Binyu Lei

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RESEARCH INTERESTS

Urban digital twins, 3D GIS, urban informatics, human-centric urban technology, human perception and urban wellbeing, data quality, crowdsourced data, GeoAI

EDUCATION

National University of Singapore (NUS)   Aug. 2021—Present
PhD Candidate in Urban Analytics Lab

University of Melbourne   Jun. 2017—Jul. 2019
Master of Urban Planning

East China Normal University (ECNU)   Sep. 2013—Jun. 2017
Bachelor of Science in Human Geography and Regional Planning (Hons)

RESEARCH EXPERIENCE

Urban Analytics Lab, Department of Architecture, NUS   Aug. 2021—Present
PhD Candidate and Research Associate (Supervisor: Dr Filip Biljecki)

- 3D City Index: developed the first framework to evaluate 3D city models encompassing 47 criteria, evaluated and benchmarked 40 authoritative 3D datasets, released a collection of open 3D city models, contributed to standardising the characterisation of 3D data and understanding the state of 3D GIS (published)

- Challenges of Urban Digital Twins: conducted a systematic review of documented challenges in the literature, designed a Delphi expert survey contributed by a panel of 52 international domain experts, identified a structured list of 23 challenges to the operation of digital twins combining technical and non-technical perspectives (published)

- Urban walking comfort: contributed to a study on leveraging computer vision and graph models to predict walking comfort outdoors, advancing a human lens in the adoption of urban digital twins (published)

- Humans as Sensors in Urban Digital Twins: proposed the first conceptual framework that addresses the role of humans in relation to the urban environment, highlighting the social and human value of urban digital twins (published)

- Building Characteristics Predictions: developed a graph-based spatially-explicit GeoAI framework to predict various building characteristics in diverse cities with Python code open-sourced, mitigated data gaps in building information, enhanced contemporary urban studies, facilitated the development of 3D GIS, such as updating 3D building settings (published)

- Human Perception in Urban Digital Twins: established the first integration of how humans perceive buildings in 3D city models and urban digital twins, developed a CityJSON Extension to accommodate the new data and validate its schema, released the Extension open-sourced, facilitated a broader adoption of semantic 3D data (published)

- A Systematic Review of GeoAI in Human Geography: contributed to a study on the current progress and status of GeoAI applications within 14 subdomains of human geography from 1516 papers using GeoAI in human geography related studies (published)
- Urban Comfort Index: developed a graph-based approach to measure urban comfort and explain its driving forces by exploiting spatial relationships between urban comfort and surrounding features, such as 3D urban morphology and environmental factors (under review)
- Urban Just-in-Time Adaptive Interventions (JITAIs) Comfort Perception: explored the bidirectional information exchange between humans and urban environments with advancements of JITAIs concept, wearable devices, and urban digital twins, evaluated the impact of urban complexity on generic urban comfort perception and behaviour, informed the design of more comfortable and accessible urban environments, with implications for urban health and wellbeing (in preparation)
- Digital Twin Definition: contributed to a study on generating the definition of digital twins leveraging natural language processing (NLP) techniques to systematically extract and analyse definitions from a corpus of 15,000 full-text articles spanning diverse disciplines (submitted)
- Sensing Urban Traffics: contributed to a study on using GeoAI and street view imagery (SVI) to predict traffic accidents (under review)
- Urban Climate Justice: contributed to a study on introducing a novel dual-GNN approach with SVI as an input, integrating a multigraph and a hypergraph to model intricate spatial patterns for classifying urban climate justice (under review)
- Book Chapter: contributed to a book chapter on GeoAI and urban geography (in preparation)
- Open Government Building Data: contributed to a study on mapping and analysing the availability of authoritative datasets on buildings worldwide (in preparation)

School of Design, University of Melbourne   Feb. 2019—Jul. 2019
Master's Studio (Supervisor: Professor Sun Sheng Han)

- Contributed to the "Healthy Cities 2050 Plan for Clayton" project, focusing on walking and cycling priority zones to build the suburb as part of a healthy future Melbourne
- Completed "Walking and Cycling Clayton 2050 Strategic Plan", including reviewed literature on cases of healthy communities with measures to encourage walking/cycling; assessed planning schemes, transport planning, and cycling policies; and visualised connectivity of active transport from Clayton Station using QGIS; presented the final report to public sectors and local companies at the planning meeting

JOURNAL PUBLICATIONS

Binyu Lei, Pengyuan Liu, Nikola Milojevic-Dupont, and Filip Biljecki. "Predicting building characteristics at urban scale using graph neural networks and street-level context." *Computers, Environment and Urban Systems* 111 (2024): 102129. DOI: https://doi.org/10.1016/j.compenvurbsys.2024.102129

Siqin Wang, Xiao Huang, Pengyuan Liu, Mengxi Zhang, Filip Biljecki, Tao Hu, Xiaokang Fu, ... **Binyu Lei**, Shuming Bao. "Mapping the landscape and roadmap of geospatial artificial intelligence (GeoAI) in quantitative human geography: An extensive systematic review." *International Journal of Applied Earth Observation and Geoinformation* 128 (2024): 103734. DOI: https://doi.org/10.1016/j.jag.2024.103734

Pengyuan Liu, Tianhong Zhao, Junjie Luo, **Binyu Lei**, Mario Frei, Clayton Miller, and Filip Biljecki. "Towards human-centric digital twins: leveraging computer vision and graph models to predict outdoor comfort." *Sustainable Cities and Society* 93 (2023): 104480. DOI: https://doi.org/10.1016/j.scs.2023.10448

Binyu Lei, Patrick Janssen, Jantien Stoter, and Filip Biljecki. "Challenges of urban digital twins: A systematic review and a Delphi expert survey." *Automation in Construction* 147 (2023): 104716. DOI: https://doi.org/10.1016/j.autcon.2022.104716

Binyu Lei, Rudi Stouffs, and Filip Biljecki. "Assessing and benchmarking 3D city models." *International Journal of Geographical Information Science* 37, no. 4 (2023): 788-809. DOI: https://doi.org/10.1080/13658816.2022.2140808

SUBMITTED OR IN PREPARATION

Binyu Lei, Pengyuan Liu, Kunihiko Fujiwara, Mario Frei, Clayton Miller, and Filip Biljecki, 2024. Advancing urban digital twins with a just-in-time adaptive interventions (JITAIs) framework for multi-dimensional urban comfort analysis. (in preparation)

Clayton Miller, Matias Quintana, Yun Xuan Chua, Mario Frei, **Binyu Lei**, and Filip Biljecki, 2024. Nudging comfort in the built environment: Using smartwatch-based Just-in-time Adaptive Interventions (JITAI) for mitigating urban-scale heat and noise. *Building and Environment.* (in preparation)

Mahmoud Abdelrahman, Edgardo Macatulad, **Binyu Lei**, Matias Quintana, Clayton Miller, and Filip Biljecki, 2024. What is a Digital Twin Anyway? Deriving the Definition for the Built Environment from over 15,000 Scientific Publications. *Building and Environment.* (submitted)

Binyu Lei, Pengyuan Liu, Xiucheng Liang, and Filip Biljecki, 2024. Developing the Urban Comfort Index: Advancing liveability analytics with a multidimensional approach and explainable artificial intelligence. *Sustainable Cities and Society.* (under review)

Pengyuan Liu, Winston Yap, Yujun Hou, **Binyu Lei**, Rudi Stouffs and Filip Biljecki, 2024. Sensing Urban Traffic: A Graph-based Human-centred GeoAI Approach for Traffic Accident Forecasting. *Accident Analysis & Prevention.* (under review).

Pengyuan Liu, **Binyu Lei**, Weiming Huang, Filip Biljecki, Yuan Wang, Siyu Li, and Rudi Stouffs, 2024. Sensing Climate Justice: A Multi-Hyper Graph Approach for Classifying Urban Heat and Flood Vulnerability through Street View Imagery. *Sustainable Cities and Society.* (under review)

CONFERENCE PUBLICATIONS

Binyu Lei, Xiucheng Liang, and Filip Biljecki. "Integrating human perception in 3D city models and urban digital twins." *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences* 10 (2024): 211-218. DOI: https://doi.org/10.5194/isprs-annals-X-4-W5-2024-211-2024

Binyu Lei, Yunlei Su, and Filip Biljecki. "Humans As Sensors in Urban Digital Twins." In *International 3D GeoInfo Conference*, pp. 693-706. Cham: Springer Nature Switzerland, 2023. DOI: https://link.springer.com/chapter/10.1007/978-3-031-43699-4_42

— Best paper award

INDUSTRY WORK EXPERIENCE

Urban Planning & Design Institute of Shenzhen (UPDIS)   Sep. 2019—Jan. 2021
Urban Planner

- Led the project "The Fourteenth Five-Year Plan in Wuchang District", focusing on comprehensive development in 5 years with a current population scale of 901,026 people, identified local demographic issues to ongoing debates about labour migration; mapped provision of community centres, green space, and public transport in Wuchang with ArcGIS; evaluated coverage area of public infrastructure and regional connectivity
- Contributed to the project "Night-Time Economy Plan in Harbin", focused on the development of the night economy with a population scale of 10 million people; identified the significance of night-time transport under consideration of transport strategies developed for the night-time economy in China, including policies and approaches; used ArcGIS to evaluate traffic accessibility of transport services provision

TALKS AND KEYNOTES

The 19th International 3DGeoInfo Conference 2024   Jul. 2024
Presenter

- Talk title: Integrating Human Perception in 3D City Models and Urban Digital Twins
- Organised by University of Vigo, Spain

The 128th Open Geospatial Consortium Meeting (OGC)   Mar. 2024
Invited speaker

- Talk title: Humans as Sensors in Urban Digital Twins
- Organised by Open Geospatial Consortium, TU Delft, the Netherlands

The 18th International 3DGeoInfo Conference 2023   Sep. 2023
Presenter

- Talk title: Humans as Sensors in Urban Digital Twins
- Organised by Technical University of Munich, Germany

London Data Week   Jul. 2023
Invited Keynote

- Talk title: Understanding Urban Data and Digital Twins in Cities, Centre for Urban Science and Progress
- Organised by the Centre for Urban Science and Progress (CUSP), King's College London

The 124th Open Geospatial Consortium Meeting (OGC)   Oct. 2022
Invited speaker

- Talk title: Understanding Challenges to Urban Digital Twins
- Organised by Open Geospatial Consortium, Lifelong Learning Institute, Singapore

NUS-SUTD PhD Symposium in Architecture   May. 2022
Presenter

- Talk title: Understanding 3D City Models and Digital Twins
- Organised by National University of Singapore and Singapore University of Technology and Design, Singapore

The 122th Open Geospatial Consortium Meeting (OGC) Mar. 2022
Invited speaker

- Talk title: Assessing and Benchmarking 3D City Models
- Organised by Open Geospatial Consortium, Virtual Event

HONOURS AND AWARDS

- 3D GeoInfo Best Paper Award (2023)
- Department of Architecture Travel Award, National University of Singapore (2024)

TEACHING AND SERVICE

Co-Supervising 2022—Present

- Yunlei Su (Master student of the Department of Geography, National University of Singapore)
- Stella Morgenstern (Research intern with a bachelor's degree in urban planning at HafenCity University Hamburg, Germany)

Grants and funding proposals 2023—Present

- NUS HSS seed fund (2/2023): drafted the grant proposal applying for NUS HSS seed fund, which was approved in November 2023 and awarded SGD$40,000
- MOE Academic Research Fund Tier 2 Singapore: drafted the whitepaper applying for MOE Tier 2 ARC 2/2025 call, waiting for the results

Teaching Assistant 2023—Present

- Methods and Tools for Urban Design (UD5625), a compulsory course for Master of Arts in Urban Design at Department of Architecture at National University of Sinagpore

Reviewer International Journals 2022—Present

- Cities
- International Journal of Geographical Information Science
- Automation in Construction
- Energy & Buildings
- Resources, Conservation & Recycling
- Building Simulation

Memberships / Societies 2021—Present

- Open Geospatial Consortium, 3D Information Management (3DIM) Domain Working Group
- International Society for Photogrammetry and Remote Sensing Individual Membership

Volunteering 2020—Present

- Social Media Account: Citypedia, contributed to sharing the latest urban studies in the community, organised Jane's Walk in Singapore 2024

TECHNICAL SKILLS AND LANGUAGES

Programming languages: Python, R, Java; GIS software: QGIS, 3dfier; Design software: Adobe Illustrator, Photoshop; Documentation: LaTeX, Markdown; Web development: HTML, Javascript; English: Fluent; Chinese: Native