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VIRTUAL GROUND STATION FOR AUTOMATED SPACECRAFT OPERATIONS

Abstract

Recent commercialization of space has led to the widespread increase in LEO satellite deployment. Often LEO satellites are deployed in constellations to cover the entire Earth which places a tremendous burden on ground station operators. A virtual ground station capable of automating daily spacecraft monitoring could greatly reduce operation costs, minimize human error, accelerate troubleshooting and maximize data return. This work aims to bring together rule-based machine learning and system identification techniques with Statistical Process Control (SPC) for the first time to develop a virtual ground terminal. This modularization enables us to recover faster from software failures and ground station accessibility. A virtual satellite model (VSM) provides the interface between the human operator and the actual spacecraft. A modified version of the Turing test is applied for VSM testing to evaluate the extent to which human operators can detect the difference between the real spacecraft and the virtual one. The learning module develops and maintains grey-box models of the critical spacecraft systems, using a Gaussian process machine learning with an enhanced Particle Swarm Optimization (PSO) algorithm based on the Bayesian theory. The SPC module implements industry-standard SPC algorithms to monitor various spacecraft systems for anomalous behavior as evidenced by abnormal patterns in the data. This paper demonstrates how the virtual ground station could benefit the space industry for future constellation missions.