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Analysis of the autonomous driving technology -- Lidar versus visual recognition

Ziheng Yu

Beijing National Day School, Beijing, China, 100039

Yuziheng040929@163.com

Abstract. With the development of human society, economy and technology, today's automobile industry is in an era of rapidly changing, and the development and application of autonomous driving-related technologies are in full swing. This paper mainly focused on autonomous driving technologies --- the comparison between lidar and computer vision cameras. Lidar and computer vision cameras are completely two different kinds of solutions for auto-drive from all aspects. These two schemes are the main current in the autonomous driving market, and this essay mainly focuses on these two solutions by researching and summarizing existing research and essay online. Through the research, it is clear that these two solutions both have their own advantages and disadvantages even disparate future development orientations.

Keywords: Lidar, Camera, Visual Identification, Autonomous Driving, Sensor.

1. Introduction

As one of today's rapidly developing industries, autonomous driving has given birth to many mature products on the road and in the market, and autonomous driving is entering the lives of millions of families and becoming an integral part of daily life. At present, autonomous driving in the market is mainly divided into two factions: Lidar and visual recognition[1]. There are both visual recognition products represented by Tesla and visual recognition solutions represented by Baidu. The main controversy in this field of autonomous driving also revolves around these two sensor factions. Lidar and visual recognition of these two sensor technology development will inevitably determine the future development of the field of autonomous driving to a large extent. This thesis focuses on how to achieve autonomous driving, the future of autonomous driving, the sensors that are generally used in autonomous driving, and the advantages, disadvantages and principles surrounding each of Lidar and vision cameras. The research is mainly summarized and generalized from existing studies, re-tenants, and summaries based on internet data. Autonomous driving technology concerns the future life of millions of households, and improving the safety and popularity of autonomous driving is the main goal of current development. The research in this paper is to discuss which of the two solutions, lidar and vision recognition, is more feasible, and it is also a choice that must be made for the future development of this industry[2].

2. An introduction to autonomous driving

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As a most hot field in Artificial Intelligence applications, autonomous driving technology is also in full swing at the present stage. With the brand new development in progression of deep learning and artificial intelligence algorithms, unmanned driving is becoming more and more practical and commercial. The automatic driving can be separated in to 5 different levels, L0 is altogether operated by the driver; The L1 level system is that the car is able to assist the driver in certain driving tasks under certain circumstances; At L2 level, autonomous driving system can achieve some driving tasks, but the driver are still required to monitor the changes of the surrounding environment and be ready to take over when there is a dangerous situation. Meanwhile, this is most of the current autonomous driving technology that autonomous vehicles products and projects could achieved. At L3, the driver hardly needs to be ready to take over all the time, and the car can complete all the actions independently. The L4 and L5 levels are absolutely independent autonomous technology, where the car is completely autonomous without a driver. The difference is that the L4 level can only fulfil fully independent in certain conditions, such as motorways, while the L5 level can operate in any condition.

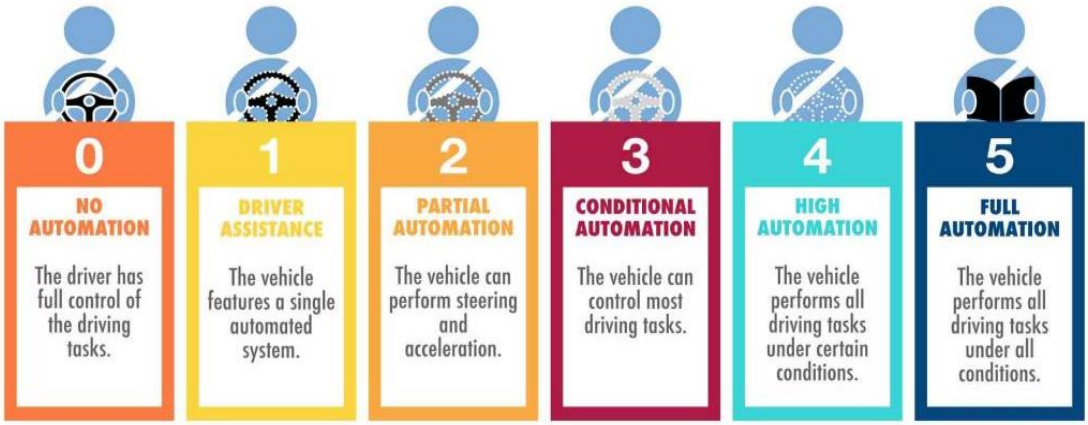

Figure 1. Different levels of autonomous driving [3].

2.1. The prospect of autonomous driving

In the autopilot area, a topic is destined to discuss between lidar and cameras, which is more outstanding, this question has been debated in the industry a lot. In fact, to know about the inducement, people have to understand first what is the principle behind these two technical routes, what are the advantages and disadvantages of each. In current, the most common autopilot car is level 2, this essay is mainly aimed at the discussion about sensors in most common autopilot cars which sensor is the future for the autonomous driving car, lidar or computer vision camera, and how these two sensors work, the advantages and disadvantages of each, and how they coordinate with other components of the vehicle to achieve autonomous driving. According to the latest market research report published by Markets and Markets, the global market size of autonomous vehicles is expected growing from 20.3 million units in 2021 to 62.4 million units in 2030, at a CAGR of 13.3%[4]. Autonomous driving, as a high-tech technology with a growing market share, offers us a whole new way of life, and furthermore improve traffic safety with the aid of autonomous driving technology, making people's life more convenient.

2.2. How to achieve autonomous driving

Before discussing how autonomous driving is achieved, it makes more sense that understand how humans walk at first. When humans walk on the street, they use their eyes to observe the circumstances, use their ears to hear the sound on street, and even use their feet and hand to touch and feel the ground. All this information no matter whether heard or seen is transmitted into the brain, individuals will do all kinds of analyses and determinations like, “I will turn right at the next crossing,

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and caution cars passing by". After making decisions with their brain, and the body begins to respond, hands, feet, and body begin to do what the brain orders "Moving your feet, turning your head left and right to observe surrounding". Therefore, people walk through the continuous cycle of the above three parts. In fact, autonomous driving also realizes the driving of vehicles through these three different parts, which are perception, decision and execution. First and foremost, as with humans, is perception. For now, the vehicle has generally installed a variety of sensors, including laser radar, millimeter wave radar, ultrasonic radar, cameras, highly precise maps, positioning system, and so on equipment, these equipment collected a enormous amount of data in the process of working, such as laser radar has collected a large amount of point cloud data, the ultrasonic radar collects range and velocity data, the camera collects a large amount of shape data, and the positioning system collects coordinate system data. All these data are transmitted to the decision module after processing. The car does decision judgment rely on the information it collected in the surroundings, identify appropriate working models and develops appropriate control strategies. After the system made a decision judgment, it automatically carries out the corresponding operation to the vehicle, like turning the steering wheel, changing gears or stepping on the throttle, something that generally like human drivers do. The system gives the order to the operating module to perform the required operation. The prospect of autonomous driving cars is promising. From the beginning of the idea to now, mainstream companies have shown test vehicles, which proves that autonomous driving technology is gradually becoming a reality, which is a big trend in intelligent transportation, and with the beginning of the 5G era, this intelligent technology will develop more rapidly[5].

3. Lidar

Lidar is a radar system that emits laser beams to detect targets. The working principle of it is shooting a laser at the target, and then the received signal reflected back from the target is compared with the transmitted signal, and the relevant information of the target is obtained after proper processing, for instance, the target distance, azimuth, altitude and other parameters. Lidar is important because it provides information about the depth of field. The idea is to emit laser light and receive reflection to create a three-dimensional image of the surrounding area. The advantage of lidar is in the aspect: high-definition 3D modeling. Lidar, which can be considered a more advanced radar, has a detection range of up to about 100 meters with a calculation error of less than two centimeters. As a result, it is able to measure several points at any one time, giving a very accurate 3D picture of its surroundings. Lidar is also immune to environmental conditions, such as heavy rain and fog. But there are two main reasons the computational vision camp doesn't like lidar. The first is the basic path with lidar as the core, which may have a high dependence on the high-precision map, but the uncertainty of the high-precision map is great. To ensure its efficient operation, in addition to technical challenges, it also requires the investment and maintenance of a large enough amount of engineering. The second is the high price of lidar. Image sensors are cheaper. In lidar's place, depth of field can be calculated using hierarchical imaging, or quasi-true lidar, or dual-vision sensors, but these technologies are still developing[6]. In the current China market, automobile companies like Apollo(Baidu), XPENG, and Pony.ai, have already published mature L3 level autonomous driving production based on multi-radar including lidar, Lidar has grown rapidly in the autonomous driving market in the last two years and has gradually become the main solution for some car companies.

4. Computational vision

The computational vision solution mainly uses the camera as the sensor input, and after a series of calculations and processing, it makes an accurate perception of the environmental information around the self-vehicle[7]. The purpose is to provide accurate and rich information to the fusion module, including the category of the detected object, distance information, speed information, and orientation information. The sensing function of road traffic mainly includes the following three aspects: dynamic target detection (vehicles, pedestrians and non-motorized vehicles), static object recognition (traffic signs and traffic lights), and segmentation of drivable areas (road areas and lane lines)[8]. The target

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recognition effect depends on the type and number of samples for deep learning, so the samples for deep learning target recognition need to be constantly iterated and updated. Among them, Tesla's model is a bit more complex, and its labeled data pool is composed of real data collected from each Tesla running on the road, and the algorithm helps the neural network system to continuously correct and amend errors through a massive amount of algorithms, forming a closed loop. At the same time, the advantages and disadvantages of this program are particularly obvious[9]. Firstly, the camera sensor technology is mature and cheap, especially the camera-based vision solution is cheaper compared to the expensive LIDAR currently on the market. Feasible. Second, the image information captured by the camera contains rich color, texture, contour, and luminance information that cannot be matched by sensors such as LIDAR, millimeter wave radar, and other sensors, such as red lights and traffic signs. The disadvantages are equally distinct: the camera sensor is a passive sensor, very sensitive to changes in light, received a large impact on the weather, the camera sensor imaging quality will be significantly reduced, making it difficult to achieve object detection recognition[10].

5. Conclusion

This paper focuses on whether LIDAR or vision cameras are superior in the field of autonomous driving. Although lidar is a small success in the current market, in the short term many problems still can not be solved, such as the price is too expensive, and the size being too large. In contrast, visual recognition is more mature and cheaper, and furthermore, its application scenario is very broad and has no special needs for hardware, which is more suitable for the promotion and development of autonomous driving. In the future, the text can also be combined with the actual project for further research on the principle of autonomous driving technology, such as analysis of the technical analysis of Tesla's visual recognition technology and technical accumulation, and whether his future development is better than LIDAR.

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