Laser Scanning

Both overview and detail are necessary during all phases of disaster management: preparedness, prevention, emergency response, recovery, mitigation and damage assessment; and both can be simultaneously provided by earth observation (EO) from air or space. Three main EO technologies can be used: optical imaging, radar and laser scanning, the latter two being active techniques emitting energy from the sensor and detecting the backscatter.

Optical imagery requires sunlight, and is most often used. Since the information is similar that perceived by the human eye, its interpretation is not restricted to GI masters. Geocoded imagery and orthophoto maps can also be automatically produced with the help of photogrammetry. Anyone can carry out simple manual measurements, such as distance, on these products. Nowadays, digital surface models (DSM) representing the canopy over natural and artificial landscape (house roofs, tree crowns, cars etc.) can too be generated automatically. However, their properties are weakly determined and they are therefore of limited use in disaster management; the main applications are in visualisation, training and (PR) communication.

Radar, especially synthetic aperture radar (SAR), provides medium to low image resolution from satellite platforms in daytime and over night, independent of cloud cover. These are good properties for the emergency response phase, but processing and interpretation of the data requires expert knowledge and several days may elapse after the occurrence of an event before satellites pass over the affected area. Also, the side-looking characteristic is unfavourable for city areas because of occlusions and other effects. When time is not critical, such as in flood-extent mapping for damage assessment, or soil-moisture change detection, SAR provides unique information that cannot be acquired by other EO methods.

Airborne laser scanning (ALS), begun in the nineties, is the youngest technology. A pulsed laser beam is scanned across the terrain and the distances from sensor to surface measured. ALS is currently restricted to use from the air. Although independent of sunlight it, like passive imagery, demands the absence of clouds, and is also restricted by flying conditions. The raw data consists of xyz coordinates of the locations from which the laser beam is reflected. DSMs and digital terrain models (DTMs) can be derived automatically and may be readily interpreted by others than GI masters, although real familiarity requires a second look. The unrivalled geometric terrain description of high resolution in particular allows characterisation of natural processes such as erosion and rock fall. For simulation of flood, even in forested areas, ALS has become a standard data source.

Datasets of large areas already exist, including parts of Europe and North America, so that seamless, high-resolution 3D information is available for modelling, monitoring, mapping and predicting hazards. Repeat acquisition of the same area over time enables analysis of change and quantification of the development of natural processes and affected infrastructure. The Centre for Natural Hazard Management alpS is investigating the role of ALS. Recently a group of European scientists with backgrounds in both laser-scanning and natural hazard research, met in a workshop funded by the European Science Foundation to stimulate interdisciplinary research.

ALS technology is developing steadily and so its role in disaster management will expand. Flying heights can be increased without affecting ground resolution, making it possible to shorten acquisition time. The back-scattered signal can also be densely sampled (full waveform laser scanning) providing more detailed information on the vertical characteristics of objects such as trees with one laser beam. Efforts towards deriving surface reflectivity from the back-scattered signal are also underway. Further developments include laser scanning with multiple lasers at wavelengths in the visible and near infrared spectrum, which aids classification and enhances visualisation. Improvements in data availability and the development of fast algorithms and data-management strategies will drive the integration of laser-scanning data and 3D-information in disaster management.

The level of automation, robustness and reliability of the generation of high-level products beyond orthophotos and DSMs/DTMs is not yet satisfactory. Integration of data sources, but also formalisation of human knowledge, will help us take the next steps. The complementary nature of optical imagery and laser scanning has barely been exploited because of lack of methodology and algorithms. With the surmounting of these problems will arise the next bottleneck: GIS systems are not well equipped for analysing EO data, although they have been very successful in integrating data management and visualisation. The shortcomings include the transformation of EO ‘raw’ data from one form to another, such as from a point-cloud to building models; combining different data layers, carrying out network analysis and so on. Solution requires further efforts concerning data and metadata standards. Finally, today’s hardware, including interfaces such as screens, and communication, limit the use of GIS in field operations, while all phases of disaster management will eventually require GIS as standard backbone.

1Upcoming publication by Geist, Höfle, Rutzinger, et al., Laser Scanning - a paradigm change in topographic data acquisition for natural hazard management, in: Veulliet et al. (Eds.) Sustainable Natural Hazard Management in Alpine Environments (Springer).