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Advantages and Challenges in BEV Algorithm Technology for Autonomous Vehicles from Environment Sensing

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ABSTRACT
With the continuous development of China's artificial intelligence and computer vision field, the field of unmanned vehicles in the field of research has gradually become a research hotspot in the field of artificial intelligence, and nowadays, unmanned vehicles in our lives from "unattainable" to "within reach! Nowadays, driverless cars have changed from "out of reach" to "within reach" in our lives. The core of unmanned autonomous driving mainly relies on high - precision maps and sensors and other technologies, of which the BEV algorithm (i.e., Bird's Eye View) provides a variety of technical routes. In this paper, we will focus on analysing the advantages and challenges brought by the three models in BEV algorithm to the automatic driving technology, and make an outlook on its future development.

KEYWORDS
Bird's eye view; Autonomous driving; Artificial intelligence; Environment perception

1 Research background

The significance of the development of the times is to make more impossible to possible, science and technology allows mankind to achieve breakthroughs again and again. Nowadays, the driverless cars that we fantasised about in our childhood have also been brought into reality, and the successful launch of the "Radish Run" unmanned self - driving taxi in Wuhan has attracted widespread attention in society. The BEV (Bird's Eye View) algorithm applied to self - driving car technology is a 3D perception technology used in the field of self - driving and robotics. Some scholars have graphically illustrated it as BEV whose view is like a bird in flight looking down, as if looking down on an object or place through a steep view [1]. It provides a comprehensive, top - down view of the environment for self - driving vehicles by integrating environmental data from multiple sensors into a self - referenced BEV space. This view enables clearer identification of the relative positions and dynamics of the road, obstacles, other vehicles and pedestrians, thus providing an accurate understanding of the environment for subsequent planning and control modules.

At present, as the heat of driverless car technology continues to rise, people also question some of the safety hazards, most of the questions are about the degree of self - driving cars on the road when travelling to the extent of mastery of the road situation, and the emergence of the BEV technology in the environment perception is a very good solution to the problem, and subsequently reflects the importance of BEV technology. To put it bluntly, the role of BEV technology is to construct a bird's - eye view of the vehicle's surroundings from the raw data acquired by the vehicle's sensors (e.g., cameras, LIDAR, etc.), and environment sensing is the first step in the process, in which the sensors need to perceive a variety of objects in the surroundings, including, but not limited to, other vehicles, pedestrians, traffic signs, and road boundaries, etc. BEV perception is the way in which the vehicle acquires a bird's - eye view or top view of the surroundings. ability to get a bird's eye view or top view information. Surrounding environment data is collected by capturing the vehicle's surroundings with the help of multiple sensors such as cameras, radar, LIDAR, etc. installed on the vehicle. Subsequently, specific algorithms are applied to process these data into a bird's eye view, which provides the basis for various subsequent sensing tasks [3].

Then no matter the advantages and convenience brought by BEV technology, or the hidden dangers and challenges it faces, it is inseparable from the environment perception supported by the technology. It is also because the multimodal fusion detection technology under BEV can provide more accurate and comprehensive environmental information for intelligent vehicles, which is conducive to self - driving cars to deal with a variety of complex traffic environment challenges, and it is one of the most critical technologies for the development of self - driving cars at present, which has received extensive attention from both academia and the industry, so this paper's research in the field of BEV is critical and necessary in my opinion.

2 Implementation and Modelling of Environmental Awareness

In BEV technology, environment sensing is mainly achieved through three models: radar (LiDAR) - based BEV model, image - based BEV model, and multimodal fusion - based BEV model.

2.1 Radar - based modelling

Radar - based environment sensing models in BEV technology are mainly based on LiDAR, which also occupies an important position as a commonly used sensor in driverless cars. It acquires the parameters of the target object by continuous laser, and realises the perception of the environment through 3D points [2]. Lidar in bird's eye view technology acquires point cloud data by transmitting and receiving laser beams, after pre - processing, it is converted to BEV representation using voxel - based or Pillar - based method, and then BEV features are generated by the detector head, which provides accurate environment sensing for self - driving vehicles and assists in decision - making and planning of vehicles.

In practical applications, vehicles rely on the point cloud data acquired by LiDAR to identify roads, obstacles, other vehicles and pedestrians, etc. to ensure driving safety.

2.2 Image - based models

The image - based BEV model mainly uses the image data captured by multiple cameras to construct the 3D environment around the vehicle, which is closely related to the camera, which provides the data base for the model, and the model is able to process the camera data to construct the BEV view, and both of them cooperate with each other to realise the environment perception function.

BEV cameras are further divided into explicit and implicit transformations. The "2D - 3D" method of explicit transformation starts from the 2D image features and enhances the 2D features to 3D space through depth estimation, so that the BEV space is closer to the 3D real space representation; the "3D - 2D " method is based on the single response matrix and uses the inherent geometric projection relationship between two views to perform an explicit transformation. Implicit transformations are divided into MLP - based implicit transformations and Transformer - based implicit transformations: the Multilayer Perceptron (MLP) is usually viewed as a complex mapping function, and MLP - based implicit transformations help the model to better understand inter - object distances, orientations, by learning and modelling the relative spatial relationships between objects in the environment and other information, and since there is an inherent inductive bias in both 2D - 3D and 3D - 2D methods, the MLP - based implicit transform avoids the inherent inductive bias contained in the calibrated camera setups; Transformer - based transforms are data - based, with weighting matrices that depend on the input data, to make the learnt mappings more accurate, and use a top - down strategy. Depending on the way BEV queries can be learnt in the Transformer decoder, Transformer - based implicit transformations can be classified into three categories: dense, sparse and hybrid queries [3].

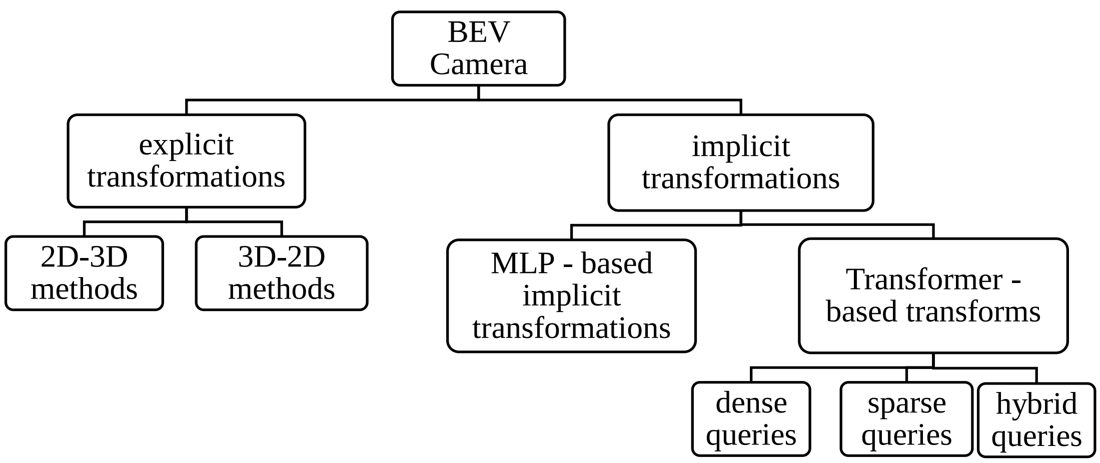

Figure 1 Specific classification of BEV cameras

2.3 Models based on multimodal fusion

Modality refers to a mode of existence of data or its source, which is a social and cultural resource. And multimodal fusion is the technique of synthesising data from many different modalities, which refers to the description of the same data object in different spatial dimensions [4].

Multimodal research has been widely used in many fields, such as medicine, intelligent robots, etc. Nowadays, with the further development of multimodal models, there is also a great progress in the field of automatic driving, in the field of automatic driving perception, the continuous development of sensor technology captures multimodal data such as text, image, video, sound and graphics [5], which provides more comprehensive for complex road situations, accurate information support.

3 Advantages offered by BEV technology

BEV perceptual learning offers significant advantages in terms of comprehensive perceptual enhancement, simplified decision - making process and safety performance improvement.

3.1 Overall perceptual capacity enhancement

Global vision: BEV technology can present the environment around the vehicle in a bird's eye view, breaking the limitations of the traditional camera view, and can simultaneously obtain 360 - degree information around the vehicle, allowing the vehicle to have a more comprehensive and complete knowledge of the overall environment in which it is located, so as to detect potential dangers and make decisions in advance.

3.2 Streamlining the decision - making process

The comprehensive and accurate environmental information provided by BEV technology enables the automatic driving system to make more reasonable and safer decisions. In the event of an emergency, such as the sudden appearance of pedestrians or vehicles, the system can quickly calculate the best braking or avoidance strategy based on the precise position and movement information provided by BEV, reducing the probability of an accident.

3.3 Improved safety performance

In addition, BEV technology fuses a variety of sensor data, when a sensor fails or is interfered with, the data from other sensors can still provide the necessary information support for the system in the BEV space to ensure the normal operation of the system, increasing the redundancy of the system while improving the reliability and safety of the entire automated driving system.

4 Challenges for BEV technology

4.1 Technical Level - Perceived Accuracy Challenges

4.1.1 Long - range target sensing

In long - distance scenarios, the perception accuracy of BEV technology for small target objects will be reduced. For example, pedestrians or small obstacles at a distance may not be accurately recognised in terms of their position and attitude due to the limitations of resolution and sensor detection distance, affecting the judgment of potential dangers by the automatic driving system.

4.1.2 Impact of complex weather

Inclement weather such as rain, fog, and snow can seriously interfere with the sensor signals, resulting in a decrease in the sensing ability of BEV technology. Especially in the case of heavy snow, the reflected signal of LIDAR will be weakened, and the camera image will become blurred, making it difficult for the BEV model to accurately obtain the environmental information, and increasing the risk of misjudgement and omission of judgement.

4.1.3 Difficulty of data fusion

Due to the different data characteristics and temporal frequencies of the sensors, issues such as data alignment and feature matching need to be addressed during the fusion process. For example, camera and radar data may have errors in time synchronisation and spatial coordinate conversion, which can affect the accurate modelling of the environment by the BEV model.

4.2 Industry level - cost challenges

Autonomous driving enterprises generally face high R&D costs and operating costs [6], in terms of hardware costs, the implementation of BEV technology needs to be equipped with a variety of high - performance sensors, such as LIDAR, high - definition cameras, etc., which are costly and increase the manufacturing cost of autonomous driving vehicles, making large - scale commercial application face price pressure; in terms of R&D costs, the development of BEV technology requires a large amount of In terms of R&D costs, BEV technology requires a large amount of capital and manpower investment, and the technological breakthroughs it requires are not achieved overnight, but require continuous R&D investment and long - time testing and validation [6], which is a huge cost burden for enterprises.

4.3 Social Dimension - Security Challenges

BEV technology as one of the key technologies for autonomous driving, however, due to the public's limited understanding of this new technology, most of them are sceptical and worried about the safety of BEV technology, which to some extent also affects the promotion and application of autonomous driving technology, and I believe that there is still an urgent need for its safety and reliability to be widely recognised by the public. However, it is undeniable that BEV technology - supported autonomous driving systems may face ethical and moral dilemmas in some extreme cases, such as how to choose the priority of protection in an unavoidable collision, etc. This still requires in - depth discussion and reflection among people from all walks of life in various fields, and the formulation of corresponding ethical guidelines and legal norms.

5 Reach a verdict

BEV technology, as an important development direction in the field of intelligent perception, has a broad application prospect and research value, in which the BEV algorithm technology for self - driving cars has made a visible contribution in the field of environment perception. Multi - view image fusion under the bird's - eye view space breaks the traditional perception limitations and allows the automatic driving system to understand the surrounding environment in a comprehensive and coherent way. The BEV algorithm has demonstrated excellent target detection capabilities in various scenarios such as highways and city streets, and can accurately identify vehicles at long distances, as well as pedestrians, non - motorised vehicles and traffic signs in complex road conditions, providing solid support for the automatic driving system to make reliable decisions in complex scenarios, and becoming the core driving force for the development of automatic driving technology.

However, the development of BEV algorithms has not been easy. Although there are still some challenges, we still have reason to believe that through the joint efforts of academics and business people, and continue to promote technological innovation and application development, BEV technology will play a more important role in the future of autonomous driving and other fields, and make a greater contribution to the realisation of "smart" travel and "smart" transport. "intelligent mobility and intelligent transport.

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