IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Advanced Satellite Services (5)

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VISION-BASED ESTIMATION OF DYNAMICS FOR SPACE DEBRIS WITHOUT INERTIAL MOMENTS KNOWN

Abstract

Active Debris Removal(ADR) is one of the hot topics of research subjects in recent years, and estimation of the target states is the precondition of success for ADR mission. Since the relative position of feature points could be directly calculated based on principle of triangle measure, Stereovisions are often adopted to determine position and attitude of target through measuring three non-collinear feature points. For rotation objects, Kalman filtering and plenty of its extended methods are primary used to estimate the rotation states and could achieve excellent outcomes only if enough priori information obtained. But for the noncooperative objects such as space debris, the state estimation is a challenge problem since lack of priori knowledge. Some researchers developed extended methods to deal with estimation problem for noncooperative objects, and these methods typically required the target's inertia moments being known, But such requirement could rarely be met in the real world. A Vision-based Estimation approach which does not need inertia moments of the target as known parameters is put forward in this paper. This method avoids the problem of inaccurate attitude dynamics modeling caused by the unknown or unobservability of the target's inertia. By modeling rotation motion through Euler equation in Principal Axis Coordinate System(PACS)and transporting the dedicated feature points to PACS. In such case, the maximum inertia axis which orientation is invariable in inertial space, estimation of the target attitude state could be achieved through estimation of orientation of rotation axis and the finite rotation rate. Under above scenary, A Vision-based Estimation approach for relative states of the target object, including rotation rate and orientation, relative position and velocity is established applying Unscented Kalman Filter (UKF) estimation scheme. Some simulation cases and results were induced to ascertain the excellent performance of proposed tracking schemes. Employing one CCD camera, at least three non-collinear feature points are required, If the ratio of sample frequency great than rotation rate, The scheme shows stable convergence performance. While the target in the camera's FOV , The larger of the ratio, the more quickly the convergence speed. When sample frequency is set to 1/20, the errors of rotation rate converge to 0.5 degree, and position converge to 0.5 meter within 40 seconds. Keywords: Non-cooperative Object Rendezvous; Dynamic States Estimate; UKF