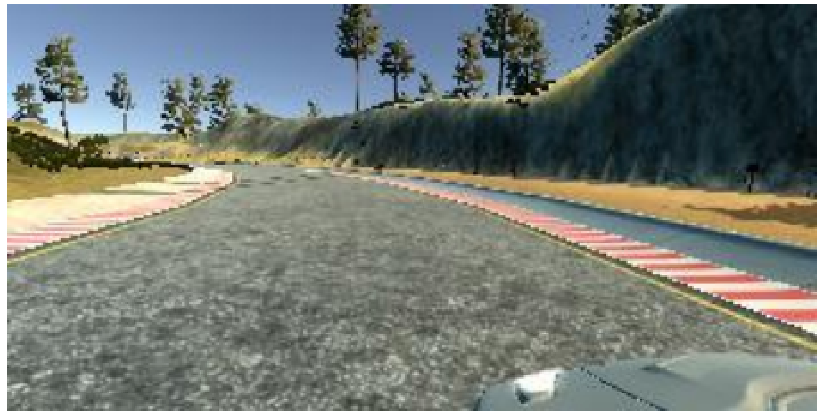
- The simulator has built the driving features in such a way that it simulates that there are three cameras on the car. The three cameras are in the center, right, and left on the front of the car, which capture continuously when we record in the training mode.

- The stream of images is captured, and we can set the location on the disk for saving the data after pushing the record button. The image set is labelled in a sophisticated manner with a prefix of center, left, or right indicating from which camera the image has been captured.

- Along with the image dataset, it also generates a datalog.csv file. This file contains the image paths with the corresponding steering angle, throttle, brakes, and speed of the car at that instance

Dataset Images

Center0001



Right0001

Left0001

Center0099

Right0099

Left0099

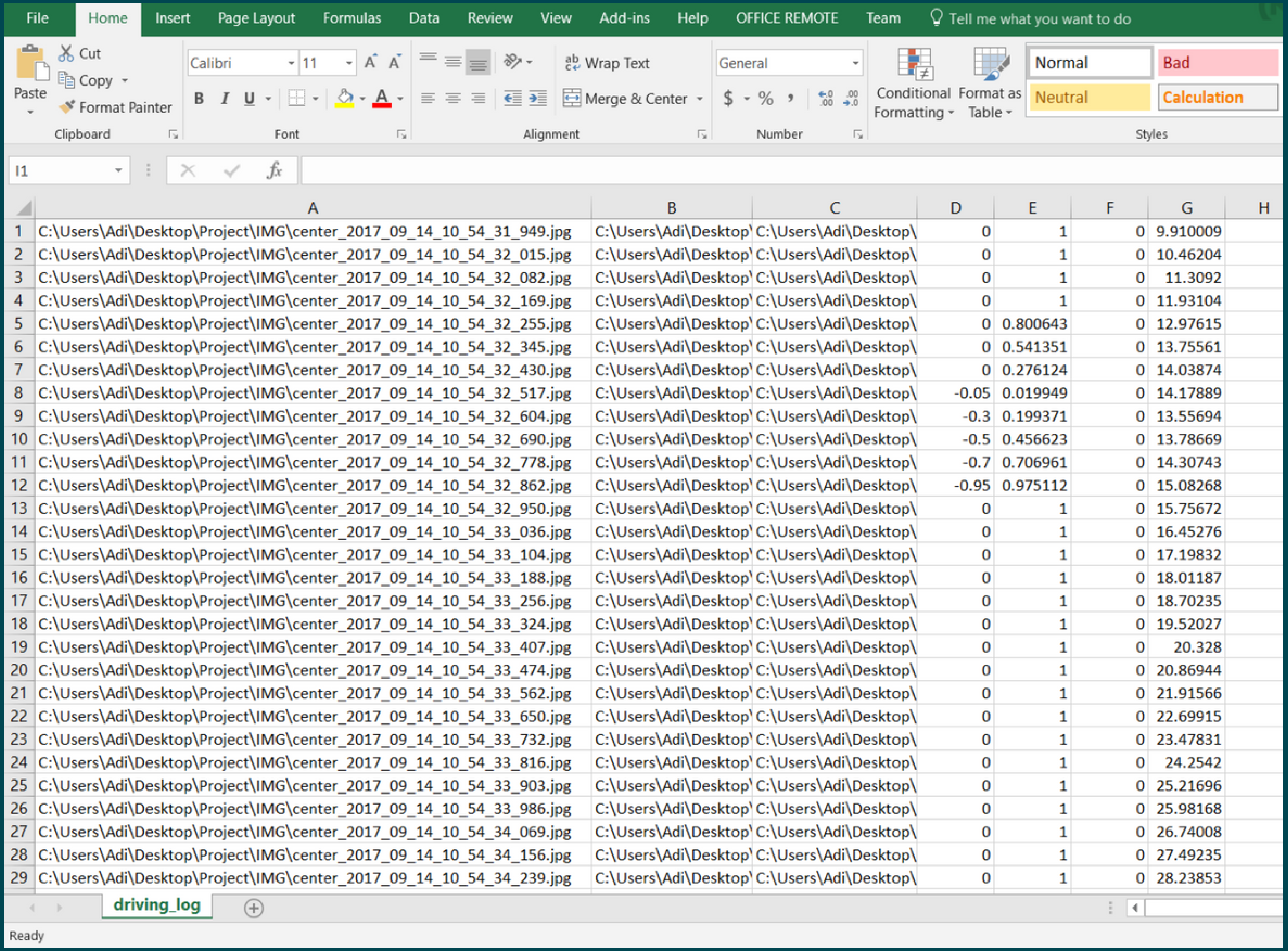
- Column 1, 2, 3: contains paths to the dataset images of the center, right, and left respectively

- Column 4: contains the steering angle Column value of 0 depicts a straight, the positive value is a right turn and the negative value is a left turn.

- Column 5: contains the throttle or acceleration at that instance

- Column 6: contains the brakes or deceleration at that instance

- Column 7: contains the speed of the vehicle



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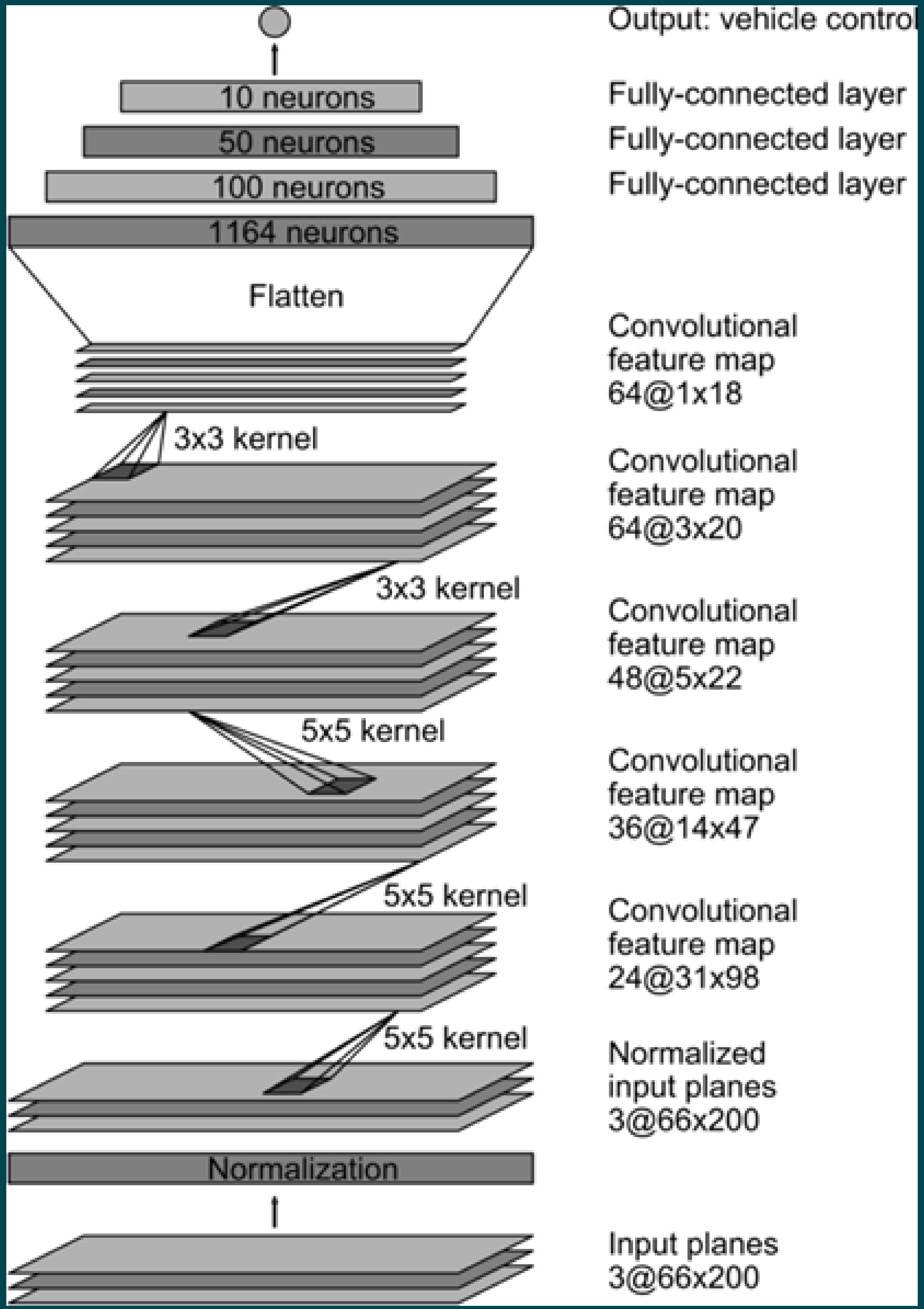
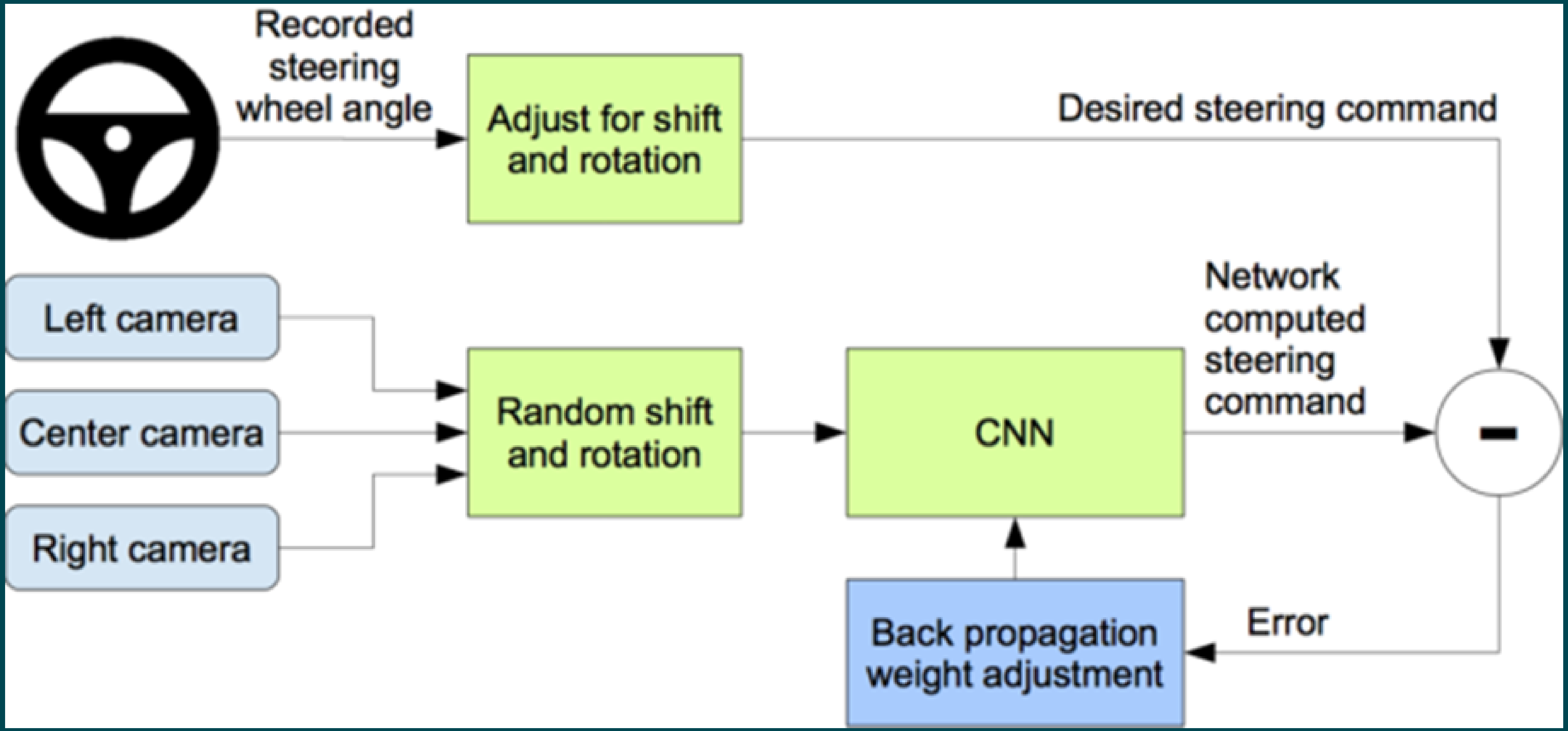
driving_log

Methodology & Architecture

NVIDIA Dave2 9-Layer CNN model



DataFlow Diagram

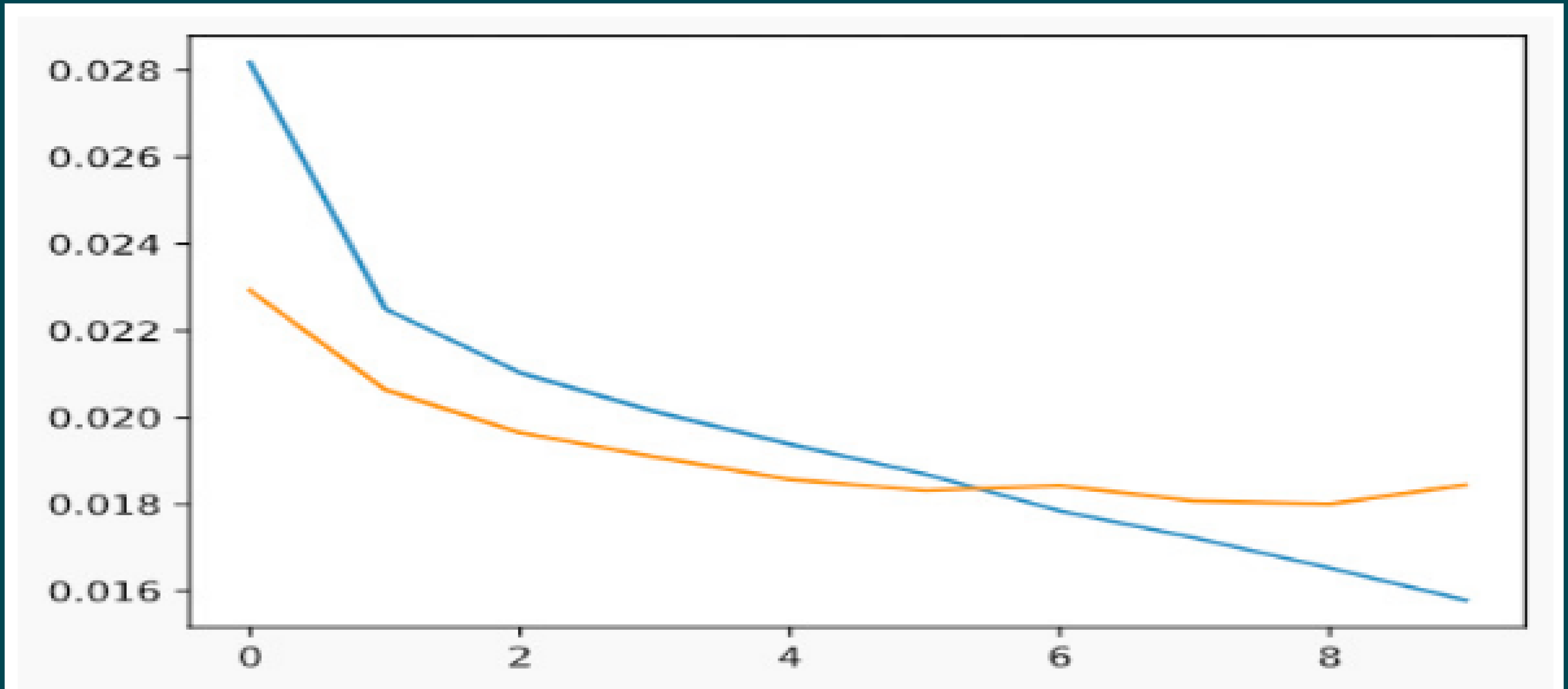


Technical Stack

1. Tensorflow
2. Keras
3. Numpy
4. Conda
5. PIL
6. Pandas
7. Matplotlib
8. Flask API
9. WSGI

Results

- Model Training
- Result Inference & Validation
- Backend Application



The model was able to achieve a 98% autonomy score (1 intervention in 300 seconds).

References

1. "End-to-end autonomous driving using an RGB camera and a CNN" by Haoming Liu et al., published in IEEE International Conference on Robotics and Automation in 2021
2. "Autonomous driving in real-world environments: A survey on perception and decision-making" by Yajie Hu et al., published in Neurocomputing in 2021.
3. "Attention-based multi-modal deep learning for autonomous driving" by Xiaoyue Liu et al., published in IEEE Transactions on Intelligent Transportation Systems in 2021.
4. "Real-time vehicle detection and tracking with deep learning for autonomous driving" by Jian Chen et al., published in Neurocomputing in 2021.
5. "Deep reinforcement learning for autonomous driving: A review" by Zhenyuan Wang et al., published in Information Fusion in 2021.
6. "An improved CNN-based lane detection method for autonomous driving" by Xian Chen et al., published in Journal of Intelligent & Fuzzy Systems in 2021

Thank You