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## Lessons Learned from Remote Sensing Activities in Recent Natural Disasters

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## Foreword

# Lessons Learned from Remote Sensing Activities in Recent Natural Disasters

Remote sensing technology has been playing an increasingly important role in rapid response to natural disasters. Recent examples for which the author has been directly involved include the floods in the States of Indiana (June 2008 and March 2009) and Georgia (October 2009), and the devastating earthquake in Haiti (January 12, 2010).

Satellite images, as well as aerial data, if needed, are often collected, geo-referenced and distributed in a timely manner during the first days or weeks of the disasters. The response is from local, regional to global. In many of the severe instances, the International Charter – Space and Major Disasters can provide various satellite images. They include optical images of IKONOS, GeoEye, QuickBird, WorldView, SPOT, ALOS PRISM. Also often made available are synthetic aperture radar (SAR) images, including Envisat, Radarsat-2, ALOS PALSAR, TerraSAR, and UAVSAR. In some instances, such as the Haiti earthquake, high resolution commercial images were also made accessible to the general public. Although it is not very typical, the Haiti earthquake has brought attention from government agencies, humanitarian organizations, as well as industry. Google, Microsoft, NASA, NOAA and The World Bank have collected their own aerial photographs, varying from true color, near infrared, thermal infrared, to microwave. Some flights even attempted to cover the entire country. Additionally, airborne LiDAR data were also collected over areas of interest in Haiti.

The collected remote sensing data are then processed to produce different value-added products for end users. Traditional and popular products are geometrically corrected or ortho corrected images and digital terrain models (DTM), generated from either stereo images or LiDAR point clouds. More intelligent and event-specific informative products may include flood extent, water depth or inundation. Such data are also often used together with the USGS gauge data along the flooded rivers and coasts. In the event of earthquake, images and DTM are useful for landslide detection, quake lake assessment, road barrier removal, and rubble cleaning. Moreover, high resolution images, both from air and space, are used to identify building damage and to deploy crews to the field. Together with relevant geospatial data layers, we are able to estimate the damage to crops, roads, and other geographic features of interest. It should also be noted that such information is very useful for future planning and rebuilding efforts.

Despite the fact that remote sensing is being used as a capable technology in rapid disaster response, there are recognized limitations that somehow hinder its applications. First of all, images distributed by the vendors or charter organizations as a rapid, first response are often not geo-referenced to the best possible accuracy.

As a result of this, images collected at different times or from different sensors are often mis-registered. Such mis-registration sometimes can be as large as a few hundred meters. This means geo-referencing is often the first step for data processors. This may not be affordable due to required rapid response and lack of accurate ground control and DTM. Consequently, poor geo-registration or co-registration makes it hard to perform reliable change detection or damage assessment. It is expected that high resolution images be geo-referenced to an accuracy of ~2 pixels at their initial release, which is unfortunately still a challenge. On the other hand, independent control, either from public resources (such as Google) or an existing repository of images, GIS layers and DTM can be used as a useful control source for further refinement.

The transmission and query of a large amount of images add a lot of unnecessary overhead to rapid response. Due to high resolution and large coverage of scenes, some high resolution images can each be as big as 2GB. The transmission from the data server to project manager, to value-added processor, and finally to the end-user can be unbearable. Sometimes intermediate results and final results must be transmitted and distributed to a broader user community. Substantial effort must be made to reach highly effective data transmission and reduce the travel of data as much as possible. As for image query, an image catalog with coverage footprint, fast view, and cloud coverage index (e.g. the USGS Global Visualization Viewer) would be very helpful for data processors to choose the images of interest. Some enhancement might be needed towards this goal.

Another difficult issue to deal with is cloud cover. During the floods in Indiana (2008, 2009) and in Georgia (2009), it turned out that a substantial period of time (up to two weeks) was largely covered by heavy cloud. A large percentage of images could not be used for valuable analysis or interpretation due to cloud cover. Under this situation, radar images were valuable alternatives for disaster situation awareness. The aforementioned radar images have been used in the recent flood mapping activities and Haiti earthquake relief. However, it should be noted that our capability to process and interpret radar images is still quite limited as compared to optical data processing. Proven processing methods and routines should be established and followed in the future. Trained specialists in radar image processing are also in demand in such extreme events.

Our capability in image processing is far behind the capability in image acquisition. Tens of satellite images for the floods, and hundreds of satellite images and tens of thousands of aerial images for the Haiti earthquake were collected during a period of days or weeks. However, their automated processing was largely limited to geometric or ortho correction and DTM generation, all of which have been a routine procedure from data providers. On the contrary, the thematic information obtained through an automated process is often subject to visual evaluation and sometimes manual correction to ensure the quality. This is especially true when working on cities with complex features and using high resolution images. Therefore, the demand on operator's skills and experience is high. We urge that cutting-

edge research work and high-end commercial tools be introduced into this highly challenging and influential application. Finally, it should be pointed out that over probably 90% of the collected data are often not analyzed and frequently their content is redundant. These images remain to be a visual “product” for most of the time. Data collection efforts are uncoordinated among the data vendors. It is highly desired that vendors and even the same vendor can reach a mode of selective data collection during the disaster.

Computation resources may not be a concern except in such time-critical applications. As pointed out above, images of terabytes need to be archived and transmitted possibly for even one project. Besides, the computation time needed for one image can be unbearable due to the combination of segmentation, classification and vectorization. On top of that, 3D building model generation also needs tens of hours of computation for a city area of over 50,000 buildings. The involved academic institutions, like Purdue, must have upgraded resources, both in software and hardware, in order to continue to serve the citizens and the community, as has been proven in the recent events. Centralized resource and staff are also needed to provide such service on a routine basis.

Finally, there is certain disconnection between product producers and end users. Besides traditional data products, such as DTM and orthoimages, advanced product producers are capable to provide more diverse products, such as flood extent, crop and road damages, land cover, 3D building models, coastal lines, rubble extent and distribution, and many others. However, this capability may not be very well recognized by the end users. Product producers may not fully understand or be aware of the needs and specifications of the end users, either. Effective communication and discussion forums among the involved parties would help in this regard.

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