**System Calibration of LiDAR-Vision Multiple Sensors Module Mounted on A Ground Disaster Investigation Robot**

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***ABSTRACT***

In order to objectively identify the causes of recent natural disasters and investigate accident sites, the National Disaster Management Research Institute (NDMI) is developing a ground disaster investigation robot to investigate disaster sites such as earthquakes and structural collapses, where access by investigators is difficult, for tasks such as disaster information detection and collapse risk assessment.

The camera and system calibration process is an essential pre-processing step for ensuring the accuracy of the LiDAR/Vision-based Simultaneous Localization and Mapping (SLAM) module. Firstly, camera calibration estimates the interior orientation parameters (IOPs). Additionally, system calibration calculates the relative positions and attitudes of individual sensors which constitute the multi-sensor module of the investigation robot, geometrically enhancing the overall observation accuracy of the system.

Experiments for camera and system calibration were conducted by placing wall targets and V-shaped three-dimensional calibration boards in indoor spaces and acquiring images and point clouds for various experimental conditions such as the field of view between the camera and LiDAR, camera resolution, distance, and indoor illumination etc. For system calibration of the multi-sensor module, images and point clouds for the V-shaped three-dimensional calibration board were obtained from 9 locations at a rate of 20 shots per second, while for camera calibration, image data for flat calibration boards on walls were obtained from 6 locations, considering distance and height variations.

The results of camera and system calibration showed precise experimental outcomes, with the camera IOP estimation error (RMSE) through the calibration experiment being 0.39 pixels and the system calibration between LiDAR and camera showing errors within 0.2 pixels. Based on the experimentally derived system and camera calibration results, it is anticipated that the enhanced SLAM accuracy of future investigation robots in indoor spaces and more precise and accurate detection and analysis of indoor disaster information could be achieved.

**Keywords:** camera calibration, system calibration, robot, vision-LiDAR SLAM, disaster investigation