# CaGIS vol. 35, No. 3 (July 2008)

**Modeling the Potential Swath Coverage of Nadir and Off-Nadir Pointable Remote Sensing Satellite-Sensor Systems**

Michael E. Hodgson and Bandana Kar

Pointable sensor systems onboard many earth resources satellites today, particularly the higher spatial resolution sensors, provide for a near infinite set of collection opportunities. Satellite orbits of these systems are not systematic repetitive tracks. Predicting future collection opportunities requires predicting where the satellite will be and then computing the potential swath coverage from a pointable sensor along these orbits. While each agency or company models its own satellite-sensor systems, few publicly available sources exist for mapping future satellite ground tracks. Evaluating collection opportunities from multiple satellite-sensor systems from different agencies/companies is problematic. The purpose of the research described in this article was to develop a generic approach for modeling future satellite-sensor collection opportunities. In this article, formulae are developed for computing the potential swath coverage, and an algorithm is designed for constructing the potential swath coverage area. The solution to the swath coverage problem is based on spherical trigonometry, a well known map projection (i.e., azimuthal equidistant map projection) used in an unconventional dynamic form, and a satellite orbital propagation model. We demonstrate how the computation of the swath coverage area can be accomplished using a temporal series of re-centered map projections.

**Equations of the Mayr Projection**

Cengizhan Ipbuker

In this study, the pseudo-cylindrical projection of Franz Mayr is examined in detail. The computation of one of Mayr's projection equations depends on the solution of an elliptical integral. It is this characteristic of the projection that most likely contributes to it being the neglected one among the group of the pseudo-cylindrical projections available today. Franz Mayr used the Legendre tables for the elliptical functions E and F and gave the plane coordinates within one-degree latitude intervals on the 90°meridian. The research reported here derives analytical

expressions instead of using the elliptical integral and the interpolation between the table values. Four different solutions have been introduced for mapping applications. The distortion quantities are also presented and discussed.
KEYWORDS: Equal-area pseudo-cylindrical projections, Mayr projection, elliptic integral

**Explaining Map-reading Performance Efficiency: Gender, Memory, and Geographic Information**
Robert Earl Lloyd and Rick L. Bunch
This paper explains the performance of a map-reading task that required subjects to locate a state on a map of the United States after being given the state's name. Response times and accuracy were hypothesized to be a function of differences among the decision makers and among the states. The cognitive science literature suggests that variation in performance can be explained by the interaction of biological and environmental variables. Individual differences in gender, working memory capacity, and brain lateralization were hypothesized to affect performance of the spatial task. Results indicated gender could be a more informative variable than sex. Subjects, who identified with both feminine and masculine characteristics, had the fastest mean response times. Subjects, who did not identify with feminine or masculine characteristics, had the most accurate responses. Subjects who combined higher verbal and spatial working memory capacities had both the fastest and most accurate performances. The results supported other studies indicating a non-linear relationship relating sex, brain lateralization, and accuracy. Covariates related to gravity model variables were also significantly related to performance.
Keywords: Map-reading task, geographic information, brain lateralization, gender, and memory capacity

**Expanding Display Size and Resolution for Viewing Geospatial Data: A User Study with Multiple-Monitor High-Resolution Displays**
Candice R. Luebbering, Laurence W. Carstensen, James B. Campbell, and Lawrence S. Grossman

Multiple-monitor configurations provide attainable, low-cost ways to create large, high-resolution displays. Increased screen space is particularly useful for viewing and interpreting rich, complex geospatial datasets, as both context and amount of detail can be simultaneously increased. To explore the utility of increasing display size and resolution for viewing geospatial data, this experiment required 57 subjects to perform map and image reading tasks using raster and vector data on one of three different monitor configurations: one (1280 × 1024 pixels), four (2560 × 2048 pixels), and nine (3840 × 3072 pixels). A computer program captured subject performance by recording answers, mouse-click locations, viewing areas, tool usage, and elapsed time. A post-experiment questionnaire obtained additional qualitative feedback about subjects' testing experiences. Overall, subjects performed more efficiently on the larger display configurations, as evidenced by a reduction in completion time and in virtual navigation (mouse clicks) used to finish the test. Tool usage also differed among monitor conditions, with navigation tools dominating on the single monitor and selection tools (tools used to provide answers) dominating on the nine-monitor display. Although overall results indicated the effectiveness of larger displays, task-level analyses showed that performance varied considerably from task to task.

# CaGIS Vol. 35, No. 2 (April 2008)

**Modeling and Visualization for Spatial Decision Support**
Suzana Dragićević
Prior research endeavors in the disciplines of spatial modeling and visualization have developed primarily along parallel streams. This is inadequate because geographic problems are too complex to yield reliable solutions from each discipline alone. Innovative theories and new technologies are now providing greater opportunities in Geographic Information Science research to embed spatial modeling and visualization concepts into spatial decision support systems. Improvements in spatial representation formalisms and computational processing capabilities have influenced how geographic problems are described, visualized, and

modeled in space and time. One drawback, however, is that existing models and analytical approaches, as well as cutting-edge geo-visual interfaces and tools, are often purely theoretical or are developed for hypothetical or non-real data. Hence, they can be viewed as toys for developing "what if?" scenarios (Couclelis 2005). This critique can be addressed by situating the spatial decision support system in a real-world context and rigorously evaluating its outcome. Consequently, specific implementations of such spatial decision support systems as planning support systems, spatial understanding and decision support systems, and collaborative GIS have emerged (Balram and Dragićević 2006).

Spatial decision support systems can be considered as praxeology component of GIScience because they represent a combination of computer-based tools that use geospatial data in semi-structured frameworks to improve real-world decision-making. When the spatial decision support system is not rooted in the realities of the problem, or when such systems contain tools that represent the problem inadequately, the end-users involved in collaborative and group decision processes are limited in their ability to estimate the risks and consequences of inappropriate management, policies, or planning strategies. Hence, the integration of spatial modeling and visualization approaches is crucial for generating new and intuitive ways of examining real-world problems.

Effective spatial decision support systems should have powerful and easy-to-use interfaces, interactive and recursive problem-solving capabilities, and analytical models with data for the exploration of solution spaces supporting multiple decision-making styles (Densham 1991). However, these characteristics are yet to be fully integrated into the systems. On the modeling front, the integration of land-use models into spatial decision support systems is still in its infancy (White et al. 2004). There is a need for enhanced visual modeling capabilities (Batty et al. 2006) and for improved, realistic, well calibrated, and validated simulation models. On the geovisualization front, more sophisticated visualization approaches capable of dealing with the spatial and temporal dimensions are progressing in the GIScience areas of geo-collaboration (MacEachren and Brewer 2004) and geo-visual analytics (Adrienko et al.

2007). Integrating the spatial modeling and visualization perspectives can provide new ways of effectively dealing with the complex nature of geographic problems.

This special issue of *Cartography and Geographic Information Science(CaGIS)* focuses on some of the work done to respond to these needs, drawing special attention to current research on integrating geospatial modeling and visualization so as to enrich and support the decision-making process. In the first paper, Jun Chen, Chaoying He, Jie Jiang, and Gang Han present a distributed method that extends speech act theory to the negotiation and reconciliation of inconsistent perspectives of different participants in a spatial decision environment. They implemented a Web prototype that permits visualization and analytical use of geospatial data and speech acts for conflict elimination in spatial decision making process applied to curbing the spread of infectious disease.

Mathieu Petit, Cyril Ray, and Christophe Claramunt outline in their paper a contextual modeling approach based on adaptive interaction in GIS which takes into consideration the relevance of geographical data, geographic context evolution, and levels of management for various user group profiles. The approach is applied to mobile and distributed GIS used in maritime navigation.

In the third paper, Shahram Yassemi and Suzana Dragićević extend a cellular automata model of forest fire propagation to a web-based spatial environment. The model augments the capacity of stand-alone dynamic models and provides a framework for real-time asynchronous decision-making process that can incorporate experts and stakeholders to intervene in disaster management situations.

Zeng Chang and Songnian Li describe the development of a three-dimensional web GIS collaborative environment for group decision-making in the fourth paper. Their prototype system permits shared 3D visualization, place-time interactions, and geospatial data.

In the final paper, Christian Stock, Ian D. Bishop, Alice N. O'Connor, Tao Chen, Christopher J. Pettit, and Jean-Philippe Aurambout present landscape planning tools using virtual reality and GIS technologies. The tools provide a collaborative multi-user decision making environment for real-time, three-dimensional exploration of spatial data and hypothetical

scenarios of process models. Collectively, these five papers capture the mainstream of current spatial decision support systems research.

## PAPERS

### Reconciliation of Inconsistent Perspectives in Collaborative GIS

Jun Chen, Chaoying He, Jie Jiang, and Gang Han

Collaborative GIS provides a spatially referenced negotiation environment for decision makers to put forward their perspectives, discuss their differences, and, ultimately, make decisions. Recent research has focused on enabling the representation of, and selection from among, different opinions, while discussion among people has been ignored. This paper reports on a discussion process aimed at reconciling inconsistent perspectives in distributed workgroups. The Speech Act Theory (SAT) of Austin was extended to define both non-spatial and spatial speech acts in the context of a negotiation. A coordination process was modeled by these speech acts. Then, inconsistent perspectives were reconciled using detection of inconsistency, or initial integration of perspectives, or reconciliation of collaborators. The method we propose makes it possible to effectively describe the speech acts and use them to naturally represent the reconciliation process. A prototype system based on this approach was implemented in experiments. Their results demonstrate that a good abstraction of the negotiation process will facilitate the coordination of discussion among people and provide a criterion for system designers.

**KEYWORDS:** Collaborative GIS, inconsistent perspectives, speech-act theory (SAT), reconciliation process modeling

### An Adaptive Interaction Architecture for Collaborative GIS

Mathieu Petit, Cyril Ray, and Christophe Claramunt

The research presented in this paper explores and models the interactions needed for the development of a collaborative and adaptive geographic information system (GIS). The proposed framework is based on a multidimensional contextual approach that differentiates between the user, the geographical, and the device contexts. The spatial distribution of the GIS functional components allows for the characterization of different geographical context configurations. These

configurations act as a support for the derivation of user groups. The interfaces and functionalities offered by the adaptive GIS are modeled at the group level and derived from the interface usages and habits. The spatial behaviours that denote user experiences within a group are shared with other users within that group. Such an approach provides an adaptive and collaborative environment that favors exchanges and enriches the quality of services offered to the users acting in such a GIS environment. The framework was tested in the context of maritime navigation.

**Web Cellular Automata: A Forest Fire Modeling Approach and Prototype Tool**

S. Yassemi and S. Dragićević

The integration of geographic information systems (GIS) and spatio-temporal modeling procedures with Internet technology can significantly improve the decision-making process for environmental and disaster management. The objective of this study is to develop an approach to integrate a cellular automata (CA) forest fire behavior model with the world wide web. The developed CA model extends the capability of the static raster GIS by incorporating spatial dynamics into the forest fire phenomena. The developed CA model comprises topographic, forest fuel and weather variables as the key drivers of forest fires. The web-based modeling environment used ASP.NET as the server-side platform, and client-side programming with JavaScript extended the functionality of the web client. The web-based CA model and its consistent user-friendly interface will provide fire managers with a decision support and rapid disaster management tool with such advantages as access to real-time geospatial and environmental data, computer platform independence, and enhanced accessibility of spatial modeling tools.

**KEYWORDS**: Web modeling, cellular automata, Web GIS, forest fires, simulation methods, spatial decision support.

**Architecture Design and Prototyping of a Web-based, Synchronous Collaborative 3D GIS**

Zheng (Eric) Chang and Songnian Li

Collaborative GIS has emerged as an efficient, spatial decision-making tool, especially when 3D GIS models are integrated. While centralized architecture is still dominating the design and development of such tools and/or systems, alternative architecture, such as peer-to-peer (P2P), and hybrids have been given increasingly more attention in designing more scalable and efficient systems. This paper presents a conceptual hybrid system architecture for the development of integrated, synchronously collaborative environments with 3D GIS tools for group decision-making and 3D information sharing. In this paper, we discuss the major design issues related to such an architectural design and identify the spatial requirements of synchronous collaborative 3D GIS. A hybrid architectural model integrating centralized and replicated computing architecture is then designed to address the identified requirements. The proposed architecture was tested using data/message flow models developed to facilitate component-based collaborative 3D GIS systems. The results show that collaborative 3D GIS require collaboration computing different from that applied in generic GIS systems, and that a component-based development approach can lead to more light-weight systems.
**KEYWORDS**: 3D GIS, synchronous collaboration, distributed environment

**SIEVE: Collaborative Decision-making in an Immersive Online Environment**

Christian Stock, Ian D. Bishop, Alice N. O'Connor, Tao Chen, Christopher J. Pettit, and Jean-Philippe Aurambout

Over the recent years, spatial data have become more accessible to members of the public, and there is an increased awareness that spatial data are an essential ingredient in the development of governance policies. In parallel, computing devices that can render real-time 3D environments in nearly photo-realistic quality have become a common household item. Integrating spatial data and virtual environments opens the possibility of presenting spatial data in a highly visual way—the same way we experience our everyday world. We have developed a landscape planning tool called SIEVE (Spatial Information and Visualization Environment), which allows users to explore existing spatial data and hypothetical future scenarios in a real-time 3D environment, links to environmental process models outcomes, and also provides a

collaborative decision-making environment. SIEVE has an automatic model-building component that allows users to select a region on a 2D map using a web portal and to download automatically generated 3D landscape environments. SIEVE not only models above-ground features but also incorporates underground features. This allows users to see the connection between below- and above-ground processes. Lastly, SIEVE incorporates a multi-user environment that allows users from different locations to gather in the virtual landscapes for exploring and decision-making purposes.

## CaGIS Vol. 35, No. 1 (Jan 2008)

**Multi-representation Databases with Explicitly Modeled Horizontal, Vertical, and Update Relations**

Matthias Bobzien, Dirk Burghardt, Ingo Petzold, Moritz Neun, and Robert Weibel

This paper presents a new approach to combining multi-representation databases with the generalization and update processes. It leads to a tightly integrated model which is a part of the existing cartographic GIS axpand. The approach is based on the mathematical concept of relations and, in particular, on three different types of relations: horizontal (within one resolution), vertical (between different resolutions), and update. Horizontal relations allow the representation of relationships between features within one resolution. Examples are partitions, neighborhoods, and topology. The vertical relation represents the relationship between features of different resolutions. This originates from a generalization or matching process. The update relation describes temporal changes of features. After a detailed theory about the relation types introduced, the paper continues with a discussion of their similarities and differences, with a focus on implementation in a multi-representation database. A prototype demonstrates the generalization of buildings and roads from vector data at 1: 25,000 to 1: 50,000 scales. The paper ends with conclusions and an outlook on further research tasks.

**Framing the Days: Place and Narrative in Cartography**

Margaret Wickens Pearce

One of the themes of critical cartography is the question of how to map space as it is experienced. The conventions of Western cartographic language—the visual variables and their grammar—are structured to communicate spaces of homogeneity and modernity, not the spaces shaped by human experience. How then can we map place? I review some of the ways in which mapmakers have addressed this question in their visual and written works and propose another technique for uncovering place, using narrativity. Through the example of a historical map project, I consider the dialectic of place and narrative and demonstrate how this dialectic can be encoded in cartographic language.

**KEYWORDS:** Place, narrative, cartographic language, graphic variables

**Supporting the Process of Exploring and Interpreting Space-Time Multivariate Patterns: The Visual Inquiry Toolkit**

Jin Chen, Alan M. MacEachren, and Diansheng Guo

While many data sets carry geographic and temporal references, our ability to analyze these datasets lags behind our ability to collect them because of the challenges posed by both data complexity and tool scalability issues. This study develops a visual analytics approach that leverages human expertise with visual, computational, and cartographic methods to support the application of visual analytics to relatively large spatio-temporal, multivariate data sets. We develop and apply a variety of methods for data clustering, pattern searching, information visualization, and synthesis. By combining both human and machine strengths, this approach has a better chance to discover novel, relevant, and potentially useful information that is difficult to detect by any of the methods used in isolation. We demonstrate the effectiveness of the approach by applying the Visual Inquiry Toolkit we developed to analyze a data set containing geographically referenced, time-varying and multivariate data for U.S. technology industries.

**Humorous Maps: Explorations of an Alternative Cartography**

Sébastien Caquard and Claire Dormann

Maps are generally viewed as functional artefacts. They are considered accurate and useful conveyors of information, helping individuals find

their way, understand environments, and inform decisions. However, maps also have a strongly pleasurable component. They generate and support narratives, they are tied to emotions, memories and adventures, and sometimes they make people laugh. In this paper, we engage with a very specific form of alternative cartography: humorous maps. We begin with an interdisciplinary review of the general theories and functions of humor to discuss the three major impediments of the use of humor in cartography: (1) the lack of recognition of the potential of humor; (2) the complexity of humor creation; and (3) the scientific orientation of modern cartography. We then turn to alternative forms of cartography to emphasize the function of humor in mapmaking through a chronological review of some examples of humorous maps. Through this review, we demonstrate that humorous maps caricature scientific cartography by drawing on the latter's persuasive power. In this sense, humorous maps can destabilize the scientific and technological bases of contemporary cartography. Freed from scientific constraints, humorous maps provide societal commentaries rather than geospatial facts. We conclude by arguing that humor—along with other forms of expression—can be combined with scientific maps to generate hybrid forms of cartography; these new representations could help us to represent anew the worlds we inhabit.