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S. C. M. Geertman · Christopher Pettit · Robert Goodspeed · Aija Staffans *Editors*

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Urban Informatics and Future Cities

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Preface

The international CUPUM conference (Computational Urban Planning and Urban Management) has been one of the premier international conferences for the exchange of ideas and applications of computer technologies to address a range of social and environmental problems relating to urban areas. The first conference took place in 1989 in Hong Kong. Since then this bi-annual conference has been hosted in cities across Asia, Australia, Europe, North America and South America (Table 1). Now, in 2021, 32 years after the first CUPUM conference, Aalto-Helsinki in Finland will host the 17th CUPUM conference.

Table 1 Past CUPUM conferences

Number	Year	Place	Country
I	1989	Hong Kong	Hong Kong
II	1991	Oxford	United Kingdom
III	1993	Atlanta	USA
IV	1995	Melbourne	Australia
V	1997	Mumbai	India
VI	1999	Venice	Italy
VII	2001	Honolulu	USA
VIII	2003	Sendai	Japan
IX	2005	London	United Kingdom
X	2007	Iguazu Falls	Brazil
XI	2009	Hong Kong	China
XII	2011	Lake Louise (Calgary/Banff)	Canada
XIII	2013	Utrecht	The Netherlands
XIV	2015	Boston	USA
XV	2017	Adelaide	Australia
XVI	2019	Wuhan	China
XVII	2021	Aalto-Helsinki	Finland

Table 2 Board of directors of CUPUM

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The CUPUM Board (Table 2) has promoted the publication of a *Springer CUPUM Book 2021* with a selection of scientific papers that were submitted to the conference. Those papers went through a competitive, double-blind review process that resulted in the selection of what the reviewers deemed to be the best CUPUM papers of 2021. All these papers fit the main overarching central theme of the Aalto-Helsinki 2021 CUPUM conference: *Urban Informatics and Future Cities*. Therein, we acknowledge that Future Cities are in need of innovative technologies, associated methodologies and their adoption by the key actors responsible for their planning and management. This will be assisted by 'gathering' (hybrid conference: online and at campus) from June 9–11, 2021 both online and at Aalto University, Helsinki metropolitan area, Finland and via the publication of this Springer CUPUM Book 2021. Through the combined efforts of the conference and book publication we hope to facilitate the exchange new ideas on this theme and bring together research and practitioners to better use data, technology and tools to address the challenges facing our cities.

Organizing the programme of an international conference and editing a volume of scientific papers requires dedication, time, effort and support.

First of all, we would like to thank all the people closely involved in the organization of the Aalto-Helsinki 2021 CUPUM conference. Organizing such a conference always turns out to be much more work and generating many more problems/challenges than envisaged before.

Second, as book editors, we would like to thank the authors for their high-quality contributions. We started with 39 proposals for interesting book chapters and finally ended up with 29 high-quality full chapters in this book. The double-blind review process was not an easy task and it is always difficult when potential authors experience the disappointment of not being selected. By fulfilling the double-blind review

Table 3 Advisors to the CUPUM board

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process and demanding at least two reviews per submission we believe that the review process has been conducted in a fair and equitable way.

Third, we would like to thank our fellows from the Board of Directors of CUPUM and the Advisors to the CUPUM Board for their time and expertise in assisting with the review process. Without their help we wouldn't be able to guarantee a double-blind reviewing process. Furthermore, their critical judgement has improved the overall quality of the book substantially.

And fourth, we would like to thank our scientific sponsors (Utrecht University, University of New South Wales, University of Michigan, Aalto University) for their contribution in time and resources to this publication. Finally, we would like to thank Springer Publishers for their willingness to publish these contributions in their academic *Urban Book Series.* This is already the fifth time that a selection of best papers from the CUPUM conference has been published by Springer. The first time was in 2013, when we published the book: '*Planning Support Systems for Sustainable Urban Development*' (Stan Geertman, Fred Toppen, John Stillwell (eds.)). The second time was in 2015, when we published the book: '*Planning Support Systems and Smart Cities*' (Stan Geertman, Joe Ferreira, Robert Goodspeed, John Stillwell (eds.)). In 2017 we published the book: '*Planning Support Science for Smarter Urban Futures*' (Stan Geertman, Andrew Allan, Chris Pettit, John Stillwell (eds.)). And in 2019 we published the book: '*Computational Planning and Management for Smart Cities'* (Stan Geertman, Andrew Allan, Chris Pettit, Qingming Zhan (eds.)). We hope more CUPUM books will follow.

Helsinki, Finland
2021

S. C. M. Geertman
Christopher Pettit
Robert Goodspeed
Aija Staffans

Contents

1 Introduction 1
Robert Goodspeed, Chris Pettit, Aija Staffans, and Stan Geertman

Part I Data Analytics and the COVID-19 Pandemic

2 Smart Governance and COVID-19 Control in Wuhan, China 17
Huaxiong Jiang, Patrick Witte, and Stan Geertman

3 Using Public-Private Data to Understand Compliance with Mobility Restrictions in Sierra Leone 33
Innocent Ndubuisi-Obi Jr, Ziyu Ran, Yanchao Li, Chenab Ahuja Navalkha, Sarah Williams, and Lily Tsai

4 Development of a Spatio-Temporal Analysis Method to Support the Prevention of COVID-19 Infection: Space-Time Kernel Density Estimation Using GPS Location History Data 51
Haruka Kato

Part II Big Data and Smart Cities

5 A Review of Spatial Network Insights and Methods in the Context of Planning: Applications, Challenges, and Opportunities 71
Xiaofan Liang and Yuhao Kang

6 Transport Infrastructure, Twitter and the Politics of Public Participation 93
Wayne Williamson

7 Public Perceptions and Attitudes Towards Driverless Technologies in the United States: A Text Mining of Twitter Data 109
Zhiqiu Jiang and Max Zheng

8 Assessing the Value of New Big Data Sources for Transportation Planning: Benton Harbor, Michigan Case Study 127
Robert Goodspeed, Meixin Yuan, Aaron Krusniak, and Tierra Bills

9 How Various Natural Disasters Impact Urban Human Mobility Patterns: A Comparative Analysis Based on Geotagged Photos Taken in Tokyo 151
Ahmed Derdouri and Toshihiro Osaragi

10 Revealing the Spatial Preferences Embedded in Online Activities: A Case Study of Chengdu, China 173
Enjia Zhang, Yu Ye, Jingxuan Hou, and Ying Long

Part III Data-Driven Research of Activity Patterns

11 Application for Locational Intelligence and Geospatial Navigation (ALIGN): Smart Navigation Tool for Generating Routes That Meet Individual Preferences 191
Ge Zhang, Subhrajit Guhathakurta, Jon Sanford, and Bon Woo Koo

12 Pedestrian Behavior Characteristics Based on an Activity Monitoring Survey in a University Campus Square 211
Toshihiro Osaragi, Yuriko Yamada, and Hiroyuki Kaneko

13 Developing a GIS-Based Tourist Walkability Index Based on the AURIN Walkability Toolkit—Case Study: Sydney CBD 233
Arsham Bassiri Abyaneh, Andrew Allan, Johannes Pieters, and Gethin Davison

14 Sequential Patterns of Daily Human Activity Extracted from Person Trip Survey Data 257
Weiying Wang, Toshihiro Osaragi, and Maki Tagashira

15 Understanding the Economic Value of Walkable Cities 277
Josephine Roper, Chris Pettit, and Matthew Ng

16 (Big) Data in Urban Design Practice: Supporting High-Level Design Tasks Using a Visualization of Human Movement Data from Smartphones 301
Angela Rout and Wesley Willett

17 Examining Passenger Vehicle Miles Traveled and Carbon Emissions in the Boston Metropolitan Area 319
Tigran Aslanyan and Shan Jiang

Part IV Open Data and Spatial Modelling

18 Development of a Household Urban Micro-Simulation Model (HUMS) Using Available Open-Data and Urban Policy Evaluation 343
Nao Sugiki, Shogo Nagao, Batzaya Munkhbat, Atsushi Suzuki, and Kojiro Matsuo

19 An Agent-Based Bushfire Visualisation to Support Urban Planning: A Case Study of the South Coast, NSW 2019–2020 371
Hitomi Nakanishi, Wendi Han, Milica Muminovic, and Tan Qu

20 Development of an Agent-Based Model on the Decision-Making of Dislocated People After Disasters 387
Yasmin Bhattacharya and Takaaki Kato

21 Evidence-Based Design Justice: Synthesizing Statistics and Stories—To Create Future 'Just' Cities 407
Prithi Yadav, Samuel Patterson, Ana Sima Bilandzic, and Sarah Johnstone

Part V Geodesign and Planning Support Systems (PSS)

22 Geodesign Between IGC and Geodesignhub: Theory and Practice 431
Shlomit Flint Ashery and Rinat Steinlauf-Millo

23 The Role of Technology Tools to Support Geodesign in Resilience Planning 447
Ripan Debnath, Christopher Pettit, Simone Zarpelon Leao, and Oliver Lock

24 Planning Support Systems for Long-Term Climate Resilience: A Critical Review 465
Supriya Krishnan, Nazli Yonca Aydin, and Tina Comes

Part VI Geospatial Data Analysis

25 Aggregation of Geospatial Data on "Street Units": The Smallest Geographical Unit of Urban Places 501
Takuo Inoue, Rikutaro Manabe, Akito Murayama, and Hideki Koizumi

26 Local Betweenness Centrality Analysis of 30 European Cities 527
Kaoru Yamaoka, Yusuke Kumakoshi, and Yuji Yoshimura

27 Model for Estimation of Building Structure and Built Year Using Building Facade Images and Attributes Obtained from a Real Estate Database 549
Takuya Oki and Yoshiki Ogawa

28 A Spatial Analysis of Crime Incidence and Security Perception Around a University Campus 575
Daniela Vanessa Rodriguez Lara and Antônio Nélson Rodrigues da Silva

29 Sightseeing Support System with Augmented Reality and No Language Barriers 591
Shinya Abe, Ryo Sasaki, and Kayoko Yamamoto

30 GeoMinasCraft: A Serious Geogame for Geographical Visualization and Exploration 613
Ítalo Sousa de Sena, Alenka Poplin, and Bruno de Andrade

Chapter 1
Introduction

Robert Goodspeed, Chris Pettit, Aija Staffans, and Stan Geertman

Abstract This book is a selection of the best papers presented at the CUPUM conference at Aalto University, Helsinki, Finland in June 2021. CUPUM stands for Computational Urban Planning and Urban Management and is a once every two years conference, held somewhere in the world. This chapter is the introductory chapter to this book. It introduces the title and central theme of the book: 'Urban Informatics and Future Cities'. Therein, three cross cutting themes can be identified: big data, disasters and resiliance, and walkability and tourism. Besides, the chapter provides an overview of the content of the volume by presenting briefly each of its consituting chapters, their titles and authors and their main content. In total 30 chapters have been included in this volume.

Keywords Urban planning · Urban management · Urban informatics · Future cities

When this volume is released in June 2021, it will appear after one of the most eventful 18 months in recent memory. After the emergence of the COVID-19 virus in Wuhan, China in December 2019, the disease has spread worldwide in the worst global pandemic in over 100 years. Simultaneously, the intensifying effects of global warming are being felt worldwide, dramatized by historic wildfires in Australia and California in late 2019 and during 2020. In the U.S., simmering anger over police brutality towards Black citizens and persistent racial injustice and inequality

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in American society boiled over into a series of historic protests in the summer of 2020, influencing a contested election. Worldwide, cities struggled to adapt to these events, as the pandemic caused profound changes to city life including the rapid growth in popularity of walking and cycling, transformed commuting patterns due to widespread working from home, and impacted public budgets.

The 2021 CUPUM conference, which for over 30 years has convened a unique global community concerned with the application of computational tools and methods to urban management and planning problems, will also be unlike any other, as it will be conducted exclusively online. Even as life hopefully slowly returns to normal in 2021, the pandemic has underscored the centrality of digital technologies to society, with so many aspects of life being conducted via internet technologies, with videoconferencing, email, and social media attracting more users than ever before. The chapters presented here also reflect the impact of extensive diffusion of digital technologies, even as CUPUM scholars continue to lead the development of novel tools, techniques, and datasets tailored to urban applications.

This volume comprises 29 chapters which will be presented at the CUPUM conference in June 2021, hosted virtually from Helsinki, Finland, and this chapter serves to introduce them in two ways. First, we comment on some of the cross cutting themes connecting these diverse chapters, and illustrate how they both reflect research on topics of longstanding interest by the CUPUM community, but also reflect the unique historical moment during which this volume appears. Second, we provide brief summaries of all of the articles, organizing them by research areas. By doing so, we hope to reflect on how the chapters illustrate the ways the CUPUM community is responding to short- and long-term societal trends, as well as provide an entree into the rich and exciting array of research contained within the volume. To conclude, we share some brief thoughts about where the field may be heading next.

1.1 Cross-Cutting Themes

In order to identify themes, we analyzed all the chapters from two perspectives: their technical and topical focuses. Technically, almost all chapters fell into just three categories: papers utilizing big data, tools and planning support systems, and analysis and modeling techniques. Among these, the largest category is **big data** with 12 chapters, which emerges as the first major theme of the volume. Topically the chapters fall generally into five categories: disasters and resilience, transport, walkability and tourism, planning practice and geodesign, and the pandemic. Although many chapters focus on transport, this topic has been of perennial interest by urban researchers. Newly popular, **disasters and resilience** and **walkability and tourism** emerge as our second and third important themes of the volume, which reflect urban priorities that–although predating the pandemic–gained new importance during (walkability) and in anticipation of an economic recovery (tourism). We conclude with a discussion of three important **minor themes** which remain important threads within the CUPUM community research: planning support systems, geodesign, and research engaging

questions of social justice. We conclude this section with some notes about why the topic of smart cities does not appear more prominently in the volume, and taking note of the geographic biases of the scholarship.

1.1.1 Big Data

One of the most important consequences of the digitization of society has been the advent of diverse forms of big data. From the perspective of urban management and urban planning, big data holds the promise of providing novel insights and understanding of cities, especially as it becomes increasingly available to researchers through open data and expanded data sharing (Hawken et al. 2020). The array of chapters engaging with big data illustrate the diverse forms it can take in cities, these include cellphone data (Chaps. 3, 4, 8, and 16), administrative datasets (Chap. 17), social media (Chaps. 6, 7, 9, and 10), analysis of photos (Chaps. 12 and 27) and the use of worldwide metrics like walkscore (Chap. 15). These chapters often demonstrate the novel analysis techniques necessary to analyze such datasets, compare them with traditional data, and show how big data can be applied to diverse topics like pandemic response, transportation, disaster response, and more. With the growing availability and maturity of diverse forms of big data, it seems clear that big data research will remain a major focus of CUPUM scholars for years to come, and we hope these chapters inspire yet further advances in this area.

1.1.2 Disasters and Resilience

Another noteworthy theme is reflected in a group of articles focused on the topic of natural disasters and resilience. As noted, the intensity and frequency of a variety of climate-related disasters, including wildfires, flooding, extreme heat and cold, and others, is increasing as a result of climate change. Responding to this development, CUPUM researchers tackled various aspects of this problem, including analyzing Flickr photos to understand how disasters impact human mobility (Chap. 10), developing agent-based models to simulate neighborhood rebuilding (Chap. 20), and the analysis of building photos to estimate vulnerability to earthquake and fire at the city scale (Chap. 27). In response to the growing prevalence of disasters, many cities are pursuing planning to become more resilient for the turbulent future which lies ahead. Chapters contributing to this include Chap. 24, which surveys PSS through a lens of resilience to aid practitioners seeking to adopt the best-suited PSS for this type of planning, and Chap. 23 where researchers explore tools suited to geodesign for resilience.

1.1.3 Walkability and Tourism

Cities have long sought to cultivate walkability, as a key quality of sustainability and urban quality of life. During the pandemic, with many working at home and many key public venues closed, walking and the activity in public outdoor space became key sites for individual physical activity and safer social interactions. Complementing these shifts in many cities, contributors to this volume include a variety of work focused on walkability, and the closely related topic of tourism. Chapters 12 and 16 analyze pedestrian use of urban spaces through the lens of novel datasets, Chap. 13 constructs a walkability index tailored for tourists, and Chap. 15 conducts an analysis showing the value of walkability in real estate prices. Another illustration of the close connection between walkability and tourism, Chap. 29 discusses a new tool that utilizes augmented reality to provide information in a way that overcomes language barriers.

1.1.4 Minor Themes

Finally, the chapters include work on three longstanding themes of research presented at CUPUM conferences. Although it has been over 30 years since the concept was proposed (Harris 1989), **Planning Support Systems** has graduated from a hypothetical idea to a rich field of technical innovation and scholarship that Geertman and Stilwell (2020) have recently argued qualifies as a planning support *science*. Indeed, many of the chapters previously mentioned report analyses specifically conducted with an eye towards their incorporation into PSS which allows the methods to be applied to practice. Increasingly, the idea of PSS has intertwined with the concept of **geodesign**, an emerging planning paradigm which calls for the coupling of the use of digital tools with stakeholder design deliberations (Foster 2016). Chapters in this volume provide the opportunity to become immersed in current debates about effective geodesign tools and practices (Chaps. 22, 23, and 24). Finally, many papers touch on the importance of **social justice**, a normative principle which translates many different ways into local contexts. These include a commitment for inclusive and participatory planning shown by many of the projects provided. Chapters with a clear focus on this issue include the design of tools specifically seeking to broaden access in the build environment regardless of disability (Chap. 11), and analysis of the equity implications for using big data which may not include minoritized populations such as Blacks in America (Chap. 8). Although not a prominent theme in this volume, we think it an important one which we urge the CUPUM community to engage more fully in the years ahead.

1.1.5 A Theme that Wasn't and a Note on Geographic Bias

Finally, we wish to say a word about a topic which readers may have expected would be a theme of this book, but wasn't: **smart cities**. Bursting into public consciousness in the early 2000s, propelled in part by a major push among technology companies seeking new markets for IT, the topic of smart cities is the subject of a myriad of books, articles, conferences, and pilot projects (Ruhlandt 2018; Angelidou 2015). However recently Mathis and Kanik (2021) observed a decline in smart city projects, also evident from this volume. The term smart city appears prominently in only three chapters, a discussion of how Wuhan used a variety of IT tools as part of a smart governance approach to control and respond to the COVID-19 outbreak (Chap. 2), and two papers reporting "smart campus" projects (Chaps. 16 and 28).

We propose two possible interpretations to the lack of work specifically on smart cities. First, perhaps the underwhelming performance of many smart city projects and developments has cooled interest in the idea, when it has become clear that although IT may have a beneficial role, it's far from the panacea for cities sold in marketing visions. Second, the chapters collectively illustrate a remarkable advance in the extent of use of advanced computational data, tools, and techniques as applied to urban problems compared with what existed 30 years ago. Whereas in 1989 PSS was simply a concept and most city data was rudimentary databases and GIS, this volume contains chapters describing where Sierra Leon engages in cutting-edge analysis of cellphone data with MIT researchers (Chap. 4), papers involving Australia's sophisticated AURIN platform (Pettit et al. 2017; Sinnott et al. 2014), and many others that rely on digital infrastructures which would have seemed miraculous 32 years ago at the first CUPUM in Hong Kong. In that sense, perhaps the hype about smart has faded because almost all cities are "smart" to some degree. In its place this volume uses the term **urban informatics** which conveys a rich, multidisciplinary field of research contributing to improved understanding, management, and planning of cities through multiple pathways to impact.

Finally we offer a note about the places represented by authors and case studies in these chapters. Although CUPUM, like research in many fields, has always reflected disproportionate participation by researchers based in wealthier parts of the world with more well developed research and technology sectors, CUPUM has always taken pride in its unique global scope, with active participants spread among all of the world regions. Indeed, this diversity is on full display in the current volume, with chapters about cities in Africa (Chap. 3), South America (Chap. 28), Europe (Chap. 26), the United States (Chap. 17), and more. However, we suspect the geographic diversity has been impacted by the pandemic. Japan and Australia are both well represented with multiple papers, perhaps a function of the significant expertise and infrastructures by scholars in these countries, but also because they both have had relatively minor COVID-19 outbreaks, lessening the need for disruptive shutdowns. Unfortunately there are only one chapter each from Africa and Latin America, and none focused on India or the Middle East, all regions hit hard by COVID-19. Finally, we think even wealthy Europe and North America may also be under-represented, although

both are home to many scholars working on these topics, as both experienced severe COVID-19 outbreaks accompanied by disruptions to academic research and society at large. In future years, we hope these discrepancies become reduced as all countries recover from the pandemic, and hope to take actions to ensure CUPUM encompasses work about and by residents of all types of cities worldwide.

1.2 Chapter Overviews

The following section provides an overview of all 29 chapters, divided into six sections: Data analytics and the COVID-19 pandemic, Big data and smart cities, Data-driven research of activity patterns, Open data and spatial modeling, Geodesign and planning support systems, and Geospatial data analysis.

1.2.1 Data Analytics and the COVID-19 Pandemic

In Chap. 2, titled 'Smart Governance and COVID-19 Control in Wuhan, China', the authors Huaxiong Jiang, Patrick Witte, and Stan Geertman provide a review of the many ways smart governance was deployed as part of China's COVID-19 response in Wuhan. By discursively analyzing existing data from multiple sources, the results show that the real 'smartness' of the smart governance of COVID-19 in Wuhan is the innovative use of technologies to develop different types of governance approaches to control COVID-19 in a targeted way. In addition to well-known measures, such a smartphone-based exposure tracking systems, the chapter mentions grassroots governance initiatives such as the use of WeChat groups to coordinate community voluntary responses.

Another way data analytics has been used to support effective pandemic response is through the use of big data to understand the impact of mobility restrictions on the possible spread of COVID. This is expressed in Chap. 3, 'Using Public-Private Data to Understand Compliance with Mobility Restrictions in Sierra Leone'. The authors Innocent Ndubuisi-Obi, Sarah Williams, Yanchao Li, Ziyu Ran, Chenab Ahuja Navalkha, and Lily Tsai describe how their research is conducted through a partnership between the country of Sierra Leone and researchers at MIT to analyze data from the phone company Africell. This collaborative piece of research demonstrates how the pandemic is also forging new and potentially valuable research partnerships among industry, government, and academia.

Chapter 4, titled 'Development of a Spatio-Temporal Analysis Method to Support the Prevention of COVID-19 Infection: Space-Time Kernel Density Estimation Using GPS Location History Data', is about the prevention of COVID-19 infections in places with high population density. In April 2020, the Japanese government implemented a soft lockdown. It is in this context, the author Haruka Kato developed a spatio-temporal analysis method based on the space-time kernel density estimation

that visualizes the space-time of a place with high population density. Point type data of the floating population with GPS location, obtained at regular intervals from smartphones (15 min), was used as an input in calculating the density estimation of people. The method is an alternative to the Japanese soft lockdown in that it enables local governments to restrict people's movements by designating specific spacetime areas. In addition, it helps citizens to change their behavior and cooperate in the prevention of COVID-19 infection.

1.2.2 Big Data and Smart Cities

With the rise of geospatial big data, new narratives of cities based on spatial networks and flows have replaced the traditional focus on locations. In Chap. 5 'A Review of Spatial Network Insights and Methods in the Context of Planning: Applications, Challenges, and Opportunities' the authors Xiaofan Liang and Yuhao Kang present their review of the theories, concepts, methods, and applications of spatial network analysis in cities and their insights for planners from five areas of concerns: spatial structures, urban infrastructure optimizations, indications of economic wealth, social capital, and residential mobility, and public health control (especially COVID-19). They outline four challenges that planners face when taking the planning knowledge from spatial networks to actions: data openness and privacy, linkage to direct policy implications, lack of civic engagement, and the difficulty to visualize and integrate with GIS. Finally, they envision how spatial networks can be integrated into a collaborative planning framework.

In Chap. 6 'Transport infrastructure, Twitter and the politics of public participation' the author Wayne Williamson describes how social media is changing the ways how many local communities seek to mobilize alternative political strategies to disrupt planning processes. The focus of the chapter is the social media and hashtag (#) use of citizens on Twitter during the planning and construction of the WestConnex motorway project in Sydney, Australia. Of particular interest is the hashtag use as a form of alternative politics. The chapter identifies the extensive use of Twitter as an additional communications channel to raise concerns at a local community level, and at a broader political level during a 2019 State election.

In Chap. 7 'Public Perceptions and Attitudes Towards Driverless Technologies in the United States: A Text Mining of Twitter Data', the authors Zhiqiu Jiang and Max Zheng make use of Twitter data to capture insights into the public perceptions and attitudes towards driverless technologies and the factors that influence them. To promote public adoption of driverless vehicles, governments need to better understand these insights and influencing factors. By performing text mining of tweets about driverless technology in the U.S. through topic modeling and sentiment analysis, a set of five latent themes were uncovered embedded in the tweets. The findings indicate that Ethics and Policy, Safety, and Design and Functionality are of major concern that may prohibit the acceptance of driverless vehicles.

In recent years we have seen the rise of mobility-related big data products which aim to support transport planners in better understanding travel behaviours of those traversing our cities. In Chap. 8 titled 'Assessing the Value of New Big Data Sources for Transportation Planning: Benton Harbor, Michigan Case Study' the authors Robert Goodspeed, Meixin Yuan, Aaron Krusniak, and Tierra Bills take a case study approach, examining the strengths and weaknesses of two commercial transport big data products available in the United State—SafeGraph and StreetLight. They undertake this comparative assessment against a conventional traditional Household Travel Survey. The results of this research suggest that big data can complement rather than replace conventional survey techniques in understanding regional travel behaviors.

Analysts continue to demonstrate the potential for analysis of social media data to shed light on various urban phenomena. In their Chap. 9 'How Various Natural Disasters Impact Urban Human Mobility Patterns: A Comparative Analysis Based on Geotagged Photos Taken in Tokyo', the authors Ahmed Derdouri and Toshihiro Osaragi demonstrate how a sophisticated analysis of the photo-sharing site Flickr can quantify the impact of several natural disasters on human mobility patterns in Tokyo. This research offers an analytics approach for revealing insights useful for urban managers tasked with disaster response.

In Chap. 10 'Revealing the spatial preferences embedded in online activities: A case study of Chengdu, China', the authors Enjia Zhang, Yu Ye, Jingxuan Hou, and Ying Long reveal the spatial preferences embedded in social media applications which can be used to better plan and design future cities. With two different types of social media data—online location tagging from Weibo and online reviews of points of interest on Dianping—they conducted a quantitative analysis to explore the relationship between online activities and elements of the built environment. The results suggest that online activities are still associated with physical urban phenomena, and the activity represented by Dianping reviews revealed more significant spatial preferences than that represented by Weibo check ins.

1.2.3 Data-Driven Research of Activity Patterns

In Chap. 11 'Application for Locational Intelligence and Geospatial Navigation (ALIGN): Smart navigation tool for generating routes that meet individual preferences' the authors Ge Zhang, Subhrajit Guhathakurta, Jon Sanford, and Bon Woo Koo develop an application to help people to navigate based on their specific preferences. The outdoor environmental barriers, such as uneven sidewalks and missing curb cuts, can significantly impair pedestrian mobility, especially for people with disabilities. The developed ALIGN app has been built for mobile devices. ALIGN intelligently identifies routes that are tailored to the individual's specific needs and abilities, based on real-time or near real-time data. Moreover, it serves to create a repository of user behaviour that can inform policy decisions.

Further on the theme of transport and mobility and in a time of smart cities and smart campuses Chap. 12 titled 'Pedestrian Behaviour Characteristics based on an

Activity Monitoring Survey in a University Campus Square' by authors Toshihiro Osaragi, Yuriko Yamada, and Hiroyuki Kaneko present a novel approach in simulating pedestrian movement. The authors apply deep learning algorithms to CCTV imagery to better understand existing pedestrian movements in order to simulate pedestrian behavior. Such a study holds many potential benefits in supporting how planners understand the existing use of open spaces and also how pedestrians might interact in future proposed open spaces in a smart campus.

Extensive research has been conducted on walkability, although the authors Arsham Bassiri Abyaneh, Andrew Allan, Johannes Pieters, and Gethin Davison point out this literature has neglected the unique needs and perspectives of tourists. In their Chap. 13 'Developing a GIS-based tourist walkability index based on the AURIN walkability toolkit—case study: Sydney CBD' they construct such a walkability index, utilizing not only well-validated built environment metrics but input from a field survey of tourists in Sydney. As tourism rebounds in the post-pandemic world, many places may be interested in using this methodology to assess and improve the walkability of tourist districts to maximize the enjoyment and financial impact of visitors.

Understanding the fine scale travel patterns of people is intrinsic for planning more accessible and functional cities. The study presented in Chap. 14 by Weiying Wang, Toshihiro Osaragi, and Maki Tagashira titled 'Sequential Patterns of Daily Human Activity Extracted from Person Trip Survey Data' provides an exploratory study using traditional Person Trip Survey Data for a number of prefectures across Japan. Using a combination of the Sequence Alignment Method (SAM) and Hierarchical Clustering the authors extract sequential patterns of daily activities. The results show that clusters that are at a similar distance to city centres have similar sequence patterns of activities across different urban geographies in Japan.

Walkability research to-date has focused foremost on the influence of the built environment on physical activity associated with health and active transport outcomes. In their Chap. 15 'Understanding the economic value of walkable cities' the authors Josephine Roper, Chris Pettit, and Matthew Ng undertook an empirical study to quantify the economic value of walkability to residential property. Specifically, they demonstrate the use of hedonic price modelling to test measures of walkability with a case study. In that, they find that the walkability index WalkScore is positively related to prices for detached houses in Sydney, Australia but has no significant relationship to apartment (unit) prices. Possible reasons and directions for future work are discussed.

In Chap. 16 '(Big) data in urban design practice: supporting high-level design tasks using a visualization of human movement data from smartphones' the authors Angela Rout and Wesley Willett claim that although extensive amounts of location data are produced daily by smartphones, existing geospatial tools are not customized to specifically support high-level urban design tasks. To remedy this, they present the SmartCampus visualization tool, representing spatiotemporal data of over 200 student pathways and restpoints on a university campus. The findings of their research showcase the need for location analysis tools tailored to concrete urban design

practices, and also highlight opportunities for Smart City researchers interested in developing domain specific, visualization tools.

The authors Tigran Aslanyan, and Shan Jiang investigate in Chap. 17 titled 'Examining Passenger Vehicle Miles Traveled and Carbon Emissions in the Boston Metropolitan Area' the GHG emissions generated by on-road passenger vehicles in Massachusetts. For that, they take advantage of two large administrative datasets and combined spatial data analytics, econometrics, and visualization tools. Based on spatial econometric models that examine socioeconomic and built environment factors contributing to the vehicle miles traveled (VMT) at the census tract level, the study offers insights to help cities reduce VMT and the carbon footprint for passenger vehicle travel. Finally, this chapter recommends a pathway for cities and towns in the Boston metropolitan area to curb VMT and mitigate carbon emissions to achieve climate goals of carbon neutrality.

1.2.4 Open Data and Spatial Modelling

Cities around the world are continually challenged by changes in population, be it rapid urbanisation or shrinking cities. The authors Nao Sugiki, Shogo Nagao, Batzaya Munkhbat, Atsushi Suzuki, and Kojiro Matsuo outline in their paper 18 titled 'Development of a Household Urban Micro-Simulation Model (HUMS) Using Available Open-Data and Urban Policy Evaluation' the application of an open data micro-simulation approach to assist planners to understand different population trajectories and future scenarios. The authors applied the HUMS models to Toyohashi City (Japan) to support the planning of sustainable urban development. The research concludes that micro-simulation based on open data offers much promise in supporting local governments in their planning future infrastructure. However, the chapter outlines a number of limitations that need to be overcome.

In Chap. 19 titled 'An agent-based bushfire visualisation to support urban planning: a case study of the South Coast, NSW 2019–2020', the authors Hitomi Nakanishi, Wendi Han, Milica Muminovic, and Tan Qu present the development of a planning support tool for visualising the bushfire spread based on an agent-based simulation platform, and discuss how an agent-based simulation can be used with residents to enhance their understanding of bushfire dynamics and planning. The presented study is done in Australia. The authors also analysed the residents' Twitter posts to understand how they prepared for evacuations in the midst of a life-threatening situation. The study concludes by outlining a number of recommendations in how simulations can support the planning and preparedness for future bushfires.

As we live in a time of changing climate there are increasing numbers of extreme events including earthquakes, floods and fires. At the same time we are witnessing rapid urbanisation in many countries which is increasing the vulnerability and risk to people. It is in this context that the authors Yasmin Bhattacharya, and Takaaki Kato contribute their research titled 'Development of an Agent-based Model on the Decision-making of Dislocated People after Disasters'. Chapter 20 outlines the

initial Agent based modelling (ABM) framework which can be used to explore future recovery scenarios, specifically to better understand how affected neighbourhoods might respond with respect to rebuilding and repopulation. This ABM offers exciting potential in supporting decision-makers and planning in post-recovery planning efforts.

In Chap. 21 'Evidence-based Design Justice: Synthesizing statistics and stories–to create future "Just" cities' the authors Prithi Yadav, Samuel Patterson, Ana Sima Bilandzic and Sarah Johnstone introduce the novel notion of Evidence-based Design Justice (EDJ). This approach draws from the strengths of both domains of Urban Science and Design Research to achieve holistic insights to address—not solve—complex issues such as homelessness. Therein, perceptive design synthesizes quantitative data-analytics and qualitative stories of lived experiences of homelessness services in Brisbane, Australia, to gain holistic insights. Outcomes of this research include ways for those experiencing homelessness to influence homelessness services and policies.

1.2.5 Geodesign and Planning Support Systems (PSS)

Geodesign is a relatively new area of both study and practice. In the past ten years, there have been about 20 international conferences and about 200 large studies in geodesign for areas undergoing contentious pressures for significant change. Chapter 22, titled 'Geodesign between IGC and geodesignhub: Theory and practice' and written by Shlomit Flint Ashery and Rinat Steinlauf-Millo compares the IGC academic approach to geodesign with the Geodesignhub approach, which is closer to the real world of interest groups practitioners. The chapter presents two case studies, one from the United Kingdom and one from Israel, and assesses the potential of geodesign as a methodology to bridge academia and practice in future-oriented policy making and spatial-temporal projects.

In Chap. 23 'The role of technology tools to support geodesign in resilience planning' the authors Ripan Debnath, Christopher Pettit, Simone Zarpelon Leao, and Oliver Lock looked at the role of technology tools within geodesign for achieving resilient urbanisation. In their research they reviewed the application of various design and planning support system (PSS) tools in resilience planning-related studies. Results indicate that the application of such PSS tools has reportedly been impacted by several usability issues. Using a geodesign case study, the authors examined the usability of several lightweight and open-source tools for collaboration. User evaluation revealed that stakeholders could interact with those tools easily, thus overcoming a significant barrier to the adoption of PSS into planning.

Planning Support Systems (PSS) enable climate-informed planning, but there have been difficulties in the uptake of PSS due to their resource-intensive nature and lack of awareness of their usefulness. In Chap. 24 titled 'Planning Support Systems for Long-Term Climate Resilience: A critical review' the authors Supriya Krishnan, Nazli Yonca Aydin, and Tina Comes aim to make a headway in understanding research

priorities and gaps that need to be addressed for PSS to address climate resilience. They conducted a literature review and a text-mining analysis of academic and non-academic (practice) literature on urban planning and climate resilience. Based on a range of identified shortcomings they propose a research agenda for improving the usage of PSS.

1.2.6 Geospatial Data Analysis

Urban analysts have often struggled with the limitations of available small spatial units used by statistical datasets, which too often group together distinct parts of cities and thereby obscure the true underlying patterns. In addition to this long standing problem, the growing availability of address-level microdata has raised the issue of what geographic units to use to link them with other urban data. In Chap. 25 'Aggregation of geospatial data on "street units": The smallest geographical unit of urban places', the authors Takuo Inoue, Rikutaro Manabe, Akito Murayama, and Hideki Koizumi effectively demonstrate how a new geography known as street units can be used to link multiple types of data, using a Japanese neighborhood as a case study.

In Chap. 26 'Local Betweenness Centrality Analysis of 30 European Cities' the authors Kaoru Yamaoka, Yusuke Kumakoshi, and Yuji Yoshimura propose a novel methodology to classify the road segments in a street network. To overcome the limitations of existing research on centrality indicators of road networks and cluster analysis, they combined the local betweenness indicator and peak analysis and completed the analyses with a new visualization method. The developed method was applied to 30 cities in Europe. As a result, they extracted important regions for pedestrians solely from the road network shapes and found common tendencies among the cities. These findings will be useful for urban planners and decision-makers in shifting from car-centric transport strategies to more pedestrian-centric plans.

As highlighted by the authors Takuya Oki and Yoshiki Ogawa, there is a paucity of city databases which comprise details on building structure and age. Such data underpins a number of city analytics applications such as understanding vulnerable building stock to extreme events such as earthquakes and fires. In Chap. 27 'Model for Estimation of Building Structure and Built Year Using Building Façade Images and Attributes Obtained from a Real Estate Database' the authors investigate the use of AI deep learning method (CNN) for automatically classifying the building stock from available photographic images. Notably, the authors investigate the use of Grad-CAM for creating activation heatmaps to understand the structure and thus transparency of the AI models developed. The results of this study hold promise in supporting the automated classification of building structure and age.

Public security is a matter of constant concern among populations, public managers, and urban planners. Although the rising crime rates may lead to a feeling of insecurity in an affected community, research in this area has not yet converged into a consensus regarding this perception. Chapter 28 titled 'A Spatial Analysis

of Crime Incidence and Security Perception around a University Campus' by the authors Daniela Vanessa Rodriguez Lara, and Antonio Nelson Rodrigues da Silva presents a study comparing the official records of crime occurrences registered by the police around a university campus in Brazil with the academic community's security perceptions. The findings point out divergences between the incidence of crimes and the security perceptions and indicate that crime occurrences are not related to the security perceptions of the community.

Chapter 29, titled 'Sightseeing Support System with Augmented Reality and No Language Barriers' shows how tourism can benefit from augmented reality and overcome language barriers. The authors Shinya Abe, Ryo Sasaki, and Kayoko Yamamoto present a sightseeing support system, which integrates location-based AR, web-geographic information system (Web-GIS) and a recommendation system with images and other non-linguistic information. The system in its current state already covers over 1,000 major sightseeing spots from all over Japan and an increase in future utilization of the system can be anticipated.

Serious games have long been an effective tool for engagement and education. The authors Italo de Sena, Alenka Poplin, and Bruno de Andrade present in their Chap. 30 the so-called 'GeoMinasCraft: A serious geogame for geographical visualization and exploration'. This is a new game constructed within MineCraft, involving realistic landscapes, buildings, and other features. It effectively immerses players into the unique landscape of the Brazilian city of Ouro Preto, where local stakeholders are working to conserve the cityscape, designated a World Heritage Site by UNESCO in 1987 but threatened by recent development.

1.3 Conclusion

The chapter summaries convey the breadth and richness of research being conducted by the CUPUM community worldwide. The research contained in this volume touches on many streams of research, each with their own preferred terminology. As previously noted, we have chosen the term urban informatics for this volume's title, since we feel it has expanded from an emphasis on how IT has changed the urban experience (Foth 2008) to encompass a wide variety of ways computational methods and techniques are applied to urban management, policy, and planning questions (Kontokosta 2018; Goodspeed 2017). As noted, the volume demonstrates how research has moved away from the smart city debate, and contains thematic focus in several areas: disasters and resilience, transport, walkability and tourism, planning practice and geodesign, and the pandemic. Many papers involve the use of urban big data, and the volume contains exciting new tools, planning support systems, analysis techniques, and even serious games created to address these topics.

With many cities looking ahead to a post-pandemic future, instead of seeking a quick return to pre-pandemic life, we have the unique opportunity to pursue cities and societies that are more resilient, sustainable, and just. This volume contains many chapters illustrating how data-driven insights and digital collaboration can be used to

support these changes. With cities forecast to continue growing in most parts of the world in the coming years, they will remain key sites for achieving societal goals of greater sustainability and resilience. We look forward to the innovations that emerge from the research community as we collectively strive to meet the urban challenges before us.

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Part I
Data Analytics and the COVID-19 Pandemic

Chapter 2
Smart Governance and COVID-19 Control in Wuhan, China

Huaxiong Jiang, Patrick Witte, and Stan Geertman

Abstract In dealing with the global COVID-19 pandemic, China has achieved reasonable success in governing COVID-19 within two months with the help of technologies. This study specifically focuses on how these massive technologies have been implemented to facilitate the smart governance of COVID-19 in Wuhan, China. By discursively analyzing existing data from multiple sources, the results obtained in this chapter show that the real 'smartness' of the smart governance of COVID-19 in Wuhan is the innovative use of technologies to develop different types of governance approaches to control COVID-19 in an effective and targeted way. As the pandemic continues to evolve worldwide, lessons learned from Wuhan, China can be beneficial to other countries in different institutional contexts to build their own, context-specific governance for controlling the pandemic.

Keywords Pandemic · SARS-CoV-2 · ICT · Smart governance · Contextualization

2.1 Introduction

In December 2019, the coronavirus (i.e., SARS-CoV-2; COVID-19) broke out in Wuhan, China. Facing with this unexpected, atypical, and damaging disease, a range of methods and means have been employed by the Chinese government and the Chinese society to contain the spread of the virus. Within two months after the initial outbreak, China has achieved reasonable success in containing the coronavirus (The State Council Information Office 2020). As COVID-19 continues to spread around the world, many discussions have been initiated on how China has succeeded in

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governing and controlling the pandemic and what insights the global community can learn from this. Two groups of discussions are identified.

First, international news reports specifically looked into the measures and actions taken by the Chinese government to control the coronavirus (Normile 2020; Jie 2020). As these reports show, China adopted extreme centralized governance measures to cut all channels (e.g., tourism, public places, public transport and entertainment) for containing the transmission of the coronavirus (Lau et al. 2020; Lin 2020). For instance, commonly informed governance measures consist of new hospitals building, full lockdown and quarantine, social distancing, strict surveillance for suspected and infected COVID-19 cases, and isolating the infected from others (Cai et al. 2020; Mozur et al. 2020; Lau et al. 2020).

Second, scientific literature focused on the governance mechanisms targeted at controlling the coronavirus (Mei 2020; AlTakarli 2020; Lau et al. 2020; Lin 2020). Some research summarizes China's model to govern the COVID-19 epidemic as a public health emergency governance approach (Ning et al. 2020; Cao et al. 2020; AlTakarli 2020). Within this approach, a leadership system—the Epidemic Prevention and Control Headquarters System (EPCHS)—was established at all Chinese administrative levels to promote a whole-of-government response to this pandemic (Ning et al. 2020; Mei 2020). Different social resources, social organizations and individuals were then mobilized to provide necessary supports (e.g., medical staff, hospital equipment, medical supplies, healthcare solutions, etc.) to control COVID-19 in Wuhan (Taghrir et al. 2020; Chan et al. 2020). Other studies focused more on the massive application of information and communication technology (ICT) to build containment measures and prevent the transmission of the pandemic (Pan 2020; He et al. 2020; Shaw et al. 2020). For instance, Kummitha (2020) concludes China's technological response to control the transmission of the pandemic as a technology-driven approach. In this process, big data, urban data analytics and artificial intelligence (AI) were widely used to govern the transmission of COVID-19 in Wuhan as follows: tracking and diagnosing COVID-19 cases, identifying a potential pharmacological treatment, quick and effective pandemic alerts, public health surveillance, real-time epidemic outbreaks monitoring, etc. (Bragazzi et al. 2020). It is worth mentioning that these initial studies improve our knowledge and understanding of the governance of COVID-19. Nevertheless, there exist apparent limitations.

First, the governance approaches summarized in the literature or news reports are explained either from a technological perspective or from a societal actor view. However, the interactions between actors and technology in creating 'smart' governance approaches to combat COVID-19 are hardly considered. Second, recent observations show that the response to COVID-19 in Wuhan has also witnessed the emergent, pop-up form of massive ICT-enabled, self-organized collaboration, characterized by large-scale, connected, and distributed interactions among citizens and digital altruism (Xinhua 2020; Wang 2020). Meijer et al. (2019) conceptualize this emerging innovative form of governance as open governance. However, few studies have recognized the existance of this newly arising governance approach and its potential and effectiveness in governing the COVID-19 pandemic.

Against this backdrop, this chapter concentrates on the socio-technical developments of smart governance for COVID-19 control in Wuhan, China. Based on the recently emerging conceptualization of smart governance (Jiang 2021), we were able to demonstrate how different types of smart governance can be established to contain COVID-19 in China. The purpose of this chapter is to present a comprehensive picture of the smart governance of COVID-19 control in China. Besides, this chapter also intends to offer useful insights obtained from China for other countries to contain COVID-19 in their respective societal contexts. To do so, Sect. 2.2 focuses on challenges of COVID-19 and explains the potential of smart governance for COVID-19 control. Section 2.3 introduces the methodology. Section 2.4 presents the results of the smart governance of COVID-19 in Wuhan. Section 2.5 ends with conclusions and lessons learned.

2.2 Smart Governance and COVID-19 Control

2.2.1 COVID-19 Challenges and Control

According to medical research, COVID-19 can cause serious health problems such as fatigue, loss of smell, shortness of breath and even death (Riggioni et al. 2020). It can also have sereve socio-economic impacts such as interruptions in the global supply chain, unemployment, less consumption, gendered effects, social safety, mental health, etc. (Atkeson 2020).

To respond, effective governance approaches are expected to be developed and delivered within a very short time span to address this threat (Taghrir et al. 2020; Janssen and van der Voort 2020). Here, we define "governance" broadly, as consisting of the entire system of public, private and semi-public and individual actors that jointly solve an issue (Treib 2007). In the face of COVID-19, the government for instance is required to publish infections data through public health platforms and handle relevant issues such as testing and contact tracing to control the transmission of the coronavirus (He et al. 2020). For non-state actors such as private companies and citizens, it is vital for them to comply with the rules and measures that can effectively prevent transmission (Kummitha 2020). In addition, the importance of developing and deploying digital public health technologies for pandemic control has received much attention (Shaw et al. 2020; He et al. 2020). For instance, Bragazzi et al. (2020) show that AI technologies can be applied to identify, track, and forecast infected people through big data analytics and enhance public security via improved face recognition and high temperature detection. Chan et al. (2020) highlight that smart and powerful devices can also contribute to diagnosing the virus and facilitating virtual communication to reduce human-to-human physical contact. Therefore, technology is deemed as an inseparable part of the governance strategy aiming to contain COVID-19.