Autonomous Disturbance Detection and Monitoring System for UAVSAR

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We will develop an autonomous disturbance detection and monitoring system for imaging radar that combines the unique capabilities of imaging radar with high throughput onboard processing technology and onboard automated response capability based on specific science algorithms. We plan to demonstrate this capability with two sensor web concepts, the forest fire sensor web and the hurricane damage sensor web.

Scenario 1: Forest Fire Sensor Web

Figure 1 shows the detection and response architecture of a forest fire sensor web. Major ecosystems of the world (boreal and tropical forests, shrub-lands, grasslands, and savannas) experience recurrent fires as a result of natural causes or human activities.

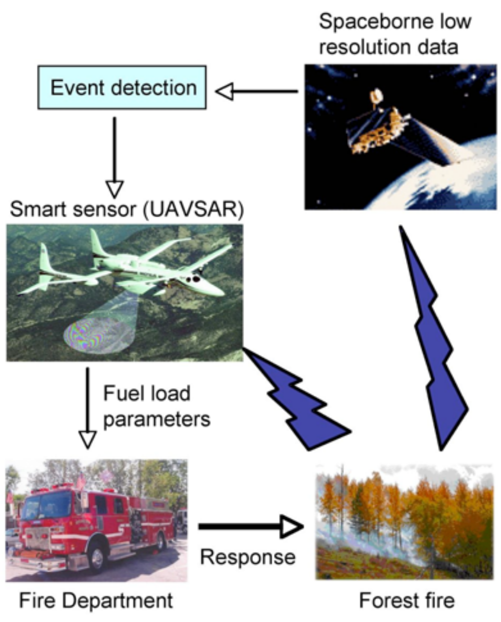

Figure 1. The detection and response architecture of a forest fire sensor web. Based on fire detection from a spaceborne observation, the smart sensor will plan new data acquisition, acquire high resolution radar data, perform onboard processing, and downlink high spatial resolution maps and fuel load parameters to the Fire Department for real-time fire management.

Understanding fire behavior characteristics and planning for fire management require maps showing the distribution of wildfire fuel loads at medium to fine spatial resolution across large landscapes. In most wildfire simulation models such as FARSITE [1], variables such as the canopy height, biomass, and moisture content are important input data layers. Current techniques to assess fire spread and damage all require these variables [2]. *Radar sensors from airborne or spaceborne platforms have the potential of providing real-time quantitative information about the forest structure and biomass components that can be readily translated to meaningful fuel loads for fire management*

[3]. Radar interferometric measurements of forest canopy height and the polarimetric data for estimating the canopy biomass and moisture are two important elements that will be explored in the forest fire scenario for intelligent onboard processing. By integrating calibrated and tested algorithms, *the processor will provide high spatial resolution maps and quantitative information for rapid response forest fire applications*.

Scenario 2: Hurricane Damage Sensor Web

Figure 2 shows the architecture of a hurricane damage rapid response sensor web. Historically, tropical storms and hurricanes have been important disturbance forces contributing to the dynamics, structure, and function of the forest ecosystems. In addition to their devastating impact of coastal properties and human life, the sustained wind speed and wind gusts of hurricane landfalls can cause intensive forest destruction in many coastal regions extending inland hundreds of kilometers. Rapid damage assessment of damaged forest land will allow us to harvest the downed trees before they decay and become unusable. Results from a study shows that a single storm can convert an equivalent of 10% of the total annual carbon sequestered by U.S. forests into dead and downed biomass [4]. There is currently no remote sensing approach to estimate the hurricane damage on the U.S. (potentially global) forests. The exceptional capability of radar remote sensing for providing timely data regardless of atmospheric conditions and the sensitivity to forest structure and moisture, makes them the most relevant techniques to monitor and assess the hurricane-induced disturbance. *We will integrate disturbance detection and forest damage assessment techniques from interferometric and polarimetric SAR data in the UAVSAR onboard processing to provide spatially refined and quantitative information for the hurricane damage scenario*.

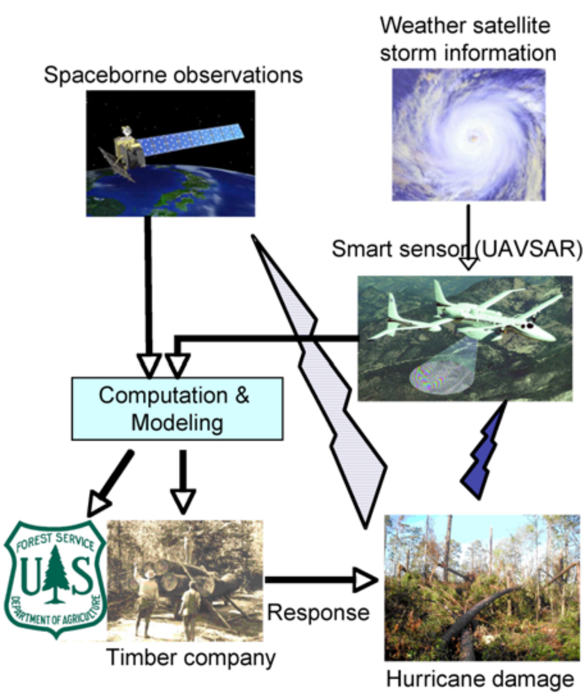

Figure 2. The architecture of a hurricane damage rapid response sensor web. The smart sensor will plan new data acquisition, acquire high resolution radar data, perform onboard science data processing, and downlink spatially refined and quantitative information to a ground-based facility for post-processing and data distribution so that downed trees can be harvested before they decay and become unusable.

With the limitations of existing Earth observing sensors to provide timely information on these man-made and natural hazards, the development and testing of this autonomous monitoring technology for UAVSAR contributes significantly to our ability to manage responses and assess these disturbances for various applications for future spaceborne missions.

References

[1] Finney, M.A., "FARSITE: Fire area simulator – model development and evaluation," Research Paper RMRS-RP-4, Ogden, UT: USDA Forest Service Rocky Mountain Research Station, 1998.

[2] Scott J.H., and E.D. Reinhardt, "Assessing crown fire potential by linking models of surface and crown fire behavior," Research Paper RMRS-RP-29, Fort Collins, CO: USDA Forest Service Rocky Mountain Research Station, 2001.

[3] Anderson, H.-E., et al., "Estimating canopy fuel parameters in a Pacific Northwest conifer forest using multi-temporal polarimetric IFSAR," Proceeding of ISPRS Commission III, WG III/3, Istanbul, Turkey, 2004.

[4] Mcnulty, S.G., "Hurricane impacts on U.S. forest carbon sequestration," Environmental Pollution 116, pp 17-24, 2002.