Robust large-scale mapping and localization

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Doctoral Dissertation

Computer Science

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. Accurate and reliable localization and mapping methods are essential to maintain autonomy and ensure system safety. This thesis presents methods with sensory robustness, utilizing radar, which exhibits tolerance to harsh weather, dust, and lighting conditions. Furthermore, the thesis presents methods with algorithmic robustness, utilizing introspective awareness of localization quality.

The 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. These methods 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 methods in real-world applications.

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 methods in real-world applications. As a result, this research represents a significant advancement toward achieving highly robust localization capabilities with broad applicability.