

Andrew U. Frank Irene Campari (Eds.)

# Spatial Information Theory

A Theoretical Basis for GIS

European Conference, COSIT'93  
Marciana Marina, Elba Island, Italy  
September 19-22, 1993  
Proceedings

Springer-Verlag

Berlin Heidelberg New York  
London Paris Tokyo  
Hong Kong Barcelona  
Budapest

Frank, Andrew U., and Irene Campari, eds. *Spatial Information Theory: Theoretical Basis for GIS*. Edited by Gerhard Goos and Juris Hartmanis. 1 vols. Vol. 716, *Lecture Notes in Computer Science*. Heidelberg-Berlin: Springer Verlag, 1993.

## Foreword

This volume collects the papers presented at the European Conference on Spatial Information Theory (COSIT'93), held in Marcellana Marina on the island of Elba (Italy) in September 1993. Spatial Information Theory collects disciplinary topics and interdisciplinary issues that deal with the conceptualization and formalization of large-scale (geographic) space. It contributes towards a consistent theoretical basis for Geographic Information Systems (GIS).

Advances in computer technology and information science and also geography are applied to the practical problem of collecting, managing and presenting spatial data and have produced Geographic Information Systems. GISs are widely used in administration, planning, and science in many different countries, and for a wide variety of application areas. The unifying concept for the GIS is the relation of all information to space, which is realized differently in different applications and cultures. Spatial Information Theory attempts to discover the universally valid principles and to understand the differences of the particular solution. Research results are relevant for GIS, but are distributed in many disciplines and contacts between researchers are therefore hindered. At the same time, development of GIS is limited by the lack of a sound theoretical base.

COSIT'93 follows the international conference "GIS: From Space to Territory. Theories and Methods of Spatio-Temporal Reasoning" that took place in Pisa in September 1992\*. That conference brought together experts from different disciplines, most notably computer science, geography, cognitive science and linguistics and was focused on spatial and temporal reasoning about geographic space. This event has established an interdisciplinary dialog within the international scientific community which has continued since and has led to the organization of COSIT'93.

The call for papers, mostly distributed by electronic mail, resulted in over 60 full papers submitted. They were of very high quality and covered a broad field of different disciplines. Each paper was distributed for review to four members of the program committee or other experts in the field. The program chairs then selected the 32 best papers based on the reviewers' assessment to be presented at COSIT'93 and to be included in the proceedings. Comments from the reviewers were sent back to the authors to help them in producing the final copy. We are grateful for the collaborative efforts of the authors and reviewers that allowed us to get this volume ready for the conference.

We thank all people who helped in organizing the conference. In particular the members of the program committee and the additional reviewers contributed generously. Sincere thanks also to Nahid Nayyeri from the ARA Congressi for the organizational and administrative support.

July 1993

Andrew U. Frank  
Irene Campari

\* The proceedings have been published by Springer-Verlag as Lecture Notes in Computer Science Volume 639.

## Program Committee Chairs

Andrew U. Frank (Austria)  
Irene Campari (Austria)

## Program Committee Co-Chair

David Mark (USA)

## Scientific Committee

Norbert Bartelme (Austria)  
Benedetto Biagi (Italy)  
Flavio Bonfatti (Italy)  
Peter Burrough (The Netherlands)  
Kai-Uwe Carstensen (Germany)  
Nick Chrisman (USA)  
Helen Couclelis (USA)  
David Cowen (USA)  
Leila De Floriani (Italy)  
Costancio De Castro (Spain)  
Pierre Dumolard (France)  
Max Egenhofer (USA)  
Giorgio Faconti (Italy)  
Giacomo Ferrari (Italy)  
Manfred Fischer (Austria)  
Ubaldo Formentini (Italy)  
Christian Freksa (Germany)  
Dieter Fritsch (Germany)  
Paolo Ghelardoni (Italy)  
Chris Gold (Canada)  
Reg Golledge (USA)  
Mike Goodchild (USA)  
Georg Gottlob (Austria)  
Dietmar Grünreich (Germany)  
Giuseppe Guarrasi (Italy)  
Oliver Günter (Germany)  
John Herring (USA)  
Stephen Hirtle (USA)

Erland Jungert (Sweden)  
Bob Jacobson (USA)  
Fritz Kelnhofer (Austria)  
Milan Konecny (Czechoslovakia)  
Karl Kraus (Austria)  
Werner Kuhn (Austria)  
Ewald Lang (Germany)  
Robert Laurini (France)  
Duane Marble (USA)  
Jan Masser (UK)  
Mark Monmonnier (USA)  
Jean-Claude Muller (The Netherlands)  
John O'Callaghan (Australia)  
Harlan Onsrud (USA)  
Stan Openshaw (UK)  
Giuseppe Papagno (Italy)  
Edoardo Politano (Italy)  
Giuseppe Pozzana (Italy)  
Alina Potrikovska (Poland)  
Francois Salgé (France)  
Michel Scholl (France)  
Hans-Jörg Schek (Switzerland)  
Timos Sellis (Greece)  
Joseph Strobl (Austria)  
M. Tinacci Mossello (Italy)  
A Min Tjoa (Austria)

## Additional Referees

Kate Beard (USA)  
Mark Biekkens (The I)  
Kurt Brassel (Swit)  
Carola Eschenbach (Gern)  
Daniel Hernandez (Gern)  
Karen Kemp (Aust)  
Benjamin Kuipers (USA)  
Robert McMaster (USA)  
Georg Nagy (USA)  
Simone Pribbenow (Gern)  
Enrico Puppo (Italy)  
Ralf Röhrig (Gern)  
Terence Smith (USA)  
Heinz Stanek (Aust)  
Waldo Tobler (USA)  
Kai Zimmermann (Gern)  
Michael Worboys (UK)

## Sponsorship

Technische Universität Wien  
Consiglio Nazionale delle Ri  
Amministrazione Provinciale  
IRPET-Istituto Regionale pe  
Comune di Marciana Marina  
Associazione Industriali di L  
Cassa di Risparmio di Livori  
INTERGRAPH Corporation

## Organizing Committee

Chair: Ubaldo Formentini

Nahid Nayyeri  
ARA Congressi (L

### Additional Referees

Kate Beard	(USA)
Mark Biekkens	(The Netherlands)
Kurt Brassel	(Switzerland)
Carola Eschenbach	(Germany)
Daniel Hernandez	(Germany)
Karen Kemp	(Austria)
Benjamin Kuipers	(USA)
Robert McMaster	(USA)
Georg Nagy	(USA)
Simone Pribbenow	(Germany)
Enrico Puppo	(Italy)
Ralf Röhrig	(Germany)
Terence Smith	(USA)
Heinz Stanek	(Austria)
Waldo Tobler	(USA)
Kai Zimmermann	(Germany)
Michael Worboys	(UK)

### Sponsorship

Technische Universität Wien

Consiglio Nazionale delle Ricerche - Istituto CNUCE, Pisa

Amministrazione Provinciale di Livorno

IRPET-Istituto Regionale per la Programmazione Economica della Toscana

Comune di Marciana Marina

Associazione Industriali di Livorno

Cassa di Risparmio di Livorno

INTERGRAPH Corporation

### Organizing Committee

Chair: Ubaldo Formentini (Università di Pisa, Italy)

Nahid Nayyeri  
ARA Congressi (Livorno, Italy)

# Table of Contents

## I. Spatial Cognition

A Cognitive Model for the Process of Multimodal, Incremental Route Descriptions .....	1
<i>Wolfgang Maas (Universität des Saarlandes, Saarbrücken, Germany)</i>	
Cognitive Maps, Cognitive Collages, and Spatial Mental Models .....	14
<i>Barbara Tversky (Stanford University, USA)</i>	

## II. Spatial Reasoning

A Logical Framework for Reasoning about Space .....	25
<i>Laure Vieu (INRA, Castanet-Tolosan, France)</i>	
Maintaining Qualitative Spatial Knowledge .....	36
<i>Daniel Hernández (Technische Universität München, Germany)</i>	
Qualitative Triangulation for Spatial Reasoning .....	54
<i>Gérard F. Ligozat (LIMSI, Université Paris XI, France)</i>	
Enhancing Qualitative Spatial Reasoning - Combining Orientation and Distance .....	69
<i>Kai Zimmermann (Universität Hamburg, Germany)</i>	

## III. Cartography

Map Semantics .....	77
<i>Ian Pratt (University of Manchester, UK)</i>	
Development of a Cartographic Language .....	92
<i>J. Raul Ramirez (Ohio State University, USA)</i>	

## IV. Query Languages

Spatial Queries and Data Models .....	113
<i>Leila De Floriani, Paola Marzano (Università di Genova, Italy), Enrico Puppo (IMA-CNR Genova, Italy)</i>	
Topological Querying of Multiple Map Layers .....	139
<i>Sylvia de Hoop (Wageningen Agricultural University, The Netherlands), Peter van Oosterom (TNO Physics and Electronics Laboratory, The Hague, The Netherlands), Martien Molenaar (Wageningen Agricultural University, The Netherlands)</i>	

**V. Temporal Reasoning**

Towards a Conceptual Data Model for the Analysis of Spatio-Temporal Processes: The Example of the Search for Optimal Grazing Strategies ..... 158  
*Jean-Paul Cheylan (GDR Cassini, GIP Reclus, Montpellier, France), Sylvie Lardon (GDR Cassini and INRA-SAD, Auzeville, France)*

The Cognitive Structure of Space: An Analysis of Temporal Sequences ..... 177  
*Stephen C. Hirtle, Thea Ghiselli-Crippa, Michael B. Spring (University of Pittsburgh, USA)*

Hierarchies of Space and Time ..... 190  
*Peter A. Whigham (CSIRO Division of Water Resources, Canberra, Australia)*

**VI. Data Models for Spatial and Temporal Data**

The Voronoi Model and Cultural Space: Applications to the Social Sciences and Humanities ..... 202  
*Geoffrey Edwards (Université Laval, Sainte-Foy, Canada)*

Interaction with GIS Attribute Data Based on Categorical Coverage ..... 215  
*Gary S. Volta, Max J. Egenhofer (University of Maine, Orono, USA)*

The Semantics of Relations in 2D Space Using Representative Points: Spatial Indexes ..... 234  
*Dimitris Papadias, Timos Sellis (National Technical University of Athens, Greece)*

Computing Visibility Maps on a Digital Terrain Model ..... 248  
*Leila De Floriani, Paola Magillo (Università di Genova, Italy)*

**VII. Cultural Differences in Spatial Cognition**

Toward a Theoretical Framework for Geographic Entity Types ..... 270  
*David M. Mark (State University of New York at Buffalo, USA)*

Land, Space and Spatial Planning in Three Time Regions ..... 284  
*Albert Z. Guttenberg (University of Illinois, Urbana, USA)*

Geographic and Manipulable Space in Two Tamil Linguistic Systems ..... 294  
*Eric Pederson (Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands)*

**VIII. Scales in Geographic Space**

Scale and Multiple Psychologies of Space ..... 312  
*Daniel R. Montello (University of California, Santa Barbara, USA)*

GIS and Modeling Prerequisite  
*Arthur Getis (State University of New York at Buffalo, USA)*

A Map Editing Kernel Implementation  
 Scale Display .....  
*Philippe Rigaux (Cedric/CM Le Chesnay, France), Agnès*

**IX. User-Interface**

Metaphors Create Theories  
*Werner Kuhn (Technische Universität München, Germany)*

Using a Landscape Metaphor  
*Matthew Chalmers (Xerox Palo Alto Research Center, USA)*

From Interface to Interplace for Interaction .....  
*Thomas Erickson (Advanced Computer Systems, Cupertino, USA)*

A Keystroke Level Analysis  
*Peter Haunold, Werner Kuhn (University of Würzburg, Germany)*

**X. Spatial Analysis**

Critical Issues in the Evaluation of Spatial Analysis  
*Yue-Hong Chou (University of California, Santa Barbara, USA)*

A Directional Path Distance  
*Cixiang Zhan, Sudhakar M. Rao (University of California, Santa Barbara, USA)*

**XI. Spatial Reasoning**

Symbolic Spatial Reasoning  
*Erland Jungert (FOA, Sweden)*

Reasoning About Spatial Information Systems .....  
*Claude W. Saunders (Argonne National Laboratory, USA)*

**XII. Posters** .....

io-Temporal  
g Strategies ..... 158  
r, France),  
ance)  
l Sequences ..... 177  
..... 190  
anberra, Australia)  
ta  
e Social  
..... 202  
Coverage ..... 215  
ono, USA)  
ive Points:  
..... 234  
rsity of Athens,  
..... 248  
aly)  
pes ..... 270  
SA)  
..... 284  
c Systems ..... 294  
Nijmegen, The  
..... 312  
a, USA)

GIS and Modeling Prerequisites ..... 322  
*Arthur Getis (State University of California, San Diego, USA)*  
A Map Editing Kernel Implementation: Application to Multiple  
Scale Display ..... 341  
*Philippe Rigaux (Cedric/CNAM, Paris, France), Michel Scholl (INRIA,  
Le Chesnay, France), Agnès Voisard (Universität München, Germany)*

**IX. User-Interface**

Metaphors Create Theories for Users ..... 366  
*Werner Kuhn (Technische Universität Wien, Vienna, Austria)*  
Using a Landscape Metaphor to Represent a Corpus of Documents ..... 377  
*Matthew Chalmers (Xerox Parc, Cambridge, UK)*  
From Interface to Interplace: The Spatial Environment as a Medium  
for Interaction ..... 391  
*Thomas Erickson (Advanced Technology Group, Apple Computer Inc.,  
Cupertino, USA)*  
A Keystroke Level Analysis of Manual Map Digitizing ..... 406  
*Peter Haunold, Werner Kuhn (Technische Universität Wien, Vienna, Austria)*

**X. Spatial Analysis**

Critical Issues in the Evaluation of Spatial Autocorrelation ..... 421  
*Yue-Hong Chou (University of California, Riverside, USA)*  
A Directional Path Distance Model for Raster Distance Mapping ..... 434  
*Cixiang Zhan, Sudhakar Menon, Peng Gao (Environmental Systems  
Research Institute, Redlands, USA)*

**XI. Spatial Reasoning**

Symbolic Spatial Reasoning in Object Shapes for Qualitative Reasoning ..... 444  
*Erland Jungert (FOA, Sweden)*  
Reasoning About Spatial Structure in Landscapes with Geographic  
Information Systems ..... 463  
*Claude W. Saunders (Argonne National Laboratory, Argonne, USA)*

**XII. Posters** ..... 478

**Andrew U. Frank Irene Campari (Eds.)**

# **Spatial Information Theory**

**A Theoretical Basis for GIS**

**European Conference, COSIT'93**

**Marciana Marina, Elba Island, Italy, September 1993**

**Proceedings**



**Springer-Verlag**