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Using Space, Air, Marine, and Ground Assets for Disaster Response and Environmental Monitoring

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Abstract

Space, Air, In-situ, and Marine assets have been integrated into sensorwebs to enable detection, tracking, and response to a wide range of terrestrial phenomena. These techniques have been used to track flooding, cryosphere, volcanism, oceanographic events, and many other events of humanitarian, scientific, and environmental importance.

We describe how sensorwebs have been deployed to monitor numerous phenomena to great impact and how artificial intelligence techniques such as machine learning, automated planning, and automated data analysis are being leveraged to enable these sensorwebs.

Introduction

Space-based sensorweb activities [Chien et al. 2005] have been ongoing focusing on the use of the Earth Observing One spacecraft over the period 2003-2013 and are ongoing. In this time period the work has grown to include other space assets, aerial platforms, marine platforms, and in-situ platforms. In my talk I will survey this work focusing on applications where artificial intelligence techniques can have significant impact.

Automated planning & scheduling for space assets is a central theme. Most of the efforts described here are enabled by the automated tasking capability of the Earth Observing One mission [Chien et al. 2000, Chien et al. 2005, Chien et al. 2010]. However, machine learning and other automated classification methods are key in event detection and data analysis.

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Wildfire Sensorweb

Sensorweb approaches have use space-based remote sensing assets to assist in wildfire management [Chien et al. 2005]. Early work was in collaboration with the United States Forestry Service [Mandl et al, 2008] and later included collaboration with NASA Ames using and Ikhana UAS. Space-based assets have also been used to track wildfires in Thailand [Chien et al. 2011].

Flooding Sensorweb

Sensorweb approaches have been applied primarily using space-based remote sensing techniques to Thailand [Chien et al. 2011, 2012, 2013]. This flooding application has also leveraged the use of high-resolution commercial products [Mclaren et al. 2012, Chien et al. 2012]. Sensorweb techniques have also been used in flood monitoring in Namibia [Alleyne et al. 2012, Mandl et al. 2012] as part of CEOS.

Volcano Sensorweb

Sensorweb approaches have been used to direct space assets and also to automatically trigger derivation of analysis products [Chien et al. 2005, Davies et al. 2006, Chien et al. 2011]. These techniques have enabled unique studies of terrestrial volcanoes such as Mount Erebus [Davies et al. 2008] and Eyjafjallajokull [Davies et al. 2013]. Space assets have also been integrated with in-situ assets at numerous volcanoes including in Antarctica, Iceland [Chien et al. 2011], Mount Saint Helens [Huang et

al. 2010], Ecuador, and Mt Etna. High-resolution commercial imagery has enabled estimation of ash plume height to provide a unique product from space-based imagery [Mclaren et al. 2012].

Marine Sensorweb

Marine assets have been integrated into a sensorweb as part of the Ocean Observatories Initiative [Schofield et al. 2010, Wang et al. 2012, Dahl et al. 2011, Thompson et al. 2010]. In related work the Monterey Bay Aquarium Research Institute has deployed considerable single and multi-asset autonomy for oceanographic exploration [McGann et al. 2008, Das et al., 2010, 2011].

UAVSAR Sensorweb

The JPL/NASA Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) [UAVSAR] has also been integrated with onboard processing [Doubleday et al. 2011a,b] and restasking to participate in an Earth Observing Sensorweb [Lou et al. 2011]. This effort has been demonstrated in several deployments culminating in flights using a surface feature detection re-tasking the UAVSAR aircraft.

Extra-terrestrial Sensorweb

There are many applications of sensorweb technologies to extra-terrestrial settings. However, there are relatively few settings in which there are enough assets to warrant the approach. At Mars, concepts have been developed that would leverage detection and response techniques of the MER rovers such as WATCH [Castano et al. 2008] and AEGIS [Estlin et al. 2012] and proposed Mars Odyssey capabilities [Castano et al. 2007].

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