DISASTER MANAGEMENT AND MONITORING

WHEN WEATHER IS DESTRUCTIVE, GEOSPATIAL IMAGERY HELPS ACCELERATE RECOVERY EFFORTS WHICH CAN TAKE YEARS TO MANAGE EFFICIENTLY AND EFFECTIVELY.

An earthquake shakes the San Francisco Bay area, causing highway overpasses to crumble. A tsunami crashes on the shores of India, washing away the hotels that support the local economy. A Category Four hurricane makes its way to the highly-populated towns along Louisiana's Gulf Coast, destroying industry, historic buildings and homes. In recent years, unusual weather-related disasters seemingly have become relentless. In each event, disaster management efforts begin immediately and continue for years after life returns to normal. Whether the area is a heavily industrialized urban epicenter, or an agriculturally dependent community, representatives from government and civilian agencies work as quickly as possible to perform search and rescue and identify damage extent, both to manmade property and to the geographic surroundings.

In each disaster, officials need a way to easily and quickly identify the specific areas that are affected and the extent to which they are damaged. Doing so allows them to convey essential information for planning search and rescue operations, or to begin repairing and rebuilding landscape and buildings.

Today, satellite and airborne imagery, commonly referred to as geospatial imagery, is widely used to make these critical assessments. Geospatial imagery provides a wealth of information that is not immediately obvious to the naked eye. When properly processed and analyzed, it can save critical time and resources, helping authorities avoid extensive "feet on ground" efforts while providing relevant, working data for management efforts.

To effectively use information from imagery, government agencies, scientists, and researchers need a software solution that is

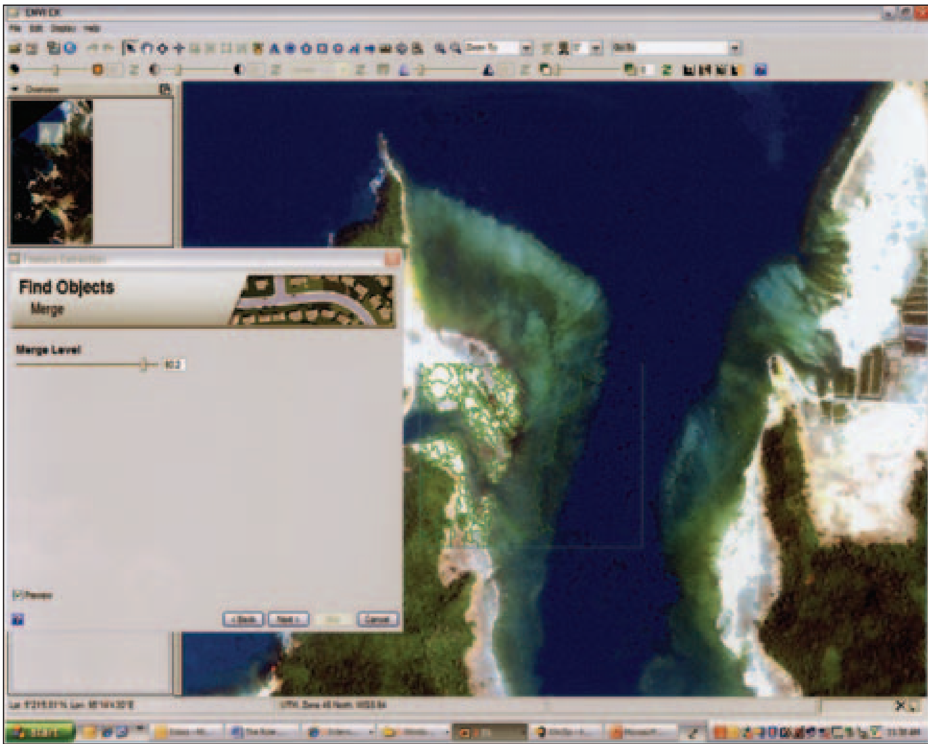

FIGURE 1: ENVI EX Feature Extraction workflow using QuickBird data (courtesy of Digital Globe) after the Indian Ocean tsunami disaster of 2004.

both easy to use and readily incorporated with existing systems such as GIS. ENVI, an integral part of the end-to-end geospatial imagery solutions from ITT, provides a robust suite of scientifically accurate and intuitive image processing and analysis tools that directly support disaster management and monitoring initiatives. ENVI is ITT's premier image exploitation software, and is widely considered a leader in the industry for its powerful ability to extract useful information from various types of imagery.

Assessing Change in the Landscape Aids in Managing Disasters

Comparing satellite imagery from before and after the event is one of the key techniques used in determining the scope and extent of a natural disaster. These images indicate just how the land cover has changed, whether that land cover is naturally occurring plant materials or man-made materials like concrete and asphalt. Depending on the type of imagery that is available and how many bands of data it provides, either a scientific analysis of the image spectra or an analysis based on the spatial features of objects within the image can be employed to determine land cover differences. ENVI provides tools that support both types of analysis, allowing users to get the information they need regardless of the type of imagery that is available to them.

Traditionally, scientists and image analysts have used the spectral approach to detect changes; analyzing the images pixel by pixel to identify damage extent. Changes in radiance or reflectance values of the land cover in an affected area are typically significant when comparing spectral imagery from before and after the disaster. With this type of analysis, land cover classification maps can be created of specific areas both before and after the event. ENVI can easily compare these classified maps to assess the amount and extent of damage, as the land damaged is typically clearly visible. In addition, the type of land cover in question can easily be identified by using the image's spectral information, which is very useful when determining dollar value of loss and costs of recovery plans.

This spectral-based approach, while comprehensive, is dependent on the availability of hyperspectral imagery, thus limiting the imagery that can be used in a post-catastrophic event. Today, imagery that is high in resolution but low in its number of spectral bands tends to be more accessible and less expensive.

Just as hyperspectral imagery requires specialized image processing and analysis technology like that found in ENVI, high resolution panchromatic and multispectral imagery also require a software tool that is capable of deciphering the image's spatial, spectral, and textural characteristics without relying on spectra-only information.

Using the properties and characteristics of the image and features of interest allows users to operate on objects, instead of individual pixels. This "object-based" approach offers more flexibility, less image analysis training, and opens the door for users of any skill level to perform advanced processes, like extracting specific features of interest from a large image scene. Extracting features is a particularly useful exercise when dealing with landscape change, allowing the person analyzing before and after images to determine critical details such as the number of buildings or roads that exist in a particular area, or the size of bodies of water.

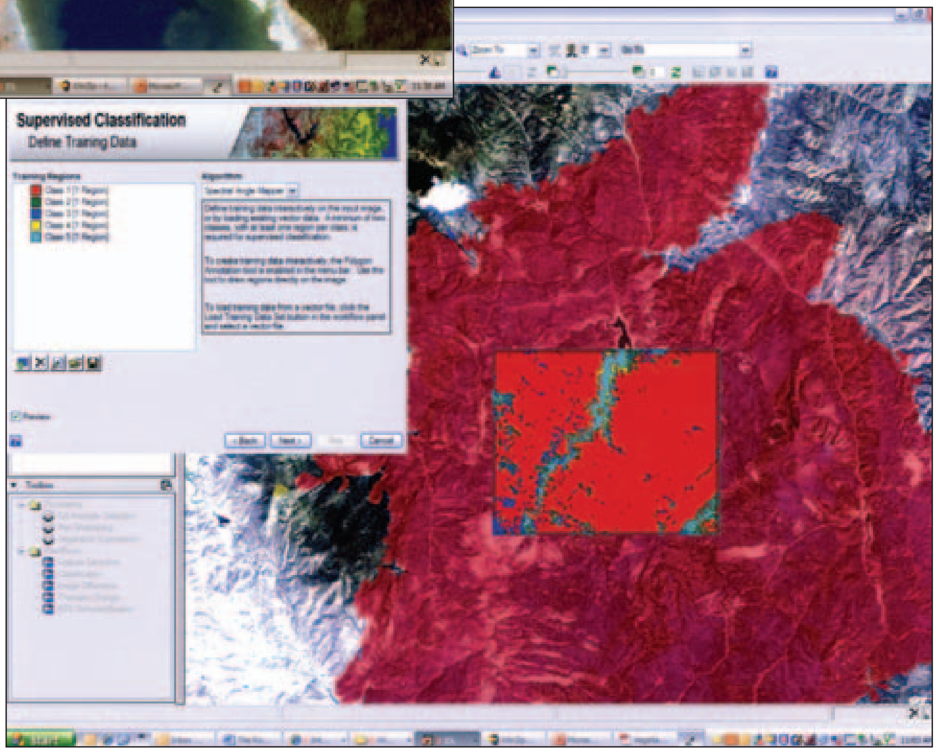

FIGURE 2: ENVI EX Classification Workflow for the Hayman Fire example.

ENVI EX, the newest edition to the ENVI line, offers a unique, object-based feature extraction tool including a wizard-like interface. ENVI EX enables users to quickly and easily find objects – such as trees, coastlines, lakes, bridges, fields, roads, and buildings - in all types of imagery, even if it has limited bands. It is optimized for extracting information from high-resolution panchromatic and multispectral imagery. Additional datasets, like raster LiDAR

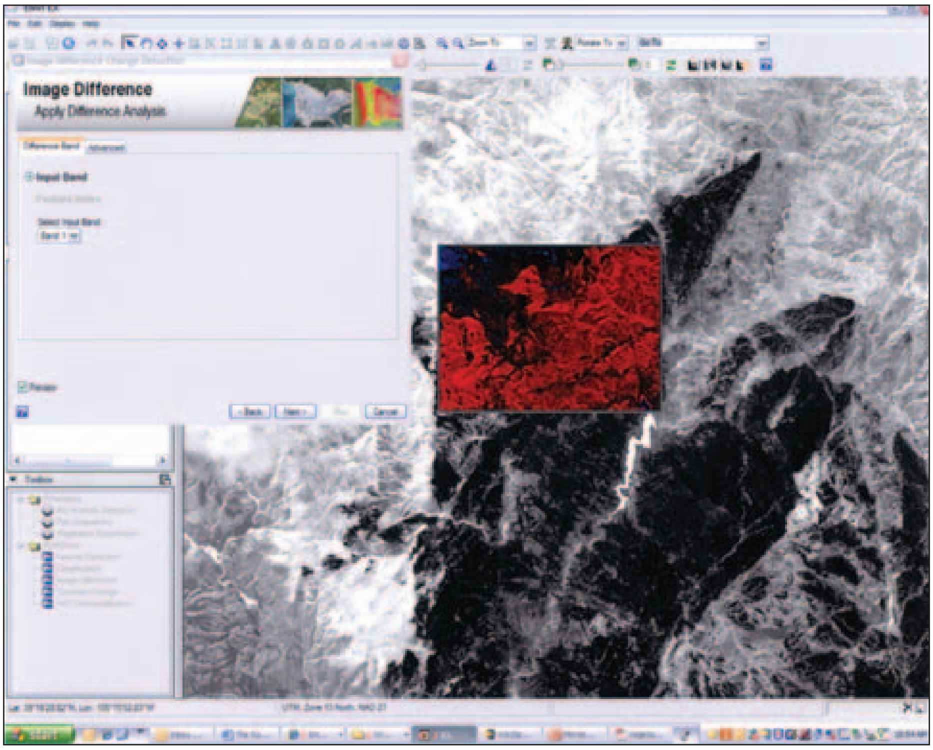

FIGURE 3: ENVI EX Image Difference Change Detection tool for the Hayman Fire example.

elevation and others, can be added easily to the workflow to enhance results.

In the feature extraction workflow, an object is defined as an area of interest with spatial, spectral (brightness and color), and/or textural characteristics that define the region. Extracting relevant features of interest is accomplished by segmenting an image into regions of pixels, computing attributes for each region to create objects, and then classifying those objects based on specific attributes. (Figure 1).

Integrating Information from Imagery with a Geographic Information System (GIS)

Maps are crucial tools for supporting emergency management efforts and aiding in rebuilding. A situation map provides not only an important overview of the area, but helps guide workers around obstacles and dangers. ENVI products can be fully integrated with ArcGIS®, the leading mapping and GIS software, thereby allowing vector layers to be visualized along with processed imagery. And, as is often necessary during disaster management response, it provides the ability to output processed results to a map, to a report, or to print and share with others, including the general public.

This integration saves time and effort, not only during the immediate, critical response to a disaster, but after the event is over and determining the damage extent. Users of ArcGIS can easily find and extract features, classify land cover, orthorectify images, and detect change and then use the results to populate, update, and assess the quality of a GIS. The following example shows how imagery and ENVI can be used throughout each stage of management and recovery from a forest fire.

Using Imagery and Image Analysis to Map Damage Extent from a Forest Fire

Forest fires and wildfires have the capacity to devastate landscapes quickly. They are also a threat to ecosystem functioning, biodiversity, and hydrologic systems. They can also affect global atmospheric chemistry by releasing large quantities of carbon dioxide.

While wildfires play a natural role in many aspects of ecosystem functioning, such as biodiversity and hydrology, they increasingly are a source of concern for environmental protection and security. Biomass burning has been on the rise for decades, releasing carbon dioxide that affects global atmospheric chemistry.

Employing systems to map the extent of the damage and plan recovery efforts has become a priority for authorities around the world. Remote sensing and geospatial imagery play a crucial role in extracting timely and harmonized information on these disasters. Using readily available data from remote satellite sensors, such as the Landsat Enhanced Thematic Mapper (ETM+), researchers can obtain better images and estimate the amount of damage caused by forest fires.

Highly accurate images help agencies plan post-fire restoration efforts in many ways. Scientists can determine which areas are most acutely affected, thereby spending the largest amount of relief dollars in those regions. In addition, gathering information on forest fires is important for verifying compliance with the Kyoto Protocol – a treaty intended to limit or reduce carbon dioxide and other greenhouse gas emissions that are excessive in wild land fires, especially in tropical areas.

Using Landsat ETM+ Data to Map Burn Severity

Large forest fires covering broad geographic regions have, in recent years, stimulated the need to quickly map burned areas. The U. S. Geological Survey (USGS) and the National

Park Service developed a burn severity index based on Landsat TM/ETM bands four (near-infrared) and seven (mid-infrared) that is called the Normalized Burn Ratio (NBR). NBR imagery allows federal land managers and fire ecologists to evaluate and compare burn severity within individual fires and between fires across various ecosystems.

The data used in this example were acquired during the Hayman Fire event, which began in the Pike-San Isabel National Forest in Colorado on 8 June, 2002. Over the course of the fire, approximately 138,170 acres (62,805 hectares) were burned. The Landsat ETM+ images used in this example were first terrain-corrected and geometrically rectified, and then processed to convert bands one through five and seven to at-satellite reflectance.

In this example, a pre-fire scene (acquired 05/12/2001) and a post-fire scene (acquired 07/02/2002) were analyzed with ENVI to create a Differenced Normalized Burn Ratio (DNBR) image. The differenced NBR (DNBR) is computed by subtracting the post-fire NBR from the pre-fire NBR. The DNBR image portrays the variations of burn severity within the fire, higher DNBR values are correlated with more severe burns.

The perimeter of the fire is delineated using ENVI classification and post-classification

Tools (see Figure 2). The perimeter polygon can then be exported to a Shapefile format for ingestion into a GIS. Information about the area that changed where the fire took place can be analyzed with ENVI change detection tools, such as the Image Difference tool shown in Figure 3.

The data collected in this study are extremely beneficial to people planning restoration efforts. Government subsidies can be distributed appropriately to damaged areas, and the damaged area can be monitored over time to help forest managers determine if reforestation efforts are needed to mitigate further damage to the area. Therefore, when researchers need a way to easily and quickly create visualizations and assess the amount and scope of damages, they can rely on tools like ENVI to support disaster management and monitoring initiatives.

Note: The data used in this example are courtesy of the U.S. Geological Survey, 47914 252nd Street, Sioux Falls, SD 57198, USA.

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