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CLASSIFICATION OF SOLAR EVENTS USING MACHINE LEARNING AND SATELLITE ACCELEROMETERS

Abstract

Space weather phenomena is known to cause significant and adverse effects to satellite electronics and communication systems. However, the effect of such events on the attitude dynamics of the spacecrafts and the space environment should also be considered, as it can impact mission lifetime and success. Atmospheric density increases due to solar eruptive events can cause orbit degradation to the semi-major axis of satellites in low-earth orbit on the order of tens of meters from a single event. Such decay, without the use of in-orbit attitude adjustments, could result in collisions between other spacecraft, and can be detrimental to scientific mission success where high-resolution data measurements are required. Current techniques of identifying solar flares and coronal mass ejections are accomplished using instruments designed specifically for imaging or radiation measurements, and do not provide satellite operator-specific details as to their impacts. This paper proposes a new, low-computational method of classifying solar events, utilizing machine learning, and pre-existing satellite instrumentation. This method is designed to use satellite accelerometers to identify when a solar event has occurred and the relative strength of the event. By using what was physically felt by the spacecraft, satellite operators can prepare for in-orbit attitude adjustments accordingly. Using data from the Gravity Recovery and Climate Experiment (GRACE) twin satellites, and the Challenging Minisatellite Payload (CHAMP) satellite, neural networks are trained and tested on both the atmospheric density datasets derived from the onboard accelerometers of the spacecraft, and the raw accelerometer data itself. The versatility of this algorithm is tested and verified by training using the GRACE-A dataset and testing on the GRACE-B and CHAMP datasets. Future use of this algorithm on CubeSats can provide both a low-cost monitoring and collision mitigation strategy for satellite operators as well as insight into atmospheric density changes from solar events at varying altitudes.