



# SSTD 2023

## 18th International Symposium on Spatial and Temporal Data

23-25 August 2023

Calgary, Alberta, Canada



# Proceedings of

## 2023 18th International Symposium on Spatial and Temporal Data (SSTD 2023)

23-25 August 2023

Calgary, Alberta

ISBN: 979-8-4007-0899-2



The Association for Computing Machinery  
1601 Broadway, 10<sup>th</sup> Floor  
New York, New York 10019, USA



ACM COPYRIGHT NOTICE. Copyright © 2023 by the Association for Computing Machinery, Inc. Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, to republish, to post on servers, or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from Publications Dept., ACM, Inc., fax +1 (212) 869-0481, or [permissions@acm.org](mailto:permissions@acm.org).

For other copying of articles that carry a code at the bottom of the first or last page, copying is permitted provided that the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, +1-978-750-8400, +1-978-750-4470 (fax).

ACM ISBN: 979-8-4007-0899-2

# 2023 18th International Symposium on Spatial and Temporal Data SSTD 2023

## Table of Contents

### Traffic and Transportation

Highway Systems: How Good are They, Really? .....	1
<i>Theodoros Chondrogiannis and Michael Grossniklaus</i>	
DEAR: Dynamic Electric Ambulance Redeployment .....	11
<i>Lukas Rottkamp, Niklas Strauß, and Matthias Schubert</i>	
Traffic Spatial-Temporal Prediction Based on Neural Architecture Search.....	21
<i>Dongran Zhang, Gang Luo, and Jun Li</i>	

### Machine Learning and Data Mining

Unveiling the Dynamic Interactions between Spatial Objects: A Graph Learning Approach with Evolving Constraints .....	31
<i>Daniel Glake, Norbert Ritter, Ulfia A. Lenfers, and Thomas Clemen</i>	
Towards Workload Trend Time Series Probabilistic Prediction via Probabilistic Deep Learning .....	41
<i>Li Ruan, Heng Guo, Yunzhi Xue, Tao Ruan, Yuetiansi Ji, and Limin Xiao</i>	
VoCC: Vortex Correlation Clustering Based on Masked Hough Transformation in Spatial Databases.....	51
<i>Nelson Tavares de Sousa, Yannick Wölker, Matthias Renz, and Arne Biastoch</i>	

### Maritime Data

Towards a Fixed-gear AIS Trajectory Differentiation .....	61
<i>Mirjam Bayer, Daniyal Kazempour, and Peer Kröger</i>	
Evaluation of Vessel CO <sub>2</sub> Emissions Methods Using AIS Trajectories .....	65
<i>Song Wu, Kristian Torp, Mahmoud Sakr, and Esteban Zimányi</i>	
DAISTIN: A Data-Driven AIS Trajectory Interpolation Method .....	75
<i>Búgví Benjamin Magnussen, Nikolaj Bläser, and Hua Lu</i>	

### Data Processing

Scalable Overlay Operations over DCEL Polygon Layers.....	85
<i>Andres Calderon-Romero, Amr Magdy, and Vassilis J. Tsotras</i>	

A Scalable Unified System for Seeding Regionalization Queries .....	96
<i>Hussah Alrashid and Amr Magdy</i>	
A New Primitive for Processing Temporal Joins .....	106
<i>Meghdad Mirabi, Leila Fathi, Anton Dignös, Johann Gamper, and Carsten Binnig</i>	
<b>Recommendation Systems</b>	
Social Community Recommendation Based on Large-scale Semantic Trajectory Analysis Using Deep Learning .....	110
<i>Chaoquan Cai, Wei Jiang, and Dan Lin</i>	
Recommending the Least Congested Indoor-Outdoor Paths without Ignoring Time .....	121
<i>Vasilis Ethan Sarris, Panos K. Chrysanthis, and Constantinos Costa</i>	
A Design of Activity-Based Mobility Intervention .....	131
<i>Joon-Seok Kim, Gautam Thakur, and Steven Carter Christopher</i>	
<b>Satellite and Sensor Data</b>	
Viper: Interactive Exploration of Large Satellite Data .....	141
<i>Zhuocheng Shang and Ahmed Eldawy</i>	
Harmonization-guided Deep Residual Network for Imputing under Clouds with Multi-sensor Satellite Imagery .....	151
<i>Xian Yang, Yifan Zhao, and Ranga Raju Vatsavai</i>	
An Energy Aware Adaptive Clustering Protocol for Energy Harvesting Wireless Sensor Networks .....	161
<i>Ning Li, Winston K.G. Seah, Zhengyu Hou, Bing Jia, Baoqi Huang, and Wuyungerile Li</i>	
<b>Demo Papers</b>	
Interactive Detection and Visualization of Ocean Carbon Regimes .....	171
<i>Sweety Mohanty, Daniyal Kazempour, Lavinia Patara, and Peer Kröger</i>	
NALSD: A Natural Language Interface for Spatial Databases .....	175
<i>Mengyi Liu, Xieyang Wang, and Jianqiu Xu</i>	
An Interactive Map-based System for Visually Exploring Goods Movement Based on GPS Traces .....	180
<i>Reza Safarzadeh, Yunli Wang, Sun Sun, and Xin Wang</i>	
RouteDOC: Routing with Distance, Origin and Category Constraints (Demonstration Paper) .....	185
<i>Thomas Frohwein, Zachary Garwood, Dylan Hampton, Kevin Knack, Nate Schenck, Britney Yu, Joe Zuber, Goce Trajcevski, Xu Teng, and Andreas Züfle</i>	
Scalable Spatial Analytics and In Situ Query Processing in DaskDB .....	189
<i>Suvam Kumar Das, Ronnit Peter, and Suprio Ray</i>	

# Message from the PC and General co-Chairs

## SSTD 2023

Welcome to SSTD 2023, the 18<sup>th</sup> International Symposium on Spatial and Temporal Data!

The International Symposium on Spatial and Temporal Data 2023 (SSTD 2023) is the eighteenth event of a series of biannual symposia that discuss new and exciting research in spatial, temporal and spatio-temporal data management and related technologies with the goal of setting future research directions. SSTD 2023 took place in Calgary, Alberta, Canada, from 23 to 25 August 2023.

The primary focus of SSTD symposia is on original results in the areas of theoretical foundations, design, implementation, and applications of spatial and temporal database technology. This year, we continued the tradition of SSTD to gather research in both academia and industry.

Following a panel discussion at SSTD 2019 in Vienna, Austria, we decided to rename SSTD from “International Symposium on Spatial and Temporal **Databases**” to “International Symposium on Spatial and Temporal **Data**”. The rationale for this change, as suggested by Prof. Dimitris Papadias at the SSTD 2019 panel, was to broaden the topic and participation to explicitly solicit research submissions that do not necessarily focus on database technologies and research. The call for papers of SSTD in the last decades had already been inclusive of research topics outside of databases and many papers published did not focus on databases. The panel and participants at SSTD 2019 agreed that this change of name of SSTD is consistent with the research focus on SSTD. This year, we implemented this change.

This year, we received 48 submissions in the Research track, among which 46 were regular papers, and two were short papers. Our program committee included 88 expert reviewers. All papers received at least three reviews. Based on the recommendation provided by the program committee we selected 15 papers for publication in the proceedings, among which 14 are regular research papers and one is a short paper. The overall acceptance rate of the research track is  $15/48 = 31.25\%$ . Apart from the Research track, we received a total of 15 submissions in the Industry/Vision/Demo tracks and accepted 8 of them: 5 Demo, 2 Industry and 1 Vision. Along with the presentations of research publications, and technical demonstrations, a panel has been organized. The program also featured two keynote talks by prestigious researchers, Juliana Freire (Institute Professor at the Tandon School of Engineering and Professor of Computer Science and Engineering and Data Science at New York University), and Li Xiong (the Samuel Dobbs Professor of Computer Science and Biomedical Informatics at Emory University). Professor Freire talked about “Democratizing Urban Data Exploration”, and Professor Xiong's talk was about “Harnessing Spatiotemporal Data for Pandemic Preparedness with Privacy-Enhancing Technologies.”

We were very fortunate to be able to count with the support and financial support from Esri, Inc. and Wherobots. We are very grateful to all of the organizing committee members for their contribution to this effort as well as the support by the SSTD Endowment. We also thank all the Program Committee members and external reviewers who contributed in the evaluation of the papers and ensuring the quality of the technical program. Our colleagues from the University of Calgary deserve special recognition for making it possible to host this year's SSTD so close to the beautiful Rocky Mountains. Finally, we thank

all the authors for their submitted contribution and ensuring SSTD continues to be well-known as an excellent research venue for spatial and temporal data.

Zheng Baihua (Singapore Management University, Singapore)

Mohamed Mokbel (University of Minnesota, USA)

Mario A. Nascimento (Northeastern University, Canada)

Chiara Renso (ISTI-CNR, Pisa, Italy)

Karine Zeitouni (University of Versailles Saint-Quentin, France)

Andreas Züfle (Emory University, USA)

# Conference Committees

## General Co-chairs

Mario A. Nascimento (Northeastern University, Canada)  
Mohamed Mokbel (University of Minnesota, USA)

## Program Co-chairs

Karine Zeitouni (University of Versailles Saint-Quentin, France)  
Andreas Züfle (Emory University, USA)

## Industry, Demo and Vision Co-chairs

Chiara Renso (ISTI-CNR, Pisa, Italy)  
Zheng Baihua (Singapore Management University, Singapore)

## Tutorial and Keynote Chair

Matthias Schubert (LMU, Germany)

## Local Arrangements Chair

Steve Liang (University of Calgary and SensoUp, Inc)

## Proceedings Chair

Suprio Ray (University of New Brunswick, Canada)

## Registration and Treasurer Chair

Xin Wang (University of Calgary, Canada)

## Publicity Chair

Theodoros Chondrogiannis (University of Konstanz, Germany)

## Sponsorship Chair

Amr Magdy (University of California Riverside, USA)

## Webmaster

Saloua Bouabba (University of Versailles Saint-Quentin, France)  
Mohammad Abboud (University of Versailles Saint-Quentin, France)

## SSTD Steering Committee

Mario A. Nascimento (Northeastern University, Canada)  
Ki-Joune Li (Pusan National University, South Korea)  
Bernhard Seeger (University of Marburg, Germany)  
Yannis Theodoridis (University of Piraeus, Greece)  
Raymond Chi-Wing Wong (HKUST, Hong Kong)  
Kjetil Nørvåg (NTNU, Norway)  
Eric Hoel (ESRI, USA)



## **Program Committees**

### **Research Track**

Amr Magdy (University of California Riverside)  
Apostolos N Papadopoulos (Aristotle University of Thessaloniki)  
Arpan Man Sainju (Middle Tennessee State University)  
Ashwin Shashidharan (Esri)  
Bart Kuijpers (Hasselt University and Transnational University of Limburg)  
Bernhard Seeger (Universität Marburg)  
Cedric du Mouza (CNAM)  
Cheng Long (Nanyang Technological University)  
Chengyang Zhang (Amazon)  
Chiara Renso (ISTI-CNR)  
Christophe Claramunt (Naval Academy Research Institute)  
Christos Doulkeridis (University of Pireaus)  
Cyril Ray (Ecole Navale)  
Da Yan (University of Alabama at Birmingham)  
Dan Lin (Vanderbilt University)  
Demetrios Zeinalipour-Yazti (University of Cyprus)  
Dev Oliver (ESRI)  
Dieter Pfoser (George Mason University)  
Dimitrios Skoutas (Athena Research Center)  
Dimitris Papadias (HKUST)  
Dimitris Sacharidis (ULB)  
Dinusha Vatsalan (Macquarie University)  
Dr.Shashi Shekhar (University of Minnesota)  
Erik G Hoel (Esri)  
Farnoush Banaei-Kashani (University of Colorado Denver)  
Flora D. Salim (University of New South Wales)  
Gao Cong (Nanyang Technological University)  
Goce Trajcevski (Iowa State University)  
Haiquan Chen (California State University, Sacramento)  
Hao Xue (University of New South Wales)  
Hua Lu (Roskilde University)  
Jeffrey Xu Yu (Chinese University of Hong Kong)  
Jia Yu (Washington State University)  
Jiamin Lu (Hohai University)  
Jianzhong Qi (University of Melbourne)  
Jie Bao (Microsoft Research Asia, China)  
Jieming Shi (The Hong Kong Polytechnic University)  
Jing Dai (University of Nottingham)  
John Krumm (University of Southern California)  
Joon-Seok Kim (Oak Ridge National Laboratory)  
Kjetil Nørkvåg (Norwegian University of Science and Technology)  
Konstantinos Tserpes (Harokopio University of Athens)  
Kostas Patroumpas (Athena Research Center)

Kristian Torp (Aalborg University)  
Kyoung-Sook Kim (National Institute of Advanced Industrial Science and Technology)  
Kyriakos Mouratidis (Singapore Management University)  
Mahmoud A Sakr (ULB)  
Man Lung Yiu (Hong Kong Polytechnic University)  
Maria L Damiani (University of Milan)  
Markus Schneider (University of Florida)  
Martin Werner (TU München)  
Matthias Renz (University of Kiel)  
Michael P. McGuire (Towson University)  
Michela Bertolotto (University College Dublin)  
Mirco Nanni (CNR-ISTI Pisa, Italy)  
Mohamed Mokbel (University of Minnesota)  
Nikos Mamoulis (University of Ioannina)  
Nikos Pelekis (University of Piraeus)  
Ouri Wolfson (University of Illinois)  
Panagiotis Bouros (Johannes Gutenberg University Mainz)  
Peer Kröger (Christian-Albrecht-University Kiel)  
Peter Revesz (University of Nebraska-Lincoln)  
Raymond Chi-Wing Wong (Hong Kong University of Science and Technology)  
Reynold Cheng (The University of Hong Kong, China)  
Ruo Chen Kong (Emory University)  
Samridhi Singla (University of California, Riverside)  
Sara Migliorini (University of Verona)  
Sepanta Zeighami (University of Southern California)  
Sergio Ilarri (University of Zaragoza)  
Shawn Newsam (UC Merced)  
Shrey Gupta (Emory University)  
Spiridon Bakiras (Singapore Institute of Technology)  
Suprio Ray (University of New Brunswick, Fredericton)  
Taylor Anderson (Simon Fraser University)  
Theodoros Chondrogiannis (University of Konstanz)  
Vassilis J. Tsotras (UC Riverside)  
Weicheng Wang (Hong Kong University of Science and Technology)  
Wei-Shinn Ku (Auburn University)  
Xin Cao (University of New South Wales)  
Xiqi Fei (George Mason University)  
Yannis Theodoridis (University of Piraeus)  
Yaron Kanza (AT&T Labs-Research)  
Yunjun Gao (Zhejiang University)  
Chih-Chieh Hung (National Chung Hsing University)  
Jianqiu Xu (Nanjing University of Aeronautics and Astronautics)  
Rui Zhu (Shenyang Aerospace University)  
Tianming Zhang (Zhejiang University Of Technology)  
Xiao Pan (Shijiazhuang Tiedao University)

**Industry, Demo & Vision Track**

Ticiano Coelho da Silva (Federal University of Ceará)

Chih-Chieh Hung (National Chung Hsing University)

Johannes Lauer (Here Technologies)

Francesco Lettich (ISTI Institute of National Research Council)

Xiao Pan (Shijiazhuang Tiedao University)

Chiara Pugliese (ISTI Institute of National Research Council)

Amilcar Soares (Memorial University of Newfoundland)

Panagiotis Tampakis (University of Southern Denmark)

Tianming Zhang (Zhejiang University Of Technology)

Rui Zhu (Shenyang Aerospace University)

Jianqiu Xu (Nanjing University of Aeronautics and Astronautics)