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HYBRID MULTI-ALGORITHMIC ATTITUDE DETERMINATION AND CONTROL ARCHITECTURE

Abstract

In recent space studies, small satellites have a significant contribution. The main reason for this is that they are low-cost. However, the low-cost property also brings some disadvantages such as design limitations and component quality. In fact, these disadvantages can cause several problems for Attitude Determination and Control Systems (ADCSs) of small satellites. The first main problem is that since the size, weight, and power consumption is limited, redundancy of a sensor or actuator is not possible for most missions. Thus in case of malfunction of the components or faulty sensor data the whole ADCS is affected. Secondly, the quality of the sensors is not high due to low-cost and tiny sensor selection. Therefore, error and fault in ADCS are most likely situations for small satellites.

In the literature, the hybrid and multi-algorithmic approach is used for designing a robust ADCS. This approach can be defined by constructing different modes according to the distinct phase of the mission and managing the mode transitions with various control and estimation algorithms. Defined modes are similar in most of the studies; however, researchers approach the transition of modes in separate ways. An important reason for this is the transition of the modes is mainly about fault detection, isolation, and recovery (FDIR) and FDIR is problematic for space applications due to a variety of error sources. Understanding the error type and recovering can be complicated because of the layered and interconnected structure of the modes and faults. In addition, most of the current ADCS design for small satellites is based on transferring the spacecraft to safe mode when an undesirable or unexpected situation has happened and this causes inefficient performance. Moreover, the stability of hybrid systems is still a subject of study in order to get a smooth transition between modes. Therefore, hybrid multi-algorithmic ADCS is an issue to be investigated for small satellites.

The main aim of this study is decreasing the probability of failure due to ADCS and increasing survivability for small satellites. For this purpose, we design a multi-algorithmic hybrid ADCS architecture which is also capable of changing to different algorithms in case of sensor/actuator malfunctions. The proposed architecture is tested in a simulation environment considering different ADCS modes and various possible errors that may be encountered throughout the mission.