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Research Article

Research on Exact Thresholds for ARAIM MHSS Fault Monitoring

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Multiple Hypothesis Solution Separation (MHSS) is the baseline algorithm for Advanced Receiver Autonomous Integrity Monitoring (ARAIM), and it detects faults by comparing the test statistic with a threshold. However, the cuboid threshold structure of the MHSS fault monitoring baseline algorithm lacks omnidirectionality, which leads to low conformity between the threshold and the spatial distribution of the test statistic and to low fault monitoring accuracy. To resolve these problems, we analyzed the distribution of a test statistic for single-, double-, and triple-fault hypotheses. By extracting the eigenvectors and eigenvalues of the solution separating variance, we designed an omnidirectional threshold structure. The simulation verifies the effectiveness of the fault detection method by detecting faults from noise. The results show that the proposed method is more exact, stable, and applicable than the MHSS fault detection baseline.

1. Introduction

Receiver Autonomous Integrity Monitoring (RAIM) is an important method of ensuring integrity. RAIM is a sensor-level integrity monitoring system that uses a self-consistency check to detect and exclude potential excessive ranging errors [1]. With the modernization of GPS and GLONASS and the development of Galileo and BDS, the number of GNSS satellites is increasing rapidly [2], and the requirements of higher accuracy and integrity are achieved using dual frequencies and multiple constellations. The future multiconstellation global navigation satellite system (GNSS) will provide a large number of redundant ranging signals, which will improve the Receiver Autonomous Integrity Monitoring (RAIM) performance but will also increase the probability of satellite faults [3]. Therefore, the Advanced Receiver Autonomous Integrity Monitor (ARAIM), which is expected to provide vertical guidance for LPV-200, has been proposed by the Federal Aviation Administration. Compared with RAIM, ARAIM can support multiconstellation and dual-frequency [4] signals. Additionally, the ARAIM nominal performance and fault probability can be updated by integrity support messages to ensure the integrity of navigation services [5].

As an important part of ARAIM, fault detection serves to avoid the use of excessive errors in positioning. Through GPS measurements and the application of the RAIM, the current study illustrates the performance of the proposed fault detection algorithm (MHSS FD) [6]. It is often only necessary to consider a single fault in the Receiver Autonomous Integrity Monitoring (RAIM) procedure, so it would be ideal if a fault could be correctly identified [7]. Compared with RAIM, ARAIM must consider more types of threats to meet the higher requirements [8]. Therefore, the fault detection must be more accurate.

The main method of fault detection focuses on the pseudorange domain and positioning domain [9, 10]. The Working Group C ARAIM Technical subgroup defined Multiple Hypothesis Solution Separation (MHSS) as the ARAIM baseline algorithm [11]. This baseline algorithm included the computation of the protection levels, the effective monitor threshold, the accuracy, and a preliminary description of an exclusion algorithm [12]. This article focuses on the effective monitoring threshold. In addition, the MHSS fault detection (FD) baseline detects faults by checking the consistency of the solutions from different subsets with the all-in-view set. The solution separation statistic is closely linked to the