CaGIS Vol. 27, No. 4 (Oct 2000)

CaGIS Vol. 27, No. 4 (2000)

Introduction - Terry Slocum

With this issue, I officially take over the editorship of Cartography and Geographic Information Science (CaGIS) from Bob Cromley. It is my intention and the goal of everyone involved in publishing CaGIS to provide, in our journal, a fair representation of the research context in which cartographers and geographic information scientists from around the world are working. As in the past, the journal will continue to publish papers with a cartographic emphasis, but we will also be interested in papers that might be labeled "pure GIS." The key is that papers should provide theoretical advancements in cartography and GIScience.

Several special issues are planned for the coming two years. For 2001, Alan MacEachren and Menno-Jan Kraak will co-edit Research Issues in Geographic Visualization, and Robert McMaster will edit Generalization Issues in Cartography. For 2002, David Woodward and Mark Monmonier will co-edit the History of 20th Century Cartography. Other special issues we are considering include GIS and public health, cognition, community mapping, geocomputation, open GIS, internet-based teaching materials, and visualization (covering completed research as opposed to research issues). I encourage every cartographer to contribute to our effort to make Cartography and Geographic Information Science one of the leading voices of our discipline and the broader field of spatial data representation and use.

In the transition period between June 1999 and October 2000, I have received more than 30 manuscripts for publication in the journal. The three appearing in this issue are an example of the topics readers may expect to find appearing in subsequent issues. Because this is the last issue in volume 27, I would also like to thank reviewers who have given graciously of their time to complete reviews.

Reviewers in 1999-2000

Marc Armstrong, David Bennett, Cynthia Brewer, Aileen Buckley, Barbara Buttenfield, Nicholas Chrisman, Keith Clarke, Helen Couclelis, William Craig, Robert Cromley, Geoffrey Dutton, J. Ronald Eastman, Stephen Egbert, Johan Feddema, Scott Freundschuh, Philip Gersmehl, Patricia Gilmartin, Michael Goodchild, Stephen Guptill, Francis Harvey, Michael Hutchinson, Piotr Jankowski, Christopher Jones, Peter Keller, Karen Kemp, Fritz Kessler, Menno-Jan Kraak, John Krygier, Mark Kumler, Nina Lam, Mitchel Langford, Peter Laskowski, Jay Lee, Robert Lloyd, William Mackaness, Alan MacEachren, Scott Mackay, George McCleary, Robert McMaster, Janet Mersey, Mark Monmonier, Joel Morrison, Timothy Nyerges, Nancy Obermeyer, Michael Phoenix, Thomas Poiker, Keith Rice, Dianne Richardson, Robert Rundstrom, Robert Rugg, Alan Saalfeld, Eric Sheppard, Daniel Steinwand, David Theobald, Derek Thompson, Barbara Tversky, E. Lynn Usery, Denis White, David Woodward, Michael Worboys, May Yuan

Designing Effective Bivariate Symbols: The Influence of Perceptual Grouping Processes

Elisabeth S. Nelson

The purpose of this research was to empirically assess perceptual groupings of various combinations of symbol dimensions (e.g., graphic variables) used in designing bivariate map symbols. Perceptual grouping ability was assessed using the theory of selective attention, a construct first proposed in psychological research. Selective attention theory contends that one's ability to analyze a symbol's dimensions-such as color or size-is affected by other dimensions present in the same symbol. Symbol dimensions are described as either separable (capable of being attended to independently of other dimensions), integral (cannot be processed without interference from other dimensions), or configural (i.e., show characteristics of both integrality and separability, which may also form new, emergent properties). Without empirical evidence describing such interactions for various combinations of symbol dimensions, cartographers cannot truly evaluate the functionality of the symbols they use on maps. The symbol dimensions or graphic combinations chosen for this study were selected to incorporate a wide

range of traditional cartographic symbolization, including line and lettering symbolization, areal shading, dot patterns, and point symbols. Combinations were examined in an abstract setting using a speeded classification task, which is the traditional means of studying selective attention. Subject reaction times provided an assessment of the levels of integrality, separability, and configurality. Results suggest that most symbol dimension combinations are either separable or exhibit evidence of asymmetrical dimensional interactions. Findings from this study will be integrated into subsequent experiments, the results of which will assist cartographers in the design of complex map symbols.

Developing a Geographic Visualization Tool to Support Earth Science Learning

Mark Harrower, Alan MacEachren and Amy L. Griffin

This paper reports on the development and assessment of the EarthSystemsVisualizer (ESV), a geovisualization tool designed to facilitate learning about global weather. Our goals in designing ESV were to evaluate two exploratory spatial data analysis (ESDA) techniques, temporal brushing and temporal focusing, and to determine whether interactive geovisualization tools influence problem solving strategies, approaches to learning, and students' ability to generate hypotheses about earth-science processes. Focus group sessions were conducted with both expert and novice users to assess an initial design for the ESV interface prior to conducting a task-based assessment of ESV use. Changes were implemented in response to the focus group results, including the redesign of a temporal legend and improved speed and direction controls. Our task-based assessment considered student reactions to components of ESV, especially whether they could use it to answer questions about global-scale weather processes, and whether the system (particularly its focusing and brushing tools) had an impact on the hypotheses generated about relationships among weather variables. The assessment revealed that focusing and brushing had little impact on students' ability to answer questions about weather processes, and that performance suffered for students who were confused by the focusing and brushing tools. In fact, students who understood the tools performed

the best, but students without the tools performed better than those who had the tools but were unsure how to use them. We also concluded that the level of the visualization system must be well matched to the knowledge users have about the application domain: students who already possessed an advanced understanding of meteorology or climatology benefited less and were more critical of the system than students with an intermediate or a novice level of understanding.
KEYWORDS: Map animation, geographic visualization, interactive cartography, temporal legends, spatiotemporal analysis, user testing

Interrogating Land Cover Categories: Metaphor and Method in Remote Sensing

Paul Robbins and Tara Maddock
The increasing sophistication of classification techniques used in land use and land cover analysis has not been matched by attention to the origin and effects of land cover categories. While classifications appear unproblematic and self-evident, they carry with them their own histories, meanings and effects, which remain largely unexamined. In an effort at such scrutiny, we examine the origins of land cover categories deployed in remote sensing and conclude that categories are theory-laden metaphors and occur epistemologically prior to any clustering algorithm, no matter how sophisticated. We describe the problematic effects that the imposition of classification systems in place of in situ knowledge of the landscape can have, especially in a colonial or post-colonial context. As an alternative to imposed classification, we propose and demonstrate an empirical technique based upon a growing body of work in participatory GIS. The method compares image classifications based on local and expert knowledge, using a case study from Rajasthan, India, concluding that differing metaphors of landscape lead to divergent measures of land cover.
KEYWORDS: Land use and land cover, remote sensing, metaphors, participatory geographic information science, Rajasthan, India

Book Reviews

Remote Sensing of the Environment: An Earth Resource Perspective

John R. Jensen. Prentice Hall, Upper Saddle River, New Jersey. 2000. ISBN 0-13-489733-1. xvi and 544 pp, appendix, photos, maps, diagrams, tables, 32 pp of color plates. Hardcopy $91.

Reviewed by: James W. Merchant, University of Nebraska-Lincoln

John R. Jensen's new book, Remote Sensing of the Environment: An Earth Resource Perspective, is a very welcome addition to the existing array of texts dealing with remote sensing, and a most able complement to his widely used book on digital image analysis, Introductory Digital Image Processing: A Remote Sensing Perspective (2nd ed., Prentice Hall, 1996). In the preface of the new book it is noted that the "book was written for physical, natural and social scientists interested in how remote sensing ...can be used to solve real-world problems." In this task, it succeeds admirably.

Remote Sensing of the Environment is comprised of 13 chapters, the first nine of which cover the physical fundamentals of remote sensing; principles of electromagnetic radiation; aerial photography and aerial platforms; elements of visual image interpretation and photogrammetry; multispectral remote sensing systems; thermal infrared systems; active and passive microwave remote sensing techniques; and lidar remote sensing. Four concluding chapters deal with applications of remote sensing in the vegetation sciences; water resources sciences; the urban landscape; and investigations of soils, minerals and geomorphology. Each of the book's chapters includes several pages of references, many from journals published as recently as 1999. The text is, in fact, distinguished throughout by its up-to-date coverage, including, for example, thorough treatments of both the IKONOS and Terra satellite systems launched in 1999, and of sensors such as EO-1 that are scheduled to become operational in the near future. An unusually detailed six-page table of contents supplements a comprehensive index to enable the reader to easily find material of interest.

The narrative is enhanced by hundreds of well selected and well designed tables, diagrams, photographs, maps and images, including 32 pages of color plates. The reproduction of both black and white and color graphics

is uniformly excellent, and enhanced by the book's relatively large (8.5 x 11 inch) format. Indeed, the artful design of the integrated text and graphics makes for a far more compelling and interesting presentation than that offered in other contemporary introductory remote sensing textbooks.

The book concludes with a thorough appendix that provides guidance to additional sources of information on remote sensing, including listings of major textbooks, on-line tutorials, professional societies, national space agencies, major journals, and sites for acquiring aerial photography and multispectral and radar data. Internet addresses are provided for virtually all listings. To augment the text and to provide for updates, the author has established two Internet sites at http://www.cla.sc.edu/geog/rsbook/links/ (still under construction as of August 2000) and http://www.cla.sc.edu/geog/rsbook/exercises/. The latter site provides 13 laboratory exercises keyed to the chapters in the book.

Remote sensing is a large, diverse, and rapidly changing area of technology with myriad applications. No single book can be expected to cover all aspects of the field in equal depth, yet Remote Sensing of the Environment is outstanding in a great many areas. Among the book's many strengths are its discussions of energy-matter interactions; physical characteristics and operation of virtually every significant sensor (past, present and near-future); analysis and applications of hyperspectral data; formulation and application of vegetation indices; and estimation of biophysical parameters via remote sensing. Complex topics such as radar interferometry and the bidirectional reflectance distribution function are treated with technical rigor, but in such a way that they will be readily comprehensible to most readers.

Of course, in order to keep the book a reasonable length, some compromises in subject matter were clearly inevitable. Procedures for collecting ground truth and methods for assessing the accuracy of products derived from remote sensing (e.g., development and analysis of error matrices) are, for example, occasionally alluded to, but never presented in detail. Moreover, there is scant discussion of digital image analysis techniques (e.g., multispectral classification), even though images and maps derived via digital image processing are scattered

throughout the book (e.g., plates 10-2 and 10-5). In the preface, it is explicitly stated that this book is intended as a companion volume to Jensen's previously published text on digital image processing (in which, incidentally, accuracy assessment is also discussed). Nonetheless, Remote Sensing of the Environment would be strengthened by an addition of an elementary, conceptual overview of some important techniques in digital image analysis, and a brief introduction to accuracy assessment. Such additions would better enable the book to serve as a stand-alone text for a one-semester survey course in remote sensing of the sort that most in the book's intended audience are likely to take.
The many virtues of Remote Sensing of the Environment: An Earth Resource Perspective set it quite apart from other contemporary works covering some of the same subject matter. It is a book that would serve as a superior text for an introductory and/or intermediate level course in remote sensing. As a reference, the volume should be in the library of virtually every remote sensing specialist.

GIS and Health

Anthony Gatrell and Markku Löytönen. 1998. Taylor & Francis, Philadelphia, Pennsylvania. ISBN 0-7484-07790. 212 p.
Reviewed by: Deborah Thomas, University of Colorado at Denver
The recent burgeoning of GIS applications in public health calls for a thorough appraisal of the use of this technology within the discipline. Gatrell and Löytönen compiled a book that not only presents the complexity of using GIS for research in public health, but also suggests future directions for GIS applications in this area. This book is the sixth in the GISDATA Series edited by Masser and Salgé that highlights advances in the European GIS community. Even with a European focus of the volume, many of the topics presented are relevant to a broader set of GIS and public health researchers.
The book is divided into two sections: methodological issues and applications. The editors set the tone of the book in Chapter 1. By their own admission, the focus of the book is on environmental/spatial epidemiology rather than on more extensive public health issues, such as access to health care or equity of provided services. Although several of

the chapters briefly touch on broader public health questions, a distinct bias toward epidemiology exists throughout the book.

The next six chapters focus on methodological issues that have come up with the use of GIS for public health analysis. Jacquez leads the way by cautioning against the "gee whiz" effect that GIS can have when misleading maps are produced. Instead, the author contends that GIS should be used within an appropriate study design and that the same set of data cannot be used to both generate and test a hypothesis. Haining and Kulldorff concentrate almost entirely on spatial statistical analysis in the next two chapters, barely mentioning GIS. Admittedly, the use of GIS is closely linked to spatial statistics and thus, one cannot be discussed without the other. In fact, many of the data and methodological issues presented are directly relevant to GIS. The discussion turns to air pollution modeling when Collins illustrates how environmental modeling and health data can be combined in a GIS environment. In the last chapter of this section, Löytönen deals with the issue of temporal and spatial analysis. The author notes that people move through space and experience differing environmental exposures, depending on where they have lived.

The next seven chapters highlight GIS applications in public health, most of which fall into the category of hypothesis generation. The first two chapters of this section focus on Italy. Trinca illustrates how the use of GIS is expanding rapidly in the study of environmental health via several successful applications in Italy. The author notes that many institutional and perceptual barriers to using the full capabilities of GIS still exist. Braga et al. present an interactive mortality atlas developed using GIS and statistical analysis that has expanded the access to this particular type of health data at a national scale. Van den Berg also portrays the establishment of an interactive spatial information system for Pomerania, Germany. Both of these interactive systems highlight challenges encountered with the visualization of data; integration of datasets; lack of geographic understanding among public health professionals; and difficulty in integrating statistical methods directly with a GIS. Another case study by López-Abente explores the use of Bayesian Analysis for assessing cancer clusters, utilizing GIS primarily for mapping, and again stressing the necessity for interfacing GIS and spatial statistical

techniques. The cancer theme is continued by Teppo, who examines the potential for analyzing cancer data in a GIS context in Finland. Shifting to the U.K., Wilkinson et al. explore the uses of GIS in public health, primarily focusing on the potential for improving population data. Lovett et al. continue this topic by looking at the potential for using patient registers in public health analysis.

Taken together, the methodological discussions and the case studies depict the status of GIS in public health analysis. Even though the chapters cover a lot of ground, several overarching themes reappear throughout the book. The collection effectively illustrates the limitations specific to the use of GIS within the context of environmental epidemiological studies. These limitations partly arise from the nature of health data, such as spatial accuracy or aggregation, but also from a lack of geographic knowledge within the public health profession. Those who often end up interpreting the maps have little geographic or GIS training and may be unfamiliar with map interpretation or the technology's limitations. Nearly all the authors propose incorporating GIS into study design appropriately. They also maintain that one of the primary strengths of GIS is in the integration of disparate datasets. There seems to be a general consensus that the best use of GIS is for hypothesis generation, at least in its current state of development.

Perhaps arising from the focus on environmental epidemiology, several topics related to GIS and public health receive little attention. While many of the authors mention issues of confidentiality, the unique difficulty of sharing public health and medical data is not explicitly discussed. Also, there is no real discussion of other technologies that integrate with GIS, such as remote sensing, and the potential use of these in the study of public health. Further, air pollution is emphasized, but there are other pathways of exposure not presented, such as groundwater contamination, that can also be modeled in a GIS environment or in conjunction with a GIS.

The sophisticated treatment of the integration of GIS with epidemiological methods assumes a basic knowledge of study design, spatial statistics, and GIS. Consequently, this book would be extremely useful for epidemiologists, geographers, or environmental scientists interested in understanding the potential uses of GIS in this field, but may be less

useful for a practitioner or someone new to this field of research. Even with the emphasis on environmental epidemiology, the collection of essays underscores that now is the time for researchers in public health to dictate the direction of the development of new GIS tools that explicitly meet the needs of rigorous study designs.

CaGIS vol. 27, no. 3 (July 2000)

CaGIS vol. 27, no. 3

The Nature of Analytical Cartography: An Introduction

Harold Moellering

Since its auspicious beginnings in the early 1960s by Prof. Waldo Tobler (1961), analytical cartography has grown and flourished scientifically, analytically, and intellectually. Analytical cartography has added a new dimension to cartography with its goal of developing a scientific base of analytical and mathematical theory as the fundamental underpinning of cartographic research. This focus on theory is in stark contrast with the traditional focus of cartography on artistry and technology in map design and production that has been practiced for more than four thousand years. Analytical cartography is also very different from the other major cartographic theme-map communication and representation-, which dates back to Robinson's (1952) seminal research that established the "Communication School" of cartography. An earlier issue of this journal dedicated to analytical cartography (Moellering 1991) contained five research articles reflecting a variety of philosophical, mathematical, technical and applied aspects of analytical cartography. These papers were carefully selected to show the breadth and depth of research going on at that time in analytical cartography. This issue systematically explores the nature of analytical cartography, defining the scope and conceptual content of the field with all of its richness, diversity, and

research opportunities. Apart from theory we examine some of the applications of analytical theory in cartographic practice, highlighting major computational limitations to such work. The discussions have also identified linkages to related cognate fields of research, especially the emerging area of geographic information science. One such link between analytical cartography and these other fields is through the Mathematical Mode of Inquiry (MMOI) advocated by Casetti (1999) for human geography.

The Development of Analytical Cartography: A Personal Note

Waldo Tobler

In the late 1960s, I initiated a course with the title "Analytical Cartography" at the University of Michigan in Ann Arbor. At the behest of Dr. H. Moellering of Ohio State University (who was at one time a student in the course), a short personal historical perspective of the development of the course was presented at the recent Hawaii meeting of the Association of American Geographers. That review tried to put the subject and the development of the course in the context of the time. This is a written synopsis of the Hawaii presentation.

On the Origins of Analytical Cartography

Keith C. Clarke and John G. Cloud

This paper examines the development of analytical cartography and the contributions Waldo Tobler has made to it, starting well before his definition of the subject in 1976. Analytical cartography's roots in World War II and the Cold War are examined, and the influences and precedents for the academic course that Tobler described are discussed. The systems of knowledge production developed for analytical cartography in its social context are summarized and are found to show a powerful dependence on a working relationship between academia, industry, government, and the intelligence mapping community. Current research trends in analytical cartography, including the organization of research, its institutions, and its priorities, are discussed, and it is proposed that declassifying the "missing pool" of analytical cartographic research

literature could be of great benefit in the future. The four-way academic/industrial/government/intelligence partnership is seen as an opportune direction forward for analytical cartography. The next generational shift in the center of the discipline may occur in networks that even Waldo Tobler did not anticipate.
KEYWORDS: Analytical cartography, Cold War, SAGE, CORONA, military intelligence

Scope and Conceptual Content of Analytical Cartography

Harold Moellering
Over the last three decades analytical cartography has grown from Tobler's concept of "solving cartographic problems" into a broader and deeper scientific specialization that includes the development and expansion of analytical/mathematical spatial theory and model building. In many instances Tobler himself has led the way to these new insights and developments. Fundamental concepts begin with Tobler's cartographic transformations; Nyerges' deep and surface structure and data levels; and Moellering's real and virtual maps; the sampling theorem; and concepts of spatial primitives and objects. This list can be expanded to include additional analytical concepts such as spatial frequencies, spatial surface neighborhood operators, information theory, fractals, Fourier theory, topological network theory, and analytical visualization, to name a few. This base of analytical theory can be employed to analyze and/or develop such things as spatial surfaces, terrain analysis, spatial data schemas, spatial data structures, spatial query languages, spatial overlay and partitioning, shape analysis, surface generalization, cartographic generalization, and analytical visualization. More analytical uses of theory, strategies of analysis, and implementations are being developed and continue to multiply as the field continues to grow and mature. A primary goal is to expand the mathematical/analytical theory of spatial data analysis, and theory building and analytical visualization as analytical cartography takes its place in the geographic information sciences. The research future for this area appears very bright indeed.

KEYWORDS: Analytical cartography, map transformations, spatial theory, real and virtual maps, deep and surface structure, sampling theorem, spatial frequencies, analytical operators, information theory, fractals, Fourier theory, spatial overlay, Warntz network theory, map generalization, analytical visualization, geographic information science

Applications of Analytical Cartography

Wm Randolph Franklin

Several applications of analytical cartography are presented. They include terrain visibility (including visibility indices, viewsheds, and inter-visibility), map overlay (including solving round-off errors with C++ class libraries and computing polygon areas from incomplete information), mobility, and interpolation and approximation of curves and of terrain (including curves and surfaces in CAD/CAM, smoothing terrains with over-determined systems of equations, and drainage patterns). General themes become apparent, such as simplicity, robustness, and the tradeoff between different data types. Finally several future applications are discussed, such as the lossy compression of correlated layers, and just good enough computation when high precision is not justified.

Complexity and Intractability: Limitations to Implementation in Analytical Cartography

Alan Saalfeld

The computational complexity of algorithms is an important consideration for all computer systems, including geographic information systems and mapping systems. Mathematical cartographers and GIS professionals need to understand and to take into account the limitations imposed on problem solving by the very nature of computation itself. We look at three active research sub-areas of analytical cartography to highlight the differences between traditional mathematical solutions and solutions with computationally tractable algorithms. The three sub-areas are map projections, map feature labeling, and map generalization.
KEYWORDS: Algorithms, computational complexity, tractability, projections, map labeling, generalization

CaGIS, Vol. 27, No. 2 (April 2000)

CaGIS, Vol. 27, No. 2

Equal Area Map Projection for Irregularly Shaped Objects

Yang Cheng and Jean J. Lorre

Approximately half of the planetary bodies in our solar system imaged by spacecraft have irregular shapes. Since maps are used to record, interpret and display these irregularly shaped bodies, a special map projection, which can display them faithfully, is desirable. Unfortunately, no mathematical approach that permits true conformal or equal-area projections has been developed. In this paper, a novel approach that permits true conformal or equal-area projection has been developed. In this paper, a novel approach to construct a special equal area map projection for irregularly shaped objects is suggested. Using this innovative approach, equal area map projections for two Martian satellites-Phobos and Deimos-are developed.

Automated Name Placement With High Cartographic Quality: City Street Maps

Francois Chirie

As maps are more and more frequently produced from geographic databases using mapmaking software there is an increasing need for automated cartography. In particular, much research into automated name placement has been done, yielding systems that produce useful results but do not rival classical cartography. An automated street name placement program is proposed in this paper, which yields cartographic quality comparable to that obtained by traditional cartographers. We improved the modeling of cartographic rules in quantity and quality by addressing all the rules about street names, and analyzing each rule in detail. The program implements a mathematical model of these cartographic rules, and uses procedural programming. The results show that one type of traditional paper map can be produced using automated name placement.

KEYWORDS: Automated name placement, traditional cartography, high cartographic quality, modeling of cartographic rules, city street map.

Reducing Linear and Perimeter Measurement Errors in Raster-based Data

David M. Theobald

An important issue in cartography and GIS is determining the appropriate resolution or cell size when converting vector data to raster. The general consensus is to make the cell size as small as possible to resolve geographic features and provide the most accurate estimates of measurements. Finer resolution results in more accurate estimates of polygon area; however, the raster data structure introduces an artifact that causes errors in the estimation of the length of linear features and of the perimeter of polygon features to increase with increasing resolution. Over-estimation as high as 41 percent is theoretically possible and was found to be around 26 percent for representative polygon maps. A method is described that uses a correction coefficient to reduce overestimation error to less than 3 percent.

Spatial Accuracy Assessment of Wetland Permit Data

Nina M. Kelly

A collection of permits granted for alterations to coastal wetlands in North Carolina from 1984 through 1992 was examined to determine the spatial accuracy of the data. Each permit site for which a precise location existed in its associated permit file was surveyed using a Global Positioning System, and the error was identified between the location described in the permit file and true location. The error was analyzed with respect to direction of error, accompanying map type, and time. Results suggest that the spatial error found in the Permit Record for coastal North Carolina was too large to perform spatial analysis. Only 50 percent of the permit sites were found within 250 meters of their true location, and the rest were in error by as much as 45 kilometers. Errors were uniformly distributed in direction and not biased in any direction. The inclusion of maps with greater detail did not significantly reduce

error in locating the permit site. There was a slight decrease in error over time, but the fit was not sufficiently strong to indicate an improvement in accuracy over time. The results suggest a need for better standards for gathering future data and call for more stringent spatial data quality controls on environmental permit data of this kind.

Medial Axis Generalization of River Networks

Michael McAllister and Jack Snoeyink

We examine some benefits of using the medial axis as a centerline for rivers and lakes. One benefit, automatic centerline generation, has been used for many years. We show that additional benefits can be derived from the geometric relationships between the medial axis and the riverbanks or lakeshores. These include area estimates, association of centerline analysis to banks, and definition of opposite for riverbanks. We also report on our experience at approximating the medial axis with a Voronoi diagram of point sites.

Institutionalization of Geographic Information Technologies: Unifying Concepts?

1. H. Erik de Man

This paper studies the role, impact and effectiveness of geographic information technologies such as GIS, Contemporary frameworks

such as economic evaluation, organization context, or diffusion -- deal with some aspects only. Institutionalization of geographic information technologies is proposed as a paradigm for studying the impact and effectiveness more comprehensively. It refers to the ongoing process within a group or society whereby this technology itself is becoming Institutionalized and gaining a strong (normative) impact on common perceptions of spatial problems and, subsequently, on collective actions to remedy these problems. Hence, it is a paradigm that encompasses value, as well as organizational and societal issues, and links these to the level of individual behavior patterns. The paradigm therefore may provide context for economic evaluation, organizational considerations, and diffusion, as well as for other interpretive perspectives. The

paper outlines the concept of institutionalization of geographic information technologies and some of its salient factors and conditions. The focus is on feedback and participatory approaches in the design, and choice and implementation of geographic information technologies; whether these are institutionalized or not. Further (empirical) research is needed to explore the practical usefulness of this concept.
KEYWORDS: GIS, geographic information technologies, effectiveness, economic evaluation, organizational context, diffusion, institutionalization, paradigm, common problem perception, society.

Modeling Dynamic Polygon Objects in Space and Time: A New Graph-based Technique

David J. Wilcox, Matthew C. Harwell, and Robert J. Orth
The analysis of dynamic spatial systems requires an explicit spatio-temporal data model and spatio-temporal analysis tools. Event-based models have been developed to analyze discrete change in continuous and feature-based spatial data. In this paper, a spatio-temporal graph model is described that supports the analysis of continuous change in feature-based polygon spatial data. The spatio-temporal graph edges, called temporal links, track changes in polygon topology through space and time. The model also introduces the concept of a spatial-interaction region that extends a model's focus beyond short-term local events to encompass long term regional events. The structure of the spatio-temporal graph is used to classify these events into five types of local polygon events and two types of spatial-interaction region events. To illustrate its utility, the model is applied to the ecological question of how patch size influences longevity in underwater plant communities in Chesapeake Bay, USA. Both a short local analysis and a longer-term regional analysis showed that patches of plants, or groups of patches, larger than one or two hectares in size were more likely to persist than smaller patches or groups of patches. Overall, the spatio-temporal graph model approach appears applicable to a variety of spatio-temporal questions.

KEYWORDS: Spatio-temporal analysis, temporal GIS, spatial-interaction region, spatio-temporal graph model, patch dynamics, submersed aquatic vegetation.

Visual and Statistical Comparisons of Surface Modeling Techniques for Point-based Environmental Data

Xiaojun Yang and Thomas Hodler

Existing studies on spatial interpolation tend to overplay statistical perspective, paying little attention the locality and the visual performance of generated surface models. In an attempt to bridge these gaps in literatures, the authors compares the performance of five surface modeling methods, using a set of integrative criteria including absolute and relative statistical accuracy, visual pleasantness and faithfulness of generated surface models, sensitivity to changing sample size and search conditions, and computational intensity. The modeling methods used were: inverse distance, kriging, linear triangulation, minimum curvature, and radial basis functions. Because terrain relief is one of the few environmental attributes whose continuous surfaces can be directly observed through appropriate procedures, we used as input data two sets of elevation points sampled irregularly from a USGS 1:24,000 topographical map covering a hilly area. We found that surface modeling methods, even if statistically accurate, may not always ensure a graphically faithful representation of reality. The surprising result of this study was that the surface models generated from a larger were less stati stically accurate than those generated from a smaller sample.
KEYWORDS: Scattered data, surface modeling, relative accuracy, visual faithfulness, sensitivity.

A Visual Basic Algorithm for the Winkel Tripel Projection

Fritz C. Kessler

National Geographic Society (NGS) has made several changes throughout the years in their choice of map projection for their world reference

maps. The van der Grinten I map projection was used from 1922 to 1988. Then, in 1988, it was replaced by the Robinson projection. Beginning in 1998, the Winkel Tripel became the map projection of choice for NGS' world maps. Given this change, cartographers and others who make maps may be interested in using the Winkel Tripel for custom applications. The goal of this paper is to show how Winkel Tripel's complex projection equations can be programmed using Visual Basic. Those who use other languages such as C++ can use this programming example to help them create a similar algorithm in the language of choice.
KEYWORDS: Map projection, Winkel Tripel, algorithm.

CaGIS Vol. 27, No. 1 (Jan 2000)

CaGIS Vol. 27, No. 1 (Jan 2000)

Guidelines for the Display of Attribute Certainty

Michael Leitner and Barbara P. Buttenfield
This research investigates how the inclusion of attribute certainty in map displays influences GIS modeling and spatial decision support. The goal is to establish empirical evidence documenting graphical guidelines that can be incorporated as GIS system defaults for mapping depiction of attribute certainty. These three variables, in addition to the level of map detail, are depiction of attribute certainty. These three variables, in addition to the level of map detail, are explored in this research. A hypermedia document had been developed to simulate decision makers' use of certainty information for two locational siting tasks: the correctness, time, and confidence of both siting decisions. The experiment further determines how variations in symbolizing attribute certainty (by value, saturation, or texture) affect the three variables of correctness, time, and confidence. A third goal focuses on whether the

difficulty of the task affects the decision. On a theoretical level, this research uncovers new information about assimilating data quality information into spatial decision support. On a practical level, it establishes symbolization schemes for representing attribute certainty on thematic maps. These should be incorporated as GIS graphical defaults in anticipation of digital data sets that include data quality information. This research is a continuation of a long-standing tradition of empirical research in map design as a paradigm for eliciting and formalizing cartographic knowledge.

The Search for Boundaries on Maps: Color Processing and Map Pattern Effects

Rick Bunch and Robert Lloyd

Keates (1982) argues that map reading could be considered as a number of map-use tasks that take place in the process of obtaining desired information. These tasks are often related and, frequently, the result produced by an earlier task becomes input for a later test.

Three-dimensional Reconstruction of the Yaolin Cave

Jianhua Gong, Hui Lin, and Xiaolu Yin

This paper reports on three-dimensional reconstruction of the Yaolin Cave in the Karst Region of Zhejiang, China. An object-oriented method was used to represent two cave classes--the class Boundary and the class Inside. The class Boundary included objects of the cave ceiling and the cave floor which are part of the topographical trend of the cave. This trend was determined by integrating topography with landform using TIN modeling. The inside of the cave with stalagmites, stalactites, dripstone-columns, and other objects was built using surveying data, photographs, and such computer graphics techniques as texture mapping and transparency. A stand-alone, 3-D visualization system-Cave3D-was developed in the Windows 98/NT platform to produce 3-D graphics and implement graphics-based computation, spatial query, and analyses. A virtual Yaolin cave was created using VRML97 and Java and posted on the Web.

Knowledge Acquisition for Generalization Rules

Tiina Kilpelainen

How to replace the human element of generalization with computer algorithms or rules in knowledge bases has been frequently discussed, but we have not succeeded in formulating these rules very well. The purpose of this article is to illustrate the problem of knowledge acquisition for generalization of topographic maps. Three studies to derive rule-based knowledge for automatic map generalization are presented and analyzed. In the tests, cartographers were asked to interpret map objects to be generalized and to describe the basis of their decisions. The studies showed that by interviewing cartographers, much of the domain knowledge can be gathered, but the most time-consuming part of documenting this knowledge is to analyze the data and formalize the results. It was also found that there is important domain knowledge on generalization that has not previously been documented. The tests performed resulted in the discovery of four categories of declarative rules: geometric, topological, context-related, and culture-related rules.

Perception of Spatial Dispersion in Point Distributions

Yukio Sadahiro

This paper analyzes the perception of spatial dispersion on point distributions. Spatial dispersion is one of the major concepts communicated by dot maps. To promote efficient communication of this concept, two experiments were conducted to investigate the relationship between the perception of spatial dispersion and such map characteristics as spatial arrangement of points, number of points, symbol size, and map scale. Regression models were built on the basis of the experimental results to describe the relationship quantitatively. The obtained models enable map authors to predict the degree of spatial dispersion perceived by map readers. From the models and the results of a computer-assisted simulation, the following conclusions were obtained: 1) map scale greatly affects the perception of spatial dispersion; 2) spatial arrangement of points and number points are also influential; 3) the size

of point symbols does not significantly affect the perception of spatial dispersion.

Solving Space Conflicts in Map Generalization: Using a Finite Element Method

Peter Hojholt

A finite element method was developed to handle conflicts during the generalization of maps. The method is holistic and solves conflict problems for the entire map surface simultaneously. When a generalized object changes size, the method immediately causes displacements in surrounding objects. Boundary constraints were introduced which make it possible to maintain the shape of objects, and simultaneously change the size of objects. An iterative solution procedure for the Finite Element problem was shown to give solutions that better fulfill topological requirements than a direct solution of the problem.

A Component Perspective on Geographic Information Services

Bin Li

This paper explores the notions of geographic information services in the context of component technology. It suggests that componentization gives rise to an alternative view on GIS as geographic information services. The change from monolithic systems to component-oriented systems requires examination of the service structure of GIS. This paper presents a general discussion on the notions of component and services. A combination of existing reference models of information services and an empirical model of software evolution is used to identify geographic information services. Application services, functional services, and common services are considered to the main groups of information services in the component architecture. The discussion focuses in the functional services and common services in the component architecture. The discussion focuses on the functional services and common services within the domain of geographic information processing. Eight groups of such services are identified. They represent a reorganization of geographic information services in light of recent advances in component

technology. The service structure is substantially different from the functional components of traditional GIS. The requirement for inter-operation adds several groups of common services, including data access, catalog, transformation, and registry. Developing the components for geographic information services presents both technical and theoretical challenges. In the theoretical domain, the problem of representation is crucial for achieving high levels of interoperability. The concepts are further elaborated through an example on how component technology makes it easy to use advanced geographic techniques through a distributed spatial statistical modeling service.