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SENSORS HYBRIDIZATION FOR DISTRIBUTED LAUNCHER SYSTEM NAVIGATION DEVELOPMENT: FIRST RESULTS OF THE NIBBIO PROJECT

Abstract

Accurate attitude determination is crucial for optimal performance and effectiveness of launch vehicles. While solutions traditionally employed on launchers guarantee high precision, their implementation is also often characterized by extremely high costs associated with "one-off" use in expendable launch vehicles. The recent advancements in the field of low-cost Micro Electronic Mechanical Systems have opened the doors to more economical hybrid navigation schemes, combining measurements from a diverse array of low-cost sensors. Limitations in their use are centered around noise present in their measurements restricting their accuracy and reliability. These limitations may however be overcome through the implementation of filtering and data fusion algorithms to produce more accurate attitude estimates, enabling this sort of solution for future use in space launch vehicles. Sapienza S5Lab is participating in a research project coordinated by the Italian Space Agency (ASI) for the study and prototyping of hybrid-distributed navigation systems for launchers. In the paper, a simulative model of a three-stage launch vehicle is developed and used to simulate noisy measurements generated from on board sensors. The sensor suite includes measurements from an Inertial Measurement Unit (IMU) made up of a gyroscope and accelerometer, and a magnetometer. An Extended Kalman Filter for attitude determination is then developed, and its performance assessed using these same noisy measurements. Performance is evaluated by comparing attitude estimates with the reference attitude extracted from the simulative model. A Montecarlo analysis of the filter's ability in attitude estimation is then performed for varying levels of measurement noise to review filter performance and evaluate the contributions of each type of measurement to the accuracy of the attitude estimate. Finally, the implementation of multiple IMUs is considered, testing the effect of additional sensors on the accuracy of the produced attitude estimates. Two different data fusion techniques are also studied and compared to assess the optimal level at which data fusion should occur. The work hereby presented will present preliminary simulative results, which have shown consistent improvements in Euler angle determination when using an array of multiple low-cost, low-quality sensors. A technology prototype demonstration is further planned for the BEXUS 34 flight within the framework of the RETINA mission, aimed at confirming the simulative findings and

investigating the feasibility and performance of this system to increase its Technology Readiness Level (TRL) for future space launch vehicle applications.