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Scale-Preserving Long-Term Visual Odometry for Indoor Navigation

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ABSTRACT

We present a visual odometry system for indoor navigation aiming at long-term robustness and consistency. As our work is targeted at mobile phones, we employ monocular SLAM to jointly estimate a local map and the device's trajectory. We specifically address the fundamental problem of estimating the unobservable scale of map and trajectory. State-of-the-art solutions approach this problem with an Extended Kalman Filter that incorporates measurements from the device's inertial sensors. This technique allows estimating the scale, but strongly relies on a good initialization of the filter and takes time to converge. Until convergence, the odometry estimates are of limited use. Inaccurate initialization prolongs this phase or may even result in divergence.

In real indoor scenarios, tracking is likely to fail frequently as buildings often exhibit sparse or ambiguous texture. Heuristic recovery approaches may succeed to resume tracking. Otherwise, re-initialization of the map becomes necessary, which introduces an unknown new scale.

We propose a fast and robust method for scale initialization that exploits basic geometric properties of the learned local map. Using random projections, we efficiently compute geometric properties from the feature point cloud produced by the visual SLAM system. Since these properties, e.g., hallway width or height, remain constant, the scale ratio between consecutive maps can be determined to recover the scale estimate before re-initialization. Thus, the correct scale is preserved given that the filter has converged once (possibly over several re-initializations).

To minimize the time required to continue tracking after failure, we perform recovery and re-initialization in parallel. This increases the time available for recovery and hence the likelihood for success, while allowing almost seamless tracking.

We evaluate our approach on extensive and diverse indoor campus datasets. Results demonstrate that errors and convergence times for scale estimation are considerably reduced, thus ensuring consistently accurate odometry for the mobile device.

KEYWORDS: Indoor navigation, visual odometry, monocular SLAM, scale estimation, scale-consistent multi-map SLAM