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DESIGN AND VERIFICATION OF A ROCKET'S MIRRORING SYSTEM BASED ON DIGITAL TWIN TECHNOLOGY

Abstract

At present, some advanced launch vehicles, especially the manned ones, are equipped with fault detection and reconstruction functions on the rockets. However, due to the limitation of hardware resources, it is difficult to carry out complex operations during the flight mission. The detection is usually based on the simple threshold value, with insufficient diagnosis ability. On the other hand, taking the advantage of strong computing power and historical data, the control center on the ground can realize more complex and accurate calculation and prediction.

With the development of information technologies such as the internet of things, big data, and artificial intelligence (AI), the Digital Twin technology has received increasing attention these years. Using the data produced by all kinds of sensors on the rocket and transmitted to the ground though the telemetry system, it is possible to create a Digital Twin to synchronize the real-time rocket's state, expanding new capabilities by the means of virtual and real interaction, data fusion analysis and decision iterative optimization.

This paper introduces the overall architecture and concrete realization of a digital mirroring system of the rocket in the control center. The mirroring system mainly consists of a database, transceiver module, fault diagnosis module, trend prediction module and the 3D visual module. The transceiver module receives real-time data from rocket telemetry and then stores them in the database. The 3D visual module demonstrates the current flight attitude and internal state intuitively. When a fault occurs, the fusion of different algorithms based on data, model and rules in the fault diagnosis module can complete the detection faster and more accurately. The trend prediction module predicts the later trajectory and accelerates the simulation to verify reconstruction strategies. Designed in a general concept, the mirroring system can provide ground services for different launch vehicles during the flight mission by loading different dynamic models, 3D models and fault diagnosis models, serving as a strong support for a successful launch in the future.

A semi-physical simulation platform is built for the system, using a rotary table, IMU and equivalent units to simulate power system and electrical system of the rocket and send the data to the mirroring system. Different fault conditions were injected into the simulated flight, and the system's information flow, real-time visual display, fault diagnosis and prediction algorithms (especially those based on neural network) were preliminarily verified. This paper presents the test results and subsequent using plans.