Onboard Radar Processor Development for Disaster Response

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1. Introduction

Natural hazards often result in significant loss of human lives, economic assets and productivity as well as significant damage to the ecosystem. Scientists have reported more frequent and intense natural disasters in recent years, which may well be attributed to climate change. Many of the disaster response efforts were hampered by lack of up-to-date knowledge of the state of the affected areas because damaged infrastructure rendered the areas inaccessible. Radar remote sensing is playing an increasingly critical role in providing timely information to disaster response agencies due to the increasing fidelity and availability of geospatial information products.

The unique capabilities of imaging radar to penetrate cloud cover and collect data in darkness over large areas at high resolution makes it a key information provider for the management and mitigation of natural and human-induced disasters such as earthquakes, volcanoes, landslides, floods, wildfires, and oil spills. These hazards occur over periods of hours to days, and need to be sampled quickly. The data latency and, in some cases, spatial resolution are issues to be addressed in order for radar data to be of use to the disaster responders. Researchers have demonstrated the use of fully polarimetric data to monitor flood extent [1], to determine forest fire extent, and to discern changes in backscattering mechanisms (volume scattering, surface scattering, and double-bounce return) due to volcano eruption, landslide, and flooding [2]. Recent proof-of-concept studies with UAVSAR have demonstrated the ability to detect levee breaches [3], decorrelation attributed to earthquake damage, glacier freezing/thawing, and forest fire extent with repeat-pass observations separated by a few hours to a few days. Given the high raw data rate, the challenge is to generate these low latency products and deliver the perishable information to disaster responders in time to be of use.

2. High Fidelity Onboard SAR Processor

We have developed a high fidelity onboard SAR processor for UAVSAR, NASA's airborne SAR test-bed, that will enable us to generate selectable resolution polarimetric SAR imagery suitable for rapid response of natural disasters. This onboard processor is phase preserving and currently generates fully focused, geolocated SAR images in near real time. Fig. 1 shows the onboard processor system architecture. The dual-channel processor design allows us to simultaneously process HH (horizontal transmit and horizontal receive) and VV (vertical transmit and vertical receive) polarization channels or HH and HV polarization channels to generate polarimetric data products suitable for rapid response applications such as flood extent or fire extent determination. Alternately, the dual channel SAR processor can be used for repeat pass interferometry to process data from current and previous flight tracks for coherent change detection [4]. The onboard radar processor adopts a hybrid hardware-software architecture that leverages the flexibility of software running on microprocessors with the speed of Field Programmable Gate Arrays (FPGAs) to produce a fast architecture that can accommodate a wide variety of products and be quickly and easily tailored to a specific disaster application at hand. We developed a bit-true Matlab model of the SAR image formation algorithm that includes motion compensation to ensure a high level of gain and phase fidelity in the FPGA processor implementation necessary for science product generation.

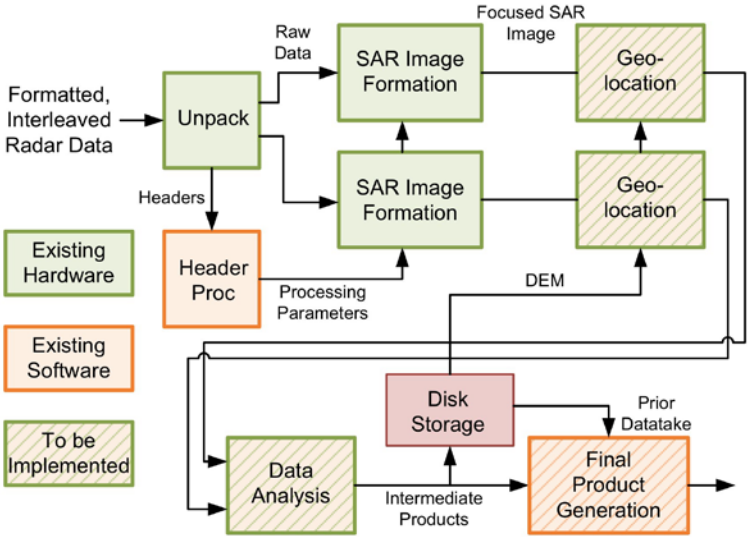

Figure 1: Disaster response onboard radar processor system architecture.

3. Examples of Disaster Monitoring Products

We are studying the potential of utilizing UAVSAR's L-band polarimetric data to generate forest burn maps over recent fires in the San Gabriel Mountain Range near Los Angeles, California. Another promising rapid response product is oil spill monitoring in coastal waters. We will present results based on UAVSAR observations of the coastal waters during the Deep Horizon oil spill in the Gulf of Mexico in spring 2011 [5]. We will present our study approach and initial results in the paper.

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References

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