AI Impact & Autonomy on Space Exploration (14)
AI Impact & Autonomy on Space Exploration - IP Session (IP)

Author: Mrs. Chippy V
ISRO Propulsion Complex, Mahendragiri, India, India

Mr. Piyush Sonkar
ISRO Propulsion Complex, Mahendragiri, India, India

APPLICATION OF MACHINE LEARNING FOR REAL-TIME FAULT DETECTION AND PREDICTIVE MAINTENANCE DURING STRUCTURAL TESTING OF CRYOGENIC LAUNCH VEHICLE HARDWARES

Abstract

This study aims to develop a Machine Learning (ML)-based system for real-time fault detection and predictive maintenance to assess and ensure the structural integrity of launch vehicle hardware, leveraging Acoustic Emission (AE) data from a series of structural tests on LVM3 propellant tank. By analyzing AE data collected from critical control locations on the tank, this approach uses ML algorithms to predict potential structural faults and enable proactive maintenance. Data preprocessing and feature engineering are employed to extract key features from high-resolution acoustic signals, such as event frequency, energy, and amplitude, which serve as indicators of material response under load and highlight early signs of degradation. Anomaly detection models, including Isolation Forest and Auto-encoders, are utilized to monitor real-time deviations from baseline acoustic profiles, while Long Short-Term Memory (LSTM) networks provide predictive insights based on patterns of historical fatigue and damage. Integrated within a real-time data pipeline, this system operates with data acquisition and PLC frameworks, triggering alerts or mitigation actions upon anomaly detection. Initial results indicate that ML algorithms applied to LVM3 tank test data enhance fault detection and maintenance scheduling, promoting structural reliability and operational efficiency in aerospace testing.