

Evaluation Form – Technical Background Review

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Technical Content

- Current state-of-the-art and commercial products
- Underlying technology
- Implementation of the technology
- Overall quality of the technical summary

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Use of Technical Reference Sources

- Appropriate number of sources (at least six)
- Sufficient number of source types (at least four)
- Quality of the sources
- Appropriate citations in body of text
- Reference list in proper format

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Effectiveness of Writing, Organization, and Development of Content •

Introductory paragraph

- Clear flow of information
- Organization
- Grammar, spelling, punctuation
- Style, readability, audience appropriateness, conformance to standards

 / 100

Total - Technical Review Paper

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Machine Learning in Autonomous Vehicles

Introduction

As technology advances, machine learning is becoming more prevalent. Whether it is image recognition, speech recognition, traffic prediction, or self-driving cars, understanding and applying machine learning is crucial for enabling a computer to deliver such tasks. In recent years, machine learning has been researched to allow for autonomy of robots and technologies such as vehicles. This technical research paper will provide a general summary of implementing machine learning, recent studies in incorporating machine learning into autonomy, as well as provide an overview of commercial applications of machine learning into autonomous vehicles.

Implementing Machine Learning in Autonomous Vehicles

With the rise of autonomous vehicles, understanding the machine learning algorithms that go into them is crucial. In order to incorporate these algorithms into autonomous driving, a data set and a computer containing machine learning algorithms are needed [4]. With this, a computer can “learn” what it is programmed to learn based on previous data and predict and in an autonomous vehicle’s case, perform actions based on the “learned” experience it is given. This begs the question of “what machine algorithms are used for the autonomous vehicles?” The algorithms used are scale-invariant feature transform (SIFT) which allows image matching and object recognition for partially visible objects such as detecting a car behind a tree, AdaBoost which is a decision matrix that ensures the adaptive boosting of learners, TextonBoost which boosts image recognition based on labelling of clusters of visual data that have the same characteristics and respond to filters in the same way, histogram of oriented gradients (HOG) which analyzes a region of an image to see in which way the intensity of an image changes, and YOLO which analyzes a complete image then breaks it down into smaller segments [4]. With these algorithms and analysis of previous data, autonomous vehicles became possible to develop.

Recent Studies of Machine Learning in Autonomous Vehicles

In a 2015 study by Kuderer, Gulati, and Burgard, they implemented a feature-based inverse reinforcement learning method to learn driving styles from demonstrations [1]. Within [1], the study incorporates a cost function that is a linear combination of mappings from trajectories to real values which capture important priorities of the driving style they want to produce. In doing so, the results from [1] state that the learned policy is can be used to replicate driving a car with similar characteristics as a real driver. Also, in another study [2], some of the challenges autonomous vehicles come across are maintaining a high accuracy, high robustness for safe driving, adapting to various weather conditions, relying on accurate HD maps for localization and detection of static infrastructure, adapting to less structured scenarios such as parking and roundabouts, and adapting to erratic behaviors of traffic and pedestrians. Incorporating these factors into autonomous vehicles is difficult due to the human-engineered modules rely on human intuition and heuristics which can be inherently incorrect, and in the case of machine learning driving policies, bridging the gap between modular and interpretable systems while keeping human level performance has not been solved yet [2]. Though, autonomous vehicles are on the rise and is progressing at an alarming rate, and eventually these problems will be solved in the near future.

Commercial Applications of Machine Learning in Autonomous Vehicles

Several companies across the globe have already began development of autonomous vehicles as commercial products to consumers. For instance, Tesla has developed the autopilot feature in their new commercial lineup. The autopilot feature applies a per-camera network to analyze raw images to perform semantic segmentation, object detection and monocular depth estimation [5]. Also, their cameras take real time video of the roads, infrastructure, and 3D objects. Tesla also developed their own autonomy algorithms which drives the car with the creation of a high-quality representation of the surroundings and plans its routes throughout that space. To achieve this, developers at Tesla must algorithmically create data from the car's sensors as it traverses through a space over a period of time [5]. With the autopilot feature incorporated into their cars, consumers would have to pay \$10,000 on top of the price of the car.

Google's Waymo is also another autonomous vehicle in creation for commercial purposes. Developers are applying deep learning and automated machine learning to develop self-driving cars. This means that neural nets are continuously training other neural nets [6]. In order to do this effectively, the

developers of Waymo used GPUs in their machine learning because they were well-suited for running neural networks [6]. Waymo is also using their “Waymo Open Dataset which is one of the largest and most diverse publicly available fully self-driving datasets” as expressed by software engineer at Waymo, Andrew Stein during an interview [3]. The dataset includes sensor data from various environments and weather conditions.

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- [2] A. Behl, A. Geiger, F. Guney, J. Janai, "Computer Vision for Autonomous Vehicles: Problems, Datasets and State of the Art," 2019. [E-book] Available: Cornell University E-book. <https://arxiv.org/abs/1704.05519> [Accessed: Mar. 7, 2021].
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- [6] A. Hawkins, "Inside Waymo's Strategy to Grow the Best Brains for Self-Driving Cars," *The Verge*, May 9, 2018. [Online]. Available: <https://www.theverge.com/2018/5/9/17307156/google-waymo-driverless-cars-deep-learning-neural-net-interview> [Accessed: Mar. 7, 2021].