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The potential of Web-based GIS

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Geographic Information Systems (GIS) are now widely accepted as powerful and integrated tools for storing, manipulating, visualizing, and analyzing spatial data. As a new and emerging technology in the early 1970s, GIS had a profound influence on the capabilities of geographic analysis, and in retrospect marked a turning point in the reinforcement of geography as an explicitly spatial discipline. Also, at that time and on a parallel course, ArpaNet – the first established prototype of the Internet networking system, followed by an adoption of the Transmission Control Protocol/Internet Protocol (TCP/IP) in 1980s – was a force in the rapid development of Information Technology and Telecommunications (Comer 2000). The benefits of the implementation of the HyperText Markup Language (HTML), the HyperText Transfer Protocol (HTTP), and the World Wide Web (henceforth referred to as Web) as one of the main application of the Internet in the early 1990s was beginning to be recognized in GIS research (Hardie, 1998). GIS are usually centralized and need knowledgeable users for effective operation. With Internet technology, GIS was now able to make its concepts more open, accessible, and mobile to everyone thereby facilitating notions such as democratization of spatial data, open accessibility, and effective dissemination. In 1993 the Xerox Corporation developed its Map Viewer as the first experimental tool for interactive spatial data exploration over the Web. In 1994, The Alexandria Digital Library Project funded by the US National Science Foundation established the first distributed library service for spatially referenced data.

With a short history of only about 10 years, the integration of the Internet and GIS technology has produced an expanding area of research referred to as Web-based GIS, Internet GIS, On-line GIS, and Internet distributed GIServices. Early implementations were mainly dissemination of static maps, then interactive maps with pan-identify-zoom features, support for client/server designs, and advanced cartographic and geo-visualization tools (Kraak and Brown 2001). Out of this progression, Internet-based GIS emerged and expanded to yield Internet distributed GIServices with the capabilities to interact with multiple and heterogeneous systems and servers that support more advanced GIS functions. The expansion of Internet-based

GIS created many new research opportunities in Geographic Information Science (GISc).

Web-based GIS has enhanced the open use of GIS in three main directions: (1) spatial data access and dissemination, (2) spatial data exploration and geovisualization, and (3) spatial data processing, analysis and modeling. These directions are addressed by a growing number of research papers dispersed across various GISc journals, several learning and reference textbooks (Plewe 1997; Green and Bossomaier 2002; Peng and Tsou 2003), and software implementations from many common GIS vendors. This special journal issue draws on the insights and knowledge of expert researchers to provide a comprehensive and balanced perspective about the potential and utility of Web-based GIS in different geographical applications, and to provide a stimulus for future research directions in the field.

The first direction on spatial data access and dissemination begins with Kraak's paper on the influence of the Web as a medium permitting new trends in mapping and democratization of spatial data and maps. Cartography, scientific geovisualization and GIS use the map as their fundamental foundation. In the Web-based environment with basic GIS functionalities, the map becomes dynamic, interactive and accessible to a wide selection of users as a visual communication tool. The paper by Peng and Zhang emphasizes the significance of spatial data interoperability and superior graphic image outputs to the potential of Internet GIS. They propose the geography markup language (GML) as a coding and data transmission mechanism to achieve interoperability, the scalable vector graphics (SVG) to enhance the quality of the data display over the Web, and OpenGIS Web feature service (WFS) specifications mechanism to improve access and retrieval of spatial data. Two case studies demonstrate the potential of these Open GIS Consortium (OGC) specifications to improve Internet and Web GIS capabilities.

The second direction on spatial data exploration and geovisualization to enhance stakeholder participation is addressed in papers by Evans et al., and Dragicevic and Balram. Evans et al. uses a Web-based GIS design to involve the public in spatial decision-making about radioactive waste management. An interactive Web-based tool was developed for participants to explore digital maps, think spatially and express opinions about the selection of various criteria related to the management problem. The authors examined the attitudes of the public towards the Web-based GIS tool and understanding of the system. They also examined how geographic information impacted spatial decisions and attitudes toward the "Not In My Back Yard" syndrome at the national level. The paper by Dragicevic and Balram develops a Web-based GIS framework using the Spatial Collaborative Delphi method to elicit expert opinion in distributed planning procedures. The authors used Web-based GIS functions in their design to facilitate spatial data exploration and provide the capability for stakeholders to represent opinions about natural resources conservation by annotating base maps using polygons, lines and points. The created maps provide the basis to structure discussions towards various levels of agreement. The advantages and potential of the Web-based GIS framework for synchrotrons and asynchronous exchange and communication between geographically dispersed stakeholders and planners are discussed.

The third direction on the capabilities for spatial data processing, analysis, and modeling using Web-based GIS are presented. The paper by Tsou proposes the integrated prototypic Web-based GIS and Analytic Tools (WGAT) that combine data archiving, information display, and spatial analysis services for remote sensing data processing. The highly functional Web-based architecture provides easy access to spatial raster data and facilitates image analysis and change detection capabilities for natural resource managers and regional park rangers. Sakamoto and Fukui develops a Web-based spatial decision support system framework that uses multi-criteria optimization and fuzzy structural modeling tools for exploratory visual analysis and mapping of the obtained results. The design principles employ an intuitive user interface for multi-criteria ranking by means of importance rather then ordinal numbers. This makes the modelling open for both technical and non-technical users. The evaluation of livable environments as an application is described. The paper by Anselin et al. integrates exploratory spatial data analysis within an Internet GIS framework. The authors used extreme value maps, smoothed rate maps, and the Moran scatterplot as spatial analysis methods to identify and visualize spatial data outliers using their Web-based analytical GeoTools. The developed analytical tools improve access to the spatial analytical methods that are still absent in typical statistical and GIS software.

The collection of papers presented in this special issue captures the broad diversity of research interests and problems that currently exists in Web-based GIS studies. Web-GIS is a transdisciplinary subject and hence its advancement relies on associated knowledge domains such as GISystems and GIScience, together with contributions from a wider area of application including geography, cartography, geo-visualization, computer science, participatory research, and spatial decision-making. Web-based GIS enhances the potential for further developments in other areas such as spatial analysis and modeling, wireless and mobile services, 3D data access and query that are anticipated to experience increased research focus in the coming years.

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