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SPACE PROPULSION SYMPOSIUM (C4)
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Author: Mr. Xiaohui Peng
College of Aerospace and Materials Engineering, National University of Defense Technology, China, ppxh8410@163.com

Mr. Zheng Yan
College of Aerospace and Materials Engineering, National University of Defense Technology, China, jjwu@nudt.edu.cn
Dr. Jianjun Wu
National University of Defense Technology, China, jjwu@nudt.edu.cn

HYBRID DIAGNOSTICS FOR SPACECRAFT PROPULSION SYSTEM

Abstract

In the twenty first century, human beings are embarking on more ambitious space ventures including robotic exploration of deep space and human-robotic exploration of Mars and the moon. Safety is a major priority for all these efforts, for manned as well as unmanned missions. One key component for autonomous operation of such systems while ensuring safety is fault detection and isolation. For safety-critical systems such as Spacecraft Propulsion System, fast and efficient fault detection and isolation techniques are necessary in order to maintain a high degree of availability, reliability, and operational safety. These systems tend to be hybrid in nature (a mix of discrete and continuous dynamics) which arises from the switching nature of components either through commands (e.g. OPEN Valve) or autonomously (Fuse arising from high current), hence both the discrete mode and continuous state of the system need to be tracked. In addition the systems and any models of the system are stochastic due to operation in unknown operating environments, the presence of sensor and process noise, insufficient/inaccurate information about the functioning of the system, approximate models among others. As a result diagnosis algorithms for such systems also need to be stochastic in nature. Accordingly, when we consider stochastic hybrid systems, diagnosis algorithms need to track both the discrete mode and the continuous state of the system in the presence of noise. Bayesian belief update techniques such as particle filters may require many computational resources to get a good approximation of the true belief state. In this paper we propose a fault detection and isolation architecture for Spacecraft Propulsion System that combines look-ahead Rao-Blackwellized Particle Filters (RBPF) with HYDE diagnosis engine. In this approach RBPF is used to track the nominal behavior, a novel n-step prediction scheme is used for fault detection and HYDE is used to generate a set of candidates that are consistent with the discrepant observations which then continue to be tracked by the RBPF scheme.