[Article] Mobile mapping for disaster relief

Mobile Mapping for Disaster Relief

David Alvarez, Piero Boccardo, Maria Antonia Brovelli, Fabio Giulio Tonolo, and Marguerite Madden

As we write the foreword to this special issue, "Mobile Mapping for Disaster Relief", on 15 May 2013, Tropical Cyclone Mahasen is traveling northeast in the Bay of Bengal toward the coasts of India, Bangladesh and Myanmar, a low area inhabited by over 8 million people. With rivers high and the ground already saturated from two weeks of steady rains, evacuation in Rakhine state (Myanmar) is complicated by the 150,000 living in temporary housing of a camp of Internally Displaced Peoples (IDP). Verification and recognition of displaced individuals is fundamental to ensure those in need receive timely assistance. Restriction of access and freedom of movement of IDPs and non-IDPs is affecting livelihood, access to basic services, and health and education, in particular. Many refugees have refused to leave their temporary shelters after fleeing from their homes due to political conflict. As yet another natural disaster unfolds before us, government agencies, non-profit organizations, and private companies around the world are combining their efforts to mobilize disaster relief operations.

A critical component of disaster relief is geospatial data acquisition, processing, and exploitation. In the United States, government agencies performing these functions include the Federal Emergency Management Agency (FEMA), the United States Agency for International Development (USAID), U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administrative (NOAA), the National Aeronautics and Space Administration (NASA) and the National Geospatial-Intelligence Agency (NGA). By prior agreement, global commercial satellite companies and coalitions of government satellite programs pool their data acquisition resources and target their sensors on the projected disaster area. A great deal of the imagery and other available geospatial data for this area are served via the web and are freely (only the derivate products are disseminated to the public) distributed for immediate humanitarian assistance. Whether it is for devastating tsunamis in Southeast Asia (2004) and Japan (2011); earthquakes in Pakistan (2005), Haiti (2010) and China (2008); hurricanes (e.g., Katrina in 2005), super storms (Sandy in 2012) and tornadoes in the United States (2005 and 2011, especially); oil spills in the Gulf of Mexico (2012) or tropical cyclones such as Mahasen in Asia today, relief workers rely on current airborne and satellite imagery, as well as other geospatial data, to inform decisions on evacuation, rescues, medical assistance, supply distribution and public safety. Archived imagery and lidar data, when available, provide critical before-disaster conditions to assess damage.

In addition to rapid access to imagery and vector data (schools, hospitals, roads, etc.), open source websites following the Ushahidi model (www.ushahidi.com) are critical to disaster response. They provide a central location for disaster victims to communicate with each other and with those outside the disaster zone through SMS messages. These messages relay status to loved ones, request life-saving assistance, and provide map relief to distribution and evacuation centers. Other online systems, such as OpenStreetMap (http://www.openstreetmap.org) and Tomnod (http://tomnod.com), allow volunteers to provide assistance via crowdsourcing to update, correct, and complete reference geospatial data (e.g., transportation networks) and/or to assess the damages caused by the disaster. Advances in disaster relief in recent years have included porting mapping tools, emergency notification, and image display to mobile devices. Increasingly, SMS texts and geotagged photos acquired and transmitted by cell phones are a primary means of communication during and immediately following disasters.

This special issue focuses on methods and technologies developed by researchers, practitioners, and decision makers around the world for enabling and using mobile disaster response. It is especially interesting to note the international distribution of authors who submitted articles to this issue. Case studies from Finland to China are used to demonstrate the growing importance of mobile mapping and location based services used on personal devices. Experience also has shown the critical need for standards and open protocols such those developed by the consensus process of the Open Geospatial Consortium (OGC) for interoperable geospatial solutions (http://www.opengeospatial.org/). Such standards enable the development of apps that can be used when clients are connected to the internet or when operating in disconnected modes with resident software and previously downloaded geospatial data.

Shanley, Burns, and Bastian of the Commons Lab of Science and Technology Innovation Program of the Woodrow Wilson International Center for Scholars in Washington, D.C., and Robson, an attorney with Robson & Robson, LLC in Conshohocken, Pennsylvania are the authors of the Highlight Article that launches this special issue with a discussion of social, legal, and policy challenges facing users of emerging technologies in times of crisis. Appropriately entitled, "Tweeting Up a Storm: The Promise and Perils of Crisis Mapping", this remarkable article reminds responders, volunteers, and the public of legal and ethical responsibilities that accompany the use of new technologies such as crowdsourcing, collaborative mapping, and geolocated social networking during disasters. The author team, consisting of decision makers, researchers, and lawyers, are uniquely positioned to address thorny issues of data uncertainty, privacy, security, intellectual property, accessibility, and liability associated with geospatial technologies for crisis response.

"Geospatial Web Services for Responding to Ecological Risks Posed by Oil Spills" by Finnish authors Altartouri and Jolma from the Department of Civil and Environmental Engineering at Aalto University; Ehrnsten from the Centre for Economic Development, Transport and the Environment for Southeast Finland in Kouvola; and Helle and Venesjarvi from the Fisheries and Environmental Management Group at the University of Helsinki addresses web and mobile geospatial services enabling real-time decisions related to ecological risk during oil spills. The authors discuss the need for proactive tools for the assessment of ecological risks posed by potential oil spills and oil combating. A web-based spatial decision support system (SDSS) using the Web Mapping Framework of the Open Geospatial Consortium (OGC) is described. This system enables standardized geo-enabled web services to: 1) serve interoperable image maps with Web Map Service (WMS); 2) serve geographic vector and raster data with Web Feature Service (WFS) and Web Coverage Service (WCS); and 3) process data with Web Processing Service (WPS) protocols. These open and standardized geospatial web services allow efficient geospatial data integration and distribution for enhanced, on-site decision making. A case study for a SDSS targeting potential oil spills in the Gulf of Finland and the Finnish Archipelago Sea is presented. OILRISK stores and combines knowledge on species biology, habitats and oil spill combating aimed to assist oil spill responders in prioritizing vulnerable areas, placing oil booms and deciding on suitable methods of oil removal in northern waters that are typically ice covered. Differences in the development and use of OILRISK SDSS on hardware devices ranging from desktops and laptops to tablets and smart phones also are addressed.

"Web-service-based Monitoring and Analysis of Global Agricultural Drought" by Deng, Di, Han, Yagci, Peng and Heo from the Center for Spatial Information Science and Systems (CSISS) at George Mason University, Fairfax, Virginia continues the theme of requirements and challenges of operational and near real-time monitoring and analysis of global agricultural drought. An open, interoperable web service approach was used to construct the Global Agricultural Drought Monitoring and Forecasting System (GADMFS) for meeting the demands of big-data and geoprocessing-modeling issues of providing complete agricultural drought information. The system allows customized access to large-volume, time-series MODIS data from the year 2000 to the present to compute NDVI baselines and dynamic changes for any specified date or area through Web-based and on-demand OGC-compliant data services. The system functionalities were mainly implemented based on existing OGC Web data and geoprocessing services with many new geoprocessing services and spatial-temporal analysis functions either specifically developed for GADMFS or based on functions of Geographic Resources Analysis Support System (GRASS). The implemented GADMFS system provides worldwide users with online and on-demand access to and analysis of historical and near real-time agricultural drought data and information at 250-m spatial resolution and daily, weekly and 16-day temporal resolutions for any part of the world with most common browsers without installing any additional software or plug-ins. GADMFS is registered in GEOSS as a community contribution. Validation and performance testing were performed in a case study comparing drought information generated by GADMFS and the widely used U.S. Drought Monitoring (USDM) system for the state of Texas. Results demonstrated the value of geospatial Web service and cyberinfrastructure technologies in GADMFS enabling near real-time monitoring and analysis of agricultural drought information.

Authors McInerney, San-Miguela, Corti, Whitmore, Giovando and Camia from the Forest Resources and Climate Unit of the Institute for Environment and Sustainability, Ispra, Italy, the Laboratory of Climate and Environmental Sciences in Gif-Sur-Yvette, France and the United Nations World Food Programme in Rome, Italy discuss a decision support system that is operational at a continental scale in their article entitled, "Design and Function of the European Forest Fire Information System". Since it became operational in 2000 and the official system of the European Union (EU) Federal Government, the European Forest Fire Information System (EFFIS) has developed into a Web-based modular system that uses Web services based on OGC standards to monitor the full cycle of forest fires, from pre-fire forecasts to monitoring the development and spread of fires in real-time. The system also provides post-fire assessments and statistical reporting of the environmental and economic impacts of the events. Initially designed for Europe, the EFFIS now covers North America and the Middle East and distributes MODIS-based data to a wide network of users. Current work includes further integration of Volunteered Geographic Information (VGI) and Web2.0 services such as spatially referenced photographs from services such as Flickr and Panoramio, tweets from Twitter, and videos from YouTube into the data acquisition work flow.

Talbot and Talbot from Simplex, LLC in Leesburg, Virginia, present a novel data dissemination concept and research prototype enabling rapid mobile access to remote sensing data for disaster response in "Fast-Responder: Mobile Access to Remote Sensing for Disaster Response." Fast performance is achieved for smart phone users via Fast-Earth, a geospatially-organized cache that subdivides the Earth into small regions called plats for rapid search and data download. Recently acquired remote sensing aerial or satellite imagery can be selected, downloaded, and flickered for situation awareness with a total phone pocket-to-pocket of about one minute using a common 3G cell wireless link. Automated man-made regions and rubble detection algorithms also allow post-disaster imagery to be analyzed on the server for assessment of disaster damage. The Fast-Responder system is demonstrated with color optical imagery of 0.15-cm pixel resolution from the 2010 Haiti earthquake. Accessing extremely large data sets of approximately 34 Mb per image with the mobile application, *Fast-Rspondr*, operating on iPhones and iPads, performance tests indicated the system could accommodate 100 simultaneous mobile responders. Although there were trades-offs of rapid image access and processing for ease of panning across tiled plats, the overall conclusion was situation awareness time was greatly reduced and automated damage assessment assisted in target recovery efforts.

The integration of satellite sensor data for integrated flood disaster management is addressed in "Geospatial Web-based Sensor Information Model for Integrating Satellite Observation: An Example in the Field of Flood Disaster Management" by Hu, Chen and Li from the State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing in Wuhan University, China. The sharable and interoperable system uses an Earth Observation Satellite Sensor Information (SSI) model for integrating satellite observations. The SSI model extends existing metadata standards to a standard metadata-filled description framework that ensures sharing and interoperability among satellite sensor observations in the emergency management cycle. This model is applied to flood observation-supporting satellite sensors (FO-SSs) for retrieval of satellite imagery related to flood events. Used in a flood emergency in the middle reaches of the Yangtze River basin in China, the system was demonstrated to benefit three kinds of users: FO-SSs providers, emergency responders and emergency managers who must schedule ground observation activities.

The final paper in this special issue addresses a participatory Geoweb project documenting public experiences with the Okanagan Mountain Park Fire. "A Hot Topic: The Role of the Geoweb after Wildfire" by Brennan and Corbett of the University of British Columbia Okanagan and examines internet mapping technologies that facilitate the development of volunteered geographic information systems to record human experiences during forest fires. The online system allows users to contribute their own multimedia information including text, photos, and videos, while also commenting on the contributions of others. Beyond the valuable archival of personal stories, this research examined: 1) the willingness of individuals to volunteer their knowledge; 2) participant engagement in terms of passive or active map use; 3) perspectives of participants-as-experts; and 4) more broadly, how the Geoweb can educate and preserve experiences about events. The authors derived some interesting conclusions that while online mapping tools facilitated location-specific narratives, some participants were reluctant to add stories they had not experienced themselves and felt they did not have the right to share. Improvements would also ensure users with less familiarity with computer mapping would have equal access to the online VGI technologies.

Conclusions

Geospatial data, including aerial and satellite imagery, provide crucial information for federal, state, and local officials, as well as the public, during natural disasters. Many areas may be inaccessible due to the impact of the disaster (e.g., volume of debris, interrupted transportation network, etc.). Near real-time imagery of the damage, coupled with other available reference mapping information, also are essential in helping emergency managers conduct search and rescue operations, route personnel and machinery, coordinate recovery efforts, and provide a cost-effective way to better understand the damage sustained to both property and the environment. In recent years new mobile mapping tools have started to become more widely available to the disaster response community. These tools leverage the aerial/satellite imagery and other mapping information available on mobile devices (e.g., through disaster response apps). Currently, the most promising apps cater to professional responders and organizations. While empowering paid professionals is a must, there has been little focus on empowering the real first responders, i.e., the disaster-affected public and volunteer relief workers. This situation underscores the often typical mismatch in demand for responder services versus supply of professional responders in a crisis situation; this is why crises are often a test for humanitarian organizations. As an example, a recent Red Cross survey found that 76% of people who post a need on social media during a disaster expect a response within three hours. Paid responders, however, cannot be everywhere at the same time during a disaster. The typical response time by professional emergency responders to these posted needs is unknown, because there is no nationwide standard for measuring emergency response times.

If disaster response communities can find a way to make effective use of crowdsourcing and supplement professional relief with decentralized volunteer relief, the time to fulfill the vast post-disaster needs may be shortened. FEMA, the Department of Homeland Security (DHS) and Federal Communications Commission (FCC) have all implemented social strategies into their emergency-management plans. In April 2011, the DHS announced that it would revise its terrorism-advisory system, including a provision that alerts would be sent out over social networks "when appropriate." Shortly thereafter, FEMA and the FCC, along with New York City Mayor Michael Bloomberg, unveiled PLAN (Personalized Localized Alert Network), the nation's first geographically targeted emergency-notification system, which sends free emergency alerts to enabled mobile devices to warn citizens of "imminent threats" in their area. This is a good first step to increase the interaction between the possible affected people and the professional relief.

Many accounts of survival following a disaster are thanks to local volunteers and resources, not external aid or relief. This explains why FEMA Administrator, Craig Fugate, has recently called on the public to become members of the response and recovery team. The majority of needs that materialize during (and after) a disaster do not require the attention of paid disaster responders. We are not all affected in the same way when disaster strikes, and those less affected are often very motivated and capable at responding to the basic needs of those around them. After all, local communities have always played a very important role as first responders. They are, and have always been, a critical part of the Search and Rescue Teams.

Disaster management groups face many challenges. It is not always clear what data, information, and tools are available, nor is it always clear how to use these tools to find, process, and interpret the data in a timely manner. By creating access and data interoperability standards across communities, leveraging new technologies, and working together as one coherent disaster response system, agencies, emergency teams, and the public can improve their level of preparedness and readiness before a natural disaster occurs. This approach could enhance the efficiency and effectiveness of response and speed up disaster recovery significantly, thus creating a safer tomorrow. Such a system would require the public, the commercial geospatial industry, and the government to work together in a partnership to maximize effective creation and use of new technologies that, in the end, would save lives.

We would like to thank the reviewers that have made this special issue possible by pouring over the manuscripts and providing the critical feedback to us and to the authors necessary for successful publication. Finally we wish to thank the PE&RS Editor-in-Chief, Dr. Russ Congalton, and the Manuscript Coordinator, Ms. Jeanie Congalton, for their patience and guidance.

References

http://www.redcross.org/news/press-release/More-Americans-Using-Mobile-Apps-in-Emergencies

http://reliefweb.int/sites/reliefweb.int/files/resources/Ref%20Doc_Rakhine_Inter-Agency_Contingency%20Plan_5_April_2013.pdf

http://www.dhs.gov/news/2011/04/20/secretary-napolitano-announces-implementation-national-terrorism-advisory-system

http://www.fema.gov/medialibrary/media_records/7766/transcripts/7207

http://www.dhs.gov/news/2011/10/25/written-testimony-fema-house-homeland-security-subcommittee-emergency-preparedness

Authors

David Alvarez, *Fluor-B&W Portsmouth* (U.S Department of Energy contractor)

Piero Boccardo, *DIST Politecnico of Torino*

Maria Antonia Brovelli, *Politecnico di Milano, Campus of Como*, Italy

Fabio Giulio Tonolo, *Information Technology for Humanitarian Assistance, Cooperation and Action (ITHACA)*, Torino, Italy

Marguerite Madden, *Center for Geospatial Research, Department of Geography, University of Georgia*