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Space Structures I - Development and Verification (Space Vehicles and Components) (1)

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STRUCTURAL FAILURE DETECTION IN VIBRATION TESTING USING MACHINE LEARNING AND DEEP LEARNING

Abstract

Early satellite structural failure detection is of great importance in the development of satellites, especially during vibration testing. The launch environment can be extensively harsh and can lead to satellite failure during launch hence adequate testing is of paramount importance to improve the survivability of the satellite. Satellite vibration testing is one of the most reliable tests in satellite development to verify the workmanship, structure design, and making the fracture control plan. Currently, vibration testing involves a series of modal surveys, random vibration, sine-burst, etc. This is done for each axis, which in turn is time-consuming, tedious, and above all, slow in detecting failure, causing major damage to the satellite, resulting in huge costs and project time delay. The quest for space technologies has seen an abrupt increase in the launching of constellations and constellation missions have significantly increased over the past years. The fast achievement of constellation development is heavily impeded by the long testing time for vibration and huge data analysis. The need for a minimized vibration testing time and quick methods of determination of failure from the acquired sensor data can make a huge impact on the satellite development process. Data science has created many gateways to solve engineering problems for automated systems using machine learning and deep learning. This paper outlines how to detect a structural failure through the examination of vibration data using machine learning and deep learning techniques. The research uses 3 axis normal and abnormal vibration data collected by orthogonally mounted accelerometers on the Horyu satellite. Condition features are extracted from the raw measurements corresponding to normal and faulty operation using the Diagnostic Feature Designer App (MATLAB) and are ranked with their probability. Features extracted are used to train 3 models that include One-class Support Vector Machines (SVM), Isolation Forest, and Long Short-Term Memory Autoencoder Network. Then use each trained model to identify if structural integrity is maintained within an allowable threshold of 5