

Application of LiDAR Recognition and Automated Inspection to the Infrastructure-Based Autonomous Driving System for Vehicle Inspection Processes

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Infrastructure-based autonomous driving is a promising approach for reducing manual vehicle-transfer work and improving productivity in vehicle manufacturing plants. In previous deployment, the system realized autonomous vehicle transport by estimating the vehicle position using infrastructure sensors, transmitting driving commands through wireless communication, and operating onboard actuators. However, applying this concept to vehicle inspection lines requires higher localization accuracy because the vehicle must travel through narrow spaces between inspection equipment while maintaining both safe driving and inspection quality.

This paper proposes the LiDAR-based vehicle recognition method for the infrastructure-based autonomous driving system used in vehicle inspection processes. The target process includes inspection equipment and the side-slip tester, where clearance between the vehicle and surrounding facilities is limited. Under such conditions, camera-based localization is difficult because the installation position of cameras and the visible vehicle features are constrained by the existing production-line layout. Therefore, two infrastructure-mounted LiDAR sensors are installed near the start and end of the driving range. Point clouds acquired from the LiDAR sensors are preprocessed by extracting points in the drivable area and removing multipath points generated by reflections from vehicle bodies and surrounding equipment. The point clouds from the two sensors are then integrated into a common coordinate system, and the vehicle pose is estimated by matching the measured point cloud with a CAD-based 3D vehicle model using Voxelized GICP.

The proposed method was evaluated on a 17 m indoor driving path using four vehicle models and two body colors. Ten trials were conducted for each condition, resulting in 80 evaluation cases. The evaluation confirmed that the proposed method satisfied the required accuracy of 100 mm in the longitudinal and lateral directions and 1.0 deg in yaw angle for all cases. These results demonstrate that infrastructure-mounted LiDAR can provide sufficient localization accuracy for autonomous driving in narrow inspection-line environments, where conventional camera-based localization is difficult to apply.

The system was also applied to automated side-slip inspection.

During the inspection, steering control is temporarily stopped while the vehicle passes over the tester, and speed control is maintained within the required range of 2 to 5 km/h. This strategy follows the conventional inspection principle while reducing variation caused by human driving operation. As shown in Fig.1, the automated inspection results exhibited smaller variation than conventional manual inspection. In addition, the longitudinal acceleration during speed control was approximately within $\pm 0.1 \text{ m/s}^2$, indicating that the influence on suspension stroke was negligible.

The main contribution of this paper is to demonstrate that LiDAR-based infrastructure recognition can support both high-accuracy autonomous driving and stable inspection operation in the actual vehicle-inspection process. Future work will define criteria for driverless inspection and expand the system to similar production processes and outdoor environments.

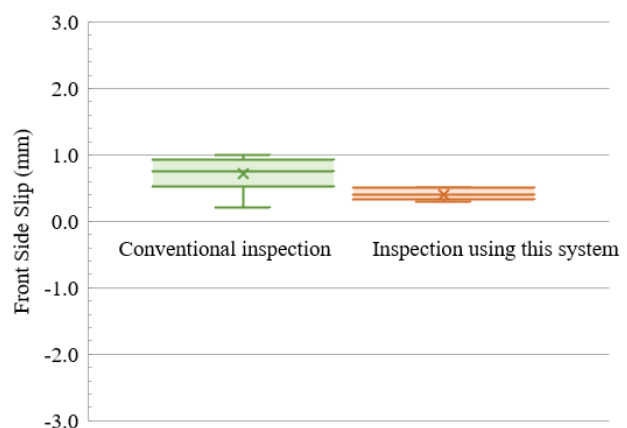


Fig.1 Comparison of side-slip inspection results