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# VISION BASED NAVIGATOR FOR MAPPING AND LOCALIZATION OF AN UNKNOWN SMALL BODY DURING EARLY CHARACTERIZATION

**Abstract**

Small bodies exploration is increasing the efforts in developing new algorithms and solutions for deep space probes operation and navigation. The limited knowledge of small bodies properties imposes numerous challenges in mission design and spacecraft operation. Current approach to small body mission is based on precise orbit determination and the down-link of optical data to estimate not only the small body characteristics but also the relative position and orientation between the probe and the small body. During close approach, i.e. when the small body is several pixels in the mapping camera field of view, the probe slowly moves radially with respect to the observed small body which is rotating around its rotation axis. The estimation of rotation pole orientation in the inertial space is crucial to define the small body reference frame and the shape reconstruction gives insights of the small body gravity under the assumption of constant density. The density is estimated during flybys by localizing the probe with respect to the small body. In the present paper a vision-based navigation solution for the early characterization phase of an unknown small body is presented and tested. The rotation axis is estimated form a series of images thanks to tracked features. Feature tracking is used to solve for the relative position and orientation between the spacecraft and the small body. Finally the shape is reconstructed by merging information from the silhouettes, thus data on the small body limbs, and from the tracked features. This process allows the characterization of the small body in terms of rotational dynamics and shape before orbiting the small body. In the second part of the characterization, the probe is doing flybys of the small body and it estimates its gravitational constant from vision-based localization data. This allow to understand the density and mass of the small body autonomously. To show the applicability of the proposed scenario, numerical results are presented and commented. The trajectory is simulated and images are generated with the SurRender software, a high-fidelity rendering engine optimized for space applications developed by Airbus Defence Space, to have a ground truth to compare the estimated poses and the reconstructed shape.