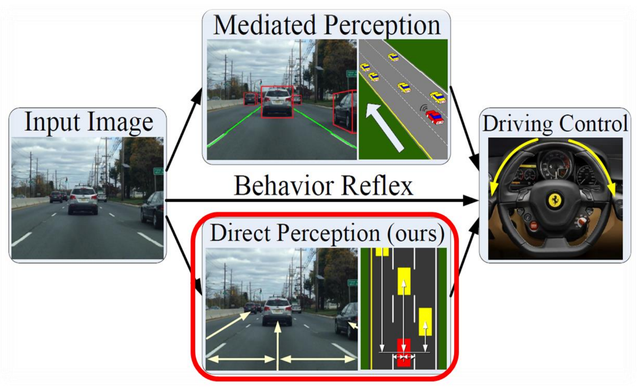
Deep Learning and Control Algorithms of Direct Perception for Autonomous driving

Der-Hau Lee[1], Kuan-Lin Chen[2], Kuan-Han Liou[2], Chang-Lun Liu[2], Jinn-Liang Liu[2]
[1]*Institute of Electrophysics, National Chiao Tung University, Taiwan*
[2]*Institute of Computational and Modeling Science, National Tsing Hau University, Taiwan*

Abstract. Based on the direct perception paradigm of autonomous driving, we investigate and modify the CNNs (convolutional neural networks) AlexNet and GoogLeNet that map an input image to few perception indicators (heading angle, distances to preceding cars, and distance to road centerline) for estimating driving affordances in highway traffic. We also design a controller with these indicators and the short-range sensor information of TORCS (the open racing car simulator) for driving simulated cars to avoid collisions. We collect a set of images from a TORCS camera in various driving scenarios, train these CNNs using the dataset, test them in unseen traffics, and find that they perform better than earlier algorithms and controllers in terms of training loss and driving stability.

Direct Perception Paradigm [1]



CNN Methods

Loss Function: Mean Absolute Error
Ground Truth Labels: 5 Real Indicators
Adam Optimizer
Optimal Velocity Car Following Model

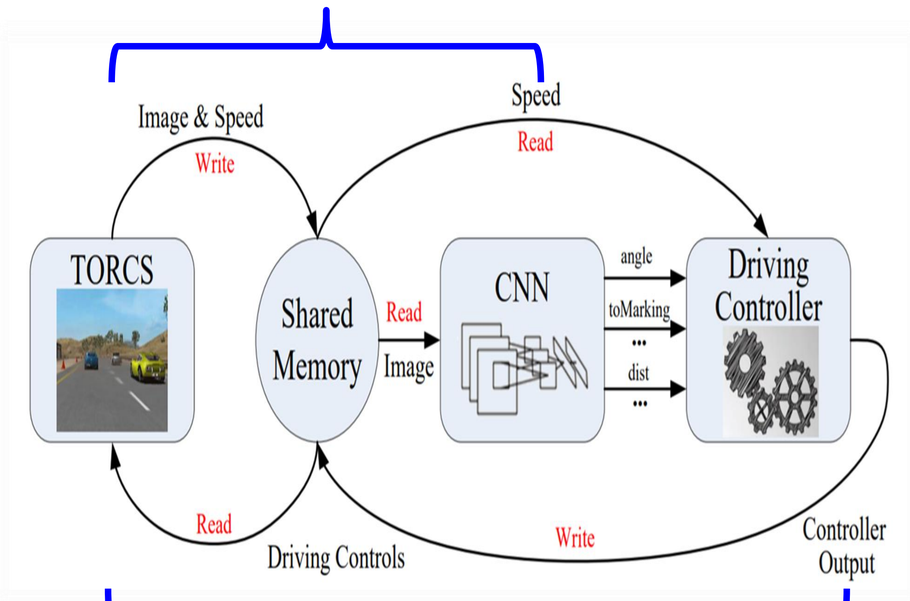
AlexNet

- 5CNN + 4FC layers
- Relu
- Dropout 0.2

GoogLeNet

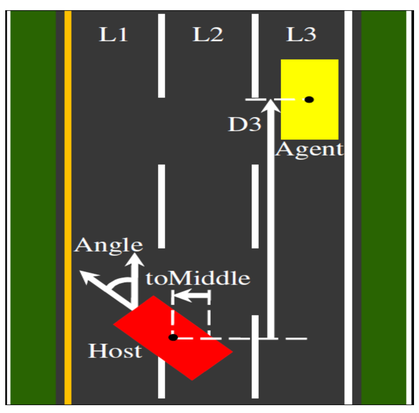
- Inception Structure
- Average Pooling
- 3 Loss Layers

Training Phase [1]



Testing Phase [1]

Five Affordances



Angle, toMiddle, D1, D2, D3

Data Generation

Key Issue in Machine Learning
By AI Agent in TORCS
With 0 to 20 Other AI Cars
In Various Speeds and Driving Behaviors

Prior Controller

Speed-Related Collisions

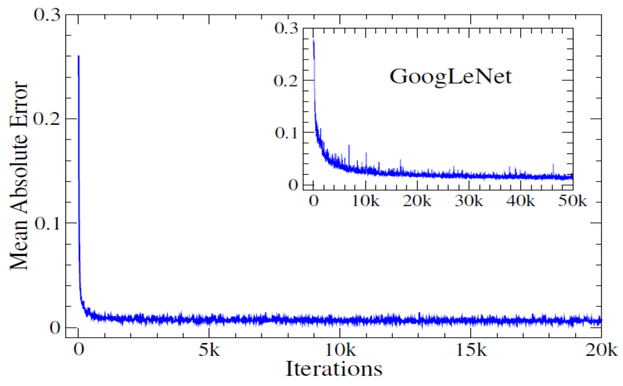
Lane Change Collisions

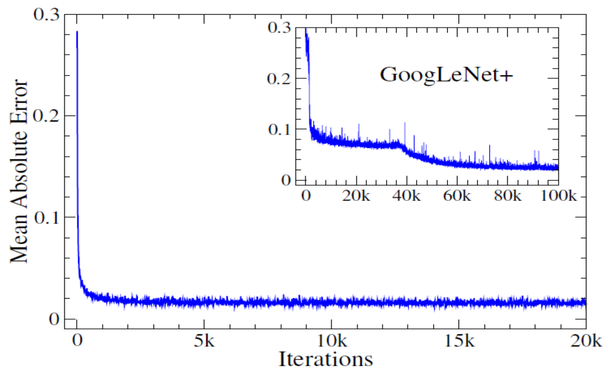
Our Controller

Driving Stably in Lane

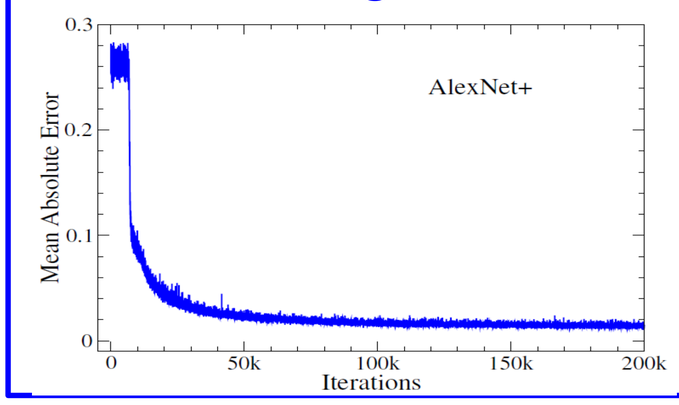
In Overtaking

Training Loss





Training Loss



Damage Value (Collisions)

CNN	Damage
AlexNet+14	413
AlexNet+5, GoogLeNet5, GoogLeNet+5	0

Objective: To Improve CNN for Autonomous Driving

Results: More Data, More Stable Controller, Better CNN

References
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[3] B. Wymann, et al., TORCS: The open racing car simulator, *Software available at http://torcs.sourceforge.net 4.6, 2000.*