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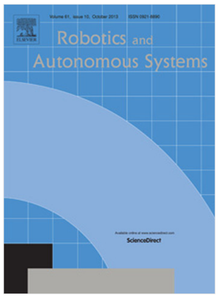

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Multi-Camera Visual SLAM for Autonomous Navigation of Micro Aerial Vehicles

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Abstract

In this paper, we present a visual simultaneous localization and mapping (SLAM) system which integrates measurements from multiple cameras to achieve robust pose tracking for autonomous navigation of micro aerial vehicles (MAVs) in unknown complex environments. We analyze the iterative optimizations for pose tracking and map refinement of visual SLAM in multi-camera cases. The analysis ensures the soundness and accuracy of each optimization update. A well-known monocular visual SLAM system is extended to utilize two cameras with non-overlapping fields of view (FOVs) in the final implementation. The resulting visual SLAM system enables autonomous navigation of an MAV in complex scenarios. The theory behind this system can easily be extended to multi-camera configurations, when the onboard computational capability allows this. For operations in large-scale environments, we modify the resulting visual SLAM system to be a constant-time robust visual odometry. To form a full visual SLAM system, we further implement an efficient back-end for loop closing. The back-end maintains a keyframe-based global map, which is also used for loop-closure detection. An adaptive-window pose-graph optimization method is proposed to refine keyframe poses of the global map and thus correct pose drift that is inherent in the visual odometry. We demonstrate the efficiency of the proposed visual SLAM algorithm for applications onboard of MAVs in experiments with both autonomous and manual flights. The pose tracking results are compared with ground truth data provided by an external tracking system.

1 Introduction

In the last decade, we have seen a growing interest in micro aerial vehicles (MAVs) from the robotics community. One of the reasons for this trend is that MAVs are potentially able to efficiently navigate in complex 3D environments with different types of terrains, which might be inaccessible to ground vehicles or large-scale unmanned aerial vehicles (UAVs), e.g. in an earthquake-damaged building (Michael *et al.*, 2012). A basic requirement for MAVs to autonomously operate in such environments is their robust pose tracking abilities, which is still a challenging task when the environment is previously unknown and external signals for providing global position data are unreliable. Meanwhile, if a map of the environment can be built, it will be able to provide support to path planning of autonomous navigation of the MAV (Schauwecker and Zell, 2014). Recently, more focus has been on using onboard visual solutions to address these issues, especially using visual simultaneous localization and mapping (SLAM) systems.

Although we have seen successful applications of visual SLAM on ground vehicles (Cummins and Newman, 2008; Strasdat *et al.*, 2011), there are more challenges in using visual SLAM to enable autonomous navigation of MAVs.

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