

LBS 2021

16th Conference on Location Based Services
24-25 November 2021 Online



Proceedings of the

16th International Conference on Location Based Services

Anahid Basiri, Georg Gartner and Haosheng Huang (Editors)

Glasgow / Online

November 24–25, 2021



ICA Commission on
Location Based Services



Editors

Anahid Basiri, Ana.Basiri@glasgow.ac.uk

School of Geographical & Earth Sciences, University of Glasgow, UK

Georg Gartner, Georg.Gartner@tuwien.ac.at

Research Group Cartography, TU Wien, Austria

Haosheng Huang, Haosheng.Huang@ugent.be

Department of Geography, Ghent University, Belgium

This document contains the proceedings of the 16th International Conference on Location Based Services (LBS 2021), held online on November 24–25, 2021.

The conference is organized by the ICA Commission on Location Based Services, and the School of Geographical & Earth Sciences at the University of Glasgow.

The editors would like to thank all the scientific committee members of LBS 2021 for help ensuring an excellent conference program, as well as Wangshu Wang for compiling the whole proceedings.

DOI: 10.34726/1741

© The copyright of each paper within the proceedings is with its authors. All rights reserved.

Preface

We are now living in a mobile information era, which is fundamentally changing science and society. Location Based Services (LBS), which deliver information depending on the location and context of the (mobile) device and user, play a key role in this mobile information era. In recent years, lots of progress has been achieved in the research field of LBS, due to the increasingly maturity of the underpinning communication technologies and mobile devices. LBS have become more and more popular in not only citywide outdoor environments, but also shopping malls, museums, and many other indoor environments. They have been applied for emergency services, tourism services, intelligent transport services, social networking, gaming, assistive services, etc.

Since its initiation by Georg Gartner from TU Wien in 2002, the LBS conference series has become one of the most important scientific events decided to LBS. The conferences have been held in Vienna (2002, 2004, 2005), Hong Kong (2007), Salzburg (2008), Nottingham (2009), Guangzhou (2010), Vienna (2011), Munich (2012), Shanghai (2013), Vienna (2014), Augsburg (2015), Vienna (2016), Zurich (2018), Vienna (2019). Starting from 2015, the LBS conferences have become the annual event of the Commission on Location Based Services of the International Cartographic Association (ICA). In November 2021, the 16th LBS conference (LBS 2021) will be hosted by the University of Glasgow.

The conference proceedings contain a selection of short papers submitted to LBS 2021. The book provides a general picture of recent research activities related to the domain of LBS. Such activities emerged in the last years, especially concerning issues of outdoor/indoor positioning, wayfinding and navigation systems, location tracking, mobility and activity analytics, social media, usability and privacy, and innovative LBS systems

We would like to thank all the authors for their excellent work. We hope you enjoy reading these papers, and look forward to your participation in the future LBS conferences.

Anahid Basiri, Georg Gartner and Haosheng Huang

November 2021 in Glasgow, UK, Vienna, Austria and Ghent, Belgium

Scientific Committee

Conference Chairs:

Anahid Basiri, University of Glasgow, UK

Haosheng Huang, Ghent University, BE / ICA Commission on Location Based Services

Program Committee:

Georg Gartner, TU Wien, AT (Chair)

Anto Aasa, University of Tartu, EE

Tinghua Ai, Wuhan University, CN

Gennady Andrienko, Fraunhofer, DE

Masatoshi Arikawa, The University of Tokyo, JP

Thierry Badard, Laval University, CA

Dirk Burghardt, TU Dresden, DE

William Cartwright, RMIT University, AU

Christophe Claramunt, Naval Academy Research Institute, FR

Sagi Dalyot, Technion, IL

Mahmoud Reza Delavar, University of Tehran, IR

Urska Demsar, University of St Andrews, UK

Sara Irina Fabrikant, University of Zurich, CH

Zhixiang Fang, Wuhan University, CN

Ioannis Giannopoulos, Vienna University of Technology, AT

Dariusz Gotlib, Warsaw University of Technology, PL
Amy Griffin, RMIT University, AU
Hartwig Hochmair, University of Florida, US
Bin Jiang, University of Gävle, SE
Carsten Keßler, Aalborg University Copenhagen, DK
Peter Kiefer, ETH Zurich, CH
Christian Kray, University of Münster, DE
Rui Li, State University of New York at Albany, US
Bernd Ludwig, University Regensburg, DE
Liqu Meng, Technical University of Munich, DE
Peter Mooney, National University of Ireland Maynooth, IE
Oliver O'Brien, University College London, UK
Ross Purves, University of Zurich, CH
Martin Raubal, ETH Zurich, CH
Tumasch Reichenbacher, University of Zurich, CH
Bernd Resch, University of Salzburg, AT
Guenther Retscher, Vienna University of Technology, AT
Kai-Florian Richter, Umea University, SE
Volker Schwieger, University Stuttgart, DE
Johannes Schöning, University of St. Gallen, CH
Jie Shen, Nanjing Normal University, CN
Takeshi Shirabe, KTH Royal Institute of Technology, SE
Martin Tomko, The University of Melbourne, AU

Nico Van de Weghe, Ghent University, BE

Monica Wachowicz, RMIT University, AU

Wangshu Wang, TU Wien, AT

Robert Weibel, University of Zurich, CH

Stephan Winter, The University of Melbourne, AU

Frank Witlox, Ghent University, BE

Table of Contents

Section I: Wayfinding and Navigation Systems

<i>Zhiyong Zhou, Robert Weibel, Kai-Florian Richter and Haosheng Huang</i> Towards a hierarchical indoor data model from a route perspective	1
<i>Fangli Guan, Zhixiang Fang and Haosheng Huang</i> Representation and modelling of the complexity of street intersections for navigation guidance	5
<i>Laure De Cock, Nico Van de Weghe, Kristien Ooms and Philippe De Maeyer</i> Adaptive mobile indoor route guidance, the next big step	10
<i>Meng Tong Qin, Weihua Dong and Haosheng Huang</i> Indoor wayfinding in real-world environments and virtual reality: A comparison	15
<i>Jingyi Zhou, Jie Shen, Jiafeng Shi and Litao Zhu</i> Indoor navigation path visualization method considering the spatial characteristics	19
<i>Litao Zhu, Jie Shen and Georg Gartner</i> Ontology-driven context-aware recommendation method for indoor navigation in large hospitals	23

Section II: Positioning

<i>Guenther Retscher, Pajtim Zariqi, Ana Oliva Pinilla Pachon, José Pablo Ceballos Cantu and Sasanka Madawalagama</i> Bluetooth Distance Estimation for COVID-19 Contact Tracing..	27
<i>Till Weigert and Guenther Retscher</i> Positioning Performance Evaluation of a Dual Frequency Multi-GNSS Smartphone	42

Delphine Isambert, Paul Chambon and Alexandre Vervisch Picois
**PPP-RTK : the advantageous result of a hybridization of GNSS
accurate positioning techniques** 63

Maryam Jafari Tafazzol and Mohammad Reza Malek
**A New Method for Indoor Positioning Based on Integrating
Wireless Local Area Network, Bluetooth Low Energy, and
Inertial Sensors** 69

*Wioleta Błaszczak-Bąk, Guenther Retscher, Joanna Janicka, Marcin
Uradziński, Michał Bednarczyk and Jelena Gabela*
Dual-frequency GNSS/Wi-Fi smartphone navigation 82

Section III: Location tracking and systems

Simon Gröchenig and Karl Rehr
**Towards C-ITS-based communication between bicycles and
automated vehicles** 88

Amna Anwar and Eiman Kanjo
**Crime Prevention on the Edge: Designing a Crime-Prevention
System by Converging Multimodal sensing with Location-Based
Data**..... 96

Caner Guney, Emre Tuncel and Hakan Ulagan
Employee Location Tracking in Retail Stores..... 101

*Guilherme Spinoza Andreo, Ioannis Dardavesis, Michiel de Jong,
Pratyush Kumar, Maundri Prihanggo, Georgios Triantafyllou, Niels van
der Vaart and Edward Verbree*
**Building Rhythms: Reopening the Workspace with Indoor
Localisation** 106

Saman Shafipour, Mahmoud Reza Delavar and Abbas Babazadeh
**Modeling accident hotspots to locate roadside equipment based
on intelligent transportation system**..... 117

Section IV: Mobility and Activity Analytics

- Achituw Cohen, Sagi Dalyot and Asya Natapov*
Machine Learning for Predicting Pedestrian Activity Levels in Cities 124
- Eun-Kyeong Kim, Elena Ebert and Robert Weibel*
The Effect of Post-Processing in Stop-Move Detection of GPS Data: A Preliminary Study 130
- James Williams, James Pinchin, Adrian Hazzard and Gary Priestnall*
Survey of Leisure Walking Behaviours and Activity Tracking Use: Emerging Themes and Design Considerations..... 136
- Jing Huang and Tong Zhang*
Personalized POI recommendation using deep reinforcement learning..... 142
- Irma Kveladze, Pelle Rosenbeck Gøeg and Niels Agerholm*
Understanding Mobility of Aalborg Commuters: A case study with a Floating Car Datasets..... 149
- Francisco Porras Bernardez and Georg Gartner*
Climate change and populists in geolocated Twitter 155
- Seyed Ali Hoseinpour*
A Real-Time Spatio-Temporal Bigdata System for Instant Analysis of Twitter Data to Monitor of Advertising Campaigns; Case Study New York City 164

Section V: User Studies, Visualization, and Analysis

- Vilma Jokinen, Ville Mäkinen, Anna Brauer and Juha Oksanen*
Would citizens contribute their personal location data to an open database? Preliminary results from a survey 171

<i>Florian Ledermann</i> Small differences: Limits of Legibility of Cartographic Symbols on High- and Ultra-High-Resolution Mobile Displays.....	177
<i>Zhenyu Liu, Runnan Fu, Linjun Wang, Yuzhen Jin, Theodoros Papakostas, Xenia Una Mainelli, Robert Voûte and Edward Verbree</i> Game Engine-based Point Cloud Visualization and Perception for Situation Awareness of Crisis Indoor Environments.....	183
<i>Lars Sloover, Laure De Cock, Bart De Wit, Samuel Van Ackere and Nico Van de Weghe</i> On the Detection of Moving Objects in Laser Scan Data: the Highest Point of Interest (HPOI) Method.....	195
<i>Gabriel Kerekes and Volker Schwieger</i> Towards Perceived Space Representation using Brain Activity, Eye-Tracking and Terrestrial Laser Scanning	204
<i>Mina Karimi, Mohammad Saedi Mesgari and Omid Reza Abbasi</i> What Can I Do There? Extracting Place Functionality Based on Analysis of User-Generated Textual Contents	210