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Author: Dr. Kikuko Miyata
NESTRA, Japan

Dr. Jozef van der Ha
Mission Design & Operations, United States

PROXIMITY NAVIGATION FOR ASTEROID MISSION USING CCD IMAGER

Abstract

Recently, the interest in deep space exploration is increasing. Especially, there is much interest in small probes for imaging missions after the mission success of HAYABUSA. For small probes, there are more severe constraints for power and for the number of instruments. In addition, it is important to achieve the suitable control performance for imaging missions using low-cost and low-mass units. In this paper, we study the efficiency of the proximity navigation by using the camera data of CCD (charge-coupled device) array for an asteroid imaging mission. This strategy reduces the number of units and helps to achieve a relatively high accuracy orbital determination autonomously on-board. The CCD of the probe is controlled to point to the surface of the target asteroid when it is in close proximity. First, we assume the attitude of the probe is perfect and estimate the relative orbit parameters from the time derivative of the position change of the target asteroid within the CCD image. The position of the target asteroid within the image can be calculated by processing of the pixel outputs over the CCD Field of View. An extended Kalman Filter (EKF) is used to estimate the B-plane miss distance parameters, the relative velocity, and the time of closest approach. The on-board computer knows the predicted a priori position of the target asteroid and this is used in the estimation of the off-set of the asteroid position within the image. This knowledge will then be used for the attitude control to correct the imager's pointing direction. For applications, we consider two scenarios. In one case, we assume a small probe with realistic constraints and estimate the relative orbit parameters including the attitude errors. For this situation, we choose the star tracker, sun sensor for attitude determination and a CMG (Control Moment Gyros) actuator. We construct the attitude control strategy for a small spacecraft with high accuracy requirements. Another scenario is the case where we use the star data in the imager field of view for the orbit determination when the probe is far from the target asteroid.