Creating Robust Neural Network Generalisation for a Single-Camera Self-Driving Car

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Complex Engineering Problem

To investigate and implement techniques regarding the design, implementation and generalisation of a Convolutional Neural Network (CNN). This CNN is to be used as a self-driving car Pilot, and should be able to function in at least three separate locations with minimal training data (15000-30000 images). This CNN along with any image processing techniques used for generalisation will replace the default CNN Pilot available in an existing open source self-driving system.

Engineering Design

The Engineering Design Methodology used was a combination of Agile, Systems Engineering-derived diagrams, and workflows proposed by Ian Goodfellow (Deep Learning, 2016) and Francois Chollet (Deep Learning with Python, 2018). This process ended up being an iterative experimental cycle to select layer types, optimizers, network size/arrangement, as well as effective generalisation solutions in addition to other factors such as optimal training iterations and data preparations. This process was logged using Neptune.ai, and all results of experiments run (300+ in total) are publicly available online (https://tinyurl.com/yarbyegl). All code written and used to train and build up the networks are publicly available on various Colab Notebooks (https://tinyurl.com/y7yswr8t).

Solution Elements

Elements	Open Source	Integrated	Implemented	Designed
Donkey Car Support Libraries	*	*		
Donkey Car Sim (Unity)	*		Driving and Testing	
OpenCV Libraries	*	*	*	
Lane Detection Algo			*	*
Keras and Tensorflow Backends	*	*		
High-Level CNN Model			*	*
Neptune Experiment Management	*	*		

Independent Learning

Note: While data science/machine learning was done in REII 424, the bulk of the project took place before the module was given – therefore all data science/machine learning skills used in this project were derived from independent learning.

Skills Acquired:

* Python Programming (bonus: List Comprehension!)

* Machine Learning Workflows

* Effective Data Preparation for Neural Network Training

* Neural Network Design and Implementation (With Keras and Tensorflow)

* Neural Network Experiment Design

* OpenCV (Image Pre-Processing)

Knowledge Gained:

* Machine Learning (history, ML Types, ML Uses)

* Generalisation Methods (Feature Engineering, K-Fold Validation, Pruning)

* Optimization Functions, Activation Functions, Layer Types, Layer Behaviours (Neural Networks)

* Machine/Deep Learning Problem setup, design and evaluation

* How CNNs, RNNs, and U-Nets function and learn

* Appropriate performance metric selection when training Neural Networks

Budget

Since the project moved to a 100% software solution – no funds were used.

Signatures:

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Student

X

Supervisor