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Recent Advances in Automated Driving Technologies

We live in the era of the advent of automated vehicles. These will bring dramatic changes in both the automotive industry and everyday life, revolutionizing the concept of passenger mobility. The issue of perception is crucial for an autonomous vehicle and presents important challenges, many of which still need to be addressed. In this context, the choice of sensors is pivotal, yet there is still no general consensus on what the potential "best" sensory equipment should consist of. Furthermore, perception-related information is then used to make timely decisions on path planning and vehicle dynamics control to ensure efficient and safe vehicle behavior. Here, machine learning algorithms are playing an increasingly important role, for example, in the generation of trajectories perceivable as "natural" by the car's occupants or in object recognition.

This special issue brings together researchers working in this field to share their latest developments on sensing and perception; path planning; and machine learning and control using data-driven learning or physics-driven algorithms, focusing on technologies directly applicable to autonomous vehicles. After a rigorous peer review process, four high-quality articles (out of 18) were selected for publication in this special issue.

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The first article, "Trajectory Prediction Using Graph-Based Deep Learning for Longitudinal Control of Autonomous Vehicles: A Proactive Approach for Autonomous Driving in Urban Dynamic Traffic Environments," by Youngmin and Yi [A1], presents a method for the trajectory prediction of surrounding vehicles and proactive longitudinal control of autonomous vehicles in urban road environments. Their control method utilizes the prediction results of the target vehicle to give action requests in a proactive manner considering both safety and ride quality.

The second article, "Cellular Localization for Autonomous Driving: A Function Pull Approach to Safety-Critical Wireless Localization," by Whiton [A2], identifies five important requirements for cellular localization for safety-critical systems, with a particular focus on autonomous driving, and puts them in the context of industrial and academic trends and standardization. The article discusses how a cellular localization sensor that can provide position, heading, and velocity estimates with error overbounds in an external reference frame is a powerful tool for autonomous driving systems.

The third article, "Integrated Sensor Fusion Based on 4D MIMO Radar and Camera: A Solution for Connected Vehicle Applications," by Lei et al. [A3], presents an integrated sensor fusion solution based on multiple-input, multiple-output (MIMO) radar, camera, and on-device computing that can estimate objects' range, velocity, azimuth angle, and elevation angle, which can be further used to estimate their length, width, and height. The proposed solution and its envisaged evolutions also have significant potential for applications on intelligent traffic management systems such as traffic signal control and roadway digital twins.

The fourth article, "Clothoid-Based Lane-Level High-Definition Maps: Unifying Sensing and Control Models," by Cudrano et al. [A4], proposes two vision-based pipelines for generating lane-level high-definition maps using clothoid models. Such maps relieve vehicles from most of the scene parsing so that the resources required by scene understanding could be invested only on dynamical objects, which require higher alertness and faster reaction times, thus allowing them to focus on dynamical objects, trajectory planning, and control. An interesting experimental validation is provided, also demonstrating that the idea can be effectively used to generate lane-level maps in extra-urban scenarios.

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Appendix: Related Articles

[A1] Y. Yoon and K. Yi, "Trajectory prediction using graph-based deep learning for longitudinal control of autonomous vehicles: A proactive approach for autonomous driving in urban dynamic traffic environments," *IEEE Veh. Technol. Mag.*, vol. 17, no. 4, pp. 18–27, 2022, doi: 10.1109/MVT.2022.3207305.

[A2] R. Whiton, "Cellular localization for autonomous driving: A function pull approach to safety-critical wireless localization," *IEEE Veh. Technol. Mag.*, vol. 17, no. 4, pp. 28–37, 2022, doi: 10.1109/MVT.2022.3208392.

[A3] M. Lei , D. Yang, and X. Weng, "Integrated sensor fusion based on 4D MIMO radar and camera: A solution for connected vehicle applications," *IEEE Veh. Technol. Mag.*, vol. 17, no. 4, pp. 38–46, 2022, doi: 10.1109/MVT.2022.3207453.

[A4] P. Cudrano, B. Gallazzi, M. Frosi, S. Mentasti, and M. Matteucci, "Clothoid-based lane-level high-definition maps: Unifying sensing and control models," *IEEE Veh. Technol. Mag.*, vol. 17, no. 4, pp. 47–56, 2022, doi: 10.1109/MVT.2022.3209503.

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