Udacity Self Driving Car Engineer Nanodegree Highlights

Term 1 Course Outline

(Dec 12, 2016 - Apr 4, 2017)

Lesson	Week No.	Brief	Notes
Introduction			

1		Welcome	• Handbook: SDCND_WelcomeHandbook_December.pdf
			• Two approaches to self-driving (both actively pursued):
			  • robotics: model based sensor fusion and navigation
			  • deep learning: learn by mimicking human driving behaviour
			• History: 'The Great Robot Race' (below) on how teams adopted different approaches to 2003/2004 DARPA Grand Challenges. Basically, a few focused on hardware as the main challenge while others focused on software. Software won, and by a big margin! The video is long but worth watching.

2	2	Finding Lane Lines (project due 22 Dec)	• Review of Canny Edge Detection and Hough Transforms • Lane detection project using OpenCV and Python (Application of my lane detection pipeline on the 'challenge' video)
Deep Learning			
3		Introduction to Deep Learning Module	-
4		Regression and Classification	• Regression by least-squares curve fitting • Cross-validation to detect underfitting or overfitting model to data

5		Neural Networks	• Perceptrons
			  • compute operations on boolean data (AND, OR, NOT, XOR)
			  • Linear and nonlinear separability
			  • training: perceptron rule, gradient descent rule
			• Back-propagation
			• Types of inductive bias - preference bias and restriction bias

6		MiniFlow	• Hands-on exercise - implementation of a TensorFlow-like system in Python
7		Introduction to TensorFlow	• Multinomial logistic classifiers: Softmax function, 1-hot encoding, cross-entropy • Initialisation and numerical stability of loss function calculations • Stochastic Gradient Descent: Momentum and Learning Rate Decay
8		Deep Neural Networks	• Rectified Linear Units (RELU) • Chain rule to setup back-propagation • Deep vs wide NNs - advantages • Regularisation to prevent overfitting and to increase robustness: L2 regularisation, 'Drop-Out' • Implementing deep NNs in TensorFlow
9		Convolutional Neural Networks	• Weight sharing • How CNNs transform input from spatial to semantic information • Dimensionality equation (number of neurons per layer) • Improving convnets: Pooling, 1x1 convolutions, Inception module • Exercise: Implement Lenet-5 deep neural network model (lecun-98.pdf) in TensorFlow
10	7	Traffic Sign Classifier (Project Due 23 Jan)	• Traffic sign recognition using multi-scale convolutional networks (sermanet-ijcnn-11.pdf) • Developed a network with 197415 parameters, trained on German traffic signs and tested on UK traffic signs • Report: https://github.com/cvilas/CarND/blob/master/P2-TrafficSigns/Traffic_Sign_Classifier.ipynb
11		Keras	• Re-implemented the traffic sign classifier using both sequential and functional APIs provided by Keras
12		Transfer Learning	• The idea of re-purposing an existing trained network for a new similar task • Feature Extraction and Fine Tuning • Repurposed AlexNet (60 million parameters, 650000 neurons) for traffic sign classification • Bottleneck features • Benchmark VGGNet, GoogLenet, ResNet on cifar10 and traffic signs datasets • The importance of experimenting with network architectures (practise is ahead of theory at the moment)
13	10	Behavioral Cloning (Project Due 13 Feb)	• End-to-end learning (i.e. no modeling or rules) and its advantages (nvidia paper: nvidia_end2end-16.pdf) • Simulator: https://techcrunch.com/2017/02/08/udacity-open-sources-its-self-driving-car-simulator-for-anyone-to-use/ • Report: https://github.com/cvilas/CarND/blob/master/P3-BehavioralCloning/submission/report/report.md • My architecture has 546619 parameters to tune. Others have achieved the same using SqueezeNet with 52 parameters: https://github.com/mez/carnd/blob/master/P3_behavioral_cloning/writeup_report.md • Batch-normalisation in improving learning ability of a network: batch_normalisation.pdf
Computer Vision			

14	12	Advanced Lane Finding (Project Due 27 Feb)	• Reversing lens distortions • Perspective transforms
15	14	Vehicle Detection and Tracking (Project Due 13 Mar)	

Additional Reading

- The curriculum for Term 1: https://medium.com/self-driving-cars/term-1-in-depth-on-udacitys-self-driving-car-curriculum-ffcf46af0c08#.api26st07
- The curriculum for Term 2: https://medium.com/udacity/term-2-in-depth-on-udacitys-self-driving-car-curriculum-775130aae502#.lra2w8s8m
- Vilas' GitHub repo: https://github.com/cvilas/CarND
- A Survey of Motion Planning and Control Techniques for Self-driving Urban Vehicles, https://arxiv.org/pdf/1604.07446v1.pdf
- Visualizing and Understanding Convolutional Networks:
    - fergus_eccv2014.pdf
    - https://www.youtube.com/watch?v=ghEmQSxT6tw
- How the future of autonomous cars will unhold. 16 questions: Video
- Dropout: A Simple Way to Prevent Neural Networks from Overfitting: JMLRdropout.pdf
- Gradient-based learning applied to document recognition (Lenet): lecun-98.pdf
- Traffic sign recognition with multi-scale convolutional networks: sermanet-ijcnn-11.pdf
- ImageNet classification with deep convolutional neural networks (AlexNet): alexnet.pdf
- Going deeper with convolutions (GoogLenet): GoogLeNet-15.pdf
- Deep residential learning for image recognition (Microsoft Resnet): resnet-15.pdf
- Very deep convolutional networks for large-scale image recognition (vggnet): vggnet-15.pdf
- End to end learning for self-driving cars (Nvidia): nvidia_end2end-16.pdf
- SqueezeNet: AlexNet level accuracy with 50x fewer parameters and < 0.5 MB model size: squeezenet-17.pdf
- Batch Normalization: Accelerating deep network training by reducing internal covariate shift: batch_normalisation.pdf