XERXEZ SOLUTIONS
DEVELOPMENT – TRAINING – RESEARCH

Project Name: Self Driving Cars Using 3D Object Detection and Semantic Segmentation

ABSTRACT: We trained a convolutional neural network (CNN) to map raw pixels from a single front-facing camera directly to steering commands. This end-to-end approach proved surprisingly powerful. With minimum training data from humans the system learns to drive in traffic on local roads with or without lane markings and on highways. It also operates in areas with unclear visual guidance such as in parking lots and on unpaved roads.

The system automatically learns internal representations of the necessary processing steps such as detecting useful road features with only the human steering angle as the training signal. We never explicitly trained it to detect, for example, the out- line of roads.

Compared to explicit decomposition of the problem, such as lane marking detection, path planning, and control, our end-to-end system optimizes all processing steps simultaneously. We argue that this will eventually lead to better performance and smaller systems. Better performance will result because the internal components self-optimize to maximize overall system performance, instead of optimizing human-selected intermediate criteria, e. g., lane detection. Such criteria understandably are selected for ease of human interpretation which doesn't automatically guarantee maximum system performance. Smaller networks are possible because the system learns to solve the problem with the minimal number of processing steps. We used an NVIDIA DevBox and Torch 7 for training and an NVIDIA DRIVETM PX self-driving car computer also running Torch 7 for determining where to drive. The system operates at 30 frames per second (FPS).

INTRODUCTION: CNNs [1] have revolutionized pattern recognition [2]. Prior to the widespread adoption of CNNs, most pattern recognition tasks were performed using an initial stage of hand-crafted feature extraction followed by a classifier. The breakthrough of CNNs is that features are learned automatically from training examples. The CNN approach is especially powerful in image recognition tasks because the convolution operation captures the 2D nature of images. Also, by using the convolution kernels to scan an entire image, relatively few parameters need to be learned compared to the total number of operations.

While CNNs with learned features have been in commercial use for over twenty years, their adoption has exploded in the last few years because of two recent developments. First, large, labeled data sets such as the Large-Scale Visual Recognition Challenge (ILSVRC) [4] have become available for training and validation. Second, CNN learning algorithms have been implemented on the massively parallel graphics processing units (GPUs) which tremendously accelerate learning and inference.

In this paper, we describe a CNN that goes beyond pattern recognition. It learns the entire processing pipeline needed to steer an automobile. The groundwork for this project was done over 10 years ago in a Defense Advanced Research Projects Agency (DARPA) seedling project known as DARPA Autonomous Vehicle (DAVE) in which a sub-scale radio control (RC) car drove through a junk-filled alley way. DAVE was trained for hours of human driving in similar, but not identical environments. The training data included video from two cameras coupled with left and right steering commands from a human operator.

In many ways, DAVE-2 was inspired by the pioneering work of Pomerleau [6] who in 1989 built the Autonomous Land Vehicle in a Neural Network (ALVINN) system. It demonstrated that an end-to- end trained neural network can indeed steer a car on public roads. Our work differs in that 25 years of advances let us apply far more data and computational power to the task. In addition, our experience with CNNs lets us make use of this powerful technology. (ALVINN used a fully connected network which is tiny by today’s standard.)

While DAVE demonstrated the potential of end-to-end learning, and indeed was used to justify starting the DARPA Learning Applied to Ground Robots (LAGR) program, DAVE’s performance was not sufficiently reliable to provide a full alternative to more modular approaches to off-road driving. DAVE’s mean distance between crashes was about 20 meters in complex environments.

Nine months ago, a new effort was started at NVIDIA that sought to build on DAVE and create a robust system for driving on public roads. The primary motivation for this work is to avoid the need to recognize specific human-designated features, such as lane markings, guard rails, or other cars, and to avoid having to create a collection of “if then, else” rules, based on observation of these features. This paper describes the preliminary results of this new effort.

RELATED WORK & EXISTING PROBLEM: We have empirically demonstrated that CNN shareable to learn the entire task of lane and road following without manual decomposition not road or lane marking detection, semantic abstraction, path planning, and control. A small amount of training data from less than a hundred hours of driving was sufficient to train the car to operate in diverse conditions, on highways, local and residential roads in sunny, cloudy, and rainy conditions. CNN can learn meaningful road features from a very sparse training signal (steering alone). The system learns for example to detect the outline of a road without the need of explicit labels during training. More work is needed to improve the robustness of the network, to find methods to verify the robustness, and to improve visualization of the network-internal processing steps.

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8. DagsHub
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