DOI: 10.54254/2755-2721/6/20230856

Research on the application of artificial intelligence to auto-driving cars

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Abstract. Since the concept of artificial intelligence was introduced in the 1950s, artificial intelligence technologies have emerged more and more frequently. Besides, the application of artificial intelligence technologies in driverless cars has increased, especially in the field of image recognition. Many deep learning methods of image recognition have emerged in the field of autonomous driving. The primary purpose of this paper is to highlight the importance and functionality of using neural networks and image recognition in artificial intelligence for driverless functions. This paper also provides a comprehensive review of the core aspects of driverless technology, the role of image recognition and person recognition in environment perception, the impact of deep learning on driverless behavior decisions, and driverless vehicle kinetic energy control systems. Although the driverless car technology is now being updated, all three modes have great accuracy and results. However, each subsystem still faces many problems and challenges, which may be solved in future research. The driverless car technology would be promoted on a large scale after its safety and suitability are ensured.

Keywords: Auto Drive, Deep Learning, Image Recognition, Artificial Intelligence, Neural Network.

1. Introduction

With the rapid changes in technology and the development of general-purpose computers at the end of the 20th century, the topic of artificial intelligence has always been presented in people’s lives, and the use of artificial intelligence is becoming more and more common. The use of driverless technology has always been a hot topic. Driverless refers to the ability of a vehicle to control its movement based on its perception and understanding of the surrounding environmental conditions and can reach the level of human driver driving.

Figure 1 shows the American Society of Automotive Industry's six levels of autonomous driving, the degrees of automation from low to high are L0, L1, L2, L3, L4, and L5, separately. L0 to L2 are classified as human-driver monitoring driving environments. In these three levels, people need to pay attention to the car's situation and be able to take timely control of the car's behavior. These three stages are the systems that most cars have now. L3 to L5 are called autonomous driving systems that monitor the driving environment, where humans can operate the car with less or no interaction between the car and people. Although there are no L5 fully autonomous cars currently available to the public, many of

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them have already been tested and experimented with in a few areas. This paper focuses on the development and future of fully autonomous cars by describing the issues related to image recognition and deep learning in the three core modules of autonomous driving systems, thereby giving a comprehensive review of the current development of artificial intelligence in autonomous driving.

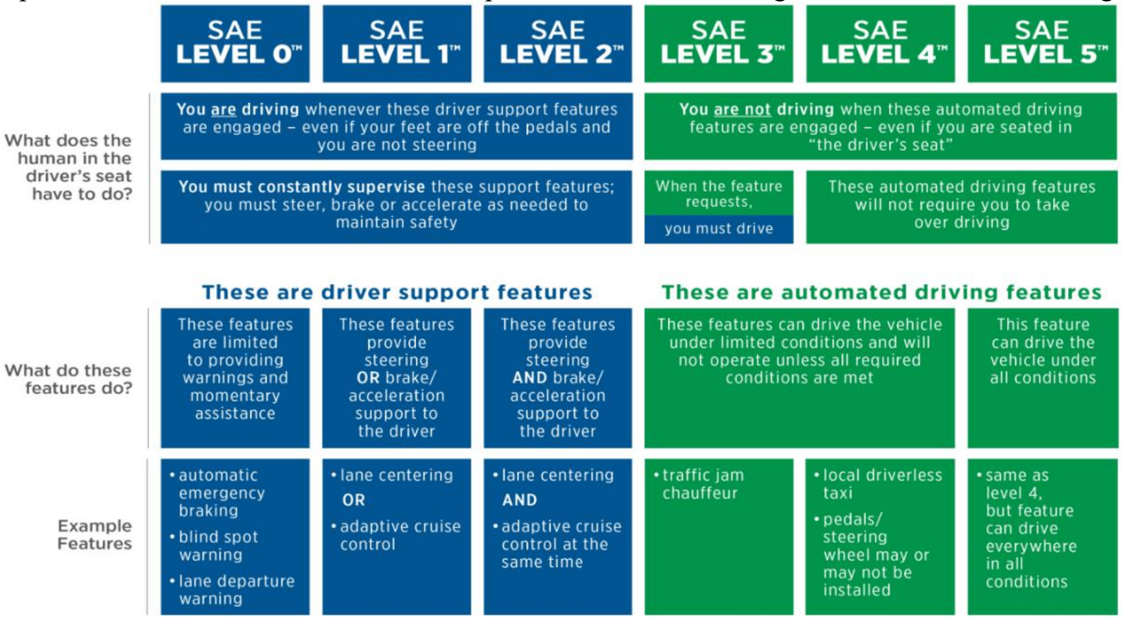

Figure 1. The American Society of Automotive Engineers (SAE)'s latest standard for automated driving with 6 levels of classification [1].

2. Three modules of the auto-driving car system

2.1. Perception module

This is the most critical module in an autonomous vehicle. The other two modules must receive the information sensed by the perception module in order to make planning and judgments. It directly affects the result given by the control system of the vehicle. The most traditional self-driving car perception module is also the one that perceives the environment through various sensor devices. And the environment perception is to achieve the analysis and recognition of the road target classification, target detection, and scene segmentation mainly through the vehicle camera, laser, radar, and deep learning image recognition technology.

2.1.1. Image recognition. Image recognition is a significant research area in artificial intelligence and a technique for object recognition by identifying objects as targets of various patterns. In the field of autonomous driving, image recognition is usually used to obtain data images by using various sensors in a vehicle. For example, vision sensors (infrared cameras, binocular cameras, etc.) are mainly used to collect and recognize basic image information such as traffic lights, traffic signs, pedestrians, vehicles, and lanes [2].

2.1.2. Deep learning. Deep learning involves three main types of methods in terms of research areas. The first method is called convolutional neural networks (CNNs), which is a neural network system based on convolutional operations [3]. The second method is called self-coding neural networks. It is based on multilayer neurons and includes two types of self-coding, namely the autoencoder and sparse coding. Recently, self-coding neural networks have received much attention [4]. The third method is called deep confidence networks (DBN). They are pre-trained through multilayer self-coding neural networks and combined with discriminative information to optimize the neural network weights further.

Deep learning is a subset of machine learning. It is essentially a neural network with three or more layers. Although it is difficult to meet this standard, these neural networks attempt to mimic the behavior of the human brain, allowing the brain to "learn" from large amounts of data. While a neural network with a single layer can still make approximate predictions, other hidden layers can help optimize the accuracy.

Therefore, deep learning can help to automatically analyze various types of targets and complete the internal refinement of various targets. For example, Figure 2 shows the result of automatic extractions of vehicles, pedestrians, traffic lights, traffic signs, etc. in the environment. It is set by humans first and then deep learning is used to analyze and segment the whole scene at the pixel level, automatically extracting target obstacle areas, target driving areas, etc. Then, through a large amount of data simulation training, the extracted scene information can be effectively transformed into data that can be recognized and assigned, and finally, these data can be used to assist the behavior module in completing tracking, acceleration, and direction control. It is also an application of image recognition in deep learning.

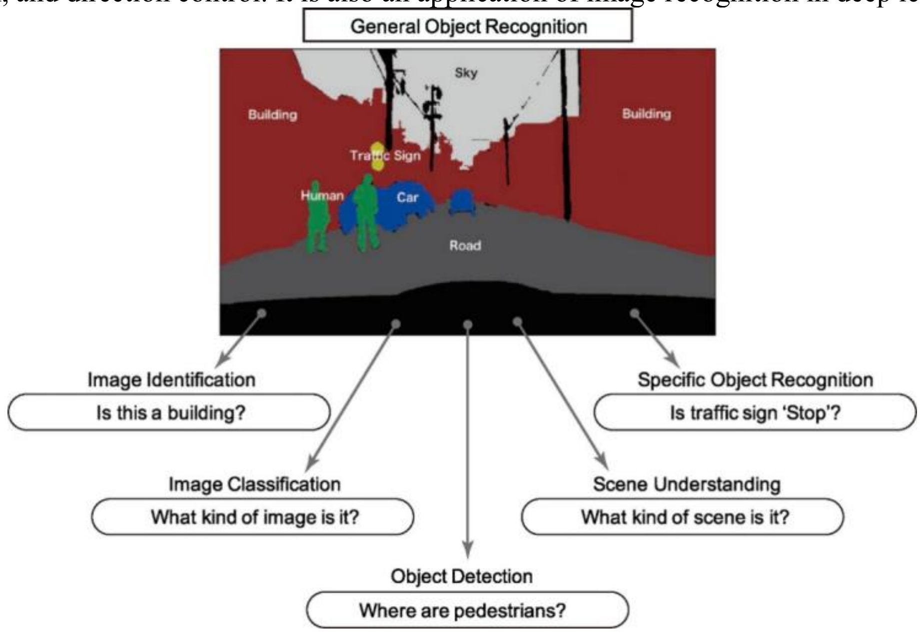

Figure 2. General object recognition by image recognition and deep learning [2].

2.2. Cognitive module

The cognitive module is the module that collects the information transmitted by the perception module and then integrates the information. It is also the principal stage where deep learning is used. In the cognitive module, a route between the start and the end points of the drive needs to be found and a path needs to be planned. In the process of planning the path, the cognitive module evaluates and perceives the surrounding environment with the information from the perception module, determines all the obstacles that exist during the drive, and plans a collision-free route. The learning solution required by the system is simple in this idealized prescribed structure of urban roads. However, in practice, autonomous driving needs to consider more complex and multifaceted factors, such as overtaking, being overtaken, merging, yielding, left turns, right turns, emergency braking, etc. While the vehicle is in motion, the cognitive module needs to apply extremely complex information processing capabilities. It is necessary to design a deep learning reward mechanism (DRL model) to divide the driving solution into two parts. One is the part that can be learned by reinforcement (e.g., overtaking behavior, yielding behavior, driving speed, etc., which is not bound by complex rules). The other part is the unlearnable part (safety, yielding to pedestrians, recognizing traffic signs, and other complex indicators that need to be followed). The reason for choosing to use DRL is that "DRL has been shown to have the following advantages. In other areas: (1) it can be used for unsupervised learning through an action reward mechanism; (2) it can provide not only an estimated solution for the current moment, but also a long-term reward." [5]. However, some data are very sparse and cannot be trained with a large number of reinforcement rewards, such as vehicle collisions. This is one of the difficulties that the cognitive module needs to overcome at this time because the lack of data may lead to wrong judgment.

2.3. Behavior module

The behavior module can be basically divided into four categories. The first one is the basic vehicle control behavior. It is the most basic control vehicle braking behavior. The second one is the basic driving behavior, driving in a straight line, stopping at intersections, changing lanes to overtake, avoiding obstacles, keeping distance, etc. The third one is the basic traffic recognition behavior, including traffic sign recognition, signal recognition, etc. The fourth one is the advanced judgment behavior, such as yielding to pedestrians, emergency braking, passing intersections, GPS navigation route judgment, and variable speed driving.

And the whole behavior logic can be divided into two parts, namely the basic behavior decision and the reinforcement learning of advanced judgment behavior decision. Basic behavior decision is based on the most important and basic rules and development. Although the logic is simple and practical, it is too rigid to be applied to any emergency situation. Targeted adjustments need to be made to reduce the decision error, thereby trying to cover all possible emergency situations. There are neural network algorithms, Q-learning algorithms [4], and other advanced judgmental behavioral decisions for reinforcement learning. Neural network (NN) or artificial neural network (ANN) [6] is a nonlinear system composed of a large number of simple computational units (neurons), which, to some extent, simulates the functions of the brain such as information processing, storage, and retrieval [7]. The error backpropagation learning algorithm of BP network is the most commonly used neural network algorithm. It uses the error after the output to estimate the error of the direct leading layer of the output layer to obtain error estimates for all other layers. The same neural network algorithm is used to analyze the environmental information around the vehicle while driving by using various sensors in the perception module and passing them to the reinforcement learning system to process the information and make behavioral decisions about the driverless car by combining it with predefined empirical patterns. This process is to simulate the process of the human brain to analyze and process all kinds of external information [8].

3. Issues and challenges faced by auto-driving cars

3.1. Safety issues

The current global traffic and travel situation are complex and driverless technology will be limited by many factors, the most influencing one being safety. For instance, vehicle factors can lead to system failures and damage to individual modules can pose a significant risk to normal driving. Moreover, environmental factors can lead to misjudgment of the sensing module. For example, in extreme weather, a big error can occur in the radar system and visual sensing module, leading to dangerous situations during the driving process. What is more, danger can also be caused by information security factors, such as network attacks from hackers who hack into the car network to obtain private information and tamper with data to threaten and hijack passengers.

3.2. Cost issues

Another issue is about the cost and specification. Since a large number of acceptable sensing module devices are needed for data collection and huge computing power is also needed for deep learning systems, auto-driving technology requires high-cost investment. At the same time, because there is no unified standard, self-driving car networks from different companies are different. The information processing required by the vehicle in the process of driving has a great correlation with time and space. Unneeded information needs to be filtered out and the information processing needs to be completed in a brief period of time. Otherwise, a non-interoperable vehicle network can lead to errors in information processing and thus be dangerous.

4. Advantages of auto-driving cars

The most significant advantage of driverless cars is that they have vehicle networking, information technology, and a unified system that will significantly reduce traffic congestion. Moreover, the learning ability, stability, and durability of artificial intelligence are higher than that of humans themselves.

Another advantage is the security guarantee. Based on artificial intelligence and the unified setting of the car network, almost all the routes are planned in the system, and each vehicle is in the optimal driving route while synchronizing the traffic conditions of their own vehicles. This has significantly reduced the occurrence of traffic accidents. In addition, artificial intelligence driving fully complies with traffic rules. There will not be any vehicle driving violations such as drunk driving, fatigue driving, speeding, etc.

Providing quality taxi service is also an advantage of driverless cars. Through the unified and reasonable distribution of vehicles, passengers can obtain a more timely and convenient riding experience. It is also possible to add some health detection systems and safety monitoring devices to the car, such as vital signs detectors, i.e. heart rate and electrocardiograph, which can automatically alert and notify emergency contacts and upload the information to the car network when there is a problem with the passenger's vital signs. If there are any emergencies, the fastest path to the hospital can be planned automatically in the system for resuscitation [9].

Finally, the implementation of autonomous driving systems can also reduce the crime rate to a certain extent. Once the driving information is uploaded to the car network, when a crime occurs and the suspect drives the car and leaves the scene, the police can quickly arrest the fugitive through the crime location of the vehicle information ranking, or even get control of the auto-driving car and “drive” it to the police station.

5. Conclusion

Nowadays, artificial intelligence technologies are applied more and more frequently in driverless cars. In this paper, the author divides the system of auto-driving cars into three subsystems and introduces the current functions, prospects, and challenges faced by self-driving cars through image recognition, deep learning, and other artificial intelligence technologies. In conclusion, the main focus should be the use of image recognition technology in the perception module and the use of deep learning in the decision module of auto-driving cars. The advantages and disadvantages of the application of driverless cars are also discussed in this paper. Although auto-driving cars still face safety issues and cost issues, they can help in reducing traffic congestion, providing passengers with quality riding experiences, avoiding driving violations, and reducing the crime rate. Therefore, future research on driverless cars can focus on overcoming the safety hazards and increasing the universality.

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