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Artificial intelligence and autonomous driving

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Abstract. With the rapid development of science and technology, artificial intelligence and autonomous driving technology are becoming a hot topic in today's society. The integration of artificial intelligence and driving systems satisfies this requirement effectively and produces a new driving technology for the sake of traffic safety and a better driving experience. To increase driving safety and comfort, computer calculations are utilized to aid the driver or eliminate the interference of human variables. First, this study introduce the basic concepts and principles of artificial intelligence and autonomous driving, as well as their importance in practical applications. Secondly, this paper discuss in detail the key technologies of artificial intelligence in autonomous driving, including the application of perception, decision making, and control. Finally, his essay explore the challenges facing artificial intelligence and autonomous driving, including technical challenges, legal and ethical considerations. Through the research of this paper, we can better understand the relationship between artificial intelligence and autonomous driving, and provide reference and guidance for future development.

Keywords: artificial intelligence, autopilot, deep learning, environmental perception.

1. Introduction

The application of artificial intelligence is becoming increasingly widespread as science and technology progress. People see the convenience and benefits of artificial intelligence in their daily lives. Artificial intelligence has a highly favorable function, particularly in the sphere of transportation, and automated driving is an example of artificial intelligence technology benefiting mankind. Deep learning, computer vision, and natural language comprehension have all made significant advances in the development of artificial intelligence, with unmanned driving being one of the outcomes.[1] Driverless automobiles rely on artificial intelligence, visual computing, radar, monitoring devices, and GPS, allowing computers to drive cars autonomously and safely without the need for human intervention. The system's precise performance ensures traffic safety. This is a high-tech general intelligence system.

Self-driving cars can assist drivers in making decisions and can handle vehicles even when no one is present. The present automatic driving system is classified into five stages by the Society of Automotive Engineers: driver assistance, partial automatic driving, conditional automatic driving, highly automatic driving, and fully automatic driving. The role of artificial intelligence varies throughout all five tiers, but they all provide helpful driving information to help drivers accomplish safe driving.

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2. Research status at home and abroad

The 64-beam laser rangefinder on the roof, which can deliver fine 3D map data within 200 feet, is at the heart of the self-driving car's external equipment. To avoid impediments and comply with traffic laws while driving autonomously, driverless cars will integrate laser measurement data with high-resolution maps to produce various sorts of data models. The front windshield camera detects objects and recognizes road signs and traffic signals.[2]

National University of Defense Technology, Beijing Institute of Technology, Tsinghua University, Tongji University, Shanghai Jiaotong University, and Jilin University all have driverless car research initiatives.[3] The Hongqi autonomous automobile, developed together by National University of Defense Technology and FAW, passed its road test. Tongji University's Automotive Engineering College has established a research platform for driverless cars, which realizes the integration of environmental awareness, global path planning, local path planning, and chassis control, and enables driverless cars to have the ability of independent "thinking and action," and can complete the driverless functions integrated into traffic flow, obstacle avoidance, adaptive cruise, and emergency stop (pedestrians crossing roads).

3. Automatic driving and deep learning

The brain is responsible for the driver's cognition, and the "brain" of a driverless car is a computer. Because the automobile may encounter shocks, vibrations, dust, and even high temperatures when driving, the computer in a driverless car is slightly different from the desktop computer and notebook computer that people typically use, and the general computer cannot run for a long period in these environments. As a result, in an industrial setting, unmanned vehicles typically select industrial computers. On the industrial computer, the operating system runs, and the driverless software runs within it.[4] The following steps are involved in applying deep learning to driverless cars: ① data preparation, preprocessing, and data structure selection to store training and test tuples; ② For the initial level of unsupervised learning, input a large amount of data. ③ Clustering the data through the first layer, categorizing related data, and making random decisions; ④ Using supervised learning to increase the accuracy of data input in the second layer by adjusting the threshold of each node in the second layer; ⑤Use a huge amount of data to do unsupervised learning on each layer of the network, train only one layer at a time, and use the training results as input to its higher layer. ⑥ Following input, supervised learning is utilized to update all layers.

Data preparation is critical in deep learning algorithms. In practice, data is frequently regularized and whitened to increase the algorithm's accuracy. To achieve the effect of data preprocessing, the PCA(Principal Component Analysis)algorithm and whitening operation can be employed to lower the dimension of data. The PCA technique is a data dimension reduction algorithm that can significantly speed up unsupervised feature learning. The high correlation between neighboring pixels in the image indicates that the input data contains more duplicated information. The input vector can be turned into a low-dimensional approximate vector with relatively little error using the PCA technique. The running time of an unsupervised feature learning neural network technique, such as an automatic encoder, is determined by the dimension of the input data. Using preprocessed low-dimensional data as input data instead of original data can dramatically accelerate operations and enhance learning efficiency.

4. Environmental awareness

Deep learning convolutional neural network (CNN) research has fostered the progressive maturation of several critical technologies in autonomous driving, such as environmental awareness, motion control, behavior decision, and so on. Following that, I will discuss the use of deep learning in autonomous driving environment perception technologies.

4.1. Target classification

Autopilot lidar is a radar technology that uses a laser beam to detect the position of a target. It can also acquire depth information around the vehicle and precisely judge obstructions in its path. For example, the laser must reach 64 velodyne Company production lines in the United States, where the company's mechanical rotating structure may create a 3D scene map of the surrounding environment in real time. Because of its excellent dependability and precision, lidar is still one of the most significant optical sensors in automatic driving systems today.[5] However, in the open area, the point cloud will be too sparse to lose points owing to a lack of feature points. Convolutional neural networks have been used to categorize three-dimensional point cloud clusters by researchers in recent years. In practical engineering applications, they will use lidar to obtain the target's depth information, and then fuse their two data with various target detection and recognition algorithms based on CNN to obtain the target position and classification from the traffic road scene. As a result, multi-sensor fusion is commonly employed in practical applications to acquire surrounding information of traffic scenarios.

4.2. Target Detection and Tracking

4.2.1. Target detection

It is a critical technical substance in the automatic driving environment perception system to recognize and detect traffic lights, people and vehicles, lane lines, driving regions, and traffic signs. Traditional target identification methods collect pictures primarily through the use of multi-scale sliding windows. Because the calculated amount of data is enormous, a redundant window will be created. The toughness is inadequate. Target information's features are easily changed by the external environment, resulting in low classification accuracy and poor generalization capacity.

The target detection technology based on convolutional neural network (CNN) algorithm is gradually being applied to actual engineering applications with the advent of deep learning algorithm. Deep learning target detection algorithms are further classified as follows: R(Region)-CNN, FAST-RCCNN, and other two-stage vehicle detection systems are used. The algorithm is divided into two steps: selecting candidate regions initially, and then classifying and regressing. 2 Vehicle detection approach based on a single stage: certain Solid State Drive(SSD) and YOLO column detection methods. The end-to-end network structure of this approach instantly changes the target identification problem into a regression problem without identifying candidate regions. Because the network topology is simpler and the amount of computation and training data is significantly reduced, the latter has superior real-time performance and is more suitable for the actual traffic scene in the environmental awareness system.

A succession of data sets are required to assess the benefits and drawbacks of these algorithms in target detection. PASCAL VOC(The PASCAL Visual Object Classes) data set, COCO(Common Objects in Context) data set, ImageNet data set, MIT (pedestrian data set), KITTI (vehicle data set), and CTSD are some of our most regularly utilized data sets. (China traffic sign data set).

4.2.2. Target tracking

Target tracking of obstacles in front of vehicles is another crucial technology in the self-driving car perception system, including vehicle trajectory tracking, non-motor vehicle trajectory tracking, pedestrian trajectory tracking, and so on. Target tracking technology is critical for improving driving safety. It can accurately forecast object trajectory, allowing the control layer to make collision warning and lane change processing decisions in advance.

According to the number of targets, the application of target tracking can be divided into single object tracking (SOT) and multi-objects tracking (MOT). In actual traffic scenes, MOT is used more. Consider the matching relationship between multiple vehicle targets in the actual movement from the previous frame to the next frame. Target tracking algorithms can be roughly divided into two categories: ①Generation: mean shift algorithm, Kalman filtering method, and so forth. ② Identification: deep learning-based correlation filtering and tracking algorithms. The latter is more robust than the former and is used in the self-driving vehicle perception system.

The general data set and evaluation index will be introduced here in order to evaluate the practicability of various target tracking techniques. The MOT data set is a standard data set that is used for pedestrian and vehicle tracking. The following are the primary issues with today's target tracking technology: ① illumination change; (2) image blurring caused by the rapid movement of objects; ③ The change of the distance between the vision sensor and the surrounding targets, also called scale change; ④ The background is messy, and the detection process of similar target objects in each frame will lead to matching errors, thus losing the tracking target.

4.3. Scene segmentation

The semantic segmentation of traffic scenes is another essential component in the automatic driving system that influences vehicle autonomous navigation and behavior decision-making. It is crucial for comprehending and interpreting the surroundings. Semantic segmentation is a pixel-level standard for categorizing items including humans, automobiles, lane lines, grasslands, and buildings. Scene segmentation is image semantic segmentation, and it is a key technique for assisting the automatic driving perception system in establishing the semantic entity model of traffic scenes, understanding the surrounding environment, and judging the driving area.

Using deep learning to segment traffic scenes is a breakthrough that increases driving safety as well as the accuracy and timeliness of traffic scene segmentation. Deep learning semantic segmentation approaches mostly include:

① the method based on hole convolution; ② Methods based on coding and decoding; ③ Method based on feature fusion; ④ the method based on RNN; ⑤ Method based on attention mechanism.

Researchers need to test particular data sets in order to evaluate the real-time and performance of the scene segmentation method. According to scene categories, the most often utilized large-scale public data sets can be classified as follows: ① outdoor scenes: Stanford background, filtered stream data sets, with the characteristics of low level and resolution; ② Driving scenes: commonly used data sets of KITTI-ROS, intelligent robots and autonomous driving; ③ City Street View: cityscape used car cameras to shoot European street views; ④ Complex scenes: ade20k and MS COCO data sets have a large number of scenes, including a large number of samples and categories.

5. Planning decision-making and control

The planning and control of autonomous vehicles are inextricably intertwined. The planning module plans a specific path before the self-driving car runs and then passes it to the control module for execution to direct the vehicle. The planning module is responsible for creating a path that avoids impediments and adheres to the vehicle dynamics model, while the control module is responsible for ensuring that the vehicle drives carefully according to the planned trajectory. The autonomous driving planning can be separated into three parts: navigation planning, decision-making, and short-term path planning.

The current map is well supported, and navigation planning is relatively sophisticated. The basic idea is to identify the shortest path between two places on a map. [Dijkstra algorithm] is the classic algorithm. Because a* algorithm saves more search time than Dijkstra algorithm, it is the most commonly used algorithm nowadays. Of course, if the system is available, it must perform extensive optimization, such as building topological maps and real-time map maintenance (road network update), in order to form an optimal solution within a limited range. This system has performed admirably.

Deep learning is currently being used to train vehicles to avoid obstacles [learn to drive] (self-driving cars in browsers), and MIT is using deep learning to tackle traffic congestion [deep traffic].(MIT 6.S094: Deep learning of self-driving cars). Deep learning is currently underutilized in autopilot control since it is a black box system that cannot explain the theory. If there is a traffic accident, you have no idea why the car will lose control. As a result, the majority way is to make control decisions using a [finite state machine]. If you come across a situation that you haven't seen before, simply add a rule.

Finally, consider your short-term path. In reality, short-term path planning must take the object's location and time dimension into account. The path search is mostly involved here. It can identify the shortest way while keeping the car safe from obstructions. The derivative of the proposed path must also be continuous due to vehicle dynamics.

After the planning module has completed the preceding procedures and generated a specified path, it will be passed to the control module. The control module must be executed in the order specified. There are now two implementations. The first is a PID controller, which is a highly common control approach, such as motor control. In a nutshell, it is adjusted based on the present mistake. (the difference between the expected position and the actual position of the vehicle). Please turn the steering wheel to the right if you turn left. Turn the steering wheel to the left if you turn right. The PID model is simple because the PID model requires fast feedback, whereas the vehicle transmission model is slow. When braking, for example, the car does not stop instantaneously, hence a model must be used to depict the braking process. In this case, [MPC control] (model predictive control), or model-based control, is used. The model has the advantage of being able to describe the vehicle trajectory; however, the calculation amount is too huge to calculate the fixed answer.

6. Conclusion

Based on artificial intelligence and automatic driving, this study discusses the principle of Environmental awareness of artificial intelligence in the field of automatic driving and the decision planning generated in the process of automatic driving. Due to traffic regulations, research and practical applications in the field of autonomous driving have been limited. At present, it is only popular in the process of human driving to play an auxiliary role and supervision role. However, it has played a role in promoting the development of rail transit and aerospace.

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