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ORION GN&C FAULT MANAGEMENT SYSTEM VERIFICATION: IMPLEMENTATION OF SEQUENTIAL MONTE CARLO NUMERICAL TECHNIQUES

Abstract

In order to ensure long-term ability to meet mission goals and to provide for the safety of the public, ground personnel, and any crew members, nearly all spacecraft include a fault management system. For a manned vehicle such as NASA's Orion capsule, the safety of the crew is of paramount importance. The goal of the Orion guidance, navigation and control fault management system is to detect, isolate, and respond to faults before they can result in harm to the human crew or loss of the spacecraft. Verification of fault management capability is challenging due to the large number of possible faults in a complex spacecraft, the inherent unpredictability of faults, the complexity of interactions among the various spacecraft components, and the inability to easily quantify human reactions to failure scenarios.

Traditional approaches to fault management system verification include factor-of-safety analysis, failure modes and effects analysis, and Monte Carlo simulations. These approaches do not adequately investigate the failure space or provide high confidence that the fault management system meets all safety requirements. Consequently the Orion GNC fault detection, isolation and recovery team has implemented a sequential Monte Carlo technique introduced in a previous paper. This technique utilises search methods and genetic algorithms to target rare events (catastrophic failures) in the search space. By targeting these rare events the efficiency can be drastically improved compared to traditional Monte Carlo analysis, reducing the computation time by many orders of magnitude.

This paper presents the theoretical background, status of the system verification software, some idiosyncrasies and hurdles confronted during development, a brief discussion of results and a comparison to traditional methods.