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Analysis on key technologies of autonomous vehicle sensing system

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Abstract. Autonomous driving technology is an inevitable result of the combination of intelligence and network technology, and is an important direction for the future development of the automotive industry. According to the American Institute of Electrical and Electronics Engineering (IEEE), autonomous vehicle will occupy 75% of the market share by 2040, which is to promote the key technology for the fourth round of artificial intelligence technology development will reshape the "pyramid" of the traditional automotive industry [1], leading a new transportation and travel ecosystem. the progress of automatic driving is the key to the further development and maturity of technology, and also the key to the industrialization of autonomous vehicle.

Keywords: Autonomous Driving, Sensors, AI decision-making

1. Introduction

With the rapid development of automotive electronic technology and advanced assisted driving technology, autonomous driving, as an advanced assisted driving technology, has become a new technological hotspot in various countries around the world. Especially in recent years, autonomous driving technology has become a milestone in people's transportation development. The rapid development of autonomous vehicle technology helps to promote the transformation of the industrial structure of the automobile industry, thus changing the existing service model and level of society, and helping to accelerate the speed of artificial intelligence and other intelligent industries.

2. Content of autonomous driving technology

2.1. Classification

Intelligent cars, intelligent connected vehicles, and autonomous driving are among the national development and reform initiatives the new concept jointly released by the three departments of the Communist Party of China, the Ministry of Industry and Information Technology, and the Ministry of Science and Technology the research objectives are all autonomous vehicle, so they are named "automatic Drive "and name them" unmanned driving". Made in China In 2025, we have listed intelligent connected vehicles as an important development goal standard, it is a new type of transportation tool that uses onboard sensors and controls devices such as controllers and actuators utilize modern communication and internet technology to achieve Seamless connection between the car's internal and external networks, with information sharing and a sense of complex environment multiple control functions such as knowledge, intelligent decision-making, and automated collaboration, combined with intelligence various auxiliary equipment such as highways are used to achieve "high efficiency, safety, comfort a new type of transportation with the goal of energy conservation. In order to facilitate accurate classification and definition of autonomous driving, many countries according to the characteristics and development process of unmanned driving technology [2], many families have developed unmanned vehicles Classification standards for driving. NHTSA and Autoworkers automatic Engineering Engineering Association, SAE is currently an authoritative classification standard internationally.

2.2. System framework

Intelligent vehicles, intelligent connected vehicles and autonomous driving are new concepts jointly issued by the National Development and Reform Commission, the Ministry of Industry and Information Technology and the Ministry of Science and Technology [2]. Their research objectives are autonomous vehicle, so they are named "autonomous driving" and "driverless driving". In "Made in China 2025", we have identified intelligent connected vehicles as an important development goal. It is a new type of transportation tool that utilizes onboard sensors, controllers, actuators, and other devices. It utilizes modern communication and internet technology to achieve seamless connection between the inside and outside of the vehicle, and has multiple control functions such as information sharing, complex environment perception, intelligent decision-making, and automated collaboration, Combined with various auxiliary equipment such as intelligent highways, it is a new type of transportation tool that achieves the goal of "efficiency, safety, comfort, and energy conservation". In order to facilitate accurate classification and definition of autonomous driving, many countries have formulated grading standards for autonomous driving based on the characteristics and development process of autonomous driving technology. The National Highway Administration (NHTSA) and the Automotive Engineering Association (SAE) are currently authoritative classification standards internationally.

2.3. System framework

To ensure the autonomous driving of vehicles, a complete sensor is first needed to replace the driver's perception of the environment. Secondly, in autonomous driving, to ensure that the relevant driving commands are consistent with the real driving environment and driving needs, it is necessary to use intelligent algorithms as the basis and high-performance control systems as support to achieve the execution of driving commands. And on this basis, provide the optimal driving route for unmanned driving according to the specific driving environment, to ensure the smooth operation of unmanned driving. During the driving process of a vehicle, the driver's manipulation behavior has a significant impact on the effectiveness of the vehicle according to Jacob [3]. To ensure the safety and stability of unmanned vehicles, it is necessary to comprehensively strengthen the perception of the environment, interior, and driver. This requires the construction of a complete perception system, which is combined with onboard sensors to obtain corresponding data information, so that the environment and state of the vehicle can be read.

3. Autonomous vehicle perception technology

In the research of vehicle autonomous driving, the key issue lies in the environmental perception and positioning issues during the process of vehicle autonomous driving. The resolution of these two issues will lay the foundation for the judgment and control of vehicle operation status. While perceiving vehicles, it is possible to obtain data information related to vehicle operation, such as the road network around the vehicle. Enhancing the perception of the environment can effectively enhance the understanding of autonomous driving in the scene. After large-scale training and fitting of autonomous driving vehicles, the vehicle's judgment ability can be enhanced [4].

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3.1. Perception

In the process of environmental perception, there is a lot of environmental information that needs to be identified. The use of radar line separation method in road recognition can effectively accelerate the acquisition of environmental information around unmanned vehicles. Due to the high cost of autonomous vehicle, it is difficult to get a wide range of applications in practical use [4].

Then, based on multi-sensor information fusion, the road contour was obtained by fitting specific coordinates. For example, the automatic recognition of traffic lights and the status information of traffic lights can be obtained using intelligent networking technology, but it cannot be popularized due to its high cost. However, it is difficult to ensure the robustness of traffic lights solely from the perspective of their color, shape, etc. In practical applications, we will use SVM based machine learning methods to train traffic lights on a large scale, achieving higher accuracy and providing more guarantees for achieving automatic vehicle driving. In vehicle positioning systems, the positioning accuracy of GPS positioning systems is relatively high, but its investment is also relatively large. This method uses vehicle position information based on sensors such as radar and camera, and combines specific probability models to obtain vehicle position information, thereby better realizing the position information of unmanned vehicles.

3.2. Planning

The most important problem in the auto drive system is how to ensure that the vehicle can reach the target safely, avoid obstacles and reach the target on time while ensuring the shortest driving path. In the auto drive system, there are three levels: task, behavior and action. Task planning determines the driving route. With the help of a directed network graph, it is possible to clearly understand the connectivity and road conditions between roads, and then use the network graph to plan the route for autonomous driving, ensuring the best route for vehicles. With the help of interpolation curve technology, the safety and comfort of car driving, as well as a series of unexpected situations encountered during the process of autonomous driving, are comprehensively considered to select a suitable driving path and determine the appropriate speed. By using behavior planning, sufficient preparation can be made for car driving, combining the surrounding environment and urban traffic conditions to judge the operating status of autonomous driving vehicles, Specifically, whether to follow, overtake, stop for pedestrians to pass, or take a detour, use effective state machines to perceive the operation of the car and make corresponding decisions to better ensure the safety of the vehicle's operation. On this basis, motion planning is carried out on the vehicle to ensure its smooth operation during motion. Then, the effectiveness of the operation is utilized to layout the vehicle, supplemented by a complete algorithm

3.3. Control

In the auto drive system, various hardware devices are used to complete relevant control tasks to ensure the safe operation of the unmanned driving system. There are two methods for this: one is traditional control methods; The other is the prediction method of the model. By conducting a comprehensive analysis of the surrounding environment of the car, precise planning of the car's movements and driving routes can be carried out to ensure accurate operation of the car, as well as precise control of signals such as throttle, direction, and braking, allowing the car to move forward according to its expected goals according to Jacob [3]. In addition, model predictive control can be combined with the motion state of vehicles to predict the motion state of vehicles in the future stage, effectively avoiding unsafe accidents. At the same time, it can be combined with specific road conditions to adjust the running state of vehicles in real-time. Based on this, dynamic programming technology is used to achieve dynamic matching between intelligent vehicles and drivers, and to achieve dynamic control of intelligent vehicles.

4. Autonomous vehicle Sensing System

Vehicle motion targets include vehicle trajectory, surrounding obstacles, and vehicle driving environment. The passability of vehicles refers to the identification of roads, including traffic lights, various signs, lane lines, roadblocks, etc. Environmental perception barriers refer to the identification of immovable obstacles such as vehicles, pedestrians, and roadblocks on the road. Perceived driving environment refers to identifying changing environments such as road surface, traffic, and weather that have a significant impact on the operation of autonomous vehicles. At present, the main sensing technologies include visual sensing, laser sensing, and microwave sensing. Visual perception mainly utilizes the image data obtained by the camera, and analyzes it using visual correlation methods to achieve recognition of the surrounding environment; Based on the point cloud information obtained by LiDAR, effective detection of the surrounding environment is achieved using methods such as filtering and clustering; It uses the target position information obtained from microwave radar to identify the target position through correlation analysis [2]. According to the characteristics of various sensing technologies and the functional requirements of different application scenarios and systems, corresponding sensing technologies should be selected. For example, on high-speed roads, vehicles often choose to have a longer detection range due to their high-speed driving; In urban areas, due to their complex environment, various detection methods such as laser and vision are often used to obtain a larger detection perspective and more information, and to provide analysis of traffic conditions, temporary traffic control important sections of pedestrian flow data, and other dynamic data. Combined with sensors of autonomous vehicles, it provides a comprehensive solution through macroscopic matching of roads, precise positioning at the micro level, and overall dynamic environment perception [3]. High precision map applications are mainly achieved through technologies such as camera image acquisition, LiDAR 3D scanning, and GPS positioning trajectory. In addition, the data center is constantly collecting the latest intelligence transmitted by vehicles on the road, and then analyzing this intelligence to confirm that it is correct, and then modifying high-precision maps to transmit this intelligence to other vehicles [4].

5. Development trend of autonomous vehicle perception system

5.1. Technical solutions led by vision and LiDAR

On this basis, a camera based machine vision technology was proposed and applied to research on assisted driving. Camera is a relatively inexpensive camera that can be used to recognize pedestrians, vehicles, traffic signs, etc. With the rapid development of technology, the accuracy of CNN continues to improve, and industrial cameras that require machine vision are gradually maturing, with higher imaging quality and stronger anti-interference ability. Due to the passive nature of the camera being affected by light, it cannot operate all day and must rely on the assistance of other sensors. This plan is representative of Tesla [5]. Autonomous driving may become a necessity, but mass production is very difficult. This method uses the ROF method to scan the surrounding environment, compare and match the obtained point cloud data with high-precision map data, achieve real-time positioning and modeling of the surrounding environment, and obtain a centimeter level three-dimensional environmental map. Although LiDAR technology can lead to the loss of color and texture in images, it has extremely high detection accuracy and 3D effects, and is therefore used by many car manufacturers [5]. Google Weimo is a typical representative of this plan [6]. Weimo uses 64 LiDAR to measure the spacing of surrounding targets, and based on the spacing, draws accurate three-dimensional terrain, and then models high-precision terrain maps to achieve L5 level. Although autonomous vehicles have a great demand for LiDAR, due to the high requirements of its production process, its application is limited to small areas such as automobiles and resource exploration. Few manufacturers can provide mature mass production solutions for LiDAR, which leads to high costs and difficulties in mass production. Therefore, facing challenges such as radar color separation and high costs, the industry mainly promotes its commercialization from two directions. Develop a hardware module based on the combination of LiDAR and LiDAR, utilizing the advantages of LiDAR and LiDAR to achieve the acquisition of polychromatic point clouds for LiDAR and LiDAR. Develop all solid-state low beam LiDAR to reduce system hardware costs at the expense of sacrificing some accuracy.

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5.2. Decision algorithms and causal reasoning

In the market, sensor hardware technology and application capabilities are already relatively mature. However, in the control execution module, it belongs to the exclusive domain of traditional car manufacturers and Tier1. Therefore, the quality of decision-making ability will affect the ranking of autonomous driving technology, and competition in autonomous driving technology will be concentrated in the decision-making process. In addition, decision algorithms make judgments based on information from the perception and cognitive layers, which can directly determine the vehicle path, which is the ultimate foothold of competition with autonomous driving. Currently, existing decision making algorithms typically have three paths: a A rule-based expert system that artificially utilizes if then rules to cover all possible scenarios to write an autonomous driving decision system can achieve precision and analysis, but does not have flexibility [7]. Using deep neural networks (such as deep neural networks), this method can handle events in specific situations appropriately through probability based methods, but the execution process of this method is a "black box" and has certain security issues. Causal inference, even using Bayesian networks, can classify the likelihood and reliability of events, with the advantages of modularity and transparency. The Bayesian model can incorporate functions such as deep learning and expert systems into the model, improving its credibility. The model has good universality and can effectively control the entire process of unmanned vehicles, as well as facilitate analysis and correction. Therefore, the model can better optimize the entire process of unmanned vehicles [7].

5.3. Multi channel sensor fusion

Different types of sensing technologies have their own advantages and disadvantages, and there is no one method that can be used to solve all working conditions. For example, camera hardware technology is already relatively mature, but recognition accuracy still needs to be further improved; Although the radar point cloud processing method is relatively simple, it has drawbacks such as high hardware cost and poor adaptability to the environment. Due to the different advantages and disadvantages of each sensor, the cooperation of multiple sensors can achieve the fusion of their respective advantages and avoidance of disadvantages [8]. Since autonomous vehicle attach great importance to driving safety, autonomous vehicle 'perception strategies also need to have certain safety. The cause of Tesla's first fatal accident was a malfunction of the front view camera, while ModelS did not detect the presence of a large trailer, indicating a certain degree of safety redundancy in a single solution. Therefore, to ensure the safe operation of unmanned vehicles, it is necessary to fully consider the cooperation and redundant information of multiple sensor nodes. At present, there is a consensus in the industry that data fusion of multiple sensors such as millimeter wave radar, lidar, and camera will become an inevitable trend in the development of unmanned driving technology in the future [8].

6. Conclusion

The perception system converts visual, physical, and event information into digital information, which is the foundation for cars to perceive and make decisions about the surrounding environment. Through sensing technology, various local information such as people, vehicles, and roads can be timely and quickly grasped, and effective responses can be made to surrounding emergencies. This method analyzes the spatial relationship between cars and other elements in the road network, providing a new approach for car travel path planning and driving experience optimization. Car-connected communication can achieve the interconnection and sharing of information among people, vehicles, and roads and achieve the large-scale, all-round, real-time, and accurate perception of environmental information. It can effectively solve the problems of limited perception distance, susceptibility to environmental interference, poor real-time perception of location and navigation, and limited perception content.

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