The 1st ACM International Workshop on Big Data and Machine Learning for Smart Buildings and Cities

Bing Dong
Mechanical and Aerospace Engineering
Syracuse University
Syracuse, New York, USA
bidong@syr.edu

Romana Markovic
Building Science Group
Karlsruhe Institute of Technology
Karlsruhe, Germany
romana.markovic@kit.edu

Salvatore Carlucci
Energy, Environment, and Water Research Center
The Cyprus Institute
Nicosia, Cyprus
s.carlucci@cyi.ac.cy

ABSTRACT

The proliferation of urban sensing, IoT, and big data in buildings, cities, and urban areas provides unprecedented opportunities for a deeper understanding of occupant behavior, transportation, and energy and water usage patterns. However, utilizing the existing data sources and modeling methods in building science to model urban scale occupant behaviors can be pretty challenging. Therefore, technological progress is needed to unlock its full potential. In order to fulfill the latter task, this workshop focuses on the methodologies for big urban and building data collection, analytics, modeling, and real-world technology deployment. The workshop aims to open discussion on the current challenges of big data in smart buildings and cities.

CCS CONCEPTS

• Applied computing → Machine learning → Architecture (buildings)

KEYWORDS

Smart Buildings; Digital Cities; Occupant Behavior; Big Data Analysis; Modeling and Prediction; Machine learning

ACM Reference format:

Bing Dong, Romana Markovic and Salvatore Carlucci. 2021. The 1st ACM International Workshop on Big Data and Machine Learning for Smart Buildings and Cities. In *Proceedings of ACM International Conference On Systems For Energy-Efficient Buildings, Cities, And Transportation (BuildSys'21). ACM, New York, NY, USA.*
https://doi.org/10.1145/3486611.3491139.

BuildSys'21, November 17–18, 2021, Coimbra, Portugal

ACM ISBN 978-1-4503-8461-2/21/09. . . $15.00
https://doi.org/10.1145/3460418.3479264

1 BACKGROUND AND WORKSHOP AIMS

By 2050, approximately 70% of the world's population is projected to live and work in cities, while two-thirds of global primary energy consumption will be attributed to cities, leading to the major production of the global direct energy-related greenhouse gas emissions. The building sector is responsible for about 40% of global energy consumption and 33% of greenhouse gas emissions [1]. One of the critical aspects for energy efficiency in smart buildings is to understand energy-related occupant behavior. The proliferation of urban sensing, IoT, and big data in buildings, cities, and urban areas provides unprecedented opportunities for a deeper understanding of occupant behavior, transportation, and energy and water usage patterns. In addition, there are several previous studies on modeling occupant behavior based on limited or standalone data sources [2]. However, utilizing the existing data sources and modeling methods in building science to model urban scale occupant behaviors can be challenging [3]. Therefore, technological progress is needed to unlock its full potential and contribute to improve the design and operation of buildings and neighborhoods. In particular, big data and machine learning can help to investigate the high degree of uncertainty caused by people in buildings and neighborhoods. To this aim is also important to share knowledge about best practices, methodologies and infrastructures created to investigate occupant behavior in buildings and neighborhoods [4]. In order to fulfill the latter task, this workshop focuses on the methodologies for big urban and building data collection, analytics, modeling, and real-world technology deployment. Additionally, a spotlight will be put on the ongoing project IEA-EBC Annex 79 Subtask 2: Data-driven occupant modeling strategies and digital tools of Annex 79 promoted by the Energy in Buildings and Communities Programme of the International Energy Agency (IEA-EBC), which focuses on investigating and developing methodologies and tools for data-driven Occupant Presence and Action (OPA) modeling [5].

The workshop aims to open discussions on 1) challenges of the current modeling approaches in building science, 2) big data modeling paradigms that could be applicable in building science, urban infrastructure data modeling, 3) requirements on the data collection infrastructure required for increasing the volume of data collection, and 4) future research directions using urban big data. An important part of the workshop will be dedicated to accelerating the open-world deployment of advanced technologies. For

instance, how the guidelines, model benchmarking, and standardization can unlock the potential of the big data, buildings, urban scale occupant behavior modeling, and energy consumption data.

2. TOPICS OF THE WORKSHOP

The objective of this workshop is to explore the opportunities and challenges of big data in smart buildings and cities. Hence, the topic covers a wide range of building and urban engineering and science, which includes the following:

- Machine learning for modeling big data from buildings, cities, and various urban-scale data;
- AI-driven building automation;
- Modeling of human mobility in cities;
- Urban sensing;
- Data-driven urban scale occupant behavior modeling;
- Scaling up models to big data and large-scale deployment;
- Model standardization and benchmarking;
- Fault-free data-driven building operation;
- City-scale model scalability;
- Urban scale building energy modeling;
- Outdoor thermal comfort.

3. PAPER SELECTION AND PUBLICATION

All submissions went through double blind peer-review process. The workshop accepted original work and work in progress. Maximum paper length is 4 pages. The acceptance criteria lied on the intersection of the topic suitability, technical quality and presented novelty. In total 8 out of 15 papers were accepted. The accepted papers will be included in the ACM Digital Library and supplemental proceedings of the BuildSys conference.

4. WORKSHOP ORGANIZERS

The workshop organizers are the IEA-EBC Annex 79 Subtask 2 co-leaders:

Bing Dong is an associate professor from Syracuse University, USA. He is working on applied machine learning in occupant behavior modeling in smart buildings, occupant-centric building controls, and human mobility

Romana Markovic is a PostDoc at the Karlsruhe Institute of Technology (KIT) in Germany. She graduated from RWTH Aachen university (Dr. Ing., summa cum laude) on the topic of generic occupant behavior modeling in commercial buildings. Her research focus lies on machine learning modeling for application in building control.

Salvatore Carlucci is a professor at the Energy, Environment, and Water Research Center of the Cyprus Institute. His principal fields of interest are adaptive and responsive building components and occupant-centric building controls for comfortable and healthy grid-interactive buildings.

5. WORKSHOP FORMAT AND SCHEDULE

We plan a half-day workshop held during the BuildSys'21 main conference between November 17th and 18th, 2021. There are two keynote speakers. Following each keynote are four presentations. The workshop concludes with remarks from workshop chairs. Table 1 shows the workshop schedule.

Table 1: Workshop schedule

Tentative Workshop Schedule (All Time in EST)	
10:00am-10:10am	Opening remarks
10:10am-10:40am	Keynote I: Panagiota Karava, A cloud-based software platform for SmartEnergy (SmartE) management in connected communities
10:40am-11:40am	Data-driven Identification of Occupant-thermostat Interactions in Small Commercial Buildings B. Huchuk, F. Bahiraei, S. Dutta Data-driven Identification of Occupant-thermostat Interactions in Small Commercial Buildings J. Leprince, C. Miller, M. Frei, H. Madsen, W. Zeiler Application of Occupant Behavior Prediction Model on Residential Big Data Analysis Y. Mo, D. Zhao Towards Sensing Urban-scale COVID-19 Policy Compliance in New York City T. Chowdhury, A. Bhatti, I. Mandel, T. Ehsan, W. Ju, J. Ortiz
11:40am-12:00pm	Break
12:00pm-12:30pm	Keynote II: Matthias Berning, Challenges in Building Ecosystems – Enabling Data-Driven Services
12:30pm-1:30pm	Building Sensor Fault Detection and Diagnostic System D. Kumar, X. Ding, W. Du, A. Cerpa Open Set Anomaly Classification M. Dix, R. Borrison Dynamic Bayesian Network-Based Fault Diagnosis for ASHRAE Guideline 36: High Performance Sequence of Operation for HVAC Systems O. Pradhan, J. Wen, Y. Chen, X. Lu, M. Chu, Y. Fu, Z. O'Neill, T. Wu, K. Candan A linked-data paradigm for the integration of static and dynamic building data in Digital Twins D. Mavrokapnidis, K. Katsigarakis, P. Pauwels, E. Petrova, I. Korolija, D. Rovas
1:30pm-1:40pm	Closing remarks

6. ACKNOWLEDGEMENTS

Part of this effort was funded by U.S. National Science Foundation under award No. 1949372, and the German Federal Ministry of Economics and Energy (BMWi) as per resolution of the German Parliament under the funding code 03EN1002A. This workshop is part of the IEA EBC Annex 79 activities. We also thank to the technical program committee members for providing valuable and extremely helpful reviews.

REFERENCES

[1] Ahmad, T. and Zhang, D., 2020. A critical review of comparative global historical energy consumption and future demand: The story told so far. Energy Reports, 6, pp.1973-1991.

[2] Carlucci, S., De Simone, M., Firth, S.K., Kjærgaard, M.B., Markovic, R., Rahaman, M.S., Annaqeeb, M.K., Biandrate, S., Das, A., Dziedzic, J.W. and Fajilla, G., 2020. Modeling occupant behavior in buildings. Building and Environment, 174, p.106768.

[3] Dong, B., Liu, Y., Fontenot, H., Ouf, M., Osman, M., Chong, A., Qin, S., Salim, F., Xue, H., Yan, D. and Jin, Y., 2021. Occupant behavior modeling methods for resilient building design, operation and policy at urban scale: A review. Applied Energy, 293, p.116856.

[4] M.B. Kjærgaard, O. Ardakanian, S. Carlucci, B. Dong, S.K. Firth, N. Gao, G.M. Huebner, A. Mahdavi, M.S. Rahaman, F.D. Salim, F.C. Sangogboye J.H. Schwee, D. Wolosiuk, Y. Zhu. 2020. Current Practices and Infrastructure for Open Data based Research on Occupant-centric Design and Operation of Buildings. Building and Environment, 177, p. 106848.

[5] W. O'Brien, A. Wagner, M. Schweiker, A. Mahdavi, J. Day, M.B. Kjærgaard, **S.** Carlucci, B. Dong, F. Tahmasebi, D. Yan, T. Hong, B. Gunay, Z. Nagy, C. Miller, C. Berger. 2020. Introducing IEA EBC Annex 79: Key challenges and opportunities in the field of occupant-centric building design and operation. Building and Environment, 178, p. 106738.