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Geospatial Information Technology for Emergency Response

Disaster management is generally understood to consist of four phases: mitigation, preparedness, response and recovery. While these phases are all important and interrelated, response and recovery are often considered to be the most critical in terms of saving lives. Response is the acute phase occurring after the event, and includes all arrangements to remove detriments and a long-term inventory of supplies to deal with irreversible damage. The timely provision of geospatial information is crucial in the decision-making process, and can save lives and rescue citizens.

The aim of this volume is to share technological advances that allow wider, faster and more effective utilization of geospatial information in emergency response situations. The volume describes current accomplishments and challenges in providing geospatial information with these attributes, and is organized in six parts:

- Practice and legislation, with a focus on the utilization of geospatial information in recent disaster events, as well as resulting legislative attempts to share and access data.
- Data collection and data products.
- Data management and routing in 3D.
- Emerging technologies, including positioning, virtual reality and simulation models.
- Integration of heterogeneous data.
- Applications and solutions.

This volume is aimed at researchers, practitioners and students who work in the variety of disciplines related to geospatial information technology for emergency response, and represents the very best of current thinking from a number of pioneering studies over the past four years.

Dr. Sisi Zlatanova is Associate Professor at the GIS Technology Section, Delft University of Technology, and currently leads a theme group on 'Geo-information for Crisis Response'. Her research interests include the use of spatial technologies in emergency response, in particular where special attention is given to the third dimension: 3D object reconstruction, 3D data structures and geo-databases, 3D spatial relationships (topology) and 3D visualization (VR and AR). Sisi Zlatanova is currently serving as chair of the ISPRS WG IV/8 'Spatial Data Integration for Emergency Services, 2004-2008', and author of numerous publications on 3D modelling and technology for emergency response.

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Zlatanova & Li
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information from imagery

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Geospatial Information Technology for Emergency Response

Edited by Sisi Zlatanova and Jonathan Li

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Geospatial Information Technology for Emergency Response

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Introduction

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Disaster management is generally understood to consist of four phases: Mitigation, Preparedness, Response and Recovery. Mitigation describes activities aimed at reducing the occurrence of emergency situations (e.g., construction specifications for buildings to be able to resist earthquakes, dikes to prevent flooding, etc.). Preparedness focuses on active preparation among rescue forces (e.g., police, ambulance, fire) for emergency situations. Response is the acute phase occurring after the event. Recovery includes all arrangements to remove detriments and a long-term inventory of supplies to deal with irreversible damage. While all phases are interrelated and important, the *response* and *recovery* phrases are often viewed as the most critical in terms of saving lives. Time constraints, stress, equipment with limited capacities (power, display, etc.), and the involvement of numerous organizations in post-disaster operations are only a few of the factors complicating response and recovery. The timely provision of geospatial information can greatly help in the decision-making process, save lives and aid citizens.

The aim of this volume is to share exciting technological advances that allow wider, faster and better utilization of geospatial information in emergency *response* situations. "Fast," "context-aware," and "data integration" are key attributes of emergency response models and decision making frameworks. The chapters in this book describe current accomplishments and challenges in providing geospatial information with these attributes.

The book is organized in six parts. The first part describes practice and legislation, and focuses on the utilization of geospatial information in recent disaster events, as well as resulting legislative attempts to share and access data. The second part focuses on data collection and data products. The third part describes data management and routing in 3D. The fourth part focuses on emerging technologies, including positioning, virtual reality and simulation models. The fifth part focuses on the integration of heterogeneous data. The final part reports on various applications and solutions.

Part 1 Practice and Legislation

In the first chapter, Kevany describes the involvement of an experienced Geographic Information System (GIS) specialist as a participant in response efforts associated with several well known emergencies, such as the 2001 terrorist attack in the USA, the 2004 tsunami in South Asia and the 2005 Hurricane Katrina in the USA. The chapter outlines the "lessons learned" and the corresponding geospatial developments in the USA since 9/11. In chapter 2, von der Dunk provides some practical context to these lessons, concentrating on issues of copyrights, access to remote sensing data, responsibilities and liabilities of data providers, and security and dual-use issues. This chapter also describes the background of charters, directives and resolutions established by international organizations and the United Nations.

Part 2 Data collection and products
The second part includes three chapters that focus on airborne, satellite, and terrestrial sensors and techniques appropriate for acquiring data during an emergency response.

Kerle et al. provide an extended overview of airborne sensors, but also provide important definitions and constraints that frame the other two chapters in this section. Zhang and Kerle focus on satellite technology, including ongoing international remote sensing initiatives that emphasize rapid data collection. Li and Chapman provide an overview of the operational principles and the state-of-the-art development of terrestrial mobile mapping technology. As innovations in this field are relatively new, this chapter also outlines future research needs and describes necessary developments in mobile mapping.

Part 3 3D data management
While significant progress has been made in processing two-dimensional data, and numerous solutions for rapid 3D visualization are also available, the management and analysis of 3D data remains a major challenge. Simply put, the variety of data models, their resolution, details, and methods of representation (B-reps, voxel, Constructive Solid Geometry), etc., are larger, and there are few generally accepted or commercial systems available. The focus in this section is on innovative ideas in the areas of indexing, 3D management and analysis (and more specifically of 3D routing algorithms and visualization), which are emerging technologies in disaster management.

Servigne et al. present two approaches for fast structuring of sensor network measurements used for the monitoring of seismic activities. Arguing that real-time processing of such measurements is most efficient if organized in the main memory of the computer, two indexing schemas have been developed and tested for spatio-temporal data collected from fixed and agile sensors, which can handle updates and perform spatio-temporal analysis by giving preference to the last collected measurements. Lee and Zlatanova argue that reliance on only one data model (representation) might be insufficient for emergency systems. A hybrid model is proposed that combines the benefits of recently investigated and implemented 3D models. Focusing on geometry, topology and the network, they argue that formally described CAD models can be semantically simplified and integrated in emergency response models. Finally, Zhu et al. focus on emergency routing for vehicles. They are confident that 3D navigation is much more efficient and less ambiguous compared to the commonly applied two-dimensional approach. The authors present their innovative 3D algorithm and extensively discuss the construction of 3D dynamic road networks, indicating that this has to be done automatically from both existing and dynamic data.

Part 4 Emerging technologies
Emerging technologies such as 3D indoor positioning, virtual reality technology for training, collaboration and command control, and advanced visuals for decision makers are described, discussed and evaluated in three chapters.

Kolodziej explores the most promising technologies for indoor and combined indoor-outdoor positioning, and the infrastructures needed to support them. TV-GPS positioning technology is featured in this chapter, which also describes the design and implementation of several positioning systems and real-world applications, and shows how these tools are being used to solve problems that can be related to emergency responses. Kjems et al. elaborate on the use of Virtual Reality (VR) techniques for training of first responders in emergency response situations. In addition to an introduction to VR and several examples, the chapter includes a discussion of immersive VR technologies (those that cannot be obtained by ordinary computer monitors). Finally, Jern addresses the emerging field of Visual Analytics (VA), the science of analytical reasoning facilitated by interactive visual interfaces and creative visualization. VA tools help the user detect both expected and unexpected events, provide timely, defensible, and understandable assessments, and finally communicate risk effectively for action. VA tools are illustrated via a specific forecasting tool, "FloodViewer." Perhaps most importantly from the point of view of "context-awareness," the tool provides collaborative visualization tools enabling end users to view and discuss the forecasting results in real time across the network before finally interacting with the media, the police, other officials and the public.

Part 5 Integration of heterogeneous data

Part 5 focuses on semantic interoperability and access to data. Pundt provides an excellent overview of formal ontology, including languages to define ontology and efforts of geospatial communities for establishing ontology standards. Kolbe et al. pay special attention to the exchange of 3D models. CityGML is a semantic model (a kind of ontology) for representing city objects that can be extended easily to incorporate underground objects such as geological formations, underground utilities and construction. CityGML has the potential to contribute to faster employment and dissemination of 3D models during emergency response.

Parker et al. discuss the philosophy of the Ordnance Survey (one of the largest data providers in managing and supplying data for emergency preparation, response and recovery in the United Kingdom). The Ordnance Survey has adopted an elaborate framework to provide data in appropriate forms at any time when requested during emergencies. This chapter focuses on experiences with informational needs at different command and control levels.

Part 6 Applications and solutions

The final part contains three chapters that describe how geospatial information technology is used in different disaster scenarios, illustrated in case studies of transport accidents, floods and fires.

Grothe et al. present the activities of the Ministry of Transport, Public Works and Water Management in The Netherlands. This chapter outlines the use of geospatial information and geoservices in disaster management within the field of national transport and water management. The adopted concepts and corresponding developments are discussed through a crisis scenario expressed by a number of scenes. Zuilekom et al. present a decision support system for preventive evacuation of a population from a dyke-ring area. A framework for modelling evacuations is presented initially, and several methods are presented to assist practitioners in designing evacuation plans. A static quick-scan is developed as an alternative for time-consuming dynamic model runs. The case study focuses on the dike-ring area of Flevoland, The Netherlands. Finally, Johnson examines how GIS helps the fire service to meet the needs of the community.

The chapters in this book are aimed at researchers, practitioners, and students who work in a variety of disciplines with geospatial information technologies for emergency response, and they represent the very best of current thinking from a number of pioneering studies over the past four years. The origins of this book can be traced to the work titled "Knowledge-based technology for improving Urban and Urgent Risk Management (U2RM)" in October 2003, and subsequently to a series of conferences including: the 1st International Symposium on Geoinformation for Disaster Management (Gi4DM2005) held in Delft, The Netherlands, March 21–23, 2005; the 2nd Symposium (Gi4DM2006) held in Goa, India, September 25–26, 2006; and the 3rd Symposium (Gi4DM2007) held in Toronto, Canada, May 23–25, 2007. In addition, several other events provided inspiration and tentative results, including: the Bentley Research Seminar held in May 2005 in Baltimore, USA; the workshop on "Technology for Emergency Response" and the workshop on "Tools for Emergencies and Disaster Management" held in September 2005; "GIS Planet 2005" held in July 2005 in Estoril, Portugal; and the Vespucci Summer School held in July 2005 in Fiesole, Italy. Finally, the efforts of our own ISPRS WG IV/8 over the past two years to continue research and development in the area of spatial data integration for effective emergency services and disaster management have provided guidance and inspiration. The book itself is the result of a collaborative effort involving 33 researchers located in ten countries.

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