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A Robust Filtering Algorithm for Integrated Navigation System of Aerospace Vehicle in Launch Inertial Coordinate

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Abstract: In ordinary aircrafts, the geographic coordinate is usually taken as reference coordinate to build navigation systems. Changes of gravity field and radius caused by the non-perfect sphere and uneven mass distribution of the earth are ignored or simplified in navigation algorithm, which have little effect on the accuracy of the navigation system in a short-time and short-distance flight. As the Aerospace Vehicles (ASVs) have to complete long-term on-orbit maneuver over wide flight enveloping, ignoring changes of gravity field and radius will bring about cumulative navigation errors and result in the declined accuracy of the navigation system. Hence, this paper first proposes an inertial navigation algorithm in launch inertial coordinate for ASVs aimed at reducing the effects caused by the inaccurate earth model on the navigation system. Then, the model of INS/CNS/GPS integrated navigation system in launch inertial coordinate is built. Considering the uncertain noise in space, the performance of Kalman filter may be poor, a robust filtering algorithm based on extended H_∞ filter is designed to realize multi-sensors information fusion; The state model and measurement model in launch inertial coordinate are built. The simulation results show that the proposed method and algorithm can improve the accuracy and reliability of the integrated navigation system for ASVs.

Key Words: Aerospace Vehicles (ASVs); launch inertial coordinate; extended H_∞ filter; integrated navigation system

1 Introduction

Aerospace Vehicles [1] (ASVs) are reusable launch vehicles with the ability of working both within and outside the atmosphere. The ASVs have large wide flight enveloping; the entire flight process can be divided into several phases [2]: launch phase, in-orbit phase, reentry phase and landing phase. Since the flight is large-span and long-duration, ASVs have an extremely high requirement on the accuracy and reliability of the navigation system.

In general, the aviation aircrafts take the local geographical coordinate as the reference coordinate to get navigation information intuitively. Changes of the gravity field and radius of curvature are always ignored or simplified since they are unobvious in short-distance flight. However, the gravity field and radius of curvature may change obviously during the ASVs' large-span flight. It is unreasonable to ignore these changes which have serious influence on the navigation system. In addition, conventional Kalman Filter requires the noise must be strict Gaussian [3]. For non-Gaussian noise, the conventional Kalman Filter is the optimal filter if and only if the system model and the properties of the noise are completely known [4]. Actually, because of the uncertainty in the flight environment, the exact measurement error model is hard to build and the statistical properties of the noise can't be obtained easily. Hence, the performance of Kalman Filter may be affected in this case. For modern large-scale industrial process, data-driven approaches [5], model-based approaches [6] and integration of data-driven and model-based