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A FAST INITIAL FINE ALIGNMENT ALGORITHM FOR A STRAPDOWN INERTIAL NAVIGATION SYSTEM OF A SATELLITE LAUNCHER

Abstract

In this paper, an initial fine alignment algorithm (IAA) is developed for the strapdown inertial navigation systems (INS) of satellite launch vehicles. To accomplish the orbit injection mission of the satellite launchers, the high accuracy of their navigation systems must be guaranteed. Since the current states of INS are obtained by integrating the measurements from initial states, initial alignments are of vital importance for this purpose. In particular, IAA must be robust enough to perform successfully even in the wind induced sway environments which the launchers are subjected to in the launch pad before launch. Also, the limited launch window restricts the alignment time, which the alignments must be carried out in a short time.

To satisfy these requirements, new IAA is developed here. The proposed algorithm is closed loop control system to regulate the reference attitudes, which can be calculated by INS acceleration measurements and azimuth angle information given by optical alignments. The attitude errors, which the difference of the current attitude obtained by integrating INS gyro measurements from the references, are feedback signals to the Proportional-Integral (PI) controller of the closed-loop system. By eliminating the errors, the initial INS attitudes and gyro biases are estimated. The simple structure overcomes the low computational speed of the Kalman filter, which is used most broadly for the initial alignment of strapdown INS. The PI controller gain is designed by considering the estimation speed and stability of the closed-loop system.

To evaluate the estimation performance of the proposed initial fine alignment algorithm, it is compared with that of a Kalman filter. To reduce the time of the alignment for the Kalman filter case also, a simple error model with low order is employed here (the accelerometer outputs are used in its measurement equations rather than the velocity error outputs). Two kind of tests are performed to demonstrate the superiority of the proposed algorithm. The first test is a static test in a laboratory using the INS developed for satellite launchers and the second is the computer simulation for the sway environments. The test results show that the proposed algorithm improves the computational speed as well as shows the alignment accuracy as comparable to that of the Kalman filter.