Chapter 10
Introduction to Urban Systems and Applications

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Abstract As new information technologies and large amounts of data from a wide range of sources become available to government agencies and the public, urban researchers have started to investigate how these data can be used to enhance the planning and management of various urban systems. As a result, new methods for collecting and analyzing complex space–time data about urban systems have been developed to address various urban issues. These urban systems include transportation systems, energy systems, and health systems. In recent years, considerable new work has been conducted to examine how new information technologies and data can enhance our understanding of and ability to address urban issues. The eight chapters in this section present various applications of urban informatics to specific urban systems or phenomena, including human mobility and travel, urban freight systems, urban resilience and disaster response, urban crime, urban governance, the use of remote sensing for environmental monitoring, health and wellbeing, and urban energy systems. All of them emphasize how new, big, or open data are useful for helping us to better understand and manage specific urban systems. They also highlight significant challenges in such applications of urban informatics, which would be particularly helpful to urban researchers and planners.

Keywords Urban informatics · Urban systems · Transportation systems · Energy systems · Health systems

Urban mobility patterns have been examined for decades using travel-survey data, which are useful for the management and planning of urban infrastructures and facilities (e.g., transport systems) but are costly and time-consuming to collect. The sample sizes for travel surveys are often limited when compared to other sources of urban big data such as point-of-interest (POI) data. In Chap. 11, Pierre Melikov and colleagues illustrate how passively collected data can be used to examine human mobility patterns based on a case study of Mexico City. Using POIs registered on

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W. Shi et al. (eds.), *Urban Informatics*, The Urban Book Series,
https://doi.org/10.1007/978-981-15-8983-6_10

Google Places to approximate trip attraction in the city, the chapter compares the trip distribution patterns obtained with the POI data and those obtained using conventional datasets based on travel surveys. The study finds that the POI data provide good estimates of the trip flows in the study area when compared to the estimates obtained with the official origin–destination matrices.

As tracking and sensing technologies are increasingly used to collect a wide range of urban data, new sources of urban data have become widely available. This, in turn, allows for the development of highly detailed transportation models that facilitate the analysis of urban freight movement and the generation of policy recommendations. In Chap. 12, André Romano Alho and colleagues review the recent developments in data-collection methods in urban freight transportation and how the new data can be used in state-of-the-art transport modeling. The chapter describes two software platforms for enhancing freight movement research. The first platform is called Future Mobility Sensing (FMS), which is a data-collection platform that integrates tracking devices and mobile applications for collecting highly accurate mobility data. The second platform is called SimMobility, which is an open-source, agent-based urban simulation platform for modeling disaggregate urban passenger and freight movements. The authors discuss how the two platforms can be used jointly to advance behavioral modeling for passenger and goods movements in urban areas.

As populations continue to increase and migrate to cities, disaster risks from events like hurricanes, earthquakes, or wildfires are increasing and becoming more pronounced in urban areas. In a world that is rapidly urbanizing, the safety of rapidly increasing numbers of urban residents is at risk. In Chap. 13, Susan Cutter discusses how the resilience concept (as an outcome or as a process of building capacity) has become more central in the last decade as a means for understanding how cities prepare for and recover from disaster events. Using selected case studies of several cities as examples, she reviews research that attempts to develop urban informatics for facilitating intervention or mitigation strategies and fostering urban resilience. She suggests that shifting from passive to active sensor data and making low-cost, near-real-time data more accessible would greatly enhance research on and responses to urban risks.

Researchers have long been interested in the relationships between urban environments and crime. Environmental criminologists now commonly accept that environmental factors have considerable influence on criminal behavior, and understanding these influences would help to shed light on what measures are effective for crime prevention. Chapter 14 by Tao Cheng and Tongxin Chen provides a useful review of the development of crime research, including historic criminology and data-driven policing, and its implications for urban security and crime prevention in practice. It discusses various analytical tools for analyzing and preventing urban crime (e.g., crime hotspot mapping and police resource allocation). The chapter proposes a comprehensive data-driven policing system as a framework for urban crime prevention and security improvement.

Transparency is a critical element in urban governance. It encourages civic engagement, ensures that elected officials are accountable for their decisions, and limits the potential for corruption. To achieve transparency in urban governance, a wide range of data about cities have to be widely available to the public. Chapter 15 by Alex Singleton and Seth Spielman addresses the need for and challenges in providing adequate data to the public to enhance transparency and civic engagement. It discusses how open-source data platforms in urban governance may facilitate the realization of these goals and how the availability of the new data offers the potential to transform urban governance. The chapter, however, highlights the risks of reproducing or developing new social inequalities as a result of the proliferation of new data and their integration into software that automatically generates results based on certain algorithms.

Recent advances in sensing technologies and retrieval methodologies (e.g., the much finer spatial and temporal resolutions of modern sensors) have greatly increased the applicability of remote sensing in urban environmental applications. Chapter 16 by Janet Nichol and colleagues reviews the latest developments in the use of remote sensing in urban pollution monitoring, including assessment of urban air quality, urban heat islands, and water quality around urban coastlines. It discusses the main sensors used and the developments in retrieval algorithms for environmental monitoring in urban areas.

The technology and information available to urban residents may help increase their access to health and health-enhancing information and thus may help enhance their health and wellbeing. Chapter 17 by Clive Sabel and colleagues explores how information technology and everyday devices connected via the Internet (the Internet of Things) are shaping global research on the health and wellbeing of urban populations. It reviews various types of data used in health research in the context of smart cities. Using examples from the big data Centre for Environment and Health (BERTHA) Project at the Aarhus University of Denmark, innovative methods for collecting individual data for examining the health and wellbeing of urban residents, such as machine learning, mobile sensing, and tracking, are discussed. The chapter also reviews ethical, privacy, and confidentiality issues related to the use of sensitive personal data in health research.

The development and maintenance of urban infrastructures are highly energy-intensive. The complex interactions between human dynamics and critical infrastructures in urban areas have significant implications for traffic congestion, emissions, and energy consumption. Chapter 18 by Budhendra Bhaduri and colleagues highlights recent research at Oak Ridge National Laboratory (ORNL) in the USA on the integration of four distinct components (i.e., data, critical infrastructure models, scalable computation, and visualization) for understanding the complex interactions between physical and social systems in urban areas. It discusses four main themes in such research: population and land use, sustainable mobility, energy-water nexus, and urban resiliency. It describes how ORNL promotes innovative interdisciplinary research that integrates its expertise in critical infrastructures and their interactions with the human population using scalable computing, data visualization, and unique data sets from a variety of sources.