FIRESAT: A Demonstrator Application for the SwRI Pleaides Development Program

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Abstract

Over the past 30 years, the total area destroyed by wildfires has increased roughly by a factor of three to four. Over the same period, the number of wildfires has declined from a record high number of 96,385 in 2006 to 58,985 in 2021. This implies that wildfires now are more likely to spread at a faster rate and, therefore, cause more damage and take more resources and time to be extinguished than before.

To minimize the risk of escalation of a fast-growing wildfire, it is not only essential to quickly detect the fire but also to make an early assessment of how fast the fire perimeter is expanding. Infrared (IR) images collected by instruments on NASA earth observing satellites are very useful in tracking the movement of a wildfire's perimeter for a week or longer. However, these images are not useful for early wildfire detection and growth assessment because of the coarse resolution (>375 m), low acquisition frequency (every 12 h) and processing delay (2.5 h).

To address the limitations of using IR satellite data for detection and real-time mapping of wildfires and to reduce the cost and increase the efficiency of using this technology on the fireground, we plan to propose the following approach to NASA: (1) build an inexpensive imaging system that is optimized for detection and real-time mapping of wildfires, (2) develop and train machine learning data analysis tools for rapid on-board image analysis, and (3) deploy the system on a constellation of small satellites to increase the frequency and resolution of the images.

Leverage

Our concept leverages the Pleiades multi-mission design, developed as a SwRI internal research and development program and demonstrated on a NASA suborbital platform. Pleiades uses mass-produced, flexible small co-registered space-based telescopes to provide broadband visible/infrared (VIS/IR) spectral coverage at low size, weight, power, and cost (SWAP-C). The instrument configurations can be rapidly mass-produced and optimized for targeted applications. This approach becomes a disruptive game changer when implemented across many SmallSats in a cross-communicating constellation.

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Additionally, the work herein is the third phase in a long-term plan to develop FireSat, a space-based facility for rapid fire detection, tracking, and predictive forecasting. FireSat would provide a complete solution of space-based sensors tailored for fire management needs fused into a single battle management network. This solution would include a network of affordable microsatellites tailored for fire management data collection needs that includes low latency accessibility (crucial for the dynamic environment fire fighters experience), leveraging existing space, air, and ground sensors, and the processing of data with AI/ML to find trends that are not readily discernable by a human interface. This type of system would provide frequent coverage in high-resolution with infrared sensors conducive for wildfire monitoring, fusion of all data into a multi- dimensional geospatial platform that uses AI/ML for wildfire modeling, and initial analysis onboard the satellite allowing a direct downlink to mobile fire units in remote areas.

Conclusions

The demonstration of a low SWAP-C sensor system capable of rapidly and affordably detecting fires will provide a new capability that will lead to future funding opportunities for implementing the system across many small satellites in a cross-communicating configuration. This will have the potential of saving civilian and firefighter lives, preventing injuries and human suffering, and reducing wildfire cost by billions of dollars.