Large-scale 3D Data Needed by Urban Areas

Geo-information for Disaster Mana

The tsunami in Asia has once again demonstrated that human beings are at risk at any time, anywhere. Disasters in highly populated environments are difficult to manage using only small-scale (1:10,000 to 1:250,000) 2D geo-information. Innovative technologies and working procedures are thus urgently required for the response phase of disaster and emergency management. International attention is drawn to the use of large-scale (1:500 to 1:2,000) 3D geo-information and 3D geo-information technology for disaster management in urban areas.

By Sisi Zlatanova, Andrea G. Fabbri, The Netherlands, and Jonathan Li, Canada

Time constraints, stress, and limited-capacity equipment are among many factors affecting rescue operations. Early warnings may help in evacuation and safety. Good collaboration and understanding is needed between teams in the health sector, the police, the fire brigade and civil rescue personnel; rescue teams of different countries should be able to collaborate as one unit. 3D geo-information plays a key role in the solution of these issues. Prior to the application of 3D geo-information, many problems concerning institutional, legal, structural and standardisation/exchange aspects have to be resolved.

Multi-user Groups

Organisations with normally distinctive mandates today design, store and manage geo-information. These organisations commonly operate independently and work only partially within a multidisciplinary environment; the interoperability of their systems is limited. Yet the real barriers to unified response lie not in lack of data or insufficient technical capabilities but rather in difficulties in making data available, providing the most appropriate data and making systems work co-operatively. Often there is automation, but only for carrying out dedicated tasks. To date, no mature system is able to support multi-user groups. With respect to multi-users, two categories of 'outdoor' users can be distinguished: rescue teams and citizens. 'Indoor' users include disaster managers, advisors, and observers such as local residents and media. The requirements demanded of a disaster management centre to serve these users, include:

- assembly and effective use of various information sources for planning and control
- provision of updated information to community and public; information on the current situation should be provided by on-site rescue teams
- transfer of on-site information in almost real-time to the centre for further analysis and redistribution
- rapid decisions on warnings and determination of evacuation routes using accurate and reliable geo-information
- communities at risk should be

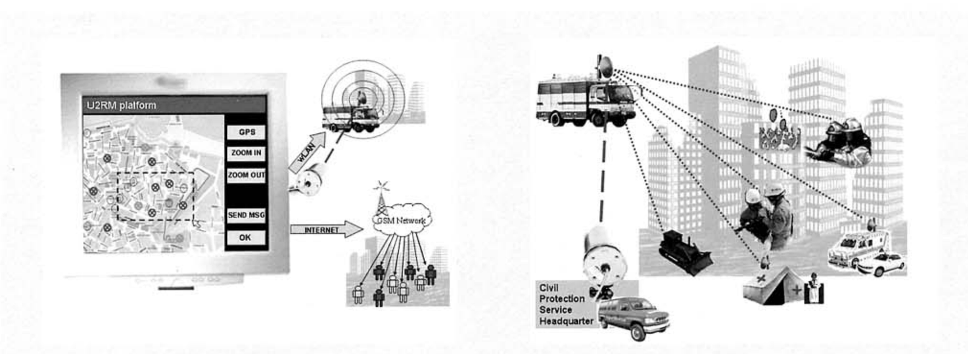

***Figure 1**, Dynamic, real-time, drag and select recipients (left) and portable, distributed, high-redundancy, ad-hoc WLAN (right). Image courtesy of FORTHnet, Greece.*

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informed within minutes of any decisions.

An intelligent disaster management system should thus be able to assist in the administration and analysis of data, predict trends and advise on any change of plans. The associated requirements of the information system include:
- information at all times, anywhere
- search, analysis and processing of all data sources
- real-time integration and presentation of data on all mobile and stand-alone systems
- alerting and guiding endangered people to safe area and guiding rescue teams to the endangered and to co-workers, under any circumstances
- individual and intuitive interfaces.

3D Data Collection

A number of surveys have shown the advantages of 3D models over 2D maps which contain just outlines of objects:
- users can better and faster orient themselves
- users get an adequate perception of the situation; the many 3D games which are part of the daily life of youngsters indicate change for real-world applications
- more sophisticated analysis and high realistic presentation of data.

Images collected from ground-based, airborne and space-borne digital imaging sensors, such as digital cameras, multi-spectral scanners, radar, and laser scanners are a major source of 3D data. Objects can be mapped from images directly geo-referenced by integrated navigation and positioning sensors. Mobile mapping meets the need for real-time data collection driven by integration of direct-geo-referencing, multi-sensor integration, data fusion, information extraction, mobile data management and value-added services. No single sensor system offers stand-alone information solutions. Moreover, the semantic contents of the various image types do not fully overlap with information needs. A practical solution is image coverage at multi-resolutions. For economic reasons, complete image coverage of the region should thus be done at coarse resolutions; where detail is insufficient additional higher-resolution imagery can be acquired on an area-by-area basis. For example, lacking detail in high-resolution satellite imagery can be supplemented by small-format digital images from ground-based and airborne platforms. When adequate data from previous surveys is available, re-mapping of unchanged areas becomes unnecessary. Multi-resolution coverage also presents image analysis challenges that go beyond change detection. These include automated geo-referencing of high-resolution images using GIS data or lower-resolution imagery, data fusion, 3D information extraction, rapid retrieval, integration, and representation of data from sensors and from servers using web technology.

3D Data Management

Systems maintaining geo-information are becoming more elaborated and richer in multiple functionality. Most software dealing with geo-data offers 3D visualisation on desktop and mobile devices. The integration of geometric data with administrative data in one model is well recognised by the industry; DBMS, CAD and GIS software can be easily integrated at database and product level for seamless exchange of data. Models such as geometry, topology, network in DBMS, CAD and GIS enable the performing of more complex analyses. With the rapid development of ICT, capacity for response has improved enormously; today this can meet the time-critical requirements of risk analysis. Nevertheless, 3D information services for disaster management still need extension of the spatial functionality with generic structures, functions and operations for performing 3D routing, generalisation, adaptation of different types of data and consistent on-site update. Extending management functionality into 3D is not a new research topic, but it is attaining critical importance for fighting crisis situations in urban areas. Research topics include:

Extending management functionality into 3D is attaining critical importance

- 3D data structures and applications addressing short-time response
- ontology for 3D data integration (multi-resolution, multi-temporal, multi-topology, indoor/outdoor, multi-domain)
- 3D analysis, especially in 3D navigation considering environmental and human factors
- data standards for import/export based on XML and GML
- context-aware engines and agents for query and analysis with respect to the front-end (content of situation, content of devices, content of human condition).

3D Positioning

Many possibilities for 3D positioning may already be under consideration, such as GNSS, telecommunication networks and LAN of hybrids of them. Advantages and disadvantages include:
- GNSS being operational outside, and quite accurate
- telecommunication networks being available inside but very inaccurate; companies are seemingly unwilling to invest in further developments towards accurate 3D positioning
- WLAN, which is broadband, being possibly mobile but requiring further research for implementing 3D positioning.

3D Visualisation

One challenging issue is the development of interfaces for hand-held devices. The use of 3D city models on handhelds is progressing fast. Viewers for 3D data already exist but these are currently adopted in some specific mobile terminals with small size and low resolution. The 3D data should be presented on a mobile device in an easily readable way for rescue teams and untrained users. Providing 3D navigation is a very important aspect for end-users. However, visualisation of a 3D route on handheld devices is still a tricky research challenge. This is because 3D representation increases the amount of data and hides information significantly when compared with 2D maps. Novel interfaces for mobile devices need further investigation. Topics may include intuitive graphics user interfaces for mobile workers and messaging (common-alert), as suggested by FORTHnet, in Greece (Figure 1).

3D Data Transmission

Communication of information between end-user and the central system is another important aspect. 3D models are large and make information communication more difficult. The bottlenecks of current data transmission will be reduced by the third generation of wireless communication networks (UMTS) with improved bandwidth. There will be an increasing demand for reduction of data volume, especially for communication on different networks, such as UMTS, and GPRS. Research and development, which is critical for disaster management, includes

- intelligent switching between different types of communication networks, and approaches for positioning systems
- compression of 3D data
- context-aware user profiles for monitoring status of mobile devices, emergency status of situations, etc.

Concluding Remarks

The development of a 3D system requires the united effort of users directly involved in the management of disasters, researchers, software developers and legal authorities. As (co-)chairs and scientific secretary of ISPRS WG IV/8, we have initiated a series of symposia which aim to open up broad discussion on advanced 3D geo-information technology able to support managing bodies, rescue teams and citizens in disaster management. The series kicks off with a 'First International Symposium on Geo-information for Disaster Management' to be held in Delft, The Netherlands, from 21st to 23rd March 2005.

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Further Reading

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Biography of the Authors

All three authors are on the board of ISPRS WG IV/8 for the period 2004-2008.

Dr Sisi Zlatanova is research scientist in the GIS Technology Section, OTB, of the Delft University of Technology. In 2000 she obtained her PhD from Graz University of Technology in Austria with a dissertation on 3D GIS for urban modelling. Her research interests focus on the 3D aspects of geo-information. She chairs ISPRS WG IV/8.

Dr Sisi Zlatanova

Dr Andrea G. Fabbri

Dr Andrea G. Fabbri is professor of Geoinformation for Risk Analysis at the Spatial Information Laboratory (SPINlab) of the Free University in Amsterdam, The Netherlands. He also holds the chair of environmental geology at the University of Milano-Bicocca in Milan, Italy. In 1981 he obtained a PhD in Geology from the University of Ottawa, Canada. His present research interests are in the digital representation of environmental indicators and indices and the spatial predictive modelling of natural hazards and environmental impacts. He is scientific secretary of ISPRS WG IV/8.

Dr Jonathan Li is assistant professor of Geomatics Engineering with the Department of Civil Engineering, Ryerson University, in Toronto, Ontario, Canada. In 2000 he obtained his PhD in Photogrammetry and Remote Sensing from the University of Cape Town, South Africa. His research interests include satellite remote sensing of urban environments, mobile mapping, Web-based environmental visualisation, wireless geospatial information systems, and spatial data integration for emergency services. He co-chairs ISPRS WG IV/8.

Dr Jonathan Li

Mrs Dr Eng. S. Zlatanova, GISt, OTB TUDelft, Jaffalaan 9, 2628 BX Delft, The Netherlands, e-mail: s.zlatanova@otb.tudelft.nl