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應用於機器人之三維重建與導航開發

Development of 3D Reconstruction and Navigation for Mobile Robots

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Abstract

This thesis investigates visual techniques for enhancing Simultaneous Localization and Mapping (SLAM), three-dimensional (3D) reconstruction, and navigation in mobile robots utilizing an RGB-D camera. The RGB-D module in ORB-SLAM3 delivers precise performance for autonomous vehicles and robotics, with minimal drift due to loop-closing detection, as demonstrated by our experiments on campus. We evaluate and augment prior work, such as GMapping, which accurately localizes in a two-dimensional (2D) grid map but fails to address loop closure. By incorporating the concept of a visual bag of words and combining a 2D LiDAR sensor with a monocular camera, we enable loop detection and pose correction.

In addition to 2D scenarios, we focus on colorful mesh reconstruction from RGB-D cameras and develop a real-time pipeline for 3D reconstruction. By integrating ORB-SLAM3 with SurfelMeshing, we determine not only the camera pose but also reconstruct the 3D environment. While most 3D navigation tasks necessitate a dense map, meshes composed of multiple 2D triangles simplify calculations in robotic navigation. Our mesh reconstruction facilitates the creation of navigation meshes (NavMesh), which can be employed to navigate a robot in 3D space due to the distinct map format. Unlike a 2D grid, it permits walkable areas that overlap above and below at different heights. Polygons of varying sizes and shapes in the form of NavMesh can represent arbitrary environments with greater accuracy than regular grids.

Prior work on DAO* and DDAO* provides effective navigation policies for robots on

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2D grid maps, even in the presence of dynamic objects. However, the iteration process is inefficient. We have improved the iteration process of DAO* to reduce computation time for each path search for 2D navigation. Besides, NavMesh offers a comprehensible solution to 3D mapping, and we compare various pathfinding methods to demonstrate successful robot navigation in 3D space, even in the presence of additional obstacles.

The potential applications of this research include enhancing the capabilities of autonomous vehicles and robots in industries such as transportation, logistics, and manufacturing. It could also have implications for virtual and augmented reality, where accurate and efficient 3D mapping is essential. Overall, this research has the potential to contribute to the development of more advanced and capable mobile robots and autonomous systems.

Keywords: 3D Reconstruction, Navigation Mesh (NavMesh), Simultaneous Localization and Mapping (SLAM), Pathfinding

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