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DEVELOPMENT OF AN ALIGNMENT TECHNIQUE FOR A LARGE NUMBER OF REDUNDANT INERTIAL MEASUREMENT UNITS

Abstract

Large clusters, or "swarms," of Inertial Measurement Units (IMUs) have been proposed by numerous researchers as a way of improving small satellite inertial navigation performance using cost-effective Micro Electro-Mechanical Systems (MEMS) technology. The authors of this paper are part of a team developing a swarm of 15+ MEMS IMUs integrated into a single board that can fit within a CubeSat framework. If made practical, such a system could enable small satellites to accomplish substantially more ambitious science missions. Although great care is taken in the manufacture of these boards, misalignments between each of the IMUs on the board is unavoidable. To achieve precision inertial navigation, these misalignments must be estimated. In order to complete this alignment, the IMU swarm board is placed on a high precision rate table and the raw data from each of the IMUs are recorded. This is repeated several times, with each data set consisting about a constant rotation about a different direction in the IMU swarm's sensor frame. By recording the angular velocity vector with each of the three-axis IMUs in the swarm, a measurement of the sensed angular velocity will be generated in each IMU frame. If all of the three-axis IMUs were perfectly aligned, then each IMU would produce the same (noisy) measurement for each case. The misalignments, however, will cause the measurements between each IMU in the swarm to vary in a systematic way. From this data, the relative alignment amongst the IMUs may be estimated. After observing several angular velocities the relative orientation of any two IMUs may be viewed as an attitude estimation problem, which may be solved via any number of popular solutions to Wahba's problem. One IMU in the swarm will be defined as the "reference" IMU, and this approach will be used to compute the misalignment of all other IMUs in the swarm with respect to this reference IMU. As a result of these constructed algorithms and materials, one should be able to quickly and inexpensively compute the alignment of a swarm of MEMS IMUs.