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Measurements (1)

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FAULT-TOLERANT FEATURE-BASED ESTIMATION OF SPACE DEBRIS ROTATIONAL MOTION DURING ACTIVE REMOVAL MISSIONS

Abstract

One of the key functionalities required by an Active Debris Removal mission is the assessment of the target kinematics and inertial properties. Passive sensors, such as stereo cameras, are often included in the onboard instrumentation of a chaser spacecraft for capturing sequential photographs and for tracking features of the target surface. A plenty of methods, which are based on Kalman filtering, are available for the estimation of the target's dynamic state from feature positions; however, in order to guarantee the filter convergence, they typically require continuity of measurements and the capability of tracking a fixed set of pre-defined features of the object. These requirements clash essentially with the actual tracking conditions: failures in feature detection often occur and the assumption of having some a-priori knowledge about the shape of the target could be restrictive in certain cases. The aim of the presented work is to propose a fault-tolerant alternative method for estimating the angular velocity and the relative magnitudes of the principal moments of inertia of the target. Raw data relative to the positions of the tracked features are processed to evaluate corrupted values of a 3-dimentional parameter which fully describe the finite screw motion of the debris and which primarily results invariant with respect to the particular set of considered features of the object. Missing values of the parameter are completely restored exploiting the typical periodicity of the rotational motion of an uncontrolled satellite: compressed sensing techniques (CS), typically adopted for recovering images or for prognostic applications, are herein used in a completely original fashion for recovering a kinematic signal that appears sparse in the frequency domain. Due to its invariance with respect to the features, no assumptions are needed about the target's shape and about continuity of the tracking. The obtained signal is useful for the indirect evaluation of an attitude signal that is used as the measurement for feeding an unscented Kalman filter for the estimation of the global rotational state of the target. The results of the computer simulations showed a good robustness of the method and its potential applicability for general motion conditions of the target.