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Editorial

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In recent decades, the research on autonomous driving technologies has enabled the automotive industry to introduce vehicles supported by Advanced Driver-Assistance Systems (ADAS) to the market. These systems render the daily driving experience safer and more attractive to humans. The majority of existing assistive driving solutions are ranked between Level-1 and Level-3 autonomy, involving mainly supportive systems. However, no one in the industry is even close to attaining Level-4 and Level-5 autonomy, a challenge that demands vehicles' operation in any road network and weather condition. It is evident that reaching the ultimate autonomous operation (Level-5) necessitates that future vehicles be equipped with advanced perception and cognition capabilities that will allow them to cope with urban, rural, and semi-structured environments. Recent advancements in sensors have provided 3D data that further augment the perception capabilities of autonomous vehicles, while the machine learning community has released powerful neural networks that amplify the vehicle's awareness regarding its surroundings. However, few such approaches have reached mass production—mainly due to the fact that such solutions typically require the existence of an abundance of data to train the respective models and powerful computational units, which hinders their adoption from the automotive industry.

This Special Issue in Machines, entitled "Autonomous Driving: Advancements in Cognitive Perception Systems for Increased Level Autonomy", compiles some of the recent research achievements and investigations in the field of autonomous driving, with an emphasis on perception methods to increase autonomy. It comprises 12 papers, which can be categorized into three groups as follows:

Surroundings perception and measurements for autonomous driving: Liu et al. [1] examine the detection of three-dimensional (3D) objects for the perception of the surroundings in autonomous driving scenarios. They address this problem by utilizing a graph neural network (GNN) detector for 3D object detection in LiDAR point clouds, which incorporates a neighbor feature alignment mechanism. Qi et al. [2] propose an extended network-based fusion target detection algorithm that combines the complementary perceptual performance of in-vehicle sensing elements, the cost-effectiveness, and maturity of independent detection technologies. Feature-level fusion is used, and training and testing are carried out on the *nuScenes* dataset and test data from a homemade data acquisition platform. Wei and Huang [3] introduce a framework for multiple object-tracking in autonomous driving that addresses occlusion issues. The framework comprises two stages: object representation and data association. Appearance, motion, and position features are used to characterize objects in the object representation stage. To generate appearance features, a spatial pyramidal pooling hash network was designed, which generates multiple-level representative features, being mapped into a similarity-preserving binary space known as hash features. These hash features retain visual discriminability while improving computational efficiency. Tong et al. [4] present a lightweight vision-based approach for detecting vehicle taillight intentions in real time, with a focus on improving small object detection using a multi-scale strategy. Detecting the intentions of vehicle taillights is a crucial task for intelligent

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vehicles to make informed decisions. However, achieving high detection accuracy while maintaining real-time performance is a significant challenge in practical scenarios. Finally, to address the measurement of the distance and speed of the vehicle ahead, Qi et al. [5] propose a multi-cue fusion monocular velocity and ranging framework to improve the accuracy of monocular ranging and velocity measurement. Existing vehicle distance and speed estimation algorithms based on monocular cameras have limitations and do not take into account the relationship between the underlying features of vehicle speed and distance, while the proposed framework utilizes the attention mechanism to fuse different feature information, and the network is trained through the distance velocity regression loss function and the depth loss as an auxiliary loss function.

Control methods for Advanced Driver-Assistance Systems: The current growth in car ownership is contributing to traffic congestion, but cooperative adaptive cruise control (CACC) technology offers a solution. Xie and Xiao [6] propose an active anti-disturbance following control method based on bystander vehicle intention recognition and trajectory prediction. This method can alleviate the disturbance caused by passing vehicles, improve passenger comfort, and suppress multi-vehicle oscillation. Han et al. [7] propose a novel tire–road peak friction coefficient estimation method that takes into account the effective contact characteristics between the tire and the 3D road. The method considers the influence of road roughness and texture on the results, thus achieving accurate estimation of the tire–road peak friction coefficient, which is crucial in the transportation field to enhance vehicle safety performance and improve road maintenance efficiency. Savari and Choe [8] investigate different forms of human feedback, including head direction versus steering and discrete-versus-continuous feedback to feed deep reinforcement learning algorithms. They use a real-time human demonstration from steering and human head direction with discrete or continuous actions as human feedback in an autonomous driving task. Chong et al. [9] propose an autonomous driving method for buses by detecting nearby obstacles and predicting their motion. A modular pipeline is developed for long-term trajectory prediction of dynamic obstacles for an autonomous bus. They propose a training method to improve the trajectory prediction module's performance and achieve a 10 Hz runtime. Practical challenges associated with deploying autonomous buses are also discussed, and solutions for each task are proposed.

Viewpoint/position papers: With the continuous advancement of the automotive sector and autonomous driving technology, it is crucial to continuously research and identify key areas that can contribute to the continuous improvement of system autonomy. In addition to designing new components, it is important to establish uniform test procedures. Moreover, though the concept of self-driving vehicles has gained widespread acceptance, there are still several aspects requiring further development. This poses several technological, legal, and economic challenges, such as data protection, liability for torts, and road traffic law. Dollorenzo et al. [10] focus on the analysis of testing phases of a vehicle, with an emphasis on post-processing the tests using suitable software and routines to create an overall summary report, with the aim being to propose a tool that: improves the generation of test maneuvers for advanced driver-assistance systems; and automates the data collection and analysis phase of tests for lane system support systems, autonomous emergency braking, and car-to-pedestrian nearside child. Balaska et al. [11] examines the concept of driverless last-mile delivery using autonomous vehicles, highlighting the challenges and limitations in the current technology that hinder level five autonomous driving. They also describe the existing perception and cognition systems of autonomous vehicles and their future capabilities in achieving complete autonomous last-mile delivery, as well as efficient robotic process automation in logistics for warehouse/distribution center-to-hub delivery. Finally, with a view to developing the regulatory framework of remote operation solutions, Hoffmann and Prause [12] examine a case study of a start-up (Vay) developing such solutions in Germany. The research is situated in the context of Smart Cities and Industry 5.0, and it proposes specific modes of compliance for future perspectives.

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