Abstract

Improving Visual Simultaneous Localization and Mapping robustness.

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This thesis presents new advancements in the field of Visual Simultaneous Localization and Mapping (VSLAM), focusing on enhancing the robustness and flexibility of VSLAM systems. The motivation behind this research stems from the growing significance of computer vision and its applications. The thesis offers several key contributions.

At the beginning of this work, both SLAM and VSLAM systems are discussed in detail. Forty years of research on localization and mapping have been compiled and analyzed, providing a comprehensive overview of the development and current state of VSLAM systems. A table of various SLAM systems has been created, serving as a guide for researchers, facilitating the effective comparison of these systems and aiding in the identification of their strengths and weaknesses. The thesis also identifies and addresses key challenges, such as outlier errors, dynamic environments, map maintenance, long-term operation, and others. These challenges are discussed and illustrated in detail to highlight their impact on the robustness of VSLAM.

It also redefines the concept of robustness in VSLAM, proposing a multi-faceted approach that considers algorithmic robustness, software resilience, and computational efficiency. Each of these aspects is thoroughly analyzed and addressed in subsequent chapters of the thesis.

The concept of Modular SLAM, an extensible architecture designed to overcome the limitations of existing SLAM systems, is introduced. It supports rapid prototyping, allowing researchers to explore new solutions efficiently. Modular SLAM combines advancements in system architecture and VSLAM to build a modular and flexible solution.

Additionally, two novel methods are introduced: VSLAM SuperPoint, a deep learning-based feature detection technique that leverages image sequence data to improve keypoint repeatability, and VSLAM RANSAC, an enhanced pose estimation method utilizing historical data to increase robustness.

Finally, directions for future research are outlined, highlighting the potential for further innovations and applications of Modular SLAM.

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