Complex by Nature

How eCognition is helping researchers gain firm footing in the unpredictable landscape of identifying, mapping, and potentially, predicting landslides.

Solution

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overview

Although the words "natural disasters" are often associated with earthquakes, flooding and hurricanes, landslides are no less destructive or deadly. They are sudden. They are swift. And perhaps most unsettling, they strike without warning. The UN Office for Disaster Risk Reduction ranks these natural hazards as the fifth most frequent and the seventh most damaging.

Location
NEW ZEALAND, TAIWAN, ICELAND

In August 2017 alone, there were landslides in China, India, Sierra Leone, the Democratic Republic of Congo, Nepal and Bangladesh that, combined, claimed nearly 1,000 lives. They destroyed entire villages, orphaned hundreds and left hundreds missing.

Such sobering, mud-caked catastrophes challenge emergency responders and landslide experts both to rapidly assess and map the extent of landslides and find adequate tools to identify high-risk areas and create planning strategies.

That is perhaps why the puzzle of landslides—how to adequately define them, categorize them, detect them, map them and plan for them—has been an intriguing focus of much research since the late 1990s. With the advancement of geospatial tools such as very high-resolution satellite imagery, synthetic aperture radar interferometry (InSAR), and powerful object-based image analysis (OBIA) technology, geoscientists have been particularly interested in developing more effective solutions for landslide detection, mapping, inventorying, monitoring, and possibly, forecasting.

Trimble® eCognition® software, the environment for object-based image analysis, has played a significant role in a host of research projects in Taiwan, Italy, Austria, New Zealand and Iceland. The overall aim of each project has been to develop new, semi-automated methods for classifying and mapping landslides.

Of all of this research, two areas that hold particular promise to better map, track and possibly predict future landslides are landslide hotspot mapping and combining optical and InSAR data Based on these encouraging studies, a groundswell of possibilities may be afoot to help organizations better assess, map, prepare and plan for the unpredictable nature of landslides.

CHALLENGE

The complexities in efficiently and accurately identifying, mapping and inventorying landslides are many. Landslides don't have uniform behaviors or patterns; they don't always look and act the same. They are quite variable in shape and size, and they can be difficult to distinguish from manmade features such as small quarries or harvested forests.

Particularly challenging is that identifying and mapping landslides is predominantly a manual process—specialists visually interpret each aerial or satellite image and manually delineate and map each landslide. This traditional work is not only tedious and slow, it also highly subjective—what is or is not a landslide is decided by the expert mapping the event.

To bring better efficacy, accuracy, and possibly, predictability to mapping and monitoring landslides, landslide experts need tools that will enable them to rapidly classify landslides, map their extent and identify high-risk areas.They also need the ability to create comprehensive, detailed landslide inventories for developing location-specific, risk mitigation measures.

SOLUTIONS

One main objective for the landslide research community has been to create more efficient and reliable mapping frameworks for landslide-prone countries to adopt and customize to suit their needs.

As part of this overall goal, Daniel Hölbling, a research scientist at the University of Salzburg, has been working since 2009 to develop such solutions through several studies in Taiwan, Italy, Austria and Iceland. Most recently, he moved closer to achieving that goal with research projects in New Zealand and Iceland, countries that are well versed in landslides.

Taiwan Landslide (2014)

In 2016, Hölbling partnered with New Zealand's Landcare Research, a Crown Research Institute headquartered in Lincoln, to test an OBIA, semi-automated approach for identifying and mapping landslide-prone "hotspots" based on historical and recent aerial photography.

The team selected an approximately 1,000-hectare (2,470-acre) study area located in New Zealand's North Island, where rain-triggered landslides are common.

They acquired five orthophotos—three black and white and two natural color—from five different years between 1944 and 2011. The color orthophotos had nominal accuracies of 15 m and a spatial resolution of up to 0.4 m. They also obtained a 15 m resolution DEM to provide ancillary data such as slope information.

To adequately compare the OBIA approach to the manual approach, Landcare researchers spent two weeks manually digitizing visible landslides on each orthophoto in ESRI ArcGIS. In parallel, Hölbling spent one day preparing the eCognition software for integrating the datasets and classifying the landslides. Using the 2011 orthophoto, he first developed a customized rule set that used spectral, spatial, contextual and morphological properties to properly classify and map all detected landslides on the image. He then applied that rule set—with a few modifications—to the other orthophotos. In a few hours, eCognition classified all visible landslides across all five time stamps.

With both the manual and automated mapping completed, the team compared the two approaches. Although the eCognition mapping was equivalent to the manual results, the eCognition approach was considerably faster, more consistent, more objective, and it was easily repeatable.

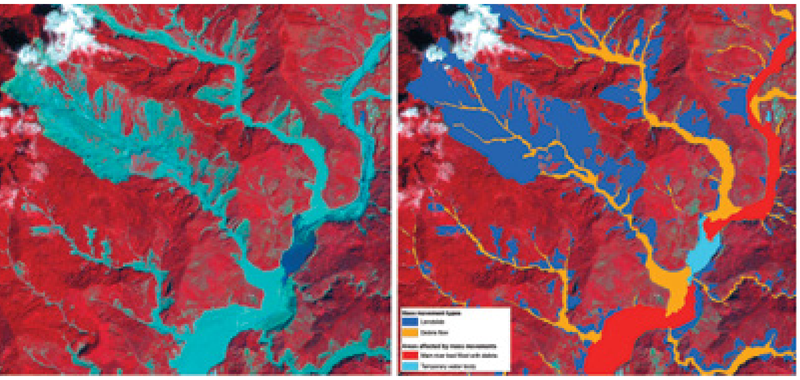
"The manual mapping was painfully slow," said Harley Betts, a researcher with the soils and landscapes team at Landcare Research's Palmerston North office. "The eCognition approach has the potential to cut out a big chunk of that manual stage. I was very impressed with that."

South Öræfajökull

The Iceland study aims to take that rapid-mapping approach to a deeper level by pairing optical satellite imagery with InSAR datasets to create a more powerful, integrated landslide tool.

Targeting a site in Iceland's southeastern Öræfajökull region, the team acquired a 5 m resolution optical RapidEye image, a 2-m-resolution LiDAR-derived DEM and two 3 m resolution TerraSAR-X StripMap scenes. In addition to calculating a vegetation index from the optical image and slope values from the DEM, they used the two SAR scenes to calculate the phase differ-ence between the two images, which helps identify areas on the ground surface that have moved.

Hölbling and his team developed an eCognition rule set to integrate the imagery and InSAR data information to identify and map all landslides as well as to test its ability to distinguish both shal-low and deep-seated landslides not visible on the optical imagery. The software not only distin-guished landslides based on the optical image but with the additional InSAR data, it identified more potentially affected landslide areas.



RESULTS

Based on the positive outcomes of the New Zealand study and preliminary Iceland results, an OBIA-based approach could provide a more efficient, reliable and customizable system for mapping and inventorying landslides, both in the immediate aftermath and in the months following.

As a complement to manual methods, an automated system would both allow experts to quickly detect and classify landslides and map their extent over large areas as well as flag unstable areas. From those overview maps, they can create comprehensive, detailed landslide inventories for developing location-specific, risk mitigation measures.

By using a multi-source, integrated mapping approach, specialists can map visible landslides with optical imagery and the underground, slow-moving slides with SAR data. The additional detail can enable experts to create complete landslide inventories, and the velocity detail from InSAR allows them to analyze land movement over time.

Tracking both visible, fast-moving landslides and deep-seated, slow-moving landslides could lead to predictive modelling.

"By studying the historical evolution of landslides and mapping the changes over time, you could use the mapping, to some degree, for prediction," said Hölbling. "Combining optical and InSAR data to map both visible and invisible slides could enable us to forecast how the landslide might continue to move based on the historical movement. That's incredibly promising."

"eCognition, with remote sensing data, is the most powerful tool for detecting and analyzing landslides."

DANIEL HÖLBLING

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