Lidar-Aided Camera Feature Tracking and Visual SLAM for Spacecraft Low-Orbit Navigation and Planetary Landing

This paper explores the state estimation problem for an autonomous precision landing approach on celestial bodies. This is generally based on sensor fusion from inertial and optical sensor data. Independent of the state estimation filter, a remaining problem is the provision of position updates without the use of known absolute support information as it appears when the vehicle navigates within unknown terrain. Visual odometry or simultaneous localization and mapping (SLAM) approaches typically provide relative position. This is quite suitable, but it can be adverse due to error accumulation. The presented method combines monocular camera images with laser distance measurements to allow visual SLAM without errors from increasing scale uncertainty. It is shown that this reduces the accumulated error in comparison to sole monocular visual SLAM. Further, the presented method integrates the matching to known landmarks if they are available in the beginning of a landing approach so that the relative optical navigation can be initialized without systematic errors. Finally, tests with a simulated moon landing are performed and it is shown that the method is capable of navigating down to the ground impact.