**Streaming Point Cloud Segmentation of GNSS/SLAM-LiDAR and**

**Multi-beam Scanning Sonar Data for Urban River Mapping**

Masafumi Nakagawa 1\*, Naoto Kimura 1, Nozomi Sadachika 1,

 Takeshi Komori 2, Nobuaki Kubo 2, Etsuro Shimizu 2

1 Shibaura Institute of Technology, Japan

2 Tokyo University of Marine Science and Technology, Japan

\*mnaka@shibaura-it.ac.jp

***ABSTRACT***

Simultaneous Localization and Mapping (SLAM) can provide point clouds and self-position data for 3D mapping, AR/VR/MR, UAV flight control, and autonomous vehicle control. In 3D mapping, 3D object recognition based on model fitting and machine learning is required for the automation of 3D mapping and modeling using dense point clouds generated by SLAM and mobile mapping. The machine learning-based 3D object recognition is classified into clustering and segmentation. The segmentation is fundamental processing for 3D mapping, scan-to-BIM, and autonomous vehicles using point clouds. The segmentation can be classified into image-based and 3D-based approaches. Each approach has strengths and weaknesses, thus we focus on the integration of image-based and 3D-based approaches embedded in SLAM and mobile mapping. In this research, we propose a methodology to improve the performance of streaming point cloud processing based on image-based and 3D-based point cloud segmentation for 3D mapping of urban river environments. We also developed a methodology of streaming point cloud segmentation embedded in GNSS/LiDAR SLAM and multi-beam scanning. In our experiments, we used a water-borne mobile mapping system at an urban river as GNSS and non-GNSS environments. We acquired dense streaming point clouds above water surfaces with GNSS/LiDAR SLAM consisting of two LiDARs (VLP-32C, Velodyne) and precise point positioning based on real-time kinematic positioning with centimeter-level augmentation service using quasi-zenith satellite system. In parallel, we also acquired dense streaming point clouds underwater surfaces with a multi-beam scanning sonar (BV5000, Teledyne BlueView) with RTK-GNSS positioning. Moreover, we experimented on streaming point cloud segmentation of acquired massive point clouds to classify streaming point clouds into bridges, revetments, buildings, and underwater surfaces. Through the experiment using the streaming point clouds, we confirmed that our methodology can improve the scalability of point cloud processing and achieve high-speed processing and precise classification as well as conventional image-based and 3D-based point cloud segmentation approaches.

**Keywords:** Streaming point cloud, Point cloud segmentation, Simultaneous localization and mapping, LiDAR, Multi-beam scanning sonar