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Author: Mr. Mehmet Burak Güzel
Middle East Technical University, Türkiye

Dr. Halil Ersin Soken
TUBITAK Uzay, Space Technologies Research Institute, Türkiye
Prof. Ozan Tekinalp
Middle East Technical University, Türkiye

IMAGING-BASED ATTITUDE DETERMINATION ALGORITHM FOR SMALL SATELLITES: DESIGN AND THE PRELIMINARY RESULTS

Abstract

Number of small satellites in orbit is growing rapidly due to the numerous advantages that these satellites provide, such as, low cost and launching of multiple satellites together. Although, the mission of the satellite varies, accurate attitude determination and control is often vital. On the other hand, size, mass and power budgets limit the possibilities for using any sensor or actuator on small satellites. Consequently, attitude sensors and actuators that has small volume and mass and low power consumption is a popular research topic. In this sense, using any of the mission payloads as an attitude sensor or actuator may also be useful.

Certainly, one of the most prominent payloads that can be used as attitude sensors are cameras. This is a promising application not just for Earth observation missions but also for future interplanetary small satellite missions, for which saving mass is an even more critical. Recent studies show that it is possible to use the camera as an Earth (or moon) sensor. However, this provides only a 2-axis attitude information. For a full 3-axis attitude estimation the camera must be aided with another sensor. There are also research going on for full attitude determination using the images taken and an algorithm to match these images with the references such as the stored images of the of the Earth. Nevertheless, successful image matching depends on several conditions. Even if the matching is successful the provided full attitude information is at a single time frame, not a continuous one. Thus, the attitude is lost for the rest until another successful image matching.

This research aims at designing an attitude estimation algorithm, which is capable of providing real-time complete attitude estimates using the payload camera as the primary sensor. Whenever the full attitude can be extracted from the images obtained, a recently proposed ellipsoid fitting algorithm is used to feed the 3-axis attitude measurements to an extended Kalman filter (EKF) algorithm that runs as the main block of the attitude estimator. The camera can also provide a partial, 2-axis, attitude information to the QUEST block of the algorithm. This block pre-processes the available vector measurements before feeding additional measurements to the EKF. The paper will introduce the architecture of the proposed algorithm together with the details on how to extract attitude information from the obtained Earth images. Preliminary results to demonstrate the success of the algorithm will also be presented.