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Abstract

There are several reasons why artificial intelligence (AI) is increasingly being used in space. AI is particularly well suited to control under undefined or unstable conditions and in environments that require a high degree of autonomy. In these situations, AI algorithms can be used to analyze and interpret data, make decisions, and adapt to changing conditions in real time.

Environmental conditions in deep space or on other planets present significant challenges due to the lack of data and the complexity of such conditions. In these conditions, main advantages of AI are the ability to learn from experience, improve performance over time and adapt to unforeseen conditions.

In addition, the delay in radio frequency (RF) propagation can make real-time control of space exploration systems impossible for human operators. To operate without constant human supervision, remote space systems like rovers and deep space explorers are being developed with autonomous capabilities that incorporate various AI functions.

When compared to traditional single satellite systems, constellation offer more competent mission solutions as of increased flexibility, redundancy, and better coverage. As a result, the number of satellites launched into space in the recent years is increasing rapidly. However, the deployment of mega-constellations, which can consist of thousands of simultaneous satellites, brings new challenges in terms of system autonomy and fault tolerant control. The dependence of a constellation on a ground operations center introduces vulnerabilities, as the simultaneous failure of multiple satellites can lead to a degradation of the constellation services. This highlights the importance of developing proactive autonomous systems and fault tolerance mechanisms that can maintain the full functionality of the constellations.

To prevent potential space systems failures, this work focuses on using ensemble machine learning techniques to predict potential faults in space systems.

The proposed solution, dubbed Fault Prediction Multi-Agent System (FPMAS), is a multi-agent architecture system designed for sub-threshold fault prediction.

Sections in this paper describe the features of FPMAS, including the prediction algorithms, agent interaction methods as well as the Matlab/Simulink behavioral models simulating a Satellite Attitude Control System (ACS).

The results of this study suggest that FPMAS could be a useful tool for predicting potential failures in space systems, potentially leading to increased reliability and availability in mega-constellations.