Computing Tools and Techniques for Emergency Response

Alfred C. Weaver, University of Virginia
Greg Byrd, North Carolina State University
Renee Bryce, University of North Texas

From social networks to autonomous robotics, computing technologies improve our ability to quickly and effectively respond to emergencies.

Disaster can strike in an instant. It comes in all shapes and sizes: natural or manmade, accidental or intentional, localized or geographically dispersed. The effectiveness of response depends on the ability to quickly assess the situation and mobilize the necessary resources.

Communication technology provides a rich two-way medium that relays essential information from survivors to emergency responders, and vice versa. Social media networks serve as a primary source of information in events such as winter storms, floods, and earthquakes. Terrestrial and aerial robots collect data and locate survivors in remote and hazardous environments. Computing, however, is the crucial tool that converts the torrent of data and observations into information that disaster management professionals use to effectively direct and deploy aid.

A wide variety of computing tools and techniques are used in the context of disaster management and response. Advances continue in many areas, including data integration, privacy and authentication, natural-language processing, data visualization, and predictive modeling. Platforms continue to emerge that harness the power of witnesses and responders around the world to collect and share information, connect victims with family members, and enlist aid. Examples include Google's Crisis Response Team (www.google.org/crisisresponse) and Japan's IT Disaster Assistance and Response Team (IT DART). (See "Supporting Disaster Volunteers from the Internet" sidebar.)

DISCLAIMER

Peer review and decision-making for "Applications of Social Networks and Crowdsourcing for Disaster Management Improvement," by L. Besaleva and A.C. Weaver, was handled by an independent, nonconflicted *Computer* editorial board member; the guest editors had no role in determining the outcome of this paper.

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IN THIS ISSUE

This special issue presents a collection of articles that describe the role of computing technology in this complex human-centered domain. A common theme is the need to collect, analyze, and disseminate reliable and timely information in the midst of a chaotic environment.

In "Emergency Informatics: Using Computing to Improve Disaster Management," Robin R. Murphy presents three case studies that illustrate computing challenges in the context of a single event: the 2015 Memorial Day weekend floods in Texas. The scale of such a disaster is immense in terms of time, space, people, and data. For example, a single 20-minute flight of an unmanned aerial vehicle (UAV), covering less than a square mile of the flood plain, totals around 1.7 Gbytes of image data; for this event, more than a dozen UAVs flew daily for two weeks. In addition to the volume of data, agencies have to deal with the uncertainty of data. Information gleaned from social media is not reliable, agencies do not always know what data other agencies have, and data can quickly become stale and inaccurate. These and other challenges point to research opportunities in data filtering, image processing, cognitive computing, planning, and resource allocation.

In "Impromptu Crisis Mapping to Prioritize Emergency Response," Marco Avvenuti, Stefano Cresci, Fabio Del Vigna, and Maurizio Tesconi address the problem of mining information from social networks to provide contextual information that emergency responders can use. Since few social media messages carry precise geospatial information, techniques such as geoparsing—extracting mentions of known locations in the message text—must be used to collect and visualize reports of damage, injuries, and missing persons. The authors describe a system that shades areas on a map to quickly and accurately identify regions with the most damage, an important tool for prioritization and resource allocation during emergencies.

In "A Biobotic Distributed Sensor Network for Under-Rubble Search and Rescue," Alper Bozkurt, Edgar Lobaton, and Mihail Sichitiu propose the use of swarm robotics and multihop wireless networking to enable detailed searching and mapping of hard-to-reach areas underneath collapsed buildings. Instead of building insect-size robots, actual insects (cockroaches) are instrumented with electrodes to stimulate antennae for navigation, and with backpacks to carry sensors, batteries, and transceivers. Distributed algorithms are used to localize the biobot within the rubble (without using GPS), to locate the survivors, and to explore and map the environment in a coordinated fashion. Because signals from deep within the rubble may not reach the surface, peer-to-peer routing is used to relay information through the biobot swarm to drones or humans above. The authors' multidisciplinary approach has the potential to provide a robust and flexible infrastructure for survivor location and hazard detection in very challenging environments.

In "Applications of Social Networks and Crowdsourcing for Disaster Management Improvement," Liliya I. Besaleva and Alfred C. Weaver discuss the ways in which social media and other Web 2.0 technologies can be used by healthcare professionals, responders, and ordinary people to both communicate and receive vital information during an emergency. Crowdsourced information is often spread across multiple sites, and can be inaccurate or misleading. The authors developed an application called CrowdHelp to be used by people willing to help other people in need, as well as by disaster-management professionals. CrowdHelp allows users to submit information relevant to an event, provides users with information about possible conditions and causes for their symptoms, dynamically populates a list of places capable of treating victims, and maintains information about users' locations and reported symptoms. Standard medical triage conventions are used to translate concrete medical symptoms (such

SUPPORTING DISASTER VOLUNTEERS FROM THE INTERNET

Dai Sato, Tohoku University

After the magnitude 9.0 earthquake in eastern Japan in 2011, millions of volunteers came out to support reconstruction. It was the first opportunity for large-scale online volunteer activities in Japan. In April 2011, we established an organization, Netvol-Miyagi (NETwork VOLunteers in the MIYAGI Prefecture), which supplied and installed network devices for shelters and schools and tweeted live information about traffic conditions, volunteer recruitment information, and so on. There were more than 20,000 tweets per day in the 3 years after the disaster. At the time, the other social networking systems (SNSs) did not have the same level of popularity in Japan to be effective for spreading information.

The use of SNSs has increased—from 9.7 percent in May 2011 to 64.2 percent in July 2015. As a result, reports from damaged areas are also higher on SNSs when a disaster occurs. Of course, the quality of information is not always reliable in terms of accuracy, timing, location, and the like.

To address this, I worked with volunteer IT colleagues to establish the IT Disaster Assistance and Response Team (IT DART) in August 2015. IT DART collects, evaluates, and broadcasts disaster information on SNSs for volunteers. An example of IT DART activities comes from the recent magnitude 6.5 and 7.5 earthquakes in the Kumamoto and Oita prefectures on 14 and 16 April 2016, respectively. We immediately opened an information-sharing Facebook group and also quickly dispatched four members to the Kumamoto prefecture to collect local information. Several other activities are now underway, including: managing an online disaster information map (http://kumamoto-jishin.info/map.html) with Gensai Info, Code for Japan, Google Crisis Response Team, and other collaborators; supporting website development for support organizations and local government agencies; and launching a fraud prevention campaign.

There are many smaller Japanese volunteer organizations and just a few large-scale ones, but through the use of online communications tools they can all improve our ability to prepare for and respond to emergencies.

DAI SATO is an associate professor in the Medical IT Center at Tohoku University Hospital. His research interests include network operation and disaster-related medical and volunteer assistance. Sato received a Master of Science and International Cultural Studies from Tohoku University. Contact him at satodai@sic.med.tohoku.ac.jp.

as bleeding and numbness) into an urgency level for each report.

These articles show some of the many creative ways that computing can enhance our ability to respond effectively when disasters strike. We applaud the authors and all those who apply computing technology to these important social challenges. Just as importantly, we honor those volunteers and professionals who put themselves in harm's way to offer aid where it is desperately needed. ■

ABOUT THE AUTHORS

ALFRED C. WEAVER is professor and associate chair of computer science and founding director of the Applied Research Institute at the University of Virginia. He is an IEEE Fellow and a member of *Computer*'s advisory panel. Contact him at weaver@virginia.edu.

GREG BYRD is associate head of the Department of Electrical and Computer Engineering at North Carolina State University. He is a Senior Member of IEEE and an area and column editor for *Computer*. Contact him at gbyrd@computer.org.

RENEE BRYCE is associate professor of computer science and engineering at the University of North Texas. She is an area editor for *Computer*. Contact her at renee.bryce@unt.edu.