Abstract ID 55

DECENTRALIZED INTELLIGENT SENSOR NETWORKS FOR WILDFIRE DETECTION AND MONITORING SYSTEMS

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Keywords: intelligent systems, aerial robotics, sensor networks, wildfires

Abstract

Due to climate change, meteorological conditions of high propensity for ignitions are more frequent, leading to an increasing number of wildfire events and extended fire seasons in several regions across the globe. These phenomena are strongly tied to complex Earth systems dynamics that develop through land and air interactions. The interplay between these elements develops in consequence of recurrent ecosystem cycles that involve vegetation growth and meteorological conditions. However, since most wildfire events have anthropogenic origins, the burnt area and fire intensity registered currently is not natural. Wildfires inherently have a high degree of spatiotemporal uncertainty, often preventing a prompt emergency response action. Conversely, with the escalation in severity of these events, there is an increased urgency in diminishing the response time for emergency teams. Hence, real-time fire detection and monitoring systems are crucial to identify and follow-up fire ignitions in an early stage.

To address this issue, this project proposes an integrated system based on satellite and sensor networks data to assist in early detection and monitoring of fire events. The system combines static sensors on the ground and dynamic sensors onboard mobile aerial platforms e.g. drones and high-altitude balloons (HABs), that can be deployed to monitor areas of high risk, based on satellite data. The decentralized, multimodal and dynamic nature of the system proposed enables its deployment in target regions in specific time-windows where there are forecasts of increased fire risk. The three-layer system comprises network, perception and inference modules. The first layer corresponds to a decentralized sensor network to be deployed in wildland and wildland-urban interface regions, that can relay real-time data relative to regions of interest. The second layer addresses the estimation and data aggregation, yielding environment perception states. The final layer employs intelligent soft-sensor approaches, identifying specific areas in the monitored region with higher risk. Leveraging HABs as high-altitude pseudo-satellites in near-space enables monitoring large- scale events and areas where fighter aircraft do not operate. In this way, this dynamic network can provide real-time Earth Observation data to decision-makers allowing its integration in existing decision support systems to generate early-warnings and optimize resource allocation.

Real-time early fire detection systems can help to avoid the occurrence of large burnt areas and the emission of greenhouse gases, while preventing the loss of natural ecosystems responsible for climate regulation through carbon sequestration. The integration, at different timescales, of data-driven intelligent systems in decision support systems for firefighting and civil protection can contribute to mitigate the social, cultural, environmental and economic effects associated with wildfires, contributing to the United Nations Sustainable Development Goals.