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SATELLITE ATTITUDE ESTIMATION WITH HYPERSPECTRAL IMAGING FOR AUTONOMOUS NAVIGATION

Abstract

The aim of this work is to demonstrate the use of hyperspectral imaging technology and modern machine learning techniques to estimate the attitudes of space objects for close proximity operations and in-orbit servicing. This work consists of developing and testing methods for the estimation of the 3D attitudes of known and unknown space objects, and the reconstruction of the relative attitude motion between the servicing satellite and the target object.

In previous work it was demonstrated that the time variation of the spectra enables the partial reconstruction of the attitude motion from single pixel images. This concept is now expanded to resolved images with multiple pixels, with the objective to estimate the 3D pose and rotational motion of an object from the time variation of the identified features on the image plane. The data available is a sequence of hyperspectral images, with high spectral resolution, but relatively low spatial resolution, obtained as the servicing satellite approaches the target, and the image of the object progressively occupies more and more pixels on the image plane and thus spectra from individual components can be resolved independently. The tracking of features on the object is to be performed by decomposing and analysing reflectivity and emissivity spectra in the visible and infrared range. Features are thus identified and tracked by their material composition and spatial distribution rather than their exact geometric shape (such as corners or edges), thus lowering the need for high resolution images and image processing cost. Once the features are tracked along the image plane, machine learning methods are applied to relate the features with the pose. Scenarios with varying amounts of 3D information on the object's 3D model are tested, including the case where no 3D information is available at all, for the scenario where the object is completely unknown as might happen in the initial stage of a debris removal mission.