nature

COMMENTARY

Mapping disaster zones

Google Earth software proved effective during relief efforts in New Orleans and Pakistan, say **Illah Nourbakhsh** and colleagues. Is there more to be gained than lost from opening up disaster operations to the wider public?

In the aftermath of any disaster, satellite and aerial images are critical for identifying priorities, planning logistics and working out access routes for relief operations. Two events last year, Hurricane Katrina in the United States and the Pakistan earthquake, catalysed a collaboration between relief workers and the Global Connection project, a partnership between Carnegie Mellon University in Pittsburgh, Pennsylvania, NASA/Ames Research Center in Moffett Field, California, Google and National Geographic. The goal was to help communities and response agencies to access post-disaster images quickly using the Google Earth geospatial image browser. The emergence of a new breed of volunteers — online data managers — highlights the potential of a web-based community approach to disaster operations.

Aerial photograph of New Orleans before and after Hurricane Katrina.

IMAGE FROM GOOGLE EARTH/SANBORN; OVERLAY BY NOAA & GLOBAL CONNECTION PROJECT

These experiences have taught us that real-time spatial image browsing can have huge benefits to aid operations. But the technology was used in a markedly different manner after Hurricane Katrina from the way it was used after the Pakistan earthquake, owing to greater technical and economic barriers in the developing world. The use of government data sources can be restricted for security reasons, and although this is true everywhere, public pressure for transparency is usually higher in the developed world.

Earth from above

Satellite images from commercial sources are not free, and are available to the public only when a third party, in this case Google, chooses to purchase and release the data. Software tools for professional image analysis and processing are also expensive. Future developments that make these tools available to a wider audience may lead to sacrifices in privacy and security. We believe such sacrifices are inevitable and can be justified by both direct and indirect humanitarian benefits.

The Google Earth model of the globe consists of hundreds of thousands of individual satellite and aerial images taken from more than one hundred data sources, including NASA's Landsat satellite, commercial satellites such as Digital Globe's QuickBird, and providers of aerial photographs. These images are stitched together to create a spatially searchable, high-resolution view of Earth. In urban areas, resolution may be as high as 6 to 12 inches. In other regions, particularly rural areas and developing countries, only 15-metre Landsat resolution may be publicly available.

This low resolution is one of the obstacles facing spatial image browsing for disaster response. Many of the tasks that relief teams encounter, such as identifying roads with crack-free surfaces after an earthquake, require images with one-metre resolution or better. A second obstacle is image freshness. Images seen while browsing Google Earth can be between six months and three years old, depending on their source. However, by making use of updated overlays provided in a format known as Keyhole Markup Language (KML), it is possible for multiple users to update Google Earth in real time. In this way, online volunteers can help to overcome resolution and image-freshness issues.

A patchwork picture

Global Connection's original mission with National Geographic produced 500 high-resolution image overlays of Africa derived from aircraft photographs taken in 2004. When viewing Africa using Google Earth, small red aeroplane icons appear; zooming in for a closer look reveals a high-resolution aerial image overlay on top of the Landsat background image.

This technique of overlaying images found an unexpected application when Hurricane Katrina flooded New Orleans and the surrounding areas on 29 August 2005. The National Oceanic and Atmospheric Administration (NOAA) captured more than 8,000 images of flood-damaged areas over 10 days using a high-resolution camera mounted on a small high-speed aircraft. This information was invaluable to rescue efforts, and in the first week some 5 million photos were downloaded from NOAA's website each day.

But navigating this huge, unprocessed data set in a meaningful way required the images to be presented in a searchable, stitched-together format. At the request of NOAA, Google Earth and the Global Connection team created new KML software tools to handle the images that NOAA released on a daily basis. These tools made the preparation of image overlays faster than was previously possible. During September, we estimated that the Global Connection server supported some 2.5 million viewings of the high-resolution overlays of post-Katrina images by users of Google Earth.

In the case of Hurricane Katrina, spatial image browsing proved useful to federal disaster agencies and, we believe, to the larger public. The technology personalized disaster data by making each individual an active explorer, capable of discovering information that was relevant to them. For instance, Google Earth images of flood-free suburbs in New Orleans helped some families in Pennsylvania to identify intact churches that could be used as an outlet for food donations.

As the Global Connection team converted the last of the NOAA images for Hurricane Rita — which reflooded New Orleans on 23 September — to overlays in October 2005, volunteers in Pakistan were already responding to the 8 October earthquake and collecting disparate satellite data of the disaster zone. Specialized mapping outfits, such as the UK charity MapAction (www.mapaction.org), began working with the United Nations in Islamabad to distribute satellite images and information maps to agencies on the ground. Even though most publicly available images had coarse resolution (limited to 15 metres), MapAction was able to collate essential logistical information, such as major road blockages and the locations and numbers of tents required throughout the area.

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Some members of the disaster response community in Pakistan who had heard of Google Earth contacted Global Connection in the hope of finding higher-resolution images. An e-mail on 12 October from Ayaz Abdulla of The Citizens Foundation (TCF), a Karachi-based organization that switched their mission from education to disaster relief when the earthquake happened, explains their need for higher-resolution data:

"I have the basic version of Google Earth which shows the terrain to some detail, but our relief workers (and logistical strategists) would be monumentally helped by images with higher resolution (especially with better clarity of roads, and so on). The TCF relief effort currently continues with limited and outdated maps that don't truly reflect the current terrain (and more importantly, the inhabited areas). Local know-how of the region is extremely useful, but I feel that this satellite technology could be priceless."

Beyond the sky

Unlike the situation after Katrina, there was no high-speed aircraft surveying the disaster area in Pakistan nor high-resolution images available, apart from commercial satellite data. But by 14 October, Google Earth had acquired, processed and published two satellite images from Digital Globe's QuickBird that were taken on 9 October, the day after the earthquake. In the five days that followed, high-resolution images taken by the commercial IKONOS satellite were released publicly on several websites, then withdrawn following Pakistan's concerns over security in Kashmir, and finally re-published by the United Nations following talks with Pakistan and India (www.nature.com/news/2005/051017/full/051017-12.html).

Even when more images became available, most were not immediately usable due to lack of computer-readable information about the projection and location of the image, known as a 'world file'. The NOAA images of Katrina recorded the aircraft's position and attitude, allowing automatic generation of world files. Fortunately, the best IKONOS images available online, prepared by the Center for Satellite-Based Crisis Information in Munich, Germany, were published with world files. Global Connection used these to generate one-metre resolution image overlays of parts of the districts of Muzaffarabad, Mansehra and Abbottabad by 24 October.

The IKONOS images yielded updated overlays for Google Earth for only a limited region, but the subsequent feedback from relief workers in the field, in this case the TCF, was extremely useful to the US-based Global Connection team. The TCF helped us to prioritize what areas of Pakistan to focus on next. Given the project's limited resources and the sudden flood of public data now available, this was essential for focusing the team's efforts.

We learned many other lessons from Pakistan, not least the need to develop tools that can adapt to local conditions on the ground. Internet connections in Pakistan were often slow and patchy, making downloads difficult. Post-disaster feedback highlighted difficulties with printing out maps and locating specific settlements among tens of thousands. Another obstacle was the mismatch between the local situation and the way existing geographic data is organized and represented. For example, Pakistani villages do not have a single position, but exist along a right-of-way extending from the valley to a ridge top, migrating up and down based on the changing seasons. Thus assigning a fixed position to a village is wrong most of the time. If Google Earth could label a village boundary, rather than a single location, this might prevent settlements being misidentified.

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More generally, the connection between city or village name and position can be flawed. Spatial image browsers such as Google Earth make use of several databases that link place names with latitude and longitude, and unfortunately all such databases suffer from inaccuracies, such as placing Islamabad 100 miles from its true location. All mapping efforts, whether community based or UN supported, would benefit from a stronger feedback mechanism, such as a community filtering system that enables authenticated individuals to update shared geographical data online. For example, we hope that database providers will support initiatives, such as the Geonames Forum (www.geonames.org/about.html).

Where will spatial image browsing take disaster response in the future? We hope that a growing awareness of such browsers will encourage greater standardization of image and data formats, including world files. This would work best with the support of a reputable organization, such as the US National Institute for Standards and Technology. Low-cost global positioning systems combined with automated image analysis could allow browsers such as Google Earth to create overlays from images taken with cheaper instruments; for example, cameras in mobile phones or camcorders in helicopters. In time, we hope to see the public's role shift from passive viewer to active contributor.

Global contribution

This prospect will no doubt raise privacy concerns. However, immediately after a disaster, few would deny the value of making high-resolution, up-to-date imagery public for rescue operations. But we would argue that the benefits go beyond the immediate logistics of disaster response. Individuals, moved by pictures, may make donations and encourage their governments to do the same. There are many organizations and individuals who can contribute in unexpected ways following a disaster. But there is also a danger of overwhelming relief operations with tens of thousands of enthusiastic image donors.

There are real challenges in scaling up such activities: from validating the accuracy of contributions to standardizing image formats. An online organization, similar to MapAction in its goals, is needed to serve as a bridge between the sourcing of high-resolution satellite data and humanitarian agencies on the ground. Moreover, we believe that the highest-resolution data, such as that from Digital Globe, should be rapidly made public following a disaster. For instance, the International Charter on Space and Major Disasters (www.disasterscharter.org) is a collaboration that provides digital maps sourced from space-agency satellites. We need to strengthen organizations such as Europe's Respond consortium (www.respond-int.org/Respond) that can acquire commercial high-resolution images, and encourage standardized source data. Such advances, combined with image-overlay technology, promise to make spatial image browsing far more timely and effective in relief efforts. ■

Illah Nourbakhsh and Randy Sargent are at Carnegie Mellon University, Pittsburgh, Pennsylvania; Anne Wright is at NASA/Ames, Moffett Field, California; Kathryn Cramer; Brian McClendon and Michael Jones are at Google Earth.

For more on Google Earth see pages 763 and 776.

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