

Development of Autonomous Driving with a Bird's Eye View Perception System Integrated with Map Information of Road Structure and Connectivity

Kento Kubota ¹⁾ Hajime Oyama ¹⁾ Kazuki Ishii ¹⁾ Kaito Sakogawa ¹⁾ Hideyuki Takao ¹⁾

¹⁾ SUBARU Corporation, Ebisu Subaru Bldg., 1-20-8 Ebisu, Shibuya-ku, Tokyo 150-8554, Japan

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Highly automated driving requires not only accurate perception of surrounding vehicles but also reliable prediction of their future behavior. Although Bird's Eye View (BEV) perception can represent surrounding traffic in a unified top-down view, perception results alone are often insufficient for evaluating interactions among vehicles traveling on different lanes or maintaining vehicle tracking during temporary perception loss. To address these challenges, we developed a surrounding vehicle sensing system that integrates a multi-camera BEV perception system with map information of road structure and connectivity.

The proposed system consists of a BEV perception module and a Map Positioning Unit (MPU). The BEV perception module detects surrounding vehicles and estimates their positions and velocities using seven onboard cameras. The MPU associates the detected vehicles with a high-definition map and converts their positions into a road-based coordinate framework represented by station distance along the lane centerline. This enables both the ego vehicle and surrounding vehicles to be represented within a common road-coordinate system, regardless of the lane on which they are traveling. The system also utilizes lane geometry and connectivity information to predict future vehicle behavior and assess potential interactions among vehicles. Furthermore, when a surrounding vehicle is temporarily lost because of occlusion, the MPU estimates its position using previously observed vehicle states and map information. By constraining the estimation to the road geometry, the proposed approach provides a more realistic prediction than conventional linear extrapolation methods (Fig. 1).

Vehicle experiments were conducted in highway merging scenarios involving curved roads. Fig. 2 shows future vehicle positions represented in the station-distance coordinate system. Vehicles traveling on both the merging lane and the main lane were successfully mapped into the same road-based framework. As a result, future trajectories could be directly compared, and potential vehicle interference during merging could be identified. These results demonstrate that the proposed representation enables consistent evaluation of vehicle interactions across different lanes and provides useful information for autonomous driving decision-making. Fig. 3 shows vehicle trajectories during a temporary perception loss caused by occlusion. The proposed map-assisted estimation method continuously tracked the surrounding vehicle along the road geometry, whereas a simple linear extrapolation deviated from the curved roadway. The estimated trajectory remained consistent with the vehicle motion observed before perception loss, demonstrating the effectiveness of incorporating road geometry and connectivity information for robust vehicle tracking.

The experimental results confirm that integrating BEV perception with high-definition map information improves both future behavior prediction and robustness against temporary perception loss. By providing a common road-based representation of surrounding vehicles and reliable map-assisted position estimation, the proposed framework offers an effective foundation for cooperative and automated driving in complex highway merging environments.

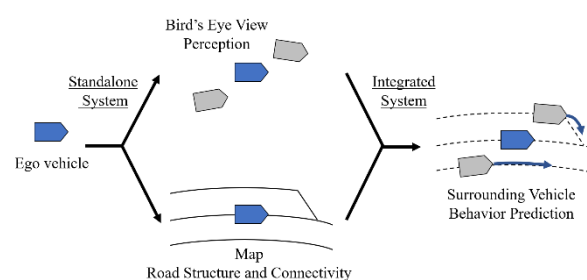


Fig. 1 Integrated System Image

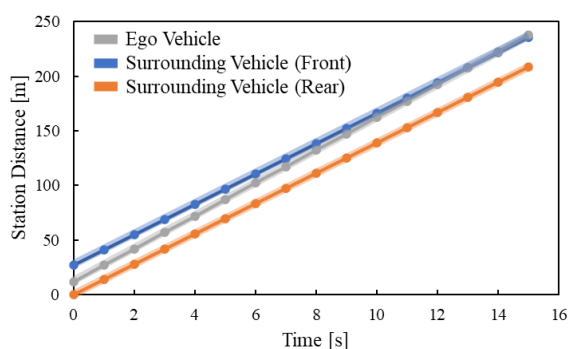


Fig. 2 Future Vehicle Positions in S-Coordinates

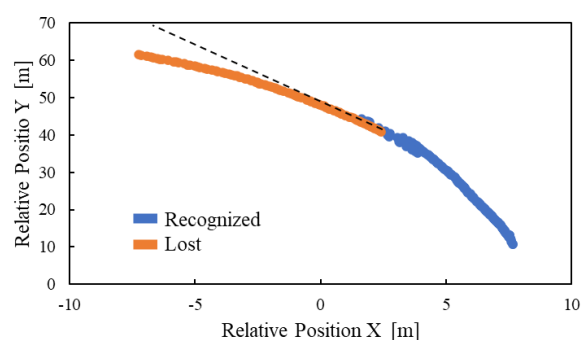


Fig. 3 Relative Position Changes to the Ego Vehicle