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MONITORING AND EARLY DETECTION OF WILDFIRES USING MULTIPLE-PAYLOAD FRACTIONATED SPACECRAFT

Abstract

The paper discusses the deployment of multiple-payload fractionated spacecraft as a surveillance system for monitoring and detecting wildfires in their early stages. The fractionated system, consisting of twelve operational CubeSats, four reserved CubeSats, and one mothership, acquires images in 13 spectral bands within the visible, near-infrared, and short-wave infrared regions with high spatial resolutions. The system, consequently, is capable of providing the essential information for detecting prospective wildfire spots in any area on the Earth's surface. Unlike a monolithic Earth observation satellite, the physical separation of the camera payloads onboard the CubeSats, would enable the fractionated system to surveil a vast area simultaneously. Further, the multiplicity of observation agents as well as the diversity of their points of view and spectral bands would allow for the development of a robust algorithm, executed onboard the mothership, to fuse and process the raw images received from the CubeSats, in order to detect the potential wildfire spots. As a result, the system can operate fully autonomously for monitoring and early detection of wildfires. After giving a brief overview of the fractionated system, a dynamic fire-hazard index is introduced, based on geographic coordinates, environmental parameters, and weather conditions, to prioritize the areas for the probability of wildfires. Then, a convolutional neural network is designed for identifying the potentially hazardous areas as well as detecting the early stages of wildfire spots. The prediction (and detection) method is based on the processed images and geographic locations as well as measurements of thermal anomalies, smoke, and unusual variations of regional atmospheric conditions. The effectiveness of the surveillance system is examined through several case studies using numerical simulations.