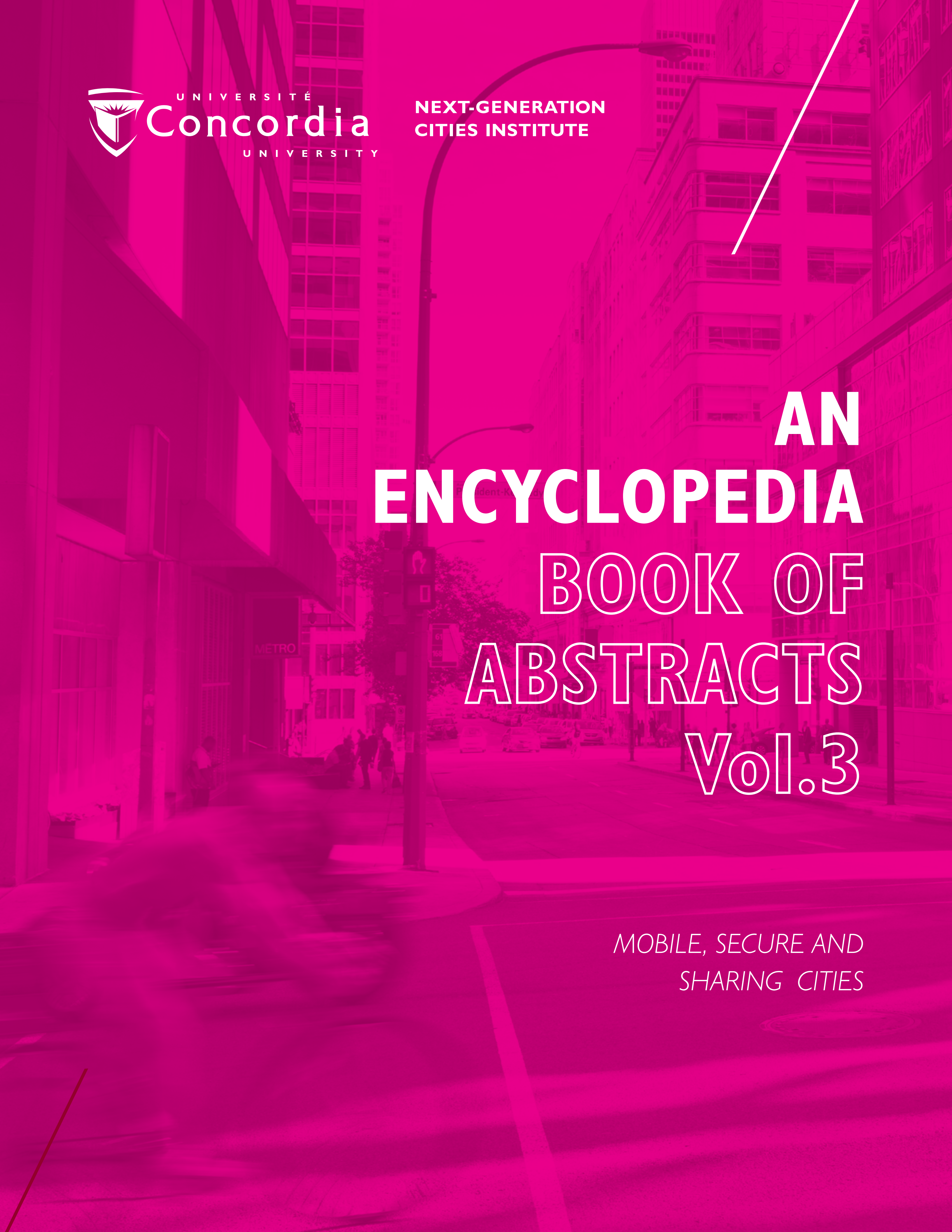


Université Concordia University

NEXT-GENERATION CITIES INSTITUTE

AN ENCYCLOPEDIA BOOK OF ABSTRACTS Vol.3

MOBILE, SECURE AND SHARING CITIES

BOOK OF ABSTRACTS / VOL. 3
FOR NEXT-GENERATION CITIES: AN ENCYCLOPEDIA

For World Scientific Publishing Co Pte Ltd
5 Toh Tuck Link, Singapore 596224
Tel: 65-6466-5775
Fax: 65-6467-7667
E-mail: wspc@wspc.com.sg

From NEXT-GENERATION CITIES INSTITUTE
CONCORDIA UNIVERSITY
2155 Rue Guy, ER-1431.35
H3H 2L9 Montréal, QC
Canada
nextgencities@concordia.ca
www.concordia.ca/research/cities-institute.html

EDITOR-IN-CHIEF
Prof. Ursula Eicker

VOLUME EDITORS
Prof. Baron Tymas
Prof. Silvano De La Llata

PUBLICATION CONCEPT AND LAYOUT
Ivona Bossert

COORDINATION
Meagan Smith
Vicktoria Kelly

DOCUMENTATION GROUP
Robert Marinov
Meagan Oxley
Femke Kocken

LAYOUT:
University Communications Services

COVER PHOTO
Credit: Royalty-free stock photo ID: 509900710, Schutterstock

"THE SOFTWARE OF THE CITY"

INDEX

PART 2

PART 3

Ursula EICKER

Editor-in-chief

Canada Excellence Research Chair (CERC) in Smart, Sustainable, and Resilient Communities and Cities, Director of Concordia University's NEXT-GENERATION CITIES INSTITUTE, Professor in the Building, Civil and Environmental Engineering (BCEE) Department at Concordia University, Canada

Chun WANG

Volume III editor

Professor, Concordia Institute for Information Systems Engineering (CIISE) at Next-Generation Cities Institute and a Co-Director Mobile, Secure and Sharing Cities Cluster at Next-Generation Cities Institute, Concordia University, Canada

Govind GOPAKUMAR

Volume III editor

Associate Professor and Chair, Centre for Engineering in Society and a Co-Director Mobile, Secure and Sharing Cities Cluster at Next-Generation Cities Institute, Concordia University, Canada

INTRODUCTION
SHAPING THE FUTURE: DIGITAL TECHNOLOGIES DRIVING SUSTAINABLE URBAN EVOLUTION

Digital technologies allow us to study cities in unprecedented ways. Cities evolving over time and pace can be visualized, scenarios of future cities can be created, and real time data can inform the everyday operation of cities. Digital twins of cities or virtual cities provide information and services, allowing activities and interactions with data and the virtual built environment infrastructure. While the video game industry initially pushed virtual city developments, today, urban planners, as well as energy and transportation engineers have begun to consider how virtual cities can help us model and visualize design alternatives.

Virtual city concepts range from simple web listings created for advertising purposes in tourism with no attempt to represent the urban built form, to 2D and 3D representations of the built environment up to effective digital equivalents of real cities which provide people with a genuine sense of an urban place. In order to provide effective digital equivalents, true virtual cities must have a sufficiently realistic built form interface, a rich diversity of services, functions and information content, and crucially, the ability to support social interaction with other people. Integrating 3D urban models in game engines facilitates such interactions and allows multiple players to experiment with their city.

An important objective of the development of digital platforms and tools that support cities and communities towards sustainability is that of assessing the current status of the city and to evaluate and monitor transformation strategies in a coherent way. This coherence has to come from three main sources. The first of which is having trust-worthy data to build on. The second is a clear data processing method and the establishment of key performance indicators (KPI) (information). The third, which is no less important, is to understand the impact of this information (knowledge). This last step, the epistemology, allows us to find and understand the key parameters for a livable city and discuss and adapt them to varying local contexts.

While data is the basis for all digital representations of cities, it remains a challenge to openly access the data needed for a comprehensive sustainability assessment, for example the 161 indicators of the United Nation's sustainable development goals.

Data and digital platforms have enabled new modes of sharing goods and services. The sharing economy is transforming the way we consume and share underutilized assets, with popular platforms such as Airbnb and Uber leading the way. However, for these platforms to succeed, effective matching mechanisms are crucial as they determine the utilization of resources, service income, and user satisfaction.

Artificial intelligence also promises ground breaking productivity increases in the digital realm. Empowered by the Internet-of-Things and Artificial Intelligence, peer-to-peer energy trading becomes possible in localized energy markets with rooftop photovoltaic panels, vehicle-to-everything technologies, packetized energy management, etc. The integration of prosumers will require advanced AI/IoT-based solutions to optimize resources, information exchange, and interaction protocols in the context of a sharing economy.

Productivity gains only improve quality of life if the community benefits from the time savings and financial gains. This means that envisioning sharing models that go beyond commercial interests and that are communal, encouraging trust and collaboration. Sharing data could enhance civic engagement and participation in municipal decision making and lead to an urban future based on solidarity, inclusion and equity. Thought further, community ownership could potentially become a third path available for our future, alongside the usually discussed and juxtapositioned governmental and private ownership options. Cooperatives and land trusts are proven models. But what if we pushed this model further and imagined that a community endowment trust could become a stakeholder in every transaction, democratically redistributing wealth towards community resilience? Such a trust could become a reality in every one of our neighborhoods and over years it owned a portfolio of community assets: co-sharing transportation, affordable housing, natural assets. Digital technologies such as smart contracts or blockchains to facilitate energy sharing transactions would be tools to support such transitions.

This third volume on mobile, secure, and sharing cities discusses the role of data in modern and sustainable transportation infrastructure and its relation to the built environment. We then introduce the Next Generation Cities Institute's extensive digital twin platform Tools4Cities, which was developed to integrate data, model scenarios for urban sustainability transitions and to engage multiple stakeholders via gamified interfaces. The challenges of moving between different spatial and temporal scales, from spaces in buildings typically described by building information models to thousands of buildings in an urban setting, are addressed. In the last part, applications from the sharing economy are shown.

Using data and digital tools in a responsible, inclusive way can thus accelerate the transition to sustainable next generation cities.

PART 1

TRANSPORTATION INFRASTRUCTURE, POLICY AND TECHNOLOGY DEVELOPMENTS

CHAPTER EDITOR:

Prof. Govind GOPAKUMAR

Ehab DIAB

Assistant Professor at the Department of Geography and Planning at the University of Saskatchewan, Canada

Dr. Diab's main areas of research are public transit planning and service operations, land-use and transportation systems integration, and social equity in planning. He has actively engaged in interdisciplinary research that incorporates transportation planning into other disciplines such as health and epidemiology. Dr. Diab is currently serving as an associate editor of the Journal of Public Transportation. He is also a member of the US Transportation Research Board-TRB's Standing Committee on Transit Management and Performance (AP010) and Standing Committee on Light Rail Transit (AP075).

Michael LU

Master's student at the Department of Geography and Planning at the University of Saskatchewan, Canada

Dr. Lu's research area centers around the concept of complete neighborhoods and measuring accessibility to achieve equitable distribution of transport infrastructure. His most recent project aims at investigating the concept of "15-minute" cities and its applicability in different contexts. He received his undergraduate degree in Planning from the University of Saskatchewan.

Jessica LAM

PhD candidate in the Department of Geography and Planning at the University of Saskatchewan, Canada

Jessica's dissertation focuses on travel behavior and perception responses to long-term closures of public transport. She earned her undergraduate degree in Civil Engineering from the University of Calgary, and her Master's of Science in Urban Agglomerations from Frankfurt University of Applied Sciences. Prior to her doctoral studies, Jessica worked as a Transportation Engineer for the City of Calgary and the City of Vancouver, where she contributed to bus, rail, and Transit Oriented Development projects.

Madhav BADAMI

Associate Professor and Graduate Program Co-Director at School of Urban Planning and the Bieler School of Environment at McGill University, Canada

Madhav is also a core faculty member in the inter-faculty BA&Sc programme in Sustainability, Science and Society at McGill. His teaching and research interests are in the areas of environmental policy and planning; urban transport; alternative transport fuels; urban infrastructure and services; and environment and development.

KEYWORDS

#ACCESSIBILITY #PROXIMITY #X-MINUTE CITY # EQUITY

ACCESSIBILITY, X-MINUTE CITY, AND EQUITY: UNDERSTANDING CONCEPTS, APPLICATIONS, AND IMPLICATIONS

Transport and land use policy have been evolving over time. Over the past few years, a greater focus has been given to the issue of integrating land use and transportation planning to address several important social, environmental, economic, and health and well-being goals, beyond enabling people to reach their desired destinations. The two-way relationship between land use and transportation planning cannot be ignored and measures that assess both of these systems in an integrated way are emerging.

This chapter includes three integrated sections. The first section focuses on discussing the concept of accessibility, while discussing different accessibility measures, their applications, and their main limitations. The distinction between local and regional accessibility is made. The second section focuses on proximity in planning and introduces the concept of the x-minute city (or 15-minute city). The concept of a 15-minute city has recently emerged and been endorsed by policymakers across the globe. This section highlights how different cities define the concept. The third section focuses on understanding the key concept of equity, while integrating the previous two sections of accessibility and 15-minute city. Understanding these issues together helps in understanding how these concepts overlap and how they are influencing our transport policies. This chapter is developed for a wide array of readers including transportation professionals, planners, academics, activists and policymakers providing information related to best practices that incorporate accessibility, social equity and x-minute city concepts, helping cities in achieving their broader environmental and social goals.

Carmela CUCUZZELLA

Dean of the Faculty of Environmental Design at the Université de Montréal, Canada

Dr. Cucuzzela's research falls within the broad domain of design studies where she investigates questions of sustainable design for urban living. Her varied background and expertise in environmental and social life cycle analysis, in green building rating systems, and in design and architecture, allows her to adopt a framework revolving around design's interrelated dimensions of the cognitive-instrumental, the moral-practical, and the aesthetic-expressive forms of conception and discourse. She has two main areas of research; In her CoLLaboratoire research, she seeks to understand how the collaborative design and implementation of interactive art-architecture in public urban spaces can contribute to a critique, deeper understanding, and/ or embodiment of sustainable urban, professional, community, and even human practices in the long term. In her second area of research, her interests lie predominantly in responsible design practices with a particular interest in understanding the challenges of accommodating sustainability diagnostic or rating tools such as Life Cycle Assessment (LCA) and LEED (Leadership in Energy and Environmental Design), alongside the creative conceptual exploration that takes place during the design process. She addresses the limits of current sustainability assessment tools as a means to gain a complex understanding of social, cultural and environmental repercussions of design practice.

Pierre GAUTHIER

Co-Director of Built and Natural Environments Cluster of the Next-Generation Cities Institute, Associate Professor at the department of Geography, Planning and Environment at Concordia University, Canada

Dr.Gauthier joined the Department of Geography, Planning and Environment in 2001. He became an Assistant Professor in 2003 and an Associate Professor in 2008. He holds a BArch from Université de Montréal, a MArch. from Université Laval and received his PhD in Urban Planning from McGill University in 2003. His research interests are related to urban morphogenesis - the evolution of urban forms; urban design and physical planning. Specific topics include: the genesis of working-class suburbs in Montréal and Québec City, the history of development and planning practices in Québec, the study of the impact of normative planning theories on urban form, and the current development wave of Large Housing Estates in China.

Omar ORTIZ MERAZ

PhD student at the department of Geography, Planning and Environment at Concordia University, Canada

Omar is spatial analyst and GIS programmer with planning skills. He possesses substantial experience in infrastructure, territorial, and environmental projects, and academic research; in complement with knowledge on processing automation and management of geospatial information, cartographic analysis, data acquisition, and map production. Having completed a Bachelor's degree of engineering in geomatics at the National University of Mexico (UNAM), Omar completed an MSc In Environmental and Infrastructure Planning at The Groningen University (Netherlands). After some years in the professional field, both in public and private institutions, he Is now completing his PhD in Geography, Planning, and Environment at Concordia University (Canada). Currently his research is focused on urban morphology and morphogenesis.

Firdous NIZAR

PhD Individualized Program (INDI) student at Concordia University, Canada

Firdous is a PhD student in Concordia's Individualized Program, and has a Master's in Design and a Bachelor's in Architecture and Urban Design. She has worked in the architecture, engineering, and construction (AEC) industry, particularly in the conception and design of residential, recreational, and educational spaces. She is a research assistant and lab coordinator at the Integrated Design and Sustainability for the Built Environment (IDEAS-BE) lab, chaired by Dr. Carmela Cucuzzella. Her current research project is titled "Critical reflections on architectural design processes through Development Journalism" – an extension of her Masters research, "Retracing Spatial Design Processes: Developing a Pedagogical Tool for Architecture," which explores hybrid and multi-disciplinary methods of learning and teaching architectural design. By leveraging the rigorous strategies of journalism, her research investigates how design processes in the AEC industry are being communicated to the wider public. In this manner, her research seeks to tackle issues of accessibility to knowledge and democratic decision-making processes in sustainable development projects.

KEYWORDS

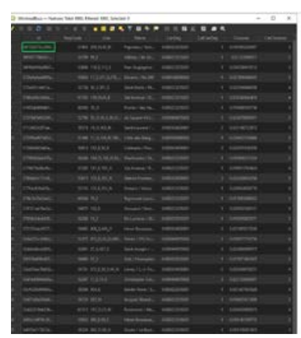
#CAMMM ATLAS #PUBLIC TRANSPORT #URBAN SPACE
#INTER-CITY TRANSPORTATION #TRANSIT NETWORKS
#MULTIMODAL MOBILITY

CAMMM ATLAS AS DIDACTIC TOOL FOR PLANNING SUSTAINABLE MOBILITY IN THE CITY

The aim of this chapter is to describe the CAMMM Atlas web application that contains a comparison atlas of public transit networks between cities. This atlas includes morphological, geographic-topological, and network analysis concepts that enable users to understand the current status and potential of different transit networks. The underlying aim for this application is to facilitate research on the domain of public transit mobility and urban form. The resulting research seeks to encourage discussions and developments of the ways multimodality plays a role in the way citizens move around urban spaces. This chapter offers a methodological description and rationale of the indicators and queries developed for the CAMMM Atlas web application.

Currently, the atlas covers a selection of cities that fit a pre-defined list of parameters. This list is intended to grow as more public transit data becomes available. In order to develop an international comparative tool, this research uses public transit data provided by the government websites of each analyzed city in the format of General Transit Feed Specification (GTFS). The data extracted from this resource includes transit services, stops, stations, routes, trips in routes, and schedules for the trips; among other variables depending on local conditions.

The atlas is developed with the intention to be used by a variety of researchers, policy makers, and local authorities. Policy makers and local authorities could potentially use the atlas to compare implementations of public transit approaches across different cities. Scholars and academics could potentially use the application to evaluate different urban spaces and their approaches to multimodal mobility. The atlas may also enable a better understanding of the relationship between the urban form, nodes of interest, and the public transit network.



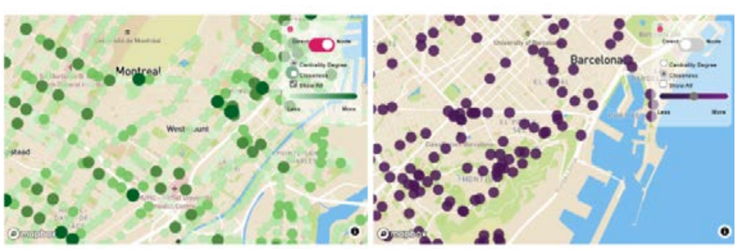


Figure 1Prototype of the Web Atlas

Mohammad KAOSAIN AKBAR

Research Associate at Concordia Institute for Information Systems Engineering (CIISE) in Concordia University, Canada

Mohammad's research interests include Machine Learning, Deep Learning, Pattern Recognition and Smart Grids. He obtained his Bachelor of Science in Computer Science and Engineering from North South University, Dhaka, Bangladesh and his Master of Applied Science degree in Quality Systems Engineering from Concordia University, Canada.

Manar AMAYRI

Assistant Professor at Institute for Information Systems Engineering (CIISE) at Concordia University, Canada

Dr. Amayri received her PhD in Energy Smart-Buildings from Grenoble Institute of Technology in 2017 and got an assistant professor position in 2020 in ENES3, INP-Grenoble, G-SCOP Lab (Sciences pour la conception, l'Optimisation et la Production). Her research interests are energy management systems, smart buildings, machine learning, pattern recognition, and data science.

Nizar BOUGUILA

Associate Professor at Institute for Information Systems Engineering (CIISE) and Fonding Director of Concorida Applied AI Institute, at Concordia University, Canada

Dr. Bouguila received his Engineering degree from the University of Tunis, in 2000, and his MSc and PhD degrees in Computer Science from Sherbrooke University, in 2002 and 2006, respectively. His research interests include image processing, machine learning, data mining, computer vision, and pattern recognition. He received the best PhD Thesis Award in Engineering and Natural Sciences from Sherbrooke University in 2007. He was awarded the prestigious Prix d'excellence de l'association des doyens des etudes superieures au Québec (best PhD Thesis Award in Engineering and Natural Sciences in Québec) and was a runner-up for the prestigious NSERC doctoral prize. He is the author or co-author of more than 300 publications in several prestigious journals and conferences. He is a regular reviewer for many international journals and serving as associate editor for several journals such as Pattern Recognition journal. Dr. Bouguila is a licensed Professional Engineer registered in Ontario, and a Senior Member of the IEEE.

Ursula EICKER

Canada Excellence Research Chair (CERC) in Smart, Sustainable and Resilient Communities and Cities, Director of Concordia University's NEXT-GENERATION CITIES INSTITUTE, Professor in the Building, Civil and Environmental Engineering (BCEE) Department at Concordia University, Canada

Dr. Eicker is a German physicist who received her Ph.D. in Solid State Physics from Heriot-Watt University and her Habilitation in Renewable Energy Systems and Building Technology from the Technical University Berlin. She has led numerous international research projects in renewable energy supply systems and building energy efficiency at Stuttgart University of Applied Sciences. A central focus of her research is zero-emission, smart and sustainable cities, integrating renewable energy sources and increasing city livability. A team of over 50 graduate students and software developers worked on numerous eco-district projects in Canada and created the urban modeling, data analytics and stakeholder engagement platform Tools4Cities. Dr. Eicker founded the Next-Generation Cities Institute in November 2020 and addresses the challenges of urban transformation with a transdisciplinary approach and develops tools and strategies for a sustainable future. As a member of the Canadian Green Municipal Fund (GMF) council since 2024, Prof. Eicker supports environmental sustainability and community development. She is a member of several advisory boards, including the Catalonian Energy Research Institute IREC, the Ireland Research Centre for Energy, Climate and Marine Research MaREI, Unibail-Rodam-co-Westfield headquartered in Paris and others.

KEYWORDS

#SMART CITIES #AI #MACHINE LEARNING
#NON-INTRUSIVE LOAD MONITORING

NON-INTRUSIVE LOAD MONITORING TECHNIQUES - A LITERATURE REVIEW ON STATE-OF-THE-ART

Non-Intrusive Load Monitoring (NILM), an approach within the smart energy management ecosystem, offers a powerful solution for disaggregating total energy consumption into individual appliance-level data. By enabling detailed insights into household or building energy usage patterns from a single metering point, NILM supports efforts to enhance energy efficiency, optimize power usage, and reduce operational costs. This chapter presents a comprehensive survey of NILM methodologies, systematically categorizing them into supervised, unsupervised, semi-supervised, and image-based approaches. We delve into the theoretical underpinnings of each approach, examining how these methods have been applied to accurately identify, monitor, and quantify the energy consumption of various appliances. Our review covers both traditional and cutting-edge NILM techniques, tracing their evolution, assessing their current capabilities, and exploring their potential future developments. In supervised NILM, where labeled training data is available, we focus on machine learning and deep learning models such as neural networks, support vector machines, and random forests. These techniques have demonstrated high accuracy in identifying specific appliance loads but often require extensive labeled datasets, which can be challenging to obtain. Unsupervised NILM approaches are discussed for their ability to analyze and interpret energy consumption data without the need for prior labeling, using clustering and pattern recognition techniques to infer appliance usage patterns autonomously.

We also explore semi-supervised methods, which integrate both labeled and unlabeled data to improve model performance while reducing dependency on large, labeled datasets. Furthermore, the chapter investigates the innovative use of image based NILM techniques, which apply image processing and computer vision methods to visualize and interpret power consumption patterns, offering new perspectives and applications in energy disaggregation. This chapter also provides an in-depth analysis of key NILM datasets, which are critical for benchmarking NILM algorithms and facilitating comparative studies. We discuss the attributes, benefits, and limitations of these datasets, emphasizing the importance of data diversity and representativeness to develop reliable NILM solutions. To comprehensively evaluate NILM performance, we review a range of evaluation metrics which are essential for assessing the effectiveness of NILM systems in various scenarios. Despite the advancements in NILM research, several challenges persist, such as scalability issues, noise interference, and the need for generalization across different appliances and household environments. This chapter addresses these challenges, discussing potential strategies to mitigate them and proposing future research directions along with a sample NILM model. Our goal is to provide a thorough understanding of the current NILM landscape, highlighting the opportunities and obstacles in this field, and to inspire further innovation and development in non-intrusive load monitoring technologies. By synthesizing the latest research and offering a forward-looking perspective, this chapter aims to serve as a valuable resource for researchers, practitioners, and policymakers involved in the pursuit of smarter and more sustainable energy solutions.

Mohammad Ali SYED

PhD student, Information and Systems Engineering at Concordia University, Canada

Mohammad received his BE in Electrical Engineering (with distinction) and MSc in Computer Engineering from the Lebanese American University (LAU). He was previously a lab instructor at LAU from 2016 to 2018 and worked in operation and maintenance of power plants between 2018 and 2020. His research interests include power generation and transmission, security of power grids, electrical power conversion, and embedded systems.

Mohammad Ekramul KABIR

Postdoctoral research fellow University of Ontario Tech, Canada

Mohammad is a formal Horizon post-doctoral fellow at Concordia University. He holds a PhD in Information and Systems Engineering. He has received his MSc and BSc in Applied Physics, Electronics and Communication Engineering from the University of Dhaka. His research interests include EV charging ecosystems, 5G technology, smart city, and cyber security of smart grid and small modular reactors.

Jun YAN

Assistant Professor, Concordia Institute for Information Systems Eneering (CIISE) and a member of the Security Research Centre (SRC) at Concordia University, Canada

Dr. Yan holds a BEng degree in Information and Communication Engineering from Zhejiang University, China, and a MSc and PhD (Hons.) in Electrical Engineering from the University of Rhode Island, USA. He was a recipient of the IEEE International Conference on Communications (ICC) Best Paper Award and the IEEE International Joint Conference on Neural Networks (IJCNN) Best Student Paper Award. His research interests include computational intelligence and cyber-physical security in smart critical infrastructures.

Mohsen GHAFOURI

Assistant Professor, Concordia Institute for Information Systems Engineering (CIISE), Concordia University, Canada

Dr. Ghafouri received a BSc and MSc in Electrical Engineering from the Sharif University of Technology, Iran, and a PhD in Electrical Engineering from Polytechnique Montreal. Before joining Concordia's Security Research Group as the Horizon Postdoctoral Fellow, he was a Researcher with the Iranian Power System Research Institute, Sharif University, and with CYME International, Eaton Power System Solutions, Montréal. Research interests include cybersecurity of smart grids, power system modeling, microgrid, wind energy, and control of industrial processes.

Chadi ASSI

Professor, Concordia Institute for Information Systems Engineering (CIISE); Tier II Concordia University Research Chair in Technologies and Trends for Future Cellular Networks; Fellow at IEEE, Canada

Dr. Assi received his PhD from the City University of New York where he received the prestigious Mina Rees Dissertation Award for his research on optical networks. He spent a year as visiting researcher at Nokia Research Center (Boston) before joining Concordia University in 2003, where he held a Concordia Research Chair (Tier 2) between 2012 and 2017 and, since 2017, a Research Chair (Tier 1). He was elevated to an IEEE Fellow in 2020 by the Communications Society for "contributions to resource allocation for optical and wireless networks" and has served on the Editorial Board of several flagship journals of the IEEE.

Mourad DEBBABI

Professor, Concordia Institute for Information Systems Engineering (CIISE) / Dean of the Gina Cody School of Engineering and Computer Science of Concordia University; Concordia Research Chair Tier I in Information Systems Security, Canada

Dr. Debbabi is President of the National Cyber Forensics Training Alliance (NCFTA Canada) and founder of the Computer Security Laboratory (CSL) at Concordia University. In the past, he was the Specification Lead of four Standard JAIN (Java Intelligent Networks) Java Specification Requests (JSRs) dedicated to the elaboration of standard specifications for presence and instant messaging. He has published three books and more than 260 research papers in journals and conferences on computer security, cyber forensics, privacy, cryptographic protocols, threat intelligence generation, malware analysis, and other areas of cyber security. He served as a Senior Scientist at the Panasonic Information and Network Technologies Laboratory; Associate Professor in Computer Science at Laval University; Senior Scientist at General Electric Research Center; Research Associate in Computer Science at Stanford University; and Permanent Researcher at the Bull Corporate Research Center.

KEYWORDS

#ELECTRIC VEHICLE #IoT #ENABLED CHARGING ECOSYSTEM
#CYBER-PHYSICAL ATTACK #CYBER-PHYSICAL SECURITY

INTRODUCTION TO ELECTRIC VEHICLES: NAVIGATING A GREENER FUTURE

Smart cities promise to put technology and connected smart systems to improve decision making and quality of human life through the creation of highly efficient and sustainable habitats for future urban populations. One of the main focuses of the smart city promise is the combat of climate change and the reduction of Green House Gas (GHG) emissions. Since the transportation sector is one of the top 3 major contributors to GHG emissions, there is a big push towards the transition to Electric Vehicles (EVs) due to their potential in reducing emissions as compared to gasoline vehicles. Around the world, the transition to EVs is gaining momentum, where governments are taking major initiatives to accelerate this transition, ranging from tax exemptions, insurance discounts to parking incentives and gasoline car bans. However, such ambitious targets might be hindered by several challenges, including shorter range compared to gasoline competitors, slower charging rates, and the availability of charging locations, which collectively contribute to higher anxieties for EV drivers. EV charging station manufacturers and operators have been hastily deploying charging infrastructure to meet the rising demand and mitigate user anxiety. This has contributed to the EV ecosystem's lack of proper security measures. I addition to that, the highly mobile and demanding charging loads can significantly shift the patterns across generation, transmission and distribution in the power grids. Coupled with the non-linear nature of the EV battery charging load, this load can have severe impacts on the power grid operation. Serving this large number of EVs under also calls for greener energy from the grids to maximize the emission reduction through EVs instead of shifting their emissions to the electricity sector.

To tackle these challenges, an Internet-of-Things (IoT)-enabled smart EV charging ecosystem across the energy and transportation sectors will be a key in the electrication of transportation revolution. A wide-area communication infrastructure that connects EVs with road-site units, smart chargers and stations (as depicted in Fig. 1) can enable effective charging scheduling, route planning, and grid upgrades for smarter and greener transportation in next-generation cities. Real time data collection and exchange over 5G networks, aided by artificial intelligence-powered edge and cloud computing capacity, will enable new solutions for both energy and transportation stakeholders. Charging stations are developed by different manufacturers and governed by multiple protocols with no path towards standardization. The complex EV ecosystem is made up of Internet-connected power devices, phone applications, communication protocols and web applications. The EV paradigm inherits the vulnerabilities of these components making it a security threat in the heart of the power grid. Through these vulnerabilities, malicious actors can take control of the EV charging process and use it to attack a disrupt power grid stability.

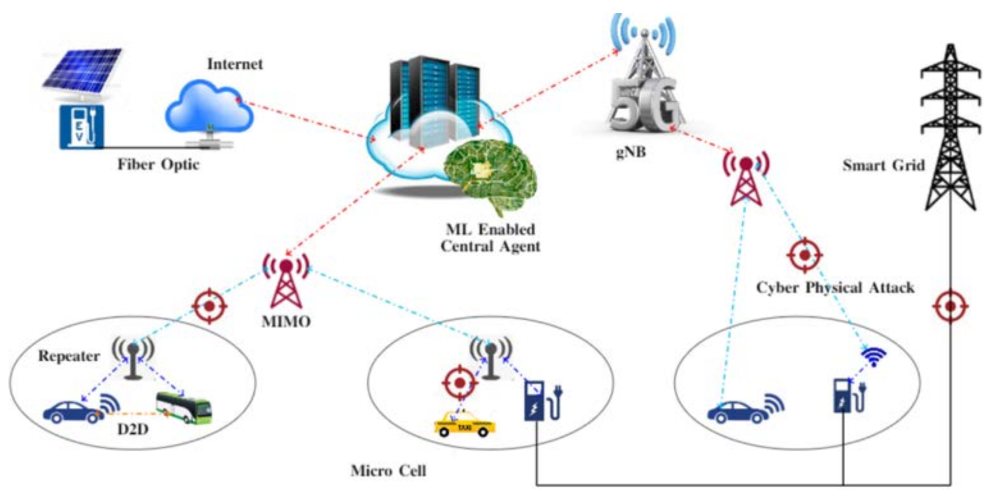


Fig. 1: An interconnected smart charging ecosystem.

Based on the above, this chapter will provide a critical and timely review of recent studies toward intelligent, efficient, reliable, and secure electrification of transportation for smart cities. Starting with an overview of EV revolution and supporting infrastructure requirements, the chapter will identify key objectives to be achieved in the smart EV charging ecosystem. Under these objectives, the chapter will investigate representative problems in system planning, resource allocation, economic behavior, cyber security and power grid stability in relation to the charging ecosystem. New progresses aided by a variety of techniques, including stochastic optimization, mechanism design, reinforcement learning, and cyber-physical security analysis and their proactive solutions, will be introduced. Case studies of the proposed methods in the context of energy-transportation-management will be presented to exemplify the progresses to date and challenges ahead. Overall, the chapter aims to inspire further discussions and solutions toward the reliable and safe EV integration by intelligence and resilient transportation electrification for smart cities.

Gaith RJOUB

Assistant Professor, Faculty of Information Technology, Aqaba University of Technology, Aqaba, Jordan and Concordia Institute for Information Systems Engineering, Concordia University, Canada

Dr. Rjoub received a master's degree in quality systems engineering and a PhD in information and systems engineering from the Concordia Institute for Information Systems Engineering (Canada) in 2014 and 2021, respectively. He is affiliated with the Aqaba University of Technology and with Concordia University. His research interests include cloud and edge computing, machine and deep learning, artificial intelligence, and big data analytics.

Hanae ELMEKKI

PhD student at Concordia Institute for Information Systems Engineering (CIISE) Concordia University, Concordia University, Canada

Hanae received her engineering diploma in telecommunications and information technology from the National Institute of Postal and Telecommunication Services (INPT) in 2014. She is currently pursuing a PhD in quality systems engineering at Concordia University (Canada). Her current research focuses on developing AI models for autonomous medical scanning. Her research interests encompass deep learning, deep reinforcement learning, robotic motion, and image processing.

Jamal BENTAHAR

Professor, Department of Computer Science, 6G Research Center, Khalifa University, Abu Dhabi, UAE, and Concordia Institute for Information Systems Engineering, Concordia University, Canada

Dr. Bentahar received the PhD degree in computer science and software engineering from Laval University, Canada, in 2005. He is a Professor with Khalifa University, UAE, and Concordia University, Canada. From 2005 to 2006, he was a Postdoctoral Fellow with Laval University, and then NSERC Postdoctoral Fellow at Simon Fraser University, Canada. He was an NSERC Co-Chair for Discovery Grants for Computer Science (2016-2018). He is an associate editor of IEEE Transactions of Services Computing. His research interests include reinforcement and deep learning, multi-agent systems, computational logics, model checking, and services computing.

Rachida DSSOULI

Professor and founding Director of Concordia Institute for Information Systems Engineering (CIISE), Concordia University, Montreal, QC

Dr. Dssouli was a professor at Université de Montréal, Université de Sherbrooke, and Université Mohammed 6. She received her Master's degree (1978), Diplôme d'Études Approfondies (1979) and Doctorat de 3eme Cycle in Networking (1981) from Université Paul Sabatier (France). She earned her PhD degree in Computer Science (1987) from Université de Montréal (Canada).

Her research interests are in software engineering more precisely in testing and verification. Her contributions are in requirements engineering, systems engineering, service engineering, quality of service, formal methods, quality assurance, testing based on models and verification. She applied her research to telecommunication, eHealth and avionics software. She published more than 170 refereed papers in journals and conferences in her area of research. She supervised/ co-supervised more than 65 graduate students among them 24 PhD students.

She served as a member of grant agencies, awards committees at the national and international levels. She also served as a member of the technical committee program of many workshops and conferences and she organized or co-organized several international workshops and conferences.

KEYWORDS

#TRANSFER LEARNING #DEEP REINFORCEMENT LEARNING
#AUTONOMOUS DRIVING #TRAFFIC EFFICIENCY
#DRIVING TRAJECTORY PLANNING

TRANSFER DEEP REINFORCEMENT LEARNING FOR AUTONOMOUS DRIVING

Recently, the concept of autonomous driving and its relation with the infrastructures in urban settings has dominated the intelligent transportation research field. This is mainly attributed to the promise of both increased safety and traffic efficiency along with fuel economy improvements and reduced travel time. Numerous studies have been conducted in this area to help autonomous vehicles (AVs) determine trajectory and velocity, but most of them only consider trajectory planning using conjunction with a limited data set (e.g., metropolitan areas, highways, and residential areas) or assume fully connected and automated vehicles environment. To tackle these problems, we design a transfer deep reinforcement learning (DRL) framework and embed it into the AVs in an edge computing environment in order to plan driving trajectories. DRL is widely regarded as one of the best methodologies for developing the trajectory planning modules for AVs. However, the biggest challenge faced by DRL in AV scenarios is how to build a real-time decision-making system under dynamically changing road conditions. In order to address this challenge, we incorporate a transfer learning (TL) technique that transfers knowledge from external experts (with a diverse and similar trajectory scenarios) to accelerate the learning process and make an efficient decision.

Technically speaking, we propose a collaborative solution to assist AVs make real-time decisions in terms of velocity and lane change. Firstly, by receiving real-time traffic information from the edge servers, an algorithm using deep Q-network (DQN) is proposed for determining the trajectory and velocity of the AV. More precisely, the AV acts as an agent by interacting with the environment to perform optimal actions, such as lane changes and velocity changes. The main originality compared to the previous works stems from using the transfer learning method in which all available AV policies are exploited to help learn several related new tasks. When new vehicles (i.e., target AVs) ask for help from the edge server, the transfer learning method addresses new tasks by leveraging the knowledge acquired in previous tasks, where the edge server plays the role of an aggregator of local Q-values, which is in control of the system that collects the expertise and builds the knowledge to share it with the target AVs. At each time step, each AV sends to the aggregator its local Q-values for all actions in the current state; then, the aggregator is responsible for merging the local Q-values into a global policy to be shared with the target AVs

Kayhan ALAMATSAZ

PhD student in the Department of Building, Civil and Environmental Engineering at Concordia University, and part of the team of Prof. Ursula Eicker CERC (Canada Excellence Research Chair in Smart, Sustainable and Resilient Communities and Cities), Canada

Kayhan is familiar with Logistics and Supply Chain Management, Transportation, Optimization, Data Science, Stochastic Optimization and interested in mathematical modeling and programming. He received his MSc in Industrial Engineering at Amirkabir University of Technology and his B.Sc. in Industrial Engineering at Isfahan University of Technology. His current research topic is EV station location planning, fast- charging infrastructure planning, and electric bus scheduling.

Frédéric QUESNEL

Professor of operations research at the Analytics, Operations, and Information Technology department of the École des Sciences de la Gestion de l'Université du Québec à Montréal (ESG-UQAM)

Dr. Quesnel received a PhD in Applied Mathematics from Polytechnique Montréal. His work focuses on solving large-scale combinatorial problems, mainly for airline applications. He also works on developing primal algorithms for integer programing. Recently Frédéric started exploring new uses of machine learning to improve the branch-and-price algorithms used to solve such problems.

KEYWORDS

#ELECTRIC BUS SCHEDULING #ELECTRIC BUS TIMETABLING #BUS TO GRID TECHNOLOGY #INTEGRATED OPTIMIZATION #ELECTRIFICATION OF BUSES #PUBLIC TRANSPORT #B2G #CHARGING INFRASTRUCTURE #SUSTAINABILITY

ELECTRIFICATION OF BUSES

The rise in electric vehicles (EVs) and electric buses (EBs) is accelerating due to growing concerns about air quality, greenhouse gas emissions, and the rising demand for sustainable energy solutions. In recent years, the greenhouse gases (GHG) emitted by public transportation have aroused environmental concerns. Buses, as one of the main modes of transportation, contribute significantly to GHG emissions. However, electric buses (EB) can prevent such issues if they are powered by clean sources of energy. EBs have exceptional advantages in improving urban air quality, high driving stability, and low noise. Thus, many bus companies and transportation authorities are switching from fuel buses to EBs. Transit authorities are facing challenges in enhancing the efficiency of their public transportation networks, particularly bus transit systems. A key factor in the performance of these systems lies in optimizing operational processes, which play a vital role in overall effectiveness. Introducing EBs into the public transit system will impact the steps in planning public transit operations, including network design, timetabling, bus scheduling, and crew scheduling. While many existing scheduling models for diesel buses exist, they are unsuitable for EBs due to their limited range and extended charging times. Given the functional and operational distinctions between conventional buses and EBs, these stages require modifications and optimization to improve service quality for bus users and lower operating costs for service providers. Network design outlines bus routes and stops, considering the geographical layout and passenger demand. Bus timetabling and scheduling are among the most vital processes in bus operations. Bus timetabling (TT) is the process of scheduling the departure and arrival times of bus services with the goal of enhancing passenger satisfaction. This is achieved by minimizing waiting and transfer times, as well as ensuring better seat availability. Vehicle scheduling is the process of assigning buses to the trips outlined in a given timetable. The main objective is to minimize the number of vehicles required to cover all the outlined trips, while also reducing operational costs. EBs have battery limitations and their operation process regarding scheduling and charging differs from conventional buses. The operating range of EBs is lower than conventional buses, and their charging time is higher than refuelling diesel buses. Thus, to improve bus scheduling, a reasonable charging strategy is required. This chapter explores the impact of introducing various types of EBs on the operational planning of public transit systems. It will demonstrate that the arrival of EBs necessitates adjustments in the design of transit route networks, as well as in the processes of timetabling and vehicle scheduling.

Sarah FARAHDEL

PhD candidate, Information and Systems Engineering at Concordia University, Canada

Sarah graduated with a Bachelor of Engineering (BEng) and Master of Applied Science (MASc) in Industrial Engineering from Concordia University. In parallel, she has acquired over 8 years of industry and consulting experience, across various sectors including, aerospace, retail, healthcare, financial management and manufacturing. She is currently pursuing her PhD in Information Systems Engineering at Concordia University, in collaboration with the s3m lab. Her research interest includes sustainability assessment for organizations, performance measurement systems, six sigma, data analytics, multi-criteria decision-making models (MDCM) and artificial intelligence in performance assessment.

Chun WANG

Professor, Concordia Institute for Information Systems Engineering (CIISE) and Cluster Co-Director for Mobile, Secure and Sharing Cities at Next-Generation Cities Institute at Concordia University, Canada

Dr. Wang has published extensively in major intelligent transportation journals, covering topics in urban mobility, mobility-on-demand, and shared mobility systems. Recent publications by Dr. Wang include research on machine learning models for rider demand forecasting, crowd-sourced delivery services optimization, multi-agent reinforcement mechanism design for dynamic pricing-based demand response, and privacy-preserving matching mechanisms for community ridesharing. His expertise lies at the intersection of economic models, operations research, and artificial intelligence. Dr. Wang also serves as an associate editor of IET Collaborative Intelligent Manufacturing.

Anjali AWASTHI

Professor and Concordia University Research Chair (Tier-II) in Connected Sustainable Mobility Systems at Concordia Institute for Information Systems Engineering (CIISE), Canada

Dr. Awasthi received a PhD in Industrial Engineering and Automation from INRIA Rocquencourt and University of Metz, France and a master's in Industrial and Management Engineering from IIT Kanpur, India. Prior to Concordia, Dr. Awasthi worked at the University of British Columbia and the University of Laval where she was involved in several projects on industrial applications of operations research. In France, she was involved in many European projects aimed at improving urban mobility in cities, city logistics and on cybernetic transportation systems. Her areas of research are modeling and simulation, data mining, Information Technology and decision making, sustainable logistics planning, quality assurance in supply chain management and sustainable supply chain management.

KEYWORDS

#URBAN TRANSPORTATION SYSTEMS (UTSS)
#SUSTAINABILITY ASSESSMENT FRAMEWORKS
#SUSTAINABILITY INDICATORS, TRIPLE BOTTOM LINE
#STAKEHOLDER ENGAGEMENT
#TRANSPORTATION SUSTAINABILITY POLICIES

ASSESSING SUSTAINABILITY FOR URBAN TRANSPORTATION SYSTEMS: A COMPARATIVE STUDY AND KEY CONSIDERATIONS

In response to rapid urban expansion, the importance of sustainable urban transportation systems (UTSs) has increased remarkably over the years, due to their substantial impact on economic, environmental, and social concerns. Despite the critical importance of assessing the sustainability performance of UTSs, the task proves to be challenging due to its inherent complexities and intricacies.

This chapter offers a comprehensive overview of sustainability assessment frameworks tailored for the UTS sector. It summarizes various assessment approaches, key considerations, and critical sustainability indicators. The review highlights a notable distinction in assessing sustainability for UTSs across the economic, environmental, and social pillars. Identified drawbacks and limitations of these frameworks include biases in selecting sustainability indicators, limited stakeholder engagement, oversight of major sustainability policies, and the lack of governmental initiatives consideration in goal setting.

This chapter also addresses the impact of future technological advancements on sustainability assessment for UTSs, shedding light on trade-offs and interdependencies. This review provides valuable insights for policymakers, researchers, and urban planners navigating the development and implementation of sustainable transportation solutions in the dynamic and rapidly evolving urban landscape.

Alexander IRELAND

Technical Leader-Project Engineering at CEA, Montreal and MASc student at Concordia University, Canada

Alexander graduated with Honors from the University of Ottawa with a Bachelor of Applied Science – Mechanical Engineering (Co-op) in 2008. Since that time, he has worked in the aerospace industry in Montreal. In 2023 Alex began a Master of Applied Science with the s3m lab at Concordia University. His research interests include Urban Air Mobility (UAM), transport systems, multi-agent systems, social equity and sustainability.

Sarah FARAHDEL

PhD candidate, Information and Systems Engineering at Concordia University, Canada

Sarah graduated with a Bachelor of Engineering and Master of Applied Science in Industrial Engineering from Concordia University. In parallel, she has acquired over eight years of industry and consulting experience across various sectors including aerospace, retail, healthcare, financial management and manufacturing. She is currently pursuing her Ph.D. in Information Systems Engineering at Concordia University, in collaboration with the s3m lab. Her research interest includes sustainability assessment for organizations, performance measurement systems, six sigma, data analytics, multi-criteria decision-making models (MDCM) and artificial intelligence in performance assessment.

Nima MORADI

PhD candidate at the Concordia Institute for Information Systems Engineering (CIISE), Canada

Under the supervision of Prof. Fereshteh Mafakheri & Prof. Chun Wang, Nima is working on the "Sustainable Last-mile Delivery Systems." He is interested in developing Exact and Heuristic/Metaheuristic methods for solving "Hard" combinatorial optimization problems that arise in application areas of Operations Research, such as Last-mile Delivery, Logistics, Vehicle Routing, and Performance Evaluation.

Chun WANG

Professor, Concordia Institute for Information Systems Engineering (CIISE) and Cluster Co- Director for Mobile, Secure and Sharing Cities at Next-Generation Cities Institute, Canada

Dr. Wang's research interest lies at the interface between economic models, operations research, and artificial intelligence. He is actively conducting research on multi-agent systems, data-driven optimization, and economic model-based resource allocation with application applications to community healthcare management, smart city, and intelligent transportation systems.

Fereshteh Mafakheri

Assistant professor at École nationale d'administration publique (ENAP), Université du Québec /Canada Research Chair in Bioenergy Transition / Affiliated assistant professor, Gina Cody School of Engineering at Concordia University, Canada

Dr Mafakheri's research has been funded by SSHRC, NSERC, FRQNT, NRCan, NRC, and MITACS. She is directing Decision Modeling & Analytics Laboratory (DeciMAL) supervising PhD and master's students. Fereshteh has a mixed background in engineering and management disciplines, helping her to target multidisciplinary research activities. Fereshteh's main research interest is in supply chain management area with a focus on public and service sectors. Dr. Mafakheri holds a PhD in Decision Sciences from Université de Montréal, and MASc and BASc in Industrial Engineering.

Anjali AWASTHI

Professor and Concordia University Research Chair (Tier-II) in Connected Sustainable Mobility Systems at Concordia Institute for Information Systems Engineering (CIISE), Canada

Dr. Awasthi received a Ph.D. in Industrial Engineering and Automation from INRIA Rocquencourt and University of Metz, France and a master's in Industrial and Management Engineering from IIT Kanpur, India. Prior to Concordia, Dr. Awasthi worked at University of British Columbia and University of Laval where she was involved in several projects on industrial applications of operations research. In France, she was involved in many European projects aimed at improving urban mobility in cities, city logistics and on cybernetic transportation systems. Her areas of research are modeling and simulation, data mining, Information Technology and decision making, sustainable logistics planning, quality assurance in supply chain management and sustainable supply chain management.

KEYWORDS

#URBAN AIR MOBILITY (UAM) #TRANSPORT SYSTEMS
#MULTI-AGENT SYSTEMS #SOCIAL EQUITY AND SUSTAINABILITY

EQUITABLE COMMUNITY INTEGRATION OF URBAN AIR MOBILITY: CHALLENGES, APPROACHES, AND OPPORTUNITIES

Urban Air Mobility (UAM) is a transformational approach to the transportation of people and goods in our communities. The technology readiness level of UAM vehicles including Uncrewed Aerial Vehicles (UAV) drones and Electric Vertical Take-Off and Landing (EVTOL) vehicles is advancing quickly which presents many challenges for governments, policy makers, and regulators around the world. The designs and capabilities of future UAM vehicles is a very active area of research and development so to ensure a smooth transition into our lives, the question of how UAM will integrate into our communities includes many areas of multi-disciplinary research. One such consideration is that a well-integrated UAM transportation system includes and promotes fair and equitable outcomes for all of society.

We found that while there is a considerable amount of transportation research related to equity, there is however limited equity research available specific to UAM transportation. More importantly, there has been no comprehensive study for UAM, which summarizes all equity challenges, approaches, and opportunities that have been identified with transportation equity considerations, until now.

This chapter aims to provide the reader with a holistic view of equity as it relates to UAM community integration outcomes. We analyze equity in transportation systems through the lens of horizontal and vertical equity, as well as positive and normative assessment to describe key challenges, approaches, and research opportunities with the intent to elaborate on the research gaps and future direction in UAM equity research.

PART 2

MODELLING OF BUILT AND NATURAL ENVIRONMENT AND TRANSPORTATION

CHAPTER EDITOR:
Prof. Ursula EICKER

Mazdak NIK-BAKHT

Assistant Professor in Building, Civil and Environmental Engineering (BCEE) Department at Concordia University, Canada

Prof. Nik-Bakht has a Ph.D. in structural Engineering and a second Ph.D. in Construction Engineering and Management, and is a licensed Professional Engineer. He is an expert in data science applications for design, construction, and operation of urban infrastructure focusing mainly on digital twins and dynamic information modeling at building and urban scales; complex mega-projects and network science applications to manage them; and semantic web and computational linguistics for knowledge management in the AEC industry. His body of works on social network analysis in construction, socio-technical model of urban infrastructure, and dynamic BIM have received international recognition.

Arash HOSSEINI GOURABPSI

Research Officer at the National Research Council of Canada

Dr. Hosseini Gourabpsi holds a PhD in Civil Engineering from Concordia University, specializing in Building Information Modeling (BIM), the Semantic Web, and the digital twinning of the built environment. He is currently a Research Officer at the National Research Council of Canada, where his work focuses on Open BIM standards, applied AI, and the digitalization of building codes.

Driven by a commitment to advancing digitalization and productivity in the construction and building sectors, Arash's expertise lies in leveraging open standards and cutting-edge technologies to enhance interoperability, streamline workflows, and automate regulatory compliance. His research supports the digital transformation of the built environment, fostering smarter, more efficient, and sustainable practices.

KEYWORDS

#DIGITAL TWINS #STATEFUL BIM #BUILT ENVIRONMENTS
#DIGITAL TRUTH #URBAN & BUILDING MANAGEMENT

"STATEFUL BIM" (BUILDING INFORMATION MODELING) FOR DIGITAL TWINNING OF THE BUILT ENVIRONMENT

Creating digital replica of the built environment has been researched and investigated for long, and has found extensive applications in planning, design, construction and operation of buildings and civil infrastructure. Building Information Modeling (BIM) offers a paradigm for modeling not only the physical components of the built environment, but also their functional attributes. Such models are typically created at early conceptualization stages of planning for building projects and continue to evolve during various phases of design and construction. Upon the start of the occupancy and operation phase of the built facility, such digital models can be connected to the physical components and spaces and create digital twins (DTs) of the built facility. On the foundation of BIM, as visual/semantic databases storing valuable information of building elements and, ideally, the users, such DTs can capture the reality of the built facility, as well as the dynamism of spaces and occupants.

While extensively used in planning, design and construction, the application of BIM in the operation of buildings and other facilities has remained limited in practice. The extensive prevalence of new sensor-based technologies, in forms of pervasive computation and the Internet of Things (IoT), has created an unmatched opportunity for releasing the potentials of BIM beyond design and construction, toward creating 'Digital Truth' of the built environment. The physical built environment sensed by IoT is accordingly linked to the entire lifecycle information and creates a strong platform for data-driven decision making towards more efficient, sustainable, and resilient solutions for the management and operation of the built environment.

While activating the power of BIM for managing building information throughout the entire building's lifecycle has been among the mandates of BIM for long, and despite the progresses made so far, the emphasis of most BIM applications has remained limited to capturing information such as geometry, assemblies, and spatial relations. Several use cases are established for BIM (known as BIM-uses), among which, only a few tap the integration with operation phase information, such as states/events of the facility, its spaces and components. However, performing data analytics on IoT data can enable a plethora of uses cases (BIM-uses) to benefit from semantic context that BIM and IoT data can contribute to DT of a facility.

Infusing historical information of states and events for the building space and components to BIM, and associating the information with the digital elements replicating such physical component, can give rise to dynamic models, referred to as "Stateful BIM". Through the integration of IoT and sensor network's data, the Stateful BIM can keep track of events and changes in the states of the building components and spaces to retrospectively provide auditing for deviations from plans. More importantly, the analytics derived from such big data can enable additional predictive uses for the Stateful BIM. Inferences-based reasoning on fault detection and diagnostics, predictive and preventive maintenance, intelligent space management, building monitoring, energy auditing, and emergency evacuation are examples of such use cases.

This chapter contextualizes the Stateful BIM and its applications. It provides a profound analysis of the existing BIM uses in the industry and examines the advantages they can take, out of shifting from a static to dynamic and stateful models. A comprehensive list of services that BIM can offer to the actors and users of the built environment is provided, and the added value from the migration to stateful model is elaborated. For enabling each service on Stateful BIM, data requirements in terms of type, frequency, quality, and potential sources are discussed. An overlay of legacy BIM with such data can migrate BIM into true DT of the built environment, which will be a foundation for processing data into actionable information, and introducing intelligence in the form of decision support system models to the operation of the built environment. The chapter illustrates a thorough overview of the works done in this regard and provides a roadmap towards reaching functional Stateful BIM and achieving its goals.

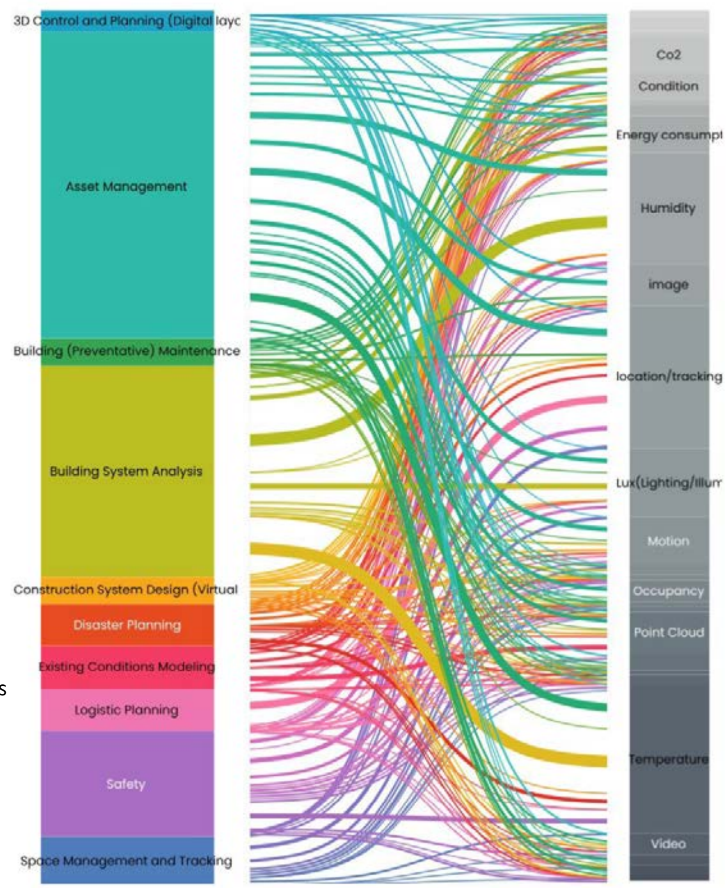


Figure: BIM uses and their integration with sensory data

Christopher GIBBS

Senior Advisor Software Development, Next-Generation Cities Institute at Concordia University, Canada

Chris has a 1st-class honors degree in Software Engineering and 35 years experience working in the video game industry. Chris was co-founder and managing director of British game developer, Attention To Detail (1988 to 2003), Executive Producer and Studio Manager for Electronic Arts (2003 -2012), and an independent developer and publisher of his own mobile game (2014-2018). Chris' primary expertise is in building and guiding teams to create original, high quality, fun and engaging player experiences. Chris joined the NGCI in spring 2021 and leads efforts to use gamification principals for engaging the community (business and public) with the benefits of the student's research.

Oriol GAVALDÀ

Lead, Zero Carbon Communities, Next-Generation Cities Institute and part of the UNIVER/CITY 2030 initiative at Concordia University, Canada

Oriol holds a degree in Industrial Engineering, a MSc in Renewable Energies and the Environment, and a degree in Economics. Oriol started his engineering career working in the development sector for six years, implementing rural electrification projects all around the globe. After this experience, he joined the cooperative AIGUASOL in 2006, working on several consultancy projects related to renewable energy and energy efficiency. Later Oriol oriented his work on deepening business models analysis and financing of energy efficiency projects. He has worked as an independent consultant for organizations as World Bank, UN, CAF, etc. Structurally, he has been R&D head of AIGUASOL for three years, and general manager (CEO) for six years, positioning Aiguasol as one of the leading sustainability companies in the Spanish energy sector.

KEYWORDS

#DIGITAL TWIN #GAME DESIGN #VIRTUAL CITIES
#CITIZENEN ENGAGEMENT #VIRTUAL TOOLS #FUN SCIENCE

TOOLS4CITIES

This chapter describes the suite of innovative software tools being developed by the NGCI, known as 'Tools4Cities'. It will explain the purpose of these tools and their origins, the research behind them, some examples use-cases and a look at future developments. The chapter will consist of the following sections: Introduction, Guiding Principles, The Eco-System, The HUB, The Tools & Services and Future Developments. There follows a description of what will be in each section.

The 'Introduction' will describe how the Tools4Cities project began, what the vision is for the project, and set out its specific goals. The 'Guiding Principles' will explain the criteria that have defined the NGCI's approach to this project. This section aims to give the reader a good understanding of the thinking behind Tools4Cities that help align and prioritise the development efforts, define the scope, and shape the roadmap of the tools and services. The 'Eco-System' section will provide an overview of all components of the project, including back-ends, front-ends and API's, and also how they connect with the NGCI student research and external stakeholders. It will include an eco-system diagram to illustrate the overview clearly, reinforcing the naming of the component parts and their relation to each other.

The 'HUB' section will elaborate on both the structure and the capabilities of this core component of Tools4Cities. It will have a technical overview of its software architecture including an XML representation of the 'central data model' it employs to represent digital twins of cities. It will also outline the various workfows, simulations and models it uses. There will be a description of how data is input to the HUB and how there is a system for persistent storage of output data. There will be a description of how reserchers can utilise the HUB programmatically from Python. Finally, there will be a description of the API's that have been developed for communication between the HUB and other parts of Tools4Cities.

The 'Tools & Services' section will describe in detail each of the currently prototyped tools, namely, CITYlayers, CITYplayer and RETROfitter. For each of the tools there will be detailed examples of what their capabilities are, what types of problem they can solve, and the impact they can have for stakeholders and end-users. This section will also explain the thinking behind the choice of delivery platform and design of each user-interface. The section will be illustrated by comprehensive screenshots of the tools, as they have been developed at the time of writing.

More specifically, the description of the CITYlayers tool will include a breakdown of the different layers of urban data it can visualize and the types of service it can offer, related to these datasets. The 'services' idea will be elaborated using examples of a 'Single Building Retrofit Analysis', a 'Mutli-Building Retrofit Strategy' and a 'Transport-Emissions Calculator'. The thinking behind the design of the user-interface will also be explained.

The description of the CITYplayer tool will explain how serious gaming is used to tackle the key objective of improving citizen engagement within urban planning. It will show the early prototype ideas around designing your perfect neighbourhood and for seeing the impact on liveability and sustainability. It will describe ideas around playing different persona to experience urban design from different people's points of view. It will give detailed examples of three use-cases. The first will be CITYplayer-Chinatown which focuses on gaining citizens input on the risks of changing population density and building heights / usages within Montreal's Chinatown. The second will be CITYplayer-MobilityHub which focuses on public consultation with the planning and development of multi-modal transport hubs in Montreal. The third will be CITYplayer-GreenSpace which uses the tool to measure citizens preferences and perceptions around the design of green spaces in urban settings, and the knock-on effects to biodiversity. There will be a technical section on the data pipelines and procedural techniques used to model and render a virtual neighbourhood.

The 'Future Developments' section will describe any opportunities for increased capabilities of the tools and the HUB, any new stakeholder categories and use-cases that could be tackled, and any performance optimizations.

Oriol GAVALDÀ

Lead, Zero Carbon Communities, Next-Generation Cities Institute and part of the UNIVER/CITY 2030 initiative at Concordia University, Canada

Oriol holds a degree in Industrial Engineering, a MSc in Renewable Energies and the Environment, and a degree in Economics. Oriol started his engineering career working in the development sector for six years, implementing rural electrification projects all around the globe. After this experience, he joined the cooperative AIGUASOL in 2006, working on several consultancy projects related to renewable energy and energy efficiency. Later Oriol oriented his work on deepening business models analysis and financing of energy efficiency projects. He has worked as an independent consultant for organizations as World Bank, UN, CAF, etc. Structurally, he has been R&D head of AIGUASOL for three years, and general manager (CEO) for six years, positioning Aiguasol as one of the leading sustainability companies in the Spanish energy sector.

Maria Del Pilar MONSALVETE

Assistant Professor, Department of Machines and Thermal Engines in the Superior School of Engineering (ESI) in Cadiz, Spain

Before Prof Monslavete took the position at Superior School of Engineering (ESI) in Cadiz at the UCA, she was a post-doctoral researcher and part of the team of CERC Prof. Ursula Eicker-Canada Excellence Research Chair for Next-Generation Cities at Concordia University. During the last decade, she has been working on building simulation and renewable technologies for smart cities. At the beginning, she was in Seville (Spain) working on the development of the tools needed for the Energy Performance Certification of Buildings required by the Spanish Directive. She then joined the Centre for Sustainable Energy Technologies at the Stuttgart University of Applied Sciences, where she completed her doctorate with the thesis “A Multi-scale Framework for Predicting Distributed Renewable Thermal Energy Integration”. Under the coordination of Prof. Eicker, she is co-operating on the development of the simulation platform TOOLS4CITIES designed to support on the decision-making processes for zero-carbon cities.

KEYWORDS

#URBAN SIMULATION MODELS #LIFE CYCLE COSTS
#RETROFIT #CO2 EMISSIONS # BUILDING SIMULATION

THE URBAN BUILDING ENERGY RETROFITTING TOOL: AN OPEN-SOURCE FRAMEWORK TO HELP FOSTER BUILDING RETROFITTING/FIRST RESULTS FOR MONTREAL

One of the most demanding segments of Building decarbonization is Building retrofits. For this reason, the Next Generation Cities Institute (NGCI) has developed an urban building retrofit tool, with all buildings simulated individually, taking into account aspects such as shading or adjacencies and considering as many details as possible. As a second step, three scenarios with different levels of ambitions have been implemented in the tool and the demands resulting from these, as well as the initial investment costs and operational costs. With all those calculations, a detailed Life Cycle Costing (LCC) strategy has been implemented. The chapter describes the robust and scalable structure that has been developed in the NGCI and the application of this structure to calculate LCC of different retrofitting scenarios in Montréal. First results for the proof of concept are plotted, and the graphs for the UI are shown. In the future developments of the tool, an upscaling to other major cities in Canada is foreseen, using the same methodologies described.

Oriol GAVALDÀ

Lead, Zero Carbon Communities, Next-Generation Cities Institute and part of the UNIVER/CITY 2030 initiative at Concordia University, Canada

Oriol holds a degree in Industrial Engineering, a M.Sc. in Renewable Energies and the Environment, and a degree in Economics. Oriol started his engineering career working in the development sector for six years, implementing rural electrification projects all around the globe. After this experience, he joined the cooperative AIGUASOL in 2006, working on several consultancy projects related to renewable energy and energy efficiency. Later Oriol oriented his work on deepening business models analysis and financing of energy efficiency projects. He has worked as an independent consultant for organizations as World Bank, UN, CAF, etc. Structurally, he has been R&D head of AIGUASOL for three years, and general manager (CEO) for six years, positioning Aiguasol as one of the leading sustainability companies in the Spanish energy sector.

Ursula EICKER

Canada Excellence Research Chair (CERC) in Smart, Sustainable and Resilient Communities and Cities, Director of Concordia University's NEXT-GENERATION CITIES INSTITUTE, Professor in the Building, Civil and Environmental Engineering (BCEE) Department at Concordia University, QC, Canada

Dr. Eicker is a German physicist who received her Ph.D. in Solid State Physics from Heriot-Watt University and her Habilitation in Renewable Energy Systems and Building Technology from the Technical University Berlin. She has led numerous international research projects in renewable energy supply systems and building energy efficiency at Stuttgart University of Applied Sciences. A central focus of her research is zero-emission, smart and sustainable cities, integrating renewable energy sources and increasing city livability. A team of over 50 graduate students and software developers worked on numerous eco-district projects in Canada and created the urban modeling, data analytics and stakeholder engagement platform Tools4Cities. Dr. Eicker founded the Next-Generation Cities Institute in November 2020 and addresses the challenges of urban transformation with a transdisciplinary approach and develops tools and strategies for a sustainable future. As a member of the Canadian Green Municipal Fund (GMF) council since 2024, Prof. Eicker supports environmental sustainability and community development. She is a member of several advisory boards, including the Catalonian Energy Research Institute IREC, the Ireland Research Centre for Energy, Climate and Marine Research MaREI, Unibail-Rodam-co-Westfield headquartered in Paris and others.

Christopher GIBBS

Senior Advisor Software Development, Next-Generation Cities Institute at Concordia University, Canada

Chris has a 1st-class honors degree in Software Engineering and 35 years of experience working in the video game industry. Chris was co-founder and managing director of British game developer, Attention To Detail (1988 to 2003), Executive Producer and Studio Manager for Electronic Arts (2003 -2012), and an independent developer and publisher of his own mobile game (2014-2018). Chris' primary expertise is in building and guiding teams to create original, high quality, fun and engaging player experiences. Chris joined the NGCI in spring 2021 and leads efforts to use gamification principals for engaging the community (business and public) with the benefits of the student's research.

KEYWORDS

#URBAN SUSTAINABILITY INDICATORS #LIVABILITY #DIGITAL TWINS
#URBAN BUILDING ENERGY SIMULATION #URBAN DATA

HOW DO WE PROPOSE TO MEASURE SUSTAINABILITY AND LIVABILITY IN CITIES AND COMMUNITIES IN TOOLS4CITIES? A REVIEW OF CURRENT EVALUATION FRAMEWORKS AND A PROPOSAL FOR IMPROVEMENT

One of the most important objectives of the development of platforms and tools that can foster the path of cities and communities towards the idea of sustainability is to be able to measure in a coherent way the current status of the city and the advantages and improvements that Next-Generation Cities can bring to people. This coherence has to come from three main sources, the first of which is having trustworthy data to build on (data). The second is developing a clear data processing method and the establishment of clear technical KPIs (information), and the third, which is no less important, is the establishment of an epistemology of the social relations with reality, to really understand the impact of this information (knowledge). This last step, epistemology, can let us understand which are the key parameters for a livable city, and despite the answer may not be unique, it is important that the methodology is clear, scientific, and well-established.

DATA

Getting good data is key for the development of indicators that can lead our cities to reach at least the planned and compromised goals. However, extensive studies (Greene, 2017) (in this case, for the US) have shown that, even for indicators as established as the SDGs, "only 19% of the 161 relevant UN indicators across the SDG framework are measurable in US cities or metros using existing national data sources". This forces us to develop, not only for the sake of future scenario creation but also for filing the gaps, tools to simulate the real data to obtain values that can, after the processing task, be as trustworthy as possible.

INFORMATION

Making cities become sustainable has been a clear goal from the Brundtland report (Brundtland, 1987) and the implementation of the Sustainable Development Goals agenda in 2015. The establishment of the SDG for cities in the last years through the work of UN-HABITAT and the SDG-Cities platform has established a common methodology to be able to establish key actions to aim at this framework. The effort from the International Standards Organization with their Technical Committee ISO/TC 268, Sustainable cities and communities, who have established a list of indicators for sustainable cities and communities (Organization, 2019) is also important to evaluate. Parallelly, from the private sector, certifications containing epistemology and different measuring criteria have been working in the same direction to develop methodologies to evaluate a taxonomy of the levels of sustainability in cities (LEED, ENVISION, BREEAM, Cities Resilience Index). But beyond that, some start to point out that the concept of sustainability, "meeting the needs of the present without compromising the ability of future generations to meet their own needs", starts to be too limited. Livability, health, well-being, and happiness appear as concepts that are barely addressed with the previous sustainability concepts. Moreover, the climate trends make it necessary for cities not only to sustain the current situation but to regenerate it as well. Regenerative cities appear as good solutions to let cities be agents of change, but again the indicators have to be clearly established.

KNOWLEDGE

All these standards ask for different KPIs to evaluate the cities. Three of the main interesting standards for sustainable cities that have been developed in the last years (ISO, SDG for Cities, and City Resilience Index) analyze lists of really exhaustive indicators. Although the three share most of them, they have different approaches and segment the indicators into different groups.

CITY RESILIENCE INDEX	SDG-CITIES	ISO 37210:2018
BUDGET /BUSINESS, FINANCE & ECONOMY / CITIZEN PARTICIPATION & AWARENESS / CITY DATA / CRIME AND POLICING / CULTURE / DISASTER MANAGEMENT / EDUCATION / EMPLOYMENT / ENERGY / ENVIRONMENT FOOD / GOVERNANCE / HEALTH / HOUSING/ ICT LEGAL AND JUSTICE / PROTECTIVE INFRASTRUCTURE / SUPPORT AND WELFARE / TRANSPORTATION / URBAN PLANNING / UTILITIES / WASTEWATER/ WATER	SOCIETY / GOVERNANCE AND IMPLEMENTATION / ENVIRINMENT / ECOMOMY / CULTURE	ECONOMY / EDUCATION / ENERGY / ENVIRONMENT AND CLIMATE CHANGE / FINACE / GOVERNANCE / HEALTH /HOUSING / POPULATION AND SOCIAL CONDITIONS / RECREATION / SAFETY / SOLID WASTE / SPORT AND CULTURE / TELECOMMUNICATION / TRANSPORTATION / URBAN PLANING / URBAN (LOCOAL) AGRICULTURE AND FOOD SECURITY WASTEWATER / WATER

Figure 1: Sub-chapters for KPIs for the different sustainable KPIs for urban analyses. As such, it implies in all cases two things, namely the importance of each indicator, and the weight, which isn't always clear.

In the first case, the fact of choosing the variables, most of them might have clear covariances between them, is clearly an epistemological statement. If you mention budget, finance, and economy in a lot of variables, you may give them excessive importance only by the fact of repeating them. With regard to the second, the weighting is clearly a decision. In the city resilience index, a doughnut diagram showing the way a city behaves in different segments is plotted. This clearly states that each indicator is as important as the other. The same happens with metabolic analyses of the cities, showing equivalently the water resource, the energy resource, and the materials resource.

But if this is not right, what is the correct way to address a city's sustainability diagnostics and next steps? Within Social Life Cycle Analysis, probably the most adequate tool is creating a methodology to inquire about people's concerns and criteria. And making use of one of the most powerful tools we have nowadays, like serious gaming, can help us understand people's concerns and priorities.

Soroush Samareh ABOLHASSANI

Postdoctoral Research Scholar at Arizona State University, USA

Dr. Abolhassani holds a Master's in Building Engineering and a Ph.D. in Information Systems Engineering from Concordia University, where he conducted research under Professor Ursula Eicker, Nizar Bouguila and Manar Amayri on Urban Building Energy Modeling (UBEM) improvements. As part of the Tool4Cities platform research team at Next-Generation Cities Institute (NGCI), he explored cutting-edge advancements such as Wi-Fi sensing technology for building occupancy behavior estimation.

Currently, Soroush is a Postdoctoral Research Scholar at Arizona State University, working with Professor David Sailor and Dr. Sami G. Al-Ghamdi as part of a collaborative team between Arizona State University and King Abdullah University of Science and Technology. Their research aims to enhance urban landscapes for improved energy efficiency. His work focuses on urban greening strategies and modeling the impacts of vegetation and innovative cooling technologies in hot desert climates, particularly in Riyadh, Saudi Arabia, and Phoenix, USA.

In industry, Dr. Abolhassani has served as a Research Scientist at Aerial AI, leveraging Wi-Fi sensing technology to estimate occupancy behavior for building energy simulation and management. He has also worked as a software developer at EnerZam, contributing to the development of building energy management software solutions.

KEYWORDS

#BUILDING ENERGY MODELLING #3D MODELS #INSEL4CITIES
#BUILDING ARCHETYPE SELECTION
#ENERGY SYSTEM PLANNING

A NEW WORKFLOW FOR DYNAMIC URBAN BUILDING ENERGY MODELING FOR TOOLS4CITIES

Urban Building Energy Modeling (UBEM) has been an important topic in recent years due to its ability to help decision-makers test different energy efficiency scenarios on an urban scale and plan for better energy supplies strategies for the future. Due to the complexity of UBEMs, it is necessary and more efficient to design them in a software structure to automatically create the 3D model of urban buildings and use different energy-related data, pre-process them and calculate the energy demand.

In order to develop an automatic UBEM in a software platform, a comprehensive library of building archetype attributes is required. The building archetype attributes include the building's materials, constructions, occupancy-related schedules, etc. On the other hand, after access to the building attributes library, defining a workflow for archetype selection and assignment is necessary. The current study introduces a comprehensive workflow for a detailed dynamic and automatic UBEM that can create the 3D urban buildings in high resolution and fully take advantage of different building information in a comprehensive library existing in the TOOLS4Cities platform. Moreover, it benefits from detailed archetype selection and assignment to building surfaces and thermal zones according to the building type, year of construction, and surface type.

The developed workflow and integration with the TOOLS4Cities platform are shown and discussed in this chapter. This modular high-resolution UBEM software platform paves the way for engineers to easily connect different urban scale models such as building's energy demand, energy system sizing, transportation, wastewater, etc.

Sadam HUSSAIN

Research Scientist at Natural Resources Canada (NRCan), CanmetENERGY, in Varennes, Canada

Dr. Hussain received his Bachelor's degree in Electrical Engineering from the University of Engineering and Technology (UET), Peshawar, Pakistan, in 2015. From 2015 to 2018, he worked as a Packet Switching Core Specialist at ZTE-Pakistan, where he gained expertise in telecommunications and network infrastructure. He completed his Master's degree in Electrical and Computer Engineering at Pusan National University, Busan, South Korea, in 2020, focusing on advanced energy systems and control strategies. He earned his Ph.D. in Electrical and Computer Engineering from Concordia University, Montreal, Canada, where his doctoral research concentrated on optimizing power systems and renewable energy technologies.

Dr. Hussain is currently a Research Scientist at Natural Resources Canada (NRCan), CanmetENERGY, in Varennes, Quebec. His research interests encompass energy management systems, renewable energy integration, distribution system analysis, smart grids, and electric vehicle technologies. His work contributes to advancing sustainable energy systems and supporting Canada's transition to a low-carbon future.

KEYWORDS

#ENERGY MANAGEMENT SYSTEMS #SMART GRID
#DEMAND RESPONSE PROGRAM #DISTRIBUTION SYSTEMS
#HOME ENERGY MANAGEMENT SYSTEM
#OPTIMIZATION, AND ELECTRIC VEHICLE

ENERGY FLEXIBILITY IN LOW VOLTAGE DISTRIBUTION SYSTEM USING MULTI-LEVEL ENERGY MANAGEMENT FRAMEWORK

With the growing popularity of electric vehicles and renewable energy sources, there is an increasing need for energy flexibility in low-voltage distribution systems (LVDS). Unfortunately, conventional Home Energy Management Systems (HEMSs) are no longer sufficient to meet this demand, which has led to the implementation of Grid Energy Management Systems (GEMSs). However, these systems often have conflicting objectives, making it difficult to achieve optimal results. To address this challenge, a multi-level energy management system that combines the strengths of both HEMSs and GEMSs is required in LVDS. This chapter offers an overview of energy management systems at various levels and emphasizes the importance of a multi-level approach in achieving energy flexibility in low-voltage distribution systems.

Mahan MOLLAJAFARI

Ph.D. student in Information and System Engineering at Concordia University, Canada

Mahan's academic background includes a B.Sc. in Civil Engineering (2016-2020) and an M.Sc. in Transportation Planning (2020-2023) from Amirkabir University of Technology (AUT), where he focused on the impacts of autonomous vehicles on travel time reliability at a network level. His research interests span several key areas, including Intelligent Transportation Systems (especially, Automated, Connected and Autonomous Vehicles), Optimization, Network Analysis, Reliability Analysis. Mahan is specializing in AI applications in Transportation Engineering.

Zachary PATTERSON

Associate Professor in the Department of Geography, Planning and Environment at Concordia University / Tier-II Canada Research Chair in Transportation and Land Use Linkages for Regional Sustainability, and director of the Transportation Research for Integrated Planning (TRIP) Lab, Canada

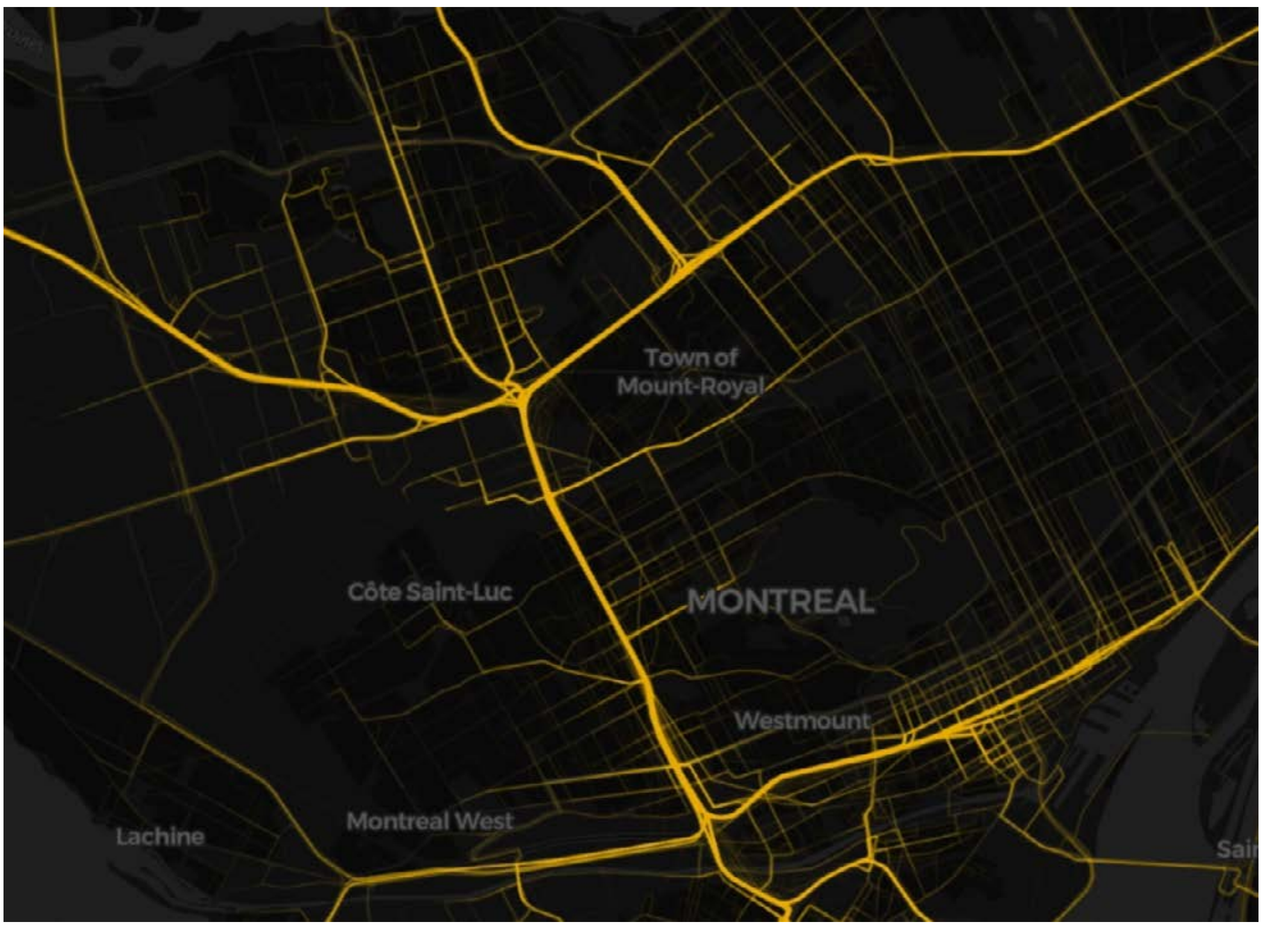
Prof. Patterson's research has four main thrusts: the use of emerging technologies in transportation data collection, GIS, Artificial Intelligence and statistical analysis. Recent research concentrates on the processing and inference of information from locational data collected from smartphones.

KEYWORDS

#TRANSPORTATION PLANNING #TRANSPORTATION PLANNING #SMARTPHONE TRAVEL SURVEY DATA #EMERGING TECHNOLOGIES #GIS #AI #ML #DATA ANALYTICS

EMERGING METHODS IN THE COLLECTION, PROCESSING AND ANALYSIS OF DATA IN TRANSPORTATION PLANNING

Transportation planning provides the analytical foundation for developing efficient and transportation systems that support societal well-being and prosperity. Therefore, it is essential for informed decision-making and the continuous improvement of transportation networks. Smartphone data has become extremely useful, providing detailed, real-time information on travel behavior and network performance to enable evidence-based, adaptive transportation policies and strategies. Smartphone travel survey data comes from dedicated smartphone travel surveys administered through smartphone applications. This data is collected through targeted surveys and provides detailed information on individual travel patterns, including origins, destinations, routes, and modes of transportation used. While revolutionary, smartphone travel survey data is nevertheless characterized by some limitations, including low participation rates, potential privacy concerns, and accuracy issues. That these issues persist is to the disappointment of many researchers in the transportation community who had very high expectations for smartphone surveys when they first appeared. Not all is lost, however, as transportation researchers develop ways of integrating other emerging technologies, such as connected, autonomous vehicles and traffic sensors, to complement smartphone and smartphone travel survey data to build more robust understandings of mobility patterns and trends. In this chapter, the incorporation of geographic information systems (GIS), artificial intelligence (AI), machine learning (ML), and statistical analysis, which enables spatial management, traffic forecasting, and the discovery of new insights from diverse transportation data sources is reviewed. By leveraging these integrated approaches, researchers can develop a more comprehensive understanding of mobility systems to inform effective transportation planning, operations, and management strategies.



Picture related to work

Anjali AWASTHI

Professor and Concordia University Research Chair (Tier-II) in Connected Sustainable Mobility Systems at Concordia Institute for Information Systems Engineering (CIISE), Canada

Dr. Awasthi received a Ph.D. in Industrial Engineering and Automation from INRIA Rocquencourt and University of Metz, France and a master's in Industrial and Management Engineering from IIT Kanpur, India. Prior to Concordia, Dr. Awasthi worked at University of British Columbia and University of Laval where she was involved in several projects on industrial applications of operations research. In France, she was involved in many European projects aimed at improving urban mobility in cities, city logistics and on cybernetic transportation systems. Her areas of research are modeling and simulation, data mining, Information Technology and decision making, sustainable logistics planning, quality assurance in supply chain management and sustainable supply chain management.

Ujjwal KHANNA

Senior Consultant in Technology Strategy & Transformation at Pricewaterhouse Coopers in Toronto, Canada

Ujjwal previously worked as a consultant with Leyton Canada's Scientific Research and Experimental Development division. Additionally, he managed technical projects at Concordia University's CERC and completed a research internship in warehouse logistics at Siemens Canada. He has a bachelor's in Computer Science from Amity University, a master's in Computer Science from Concordia University, and with a diploma in project management from McGill University. He was able to win numerous scholarships and awards related to his experience in data science and IoT. (IEOM-Best Master's Thesis & Best Thesis Poster, Merit Scholarship-Concordia University).

KEYWORDS

#INTERNET OF THINGS (IOT) #COMPUTER VISION #TRAFFIC ANALYSIS #URBAN SAFETY #SMART CITIES #DATA VISUALIZATION #OBJECT DETECTION #CLOUD-BASED SOLUTIONS #MONTREAL TRAFFIC STUDY

COMPUTER VISION AND INTERNET OF THINGS APPLICATION TO ENHANCE PEDESTRIAN SAFETY ENHANCING PEDESTRIAN SAFETY THROUGH THE APPLICATION OF COMPUTER VISION AND THE INTERNET OF THINGS

In urban settings worldwide, the escalating population intensifies concerns around pedestrian safety, highlighting the urgent need for effective safety measures and accident reduction strategies. This study introduces a solution that employs computer vision and cloud technology to bolster pedestrian safety, focusing on analyzing and visualizing data on pedestrian and vehicle movements at various intersections within Montreal. Historical data reveal a significant number of pedestrian-related accidents in the city, underscoring the critical need for this research.

To this end, approximately 200,000 images were harvested from traffic cameras at 43 key intersections around Montreal, spanning from March 8, 2020, to March 22, 2020, and subsequently from May 1, 2020, to May 11, 2020. Utilizing the Faster RCNN algorithm, an object detection and classification model were developed to identify both pedestrians and vehicles within these intersections. This model facilitated the creation of a comprehensive dataset illustrating pedestrian and vehicle counts at various intersections, enabling the identification of traffic patterns, including peak and off-peak hours, as well as intersections posing higher fluctuations as per the analysis.

Ursula EICKER

Canada Excellence Research Chair (CERC) in Smart, Sustainable and Resilient Communities and Cities, Director of Concordia University's NEXT-GENERATION CITIES INSTITUTE, Professor in the Building, Civil and Environmental Engineering (BCEE) Department at Concordia University, Canada

Dr. Eicker is a German physicist who received her Ph.D. in Solid State Physics from Heriot-Watt University and her Habilitation in Renewable Energy Systems and Building Technology from the Technical University Berlin. She has led numerous international research projects in renewable energy supply systems and building energy efficiency at Stuttgart University of Applied Sciences. A central focus of her research is zero-emission, smart and sustainable cities, integrating renewable energy sources and increasing city livability. A team of over 50 graduate students and software developers worked on numerous eco-district projects in Canada and created the urban modeling, data analytics and stakeholder engagement platform Tools4Cities. Dr. Eicker founded the Next-Generation Cities Institute in November 2020 and addresses the challenges of urban transformation with a transdisciplinary approach and develops tools and strategies for a sustainable future. As a member of the Canadian Green Municipal Fund (GMF) council since 2024, Prof. Eicker supports environmental sustainability and community development. She is a member of several advisory boards, including the Catalonian Energy Research Institute IREC, the Ireland Research Centre for Energy, Climate and Marine Research MaREI, Unibail-Rodam-co-Westfield headquartered in Paris and others.

Ramanunni PARAKKAL MENON

Researcher at the Institute of Solar Research of the German Aerospace Centre (DLR), Köln, Germany

Raman's fields of expertise include Energy Management, Optimization and Operations Research, Optimal Control, Internet-of-Things (IoT) hardware and software, Smart Buildings and Networks, Smart Grids, Machine Learning for Smart grids and Energy system integration and system design for communities and cities. He completed his B.E in Chemical Engineering from BITS-Pilani, Goa in India, his MSc in Energy from Heriot-Watt University, Edinburgh in Scotland, and his PhD in Energy from EPFL Lausanne in Switzerland on "Model Predictive Control Strategies for Polygeneration Systems and Microgrids". He worked within the EU Horizon 2020 project "Sim-4Blocks" and as a Postdoctoral Fellow at the CERC (Canada Excellence Research Chair in Smart, Sustainable and Resilient Communities and Cities) in Concordia University, Montreal in Canada prior to his current tenure at DLR.

KEYWORDS

#URBAN IoT #OPTIMIZATION #URBAN INFRASTRUCTURE
#AUTOMATION TECHNOLOGY

IoT (INTERNET-OF-THINGS): SENSORS AND HARDWARE

Since the early 2000s, a progressive drop in hardware manufacturing costs, the continued improvement in processor computational power, telecommunication standards, and technology has enabled rapid digitalization of the automation infrastructure. This, combined with the maturing of advanced data management and control algorithms and machine learning, has made it possible to optimize assets and networks within the city that was previously thought to be impossible.

A smart city depends on smarter citizens capable of making informed decisions owing to the presence smart infrastructure and sensors. The smart infrastructure and frameworks require the appropriate hardware, wireless networks that facilitate communication of information, and a software framework which would make it capable of impacting the quality of life and provide advanced automated and semi-automated services.

However, this adoption and implementation of automation technology remains rather haphazard within the urban environment. Sectors that have traditionally been monitored at some level continue to lead the way in how automation is implemented within the urban environment. As a result, the electrical grid and the HVAC (Heating, Ventilation and Cooling) systems within the built environment lead the way in implementation of IoT (Internet-of-Things). Measurement of air quality, temperatures within the built environment, and information on the other sectors within the urban environment such as waste management, transport, and fostering interconnectivity between these sectors is still nascent or non-existent.

As a result, to truly understand IoT hardware and frameworks for each sector, the state-of-the-art for hardware for each of the following sectors will be discussed: (i) Electric grid and networks IoT; (ii) Building electricity consumption and sub-metering IoT; (iii) Building HVAC system IoT; (iv) Transport IoT; (v) Urban air quality and greenery IoT; (vi) Waste collection and management IoT; (vii) Wireless tech enabling communication between sectors. Each section will look at the existing standards and protocols in use, and briefly cover the advantages and disadvantages while also proposing some solutions to overcome a few of the limitations.

Thus, this section focuses on the state-of-the-art of the IoT hardware in the present-day urban environment. The chapter looks at the siloes of hardware, software and communication protocols that exist across the various sectors and the work that is being done to bridge the gaps to create a holistic IoT architecture and hardware/software framework within the modern city.

PART 3

SHARING ECCONOMY SYSTEMS

CHAPTER EDITOR:

Prof. Chun Wang

Jie GAO

Assistant Professor in Multimodal Transport Network Sustainability at the Department of Transport and Planning at TU Delft, Netherlands

Dr. Gao's research centers on the area of smart transportation, developing innovative methodologies and applications to address efficiency and sustainability issues in shared mobility systems and electric vehicle (EV) charging scheduling.

Chun WANG

Professor, Concordia Institute for Information Systems Engineering (CIISE) and Cluster Co-Director for Mobile, Secure and Sharing Cities at Next-Generation Cities Institute at Concordia University, Canada

Dr. Wang has published extensively in major intelligent transportation journals, covering topics in urban mobility, mobility-on-demand, and shared mobility systems. Recent publications by Dr. Wang include research on machine learning models for rider demand forecasting, crowd-sourced delivery services optimization, multi-agent reinforcement mechanism design for dynamic pricing-based demand response, and privacy-preserving matching mechanisms for community ridesharing. His expertise lies at the intersection of economic models, operations research, and artificial intelligence. Dr. Wang also serves as an associate editor of IET Collaborative Intelligent Manufacturing.

KEYWORDS

#DATA DRIVEN OPTIMIZATION #SCHEDULING
#MULTIAGENT SYSTEMS #AUCTIONS MOBILITY ON DEMAND
#INTELLIGENT TRANSPORTATION SYSTEMS

MATCHING MECHANISMS FOR THE SHARING ECONOMY

The sharing economy is transforming the way we consume and share underutilized assets, with popular platforms such as Airbnb and Uber leading the way. However, for these platforms to succeed, effective matching mechanisms are crucial as they determine the utilization of resources, service income, and user satisfaction. This chapter discusses the challenges and opportunities of designing matching mechanisms for the sharing economy. One key challenge is the decentralized nature of these platforms, where users have conflicting objectives and private preferences. To address these challenges, market-based mechanisms that incentivize users to reveal their information truthfully and accommodate their preferences in a privacy-preserving manner are essential. Additionally, matching problems are highly dynamic, as users' behavior changes over time and unpredictable events occur, such as urgent requests, cancellations, and no-shows. Robust optimization approaches are needed to handle the contingencies caused by the uncertainty of future demand and supply. Furthermore, network effects play a crucial role in matching mechanisms, as more offers and requests become available over time, leading to better matches. Developing sustainable sharing platforms for next-generation cities requires quantifying the long-term effects of optimization-based matching and integrating them into matching mechanisms. This chapter highlights the importance of efficient and effective matching approaches for sharing platforms and discusses the challenges and solutions to design sustainable sharing platforms for the next generation of cities.

Chun WANG

Professor, Concordia Institute for Information Systems Engineering (CIISE) and Cluster Co-Director for Mobile, Secure and Sharing Cities at Next-Generation Cities Institute at Concordia University, Canada

Dr. Wang has published extensively in major intelligent transportation journals, covering topics in urban mobility, mobility-on-demand, and shared mobility systems. Recent publications by Dr. Wang include research on machine learning models for rider demand forecasting, crowd-sourced delivery services optimization, multi-agent reinforcement mechanism design for dynamic pricing-based demand response, and privacy-preserving matching mechanisms for community ridesharing. His expertise lies at the intersection of economic models, operations research, and artificial intelligence. Dr. Wang also serves as an associate editor of IET Collaborative Intelligent Manufacturing.

KEYWORDS

#SHARED MOBILITY #TWO-SIDED MATCHING #SCHEDULING #SUPPLY SIDE BEHAVIOR MODELING #MACHINE LEARNING #MULTI AGENT SYSTEMS

STABLE MATCHING MECHANISMS FOR SHARED MOBILITY SYSTEMS

As an innovative transportation strategy, shared mobility addresses traffic congestion, parking scarcity, and climate change by shifting mobility from a vehicle ownership model to service-based operations. Unlike public transit systems, shared mobility platforms operate in a market environment in which a supplier (driver) is free to decide whether to comply with the ride request assigned by the platform. In such a transport mode, drivers' ride acceptance behavior can significantly influence the performance of a shared mobility platform in terms of riders' waiting time, drivers' occupation rate and idle time, and platform revenue and reputation. The past several years have witnessed a rapid increase in driver ride decline rates, which indicates that the current matching mechanisms are not stable in the sense that drivers often have the incentive to decline assigned ride requests.

In this chapter, we discuss three important and unique challenges in designing stable matching mechanisms for shared mobility systems which are not addressed in standard two-sided matching literature. Related literatures are summarized. Potential solutions are also suggested.

Luyang HOU

Research Associate Professor School of Computer Science (National Pilot Software Engineering School), Beijing University of Posts and Telecommunications (BUPT), China

Prof. Hou received the Ph.D. degree in information systems engineering from Concordia University, Canada, in 2020. Before joining BUPT, he was a Postdoctoral Research Fellow at the Energy Innovation Laboratory of MéridaLabs, The University of British Columbia from January 2021 to February 2022, and at the Institute for Information Systems Engineering, Concordia University from March 2022 to October 2022. His research interests include operational optimization, mechanism design, and reinforcement learning with applications to Energy Internet, vehicle edge computing, electricity market design, and so on.

Jun YAN

Assistant Professor with the Institute for Information Systems Engineering (CIISE) and a member of the Security Research Centre (SRC) at Concordia University, Canada

Prof. Yan holds a B.Eng. degree in Information and Communication Engineering from Zhejiang University, China, and a M.S. and Ph.D. (Hons.) in Electrical Engineering from the University of Rhode Island, USA. He was a recipient of the IEEE International Conference on Communications (ICC) Best Paper Award and the IEEE International Joint Conference on Neural Networks (IJCNN) Best Student Paper Award, among others. Research interests include computational intelligence and cyber-physical security in smart critical infrastructures.

Yuankai Wu

Research Professor at the College of Computer Science, Sichuan University, China

Dr. Wu received the Ph.D. degree from the Beijing Institute of Technology (BIT), Beijing, China, in 2019. He is currently a tenure-track professor at the College of Computer Science, Sichuan University, China. Prior to joining Sichuan University in March 2022, he was an IVADO postdoc researcher with the Department of Civil Engineering, McGill University. His research interests include spatiotemporal data mining, intelligent transportation systems, and intelligent decision-making.

Tie QIU

Professor at School of Computer Science and Technology, Tianjin University, China

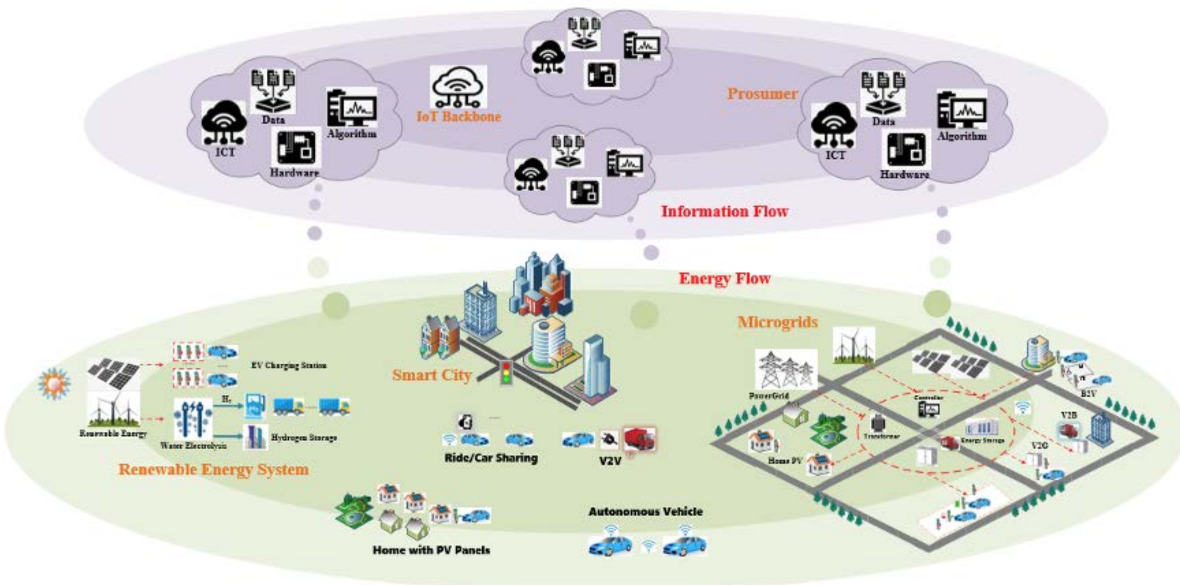
Before becoming a full professor at Tianjin University, Dr.Qui held the position of assistant professor in 2008 and associate professor in 2013 at School of Software, Dalian University of Technology. He was a visiting professor at department of electrical and computer engineering of Iowa State University in U.S. (2014-2015). He serves as an associate editor of IEEE/ACM Transactions on Networking (ToN), IEEE Transactions on Network Science and Engineering (TNSE) and IEEE Transactions on Systems, Man, and Cybernetics: Systems, etc. He has authored/co-authored 10 books and over 200 scientific papers, he is also a distinguished member of China Computer Federation (CCF) and a Senior Member of IEEE and ACM.

KEYWORDS

#MACHINA ECONOMICUS #ENERGY INTERNET
#ARTIFICIAL INTELLIGENCE #ECONOMICS #MULTI-AGENT SYSTEMS

MACHINA ECONOMICUS: A NEW PARADIGM FOR PROSUMERS IN THE ENERGY INTERNET OF SMART CITIES

Energy Internet (EI) is emerging as new share economy platform for flexible local energy supplies in smart cities. Empowered by the Internet-of-Things (IoT) and Artificial Intelligence (AI), EI aims to unlock peer-to-peer energy trading and sharing among prosumers, who can adeptly switch roles between providers and consumers in localized energy markets with rooftop photovoltaic panels, vehicle-to-everything technologies, packetized energy management, etc. The integration of prosumers in EI, however, will encounter many challenges in modeling, analyzing, and designing an efficient, economic, and social-optimal platform for energy sharing, calling for advanced AI/IoT-based solutions to resource optimization, information exchange, and interaction protocols in the context of the share economy. In this study, we aim to introduce a recently emerged paradigm, Machina Economicus, to investigate the economic rationality in modeling, analysis, and optimization of AI/IoT-based EI prosumer behaviors. The new paradigm, built upon the theory of machine learning and mechanism design, will offer new angles to investigate the selfishness of AI through a game-theoretic perspective, revealing potential competition and collaborations resulting from the self-adaptive learning and decision-making capacity. This study will focus on how the introduction of AI will reshape prosumer behaviors on the EI, and how this paradigm will reveal new research questions and directions when AI meets the share economy. With an extensive case analysis in the literature, we will also shed light on potential solutions for advancements of AI in future smart cities.



Hongde WU

Researcher in 2012 Lab at Huawei, Ireland

Hongde received his BEng degree in Biomedical Engineering with an outstanding graduate from Beijing Institute of Technology in 2017 and received his MEng degree (research degree), under the supervision of Dr. Mingming Liu, from Dublin City University in 2022. Currently he works as a researcher at the 2012 Lab a media technology innovation and engineering competence center of Huawei. His interests are deep learning, graph neural network and smart transportation.

Sen YAN

Ph.D. candidate, School of Electronic Engineering and Insight SFI Centre for Data Analytics, Dublin City University, Ireland

Sen is working on his Ph.D. thesis under the supervision of Dr. Mingming Liu and Prof. Noel E. O'Connor. He received his BEng in Internet of Things Engineering from Shandong University, China in 2018, and his MSc in Computer Science from Trinity College Dublin in 2020. Sen is working in the field of intelligent transportation and micromobility, with additional research interests in image processing, computer vision, and machine learning.

Mingming LIU

Assistant Professor in the School of Electronic Engineering at Dublin City University (DCU), Ireland

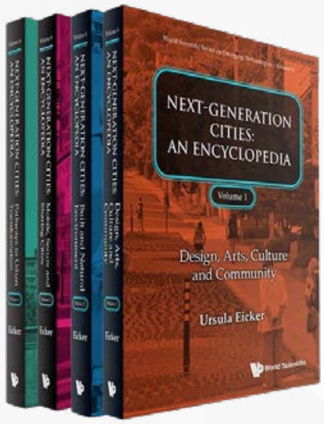
Prof. Liu received the BEng (1st Hons) in Electronic Engineering from National University of Ireland Maynooth in 2011 and the PhD in Control Engineering from the Hamilton Institute at the same university in 2015. He is an IEEE senior member and has published over 50 papers to date, including "IEEE Transactions on Smart Grids", "IEEE Transactions on Intelligent Transportation Systems", "IEEE Transactions on Automation Science and Engineering", "IEEE System Journal", "IEEE Transactions on Transportation Electrification", "Scientific Reports" and "Automatica". Since 2018, he has secured more than 1.2 million euros in research funding as the sole PI. Currently, he is the management committee member in Ireland for EU COST Actions CA19126, CA20138 and CA21131. He is also affiliated with the SFI Insight Centre for Data Analytics as a Funded Investigator. His research interests include control, optimization and machine learning with applications to 5G & IoT, electric vehicles, smart grids, smart transportation, smart healthcare and smart cities. Dr. Liu is also a Principal Investigator for Huawei Cloud.

KEYWORDS

#E-MOBILITY#DISTRIBUTED CONTROL AND OPTIMIZATION
#INTELLIGENT TRANSPORTATION SYSTEMS

RECENT ADVANCES IN GRAPH-BASED MACHINE LEARNING FOR APPLICATIONS IN SMART URBAN TRANSPORTATION SYSTEMS

The Intelligent Transportation System (ITS) is an important part of modern transportation infrastructure, employing a combination of communication technology, information processing and control systems to manage transportation networks. This integration of various components such as roads, vehicles, and communication systems, is expected to improve efficiency and safety by providing better information, services, and coordination of transportation modes. In recent years, graph-based machine learning has become an increasingly important research focus in the field of ITS aiming at the development of complex, data-driven solutions to address various ITS-related challenges. This chapter presents background information on the key technical challenges for ITS design, along with a review of research methods ranging from classic statistical approaches to modern machine learning and deep learning-based approaches. Specifically, we provide an in-depth review of graph-based machine learning methods, including basic concepts of graphs, graph data representation, graph neural network architectures and their relation to ITS applications. Additionally, two case studies of graph-based ITS applications proposed in our recent work are presented in detail to demonstrate the potential of graph-based machine learning in the ITS domain.



In conclusion, THE BOOK OF ABSTRACTS / VOL. 3 for the "Next-Generation Cities: An Encyclopedia" series, published by World Scientific Publishing Co Pte Ltd, introduces the diverse and interdisciplinary topics covered in the four volumes. Both publications are co-edited by Prof. Ursula Eicker, Canada Excellence Research Chair (CERC) in Smart, Sustainable, and Resilient Communities and Cities, and founding Director of the Next-Generation Cities Institute (NGCI), along with the team of Co-Directors representing the Institute's three research clusters: Built and Natural Environment (BAN), Mobile, Secure, and Sharing Cities (MSS), and Design, Arts, Culture, Community (DAC).

The presented abstracts offer the perspectives of authors who are primarily experts in the field of urban studies from Concordia University in Montreal, along with related experts from Canada and around the globe. In this way, this collection creates an international overview. It highlights the multifaceted nature of urban development, integrating insights from various fields to understand the challenges and opportunities facing our cities today. We invite you to explore the subsequent volumes, each offering unique perspectives on next-generation cities. Together, these volumes form a rich resource for shaping the future of urban environments.


PUBLIC
2020

UNIVERSITÉ
Concordia
UNIVERSITY

NEXT-GENERATION
CITIES INSTITUTE

World Scientific
Connecting Great Minds

www.worldscientific.com

T25-95418