

Commenced Publication in 1973

Founding and Former Series Editors:

Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

Editorial Board

David Hutchison

Lancaster University, UK

Takeo Kanade

Carnegie Mellon University, Pittsburgh, PA, USA

Josef Kittler

University of Surrey, Guildford, UK

Jon M. Kleinberg

Cornell University, Ithaca, NY, USA

Alfred Kobsa

University of California, Irvine, CA, USA

Friedemann Mattern

ETH Zurich, Switzerland

John C. Mitchell

Stanford University, CA, USA

Moni Naor

Weizmann Institute of Science, Rehovot, Israel

Oscar Nierstrasz

University of Bern, Switzerland

C. Pandu Rangan

Indian Institute of Technology, Madras, India

Bernhard Steffen

TU Dortmund University, Germany

Madhu Sudan

Microsoft Research, Cambridge, MA, USA

Demetri Terzopoulos

University of California, Los Angeles, CA, USA

Doug Tygar

University of California, Berkeley, CA, USA

Gerhard Weikum

Max Planck Institute for Informatics, Saarbruecken, Germany

Dieter Pfoser Yufei Tao
Kyriakos Mouratidis Mario A. Nascimento
Mohamed Mokbel Shashi Shekhar
Yan Huang (Eds.)

Advances in Spatial and Temporal Databases

12th International Symposium, SSTD 2011
Minneapolis, MN, USA, August 24-26, 2011
Proceedings

Volume Editors

Dieter Pfoser
Research Center "ATHENA", Athens, Greece
E-mail: pfoser@imis.athena-innovation.gr

Yufei Tao
Chinese University of Hong Kong, China
E-mail: taoyf@cse.cuhk.edu.hk

Kyriakos Mouratidis
Singapore Management University, Singapore
E-mail: kyriakos@smu.edu.sg

Mario A. Nascimento
ATH University of Alberta, Edmonton, AB, Canada
E-mail: mario.nascimento@ualberta.ca

Mohamed Mokbel
Shashi Shekhar
University of Minnesota, Minneapolis, MN, USA
E-mail: {mokbel, shekhar}@cs.umn.edu

Yan Huang
University of North Texas, Denton, TX, USA
E-mail: huangyan@unt.edu

ISSN 0302-9743
ISBN 978-3-642-22921-3
DOI 10.1007/978-3-642-22922-0
Springer Heidelberg Dordrecht London New York

e-ISSN 1611-3349
e-ISBN 978-3-642-22922-0

Library of Congress Control Number: 2011933231

CR Subject Classification (1998): H.2.0, H.2.8, H.2-4, I.2.4

LNCS Sublibrary: SL 3 – Information Systems and Application, incl. Internet/Web and HCI

© Springer-Verlag Berlin Heidelberg 2011

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

The use of general descriptive names, registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

SSTD 2011 was the 12th in a series of events that discuss new and exciting research in spatio-temporal data management and related technologies. Previous symposia were successfully held in Santa Barbara (1989), Zurich (1991), Singapore (1993), Portland (1995), Berlin (1997), Hong Kong (1999), Los Angeles (2001), Santorini, Greece (2003), Angra dos Reis, Brazil (2005), Boston (2007), and Aalborg, Denmark (2009). Before 2001, the series was devoted solely to spatial database management, and called SSD. From 2001, the scope was extended in order to also accommodate temporal database management, in part due to the increasing importance of research that considers spatial and temporal aspects jointly.

SSTD 2011 introduced several innovative aspects compared to previous events. In addition to the research paper track, the conference hosted a demonstrations track, and as a novelty, a vision and challenges track focusing on ideas that are likely to guide research in the near future and to challenge prevalent assumptions.

SSTD 2011 received 63 research submissions from 22 countries. A thorough review process led to the acceptance of 24 high-quality papers, geographically distributed as follows: USA 9, Germany 3, Greece 2, Canada 2, Switzerland 1, Norway 1, Republic of Korea 1, Japan 1, Italy 1, Hong Kong 1, Denmark 1, China 1. The papers are classified in the following categories, each corresponding to a conference session: (1) Moving Objects and Sensor Networks, (2) Temporal and Streaming Data, (3) Knowledge Discovery, (4) Spatial Networks, (5) Multidimensional Query Processing, (6) Access Methods.

This year's best paper award went to "FAST: A Generic Framework for Flash-Aware Spatial Trees." The paper presents a general technique for converting a traditional disk-oriented structure to an access method that works well on flash-memory devices. Applicable to several well-known structures (including the B- and R-trees), the technique aims at achieving two purposes simultaneously: (a) minimizing the update and query overhead, and (b) preventing the loss of data even in a system crash, thus ensuring data durability. The paper contains several novel ideas, which are of independent interests since they may also be useful in designing other flash-aware algorithms. In addition, the paper features a real system that implements the proposed technique and is demonstrated to have excellent performance in practice through extensive experiments. Besides the best paper, a few other high-quality research papers were selected and the authors were invited to submit extended versions of their work to a special issue of the *Geoinformatica* journal (Springer).

Although the previous symposium in the SSTD series (2009) also included a demonstrations track, submissions were evaluated alongside regular research papers by a single Program Committee. SSTD 2011, for the first time, appointed dedicated Co-chairs to organize an autonomous demonstrations track, who in

turn recruited a separate Program Committee comprising 9 members. The purpose of this track was to illustrate engaging systems that showcase underlying solid research and its applicability. The track received 16 submissions from a total of 51 authors or co-authors coming from Germany (21), USA (21), Canada (5), Italy (2), Switzerland (1), and France (1). The selection criteria for the demonstration proposals included novelty, technical advances, and overall practical attractiveness of the demonstrated system. Out of the 16 submissions, 8 were accepted and presented in a special session of the symposium. The best demonstration paper was recognized with “SSTD 2011’s Best Demo Award.”

Another novelty in SSTD 2011 was the vision and challenges track. The aim of this track was to describe revolutionary ideas that are likely to guide research in the near future, challenge prevalent assumptions in the research community, and identify novel applications and technology trends that create new research directions in the area of spatial and spatiotemporal databases. A separate 12-member Program Committee was formed for this track (coordinated by the same Co-chairs of the demonstrations track). Twenty-one submissions were received from a total of 58 authors and co-authors from USA (19), Germany (7), Italy (2), Greece (2), Brazil (1), U.K. (1), Switzerland (1). Eight of the submissions were accepted and were presented in the symposium in two dedicated sessions. The top three contributions, chosen based on their technical merit as well as their presentation in the symposium, received the Headwaters Awards. The awards were valued at \$1,000, \$750, and \$500 for the three selected contributions (in the form of travel reimbursements), and were kindly sponsored by the Computing Community Consortium (CCC) of the Computing Research Association (CRA).

The keynote address titled “Underexplored Research Topics from the Commercial World” was delivered by Erik Hoel (ESRI). Two panels were held. Panel A titled “Envisioning 2020 Spatial Research Challenges and Opportunities” was chaired by Erwin Gianchandani (CCC) and Panel B titled “Sustainable Energy: Spatial Challenge” was chaired by Ghaleb Abdulla (USDOE LLNL).

To be able to create such a highly attractive SSTD 2011 symposium program, we owe our gratitude to a range of people. We would like to thank the authors, irrespectively of whether their submissions were accepted or not, for their support of the symposium series and for sustaining the high quality of the submissions. We are grateful to the members of the Program Committees (and the external reviewers) for their thorough and timely reviews. In addition, we are grateful to Nikos Mamoulis for his advice and support. We hope the technical program put together for this edition of the SSTD symposium series leads to interesting and fruitful discussions during and after the symposium.

June 2011

Dieter Pfoser
 Yufei Tao
 Kyriakos Mouratidis
 Mario Nascimento
 Mohamed Mokbel
 Shashi Shekhar
 Yan Huang

Organization

Steering Committee

The SSTD Endowment

General Co-chairs

Shashi Shekhar

University of Minnesota, USA

Mohamed Mokbel

University of Minnesota, USA

Program Co-chairs

Dieter Pfoser

IMIS/RC ATHENA, Greece

Yufei Tao

Chinese University of Hong Kong, SAR China

Demo Co-chairs

Mario Nascimento

University of Alberta, Canada

Kyriakos Mouratidis

Singapore Management University, Singapore

Publicity Chair

Jin Soung Yoo

IPFW, USA

Treasurer

Jing (David) Dai

IBM, USA

Sponsorship Chair

Latifur Khan

University of Texas at Dallas, USA

Proceedings Chair

Yan Huang

University of North Texas, USA

Registration Chair

Wei-Shinn Ku

Auburn University, USA

Local Arrangements

Francis Harvey University of Minnesota, USA

Webmaster

Michael R. Evans University of Minnesota, USA

Program Committee

Divyakant Agrawal	Feifei Li	Cyrus Shahabi
Walid Aref	Jianzhong Li	Rick Snodgrass
Lars Arge	Xuemin Lin	Yannis Theodoridis
Claudia Bauzer Medeiros	Nikos Mamoulis	Goce Trajcevski
Michela Bertolotto	Test Member	Anthony Tung
Thomas Brinkhoff	Beng Chin Ooi	Agnes Voisard
Bin Cui	Dimitris Papadias	Carola Wenk
Maria Luisa Damiani	Stavros Papadopoulos	Ouri Wolfson
Ralf Hartmut Güting	Chiara Renso	Xiaokui Xiao
Marios Hadjieleftheriou	Dimitris Sacharidis	Xing Xie
Erik Hoel	Simonas Saltenis	Ke Yi
Christian S. Jensen	Markus Schneider	Man Lung Yiu
George Kollios	Bernhard Seeger	Yu Zheng
Bart Kuijpers	Thomas Seidl	Shuigeng Zhou

Vision/Challenge Program Committee

Spiros Bakiras	Erik Hoel	Simonas Saltenis
Thomas Brinkhoff	Vagelis Hristidis	Vassilis Tsotras
Ralf Hartmut Güting	Panos Kalnis	Ouri Wolfson
Marios Hadjieleftheriou	Matthias Renz	Baihua Zheng

Demo Program Committee

Feifei Li	Stavros Papadopoulos	Xiaokui Xiao
Hua Lu	Dimitris Sacharidis	Man Lung Yiu
Apostolos Papadopoulos	Marcos Salles	Karine Zeitouni

External Reviewers

Achakeyev, Daniar	Jestes, Jeffrey	Shirani-Mehr, Houtan
Armenantzoglou, Nikos	Jeung, Hoyoung	Stenneth, Leon
Booth, Joel	Kashyap, Abhijith	Sun, Guangzhong
Bouros, Panagiotis	Kazemi, Leyla	Tang, Mingwang
Buchin, Maïke	Kellaris, George	Thomsen, Christian
Cheema, Aamir	Khodaei, Ali	Trimponias, George
Chen, Zaïben	Kremer, Hardy	Wang, Lixing
Cheng, Shiwen	Le, Wangchao	Wang, Lu
Demiryurek, Ugur	Li, Xiaohui	Wijsen, Jef
Dittrich, Jens	Marketos, Gerasimos	Xu, Bo
Dziengel, Norman	Moelans, Bart	Xu, Linhao
Fishbain, Barak	Moruz, Gabriel	Yang, Bin
Fries, Sergej	Omran, Masoud	Yao, Bin
Färber, Ines	Patt-Shamir, Boaz	Zhang, Wenjie
Giatrakos, Nikos	Pavlou, Kyriacos	Zhang, Ying
Green Larsen, Kasper	Pelekis, Nikos	Zhang, Zhenjie
Hassani, Marwan	Ruiz, Eduardo	Zheng, Wenchen
Huang, Zengfeng	Sakr, Mahmoud	Zhu, Qijun
Hung, Chih-Chieh	Shen, Zhitao	Zhu, Yin

Table of Contents

Keynote

Keynote Speech: Underexplored Research Topics from the Commercial World	1
<i>Erik Hoel</i>	

Research Sessions

Session 1: Knowledge Discovery

SSCP: Mining Statistically Significant Co-location Patterns	2
<i>Sajib Barua and Jörg Sander</i>	
An Ontology-Based Traffic Accident Risk Mapping Framework	21
<i>Jing Wang and Xin Wang</i>	
Comparing Predictive Power in Climate Data: Clustering Matters	39
<i>Karsten Steinhaeuser, Nitesh V. Chawla, and Auroop R. Ganguly</i>	
Region of Interest Queries in CT Scans	56
<i>Alexander Cavallaro, Franz Graf, Hans-Peter Kriegel, Matthias Schubert, and Marisa Thoma</i>	

Session 2: Spatial Networks

A Critical-Time-Point Approach to All-Start-Time Lagrangian Shortest Paths: A Summary of Results	74
<i>Venkata M.V. Gunturi, Ernesto Nunes, KwangSoo Yang, and Shashi Shekhar</i>	
Online Computation of Fastest Path in Time-Dependent Spatial Networks	92
<i>Ugur Demiryurek, Farnoush Banaei-Kashani, Cyrus Shahabi, and Anand Ranganathan</i>	
Dynamic Pickup and Delivery with Transfers	112
<i>Panagiotis Bouros, Dimitris Sacharidis, Theodore Dalamagas, and Timos Sellis</i>	
Finding Top-k Shortest Path Distance Changes in an Evolutionary Network	130
<i>Manish Gupta, Charu C. Aggarwal, and Jiawei Han</i>	

Session 3: Access Methods

FAST: A Generic Framework for Flash-Aware Spatial Trees 149
Mohamed Sarwat, Mohamed F. Mokbel, Xun Zhou, and Suman Nath

MIDAS: Multi-attribute Indexing for Distributed Architecture
Systems 168
George Tsatsanifos, Dimitris Sacharidis, and Timos Sellis

Thread-Level Parallel Indexing of Update Intensive Moving-Object
Workloads 186
*Darius Šidlauskas, Kenneth A. Ross, Christian S. Jensen, and
Simonas Šaltenis*

Efficient Processing of Top-k Spatial Keyword Queries 205
*João B. Rocha-Junior, Orestis Gkorgkas, Simon Jonassen, and
Kjetil Nørkvåg*

Session 4: Moving Objects and Sensor Networks

Retrieving k-Nearest Neighboring Trajectories by a Set of Point
Locations 223
*Lu-An Tang, Yu Zheng, Xing Xie, Jing Yuan, Xiao Yu, and
Jiawei Han*

Towards Reducing Taxicab Cruising Time Using Spatio-Temporal
Profitability Maps 242
Jason W. Powell, Yan Huang, Favyen Bastani, and Minhe Ji

Computing the Cardinal Direction Development between Moving
Points in Spatio-temporal Databases 261
Tao Chen, Hechen Liu, and Markus Schneider

Continuous Probabilistic Count Queries in Wireless Sensor Networks ... 279
*Anna Follmann, Mario A. Nascimento, Andreas Züfle,
Matthias Renz, Peer Kröger, and Hans-Peter Kriegel*

Session 5: Multidimensional Query Processing

Geodetic Point-In-Polygon Query Processing in Oracle Spatial 297
Ying Hu, Siva Ravada, and Richard Anderson

MSSQ: Manhattan Spatial Skyline Queries 313
Wanbin Son, Seung-won Hwang, and Hee-Kap Ahn

Inverse Queries for Multidimensional Spaces 330
*Thomas Bernecker, Tobias Emrich, Hans-Peter Kriegel,
Nikos Mamoulis, Matthias Renz, Shiming Zhang, and Andreas Züfle*

Efficient Evaluation of k -NN Queries Using Spatial Mashups	348
<i>Detian Zhang, Chi-Yin Chow, Qing Li, Xinming Zhang, and Yinlong Xu</i>	

Session 6: Temporal and Streaming Data

SeTraStream: Semantic-Aware Trajectory Construction over Streaming Movement Data	367
<i>Zhixian Yan, Nikos Giatrakos, Vangelis Katsikaros, Nikos Pelekis, and Yannis Theodoridis</i>	
Mining Significant Time Intervals for Relationship Detection	386
<i>Zhenhui Li, Cindy Xide Lin, Bolin Ding, and Jiawei Han</i>	
A Uniform Framework for Temporal Functional Dependencies with Multiple Granularities	404
<i>Carlo Combi, Angelo Montanari, and Pietro Sala</i>	
Quality of Similarity Rankings in Time Series	422
<i>Thomas Bernecker, Michael E. Houle, Hans-Peter Kriegel, Peer Kröger, Matthias Renz, Erich Schubert, and Arthur Zimek</i>	

Vision and Challenge Papers

Managing and Mining Multiplayer Online Games	441
<i>Hans-Peter Kriegel, Matthias Schubert, and Andreas Züfle</i>	
Citizens as Database: Conscious Ubiquity in Data Collection	445
<i>Kai-Florian Richter and Stephan Winter</i>	
Spatial Data Management over Flash Memory	449
<i>Ioannis Koltsidas and Stratis D. Viglas</i>	
Tipping Points, Butterflies, and Black Swans: A Vision for Spatio-temporal Data Mining Analysis	454
<i>James M. Kang and Daniel L. Edwards</i>	
On User-Generated Geocontent	458
<i>Dieter Pfoser</i>	
Localizing the Internet: Implications of and Challenges in Geo-locating Everything Digital	462
<i>Michael R. Evans and Chintan Patel</i>	
From Geography to Medicine: Exploring Innerspace via Spatial and Temporal Databases	467
<i>Dev Oliver and Daniel J. Steinberger</i>	

Smarter Water Management: A Challenge for Spatio-Temporal Network
Databases 471
*KwangSoo Yang, Shashi Shekhar, Jing Dai, Sambit Sahu, and
Milind Naphade*

Demonstrations

FlexTrack: A System for Querying Flexible Patterns in Trajectory
Databases 475
Marcos R. Vieira, Petko Bakalov, and Vassilis J. Tsotras

A System for Discovering Regions of Interest from Trajectory Data 481
*Muhammad Reaz Uddin, Chinya Ravishankar, and
Vassilis J. Tsotras*

MARiO: Multi-Attribute Routing in Open Street Map 486
*Franz Graf, Hans-Peter Kriegel, Matthias Renz, and
Matthias Schubert*

TiP: Analyzing Periodic Time Series Patterns 491
*Thomas Bernecker, Hans-Peter Kriegel, Peer Kröger, and
Matthias Renz*

An Extensibility Approach for Spatio-temporal Stream Processing
Using Microsoft StreamInsight 496
*Jeremiah Miller, Miles Raymond, Josh Archer, Seid Adem,
Leo Hansel, Sushma Konda, Malik Luti, Yao Zhao,
Ankur Teredesai, and Mohamed Ali*

Efficient Spatio-temporal Sensor Data Loading for a Sensor Web
Browser 502
Chih-Yuan Huang, Rohana Rezel, and Steve Liang

A Visual Evaluation Framework for Spatial Pruning Methods 507
*Tobias Emrich, Hans-Peter Kriegel, Peer Kröger, Matthias Renz,
Johannes Senner, and Andreas Züfle*

Spatial Outlier Detection: Data, Algorithms, Visualizations 512
*Elke Achteert, Ahmed Hettab, Hans-Peter Kriegel,
Erich Schubert, and Arthur Zimek*

Author Index 517