**SegDF: Segment Based Dynamic Filter in 3D Point Cloud**

*Abstract*

Dynamic objects in lidar data often leave unwanted traces in 3D point clouds, affecting the quality of maps and localization performance. We propose a novel static reconstruction method, called SegDF, for focusing on filtering the dynamic objects on the ground with high mobility in urban environment. Given pairs of registered scans, we build a curved-voxel map assisted by sensor intensity to cluster them into instances and obtain semantics through geometric verification. Meanwhile, we represent the occupancy state of the volume of space by curved-voxels to remove dynamic points in object level. Furthermore, our approach tightly couples the instance segmentation and dynamic detection to improve the removal accuracy and compensate the imperfect clustering in the process of building a static object map. We validate SegDF on the KITTI dataset using SemanticKITTI as ground truth and prove that it works well in real urban streets.

Ⅰ. INTRODUCTION

Recent advances in 3D light detection and ranging (LiDAR) mapping have been reported leveraging LiDAR odometry [1, 2, 3], place recognition [4, 5, 6], and simultaneous localization and mapping (SLAM) [7, 8, 9]. Most autonomous robotic systems always assume that all observations are available, but only relying on static objects while rejecting dynamic objects as outliers can avoid confusion and achieve robustness.

During a process of SLAM using lidar in urban sites containing various dynamic objects like vehicles, pedestrians and so forth[14], we encounter non-static points with low interpretability in a raw scan data. The changes of maps are equivalent to the diversity of point cloud between two registered scans, and existing algorithms [10, 11, 12, 13] also utilize this idea to remove dynamic objects. Unfortunately, the difference of maps are divided into a) moving object and b) residual caused by restricted view as in Fig.1(体现遮挡和动态残影), the former can be reflected as ghost trail effect [10, 13] by sequential accumulations of the scan data, but the latter might be misjudged as a dynamic point according to the comparison in local maps. To tackle this problem, we propose a segment based dynamic filter in 3D point cloud,

Reference

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| [1] | Zhang, Ji, and Sanjiv Singh. "LOAM: Lidar odometry and mapping in real-time." Robotics: Science and Systems. Vol. 2. No. 9. 2014. |
| [2] | Shan, Tixiao, and Brendan Englot. "Lego-loam: Lightweight and ground-optimized lidar odometry and mapping on variable terrain." 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). IEEE, 2018. |
| [3] | Shan, Tixiao, et al. "Lio-sam: Tightly-coupled lidar inertial odometry via smoothing and mapping." 2020 IEEE/RSJ international conference on intelligent robots and systems (IROS). IEEE, 2020. |
| [4] | Kim, Giseop, and Ayoung Kim. "Scan context: Egocentric spatial descriptor for place recognition within 3d point cloud map." 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). IEEE, 2018. |
| [5] | Wang, Han, Chen Wang, and Lihua Xie. "Intensity scan context: Coding intensity and geometry relations for loop closure detection." 2020 IEEE International Conference on Robotics and Automation (ICRA). IEEE, 2020. |
| [6] | Dubé, Renaud, et al. "Segmatch: Segment based place recognition in 3d point clouds." 2017 IEEE International Conference on Robotics and Automation (ICRA). IEEE, 2017. |
| [7] | Durrant-Whyte, Hugh, and Tim Bailey. "Simultaneous localization and mapping: part I." IEEE robotics & automation magazine 13.2 (2006): 99-110. |
| [8] | Bailey, Tim, and Hugh Durrant-Whyte. "Simultaneous localization and mapping (SLAM): Part II." IEEE robotics & automation magazine 13.3 (2006): 108-117. |
| [9] | Cadena, Cesar, et al. "Past, present, and future of simultaneous localization and mapping: Toward the robust-perception age." IEEE Transactions on robotics 32.6 (2016): 1309-1332. |
| [10] | Pagad, Shishir, et al. "Robust method for removing dynamic objects from point clouds." 2020 IEEE International Conference on Robotics and Automation (ICRA). IEEE, 2020. |
| [11] | Schauer, Johannes, and Andreas Nüchter. "The peopleremover—removing dynamic objects from 3-d point cloud data by traversing a voxel occupancy grid." IEEE robotics and automation letters 3.3 (2018): 1679-1686. |
| [12] | Kim, Giseop, and Ayoung Kim. "Remove, then revert: Static point cloud map construction using multiresolution range images." 2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). IEEE, 2020. |
| [13] | Lim, Hyungtae, Sungwon Hwang, and Hyun Myung. "ERASOR: Egocentric ratio of pseudo occupancy-based dynamic object removal for static 3D point cloud map building." IEEE Robotics and Automation Letters 6.2 (2021): 2272-2279. |
| [14] | Behley, Jens, et al. "Semantickitti: A dataset for semantic scene understanding of lidar sequences." Proceedings of the IEEE/CVF international conference on computer vision. 2019. |
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