Robust large-scale mapping and localization

Combining robust sensing and introspection

av

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Akademisk avhandling

Avhandling för teknologie doktorsexamen i datavetenskap,
som kommer att försvaras offentligt
Tisdagen den 31 oktober 2023 kl. 13.00,
Hörsal L2, Långhuset, Örebro universitet

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Abstract

Daniel Adolfsson (2023): Robust large-scale mapping and localization—Combining robust sensing and introspection. Örebro Studies in Technology 100.

The presence of autonomous systems is rapidly increasing in society and industry. To achieve successful, efficient, and safe deployment of autonomous systems, they must be navigated by means of highly robust localization systems. Additionally, these systems need to localize accurately and efficiently in real-time under adverse environmental conditions, and within considerably diverse and new previously unseen environments.

This thesis focuses on investigating methods to achieve robust large-scale localization and mapping, incorporating robustness at multiple stages. Specifically, the research explores methods with *sensory robustness*, utilizing radar, which exhibits tolerance to harsh weather, dust, and variations in lighting conditions. Furthermore, the thesis presents methods with *algorithmic robustness*, which prevent failures by incorporating introspective awareness of localization quality. This thesis aims to answer the following research questions:

How can radar data be efficiently filtered and represented for robust radar odometry? How can accurate and robust odometry be achieved with radar? How can localization quality be assessed and leveraged for robust detection of localization failures? How can self-awareness of localization quality be utilized to enhance the robustness of a localization system?

While addressing these research questions, this thesis makes the following contributions to large-scale localization and mapping: A method for robust and efficient radar processing and state-of-the-art odometry estimation, and a method for self-assessment of localization quality and failure detection in lidar and radar localization. Self-assessment of localization quality is integrated into robust systems for large-scale Simultaneous Localization And Mapping, and rapid global localization in prior maps. These systems leverage self-assessment of localization quality to improve performance and prevent failures in loop closure and global localization, and consequently achieve safe robot localization.

The methods presented in this thesis were evaluated through comparative assessments of public benchmarks and real-world data collected from various industrial scenarios. These evaluations serve to validate the effectiveness and reliability of the proposed approaches. As a result, this research represents a significant advancement toward achieving highly robust localization capabilities with broad applicability.

Keywords: SLAM, Localization, Robustness, Radar

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