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A STUDY ON AI-BASED SYSTEM ANOMALY DETECTION AND MONITORING METHOD USING KOREA PATHFINDER LUNAR ORBITER (KPLO) OPERATION DATA

Abstract

The existing signal monitoring methods of satellites and space exploration devices have limitations in that it is difficult to make complex judgments in real time by monitoring individual and instantaneous telemetry signals, and that problems below those values cannot be properly identified because the critical points (CP) are set. AI-based system anomaly detection and prediction models were studied to supplement these and use them as useful decision-making aids for developers and operators. The data set secured through the development and operation of the Korea Pathfinder Lunar Orbiter (Danuri) was utilized. The learning model used semi-supervised and unsupervised methods in consideration of the data labeling status before (using simulator generation data) and after (using telemetry data transmitted in actual operation) Danuri launch and implemented as a complex deep neural network. Since the simulation data before Danuri launch is in a state where labeling (normal and abnormal states) exists, but the data imbalance in which normal data exists relatively large, the method of measuring the reconstruction error based on the generative model (VAE and GANomaly) was used. Telemetry data after Danuri launch can be processed as unsupervised learning as unlabeled data because it is difficult to distinguish between labeling (normal and abnormal conditions). Therefore, a Transformer-based anomaly detection technique was selected to learn the correlation between multivariate time series sensor-based data. As a result, a semi-supervised and unsupervised learning-based AI anomaly detection model with accuracy of more than 98% was developed through the analysis and utilization of Danuri (attitude control system) operation data. To verify the learning model using actual operation data, this result was compared and verified by using a total of four training datasets (simulation data generated by reflecting scenarios such as actual operation data, mixing actual and simulation data, and including only temporary failure conditions among simulator data). This study can improve the reliability of the system's anomaly detection and monitoring by enabling a comprehensive determination of abnormalities by combining various types of physical parameters away from individual data monitoring methods. It can also be used to minimize the analysis efforts of the satellite expert group and to provide data that are advantageous for real-time judgment and prediction.