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A GENERAL VISION-BASED FRAMEWORK FOR SPACE TARGET TRACKING

Abstract

Space target tracking has extensive application prospects such as spacecraft on-orbit servicing, space debris mitigation, asteroid landing and so on. The basic idea behinds space target tracking is to estimate the relative state of the observed object through measurements from sensors. Here, relative state refers to relative translation, linear velocity, relative attitude and angular velocity between explorer and target. However, most space targets are non-cooperative or passive objects which do not send useful signals for relative state estimation. For those targets, only passive sensors like laser radar, camera or infrared camera could be used for measuring.

In order to meet the future challenge of space tasks, a general vision-based framework for space target tracking is proposed in this paper. Star sensor, laser radar, camera and inertial measurement unit (IMU) are used as measuring devices for the system. The framework consists of two subsystems: ego-motion estimation system for explorer and relative motion estimation system for target. Ego-motion estimation system outputs the changes of attitude and translation of the explorer during the task by fusing the data from star sensor and IMU. Relative motion estimation system combines data from laser radar and camera to track the relative pose and reconstruct surface of the target.

When tracking the target's pose, the uncertainty caused by nonlinearity of the relative dynamic motion model could be reduced by integrating the estimated motion of the explorer. Laser radar could detect the range image but shows poor performance when doing pose tracking, while camera would do much better in pose tracking but could not perceive depth information directly. To get better performance of reconstruction and pose tracking, therefore, the laser radar and camera are combined together to reconstruct the surface of the target and track the relative pose.

Finally, to demonstrate the performance of the proposed framework, a synthetic target is simulated by a set of 3D points rotating and translating according to the dynamic model. Then the proposed method is implemented to estimate the relative pose of the target and reconstruct the surface at the same time.