Smart GEO Expo 2023
2023 스마트국토엑스포

2023 ICGIS

International Conference on Geospatial Information Science

Geosimulation for Better Life

KRIHS 국토연구원

CONTENTS

Smart GEO Expo 2023
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2023 ICGIS International Conference on Geospatial Information Science

Pre-registration
http://www.icgis2023.com

Geosimulation for Better Life

더 나은 삶을 위한 Geo시뮬레이션의 활용과 도전

Nov, 9 (THU), 2023, 12:30 - 17:00

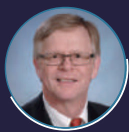
Conference Room 401, KINTEX 2 (4F), Goyang-si

Program

Time	Content
12:30~13:00	Registration
13:00~13:05	Opening Remarks
13:05~13:40	Keynote Speech
13:05~13:40	Geo AI - The New Frontier in Health Systems Modeling Geo AI - 의료 시스템 모델링의 새로운 지평 Jean-Claude Thill Distinguished Professor, University of North Carolina at Charlotte
13:40~14:00	Coffee break
14:00~15:50	Invited Talk
14:00~14:25	Research for DXing municipal decision making using urban spatial information and AI to realize a better life 더 나은 삶을 구현하기 위해 도시공간정보와 AI를 활용한 DXing 도시 의사결정 연구 Yuki Akiyama Associate Professor, Tokyo City University
14:25~14:50	Advancing urban modelling with emerging geospatial datasets and AI 새로운 지리공간 데이터 세트와 AI를 통한 도시 모델링 발전 Filip Biljecki Assistant Professor, National University of Singapore
14:50~15:10	Addressing Urban Complexity with AI Toward Sustainable City Future 지속 가능한 도시의 미래를 위해 AI로 도시 복잡성 해결 Steven Jige Quan Associate Professor, Seoul National University
15:10~15:30	A Simulation of Urban Population Movement by Agent Based-Modeling Methodology and Sejong City Policy Application 에이전트 기반 모델링 방법론에 의한 도시 인구 이동 시뮬레이션 및 세종시 정책 적용 사례 Yung Joon Jung Director, ETRI
15:30~15:50	The Future of Urban AI: Implementations and challenges 도시 AI의 미래: 구현과 도전 과제 Sewon Lee Associate Research Fellow, KRIHS
15:50~16:00	Coffee break
16:00~17:00	Panel Discussion

Speakers

Keynote


Jean-Claude Thill
University of North Carolina at Charlotte


Yuki Akiyama
Tokyo City University


Filip Biljecki
National University of Singapore


Steven Jige Quan
Seoul National University


Yung Joon Jung
ETRI


Sewon Lee
KRIHS

Panels

Moderator


Chulmin Jun
University of Seoul


Daejong Kim
KRIHS


Taeyoung Kim
AIFactory


Dae Sup Lee
Ministry of Land, Infrastructure and Transport


Bogyeong Mun
The Electronic Times

KRIHS 국토연구원

KEYNOTE SPEECH

Jean-Claude Thill

jean-claude.thill@charlotte.edu
University of North Carolina at Charlotte

Keynote Speech

Geo AI- The New Frontier in Health Systems Modeling

Geospatial Artificial Intelligence (GeoAI) has emerged over the past few years as a significant spatial analytical framework for data-intensive GIScience. It stands at the intersection of artificial intelligence and machine learning on the one hand, and geospatial thinking and spatial analysis on the other hand. This talk discusses some of the recent trends in this respect and addresses the contribution of GeoAI to the study of infectious disease transmission and human health conditions. It is argued that GeoAI makes a considerable contribution to the understanding and prediction of the spatio-temporal dynamics of a disease across population. Three related studies at the cutting edge of research in this area are presented to demonstrate the transformational nature of the contribution made by GeoAI in health systems modeling.

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CHARLOTTE
SCHOOL OF DATA SCIENCE

GeoAI – The New Frontier in Health Systems Modeling

Jean-Claude Thill, Ph.D.

Knight Distinguished Professor

Contents

Geo + AI

- GeoAI, aka Geospatial Artificial Intelligence
- Geospatial studies using analytical approaches of artificial intelligence
  - Spatially explicit
  - Artificial intelligence (AI)
    - Any technique that enables computers to mimic human intelligence (using logic, if-then rules, decision trees…)
    - Machine learning is often seen as a part of AI
- What is behind the plethora of terms: GIS, GIScience, Geoinformatics, GIS&T, spatial analysis, geocomputation, geospatial analytics…. and GeoAI

Geo + AI

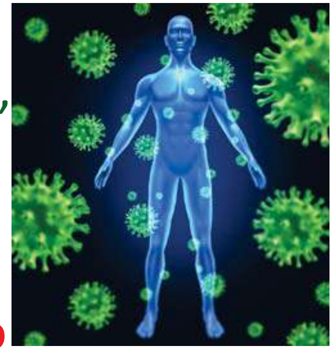
- How new is GeoAI?
  - Not clear who coined the term
  - Old wine in a new bottle?
    - Spatial analysis is one of the pillars of GIScience (UCGIS)
    - Spatial analysis as well as other themes of GIScience (accuracy, multiscalarity, generalization, spatial cognition, ontology, etc) have used AI principles since the 1980s
      - Spatial heuristics
      - Fuzzy sets theory
      - Spatial decision support systems
    - On the other hand, new conceptual and technical developments in AI, ML, etc
      - HPC, GPU
      - In data analytical methods: from Artificial Neural Nets (ANN) to Convolutional NN (CNN)
      - From deductive to abductive approach to scientific knowledge creation
      - ML as extension of spatial econometrics
- GeoAI is more than incremental, more akin to the onset of GIScience from the ashes of computer mapping

Geo + AI

- Adept at overcoming challenges of geospatial data research
  - Data volume
  - Data non-normality
  - Non-linearity
  - Data uncertainty
  - Data variety (structured and unstructured)
  - Data generalization and classification (feature extraction through iterative learning)
  - Dichotomy between exploratory and confirmatory

Health Systems Modeling

- Population health is a critical area of contemporary research
  - Aging and aspiration for greater life longevity
  - Infectious diseases (aka communicable diseases) are multiscalar (cell, organ, human body, communities)
  - They are spatial and relational
  - They are temporally dynamic
  - Tied to outbreaks, which make them events and conditions harder to predict
- Prediction of the dynamics of infectious diseases is “wicked”
  - Covid-19 pandemic
  - Flu, RSV, dengue, norovirus, …



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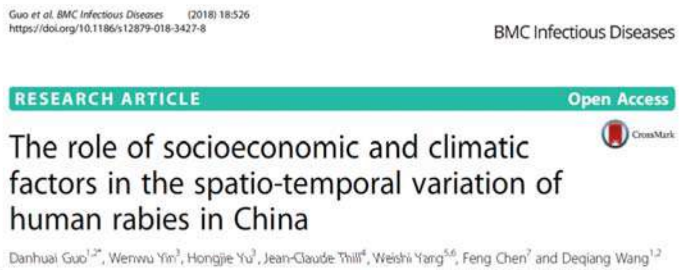
Health Systems Modeling

- Three main groups of spatio-temporal analyses of infectious diseases:
  - Ecological modeling
    - Aggregated, incidence rates: Disease clusters & hotspots
    - Usually econometric, not GeoAI


Guo et al. BMC Infectious Diseases (2018) 18:526
https://doi.org/10.1186/s12879-018-3427-8

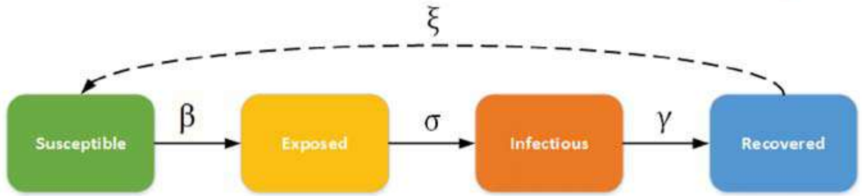
BMC Infectious Diseases

RESEARCH ARTICLE Open Access

The role of socioeconomic and climatic factors in the spatio-temporal variation of human rabies in China

Danhuai Guo[1,2*], Wenwu Yin[3], Hongjie Yu[3], Jean-Claude Thill[4], Weishi Yang[5,6], Feng Chen[7] and Deqiang Wang[1,2]

  - Mechanistic models
    - SEIR (compartmental) models
    - Ordinary differential equations, etc
    - 70% of Covid-19 predictive models are SEIR models



  - Machine learning

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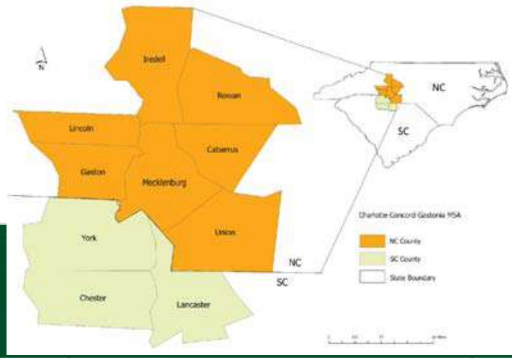
Study I - Spatial SEIR Model

- Variant of SEIR with spatially explicit components
- Spatial system of multiple zones (10 counties in a metropolitan region)
- Spatial elements:
  - Exposure probabilities (transition from S to E) depend on
    - local exposure-related covariates (mobility, vaccinations, population demographics, non-pharma interventions, weather, political leaning), either time invariant (spatial heterogeneity) or time variant (spatio-temporal heterogeneity)
    - Spatial weight structures
- Fitting on March 29, 2020 to March 13, 2021 and prediction on March 20-April 10, 2021
- Goodness of fit: RMSE



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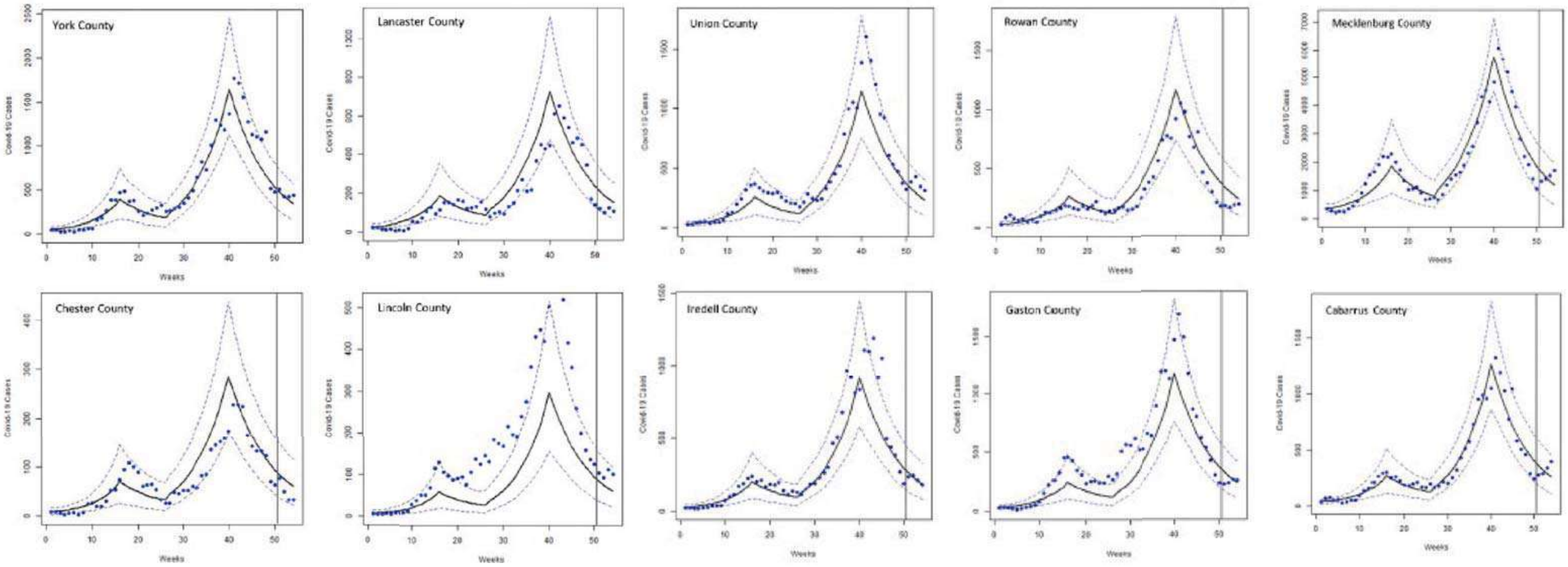
Study I - Spatial SEIR Model



Study I - Spatial SEIR Model

- RMSE shows good fit
- Fit varies across zones
- Our model outperforms RMSE of benchmark model:
  - CDC's Ensemble model is benchmark

County	Cabarrus	Gaston	Iredell	Lincoln	Mecklenburg	Rowan	Union	Chester	Lancaster	York
Spatial SEIR—Model 1	110	54	26	48	311	56	111	18	70	63
Spatial SEIR—Model 2	86	60	14	32	326	113	90	26	70	56
Spatial SEIR—Model 3	184	115	108	72	332	54	220	19	21	218
Ensemble	174	92	102	23	882	86	148	18	22	139

	Model 1	Model 2	Model 3	Ensemble
RMSE- average weighted by county population	172	177	224	440
RMSE- unweighted average	87	87	134	169

Study II – Deep Learning Predictions

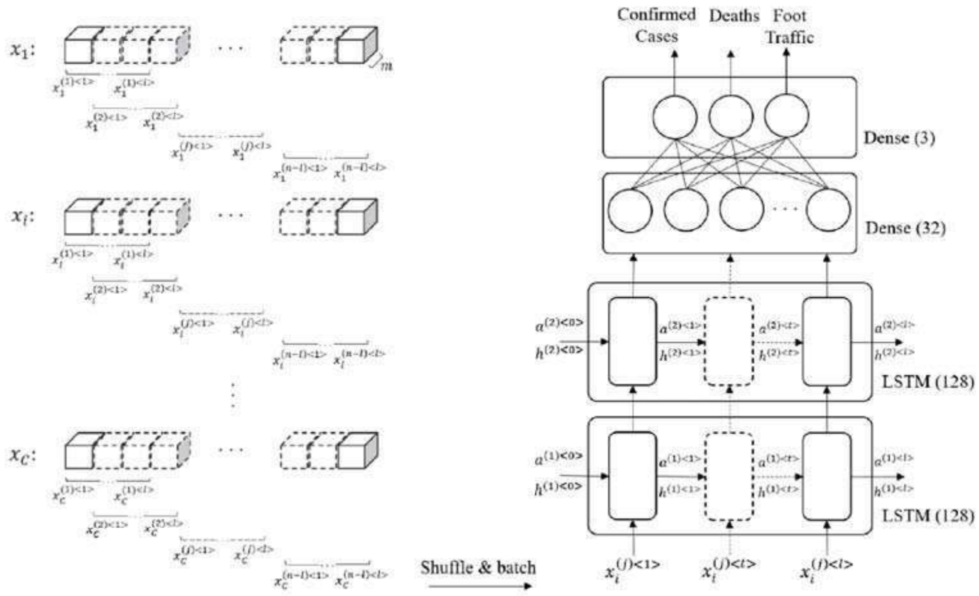
- Compartmental models have built-in rigidities
  - Hence the emergence of hybrid SEIR/ML models and pure ML models
- Spatio-temporal models yield better prediction (higher prediction accuracy and lower tendency to over- and under-fit than traditional compartmental or ML models
- Deep learning-based space-time Long Short-Term Memory (LSTM)
  - Multi-variate and multi-time series
  - Simultaneous forecast of confirmed cases, deaths, and mobility
  - Spatially disaggretated, allowing for spatial heterogeneity
  - LSTM, a recurrent neural network, excels at temporal dependence

Study II – Deep Learning Predictions

- Implementation at US county level (3,129)
  - 33 weeks of data (January 26 to September 12, 2020)
  - Outcomes: confirmed Covid-19 cases, deaths, foot traffic (SafeGraph)
  - Out-of-sample validation (70% for training, 30% for validation)
  - Time lag (window) of 3 weeks
  - Reported predictions 4 weeks ahead
  - RMSE statistics for goodness-of-fit

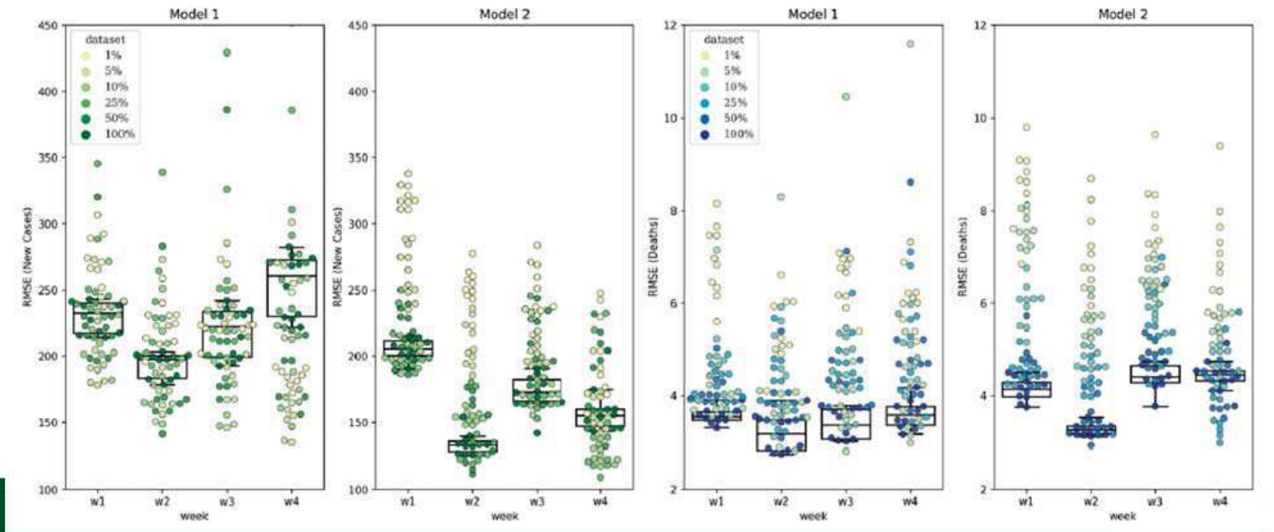
Study II – Deep Learning Predictions

- Implementation at US county level (3,129)
  - Experimentation with sampling among counties
  - Two LSTM layers of 128 neurons
  - A fully connected layer of 32 neurons



Study II – Deep Learning Predictions

- Various independent variables were not found to be influential:
  - Population density, race composition, educational attainment, etc
- Social contact / mobility is sole significant predictor of the dynamics
- Great predictive performance up to 4 weeks ahead



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Study II – Deep Learning Predictions

- Good predictive performance compared to CDC's Ensemble model

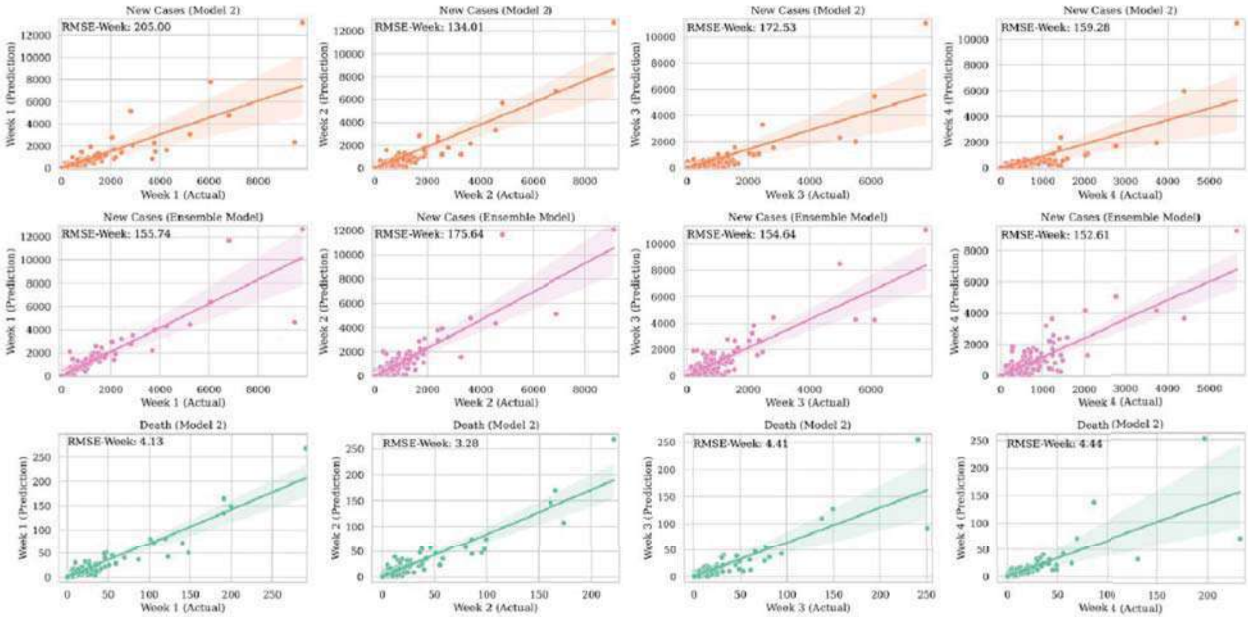
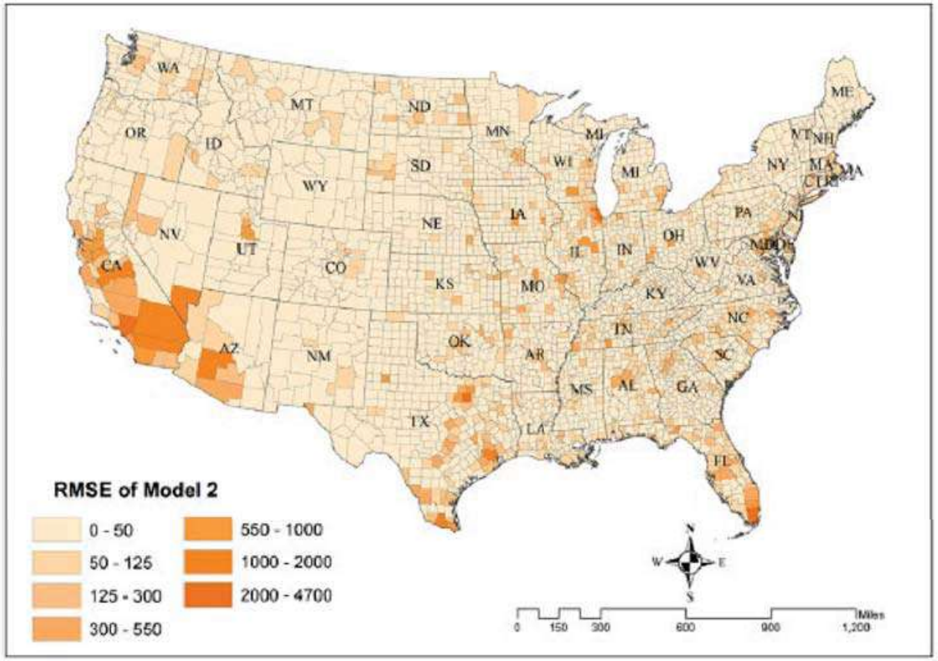
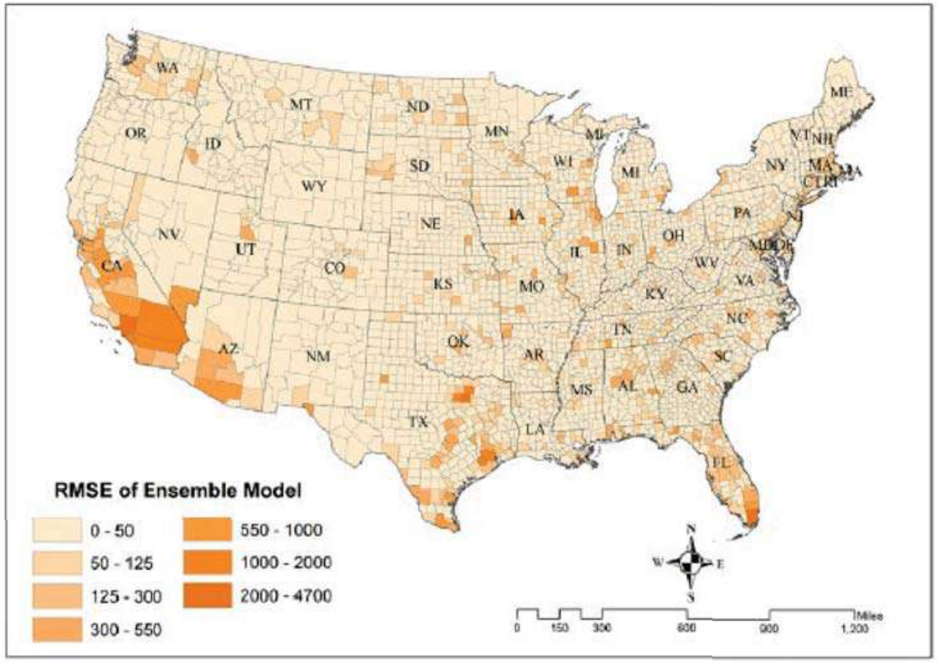


Figure 5. Predicted vs. real observations for new cases in Model 2 (top), new cases in ensemble model (middle), and deaths in Model 2.

Study II – Deep Learning Predictions

- LSTM vs CDC Ensemble Model, spatially





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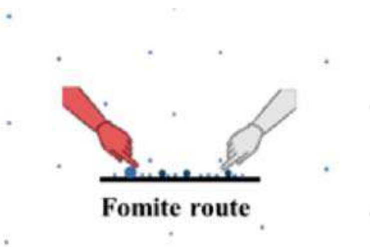
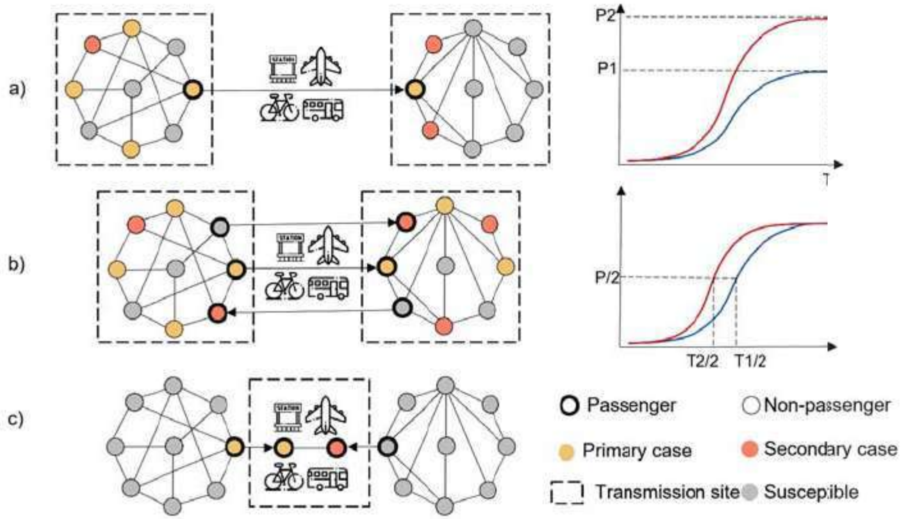
Study III – Spatial Agent-based Model

- LSTM and other deep learning models may be excellent for prediction, but they are ill-suited for *ex ante* planning and policy making
  - “Process-based” models fit this task better
- Given the role of geography in viral transmission (esp. mobility and transportation), are some modes of travel conduits for human-to-human viral spread?
  - During the COVID-19 pandemic, public rail and buses were under the spot light
- Micromobility: shared bikes and scooters
  - Role of surfaces (fomites)

Study III – Spatial Agent-based Model

- Role of public/shared transportation
  A. Introduction of pathogens to new area
  B. Acceleration of diffusion
  C. Becoming a disease vector
    - Transportation vehicle as active agents (C)
    - Explicit modeling of fomites





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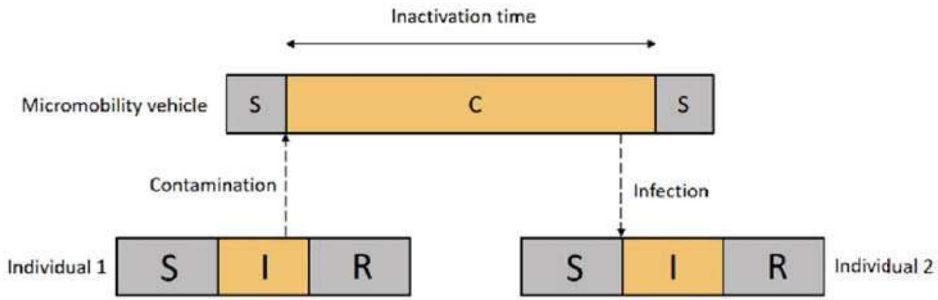
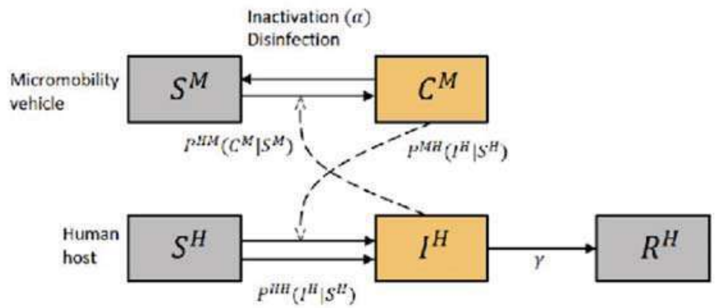
Study III – Spatial Agent-based Model

- Core model of disease transmission
  - MV contamination
  - Transmission in MVs
  - Infection of human riding MV
  - S[E]IR for human-to-human
- Of course, there is also transmission in baseline population





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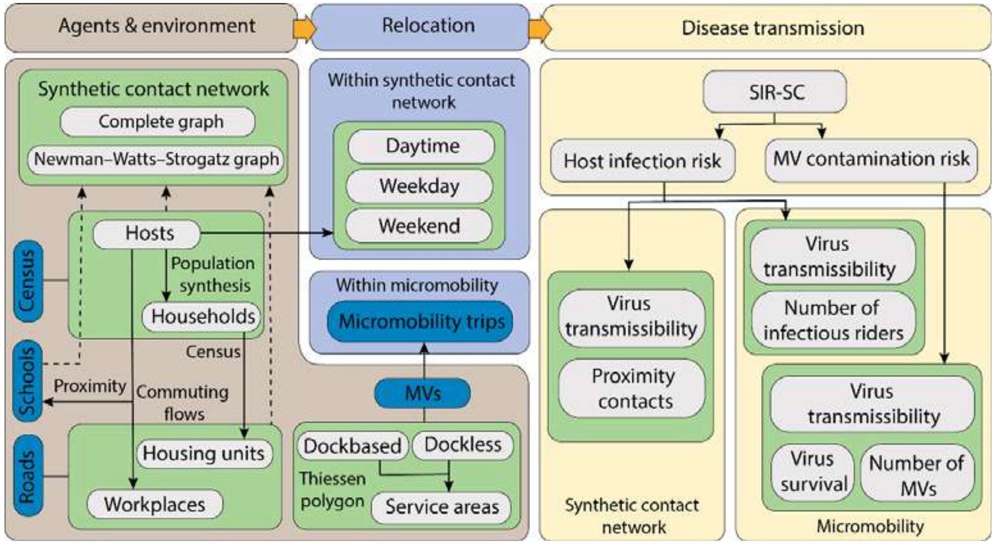
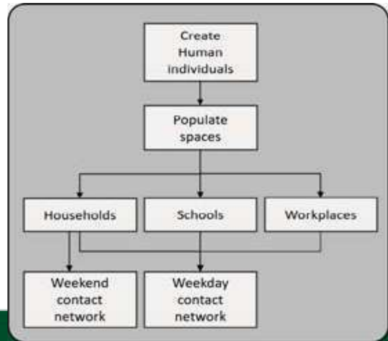
Study III – Spatial Agent-based Model

- Modular simulation system
  - Based on actual population and micromobility data
  - Disease transmission (SIR-SC)
    - Micromobility based
    - Baseline population
      - Contact networks
  - Actual microlevel micromobility data
  - A synthetic population of agents
    - Microlevel
    - Fitted to small area census data
    - Spatially disaggregated
    - Contact networks
    - Assigning people to work places
    - Assigning people to micromobility trips
    - Assigning people to housing units





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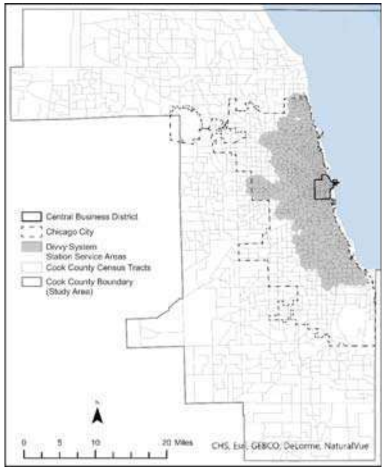
Study III – Spatial Agent-based Model

- Programming and Software
  - Python coding
  - Graph-tool and Networkx packages
  - ArcGIS 2.8
- Scenarios implemented on Orion, general use Slurm partition on a Redhat Linux based HPC
- Case study
  - Cook County, Illinois
  - Study period: June-July 2018
  - Population: 5,194,675 (2,746,388 live in the City of Chicago)
  - Chicago City public bikesharing system: Divvy (since 2013)
    - One of the largest station based shared bike systems in US
    - 595 stations; 5874 Bikes; more than 3.5 million trips each year
    - Includes demographic information (age and gender) of users



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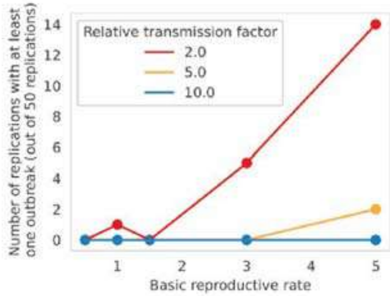
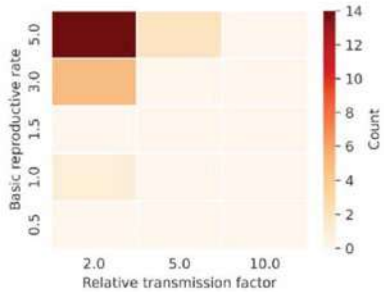
Study III – Spatial Agent-based Model

- Emergence of a viral disease through micromobility
  - Initial conditions
    - No infectious individual
    - A single contaminated bike (located in CBD)
  - Count of the number of outbreaks (at least one other infected person) in 30-day period
    - 50 replications in the simulator
    - Even with small R0 values, outbreaks are possible
    - Up to 14 out of 50 outbreaks (28%)
    - Micromobility to start a major viral event





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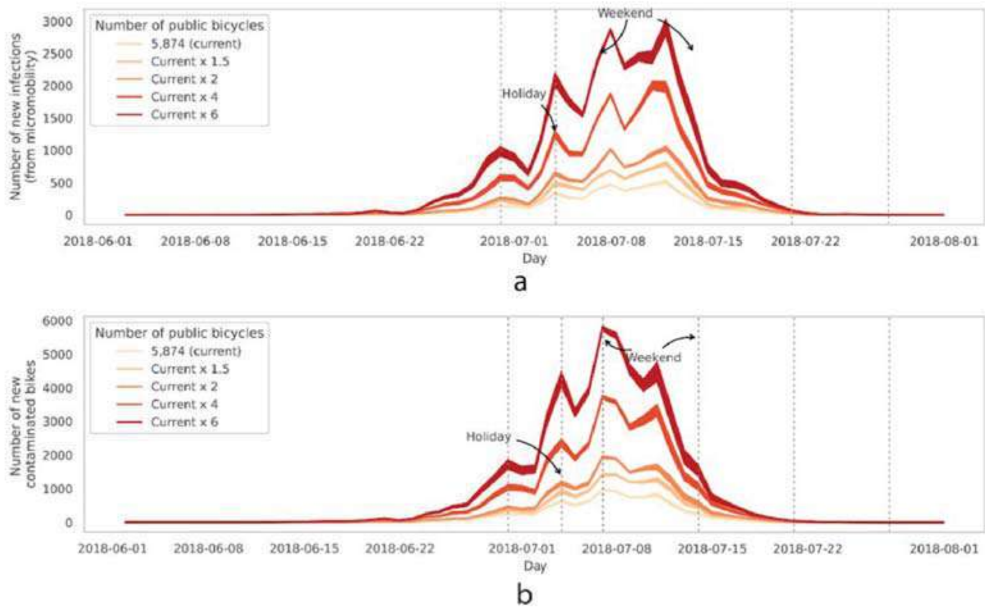
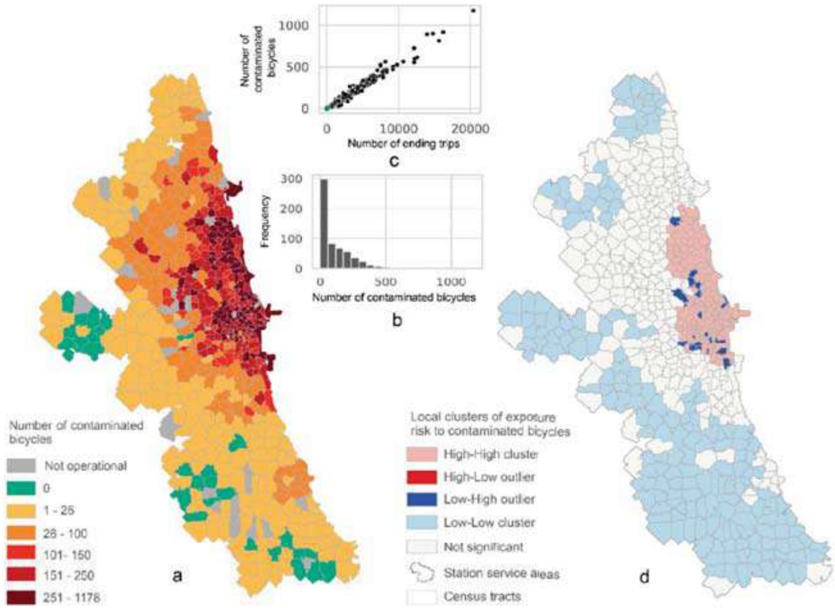
Study III – Spatial Agent-based Model

- Dynamics of a viral disease through micromobility
    - Under various scenarios, micromobility does not significantly affect viral disease dynamics



Study III – Spatial Agent-based Model

- Risk exposure to a viral disease in micromobility
    - Initial conditions: 100 randomly selected infectious individuals
    - 50 simulation replications
    - Tracked cumulative infections
    - A small number of stations have a high exposure
    - Strong spatial pattern in exposure risk (hot spots and cold spots)



In Guise of Conclusion

- GeoAI is part of the natural evolution of GIScience
  - Greater analytical capability
  - Leveraging microlevel data
  - Leveraging computational innovations
- In study of infectious diseases, GeoAI is making a breakthrough
  - Spatio-temporal dynamics is better understood, better predicted
- Through 3 studies, I have shared my own experiences with modeling frameworks with various levels of innovations in spatially explicit GeoAI
  - Two distinctive assets are external validity and knowledge discover through scenario simulation

GeoAI – The New Frontier in Health Systems Modeling

Jean-Claude Thill, Ph.D.

Jean-Claude.Thill@charlotte.edu

Collaborators: Behnam Nikparvar, Faizeh Hatami, Md. Mokhlesur Rahman, Rajib Paul, Shi Chen

INVITED TALK

Yuki Akiyama

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Tokyo City University

Research for DXing municipal decision making using urban spatial information and AI to realize a better life

Research for DXing Municipal Decision Making Using Urban Spatial Information and AI to Realize a Better Life

ICGIS 2023 @KINTEX
Nov. 09, 2023

Yuki AKIYAMA, Ph.D.
Associate Professor
Department of Urban and Civil Engineering,
Faculty of Architecture and Urban, Tokyo City University (TCU)

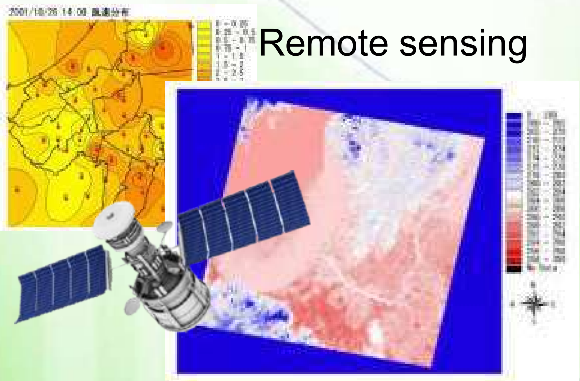
Self Introduction

Name : Yuki AKIYAMA (秋山祐樹)

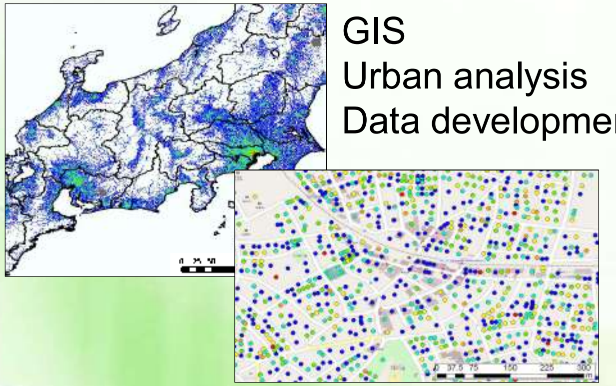
Birthplace : Okayama city, Okayama pref. Japan

Affiliation : Associate Professor
Department of Urban and Civil Engineering
Faculty of Architecture and Urban,
Tokyo City University (TCU)

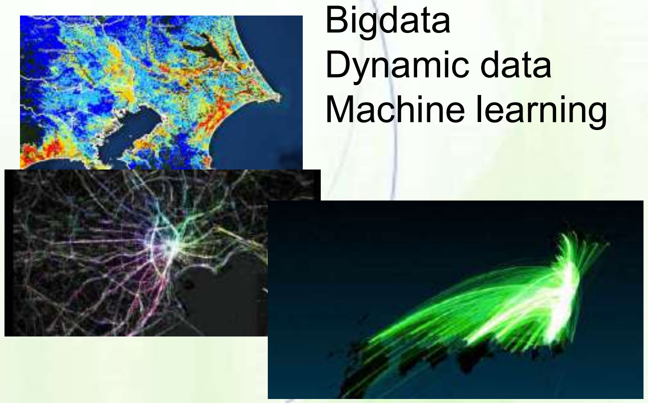
Main fields: Spatial information Science, Urban engineering
Urban Geography, Transportation engineering



Remote sensing



GIS
Urban analysis
Data development



Bigdata
Dynamic data
Machine learning

Self Introduction

Name : Yuki AKIYAMA (秋山祐樹)

Birthplace : Okayama city, Okayama pref. Japan

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Department of Urban and Civil Engineering,
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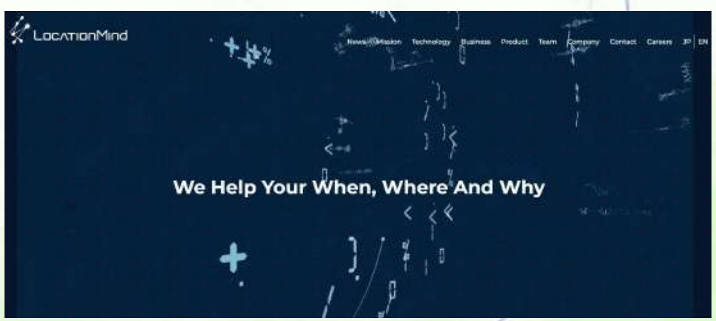
Visiting Associate Professor, Reitaku Uni
Visiting Researcher, CSIS, The Univ. of Tokyo

Technical advisor, Microbase Co. ltd.
Council, LocationMind Inc.

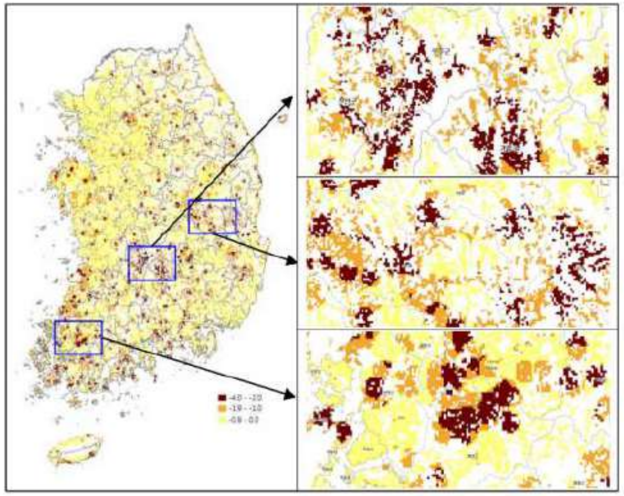
https://www.microgeo.biz/



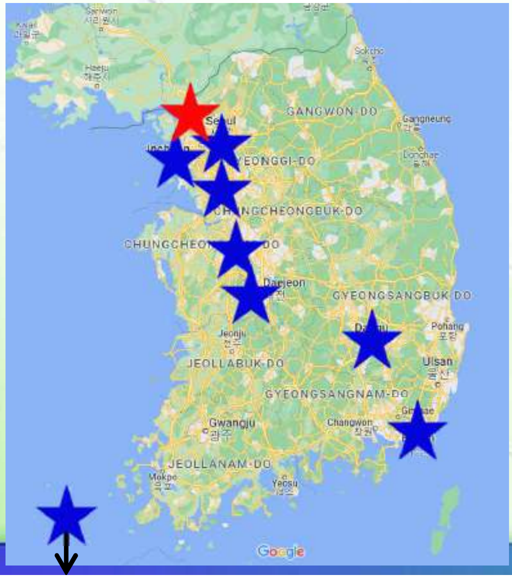
https://locationmind.com/

My experiences of Korea

Visiting researcher in KRIHS (2015-2017)



Join many conferences and seminars



Seoul (So many times!)
Busan
Daegu
Inchon
Sejong
Daejeog
Jeju
Goyang New!!

Outline

1. Brief Introduction of My Research Activities

2. Introduction of Research Using Urban Spatial Information and AI for DXing Municipal Decision Making

3. The Potential of Urban Spatial Information and AI for DXing Municipal Decision Making

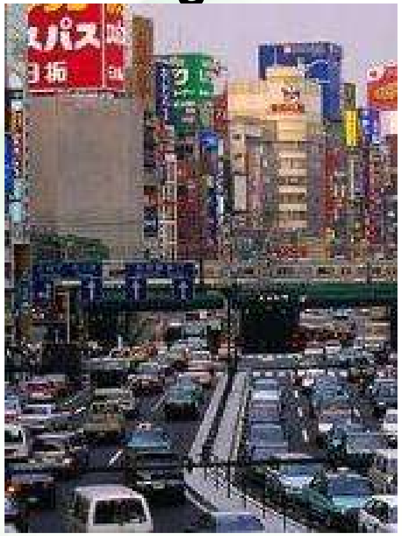
Background

Many problems in urban area

Decline of city center

Aging

Traffic management



Disaster prevention

Environmental problems

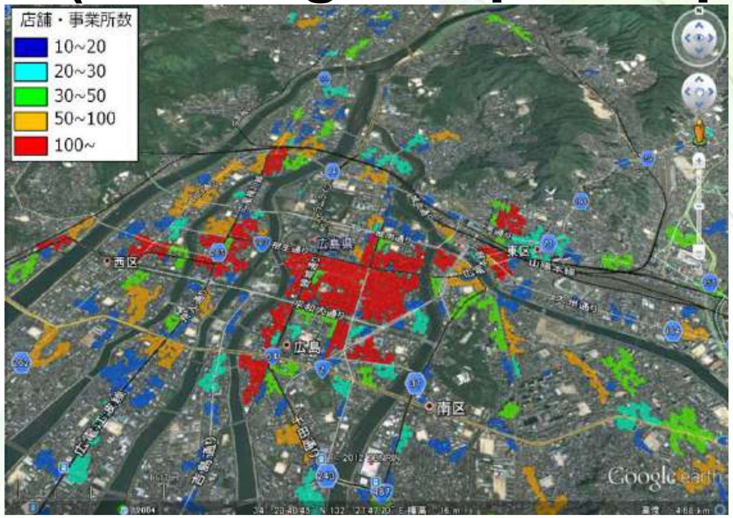
Various kind of geospatial data and census can support to solve them.

Design urban planning to realize smart city and society

Various spatial big data in Japan

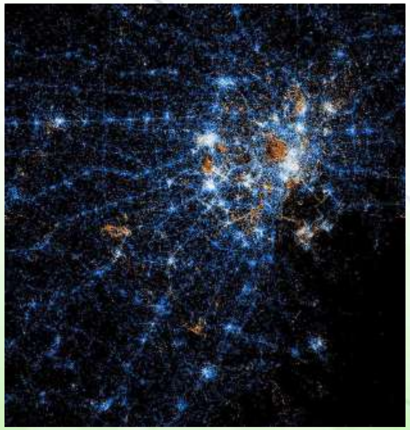
Various spatial data (Building, shop, company etc.)

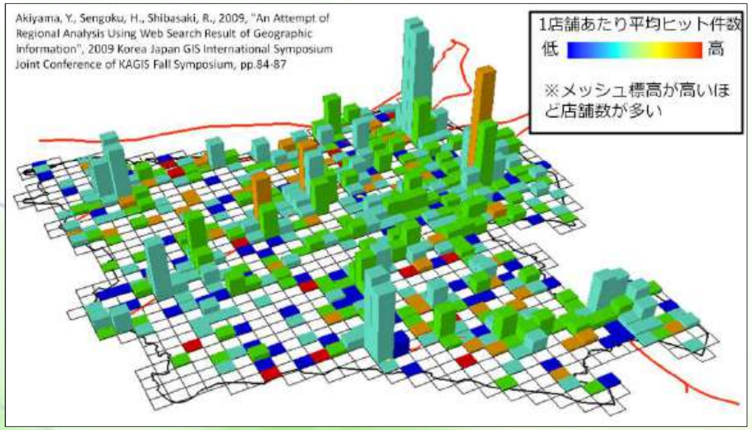
Digital map,
telephone directory



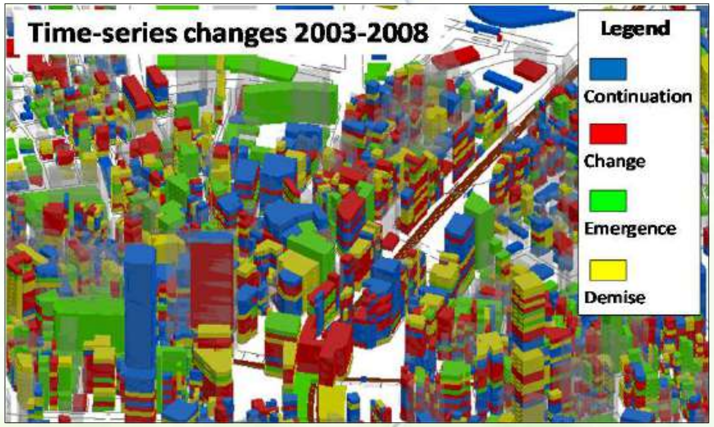
Commercial accumulation
statistics

B-B transaction bigdata





Web information
(SNS with geotag, search results etc.)



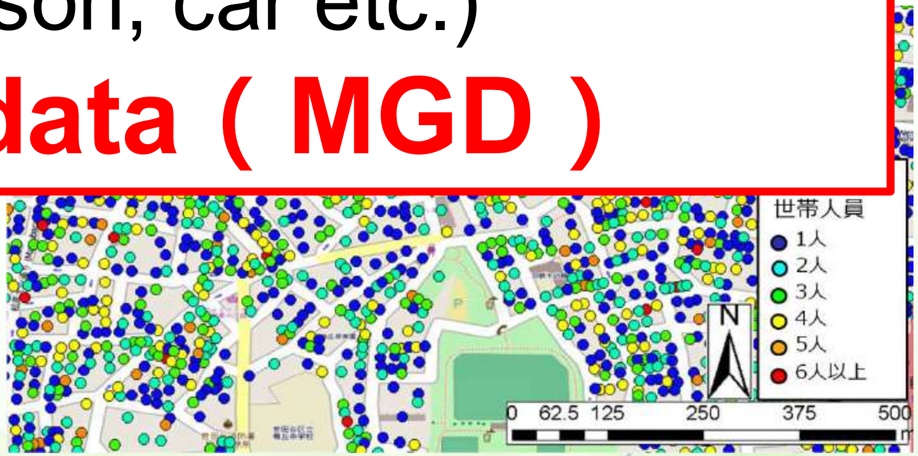
Time-series data

Various spatial big data in Japan

Various spatial data (Person location and flow)

High resolution geospatial data
which can monitor each POI
(building, person, car etc.)
= Micro Geodata（MGD）

Estimated person flow data
Based on SNS locations

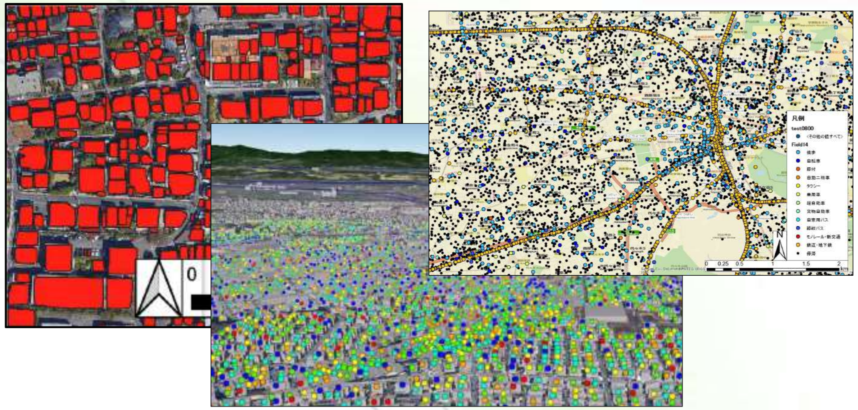


Micro population census

Research strategy of our lab

Micro Geodata（MGD）

Micro data with location and time information



Spatial bigdata, Satellite image, Census

Municipal owned data + Field survey

Open data + Basic Resident Register, Building registration data, Water supply data etc.

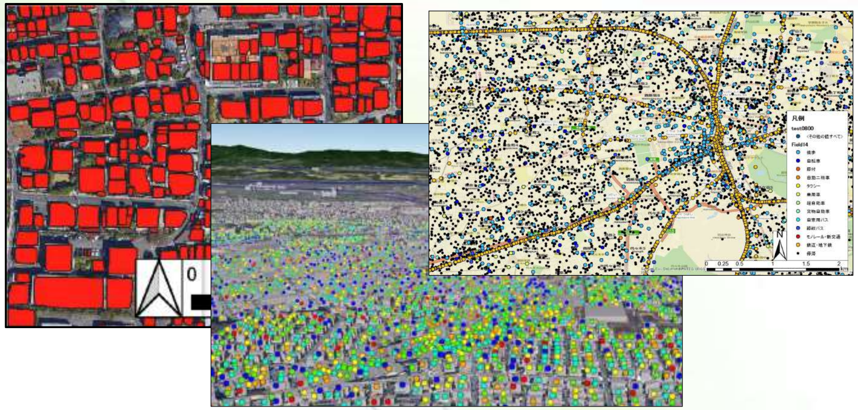
GIS ＋ **Statistical analysis**
AI
Visualization
Data development

Finding and resolution of Urban problems and their support

Research strategy of our lab

Micro Geodata（MGD）

Micro data with location and time information



Spatial bigdata, Satellite image, Census

Municipal owned data + Field survey

Open data＋Basic Resident Register, Building registration data, Water supply data etc.

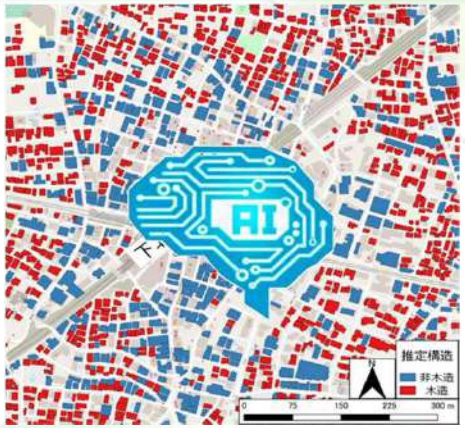
USIS LAB

URBAN SPATIAL INFORMATION LABORATORY

Urban Spatial Information Science Laboratory (USIS LAB)

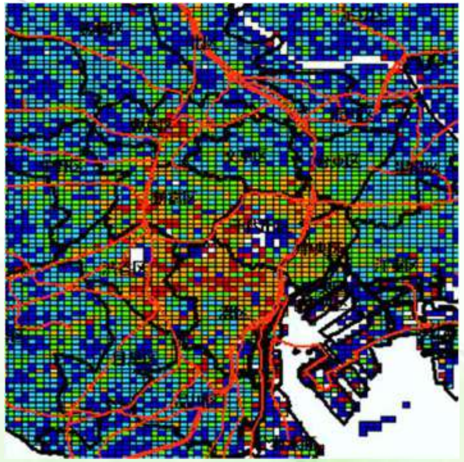
Main research topics of our lab

⊖ Traffic analysis using human flow big data



⊜ AI-based Estimation of various building attributes

⊛ Development of estimating method for the distribution of vacant houses using municipal owned data



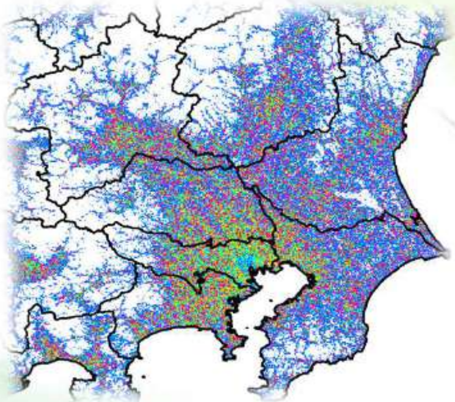
④ Time-series transition analysis of stores and establishments using digital telephone directories

⑤ Developing global micro-population data using satellite imagery and AI

⑥ Photovoltaic potential analysis using 3D urban model (PLATEAU)

Main research topics of our lab

⑦ Monitoring of underutilized real estate by drone



⑧ Economic impact analysis of Covid-19 using person flow big data

⑨ Development of AI-based automatic detection method for suitable development sites

Please visit our website!
(Joint research is always welcome!)

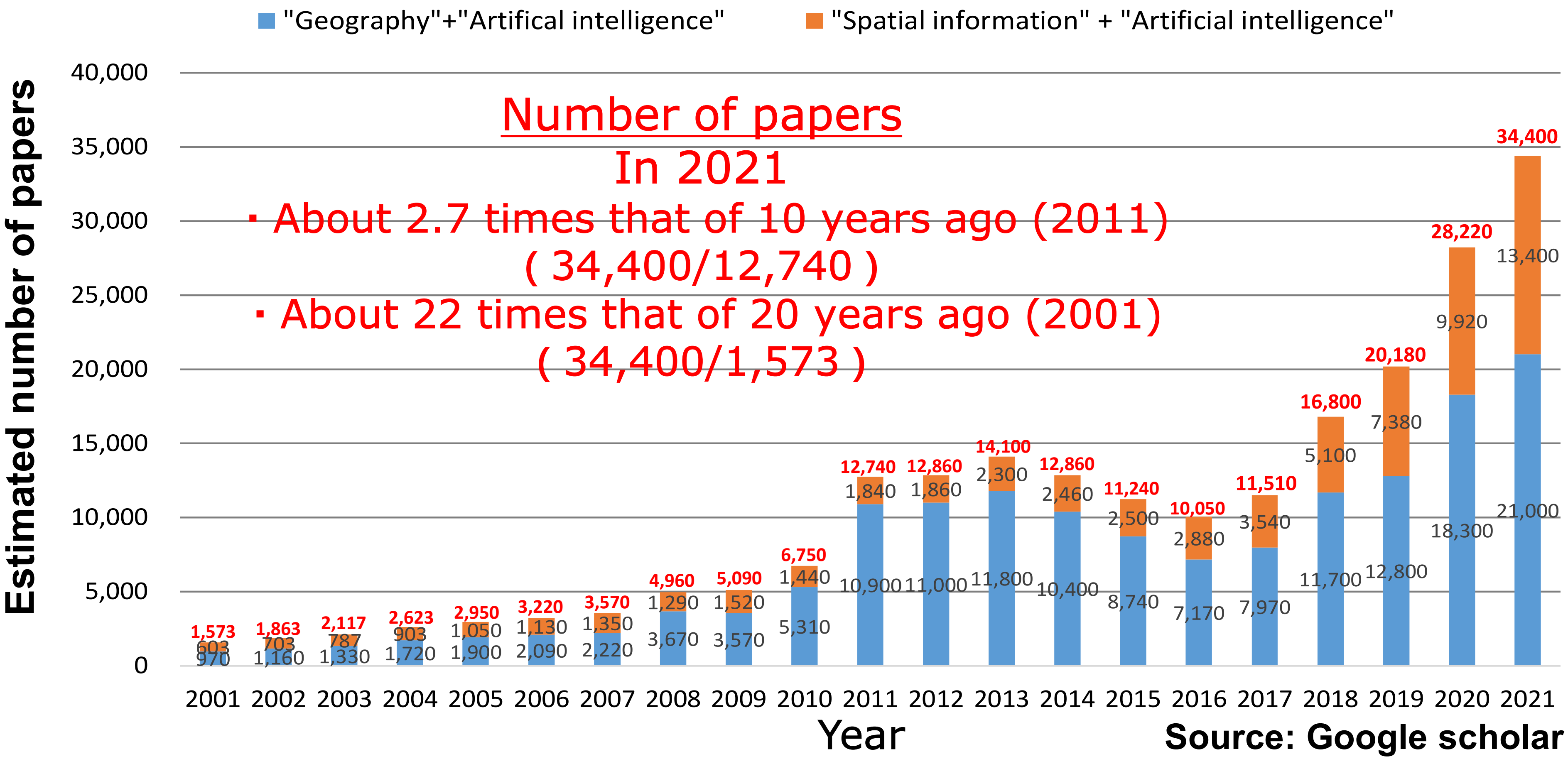
Akiyama lab at TCU
(USIS LAB)
https://usis.jp/

USIS LAB
URBAN SPATIAL INFORMATION LABORATORY

Yuki AKIYAMA website
https://akiyama-lab.jp/yuki/

YUKI AKIYAMA

Time-series changes in the number of papers that include “Spatial information science” of “Geography” and "Big data" in the title or text



Studies on geospatial information science and AI have a significant academic and international impact.

Outline

1. **Brief Introduction of My Research Activities**
2. **Introduction of Research Using Urban Spatial Information and AI for DXing Municipal Decision Making**
3. **The Potential of Urban Spatial Information and AI for DXing Municipal Decision Making**

Outline

2. Introduction of Research Using Urban Spatial Information and AI for DXing Municipal Decision Making

ｉ）Estimating the distribution of vacant houses using municipal data and AI (Domestic)

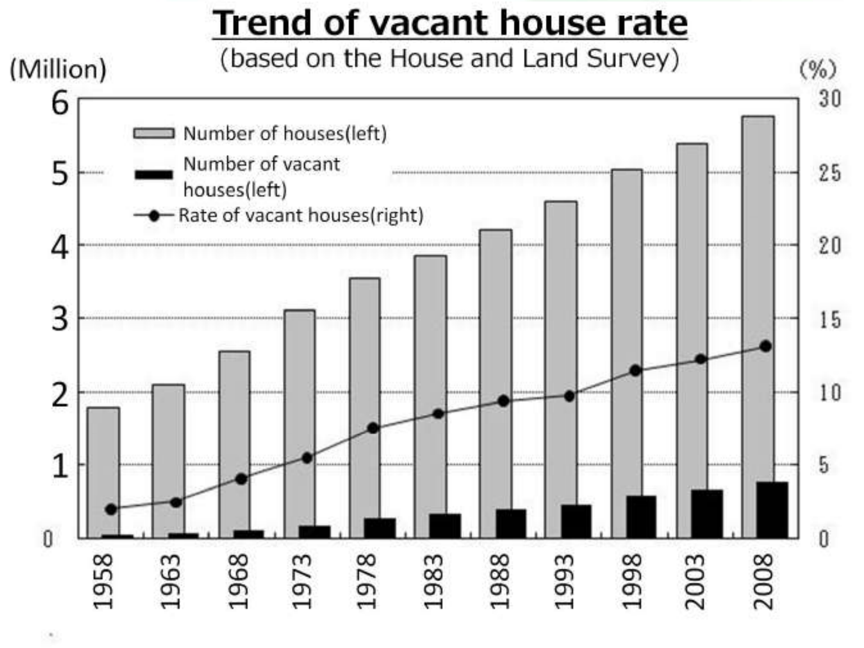
ｉｉ）Developing micro population data to support urban development in developing countries (International)

ⅰ) Estimating the distribution of vacant houses using municipal data and AI

One of the most serious and urgent problem for Japanese local government is **increasing vacant house**.

An increase of vacant houses will have a negative impact on the entire region (e.g. disaster prevention and crime prevention obstacles, lower tax revenue, deterioration of the landscape)

Japanese government requires local governments to survey vacant houses (2016~)



Local governments need a method to survey vacant houses.

i) Estimating the distribution of vacant houses using municipal data and AI

Basically, monitoring method
for spatial distribution of vacant house is

Field survey (visual inspection)

Field survey in board area (whole municipal area) needs

Many time!

Large amount of labor!

Large cost!

Three problems for municipalities in surveying vacant houses by the field survey

(Based on interviews with several local governments)

⊖Cost

Expenses for outsourcing
(In case of Maebashi City: about 100,000 surveys)

<u>About 13 million Yen</u>
(≒85,000 USD)
(≒120 million ₩)

⊜Time

Field survey period
= About 1.5 years
↓
Organize survey results by research firm
= About 0.5 years
↓
<u>Over 2 years</u>

⊛Judge

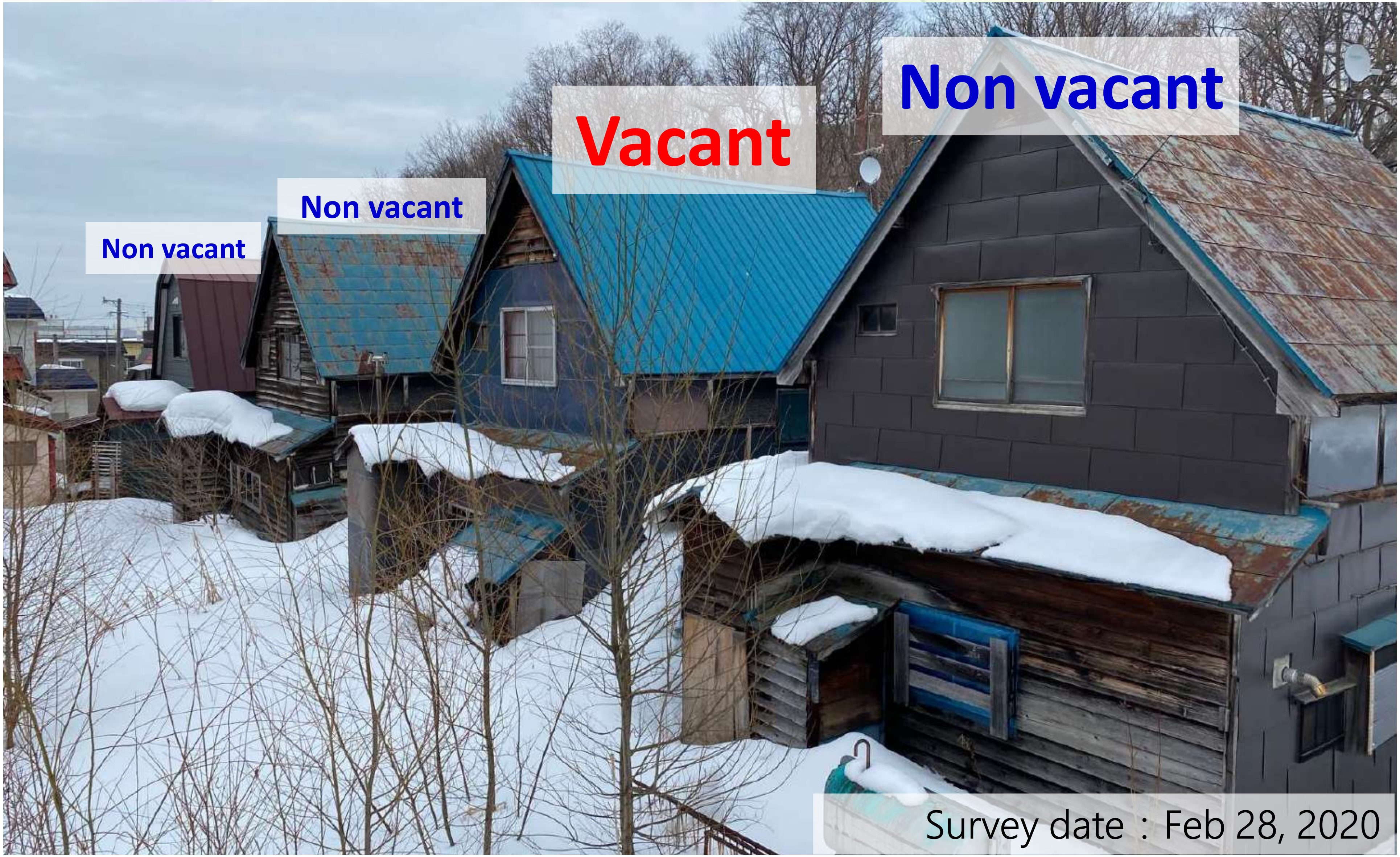
It is difficult to judge from the outside.

There is a bias in the results depending on the surveyor.

<u>Variation of results</u>

Let's try visual inspection of vacant house!

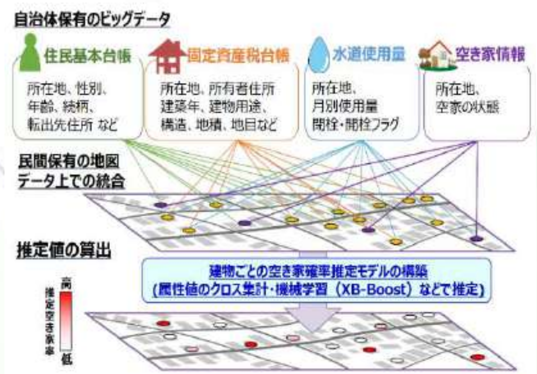
Let’s try visual inspection of vacant house!



ⅰ) Estimating the distribution of vacant houses using municipal data and AI

Development of methods for estimating the spatial distribution of vacant houses to reduce the burden of field survey by municipalities

⊖ Using municipal data and AI



⊜ Using building image and AI

⊛ Using drones

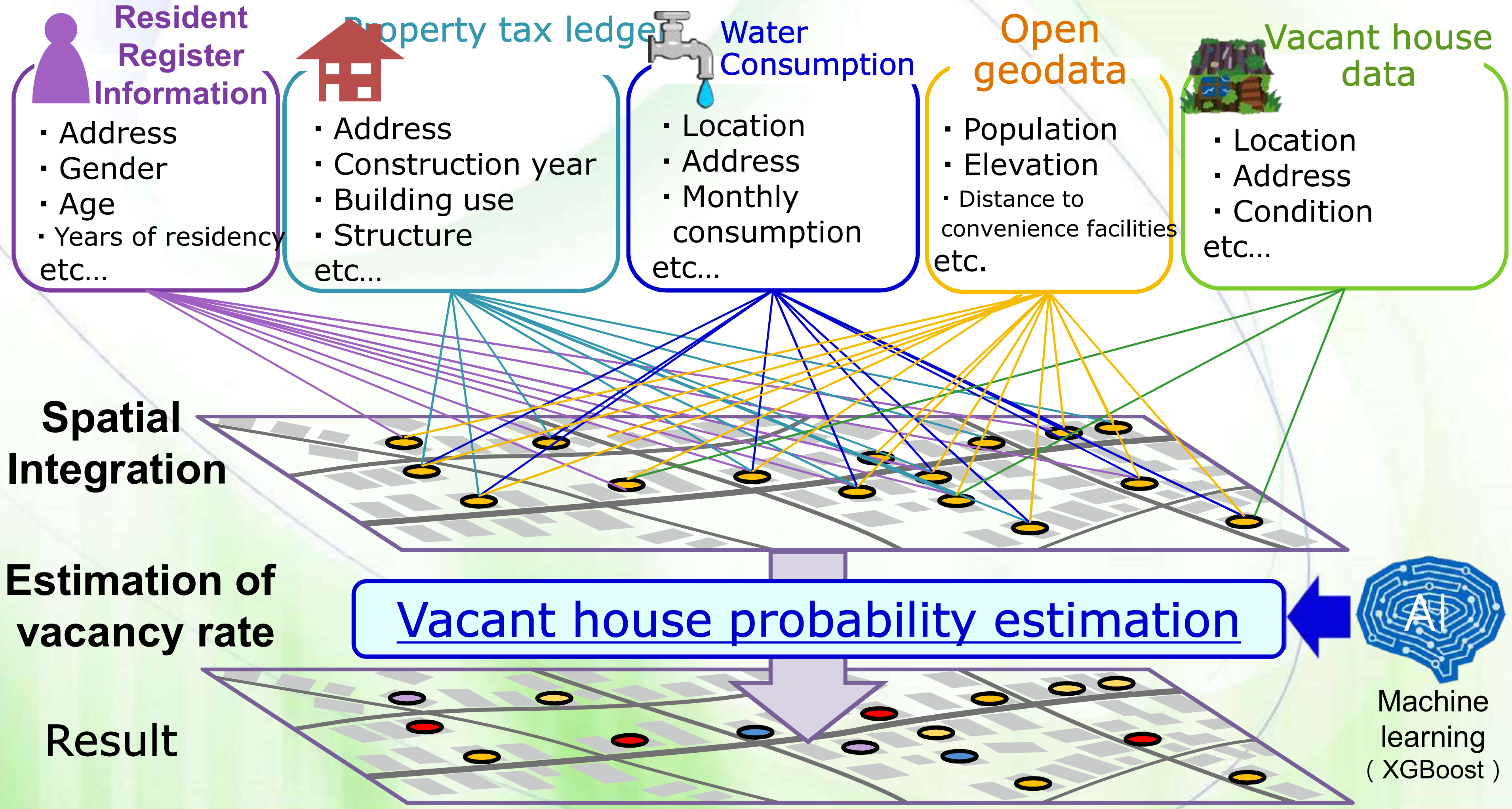
④ Using open census

Realization of vacant house survey technology applicable to various municipalities by integrating methods ⊖ ~ ④

- Provide vacant house survey method according to available data and budget
- Support for DXing of vacant house measures

i) Estimating the distribution of vacant houses using municipal data and AI

DXing of vacant house distribution surveys using municipal data



i) Estimating the distribution of vacant houses using municipal data and AI

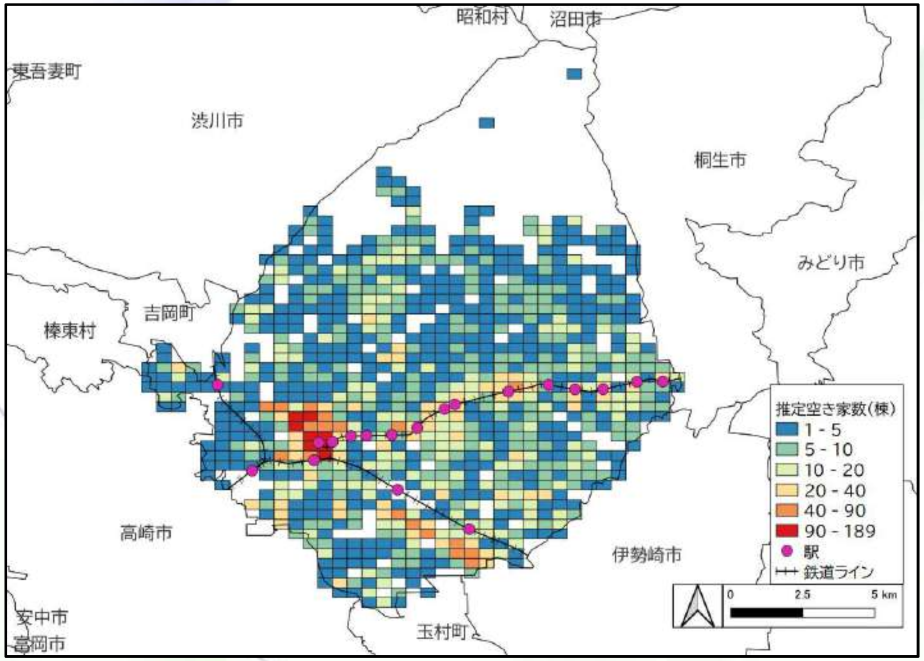
Estimated result of each building (e.g. Maebashi city)

秋山祐樹，自治体データ・民間データを活用した空き家分布推定手法の開発, 土地総合研究, 28(2), 35-49, 2020.

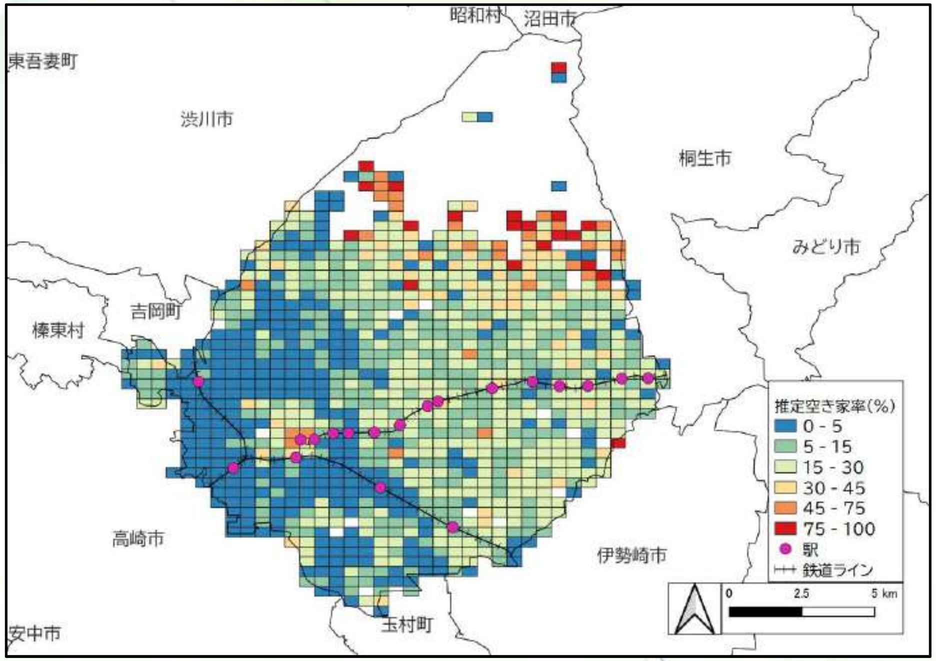
Tomita, K., Akiyama, Y., Baba, H. and Yachida, O., Estimating the Spatial Distribution of Vacant Houses with Machine Learning Using Municipal Data, *IGARSS 2022 Proceedings*, #3960, 2022.

i) Estimating the distribution of vacant houses using municipal data and AI

Distribution of number and percentage of vacant houses by 500m grids throughout Maebashi city



Number of vacant house



Rate of vacancy

Areas where both values are high
= high priority for countermeasures

Municipality can prioritize areas where vacant house surveys should be conducted

Reliability of the model

		Estimation value	
		Non-vacant	Vacant
True value	Non-vacant	73,772 (TN)	7,474 (FP)
	Vacant	878 (FN)	1,409 (TP)

Evaluation index	
Accuracy (%)	90.0
Recall (%)	61.6
Specificity (%)	90.8

Accuracy
= (TN + TP) / (TN+TP+FN+FP)
Recall = TP/(TP+FN)
Specificity = TN/(TN+FP)

The model can predict with high accuracy (90%)
especially non-vacant houses

i) Estimating the distribution of vacant houses using municipal data and AI

Confirmation of applicability in other municipalities (Case of urban area)

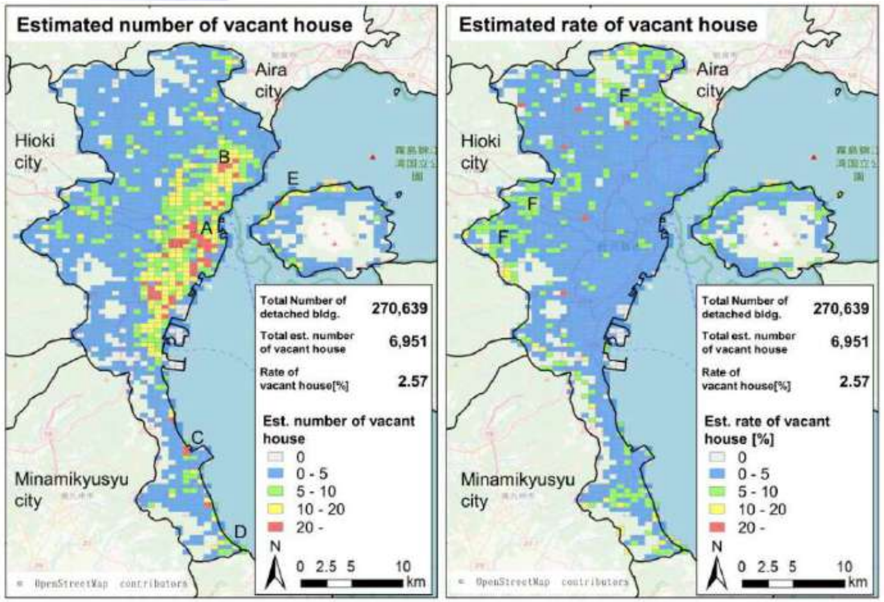
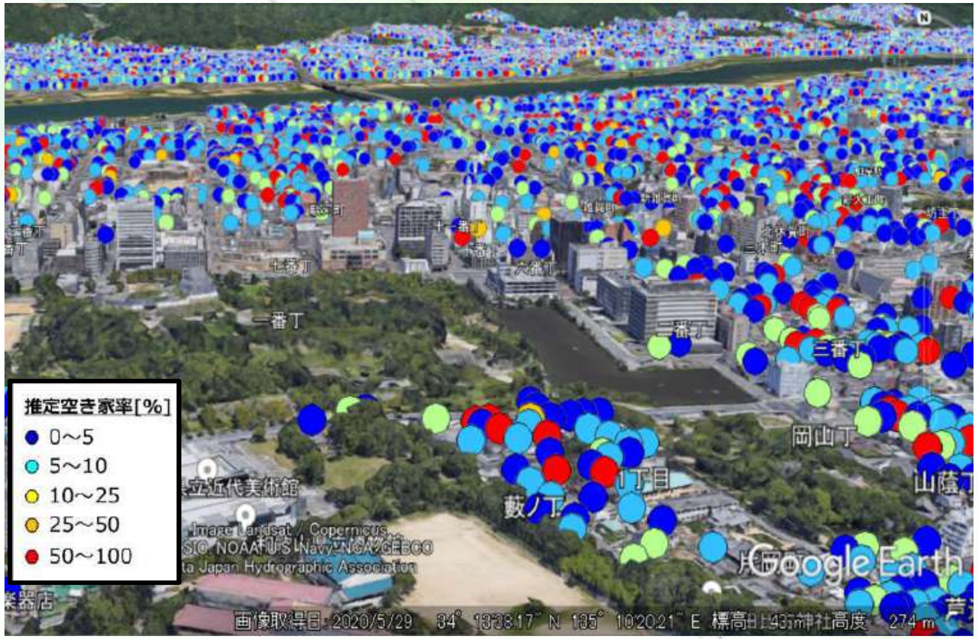


Fig. 7. Estimated number and rate of vacant houses in the entire area of Kagoshima accumulated by 500-m square grids



Case of Kagoshima city

Akiyama, Y., Ueda, A., Ouchi, K., Ito, N., Ono, Y., Takaoka, H. and Hisadomi, K., Estimating the Spatial Distribution of Vacant Houses using Public Municipal Data, *Geospatial Technologies for Local and Regional Development*, 165-183, 2020.

秋山祐樹・馬場弘樹・大野佳哉・髙岡英生, 機械学習による空き家分布把握手法の更なる高度化　自治体の公共データを活用した空き家の分布把握手法に関する研究（その3）, 日本建築学会計画系論文集, 86(786), 2136-2146, 2021.

Case of Wakayama city

Baba, H., Akiyama, Y., Tokudomi, T., and Takahashi, Y., Learning Geographical Distribution of Vacant Houses Using Closed Municipal Data: A Case Study of Wakayama City, Japan, *ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci.*, VI-4/W2-2020, 1–8, 2020.

Sayuda,K., Hong, E., Akiyama, Y., Baba, H., Tokudomi, T. and Akatani, T., Accuracy of vacant housing detection models: An empirical evaluation using municipal and national census datasets, *Transactions in GIS*, https://doi.org/10.1111/tgis.12992, 2022.

i) Estimating the distribution of vacant houses using municipal data and AI

Confirmation of applicability in other municipalities (Case of rural area)

白馬村
HAKUBA VILLAGE

Problems to use municipal data

Collect and utilize of municipal data is difficult.
(in terms of personal data protection)

Municipal data is pinpoint data and very reliable.
→ They are very useful for DXing Municipal Decision Making

There is a possibility…
Local government will provide municipal data if we can show objective and usefulness clearly!

Outline

2. Introduction of Research Using Urban Spatial Information and AI for DXing Municipal Decision Making

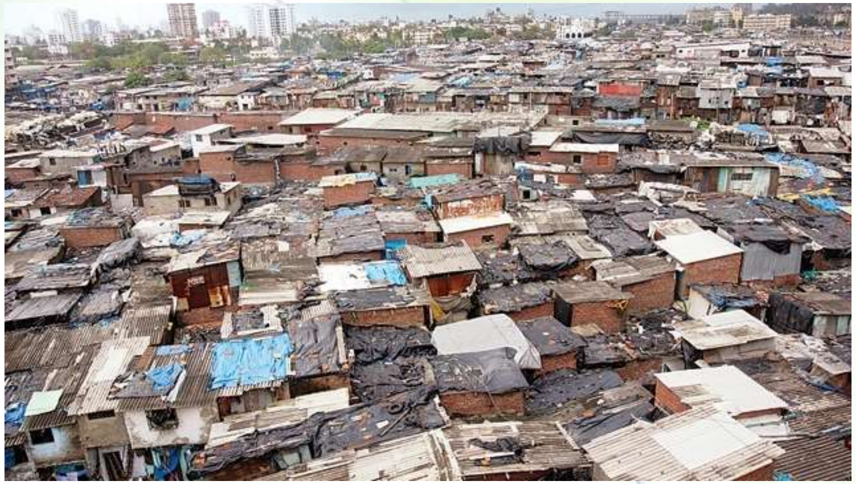
ｉ）Estimating the distribution of vacant houses using municipal data and AI

ｉｉ）Developing micro population data to support urban development in developing countries

ii) Developing micro population data to support urban development in developing countries

Background

Rapid urbanization and population growth in urban areas of developing countries



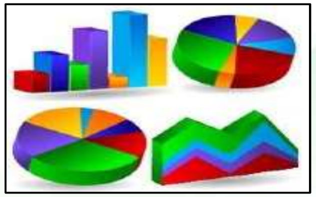
Proper urban and transportation planning is even more important than in developed countries for the sustainable development of cities in developing countries

- Population information is essential for proper planning.
- In some areas of the developing countries, population census are incompletely developed.

ii) Developing micro population data to support urban development in developing countries

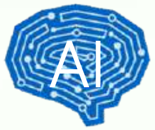
Development of global micro population data (MPD) using satellite image and AI

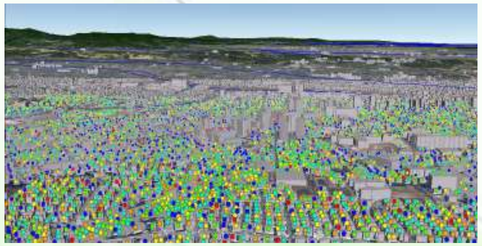
Development of MPD in areas where maps and census are well managed (developed countries)



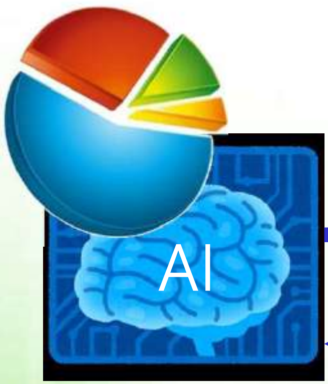
Development of MPD in areas where maps and census are not available (developing countries)

Development building data





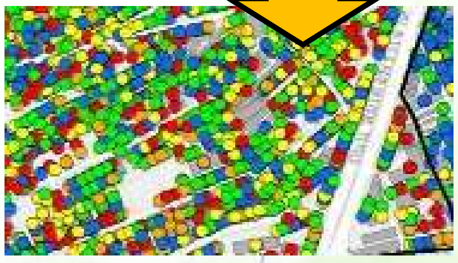
MPC in developed countries



Development of a model to estimate the number of households and population per building

Apply

Model update

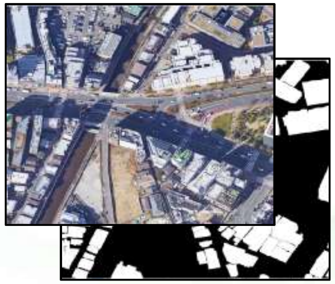


MPC in developing countrie

ii) Developing micro population data to support urban development in developing countries

Development of method to extract buildings from satellite images

Create training data → Develop deep learning model → Extract building



Accuracy of building extraction (e.g. Tokyo)

	Center of Tokyo (Shinjuku)	Suburb of Tokyo (Hachioji city)	Previous study (Suburb of Christchurch)
IoU (%)	62.8	75.4	83.3
Extraction rate (%)	68.1	91.9	89.0

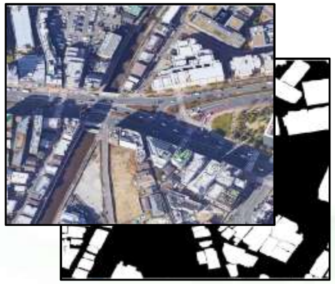
* Wu, G., Shao, X., Guo, Z., Chen, Q., Yuan, W., Shi, X., Xu Y. and Shibasaki, R. :Automatic building segmentation of aerial imagery usingmulti-constraint fully convolutional networks, Remote Sensing, Vol.10, No.3, 2018.

Even in Tokyo, where buildings of various heights and shapes are densely clustered, our model showed similar performance to existing studies.

ii) Developing micro population data to support urban development in developing countries

Development of method to extract buildings from satellite images

Create training data → Develop deep learning model → Extract building



<u>In Japan</u>
Detailed building data are available. → training data for AI.

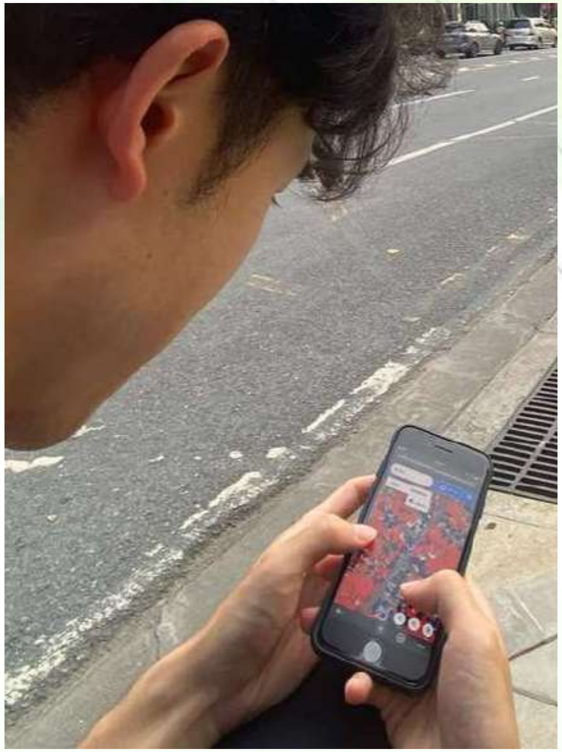
<u>Developing countries</u>
Reliable building data dose not exist.

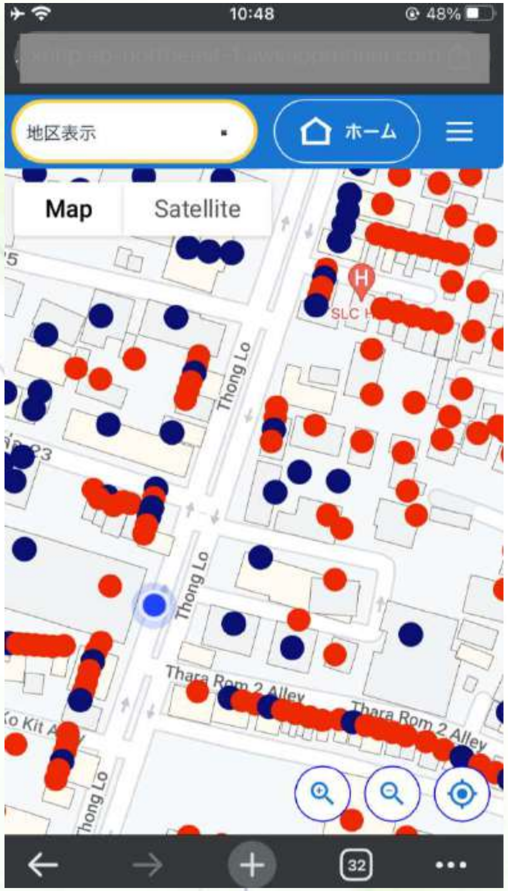
Developing training data
by field surveys of cities in developing countries

Target city: Bangkok

ii) Developing micro population data to support urban development in developing countries

Field survey in Bangkok (Oct. 2023)



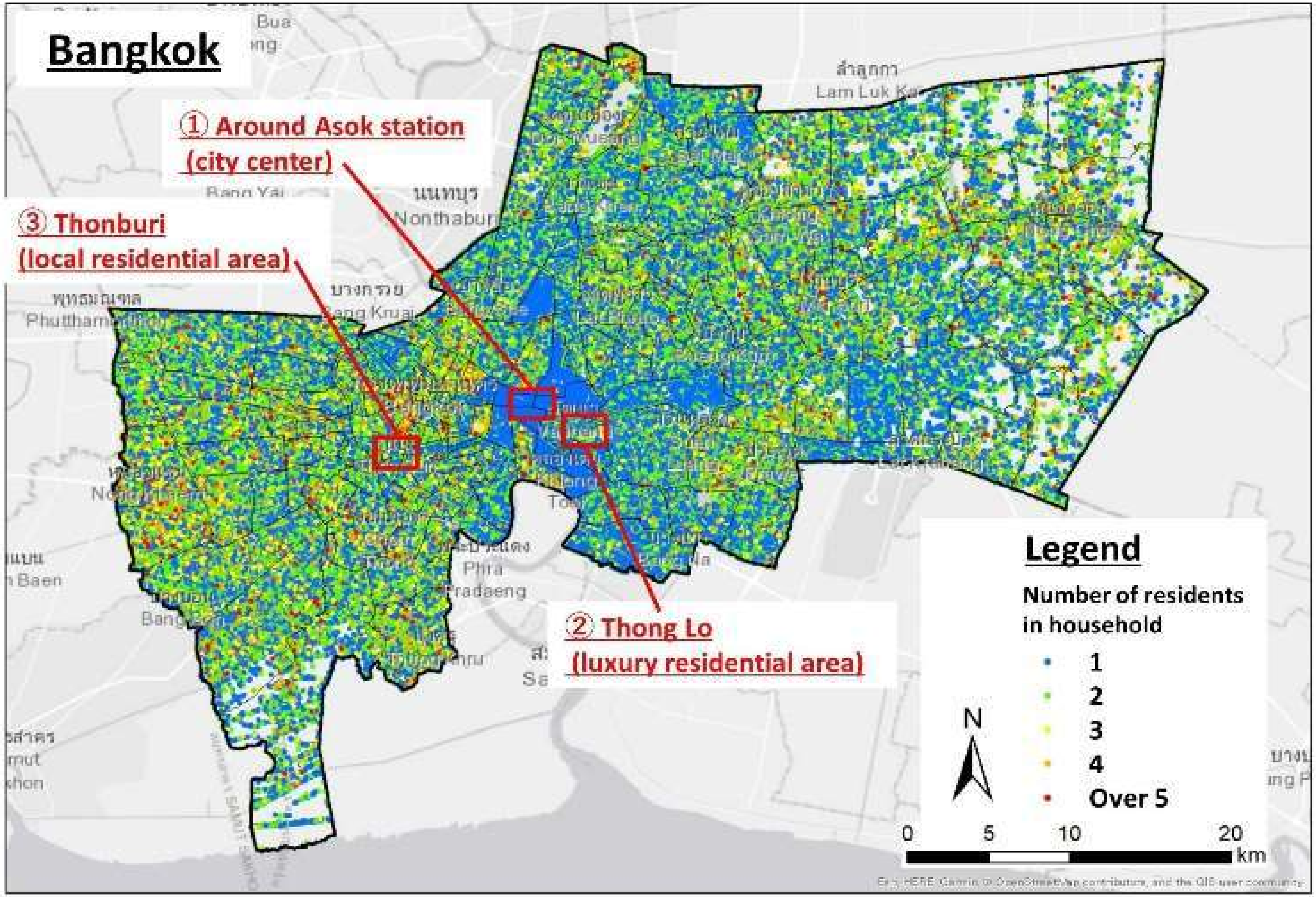


Survey items

- Location of individual buildings
- Type of building
- Number of floors
- Number of households (for condominiums)

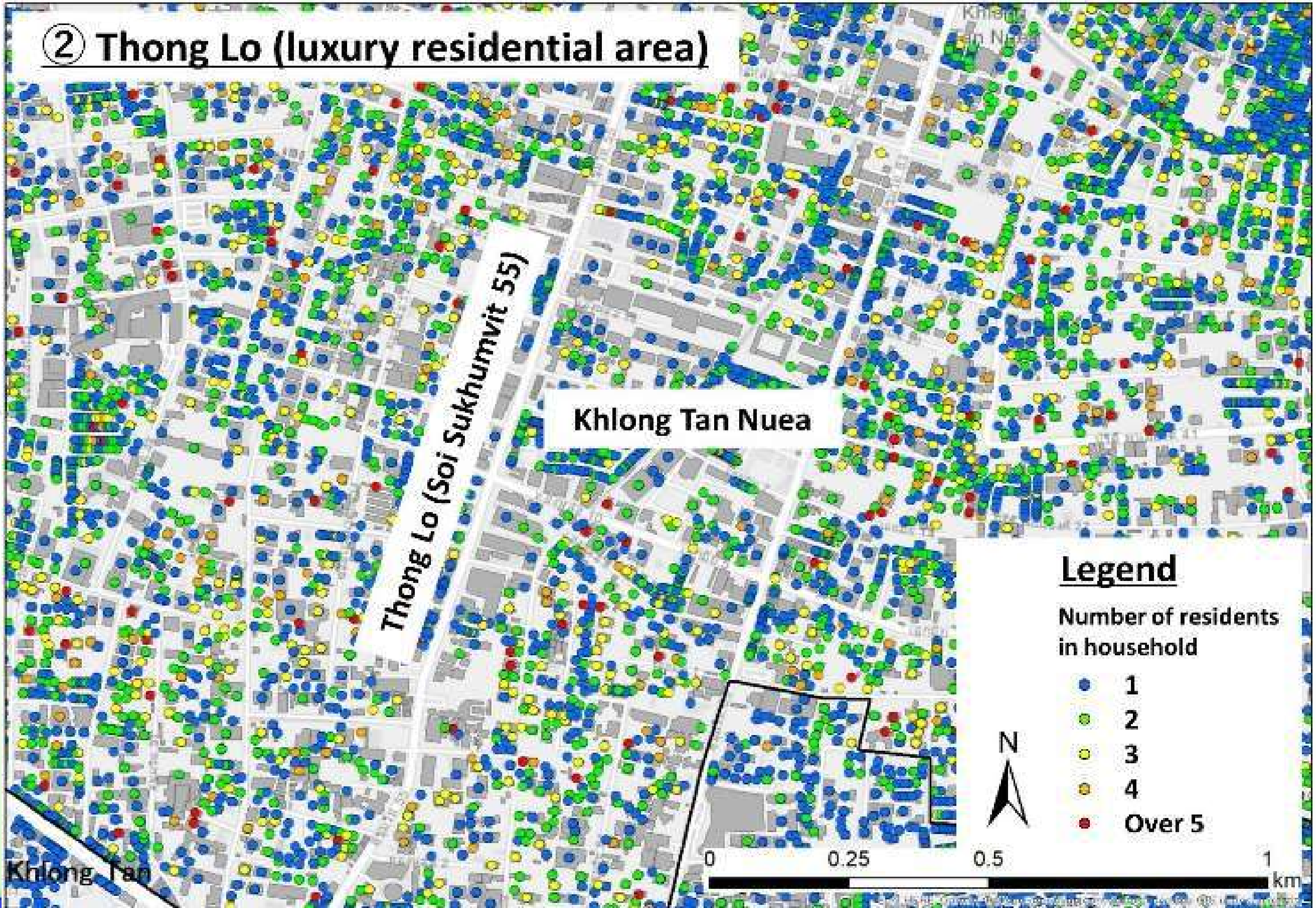
ii) Developing micro population data to support urban development in developing countries

Prototype of the MPC on Bangkok



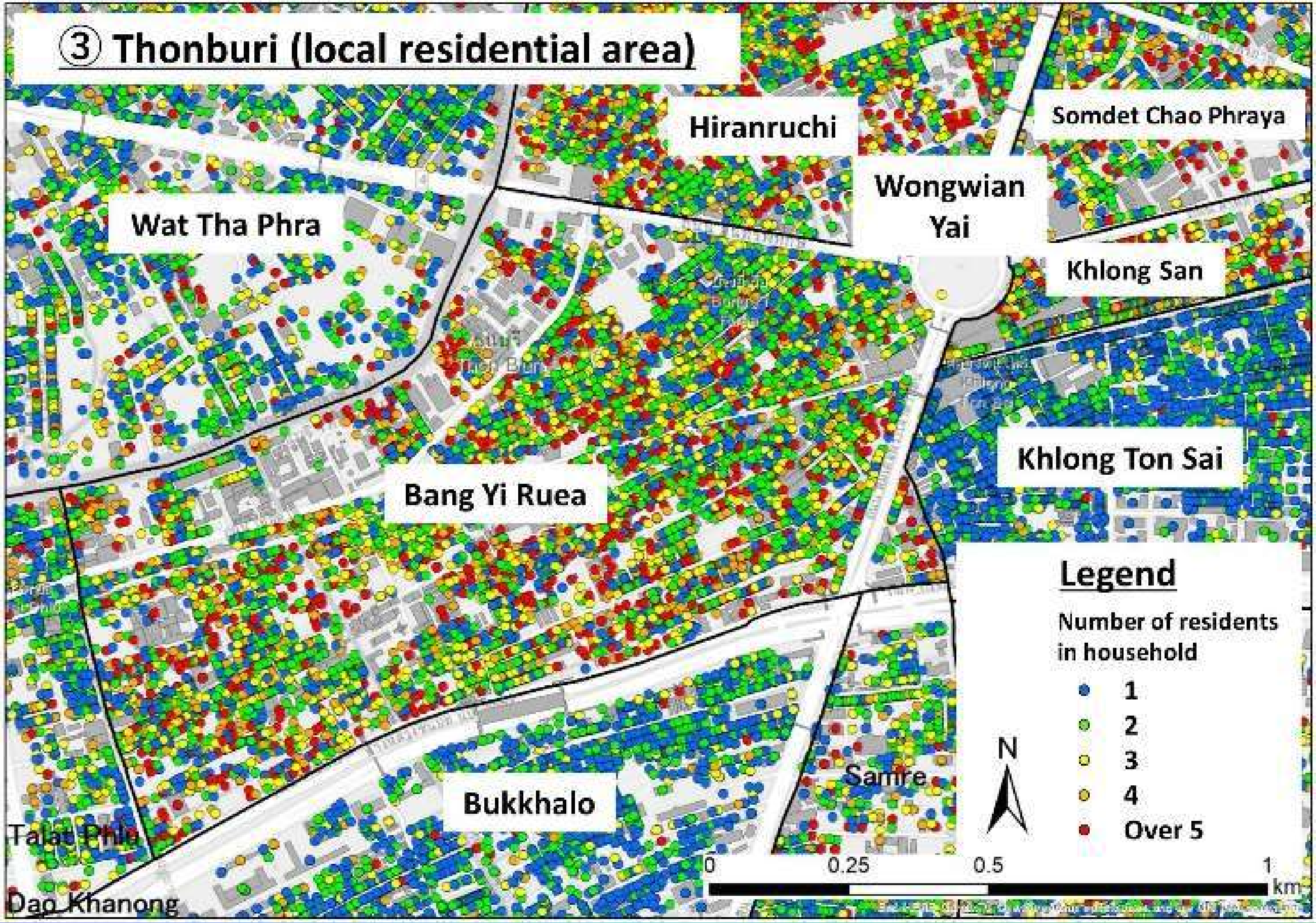
Akiyama, Y., Miyazaki, H. and Sirikanjanaanan , S., Development of Micro Population Data for Each Building: Case Study in Tokyo and Bangkok, *2019 First International Conference on Smart Technology and Urban Development (STUD)*, 1-6, 2019.

Prototype of the MPC on Bangkok



ii) Developing micro population data to support urban development in developing countries

Prototype of the MPC on Bangkok



ii) Developing micro population data to support urban development in developing countries

Toward DXing Bangkok's Urban Planning

- Participated in JST's SATREPS "Smart Transportation Strategy to Realize Thailand 4.0" project.
- Discussing the possibility of MPD-based planning in collaboration with researchers in Thailand, planners in Bangkok, JICA (Japan International Cooperation Agency), and others.

Outline

1. Brief Introduction of My Research Activities

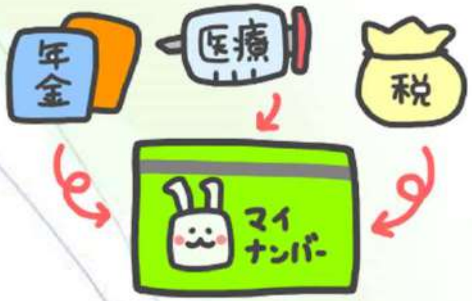
2. Introduction of Research Using Urban Spatial Information and AI for DXing Municipal Decision Making

3. The Potential of Urban Spatial Information and AI for DXing Municipal Decision Making

In 2020s of Japan and all over the world…

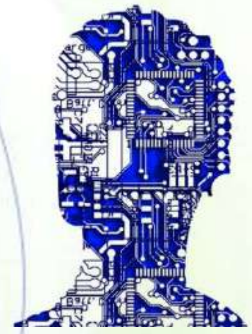
Era of urban engineering + IT (ICT・IoT・AI)

Urban planning in the 2020s will change as follows (maybe?)
***This is my personal opinion...**



Use of closed data (personal information)
→Anonymization techniques and data literacy will be improved.

Use of real-time big data
→Realization of multiple super cities



AI will be utilized society and local government
→AI makes candidate answers. The job of humans is to make the right choices and execute them.

Increase the frequency and speed of "actions"
→Create a reason to make actions based on the data (= Evidence).
→Quicker and faster actions
→Improve actions by repeating trial and error quickly.

Finally…

- The national government, local governments, and companies have various useful data and statistics.

- To collect, integrate, and use them, there is great potential to create new value.

- AI has the potential to support to create the new value.

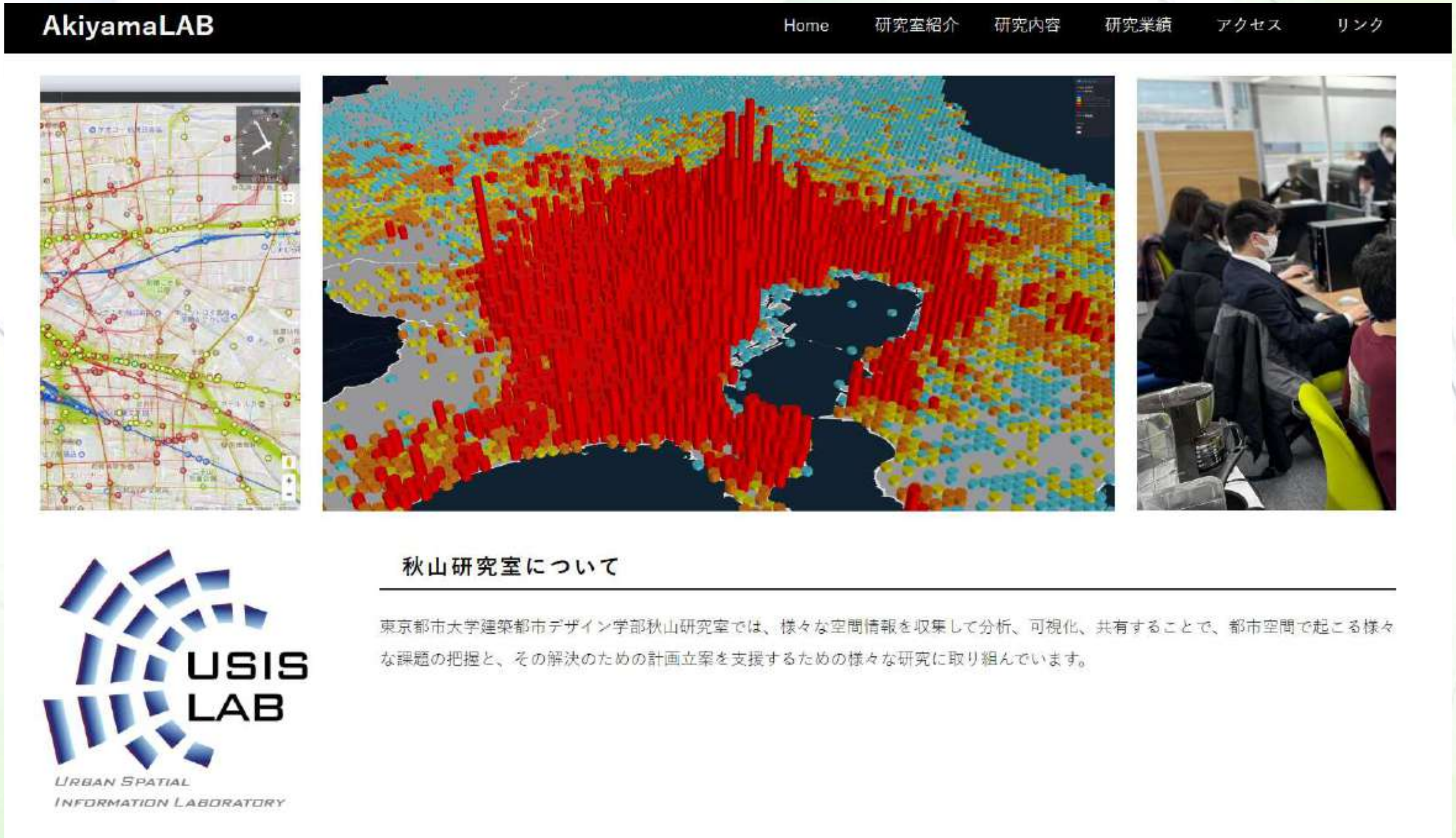
- To promote the utilization of data and statistics, "MX" (Mind Transformation) is more necessary than DX.

  →It is important for everyone to have a mindset that is
  willing to take on new challenges using data.

Thank you for your kind attention!

If you are interested in our research and our lab, Please visit our website!

https://usis.jp



경청해 주셔서 감사합니다!

Filip Biljecki

filip@nus.edu.sg
National University of Singapore

Advancing urban modelling with emerging geospatial datasets and AI

The talk will present recent research efforts on urban and geospatial modelling at the NUS Urban Analytics Lab, and it focuses specifically on understanding the usability of emerging datasets and crowdsourcing. The Lab spearheads a holistic and intertwined research agenda that covers the entire geospatial process in the urban realm: from advancing means to acquire data and standardising it to developing new use cases and unlocking value with AI & analytics. For example, the group has developed the first global open registry of rooftops for urban sustainability, and is currently working on developing a multi-scale digital twin in the NUS campus aspiring to break silos among disparate domains and research groups.

Advancing urban modelling with emerging geospatial datasets and AI technologies

Filip Biljecki
Assistant Professor, National University of Singapore
Director, NUS Urban Analytics Lab

NUS National University of Singapore

urban analytics lab

Background image: Mapillary data in Helsinki

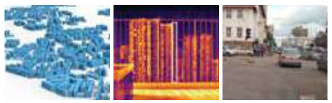
Our research group
NUS Urban Analytics Lab

- Urban data science & geospatial engineering. Breaking the silos between GIS and urbanism

Applications / analytics

Geospatial foundation

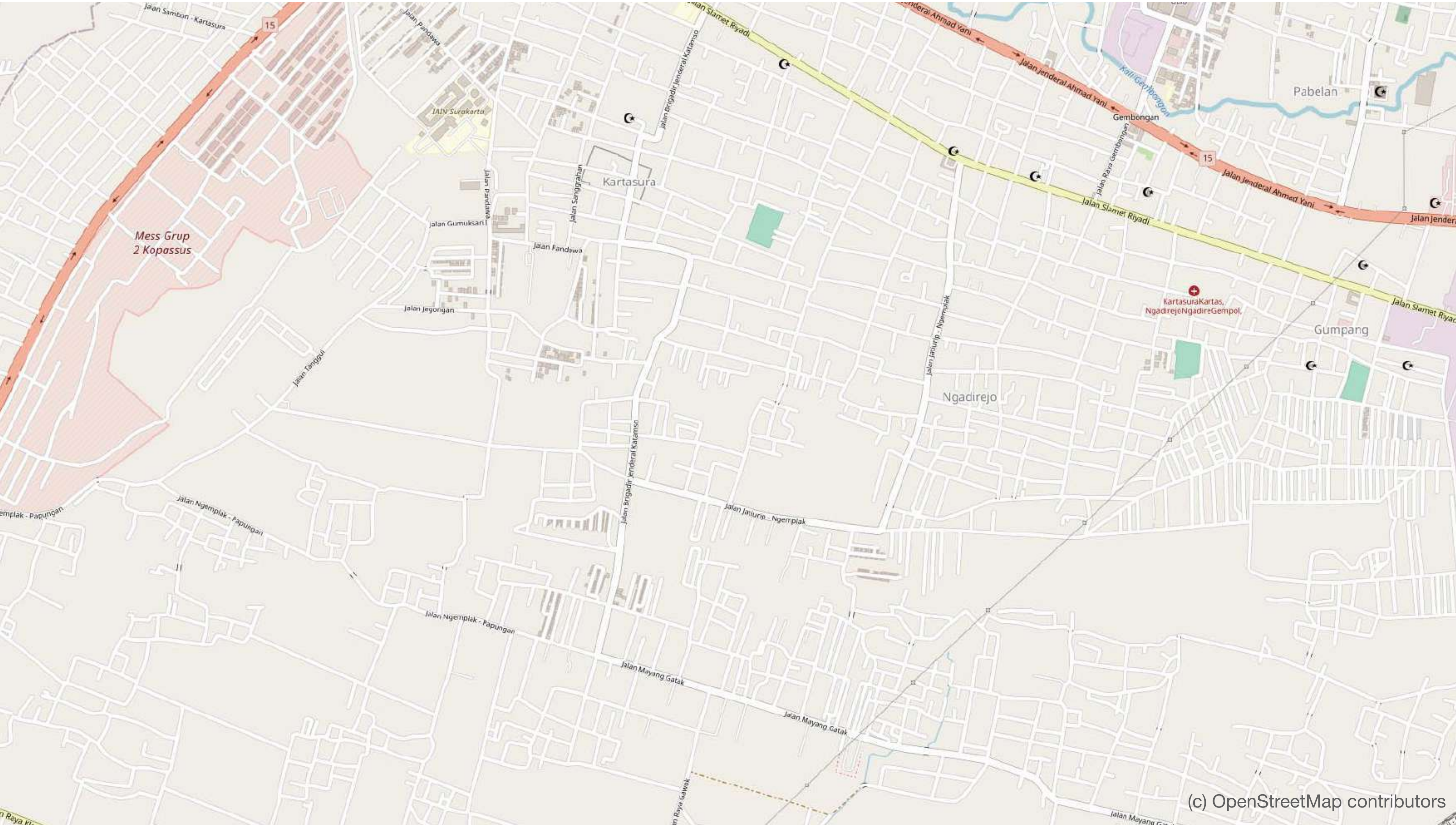
Acquisition	Standards	Processing	Quality

- Emerging urban data sources 
- GeoAI 
- Crowdsourcing 

NUS National University of Singapore

urban analytics lab

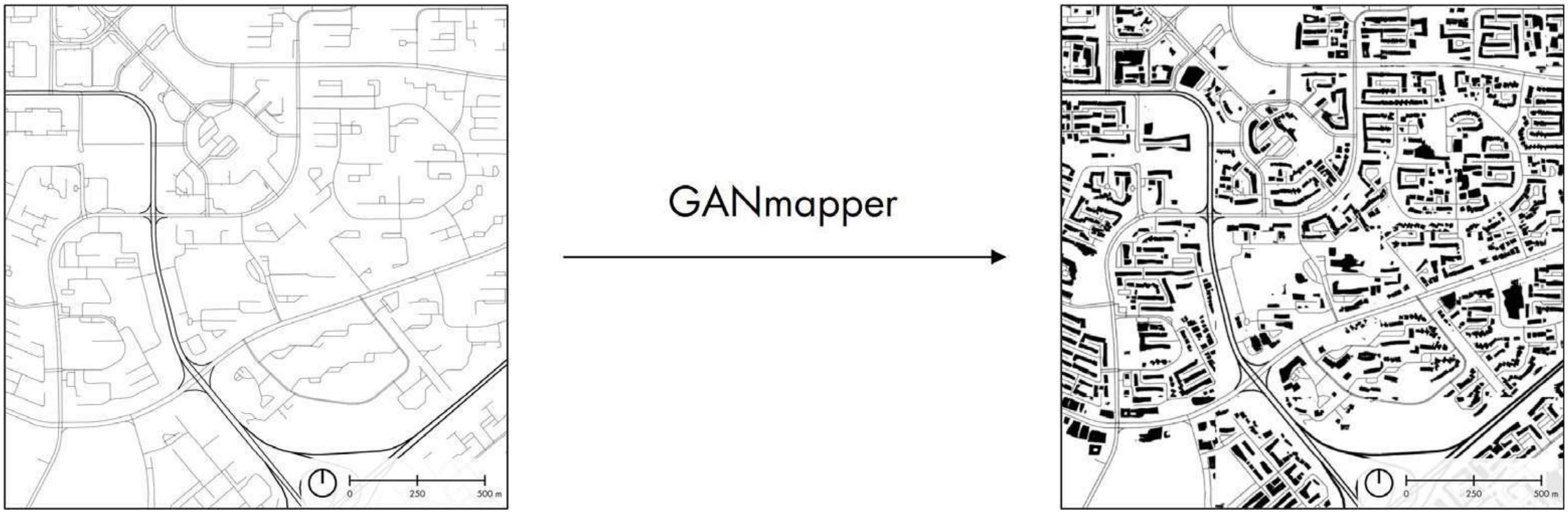
OpenStreetMap
Edit
History
Export
GPS Traces
User Diaries
Communities
Copyright
Help
About
Log in
Sign Up
Search
Where is this?
Go
Daehwa Agricultural Park
고양체육관
대화중학교
장촌초등학교
대화공원
장촌공원
고양체육관사거리
장성2단지사거리
장성3단지사거리
문촌19단지사거리
문촌18단지사거리
문촌16단지사거리
대화공원사거리
장촌공원사거리
한국국제전시장 1전시장
킨텍스제1전시장
킨텍스제2전시장
킨텍스지하차도
킨텍스로
호수로
고양대로
중앙로
일산로
KICT
MEGABOX
문촌마을19단지신우아파트
문촌마을18단지대원아파트
문촌마을17단지신안아파트
문촌마을15단지부영아파트
문촌마을14단지세경아파트
장성마을4단지대명아파트
장성마을3단지건영아파트
장성마을2단지대명아파트
한수중학교
한수초등학교
인제대학교일산백병원
50 m
300 ft
© OpenStreetMap contributors ♥ Make a Donation. Website and API terms


Jalan Sambon - Kartasura
15
Jalan Pandawa
IAIN Surakarta
Mess Grup
2 Kopassus
Kartasura
Jalan Brigadir Jenderal Katamso
Jalan Sanggrahan
Jalan Gumuksari
Jalan Pandawa
Jalan Jegongan
Jalan Tanggul
Jalan Slamet Riyadi
Jalan Jenderal Ahmad Yani
Kali Gembongan
Gembongan
Pabelan
Jalan Raya Gembongan
15
Jalan Jenderal Ahmad Yani
Jalan Slamet Riyadi
KartasuraKartas,
NgadirejoNgadireGempol,
Gumpang
Ngadirejo
Jalan Jaturip - Ngemplak
Jalan Brigadir Jenderal Katamso
Jalan Ngemplak - Papungan
Jalan Ngemplak - Papungan
Jalan Mayang Gatak
Jalan Mayang Gatak
Jalan Raya Gawok
(c) OpenStreetMap contributors

GANmapper — geographical data translation

by Abraham Noah Wu

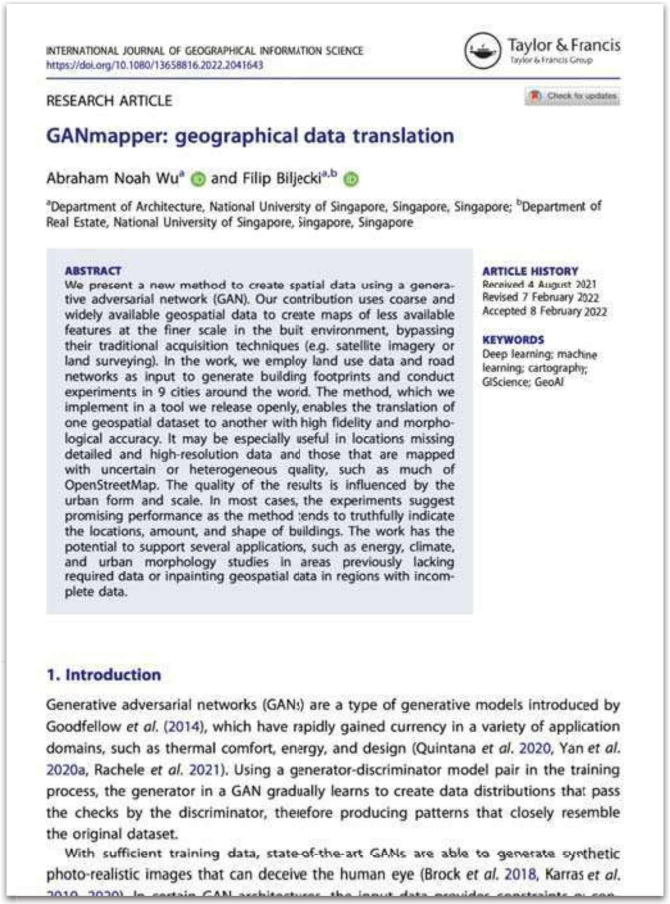
New means of building data generation using Generative Adversarial Network



Published in the International Journal of Geographical Information Science. Credit: Abraham Noah Wu

GANmapper — geographical data translation

New means of building data generation using Generative Adversarial Network



INTERNATIONAL JOURNAL OF GEOGRAPHICAL INFORMATION SCIENCE
https://doi.org/10.1080/13658816.2022.2041643

Taylor & Francis
Taylor & Francis Group

RESEARCH ARTICLE

Check for updates

GANmapper: geographical data translation

Abraham Noah Wu[a] and Filip Biljecki[a,b]

[a]Department of Architecture, National University of Singapore, Singapore, Singapore; [b]Department of Real Estate, National University of Singapore, Singapore, Singapore

ABSTRACT

We present a new method to create spatial data using a generative adversarial network (GAN). Our contribution uses coarse and widely available geospatial data to create maps of less available features at the finer scale in the built environment, bypassing their traditional acquisition techniques (e.g. satellite imagery or land surveying). In the work, we employ land use data and road networks as input to generate building footprints and conduct experiments in 9 cities around the world. The method, which we implement in a tool we release openly, enables the translation of one geospatial dataset to another with high fidelity and morphological accuracy. It may be especially useful in locations missing detailed and high-resolution data and those that are mapped with uncertain or heterogeneous quality, such as much of OpenStreetMap. The quality of the results is influenced by the urban form and scale. In most cases, the experiments suggest promising performance as the method tends to truthfully indicate the locations, amount, and shape of buildings. The work has the potential to support several applications, such as energy, climate, and urban morphology studies in areas previously lacking required data or inpainting geospatial data in regions with incomplete data.

ARTICLE HISTORY
Received 4 August 2021
Revised 7 February 2022
Accepted 8 February 2022

KEYWORDS
Deep learning; machine learning; cartography; GIScience; GeoAI

1. Introduction

Generative adversarial networks (GANs) are a type of generative models introduced by Goodfellow *et al.* (2014), which have rapidly gained currency in a variety of application domains, such as thermal comfort, energy, and design (Quintana *et al.* 2020, Yan *et al.* 2020a, Rachele *et al.* 2021). Using a generator-discriminator model pair in the training process, the generator in a GAN gradually learns to create data distributions that pass the checks by the discriminator, therefore producing patterns that closely resemble the original dataset.

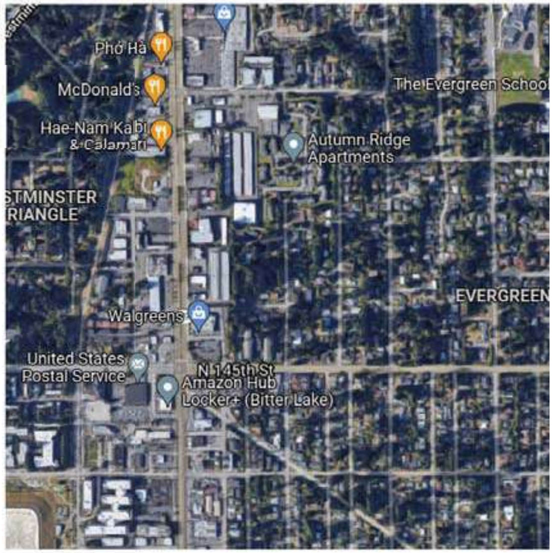
With sufficient training data, state-of-the-art GANs are able to generate synthetic photo-realistic images that can deceive the human eye (Brock *et al.* 2018, Karras *et al.*

Jakarta (OSM)

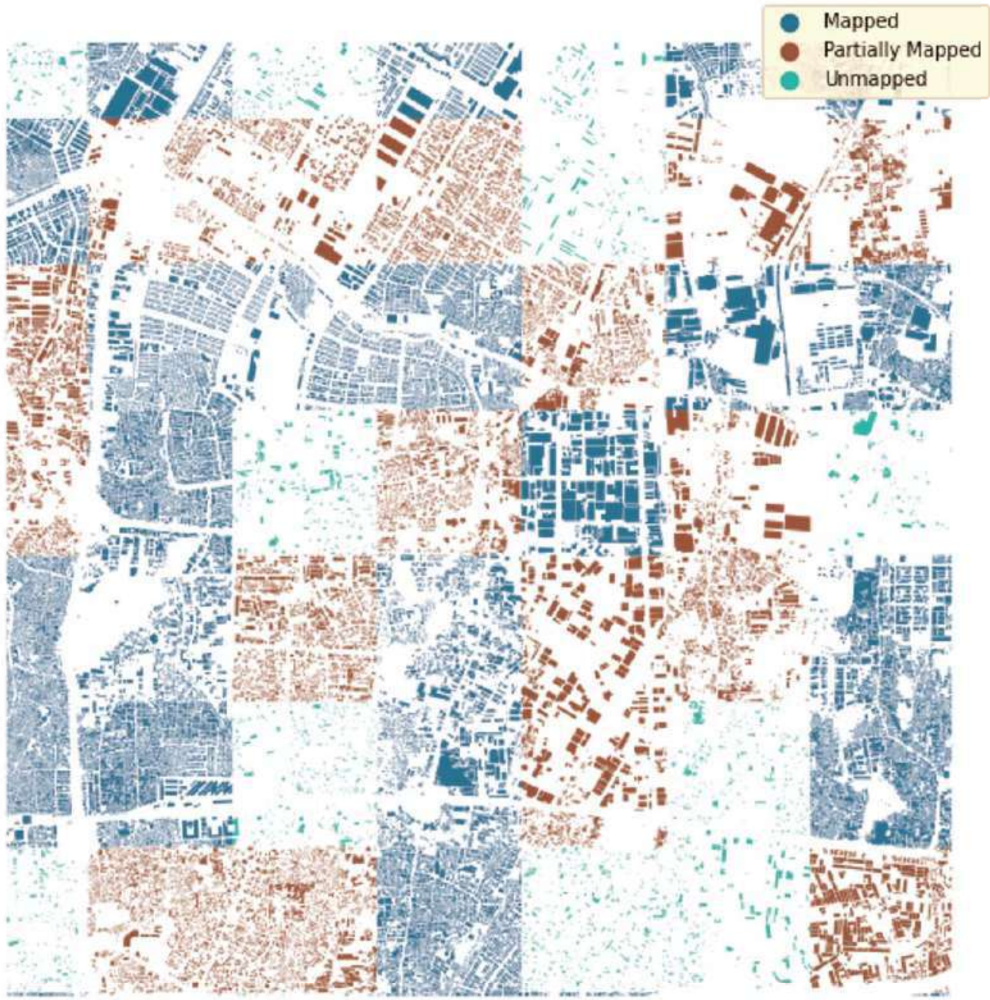
Jakarta (Satellite)

Predicted no. of buildings = 50
No. of buildings mapped in OSM = 1
🔍 Poor OSM completeness 😐

Seattle (OSM)



Seattle (Satellite)


Mapped
Partially Mapped
Unmapped

Sensing cities from accommodation reviews

by Wang Jiaxuan

Uncovering a latent type of VGI?

airbnb

listing_id	reviewer_id	date	Review
25123	225409357	2020-01-04	Grace is an amazing person, very friendly, receptive, cheerful and always willing to help. The house is excellent and my room was very nice, just like the pictures. The accommodation is well cared for and very clean. It is near the subway station and the market. Thanks for the tips, the hospitality and the kindness, Grace. Highly recommend, grade 10.
36660	57512966	2021-05-03	If I could give this home 10 stars I would. Agri & Roger are so warm & accommodating, I felt like I was amongst family. The garden and the room are an absolute dream. I can't get over how beautiful the garden is, and the room is furnished with lovely floral touches and vintage furniture. Agri & Roger, kindly allowed me to hold a photoshoot in their gardens for my business, and it was the best decision I could have made, it was an absolute dream stay and I will definitely be coming back ❤️
36299	250644756	2019-07-01	Great location to explore Kew Gardens and easy access to London with tube station nearby! Great flat with lovely backyard space. We enjoyed using this as our base for exploring the London area.

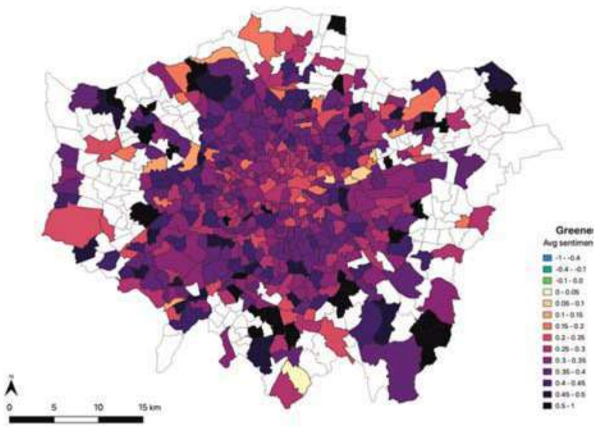
Source: Inside Airbnb

Wang J, Chow YS, Biljecki F (2023): Insights in a city through the eyes of Airbnb reviews: Sensing urban characteristics from homestay guest experiences. Cities 140: 104399.

Sensing cities from accommodation reviews

by Wang Jiaxuan

- Five aspects:
  - Greenery
  - Public transport accessibility
  - Crime
  - Noise
  - Density of amenities



Cities 140 (2023) 104399

Contents lists available at ScienceDirect

Cities

journal homepage: www.elsevier.com/locate/cities

Insights in a city through the eyes of Airbnb reviews: Sensing urban characteristics from homestay guest experiences

Jiaxuan Wang[a], Yoong Shin Chow[a], Filip Biljecki[a,b,*]

[a] Department of Architecture, National University of Singapore, Singapore
[b] Department of Real Estate, National University of Singapore, Singapore

ARTICLE INFO

Keywords:
Urban data science
Urban planning
GeoAI
Volunteered geographic information
Crowdsourcing

ABSTRACT

There is a growing interest in deriving insights about cities from crowdsourced data. We advance the discourse by employing homestay guest experience to sense urban characteristics. We evaluate the relationship between subjective perceptions and objective indicators thanks to rich information in textual reviews that we posit reflect urban qualities. Next, we investigate dominant topics about urban characteristics in Airbnb reviews (transportation, greenery, amenities, safety, and noise) with natural language processing techniques, i.e. a rule-based dependency parsing method designed to extract relevant information. Then, we establish the associations between sentiments and proxies representing the physical patterns of urban areas. The multi-scale results of the experiments in three cities (London, Singapore, and NYC) suggest that reviews on homestay platforms reflect transportation convenience, amenities, sense of safety, and noise pollution. The correlation is stronger at a higher administrative division level, while the perception of people on safety is more sensitive at a more granular scale. Densities of transportation and amenities in nearby districts are more likely to be perceived similarly. Furthermore, the spatial distribution of perceptions is possibly affected by the morphology and development of a city, and the diversity of guests. This study reveals new possibilities for sensing urban characteristics through user-generated information and introduces a new application of accommodation reviews, which may help alleviate gaps in availability of data required for planning.

1. Introduction

Reviews on online platforms or social media, such as dining experiences, are a useful textual representation of human perceptions of various aspects of cities (Hu et al., 2019; Jang & Kim, 2019; Olson et al., 2021), in line with the observation of Goodchild (2007) that citizens can observe a great variety of geographic information as *sensors*. Over the past decades, the advancement and popularity of social media, crowdsourcing, and online reviews have tremendously expanded the volume of volunteered geographic information (VGI) and research around it (Hu et al., 2019; Tateosian et al., 2023; Yan et al., 2020). A variety of geotagged social media data has been widely used in urban analysis, including but not limited to socioeconomic and demographic research (Arnaboldi et al., 2017; Cheng & Jin, 2019; Cui et al., 2021; Feng et al., 2022; Fried et al., 2014; Hu et al., 2019; Kiatkawsin et al., 2020; Lansley & Longley, 2016; Liu & Biljecki, 2022; Longley & Adnan, 2015; Quercia et al., 2012), as well as studying urban mobility (Cunliffe et al., 2020; Li et al., 2019; Phillips et al., 2021; Serna et al., 2017). Among different types of geotagged data crowdsourced from various venues such as social media, reviews are unique due to their subjectivity and multifaceted expressions. As reviews relay human perceptions, they may offer a vehicle for studying the relationship between subjective perceptions and objective artefacts in cities.

In this paper, we posit that homestay guest experience such as Airbnb reviews, besides their primary purpose of assessing the accommodation and its host, are rich in information about people's perception on the surrounding urban development. We build on the rich body of knowledge that has taken advantage of the wealth of information available in Airbnb reviews, and expand it for a different purpose – beyond understanding specific attributes about an Airbnb property (Zhang et al., 2020) to gather the perception and condition of neighbourhoods. Combined with location information that is generally available in such data, we postulate that it has potential to relate the content of reviews to the actual urban development in a city, and to evaluate the relationship between subjective perceptions and objective attributes of developments in urban areas.

* Corresponding author at: Department of Architecture, National University of Singapore, Singapore.
E-mail addresses: jiaxuan_w@u.nus.edu (J. Wang), yoongshin@nus.edu.sg (Y.S. Chow), filip@nus.edu.sg (F. Biljecki).

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Received 5 July 2022; Received in revised form 19 February 2023; Accepted 21 May 2023

Wang J, Chow YS, Biljecki F (2023): Insights in a city through the eyes of Airbnb reviews: Sensing urban characteristics from homestay guest experiences. Cities 140: 104399.

Unlocking rooftops

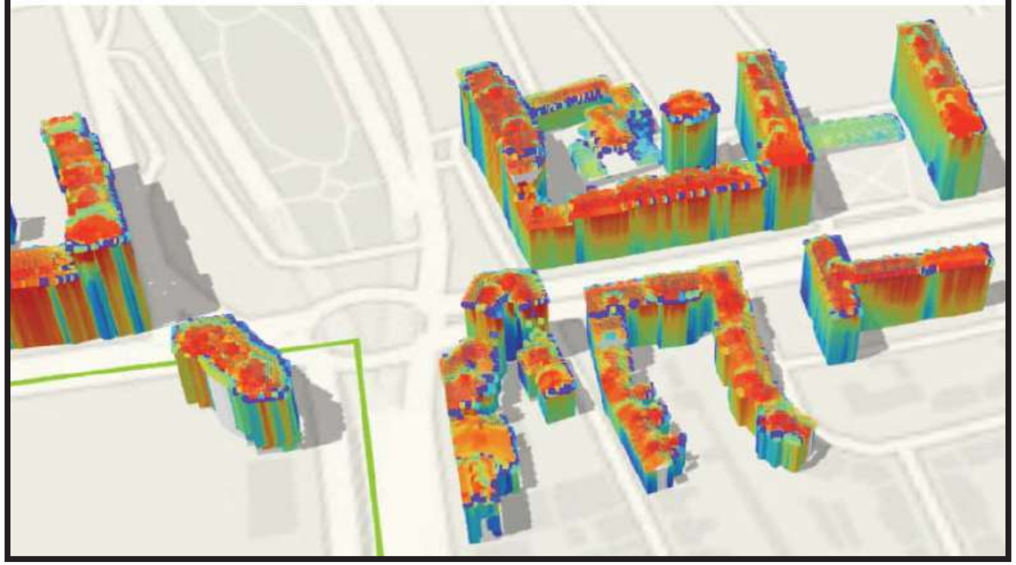
Potential for green roofs, farms, solar panels…



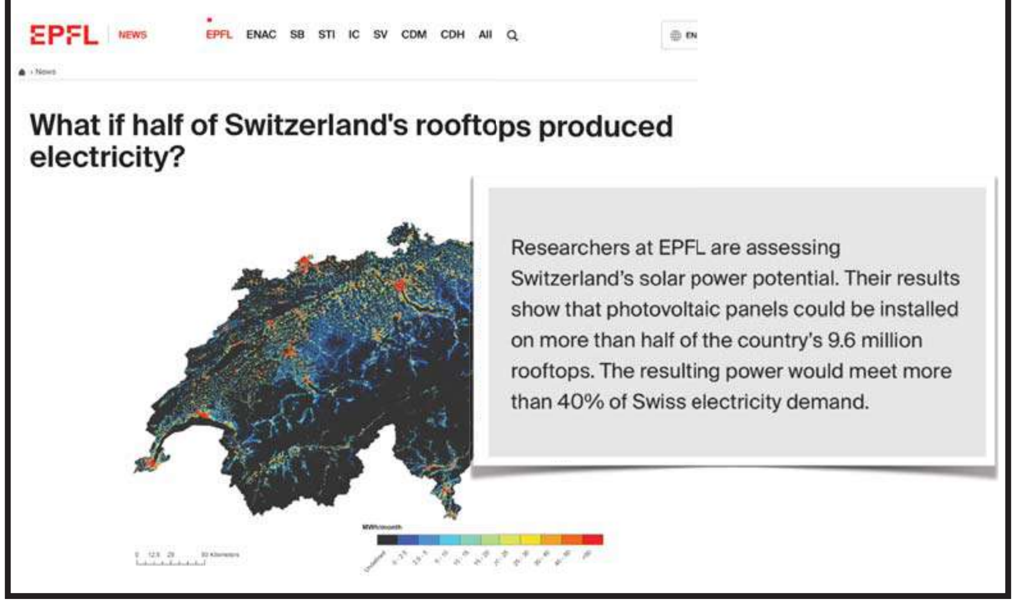
Unlocking rooftops

Research on potential for solar panels, green roofs, farms, …

(1) Identifying the best locations



(2) Quantifying the potential at large-scale

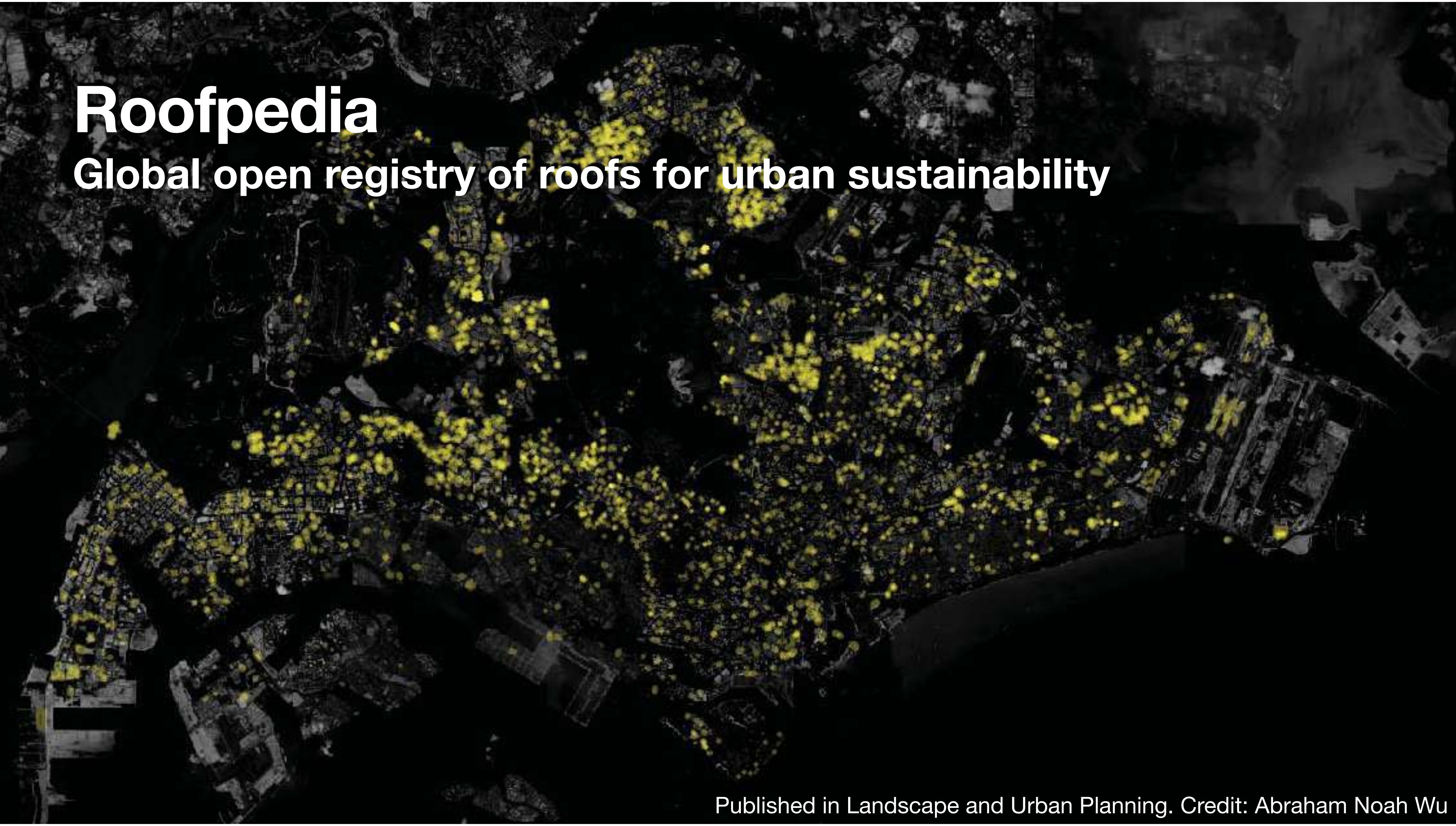


Brito, M. C., Redweik, P., Catita, C., Freitas, S. & Santos, M. 3D Solar Potential in the Urban Environment: A Case Study in Lisbon. Energies 12, 3457–13 (2019).
https://actu.epfl.ch/news/what-if-half-of-switzerland-s-rooftops-produced-el/

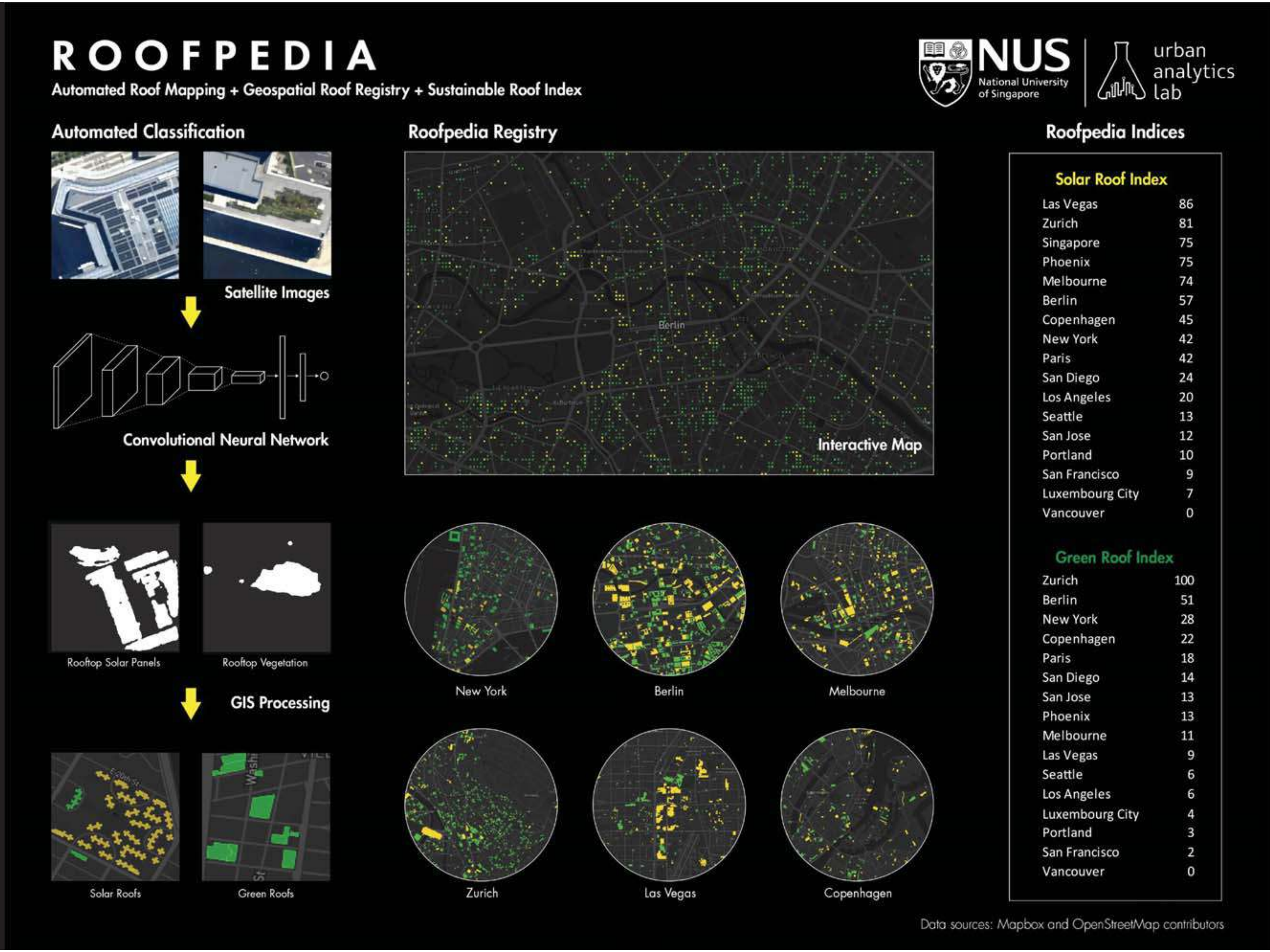
We know the potential in future. But what about the current situation and actual status *today*? What is the rooftop utilisation rate?

Roofpedia

Global open registry of roofs for urban sustainability


Roofpedia
Global open registry of roofs for urban sustainability
Published in Landscape and Urban Planning. Credit: Abraham Noah Wu

by Abraham Noah Wu



Obtained from Google Street View

Human perception
Appearance, audits, walkability, and socio-economic studies

Infrastructure
Spatial data collection, real estate, transport, and health studies

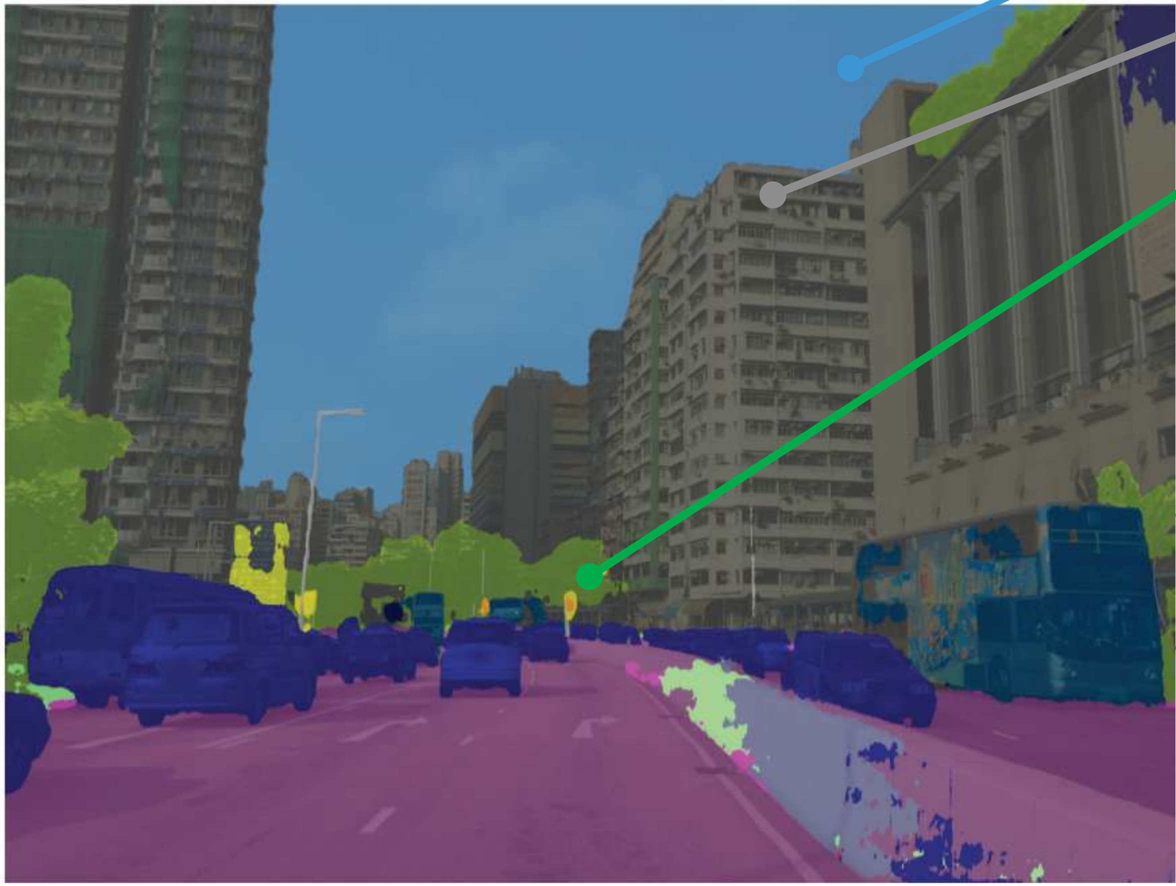
Activities
Human traffic, place semantics, vibrancy, and economic activity

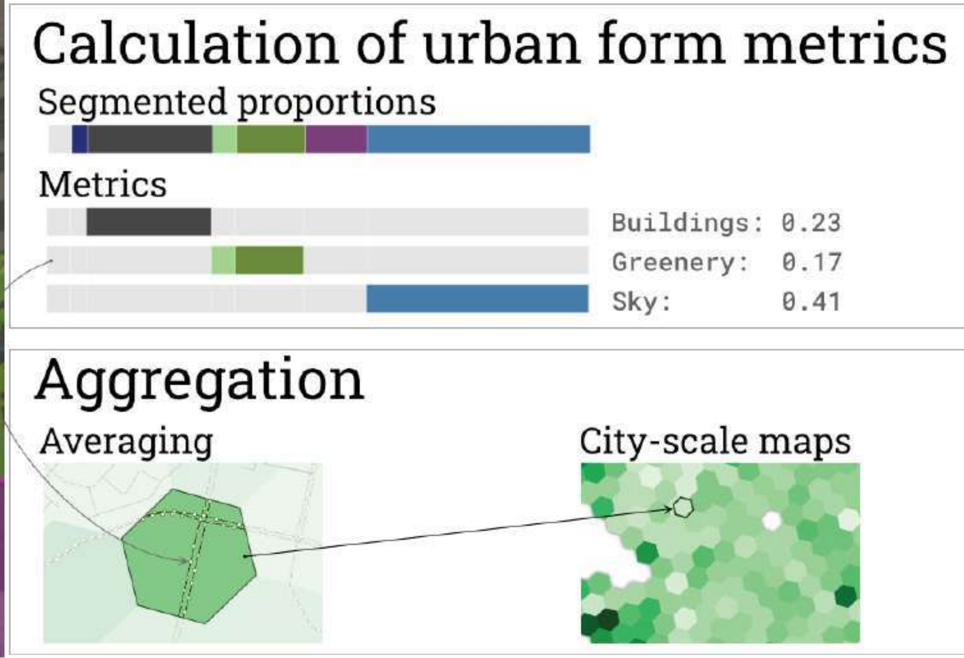
Urban form
Sky view factor and share of vegetation in urban canyons

Images are obtained from Mapillary following a manual exploration

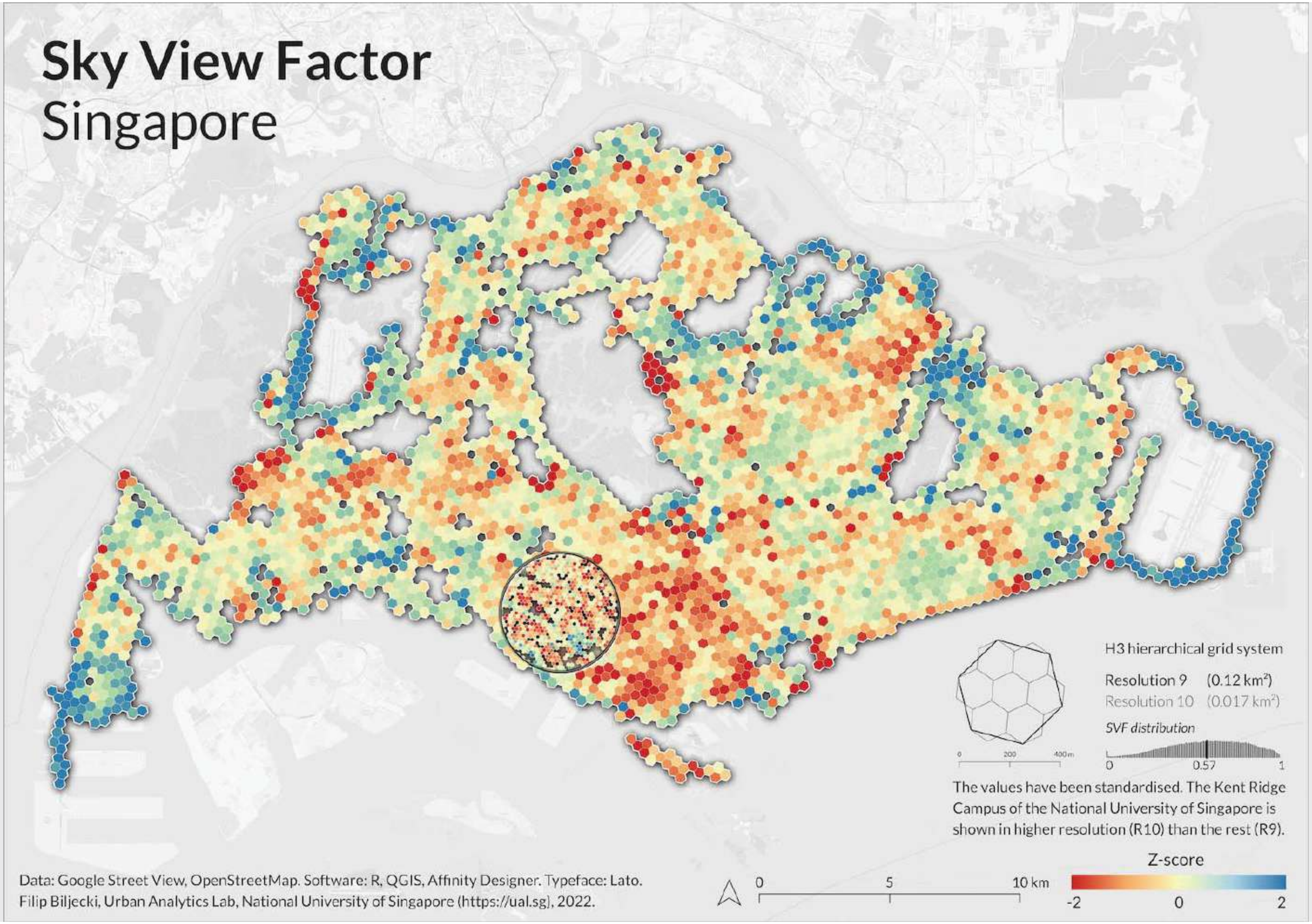
Urban form

Sky view factor and share of vegetation in urban canyons





Images are obtained from Mapillary following a manual exploration

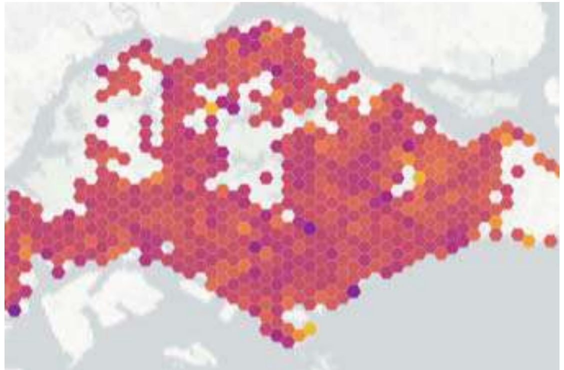

Sky View Factor
Singapore
H3 hierarchical grid system
Resolution 9 (0.12 km²)
Resolution 10 (0.017 km²)
SVF distribution
0 200 400m
0 0.57 1
The values have been standardised. The Kent Ridge Campus of the National University of Singapore is shown in higher resolution (R10) than the rest (R9).
Z-score
-2 0 2
0 5 10 km
Data: Google Street View, OpenStreetMap. Software: R, QGIS, Affinity Designer. Typeface: Lato.
Filip Biljecki, Urban Analytics Lab, National University of Singapore (https://ual.sg), 2022.

Assessing bikeability from street view imagery

By Koichi Ito

Orchard Rd, Singapore from Mapillary

Bikeability 🚲

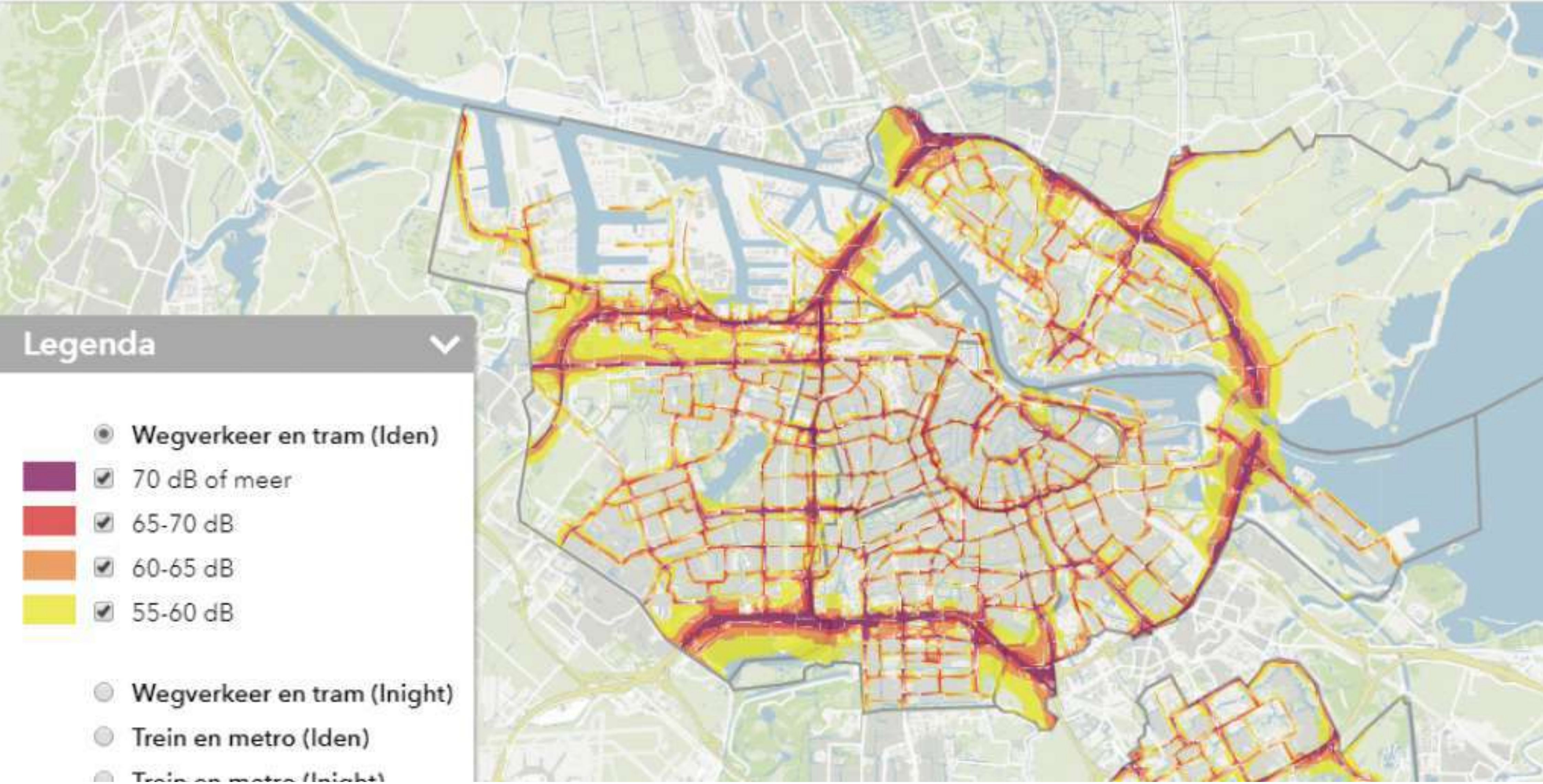


Credit: Koichi Ito

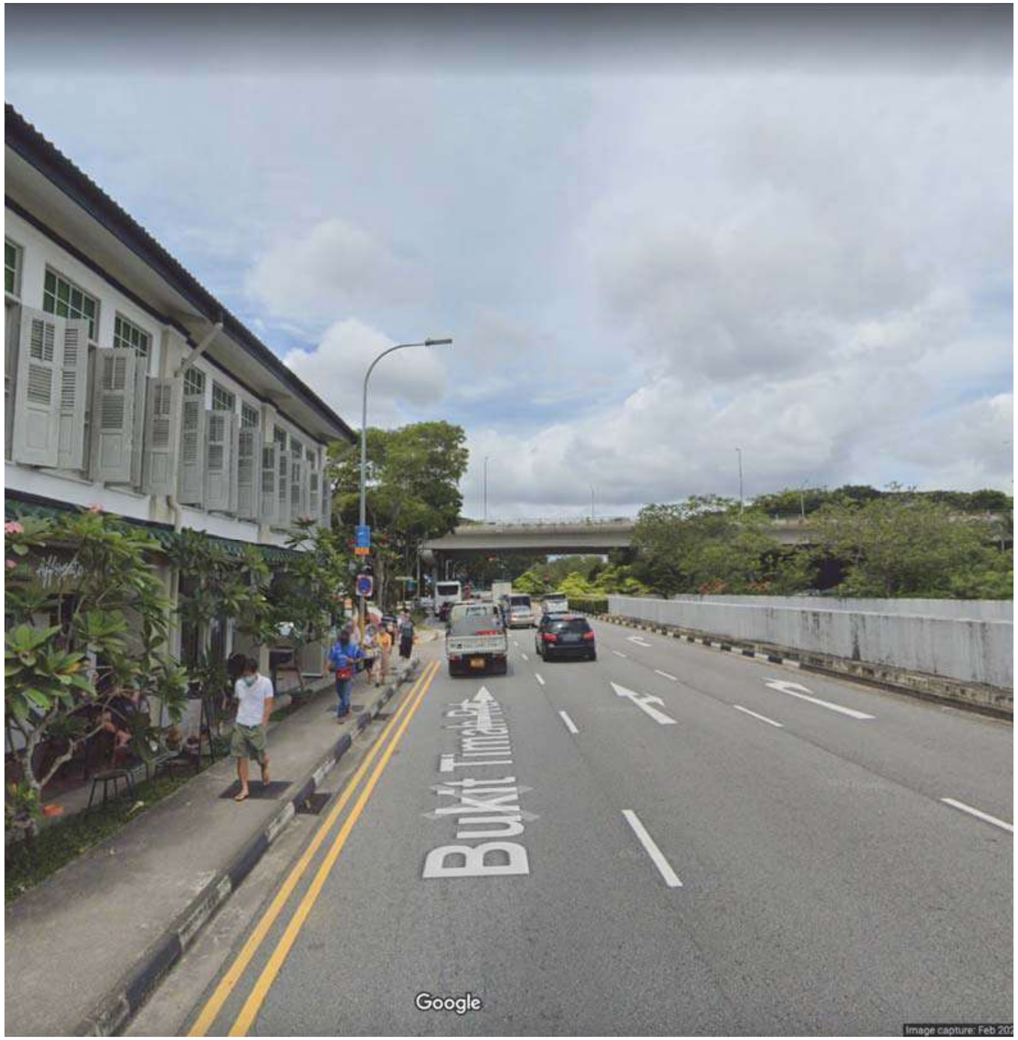
Gemeente
Amsterdam

Geluidskaart 2018

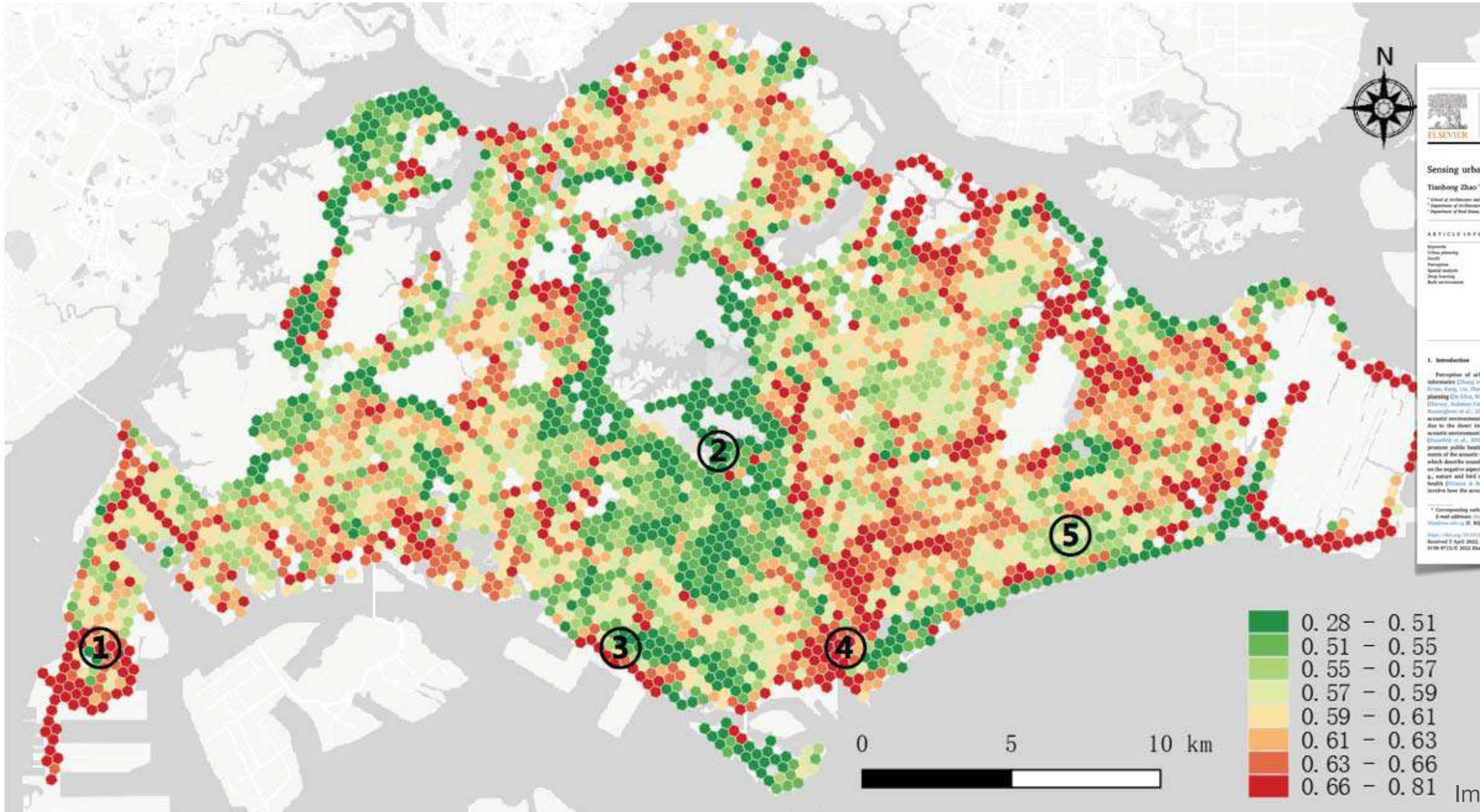
Sound map of Amsterdam 2018, Source: Sound map of Amsterdam 2018 / Topografische ondergrond © Gemeente Amsterdam



Sensing urban soundscapes from street view imagery



- SVI — a new instrument to sense noise?
    - Bypassing field measurements and an alternative to simulations
- Sound intensity…
    - + also nature & quality of sound
        - Traffic, Nature, Human noise
        - Pleasant, annoying, …




ELSEVIER

Computers, Environment and Urban Systems

Sensing urban soundscapes from street view imagery

Tianhong Zhao, Xiucheng Liang, Wei Tu, Zhengdong Huang, Filip Biljecki

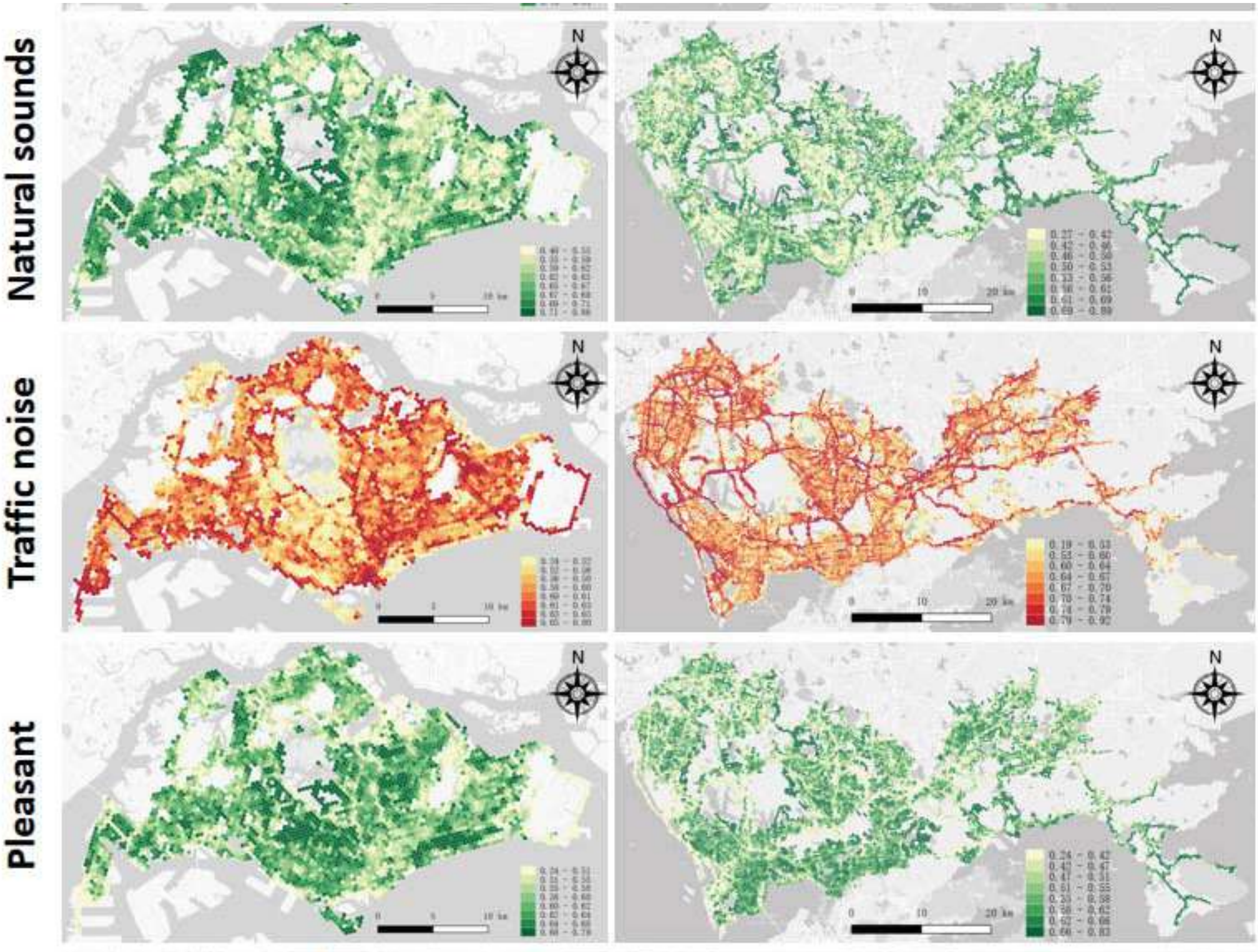
ARTICLE INFO

ABSTRACT

1. Introduction

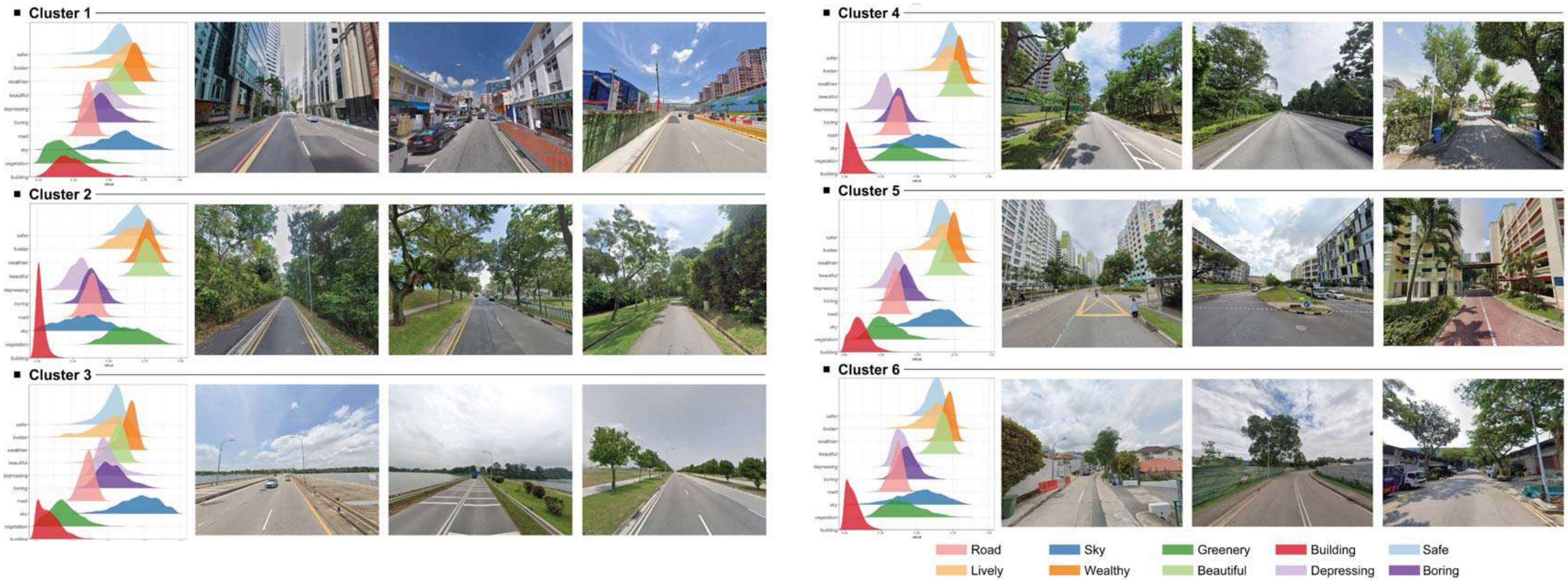
Imagery source: Google Street View

Zhao T, Liang X, Tu W, Huang Z, Biljecki F (2023): Sensing urban soundscapes from street view imagery. Computers, Environment and Urban Systems 99: 101915


Natural sounds
Traffic noise
Pleasant
N
0
10
20 km

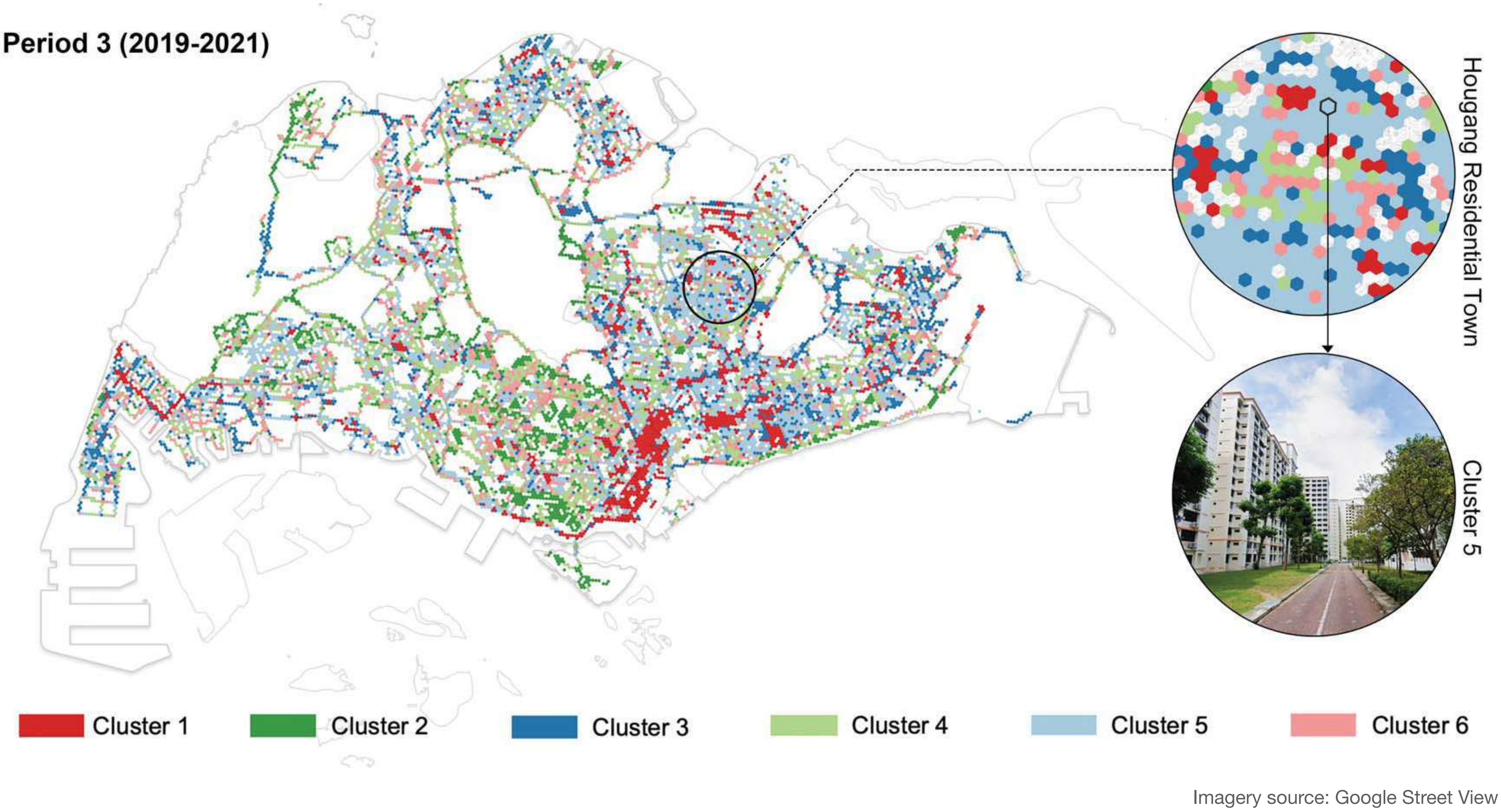
Revealing spatio-temporal evolution of urban visual environments

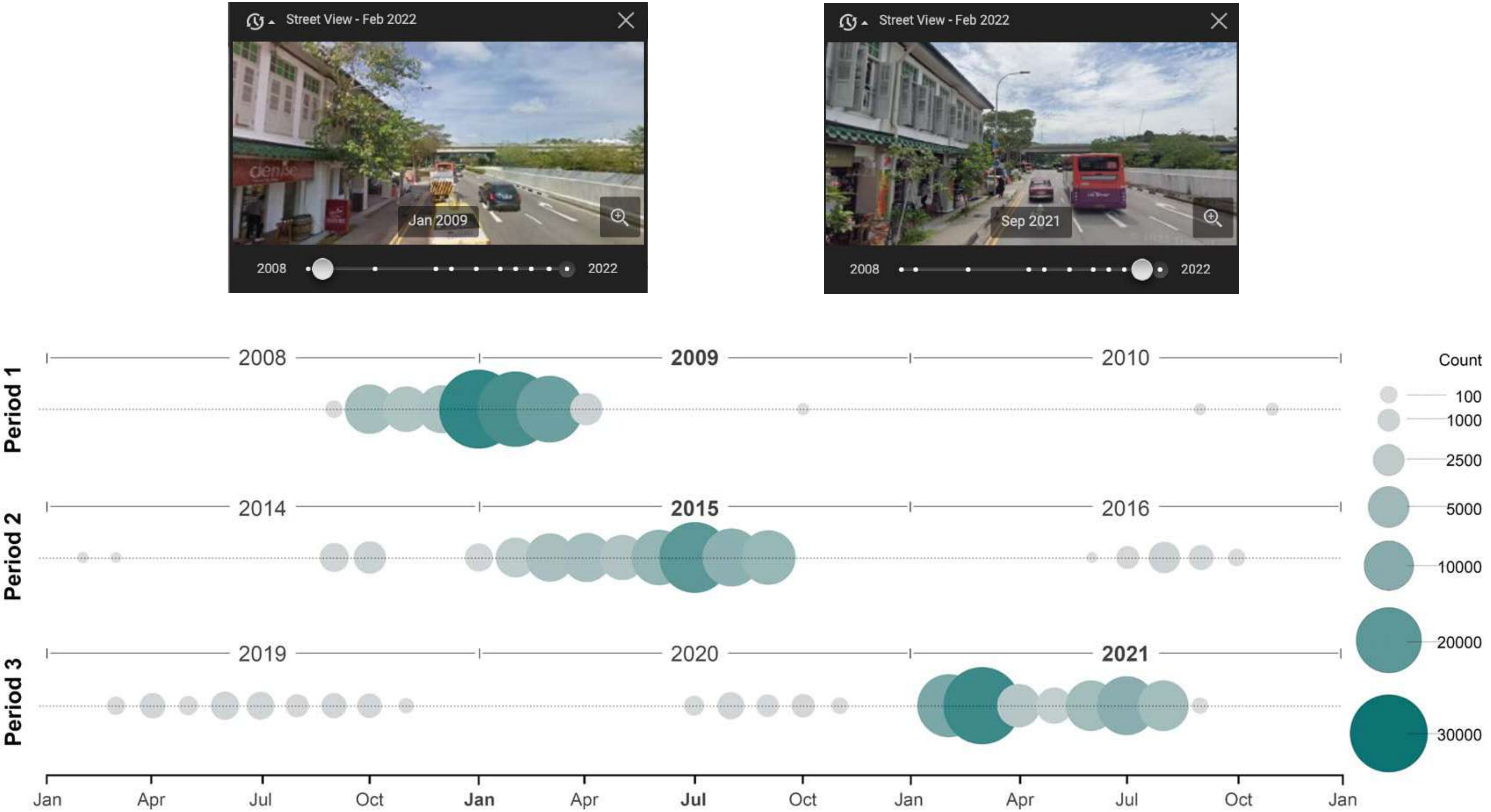
Research led by Liang Xiucheng



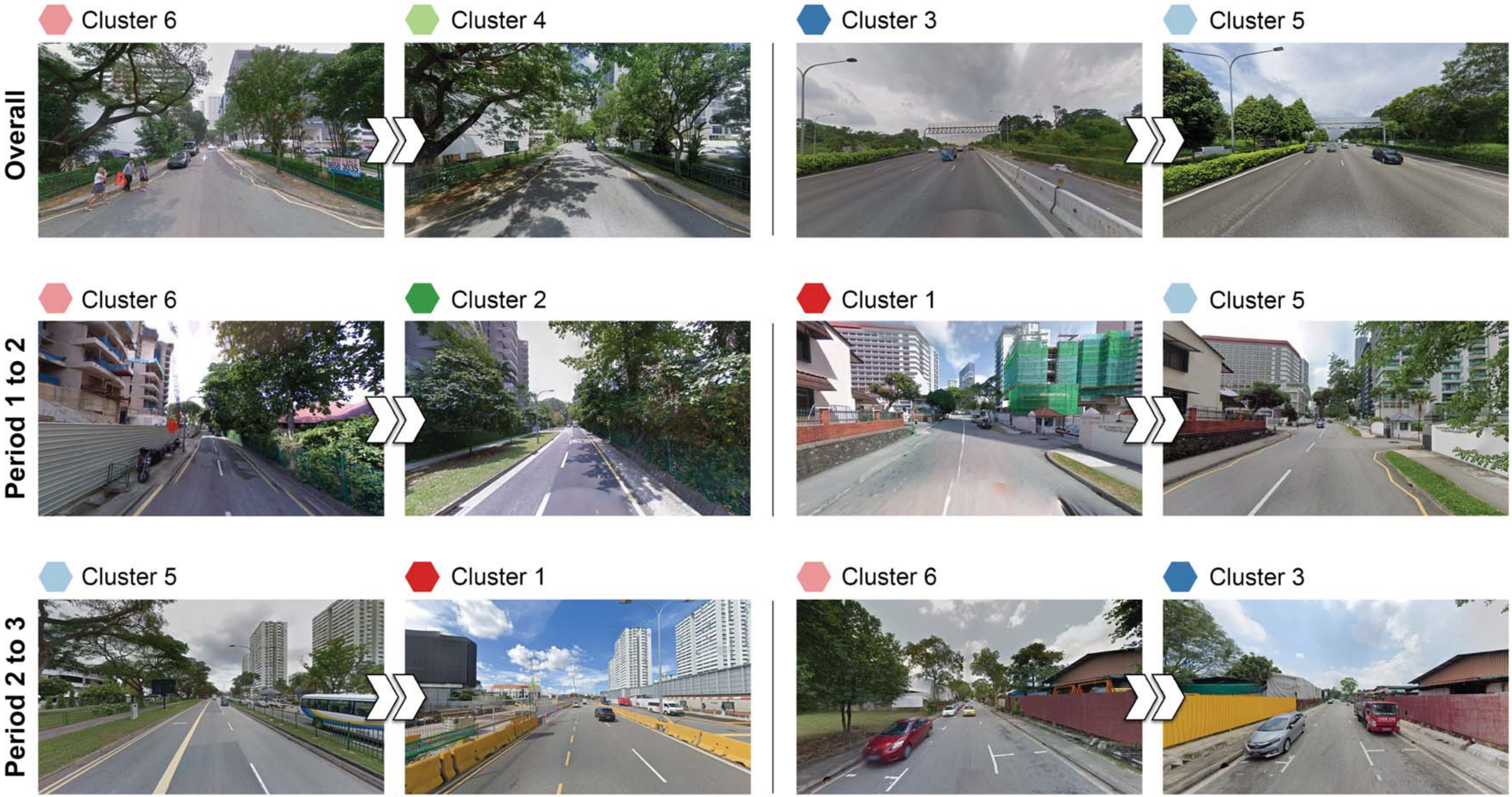
1 — Urban Jungle; 2— Flanked by Nature; 3— Expansive Horizons; 4— Balanced Living; 5— Concrete Heights; 6— Sparse Neighbourhoods

Imagery source: Google Street View

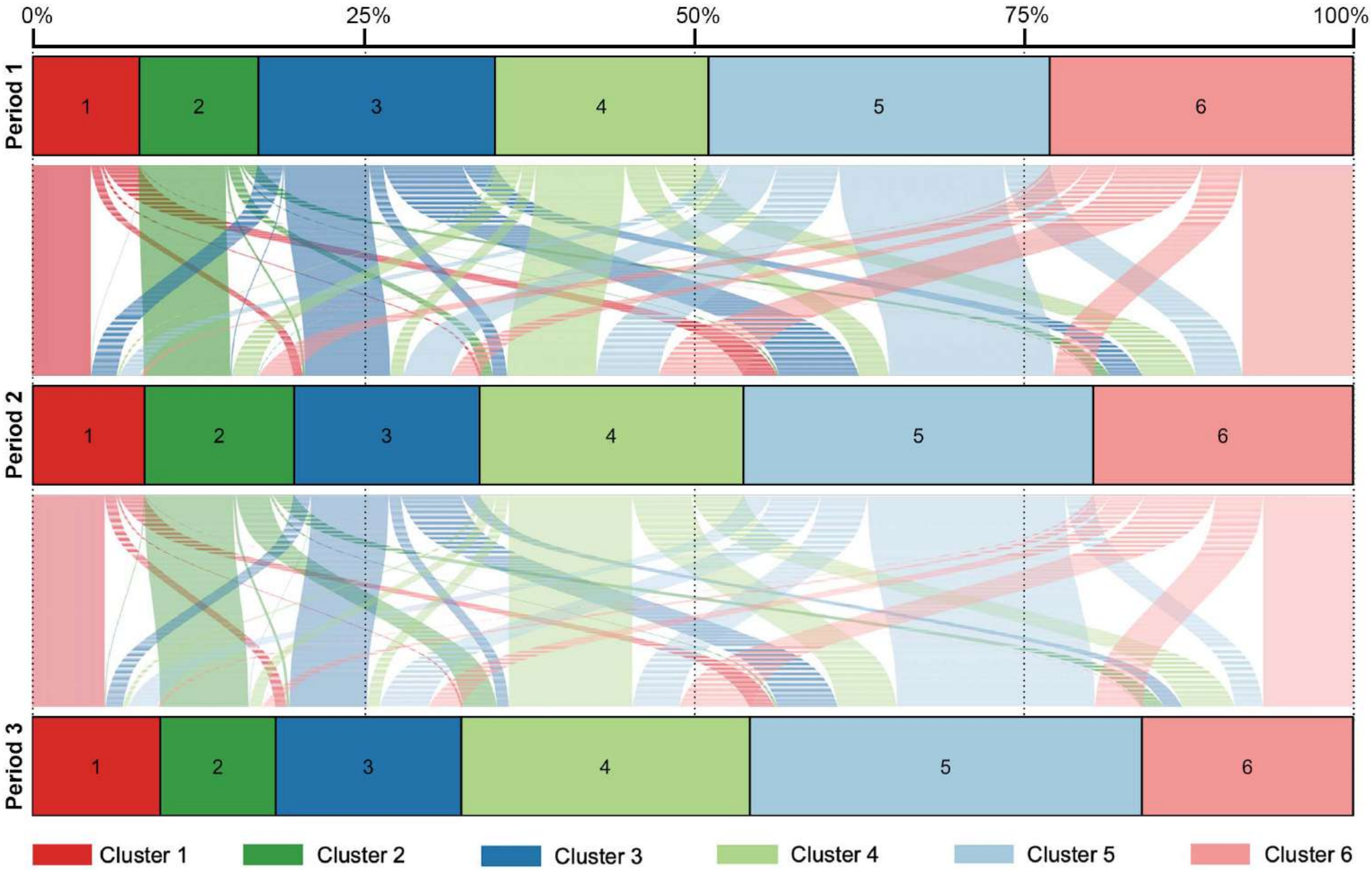

Period 3 (2019-2021)
Hougang Residential Town
Cluster 5
Cluster 1
Cluster 2
Cluster 3
Cluster 4
Cluster 5
Cluster 6
Imagery source: Google Street View



Imagery source: Google Street View



Imagery source: Google Street View


0%
25%
50%
75%
100%
Period 1
Period 2
Period 3
1
2
3
4
5
6
Cluster 1
Cluster 2
Cluster 3
Cluster 4
Cluster 5
Cluster 6

Concluding remarks…

- Understanding the entire ‘geo-pipeline’ is beneficial — urban analytics should transcend applications and include data production, standards, quality, …
- Much of these developments and new use cases are enabled by novel data and advancements in data science/(Geo)AI, but data availability & quality remain an important consideration
    - Crowdsourced data plays a role too
        - Crowdsourced data will grow in importance and availability. Various advantages over other sources of data, but also complementary

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Funding & support: NUS, Takenaka Corporation, NRF, FCL Global, AWS, Google

Steven Jige Quan

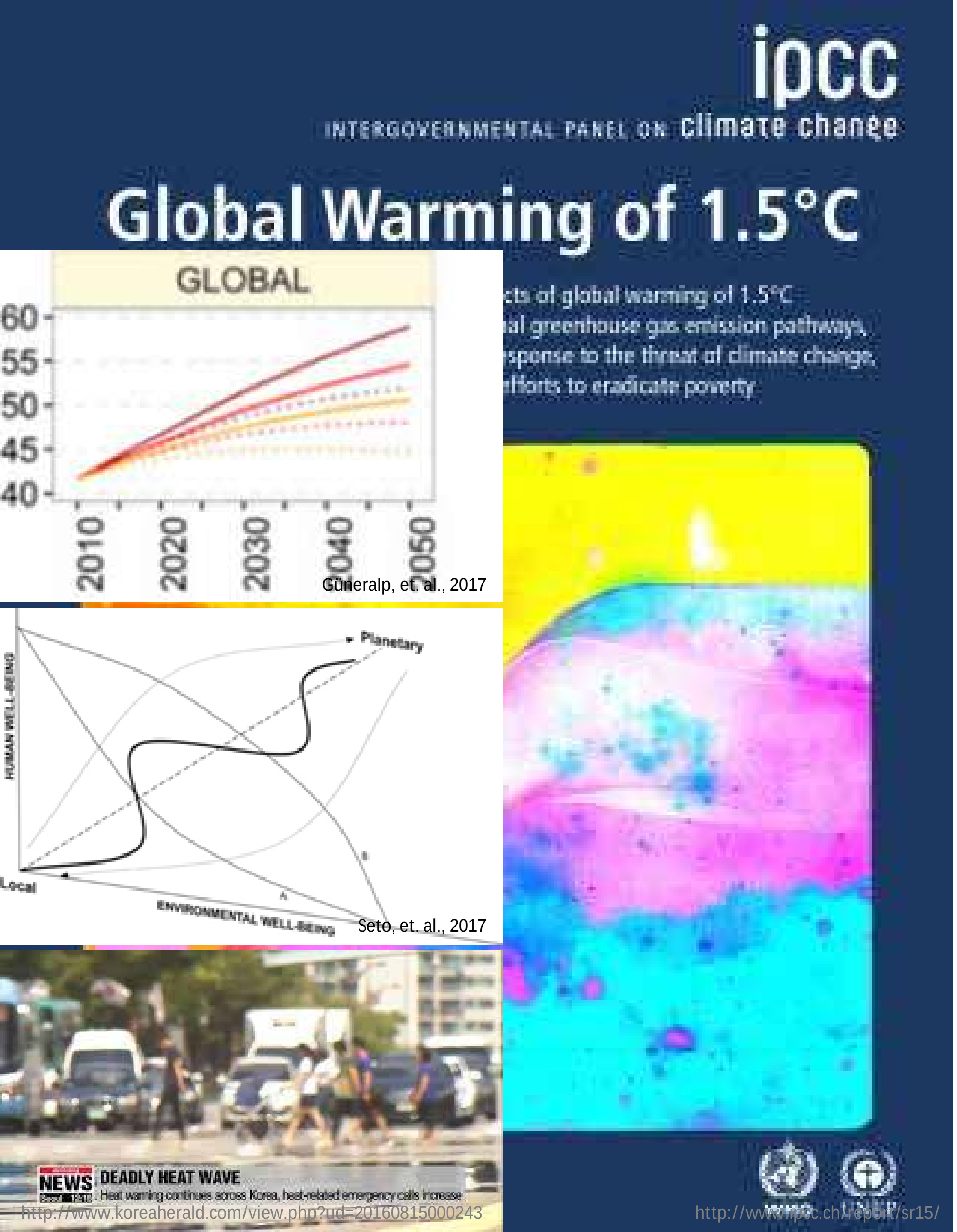
sjquan@snu.ac.kr
Seoul National University

Addressing Urban Complexity with AI Toward Sustainable City Future

The imperative of urban sustainability takes on heightened importance in the face of climate change. However, research in this domain often grapples with the high level of complexity in the urban environment. At the same time, the rapid advancements in AI in recent years provide innovative methodologies and insights for addressing such a challenge. This study discusses the promising potential of using AI to better reveal, represent, and reshape urban complexity, drawing upon research projects of the City Energy Lab at Seoul National University, South Korea. Furthermore, the study explores emerging theories in AI-aided environmental planning and design, underscoring their significance in bolstering a sustainable city future.

Addressing Urban Complexity with AI Toward Sustainable City Future

Steven Jige Quan, Associate Professor
City Energy Lab
Graduate School of Environmental Studies
Artificial Intelligence Institute
Seoul National University



Güneralp, et. al., 2017

Seto, et. al., 2017

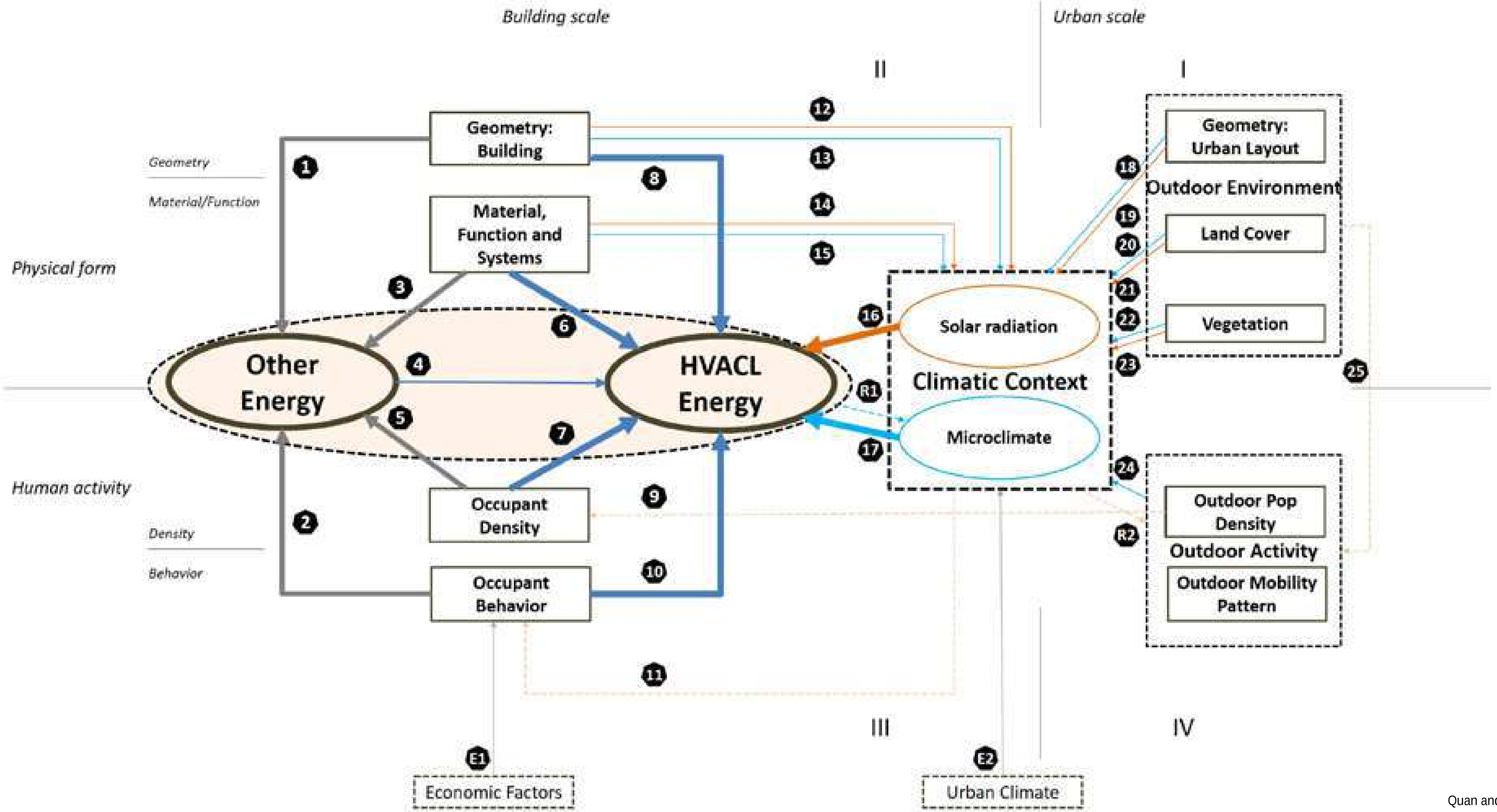
http://www.koreaherald.com/view.php?ud=20160815000243

http://www.ipcc.ch/report/sr15/

How Do We Utilize the Power of AI to Better Understand and Design Our Cities Toward Sustainability?

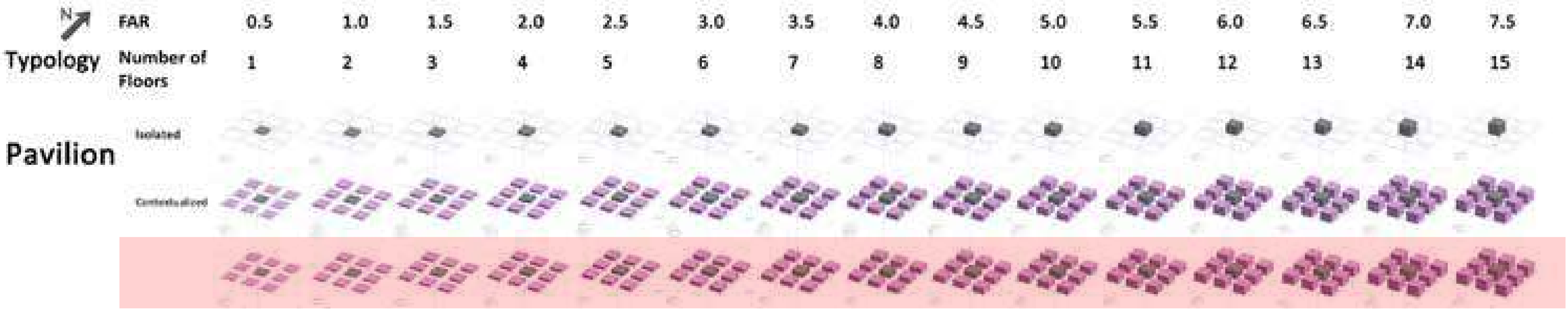
Revealing Urban Complexity: Interactions and Nonlinearity

Complex Urban Systems: Mechanisms Behind Form-Energy Relationship

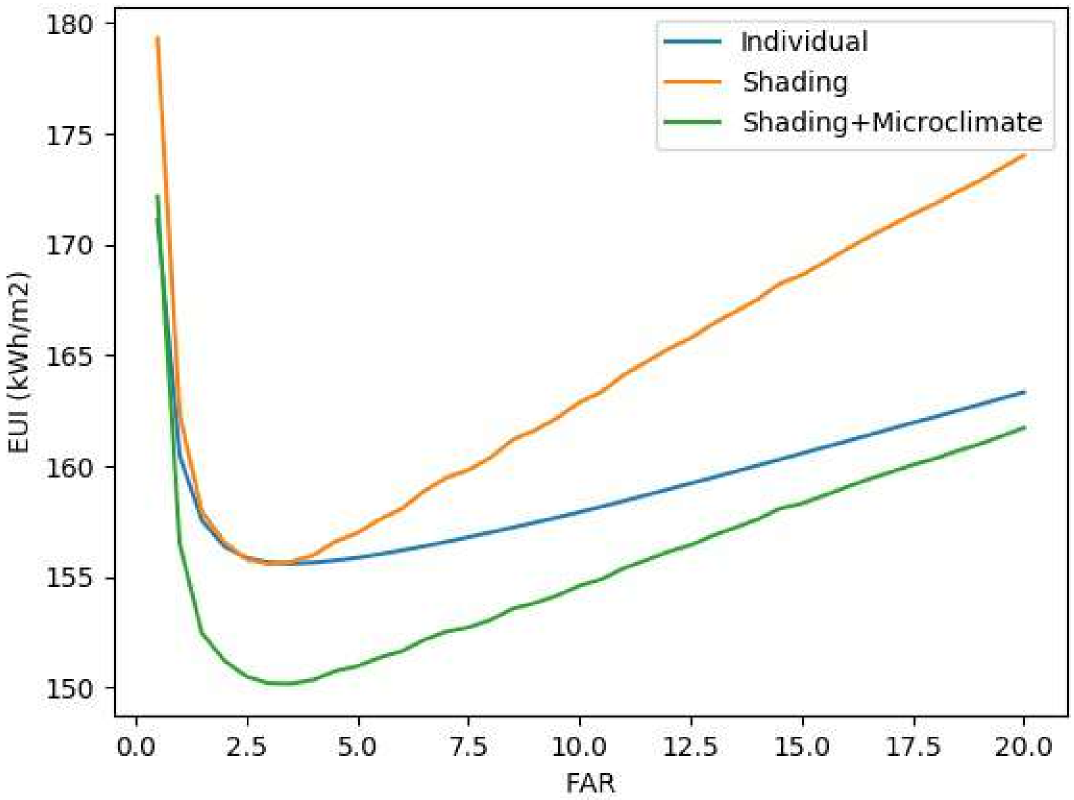


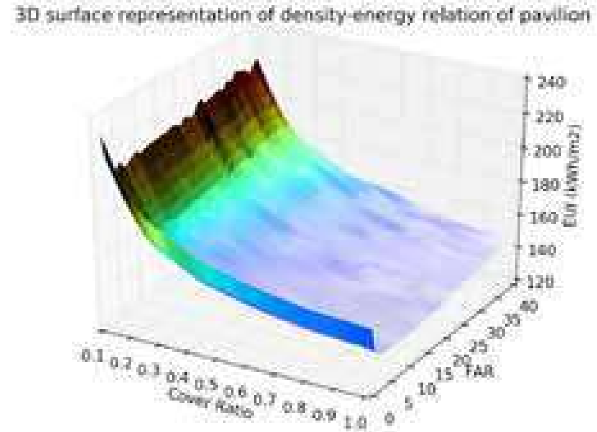
Quan and Li, 2021

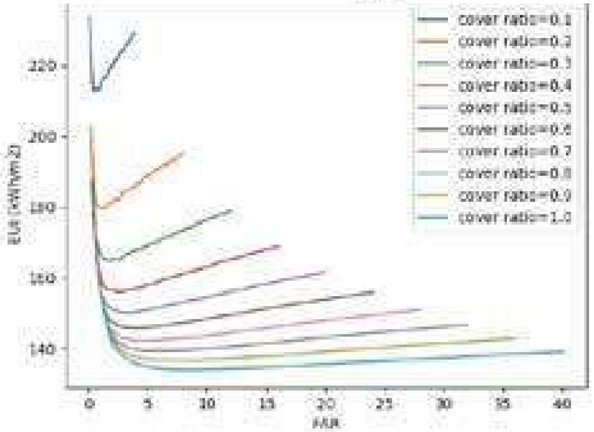
Simulations Suggest Strong Interactions and Nonlinearity



Cover Ratio = 0.5, Number of Floors: 1~40, FAR: 0.5~20

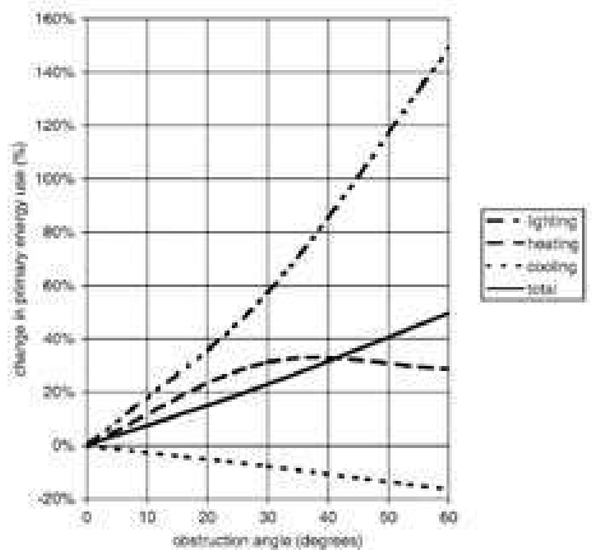






Quan et. al., 2020

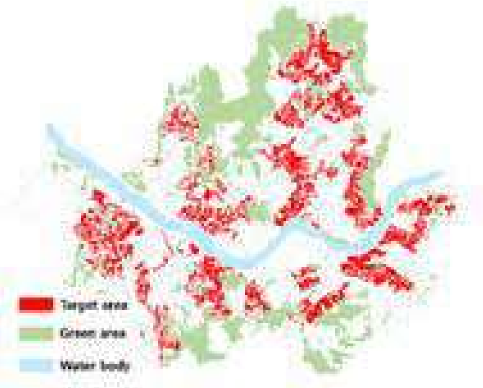
- **Simplified urban settings**
- **Computationally heavy**



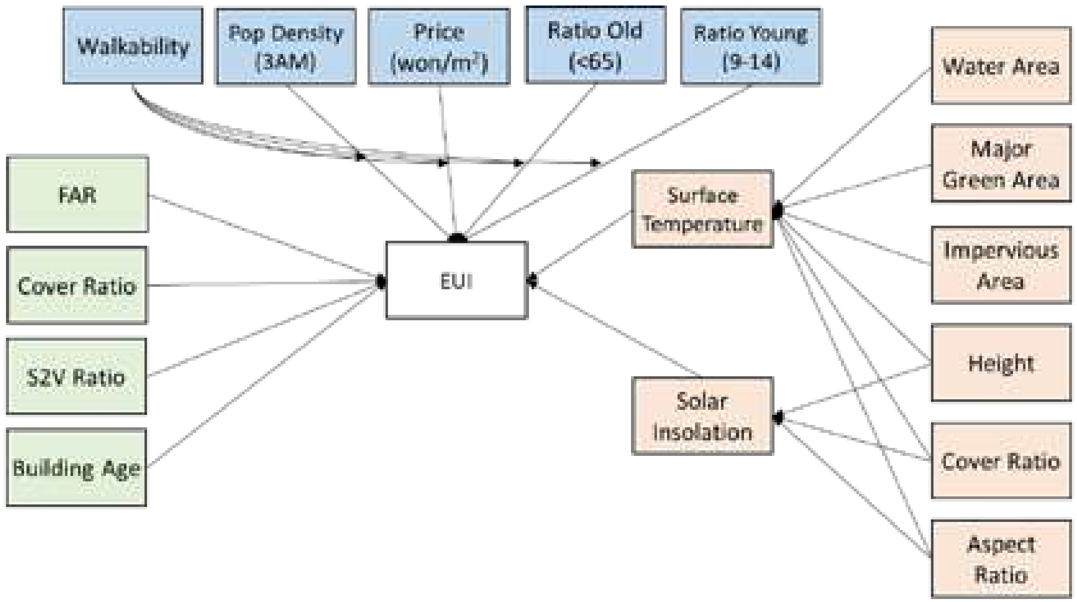
Steemers & Ratti, 1999

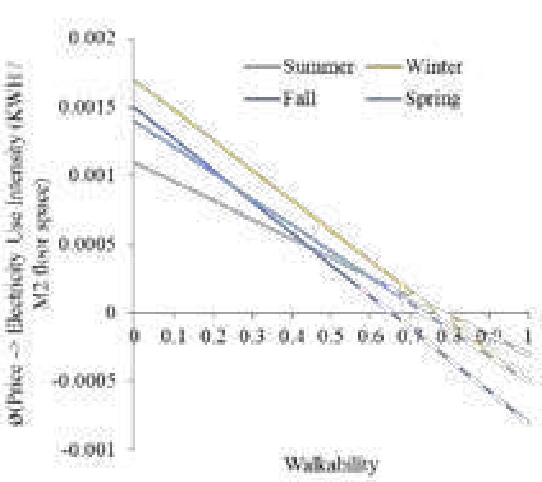
Statistical Models to Approximate Urban Complexity

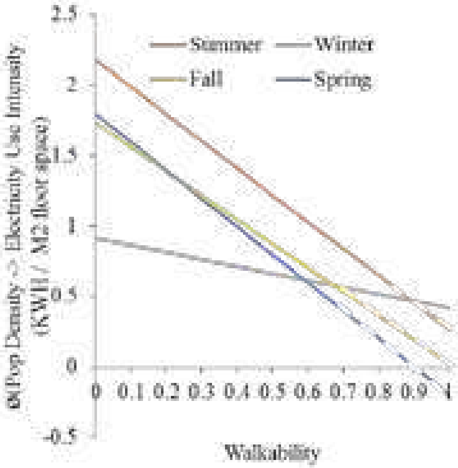
- **Limited in modeling interactions and nonlinearity**
- **Requires assumptions**



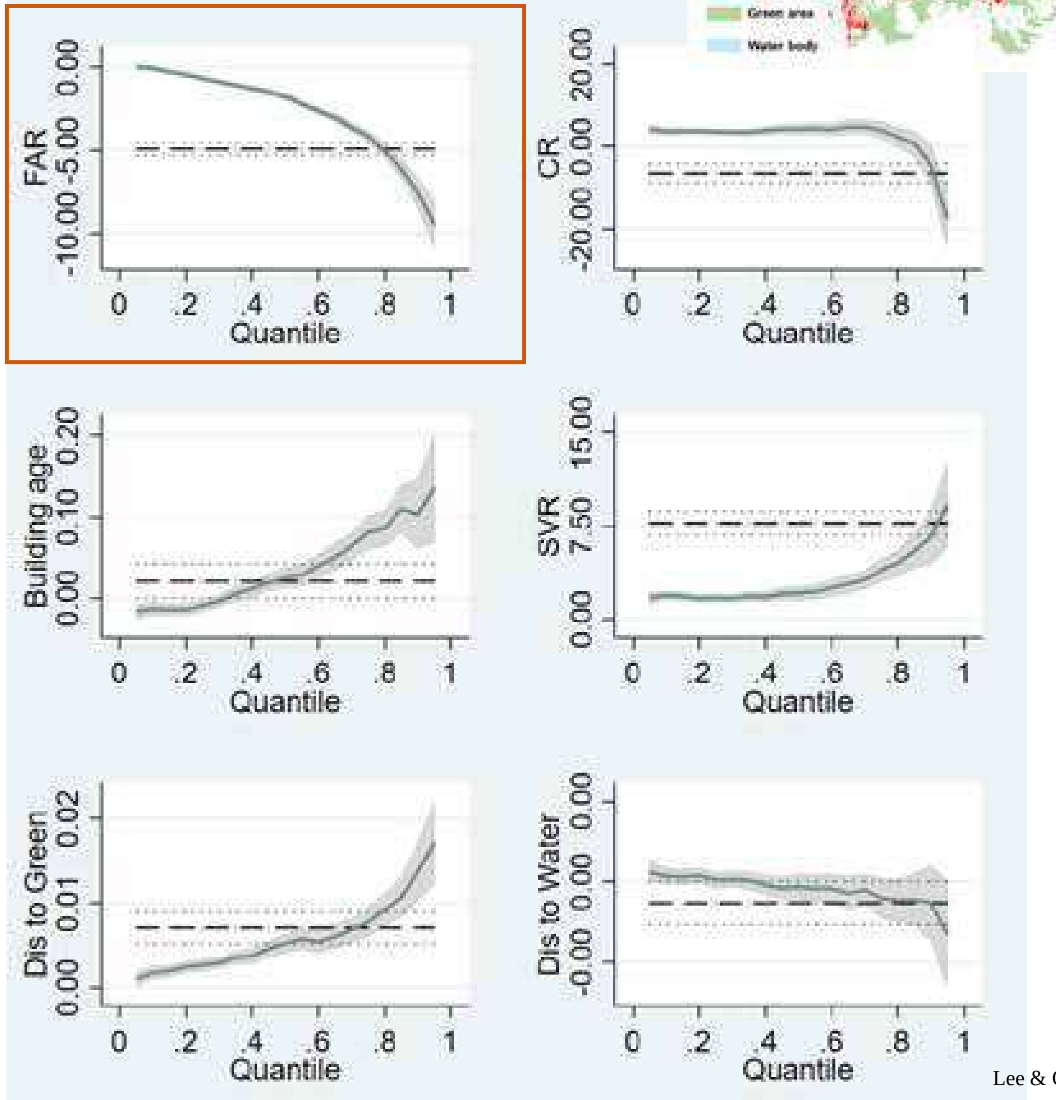
Variable Transformation & Using Interaction Terms







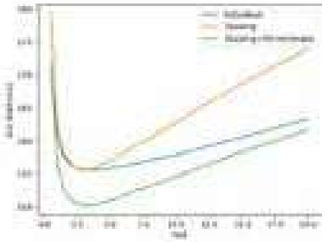
Quantile Regression Model



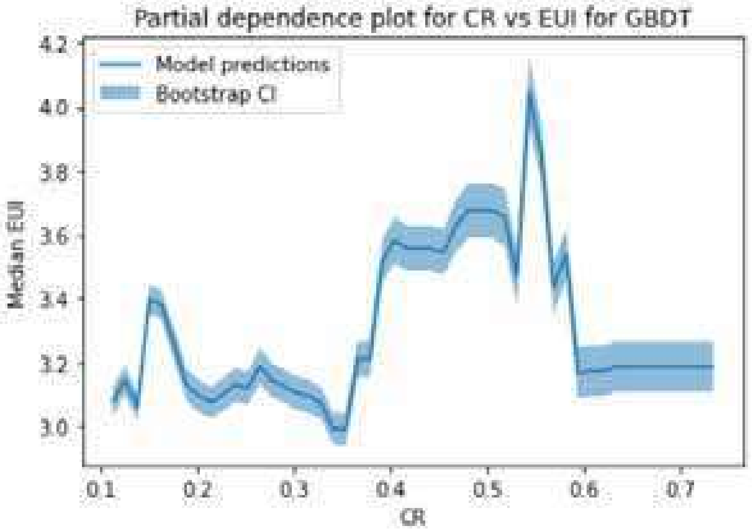
Lee & Quan, 2021

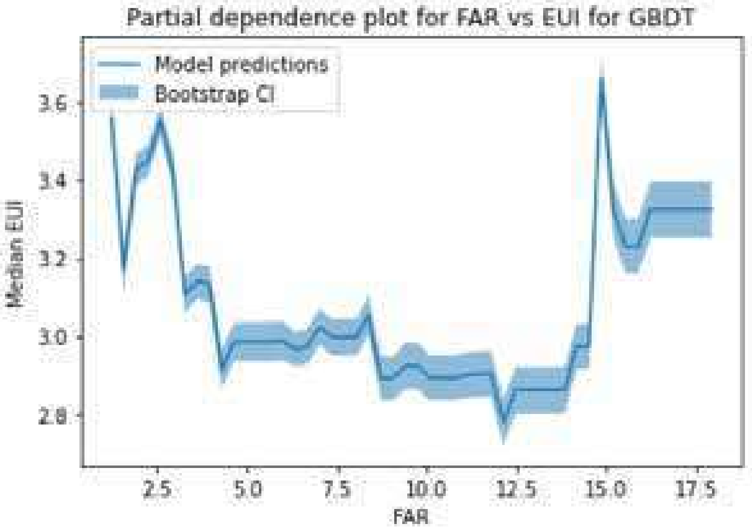
Machine Learning to Reveal Nonlinearity

- XGBoost
- GBDT



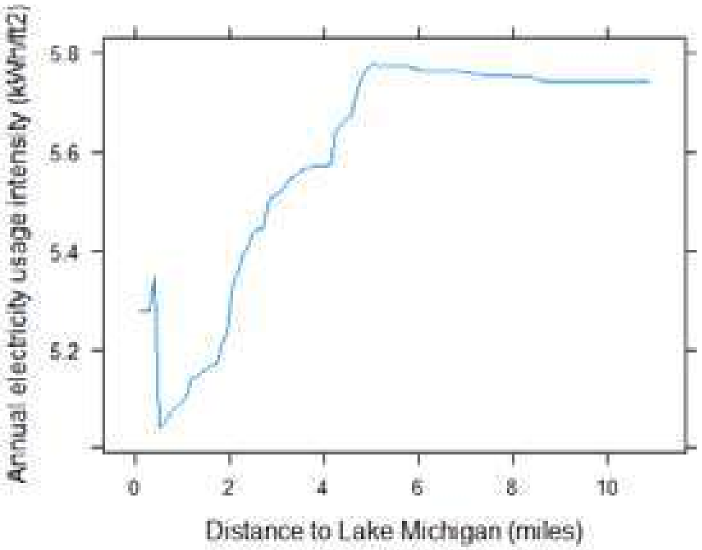
Seoul

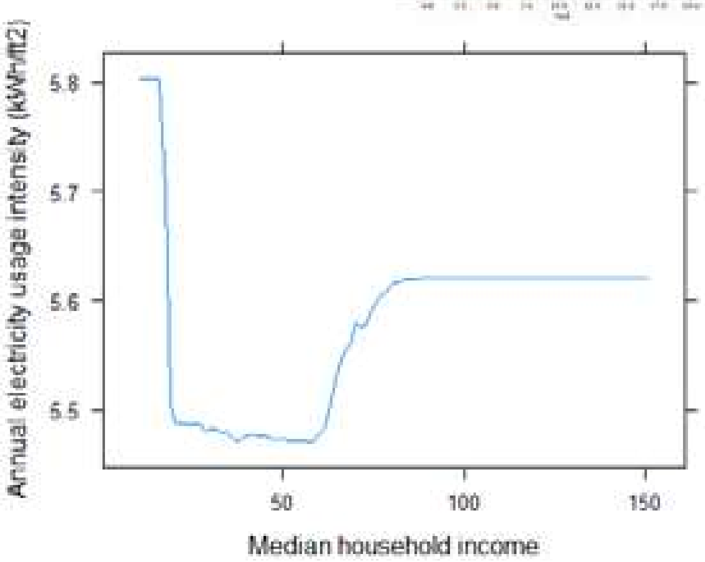


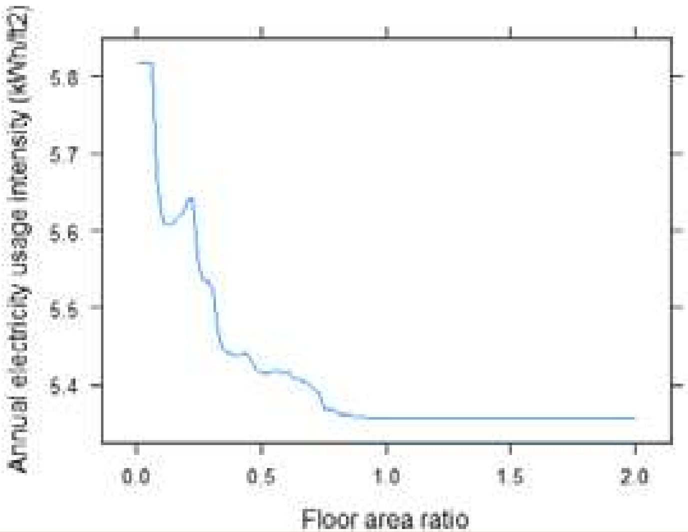


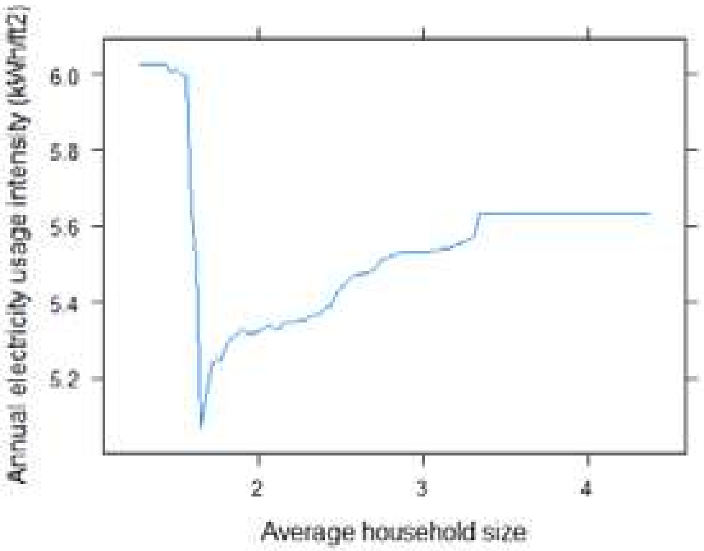
Lee & Quan, 2022

Chicago



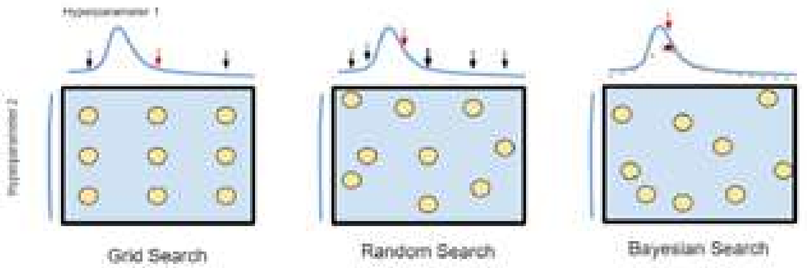




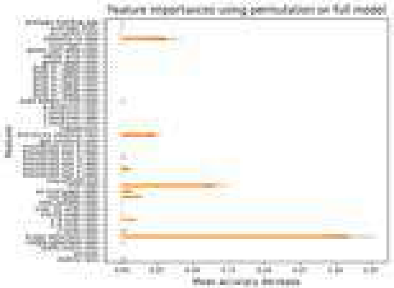


Yang, Quan & Li, 2022

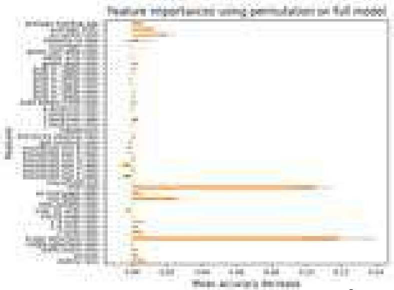
Feature Importance of Learning Models – Unravelling the Complexity



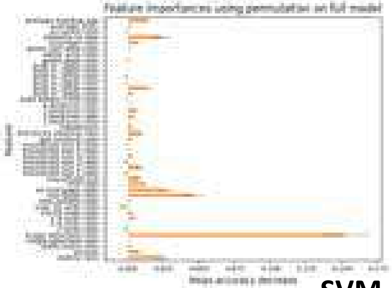
https://towardsdatascience.com/hyperparameter-tuning-always-tune-your-models-7db7aeaf47e9



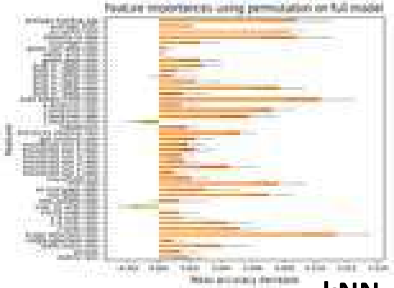
Decision Tree



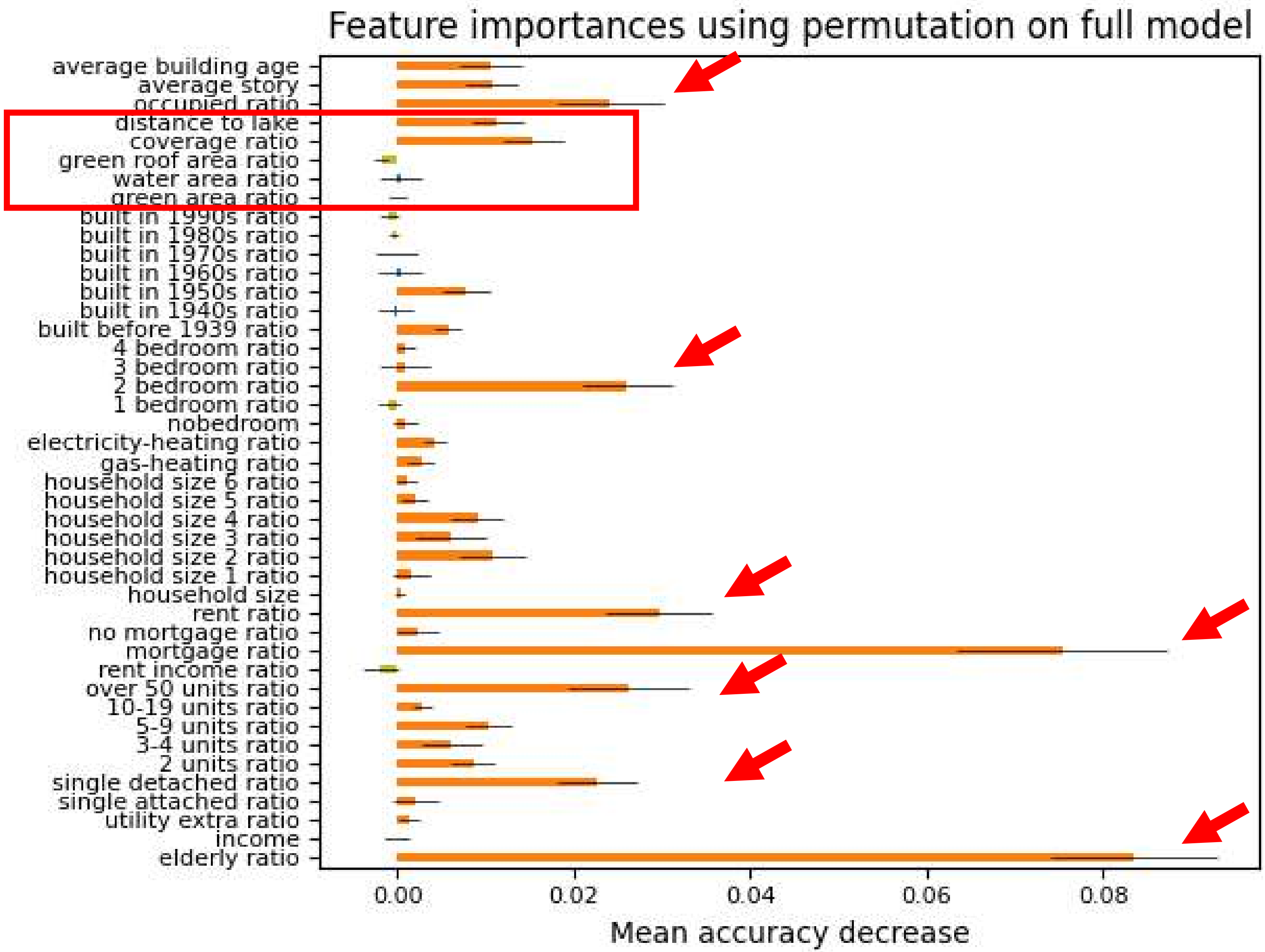
Boosting



SVM



kNN

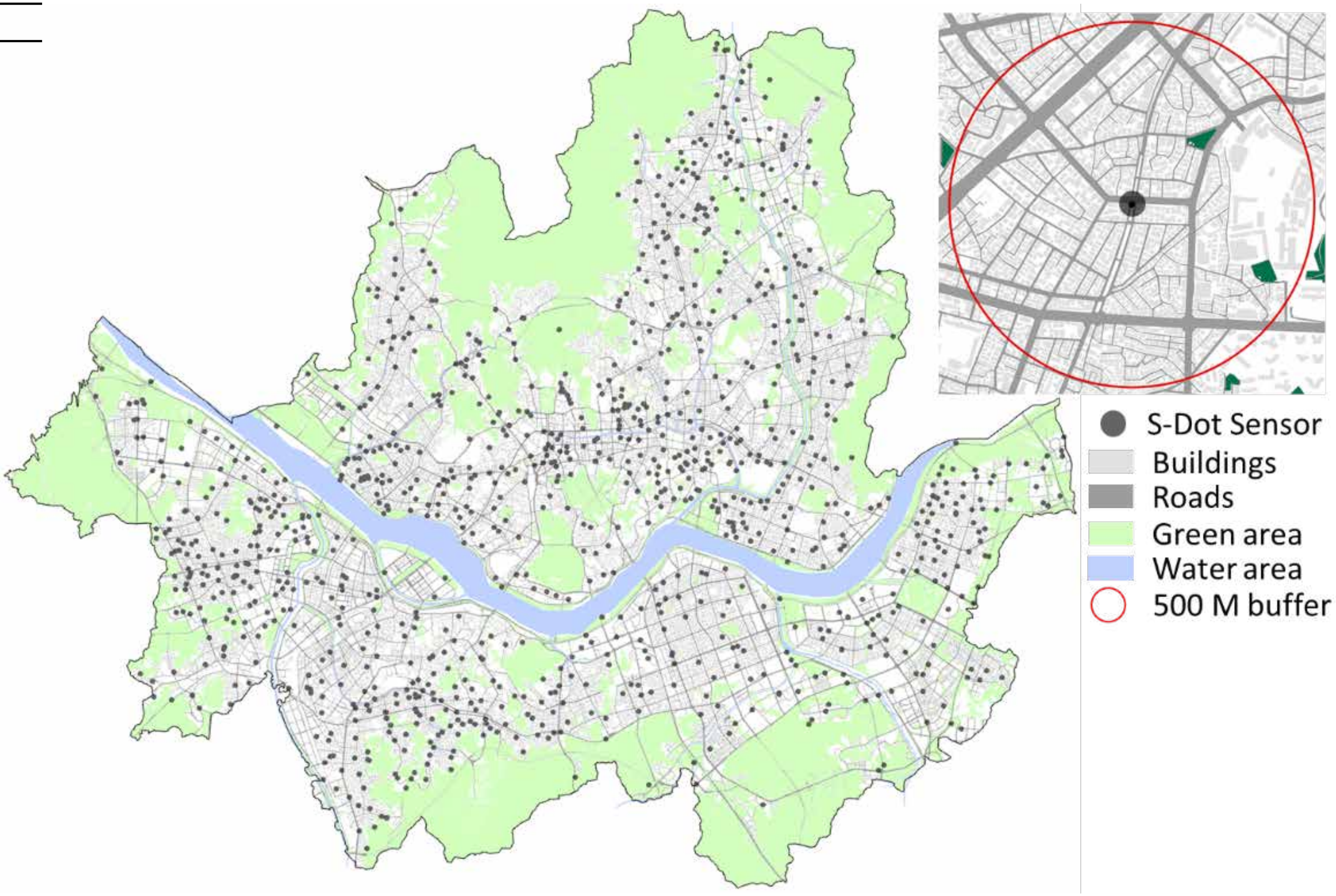


Quan, 2021

Spatial Location

- GBDT
- Spatial location

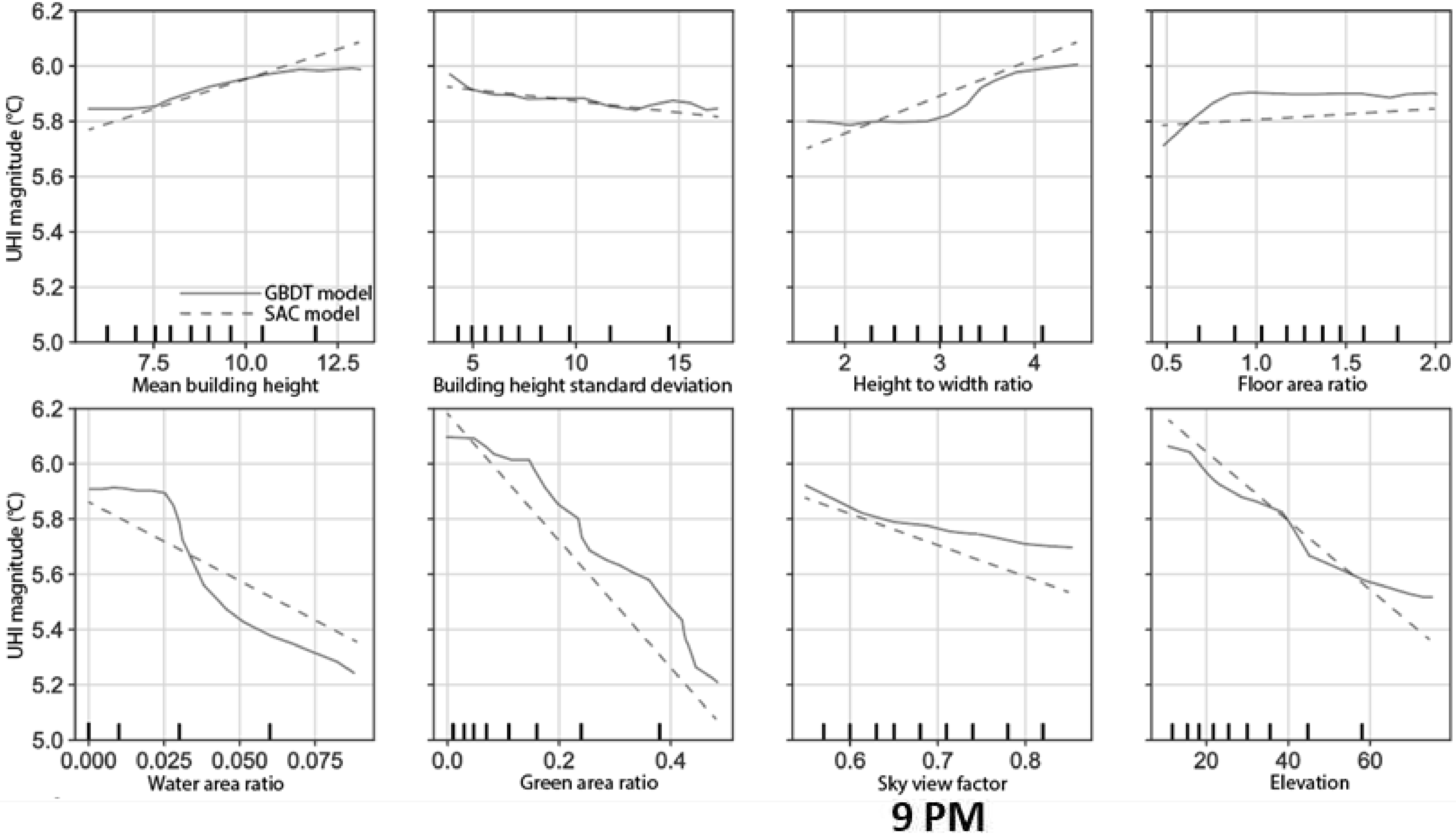
Metric	Model type	9:00 AM	3:00 PM	9:00 PM
MSE	OLS	0.36	1.21	0.30
	SAC	0.32	1.15	0.25
	GBDT	0.25	1.12	0.21
	GBDT-LL	**0.24**	**1.09**	**0.19**
MAE	OLS	0.42	0.94	0.41
	SAC	0.40	0.91	0.38
	GBDT	0.34	0.81	0.31
	GBDT-LL	**0.33**	**0.79**	**0.30**
MAPE	OLS	0.14	0.25	0.12
	SAC	0.13	0.22	0.10
	GBDT	0.10	0.19	0.07
	GBDT-LL	**0.09**	**0.17**	**0.06**
R^2	OLS	0.51	0.21	0.55
	SAC	0.56	0.25	0.58
	GBDT	0.63	0.29	0.67
	GBDT-LL	**0.65**	**0.32**	**0.68**



Parth & Quan, 2023

Comparison with Traditional Regression

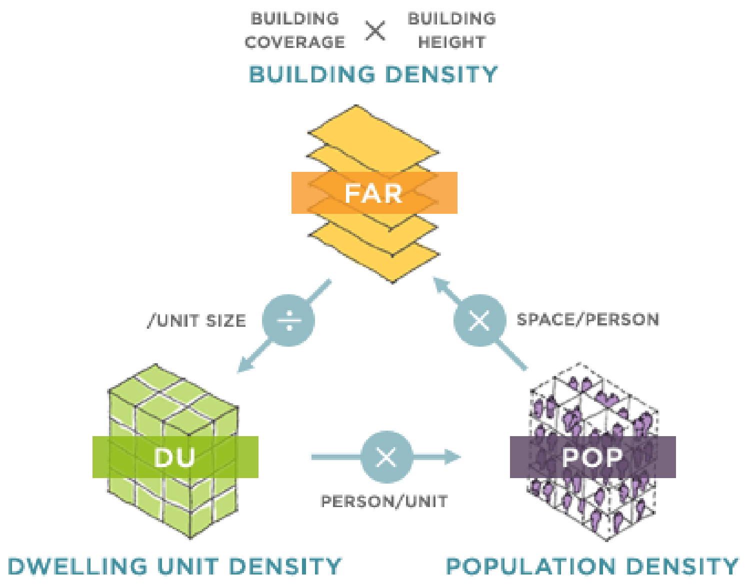
- PDPs
- PPs

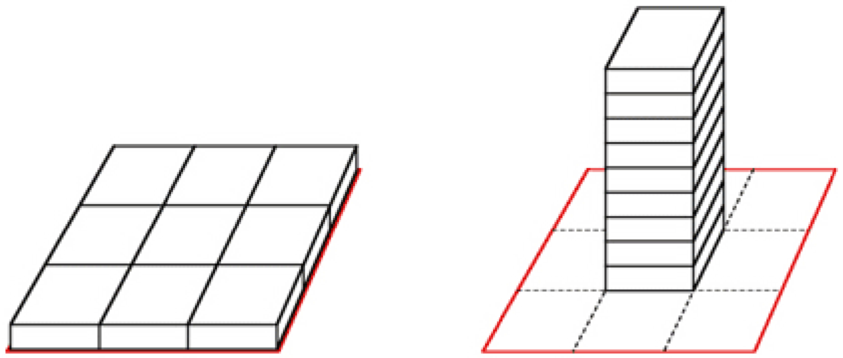


Parth & Quan, 2023

Representing Urban Complexity: From Indicator to Typology

How Do We Represent Urban Form – Conventional Indicator Approach





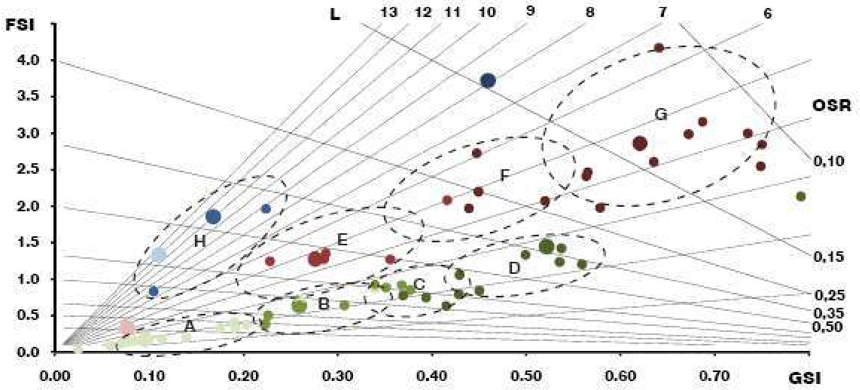
FAR = 1.0
COVERAGE = 100%

FAR = 1.0
COVERAGE = 11%

Three types of measurements of urban density and the development with the same FAR and different Coverages (MIT Densityatlas 2011a)

Type	Indicators
Density measures	Floor area ratio (FAR)[a], coverage ratio (CR)[a], population density, dwelling unit density, urban sprawl index
Geometric measures	Surface-volume ratio (S/V)[a], glazing ratio[a,b], height, building orientation, street height-width ratio (H/W)[a], sky view factor (SVF), street orientation, urban porosity
Land use and land cover (LULC) measures	Vegetation cover, road coverage ratio, impervious surface cover, water body index

Quan and Li, 2021

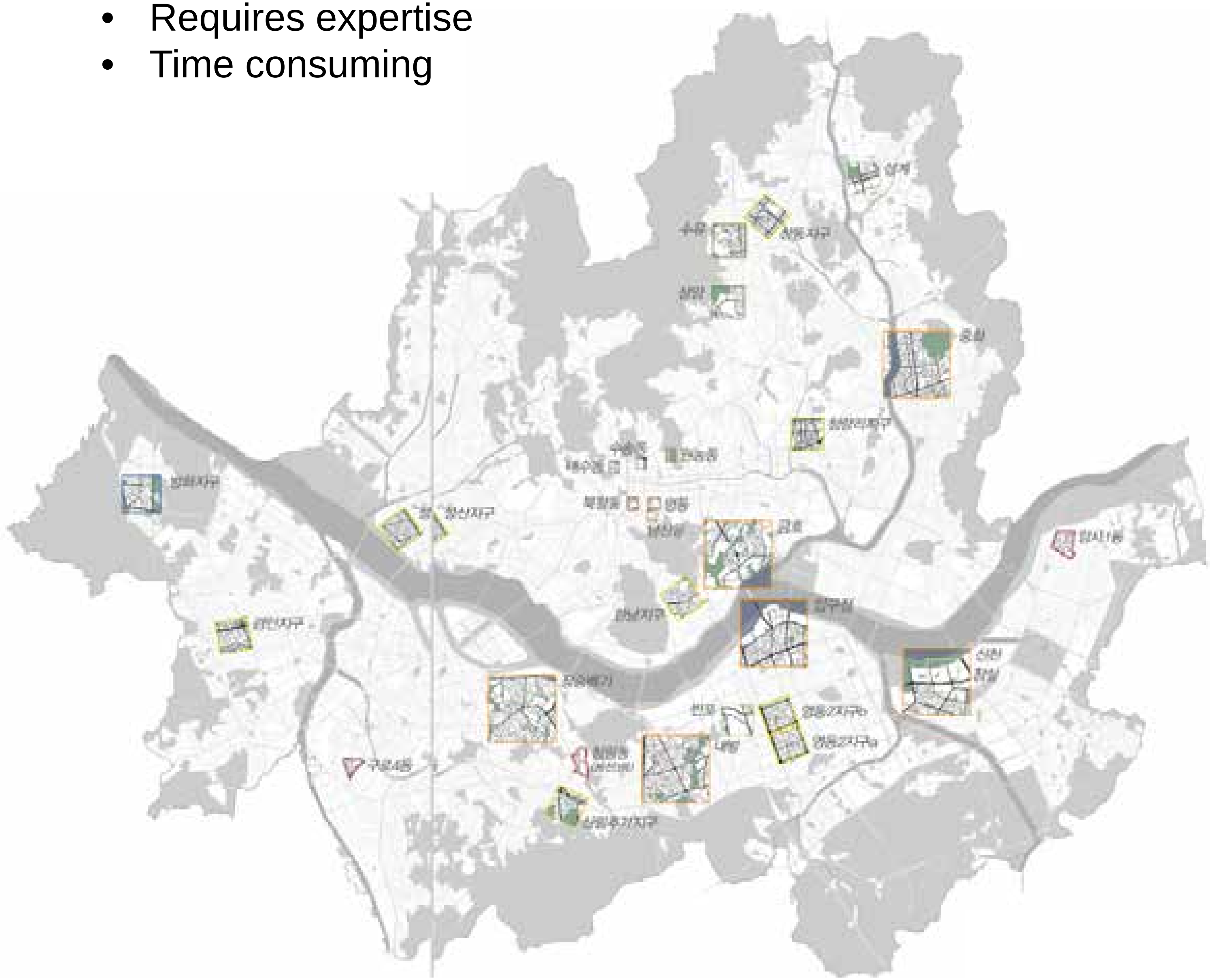


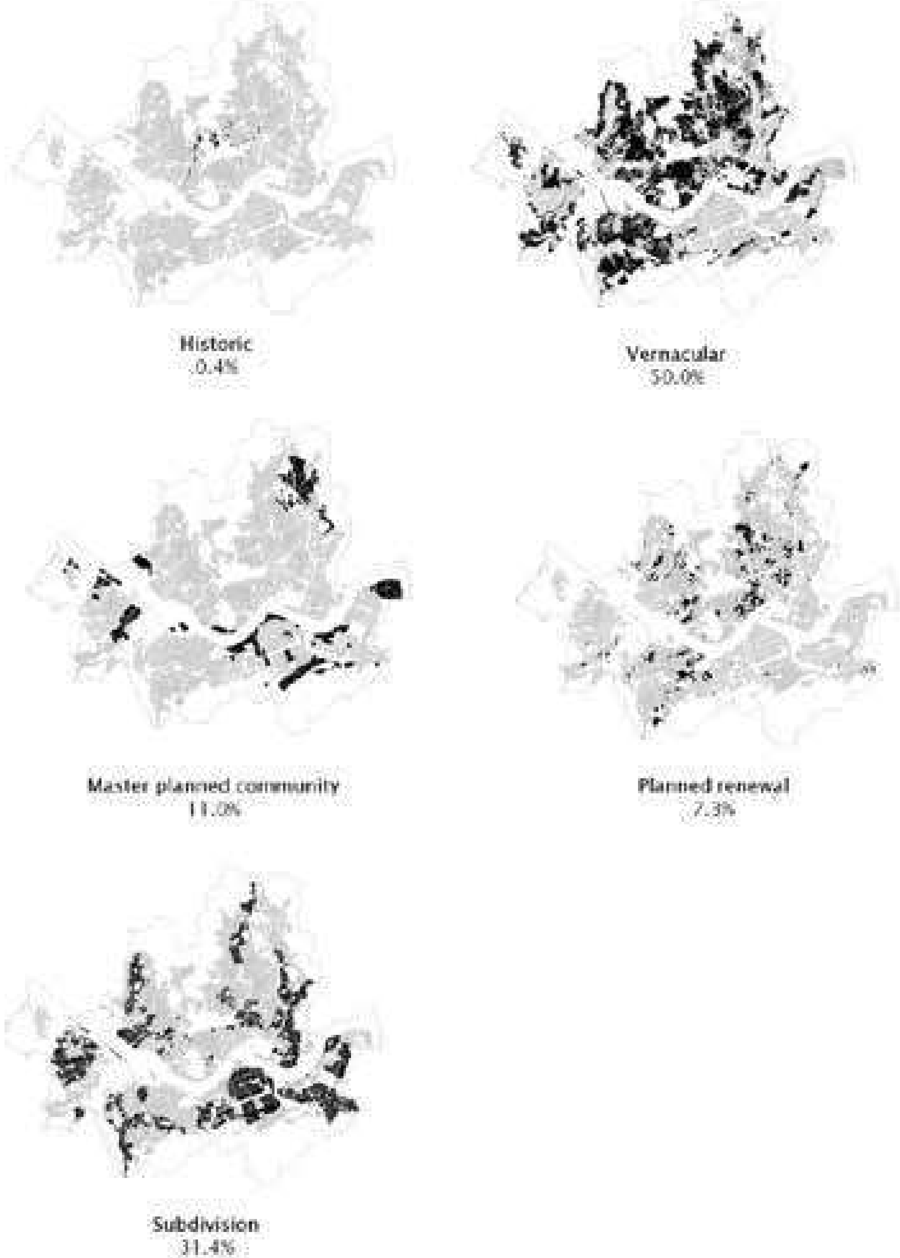
A	point type, low rise	E	street type, mid rise	Figure 13.
B	street type, low rise	F	hybrid street/block type, mid rise	Clusters of building
C	hybrid street/block type, low rise	G	block type, mid rise	types in Spacemate
D	block type, low rise	H	hybrid point/street type, high rise	(scale: island).

Pont & Haupt 2009

Manual Identification of Urban Form Typology

- Requires expertise
- Time consuming

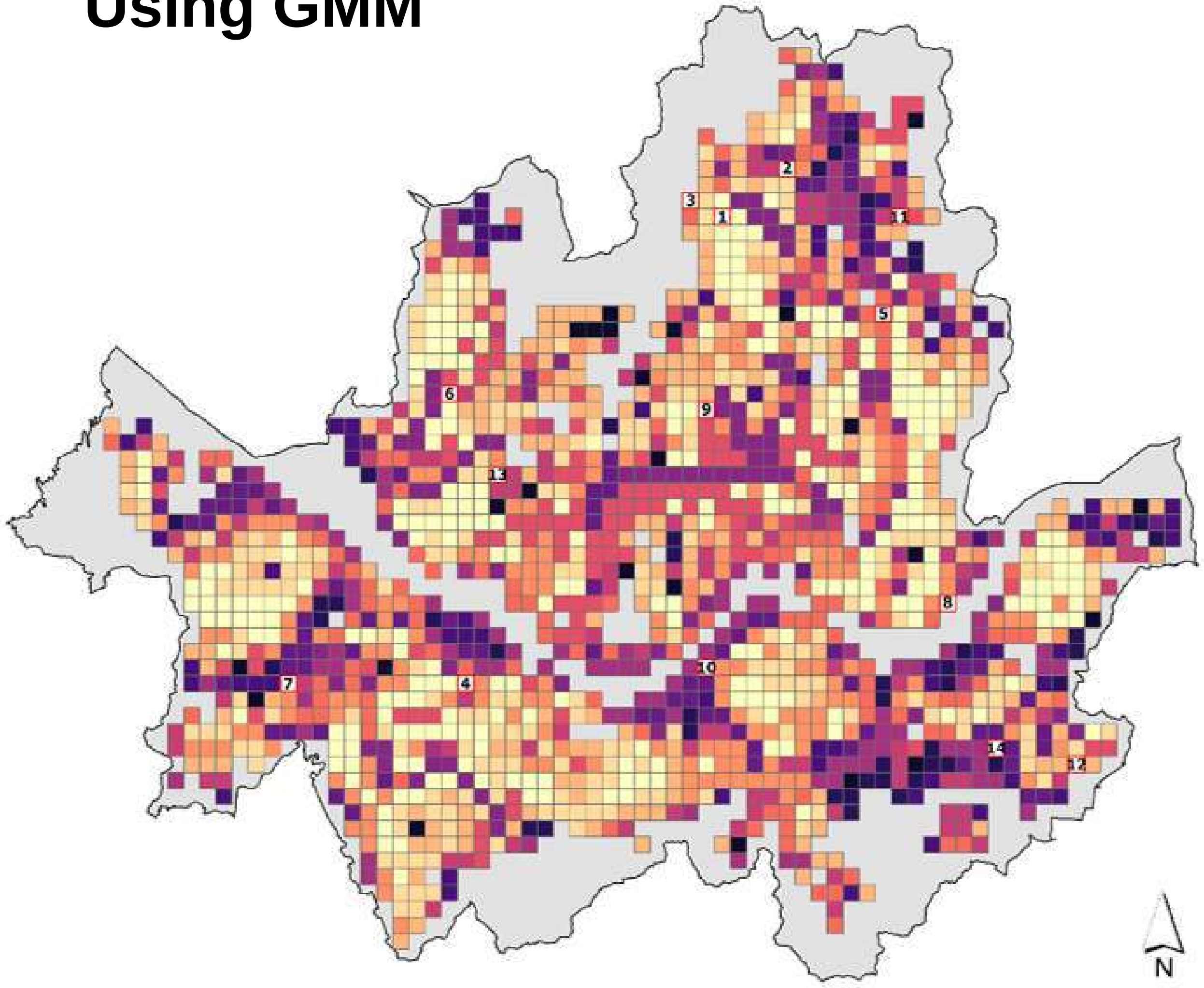


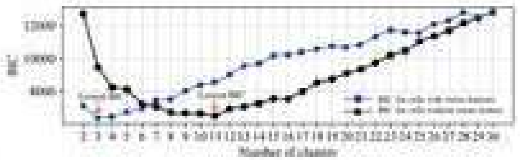


Park, H., et al., 2010 & Seoul Development Institute, 2010

Kim, K., et al., 2003

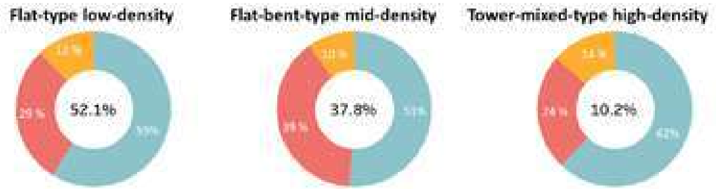
Identification of Urban Form Typology Using GMM

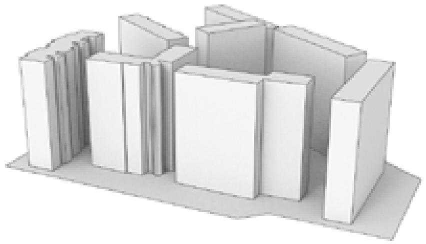


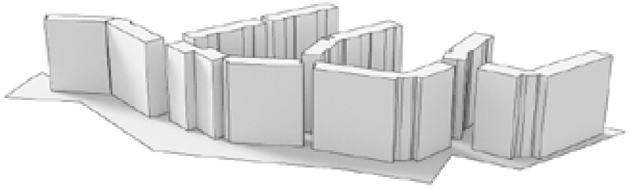


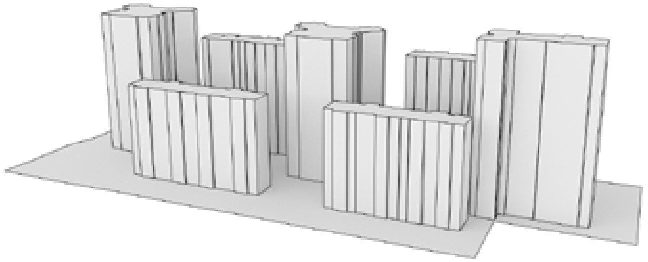
Li & Quan, 2022

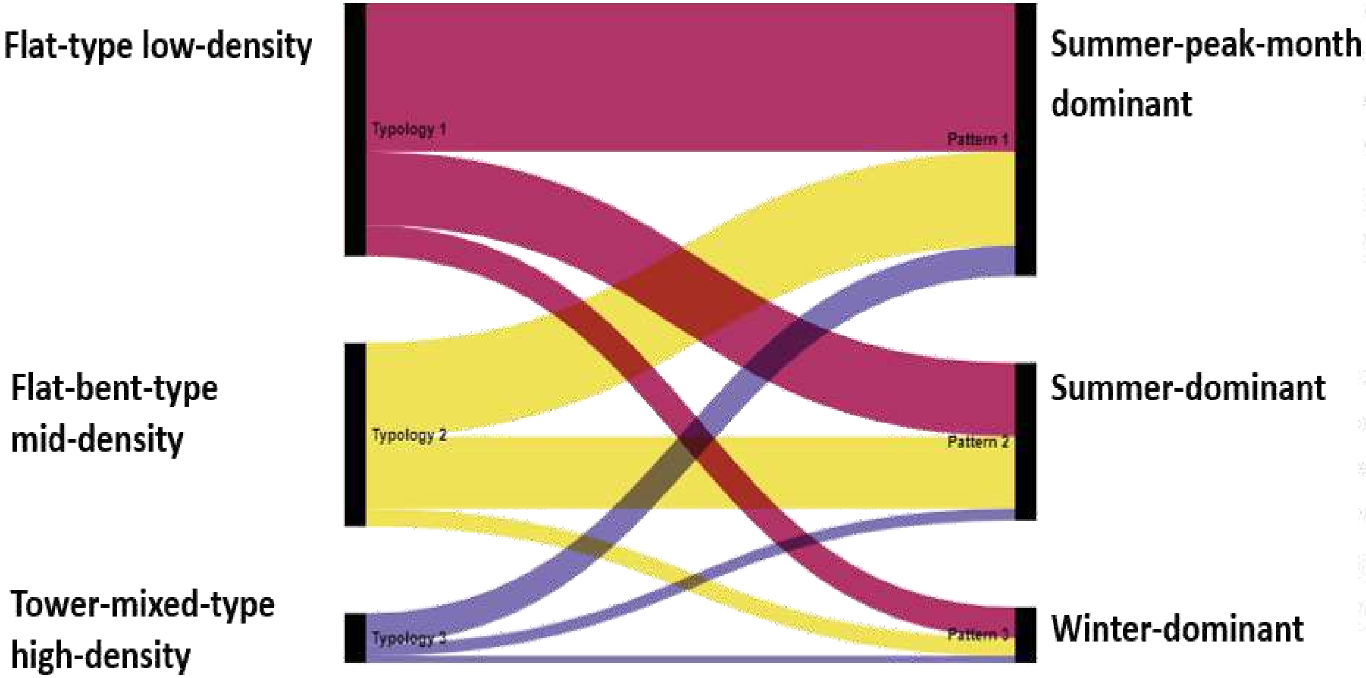
An Exploration of Form Typology and Energy Pattern

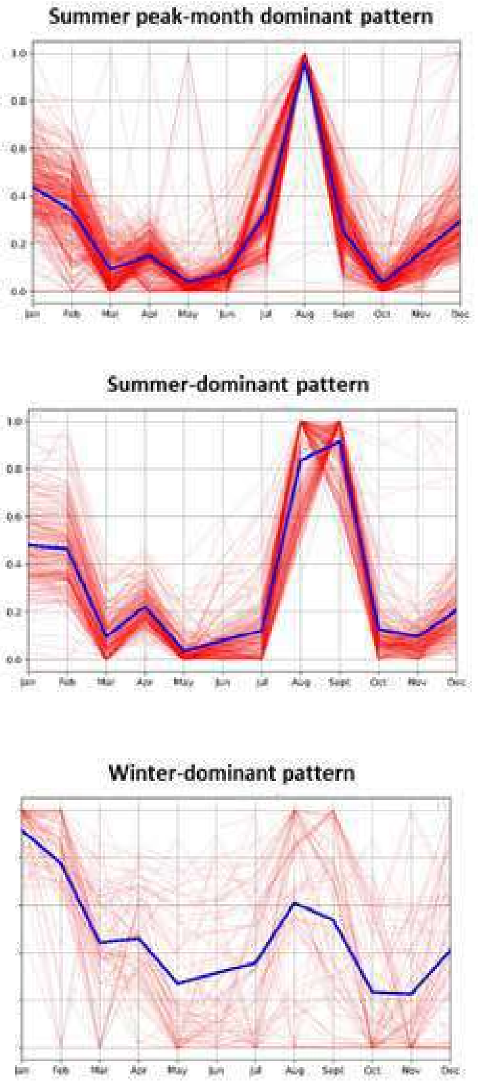


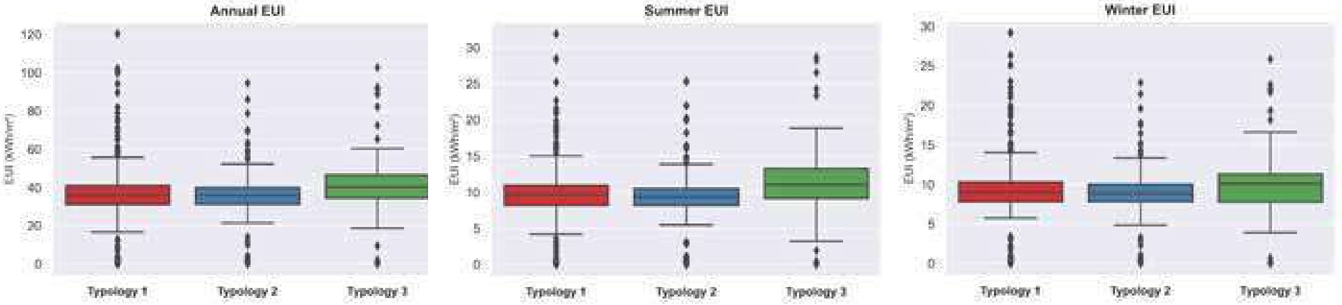












Li & Quan, 2023

Apply AI to Integrate Science Into Planning and Design Process

Reshaping Urban Complexity: AI-aided Design (AIAD)

Shanghai

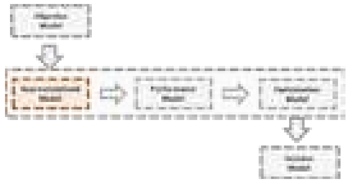
Design for Sustainable Neighborhoods:

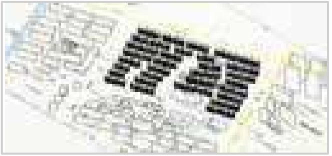
- **Economic outcome**

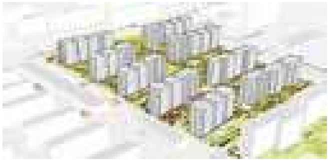
  Objective function:
  Maximizing FAR

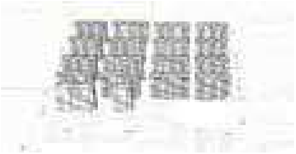
https://pixel.nymag.com/imgs/daily/intelligencer/2016/01/22/22-shanghai-tower.w710.h473.jpg

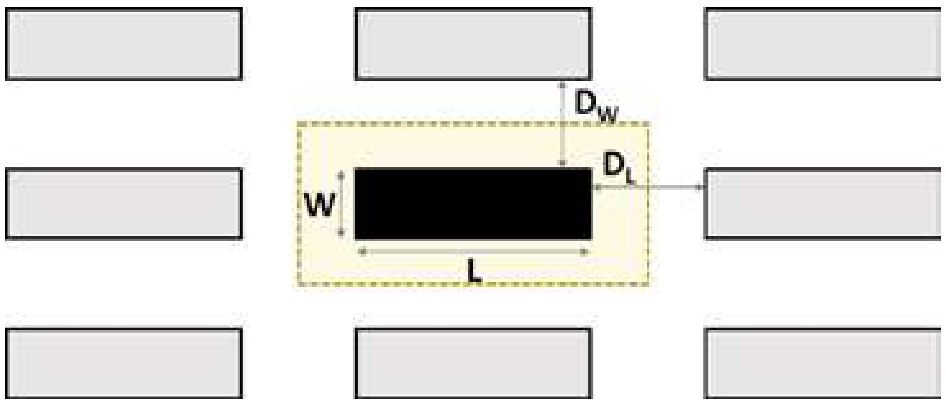
Representations of Urban Form: Parameterization











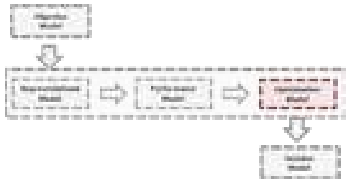
• Safety • Privacy • Sunlight • Elevator

Number of Floors	Minimum D_W (m)	Minimum D_L (m)
1-3	max(1.2H,6)	max(0.5H,4)
4-8	1.2H	max(0.5H,4)
>8	max(0.5H,30)	13

Parameter	Min	Max	Step
FAR	0.5	3.0	TBD
Number of Floors	3	18	1 (number of floors)
L (m)	24	72	12 (unit width)
W (m)	15	15	--
D_L	10	64	TBD
D_W	10	64	--

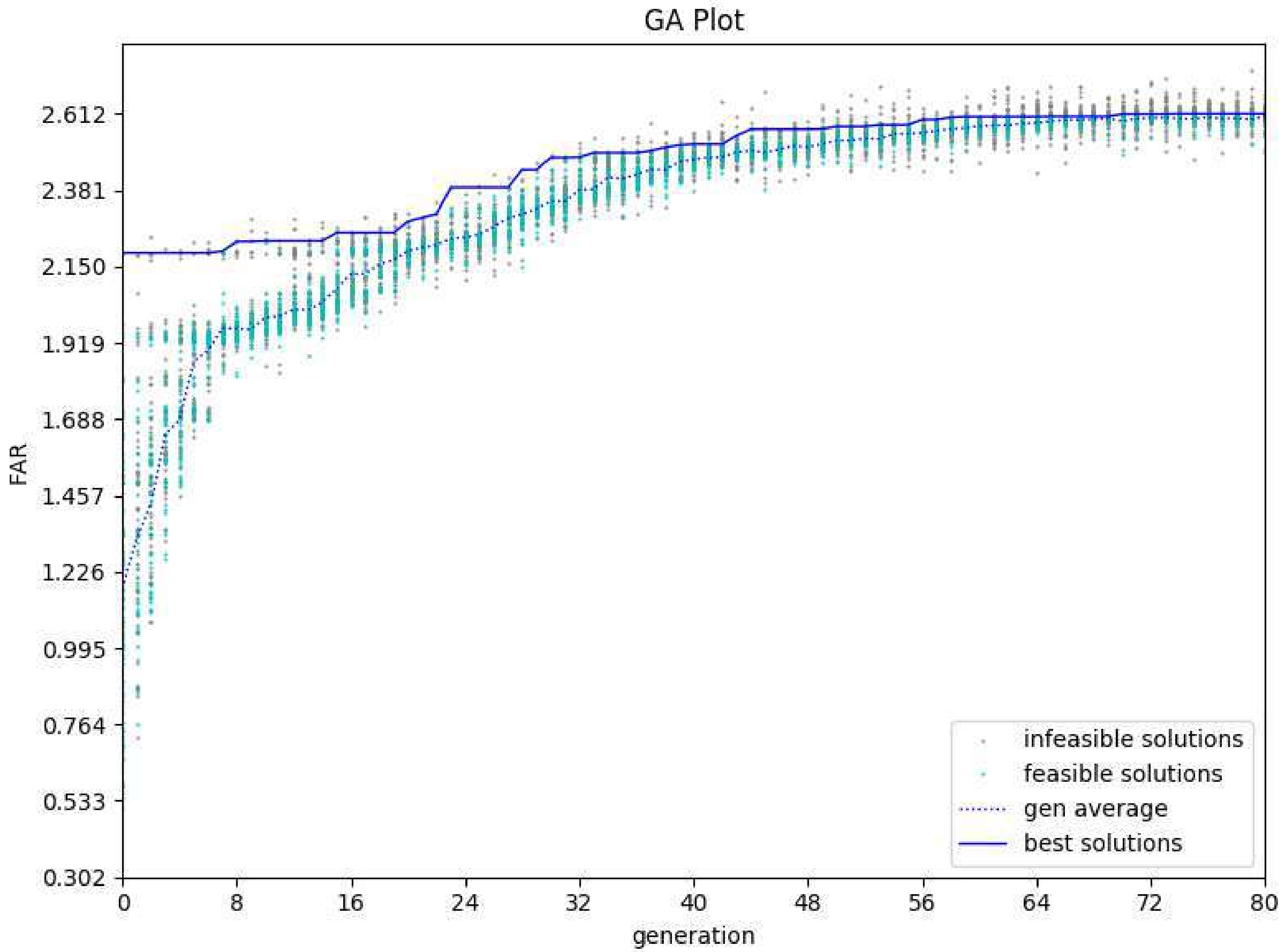
Fixed Apartment Unit Size: 6 m x 15 m based on government policy of occupant density (35m2/person) and Shanghai projected household size (2.65 person/household)

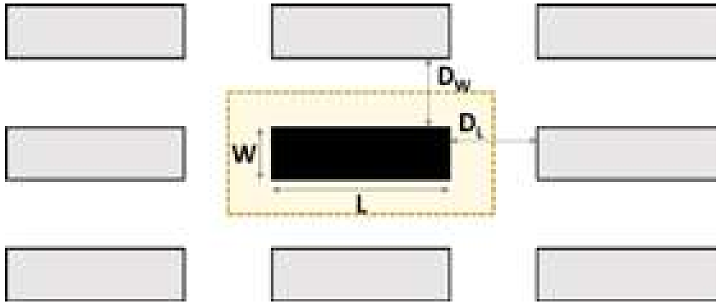
Quan, 2019



Optimization Results

Objective Function: maximize FAR





Quan, 2019

Shanghai

Design for **Sustainable** Neighborhoods:

- **Economic outcome**

  Objective function:
  Maximizing FAR

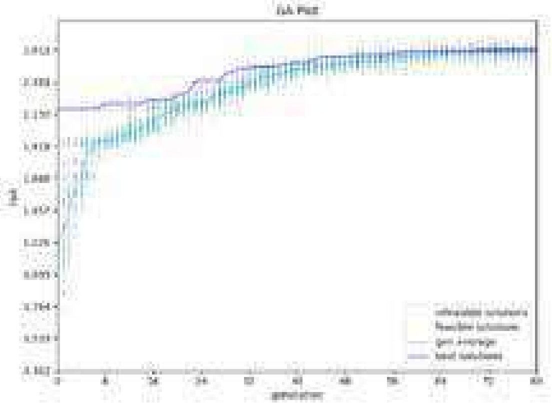
- **Low carbon**

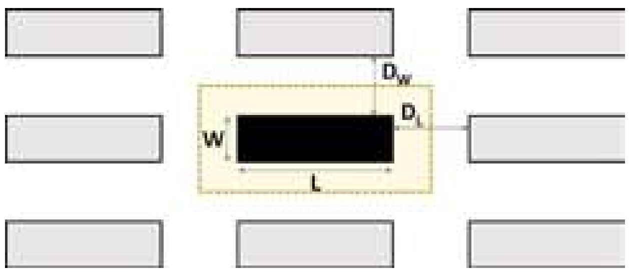
  Objective function:
  Minimizing Building Energy

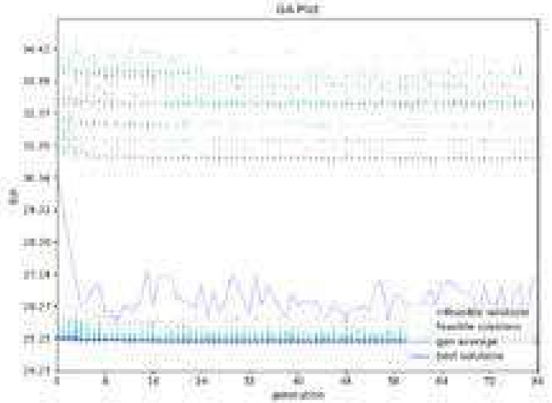
- **Outdoor human comfort**

  Objective function:
  Minimizing outdoor discomfort

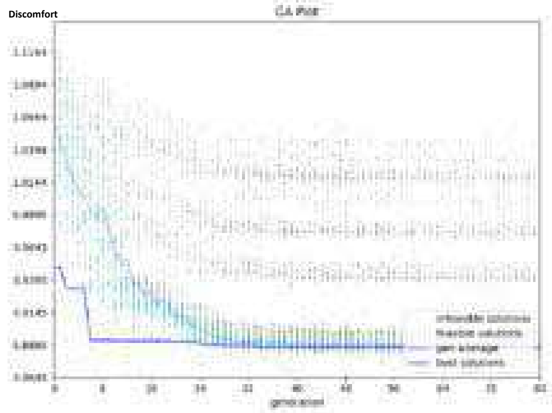
- …

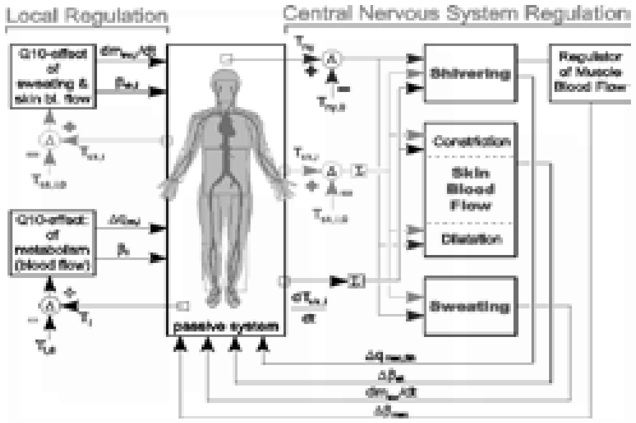






Quan et al, 2015

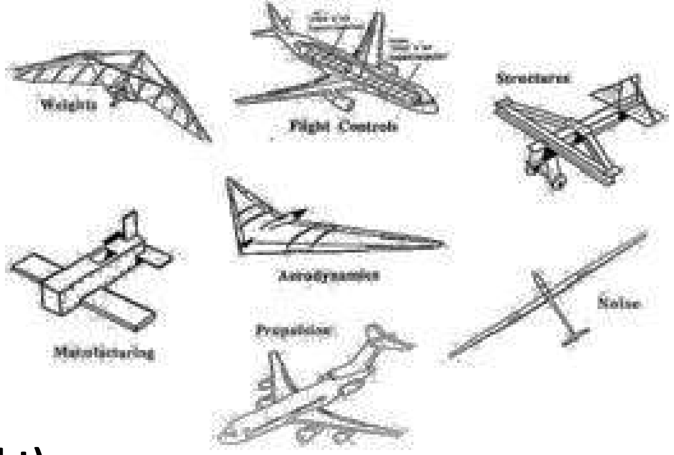




Fiala et al., 2001

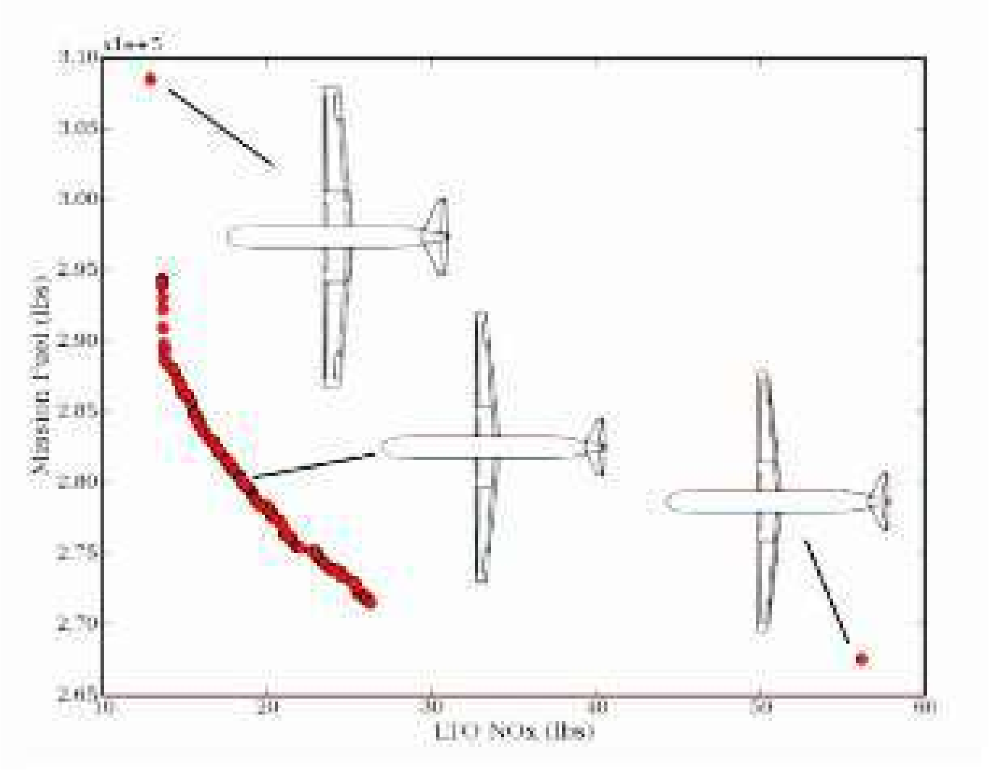
Multi-objective Optimization in Engineering

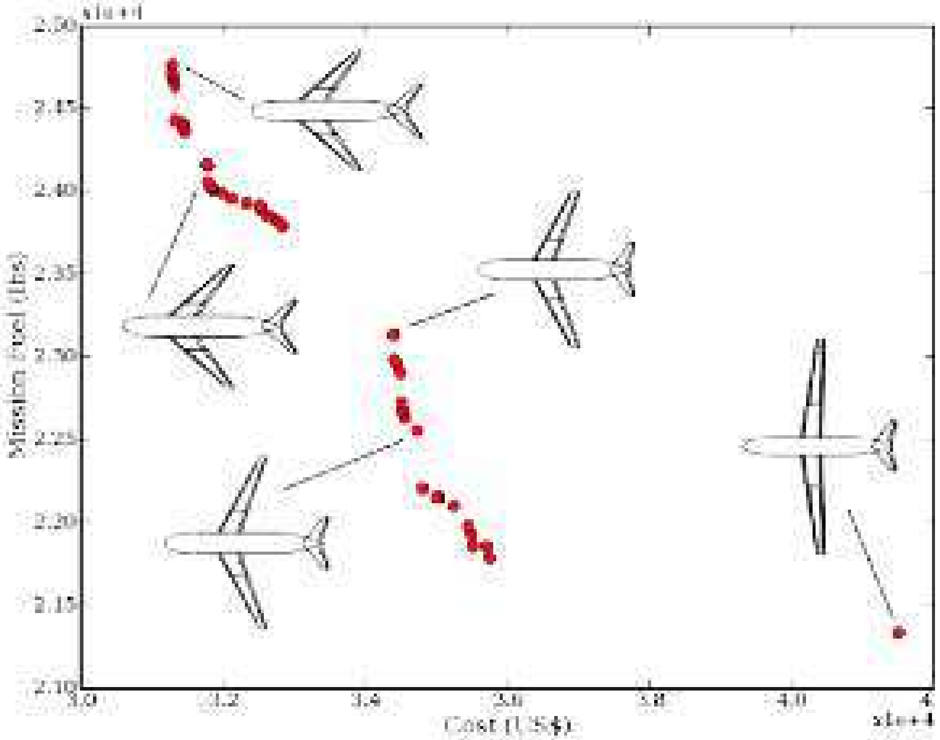
- **Pareto front**: Equally optimal solutions



Martins & Lambe, 2013; McMasters, 1985

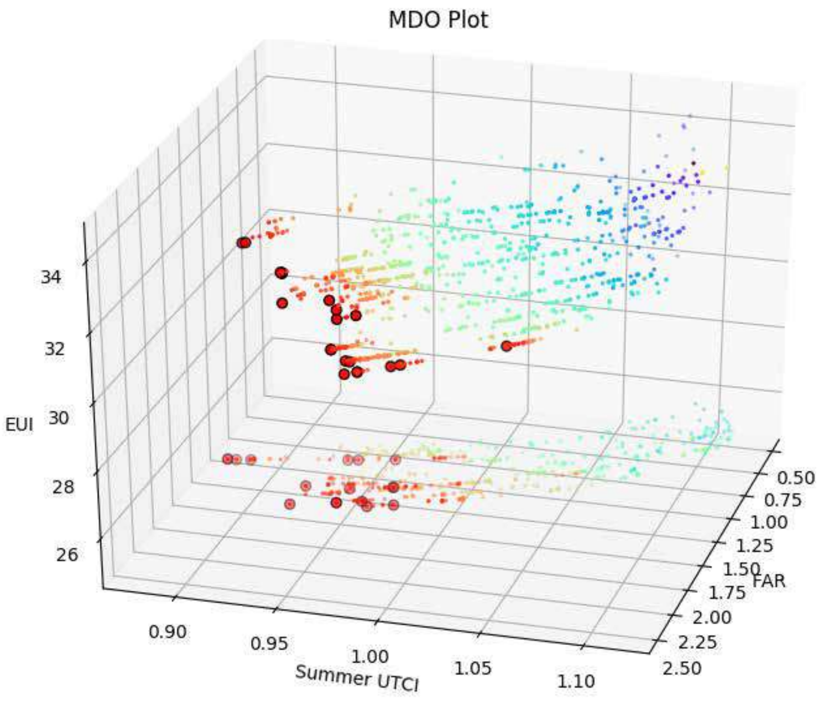
Pareto frontier of optimizations of aircraft designed for minimum fuel burn and NOx (left) and minimum fuel burn and cost (right)





Henderson et al., 2012

FAR (maximize) vs Building Energy (minimize) vs Comfort (minimize UTCI ASR)



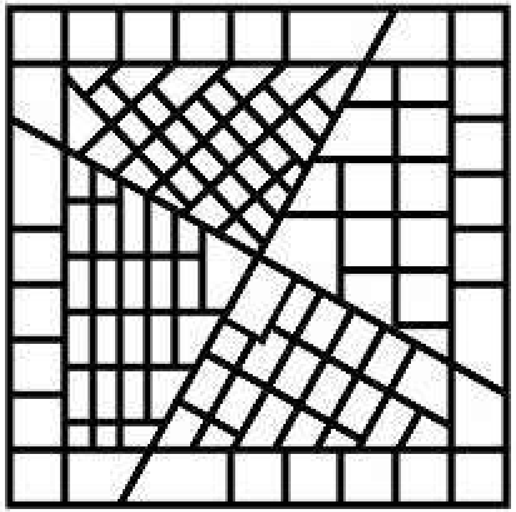
38 “equally optimal solutions” in the Paretofront

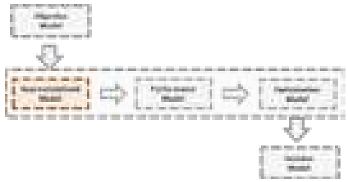
Quan, 2019

Case Study

Seoul

Energy-efficient Gangnam Superblock Design





326 Parameters

- Dimensions
- Angles
- Coordinates

22 Constraints

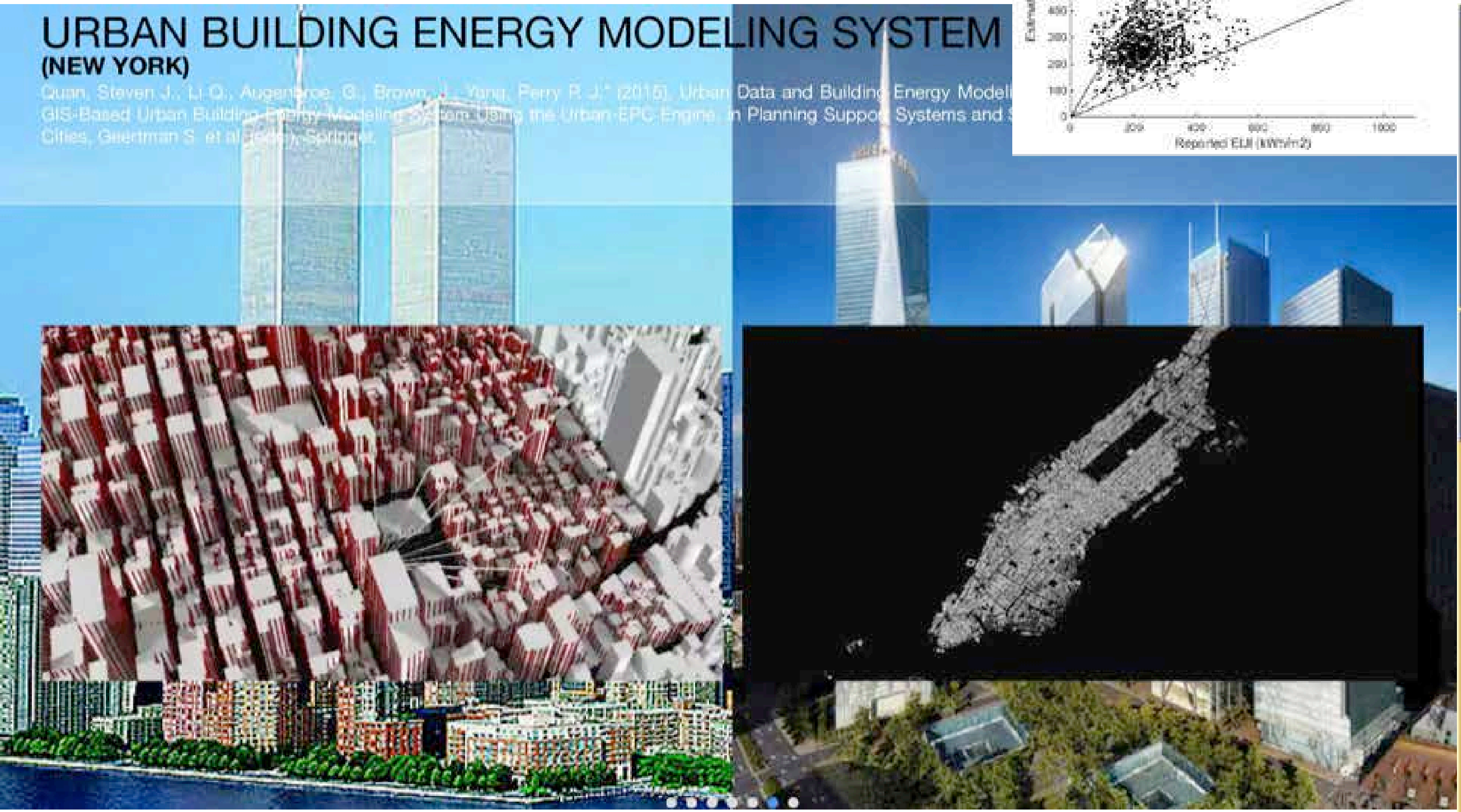
- Reasonable dimensions and feasible patterns
- **FAR = 3.6**

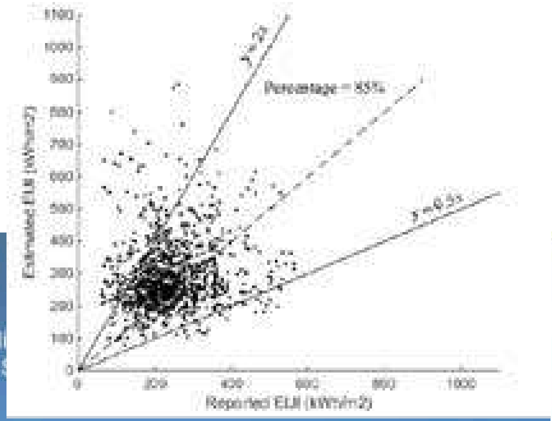
No.	Parameter	Spatial Scale	Min	Max
1	Rotation angle of the axis	Region	15 degrees	70 degrees
2	Peripheral block length	Block group	60 m	120 m
3	Peripheral parcel length	Block	35 m	70 m
4	X of the anchor point	Region	230 m	630 m
5	Y of the anchor point	Region	-630 m	-230 m
6	Interior parcel length	Block	20 m	40 m
7-10	Translation in X of the grid for four interior block groups	Block group	-60 m	60 m
11-14	Translation in Y of the grid for four interior block groups	Block group	-60 m	60 m
15-18	Rotation of the grid for four interior block groups	Block group	0 degrees	75 degrees
19-22	Block length of the grid for four interior block groups	Block group	60 m	120 m
23-26	Block width of the grid for four interior block groups	Block group	60 m	120 m
27-86	Numbers of floors of buildings on 60 peripheral blocks	Block	1	32
87-326	Numbers of floors of buildings on 240 interior blocks	Block	1	8

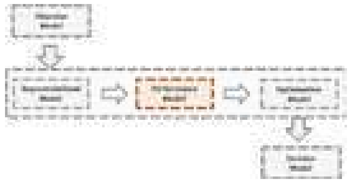
No.	Parameter	Spatial Scale	Value	Constraint
1	Superblock length	Superblock	800 m	
2	Superblock width	Superblock	800 m	
3	City street width	City	60 m	
4	Superblock street width	Superblock	10 m	
5	Building setback	Parcel	3 m	
6	Peripheral block width	Block	60 m	
7	Anchor block length	Block	120 m	
8	Anchor block width	Block	60 m	
9	Distance from superblock street intersections to city street intersections	Superblock		>=30 m
10	Grid generation ratio for peripheral blocks and parcels	Block and Parcel		>=0.6
11	Peripheral extended block area	Block		>=300 m²
12	Peripheral block area	Block		>=300 m²
13	Peripheral parcel area	Parcel		>=300 m²
14	Peripheral building footprint area	Building		>=200 m²
15	Peripheral parcel width	Parcel		>=20 m
16	Grid generation ratio for interior blocks and parcels	Block and Parcel		>=0.6
17	Interior extended block area	Block		>=300 m²
18	Interior block area	Block		>=300 m²
19	Interior parcel area	Parcel		>=150 m²
20	Interior building footprint area	Building		>=50 m²
21	Interior parcel width	Parcel		>=15 m

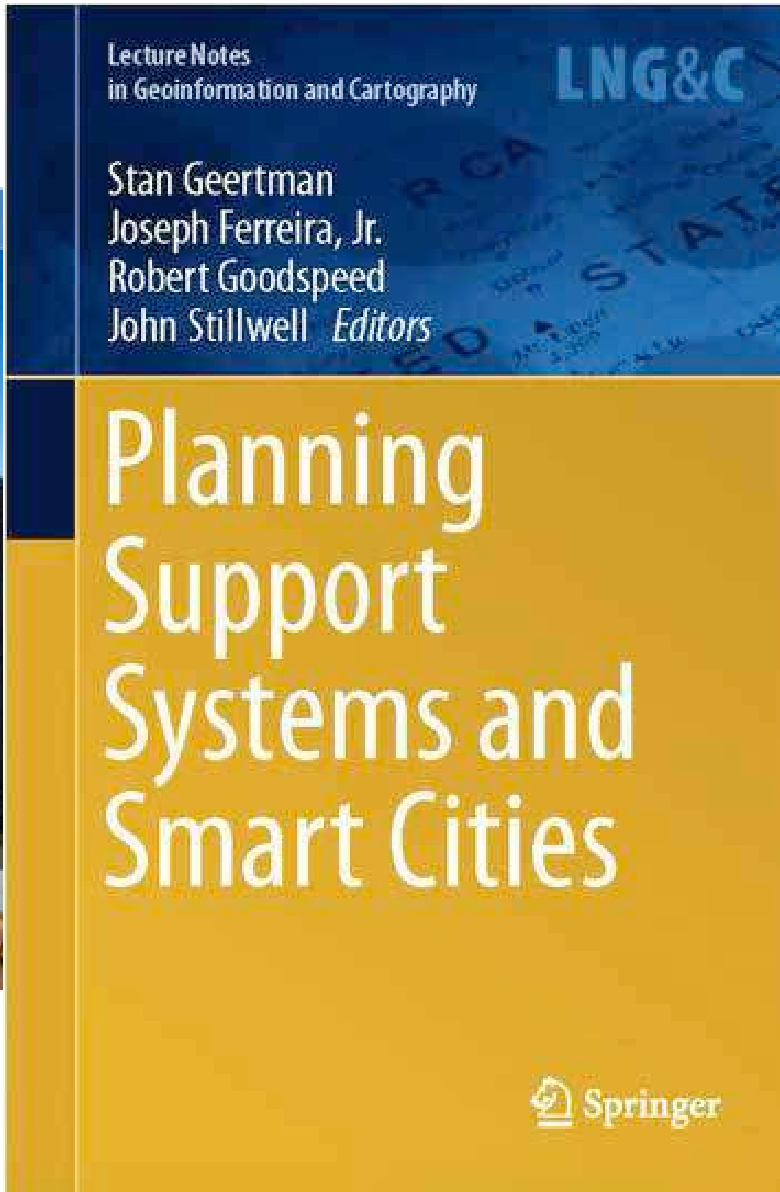
Quan, 2019

Performance Model
Urban Scale Building Energy Modeling





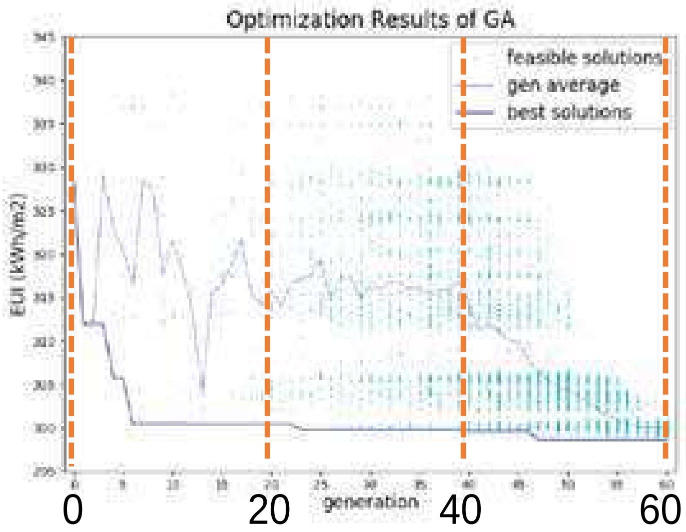


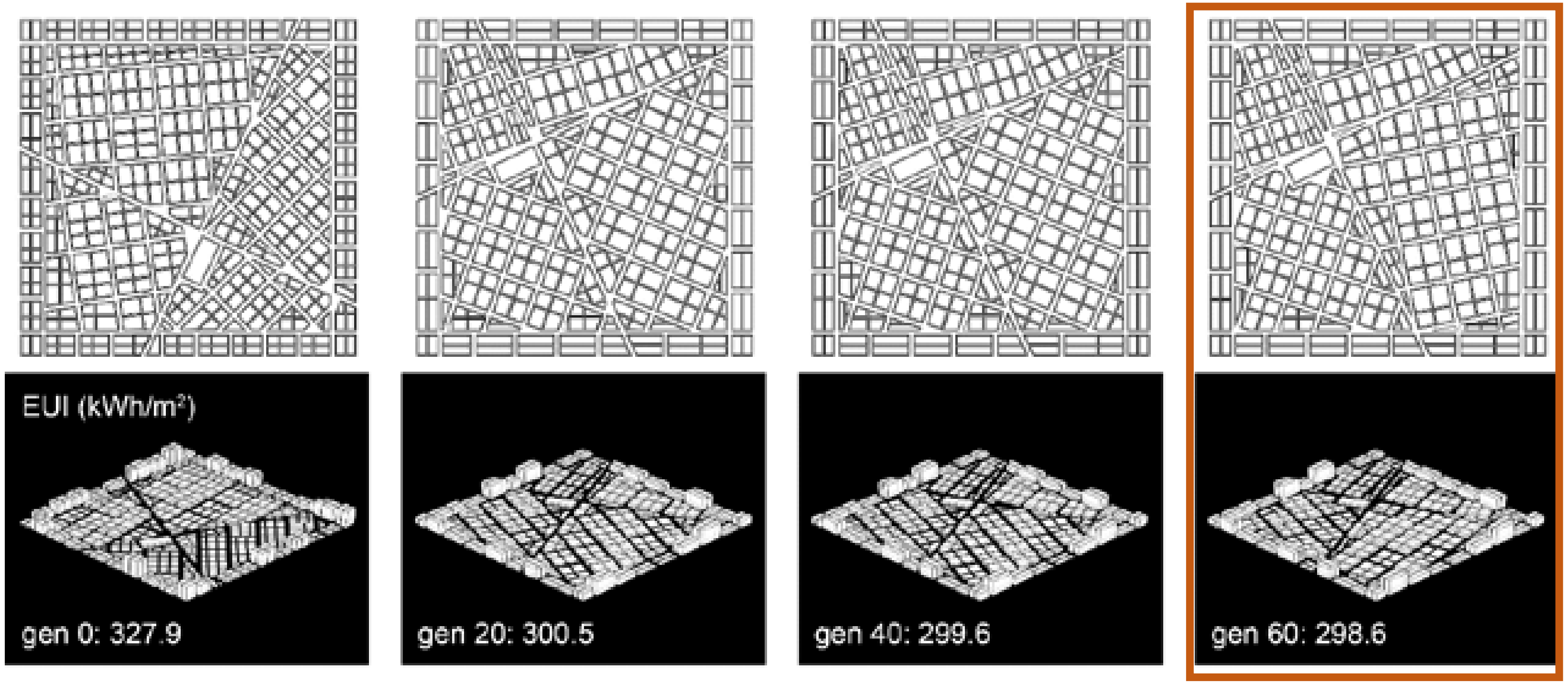


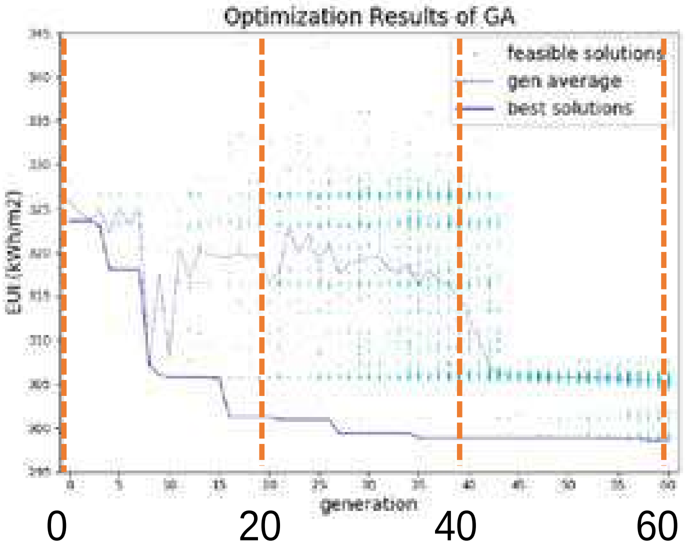
S. J. Quan, Q. Li, G. Augenbroe, J. Brown & P. P. Yang (2015). Urban Data and Building Energy Modeling: A GIS-based Urban Building Energy Modeling System Using the Urban-EPC Engine, in S. Geertman, J. Ferreira, Jr. R. Goodspeed & J. Stillwell (eds.) Planning Support Systems and Smart Cities. 2015
S. J. Quan, Q. Li, G. Augenbroe, J. Brown & P. P. Yang (2015). A GIS-based Energy Balance Modeling System for Urban Solar Buildings. Energy Procedia. 2015

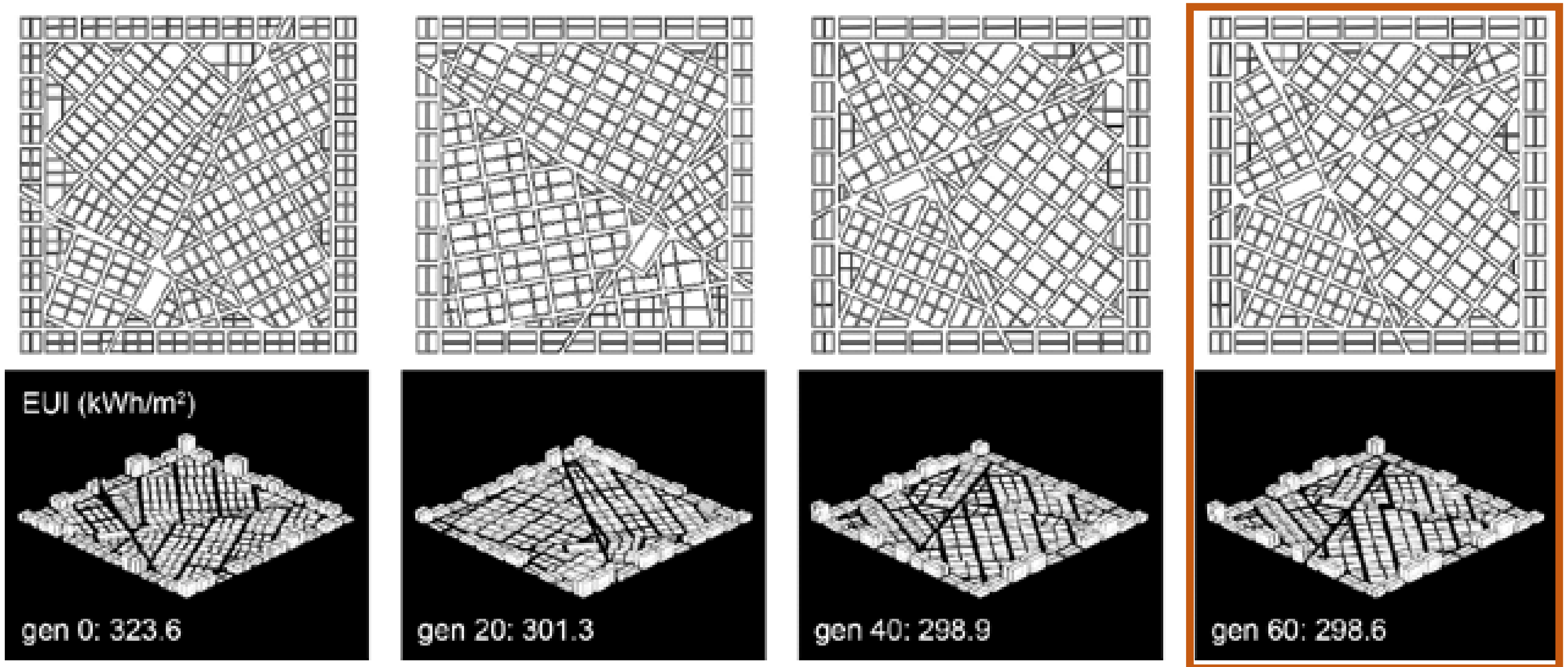
Optimization Results

Two Runs





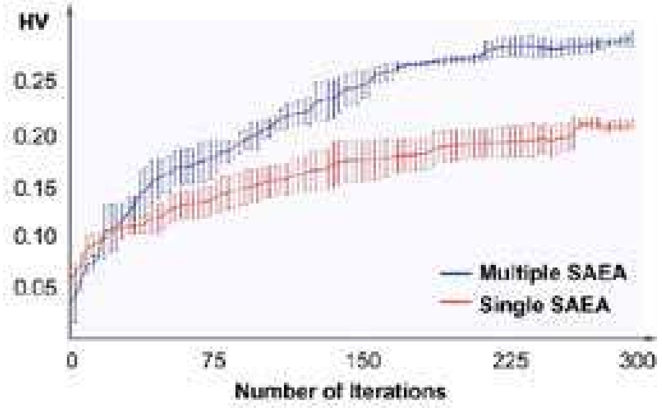


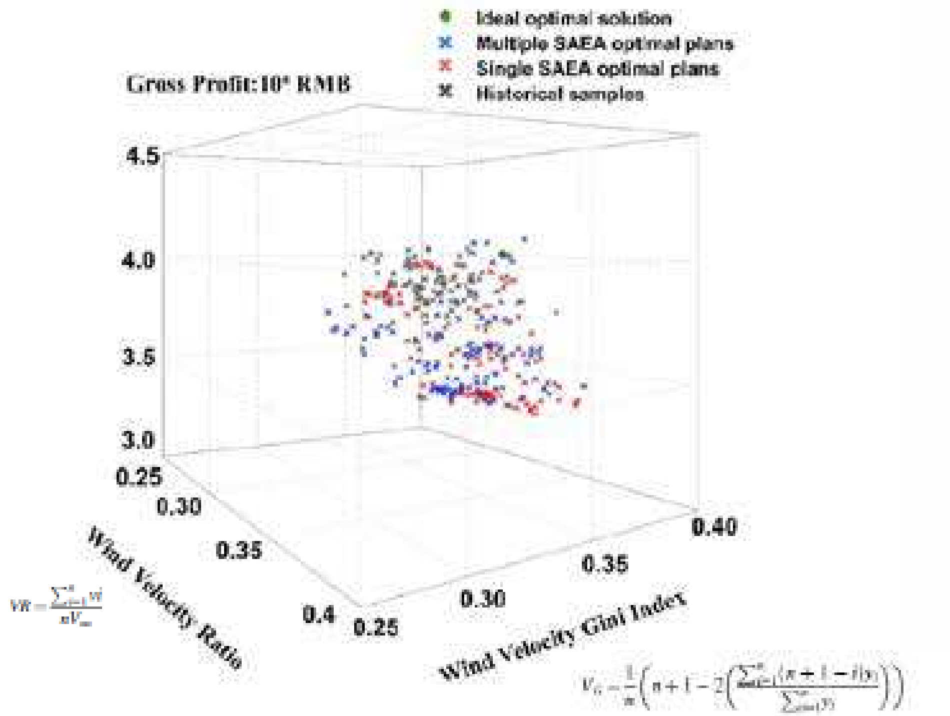


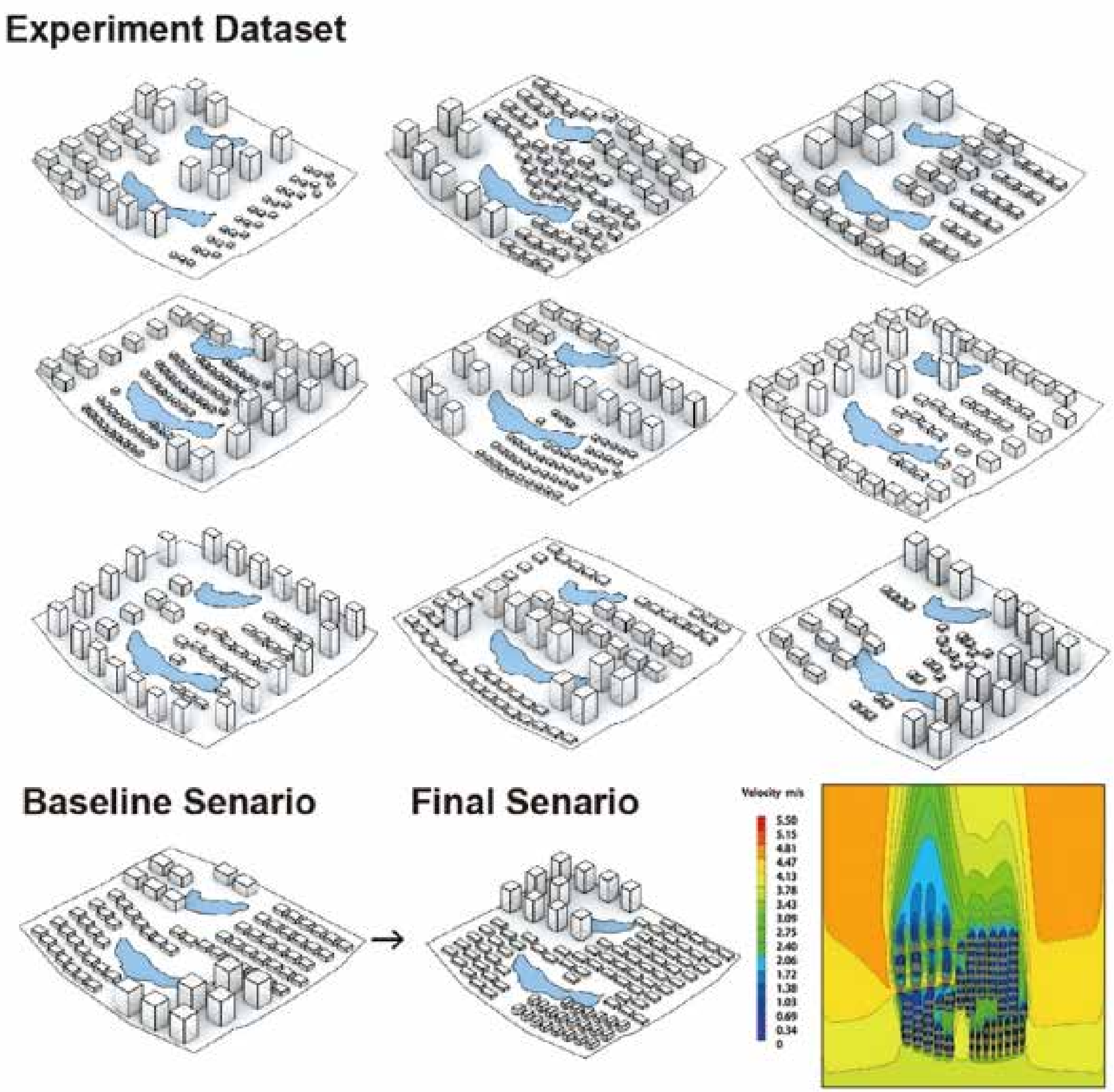
Quan et al, 2019

Extended From Classic Design Optimization: Heavy Simulations

Surrogate-assisted Optimization







Wu, Zhan, & Quan, 2021

A New Framework: City Science, Big Data, and Public Participation

Measurable and immeasurable

Ewing & Handy, 2009

- Some qualities of the design are well measured (environmental performance)

  Simulations at urban scale are hard

- Some are not easily measurable (social and subjective performance)

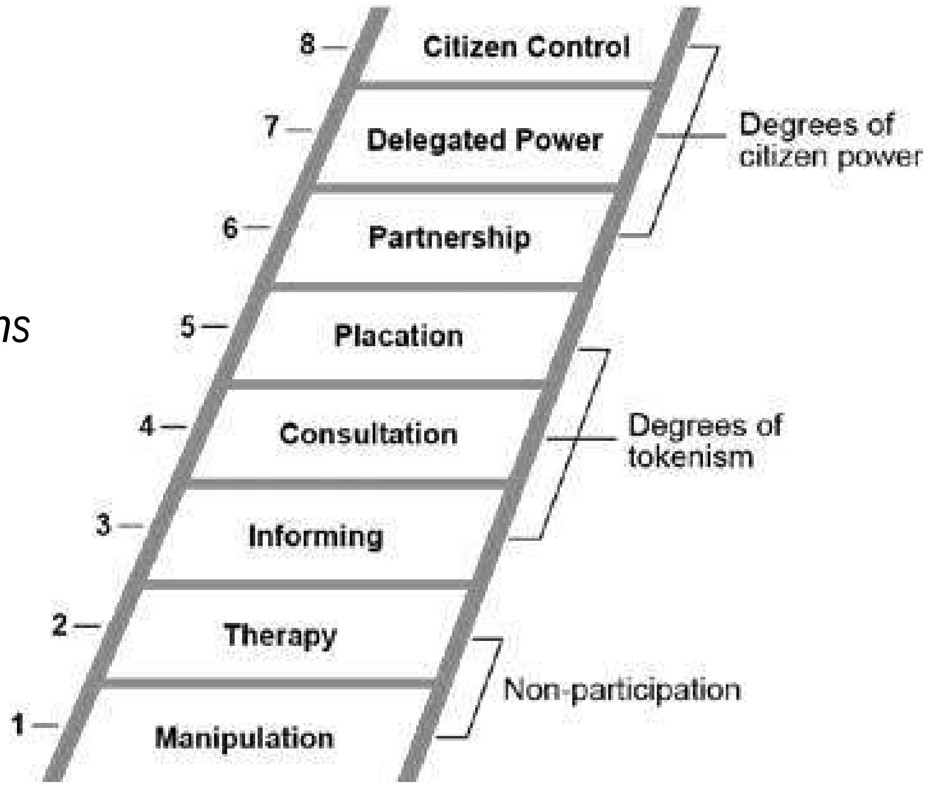
  Simulations may not be available

Public participation in design

Quan, 2022

- Design for the public *Conventional design computation*
- Design with the public *Participatory planning support systems*
- **Design by the public** *How?*

Can We Apply AI and Big Data to Better Support Design Empowerment?

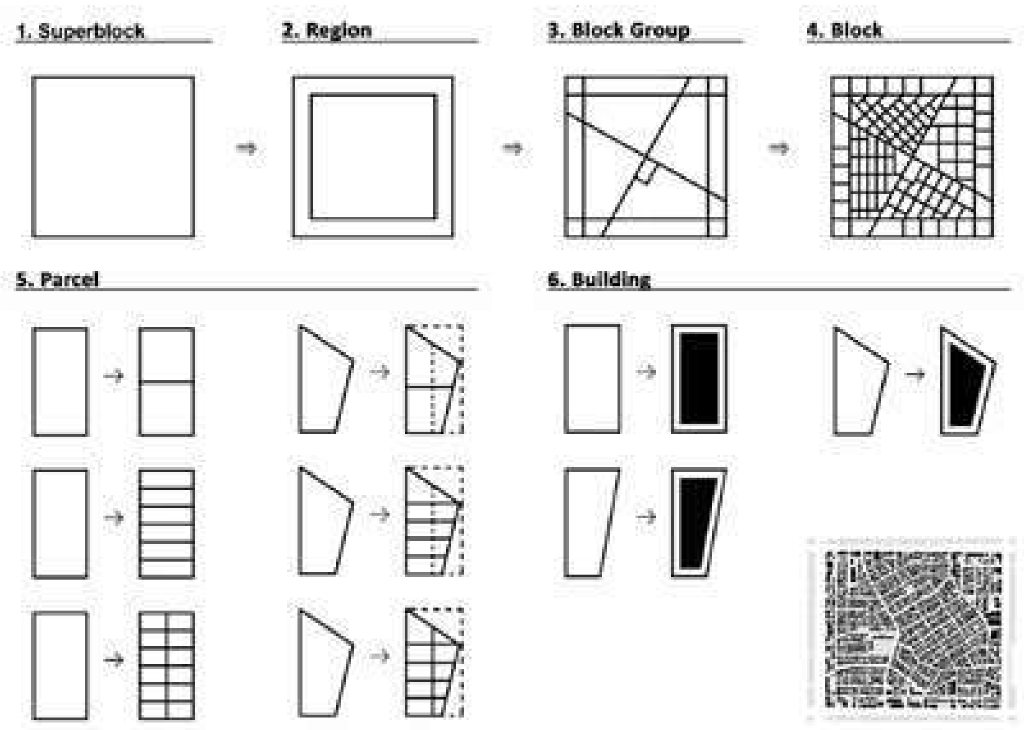


Arnstein, 1969

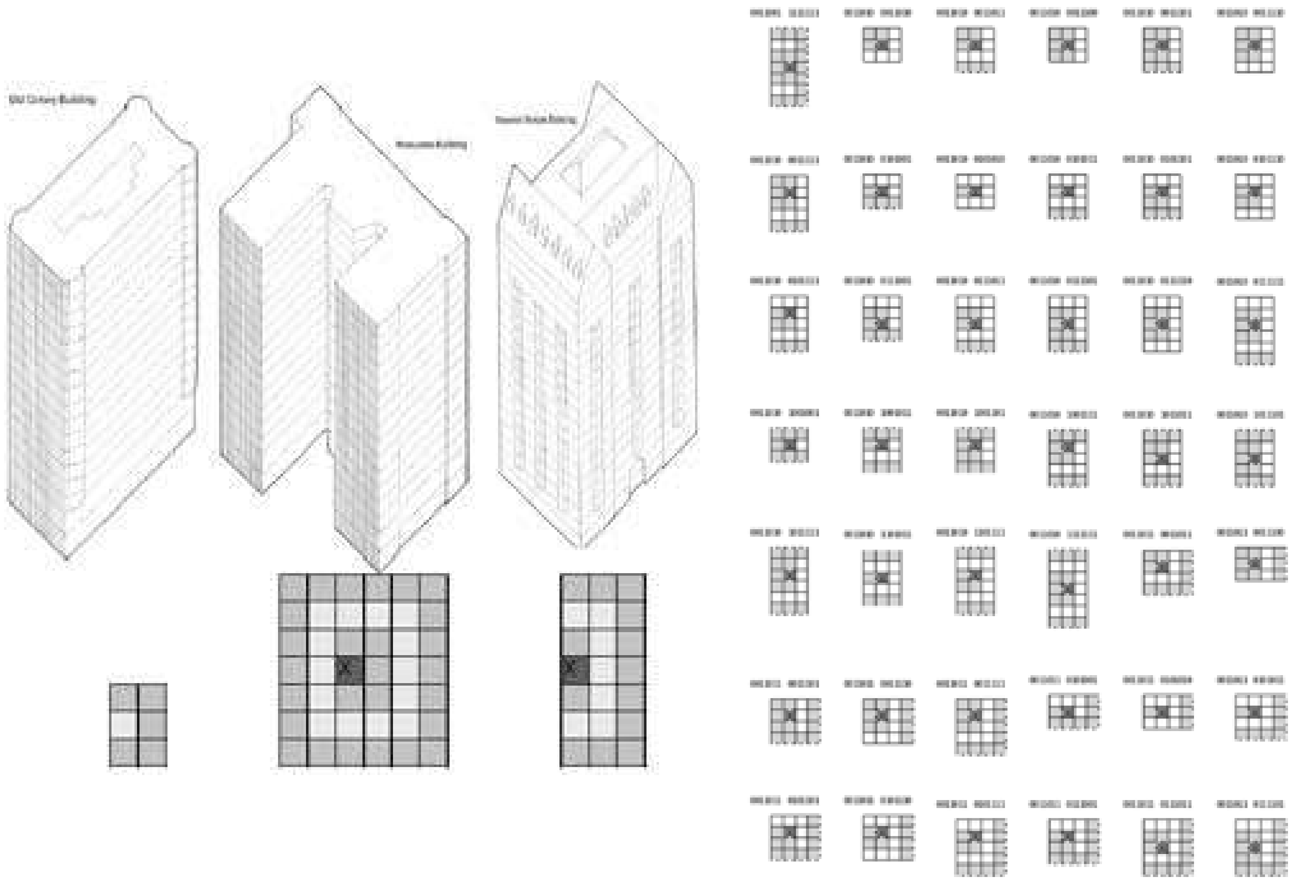
Difficulty in Schemata Definition and Design Knowledge Acquisition

Defining Design Space with Representation

- Symbolic (geometry properties)
  Prior design schemata, oversimplification
- Sub-symbolic (grid)
  Lack of meaning, curse of dimensionality



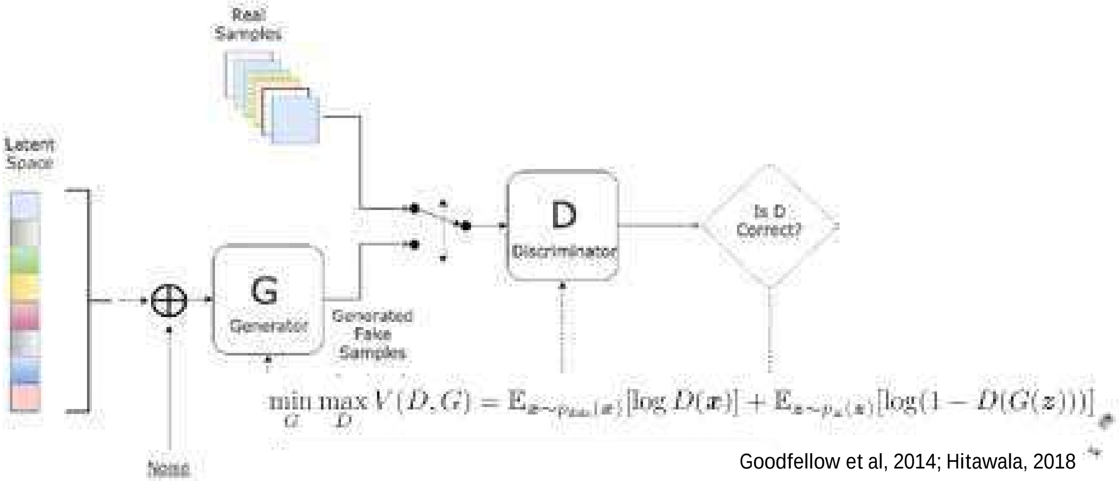
Quan, et. al., 2019



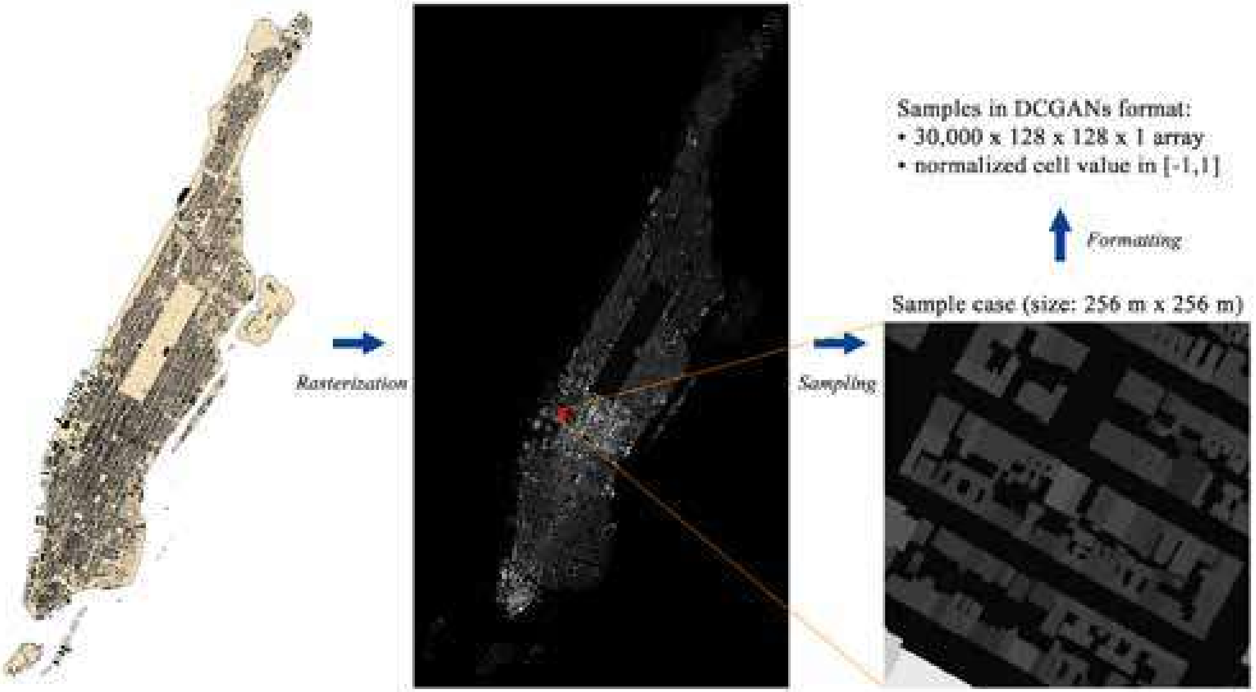
Steadman, 2001

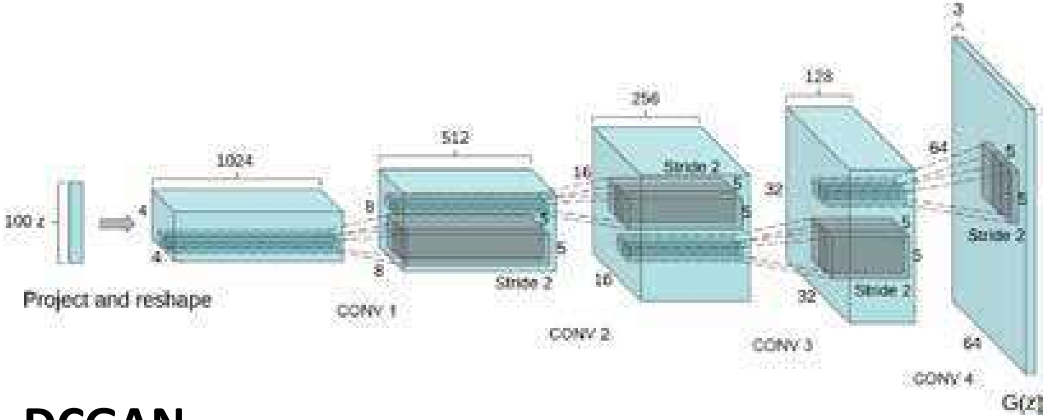
Representation Learning

Generative Adversarial Networks (GAN)



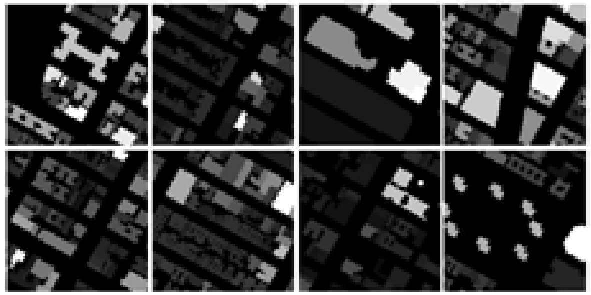
Goodfellow et al, 2014; Hitawala, 2018

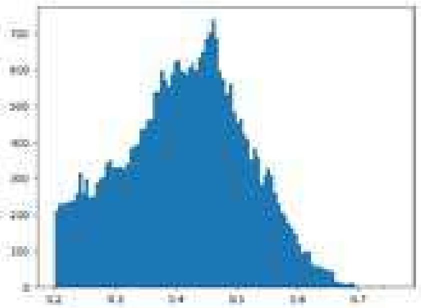




DCGAN

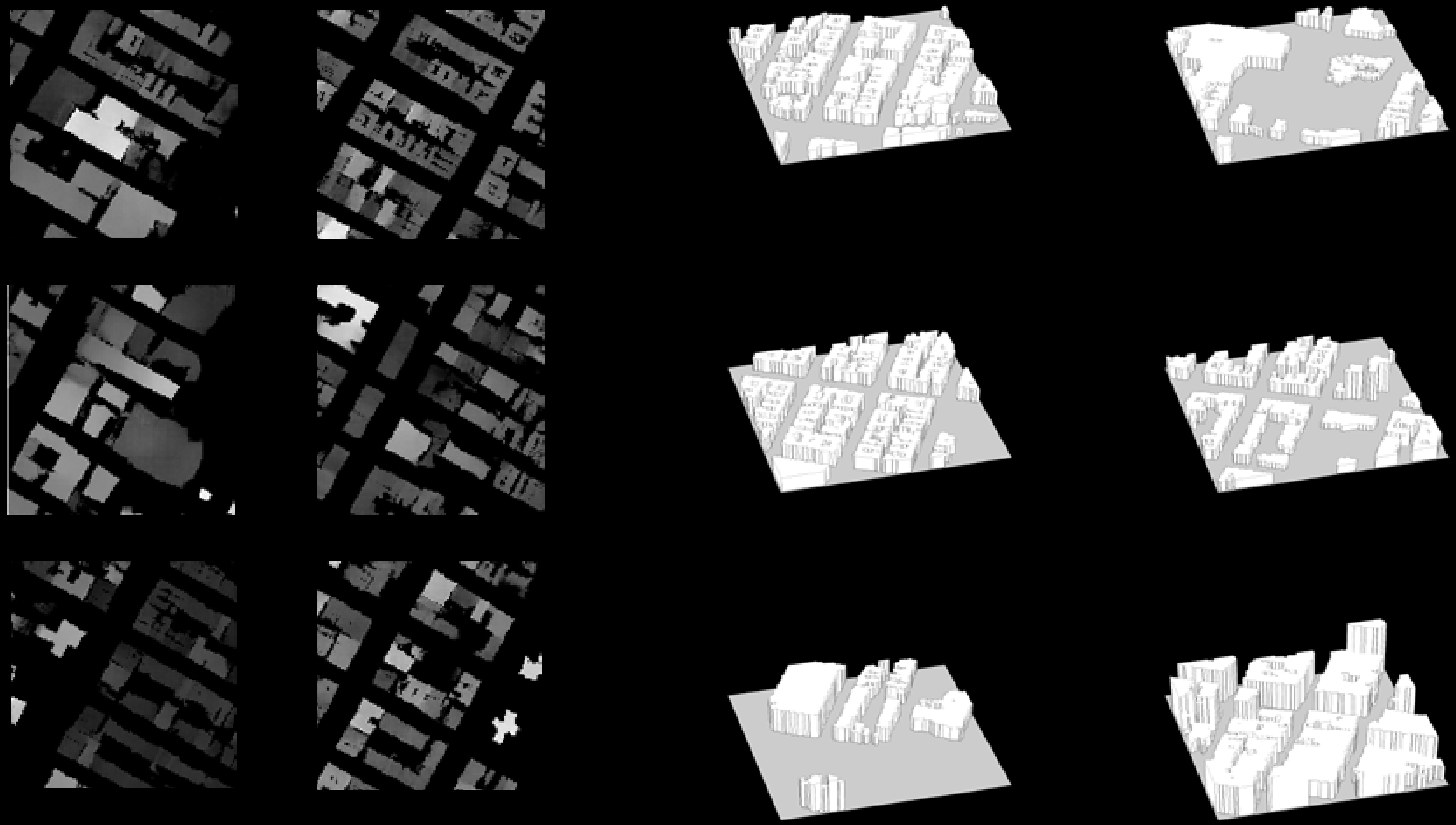
Radford, et al, 2016





Cover Ratio:
0.2 – 0.8

Urban-GAN



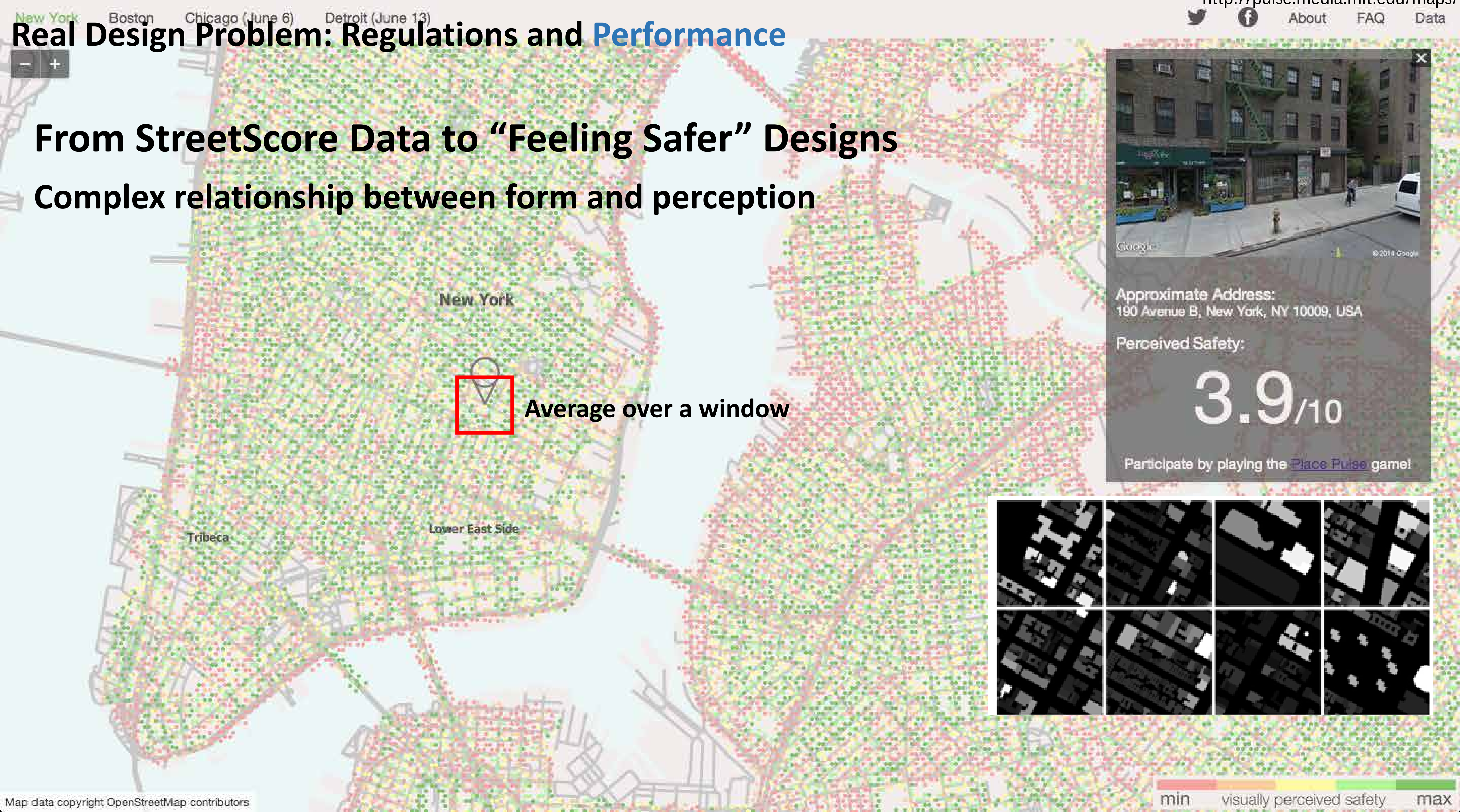
Quan, 2019

http://pulse.media.mit.edu/maps/

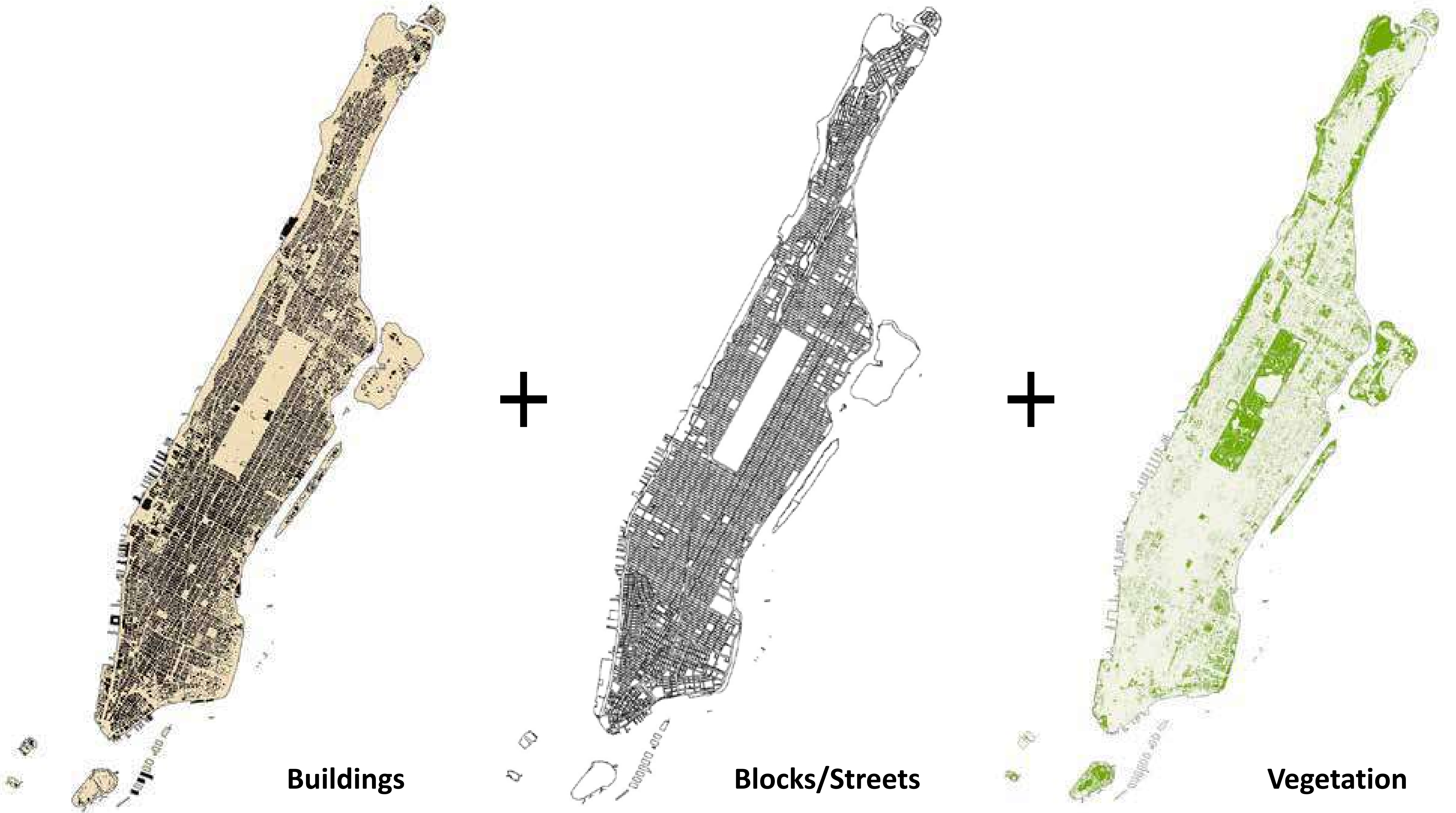
Real Design Problem: Regulations and Performance

From StreetScore Data to “Feeling Safer” Designs

Complex relationship between form and perception



Average over a window

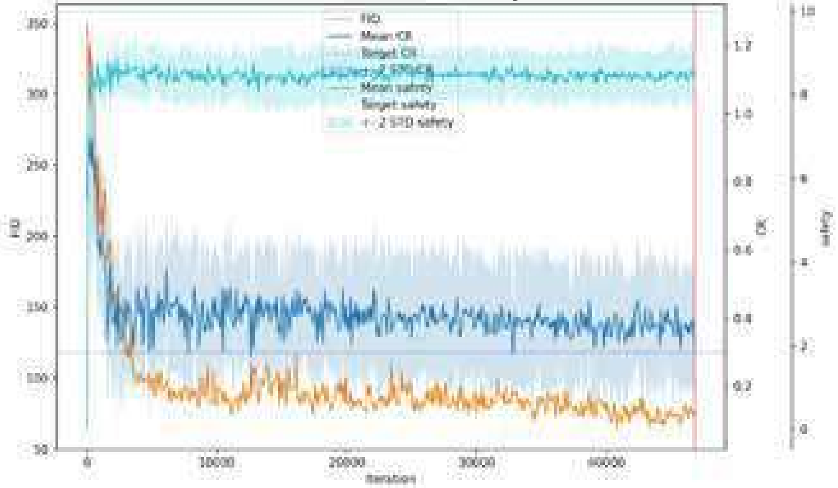

Buildings
+
Blocks/Streets
+
Vegetation

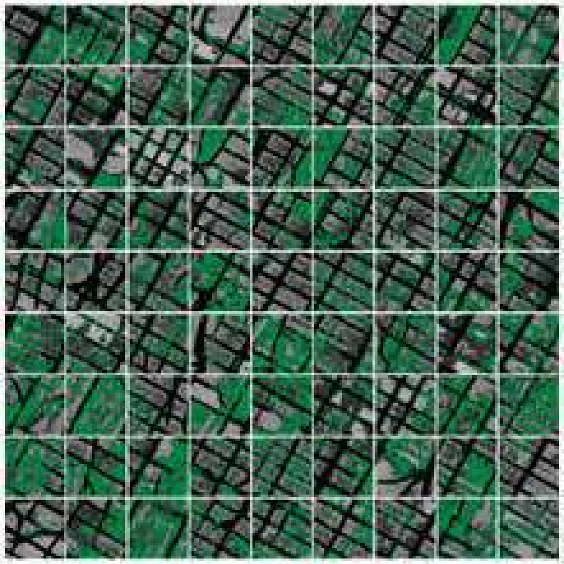
Constrained-UrbanGAN (cUrbanGAN)

Constraints:

- **Cover Ratio -> 0.3, Safety score -> 10**

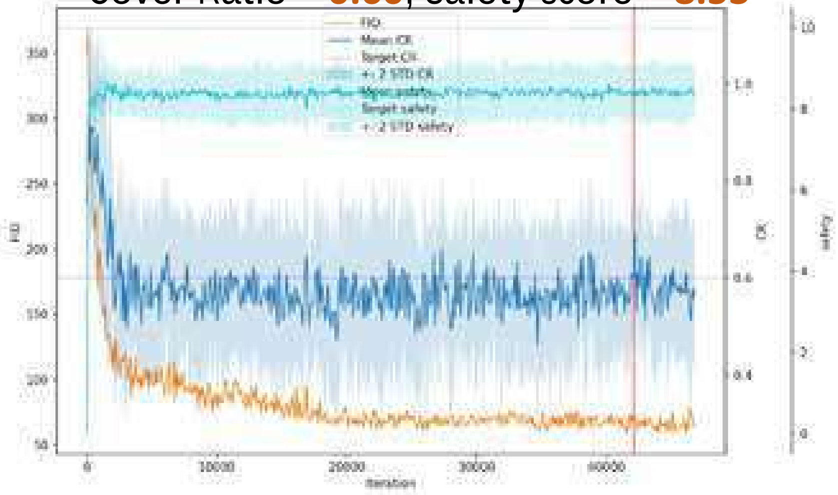
  Cover Ratio = **0.30**, Safety score = **8.49**

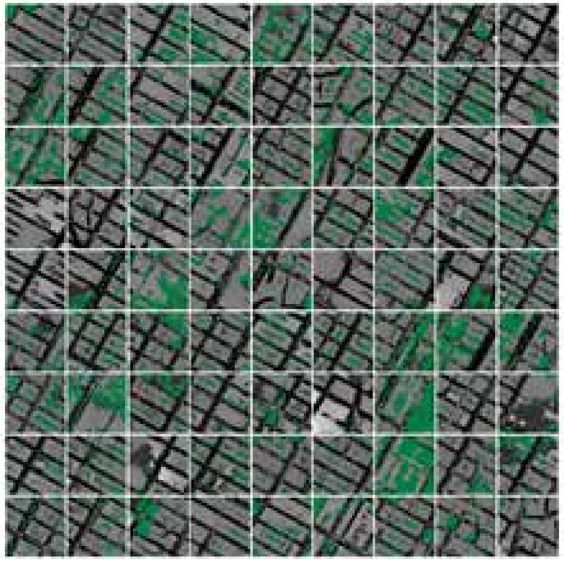




- **Cover Ratio -> 0.6, Safety score -> 10**

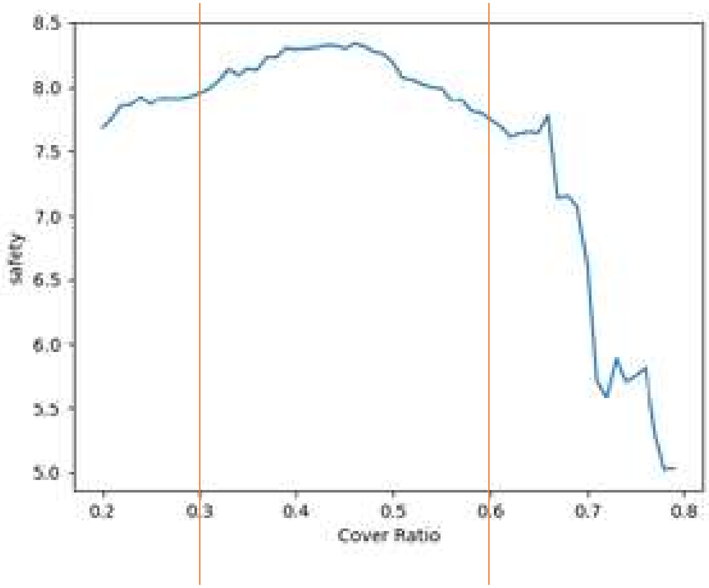
  Cover Ratio = **0.60**, Safety score = **8.53**





Overall average
Safety = 8.11

Urban Data



CR = 0.3
Safety = **7.96**

CR = 0.6
Safety = **7.74**

Training for 100 epochs

Quan, 2021

Conclusion

- **Revealing Urban Complexity: Interactions and Nonlinearity**
- **Representing Urban Complexity: From Indicator to Typology**
- **Reshaping Urban Complexity: AI-aided Design (AIAD)**
- **A New Framework: Integrating City Science, Big Data, and Public Participation**

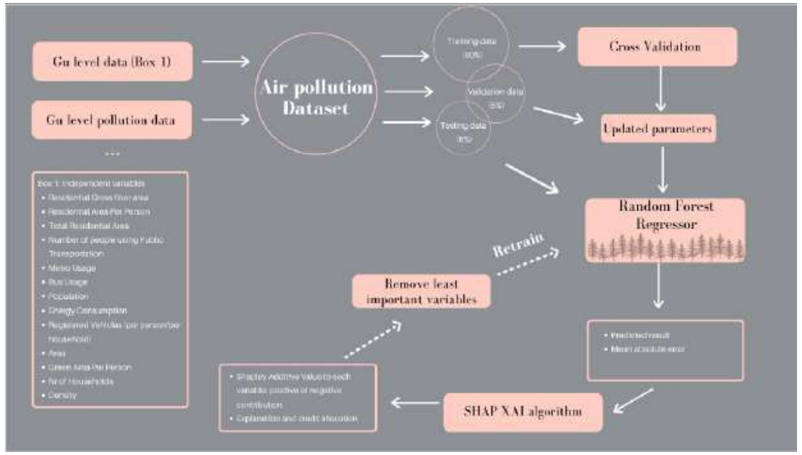
AI + Planning and Design → Planning and Design + AI

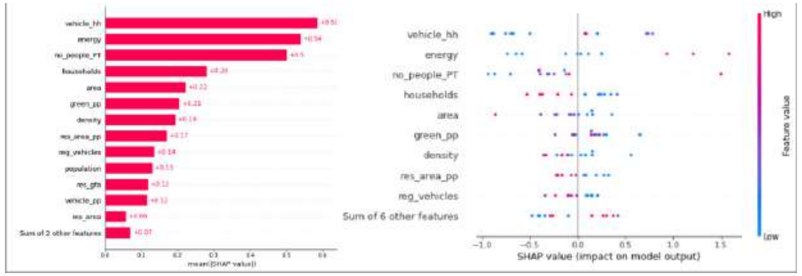
- Supporting Planning with Explainable AI: Fairness, Accountability, and Transparency
- Educating the Next Generation of Planners, Designers, and Policymakers.

New Course Series

AI in Urban Planning and Design 1 (Spring 2021, 2022, 2023)
AI in Urban Planning and Design 2 (Fall 2022, 2023)

Predicting Air Pollution in Cities

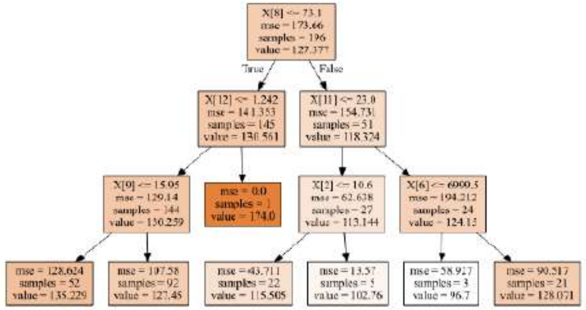




Alva Markelius, James Jung, Yao Yao

Built Environment and Public Health

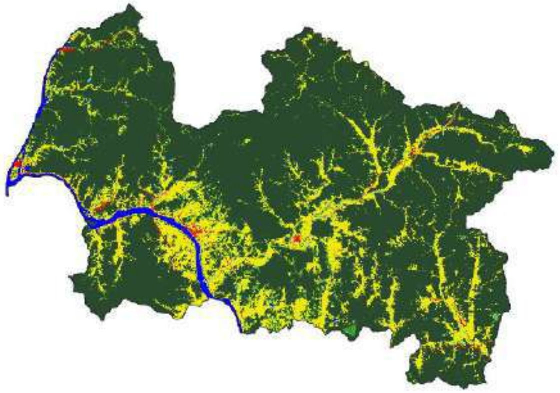
Contradicting judgement on the cause of Mortality Gap



Sangkyo Jeong, Yeyeong Lee

Land Use Land Cover Prediction

Future prediction map of 2029



Sarah Yang, You Sun Jung, Naeun Lee

Clustering Urban Decline in Korean Cities

Clustering Elderly Residence in Seoul

Impact of Built Environment on Commuting Distance in Seoul

An Expert System for computed plant selection

Thanks

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A Simulation of Urban Population Movement by Agent Based Modeling Methodology and Sejong City Policy Application

Recently, there has been an increasing number of cases of using technologies such as data-based analysis and prediction to establish various policies such as urban transportation, welfare, and economy. And, as the number of such cases increases, various methodologies are emerging. Among these, research cases of agent-based models are also increasing. The reason is that in the past, agent-based model research was very difficult because it required a lot of data and large-scale computing. However, recently, more and more diverse data has become accessible, and the number of ways to utilize large-scale computing in research sites is increasing.

Meanwhile, a basic analysis that can be used in urban transportation policy is analyzing population movement. Therefore, in this presentation, we use various data such as geographical information, facility information, commercial information, business information, public transportation information, and citizen information of Sejong City in Korea to develop an agent-based model to analyze population movement on weekdays in one-minute increments. We present a method to build and simulate. Additionally, in this presentation, we will mention cases where simulation results were utilized in actual policies. Actual use cases include the establishment of a new metropolitan express bus route (M-bus) between Sejong City and Daejeon, analysis of ripple effects according to the location of new bridges, and prediction of major social indicators by year.

A Simulation of Urban Population Movement by Agent Based Modeling Methodology and Sejong City Policy Application

Nov. 9, 2023

ETRI YungJoon Jung

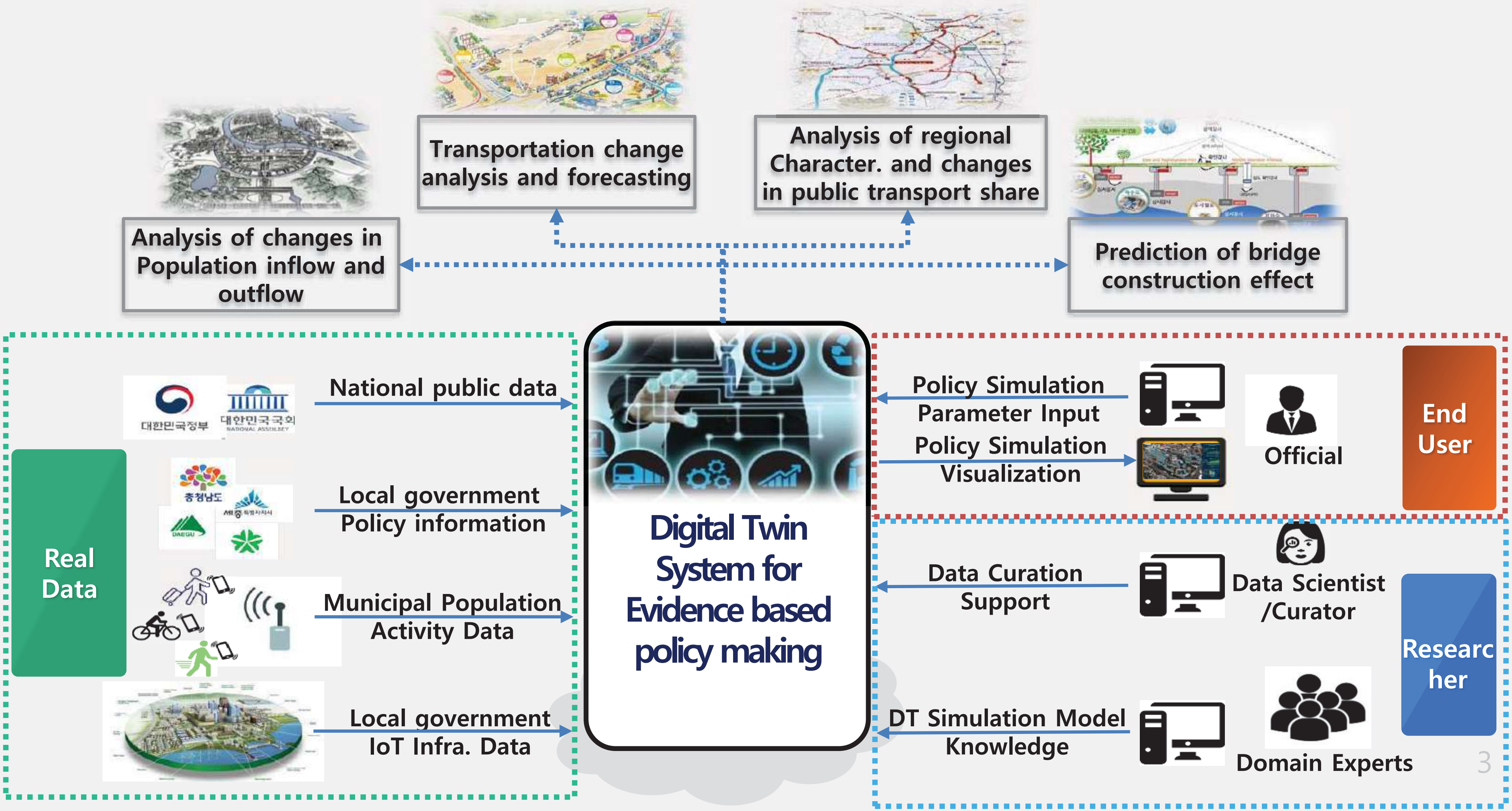
ETRI 한국전자통신연구원 세종특별자치시 KAIST 행정대학원 VAIV 국립 한밭대학교 HANBAT NATIONAL UNIVERSITY

01 Project Overview

Project Title	Development of City Interior Digital Twin Technology to establish Scientific Policy
Period	2018. 2. 1. ~ 2022. 12. 31. (5 years)
General Research / Leader	Electronics and Telecommunications Research Institute (ETRI) / YungJoon Jung
Co-Research	Sejong City, Seoul National University, KAIST, VAIV Company

02 Project Overview-Concept

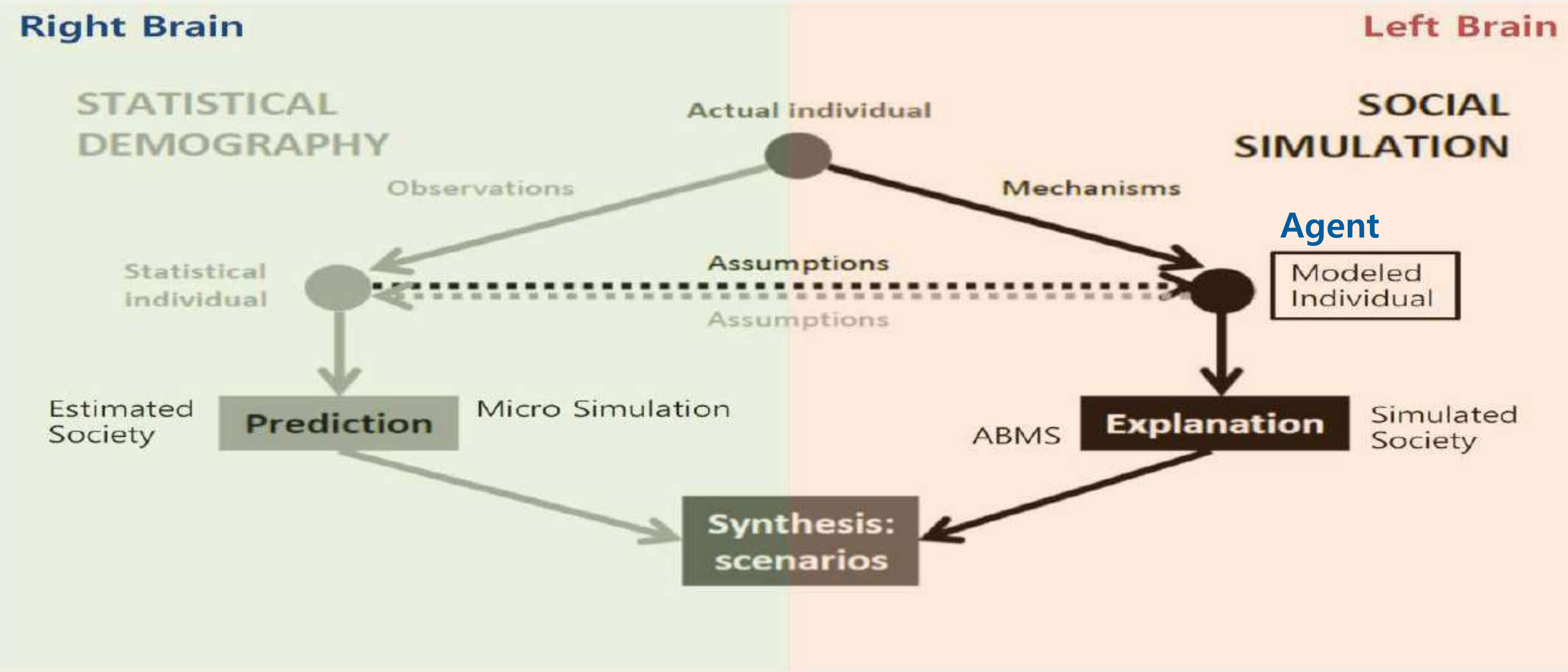
Research and develop digital twin technology to support evidence-based policy making and apply it to real city



03 R&D Core Concept (1/2) – Agent based Activities Modeling of Citizens

Analysis and prediction of urban phenomena based on agent modeling

- Statistical analysis is limited to cause analysis
- Agent based model is easy to analyze but difficult to implement



* Source : Eric Silverman et al., "When Demography Met Social Simulation: A Tale of Two Modelling Approaches," Journal of Artificial Societies and Social Simulation, Oct. 2013

The difficulty of implementing the agent-based model lies in the collection of micro-data and the limitation of computing power

03 R&D Core Concept (2/2) – Simulate change in population movement according to policy

Change the agent's information according to the policy and simulate changes in the city's movement phenomenon

- Agent : Citizen
- Simulation Step : 1 minute

Agent

Social (Citizen)	Job	Income
	Dwelling	housing
	Age	Consum.
	Gender	Move
Facility Infra.	Bicycle	taxi
	Car	Bus rout
	Store	Parking
	Road Env.	Building
Geo. Spatial Infra.	Road	Market
	Restrict	Commercial
	Geo	Regional

\+

Behavior

Interaction

SNS	OD
Velocity	Credit
Traffic	M pop.
Resident	In-flow

Traffic DB
Time Use Data
Residential Info.
MDIS

Identify city status, problems, improvement points

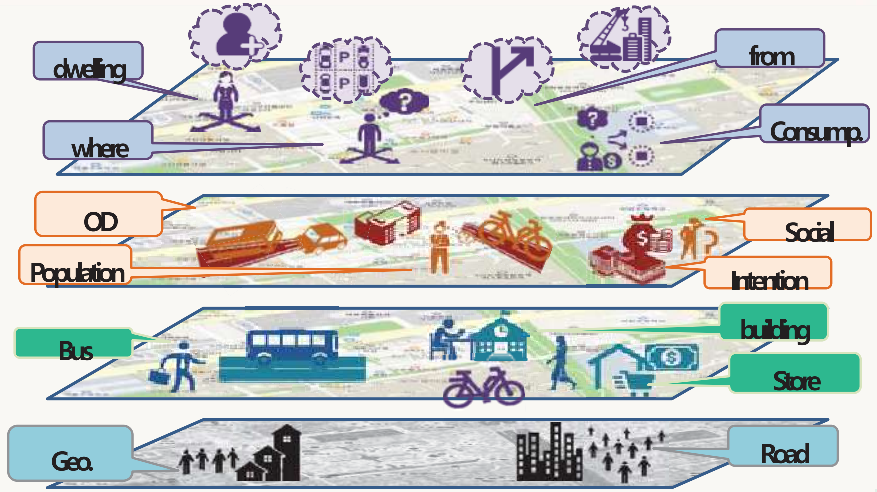
tourism | Edu. | traffic | Consum. | dwelling

Agent based digital twin Sejong City

Agent Information

(Citizen) Who/Job/When/Behavior/From/Why/Where

(Bus) Route/Passenger/Transit



Agent Info. Change / City Simulation

- Real-life area mapping based on non-identifying resident registration info.
- Behavior mapping by gender, age, and occupation based on personal life time survey

04 Agent based Digital Twin Virtual Sejong City Simulation Data

Simulates movement in 1-minute units of a day on weekdays and weekends

Interaction

- AI based transportation selection model(walking, car, bus, bicycle, etc.) mapping
- Household Travel Survey, National business survey, Building, OD, Probability distribution model by travel purpose (Frata and Gravity model) mapping
- Behavior: Sendoff, Go to work, go to school, back to work, back to home, work, Academy, shopping, leisure, Eat out, Visit, etc.

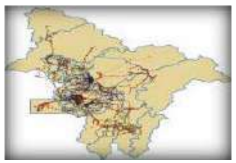
Citizen (Agent)

- Planned 5, 6 Sector: Planned number of household
- Nearby city: Daejeon, Cheong ju, Chun an, Gong ju, etc. mapping
- Location: Non-Identified Resident Registration DB mapping
- Occupation: Industry classification, MDIS, Employment survey mapping
- 440,000 People(Ages, Gender, Location, 9 Job (Official, Self-employed, Employee, Student, College, Office worker, Edu., Medical, Housewife, inoccupation) mapping

Facility Infra.

- 140,000 cars, 2,596 public bicycles, 594 public bicycles station
- 1,979 bus stops, 4,860 buses, 169 bus routes
- 36,313 Buildings (Kinds of business, Small Enterprise, License, Public Facility)

Geo. spatial Infra.



- Planned 5, 6 Sector(5-1, 6-3, 6-4, in 2025)
- 7,879 road networks, 3,090 inter sections
- 700 zone (Statistical Office 700 zone, 19 regional section, 37 inter region(Sejong/ Daejeon/Cheong ju/Chun an/Gong ju, etc.)

05 Some results - videos

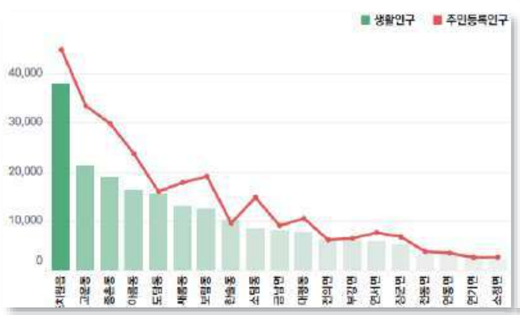
06 Research results (1/2)

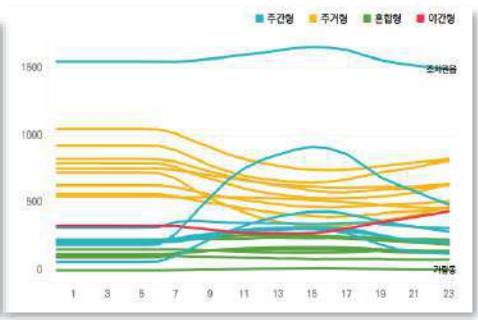
❖ Simulate the movement of all citizens of the city and understand the status

Model	Age	Gender	Dwelling	Job	Time	Behavior	Store	Where	Transportation
Behavior				In	In	Out			
Movement			In			In		In / Out	
Transportation	In	In			In	In		In	Out
Simulation Results	30	Male	A region	Official	8	Go work	office	A	car
					12	Eat out	Rest.	B	walk
					18	Shopping	shop	C	car
					20	leisure	leisure	Z	bus
					22	Back home	house	A	bus

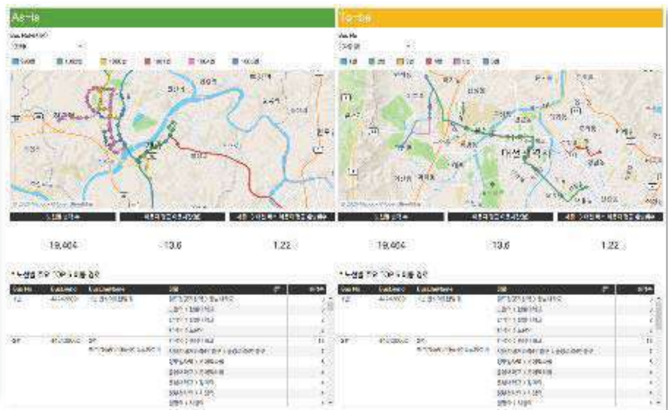
Activities of each Agent per minute

❖ Pre-simulation of preliminary policies possible





By time / By region Living Population

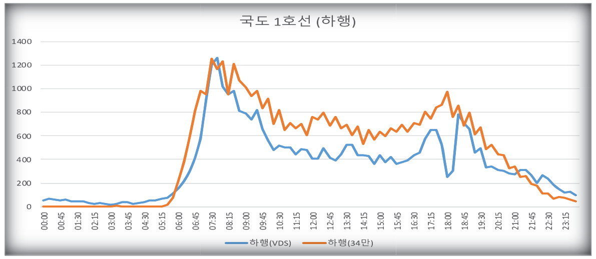


Usage Status of transportation

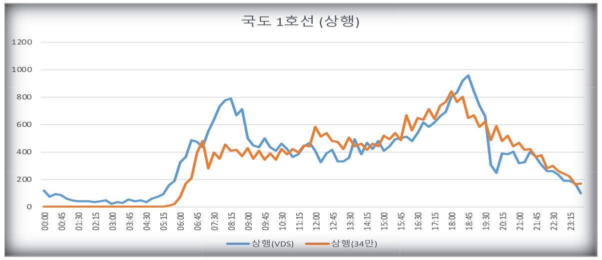
06 Research results (2/2)

- ❖ Primary verification through comparison of simulation results with real traffic card and VDS data
  - ❖ (Traffic card data) Comparison of the number of passengers using bus card data between Sejong City and Daejeon City
    - ❖ Ascending/Descending Adjustment(1-error rate): 90.9% / 71.5% -> average 81.2%
  - ❖ (VDS data) Comparison of the number of vehicles passing by time on major roads in Sejong City
    - ❖ Location: South Sejong IC (August 10th in 2020)
    - ❖ Ascending: VDS-35,644, Simulated data-33,030, error rate-7.33%
    - ❖ Descending: VDS-35,630, Simulated data-46,461, error rate-30.4%
    - ❖ Result: Hourly real and more than 80% reliability
    - ❖ As the reliability of the existing survey-based simulation is at 70%, the simulation result is excellent. However, more local verification is needed

VDS comparison location



Descending VDS comparison



Ascending VDS comparison

- Blue: VDS,
- Red: Simulated results

07 Examples of applicable policies

❖ Policy establishment demand-based R&D and policy simulation service promotion

Digital twin policy simulation service

- Prediction of movement of citizens by year (2021)
- Predicting the appropriate number of public bicycle relocations by rental stations (2021)
- Efficient garbage collection operation (2021)
- Analysis of civic behavior characteristics based on social data (2022)
- Report policy recommendations (2022)
- Sales forecast for small business (2019)
- Improvement of public bicycle operation (2020)
- Prediction of new rental stations for personal mobility (2020)
- Analysis of demand for new regional express bus routes (2020)
- Analysis of demand for new bridge locations (2020)

Visualization

- Status analysis dash board Solution
- Simulation Data Input and Output User Interface based policy decision making tool

Digital twin analysis and simulation framework

- **Activity Model of Agent of Citizen based Sejong Digital twin Simulation Framework** (Agent based Model & Simulation Digital twin)
- **Distributed High Performance Simulation Engine** (DTSim)
- **Digital twin data storage** (Sejong City's Big Data Hub System Connected)

❖ Calculation of evaluation indicators for virtual demand-based simulation results and selection of candidate routes

- ❖ Sejong-Daejeon bus card data analysis
  - ❖ Information on bus use for two weeks in Nov. 2019.
  - ❖ Sejong-Daejeon bus route data filtered by 6 routes
    - ❖ 990, 1000, 1001, 1002, 1004, 1005 routes
- ❖ Calculation of evaluation indicators
  - ❖ Traffic, Bend degree, Number of transfers, Potential demand
- ❖ Evaluation Method
  - ❖ Evaluate by weighting individual indicators
    - ❖ Traffic 3, Number of transfers 2, Bend degree 1
- ❖ Further refinement for selection of candidate routes
  - ❖ Route distance and route consideration
  - ❖ Comparison with bus card analysis results

No	BusStopName	passengers	score	busstop_x	busstop_y	버스카드 통행량
1	새뜸마을4단지(가온마을1단지)	75	3.459880778	127.24484	36.48946	1,106
2	아름동커뮤니티센터	109	3.22179152	127.24733	36.51182	1,624
3	종촌고등학교	63	3.174201862	127.24438	36.50524	3,771
4	수루배마을1단지	51	3.167125349	127.3076	36.50018	1,183
5	세종세무서	149	3.166913611	127.26304	36.49609	1,327
6	고운동커뮤니티센터남측	55	3.022792441	127.23478	36.50433	2,062
7	대평동커뮤니티센터	39	2.995775409	127.27883	36.47225	3,400
8	반곡동(수루배마을)	33	2.742212377	127.31096	36.49754	2,476
9	가재마을7단지	48	2.724151263	127.24897	36.50514	4,608
10	조치원역뒤편	40	2.684941234	127.29509	36.60061	6,959
11	도담동	1,741	2.651539224	127.25896	36.51483	27,790
12	세종시청.교육청.시의회	342	2.455648657	127.28835	36.47819	18,098
13	첫마을1단지	125	2.369463739	127.2592	36.48385	1,010
14	가재마을11단지	21	2.356009912	127.25017	36.50438	1,975
15	새뜸마을5&8단지	35	2.331628886	127.25352	36.4825	2,571
16	가재마을5&8단지	46	2.308482702	127.24986	36.50047	6,098
17	신흥사거리	48	2.294530903	127.29097	36.59447	2,157
18	신안리마을회관	22	2.245164703	127.28695	36.61655	2,446
19	가락마을9&11단지	48	2.201838554	127.22989	36.51068	1,201
20	범지기마을8&12단지	44	2.135123245	127.25041	36.5125	3,080

No	BusStopName	passengers	score	busstop_x	busstop_y	버스카드 통행량
1	용문역5번출구	89	2.925170728	127.39248	36.339157	92
2	서대전네거리역5번출구	40	2.912493961	127.410805	36.32414	49
3	월평역	64	2.702742278	127.362434	36.35873	2,119
4	시청역	142	2.581740876	127.38868	36.351147	5,590
5	탄방역1번출구	94	2.581281924	127.38429	36.34527	5
6	복합터미널	4257	2.492877107	127.437195	36.349037	2,657
7	유성온천역5번출구	394	2.400336427	127.33994	36.35428	105
8	한밭대학교	350	2.385733533	127.29755	36.350746	2,286
9	정부청사역	394	2.291976958	127.38209	36.35786	6,528
10	롯데백화점	28	2.145236727	127.39074	36.340076	41
11	한남대학교	398	2.130349241	127.42255	36.351494	2,104
12	노은역	161	1.775304261	127.31804	36.37459	3,688
13	충남대학교	271	1.697181615	127.34368	36.36265	7,361

08 New Metropolitan bus(M-bus) route Selection (2/3)

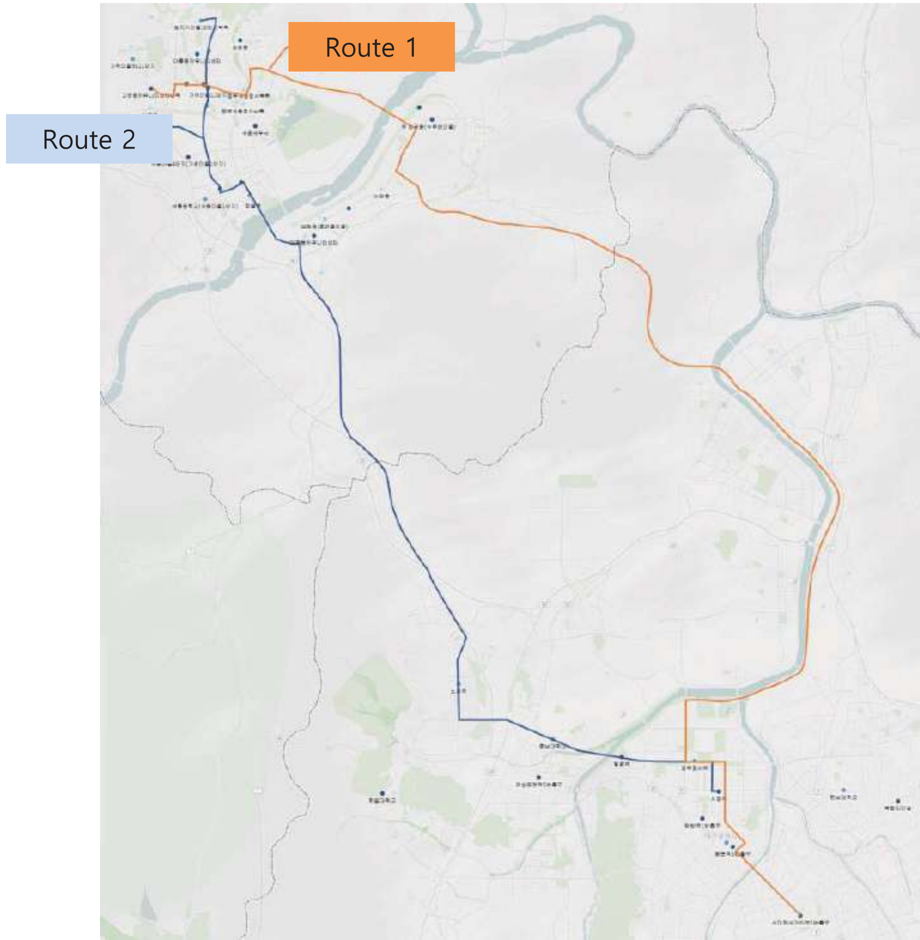
- Simulate and compare expected usage demand for various bus routes to find the best new M-bus route
  - Candidate bus route #1: passenger increase
  - Candidate bus route #2: passenger increase, increased travel time
  - Candidate bus route #3: reduced number of passengers on existing routes
  - Candidate bus route #4: passenger slight increase

routes	Existing routes		Candidate #1		Candidate #2		Candidate #3		Candidate #4	
	S→D	D→S	S→D	D→S	S→D	D→S	S→D	D→S	S→D	D→S
990	2,246	3,593	2,507	2,975	2,878	3,384	2,318	3,612	2,157	3,029
1000	2,126	2,657	1,491	2,415	1,552	2,527	2,011	2,596	2,120	2,512
1001	3,718	3,530	3,702	3,436	3,714	3,499	804	2,096	3,719	3,513
1002	2,770	1,525	2,699	1,612	2,593	2,016	2,712	1,732	2,502	1,446
1004	1,694	1,219	1,733	1,290	1,456	1,072	1,742	1,154	1,765	1,132
1005	1,411	846	1,333	749	1,277	729	1,189	757	1,328	778
Candidate			3,838	3,511	3,771	3,288	4,059	3,421	1,337	1,344
T. Time	58.70	52.32	55.77	50.28	56.31	51.38	53.63	52.01	58.19	52.57
Bend D.	1.11	1.09	1.12	1.12	1.12	1.10	1.13	1.09	1.10	1.09
No. transit	1.79	1.88	1.80	1.84	1.80	1.84	1.92	1.88	1.79	1.87

08 New Metropolitan bus(M-bus) route Selection (3/3)

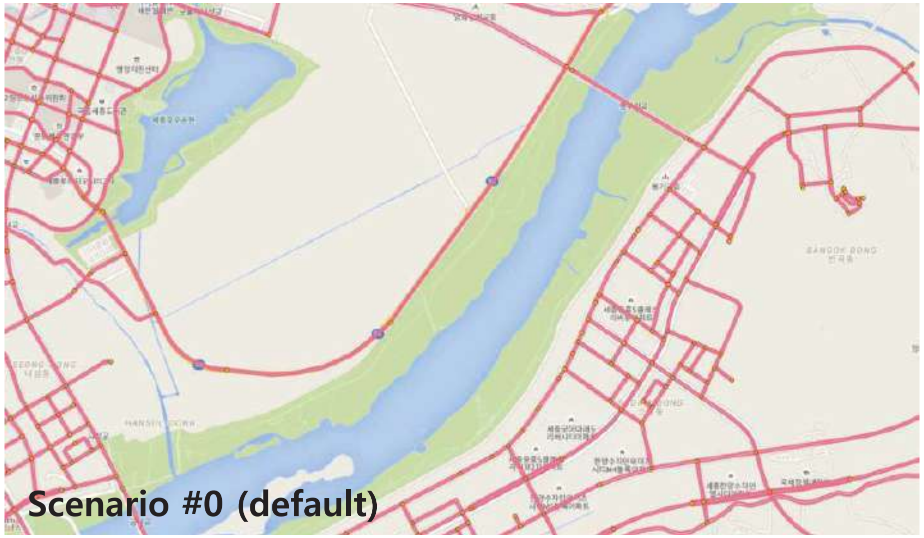
❖ Selection of high-priority routes using simulation results

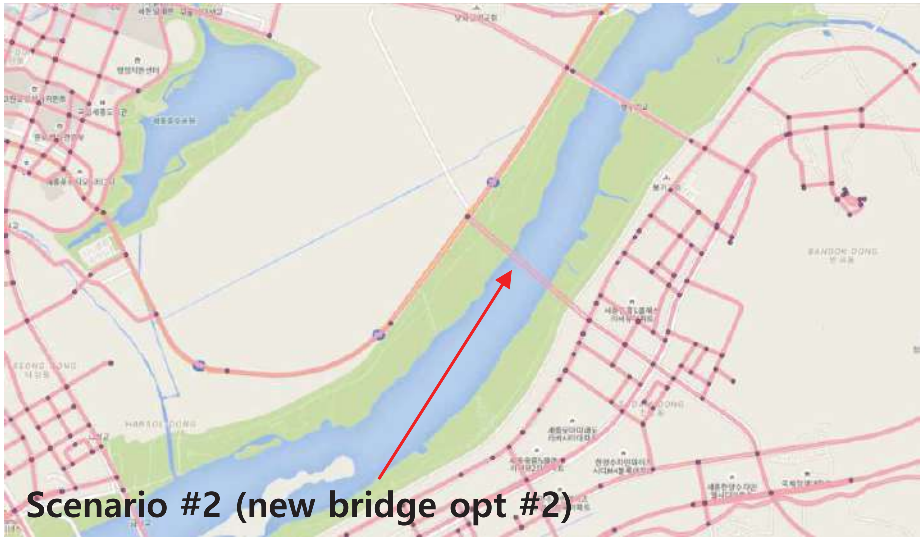
route #	Sejong City	Daejeon City
route 1	Goundong Community Center South	Government building station
	Jongchon High School	City Hall Station
	Gajae Village 7 Complex	Yongmun Station
	North side of Government Complex Sejong	Seodaejeon Intersection Station
	East side of national research complex	
route 2	North side of Beomjigi Village Complex 10	Noeun Station
	Arum Elementary School	Chungnam Univ.
	Gajae Village 7&12 Complex	Wolpyeong Station
	Saeteum Village 5*8 Complex	Government building station
	First Village Complex 1	City Hall Station
route 3	Hansol-dong	Hanam Univ.
	Daepyeong-dong	Complex terminal
	Boram-dong	
	Sejong City Hall	
	Sodam-dong	
route 4	Sodam-dong	Noeun Station
	Sejong City Hall	Hanbat Univ.
	Boram-dong	
	Daepyeong-dong	

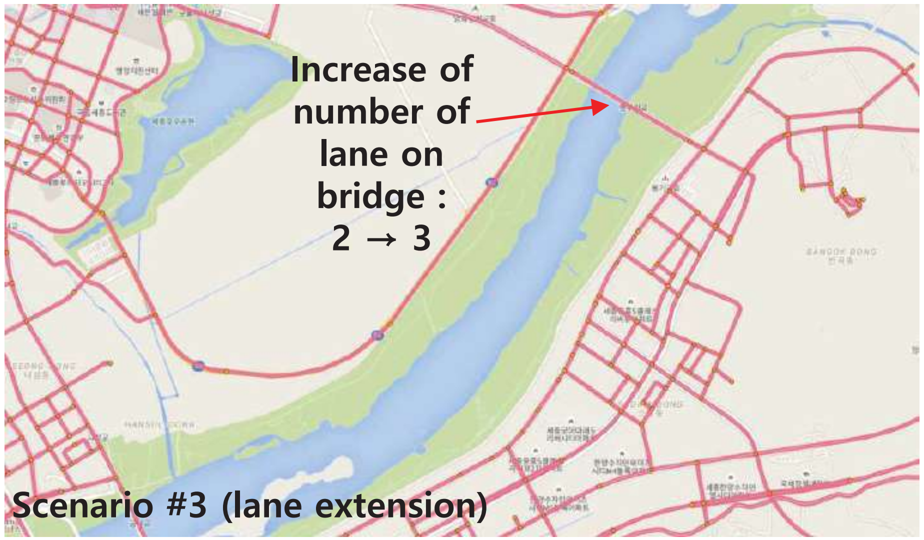


09 Analysis of the effect of new bridge construction (1/2)

❖ Simulation of traffic volume change due to new bridge location change

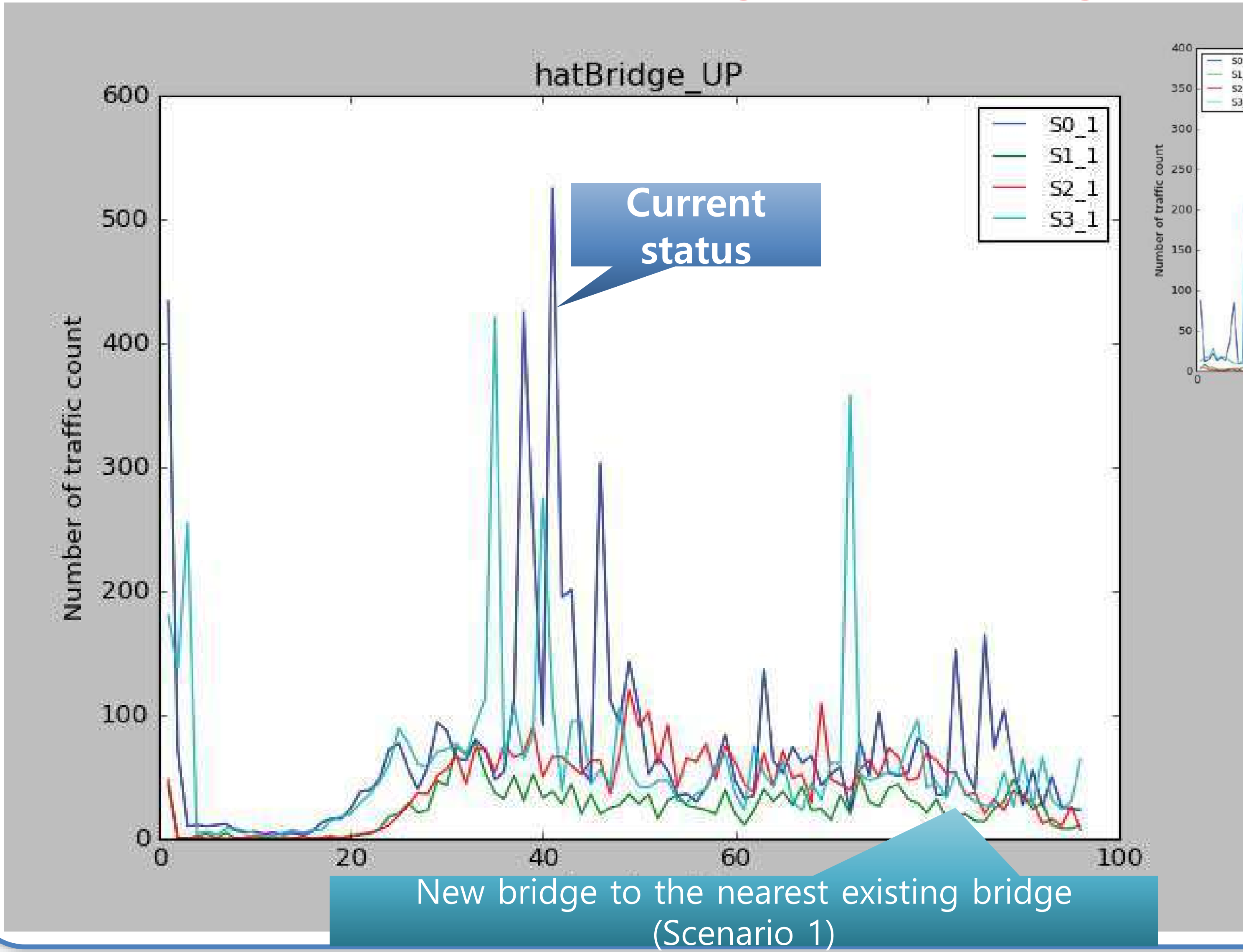


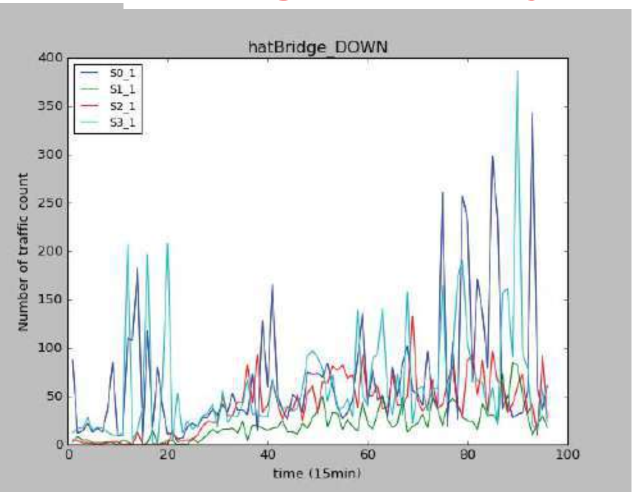




09 Analysis of the effect of new bridge construction (2/2)

❖ Simulation result of traffic volume change due to new bridge location change (Weekday)





10 Efficient operation policy of public bicycles (1/2)

❖ Sejong City Public Bike Operation Improvement Policy Media Report ('20.07.)

❖ 2,595 public bicycles, 577 rental/return stations

제292회 시정 브리핑
[2020. 7. 16(목) 11:00 정음실]

▷ 오늘은 이백 아흔 두 번째 정례브리핑으로,

▷ 먼저, 지난 제281회 정례브리핑을 통해 말씀드린 시티스마트 프로젝트의 일환으로 추진 중인 '빅데이터를 활용한 공영 자전거 운영 개선'에 대해 말씀드리겠음

1 **빅데이터를 활용한 공영자전거 운영 개선**

빅데이터로 어울링 개선안 마련했다

<市-ETRI '디지털 트윈' 빅데이터 연구 첫 프로젝트>
- 대여소 시간대별 이용현황 분석, '재배치 예측' 모델 만들어 -
- 자전거·대여소 지속 확충… 버스와 연계 마일리지 제도 도입 -

1. 추진 배경

☐ 우리시는 2014년 공영자전거 어울링을 도입하였으며, 현재 자전거 2,595대와 대여소 577개소를 운영*하고 있음

* 구어울링(주황색) 735대 / 대여소(키오스크 방식) 72개소('14년-'18.8월)

** 뉴어울링(파란색) 1,860대 / 대여소(GPS위치지정 방식) 505개소('18.8월~)

- 1 -

세종시 빅테이터 이용 '어울링' 개선 방안 마련

ETRI 디지털트윈 데이터 토대로 이용 형태 분석
대여소 지속 확충과 버스 연계 마일리지제 도입

기사입력 : 2020년07월16일 16:09 최종수정 : 2020년07월16일 16:09

가 + 가 - 프린트

[세종=뉴스핌] 홍근진 기자 = 세종시가 지난 2018년부터 2년간 한국전자통신연구원(ETRI)의 디지털트윈 빅데이터를 토대로 공영자전거 어울링 이용 행태를 분석해 개선 방안을 마련했다고 16일 밝혔다.

세종시는 지난 2014년 어울링을 도입한 이래 자전거 2595대와 대여소 577개소를 운영하고 있다. 구어울링(주황색)은 735대에 72개 대여소, 뉴어울링(파란색)은 1860대 505개 대여소를 운영중이다.

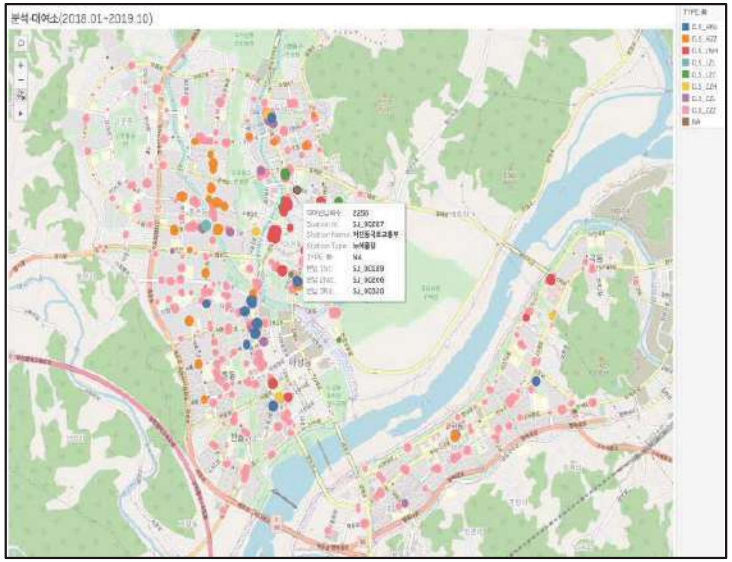
현재 어울링 인력과 예산으로는 시민들의 요구에 대응이 어려워 대책 마련이 필요한 싯점이다. 이에 따라 시는 구어울링과 뉴어울링의 이용 행태를 분석해 개선방안을 마련하게 됐다.

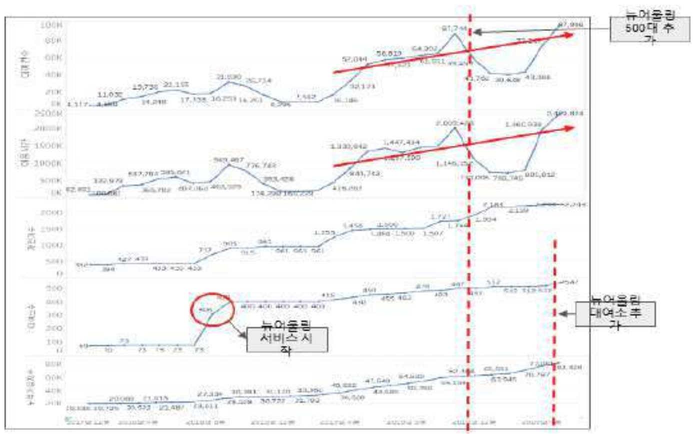
구어울링 자전거와 대여소 전경.[사진=세종시] 2020.07.16 goongeen@newspim.com

Related Media Report

10 Efficient operation policy of public bicycles (2/2)

❖ Establishment of policies to improve public bicycle operation through digital twin analysis





Analysis Item	Contents
General Analysis	Number of uses, subscribers, age groups
	Number of rentals/returns per hour
	Status of use of station by public bicycle model
Users compared to the number of users	Membership distribution by number of rentals
Adequacy of the number of public bicycles	Maximum number of rentals per rental station per hour
	Turnover ratio in peak and off-peak season
	Relocation demand by time of rental stations
Usage Trends by public bicycle model	Utilization rate by model, turnover ration
	Preference by Public Bike Model
	Proximity rental rates by public bicycle model

Digital twin analysis

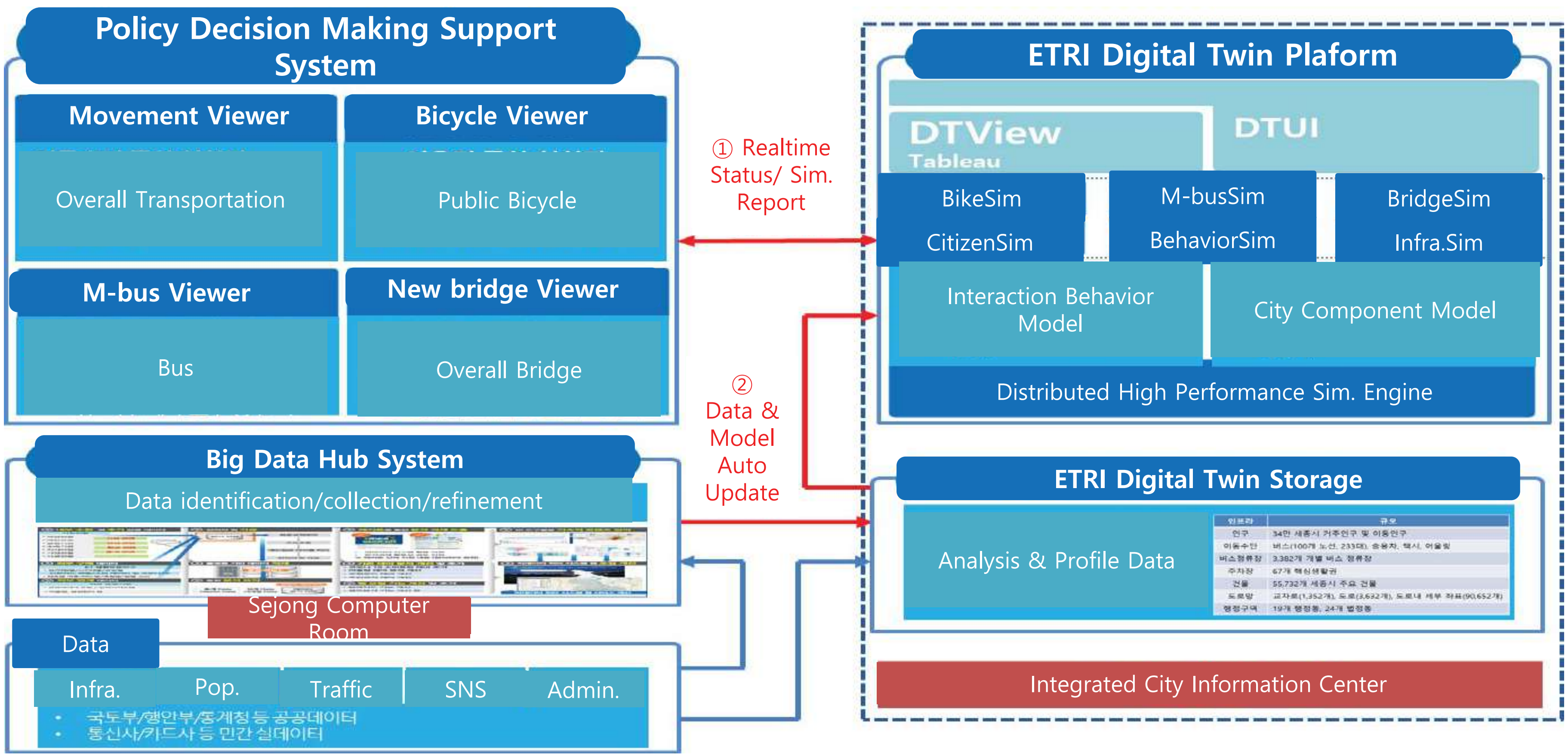
- Operational status analysis
- Encouraging non-used members to reuse
- Relocation guide for each rental station by time
- Recalculation of the right number of holdings
- Expansion of number of bicycle and station of popular models

Established policies

❖ **Identify and analyze the general status of digital twin virtual cities**

❖ **① Promoting future prediction simulation-oriented research & development**

❖ **② Promotion of automatic synchronization(auto update data & model) technology between virtual and real cities**



Sewon Lee

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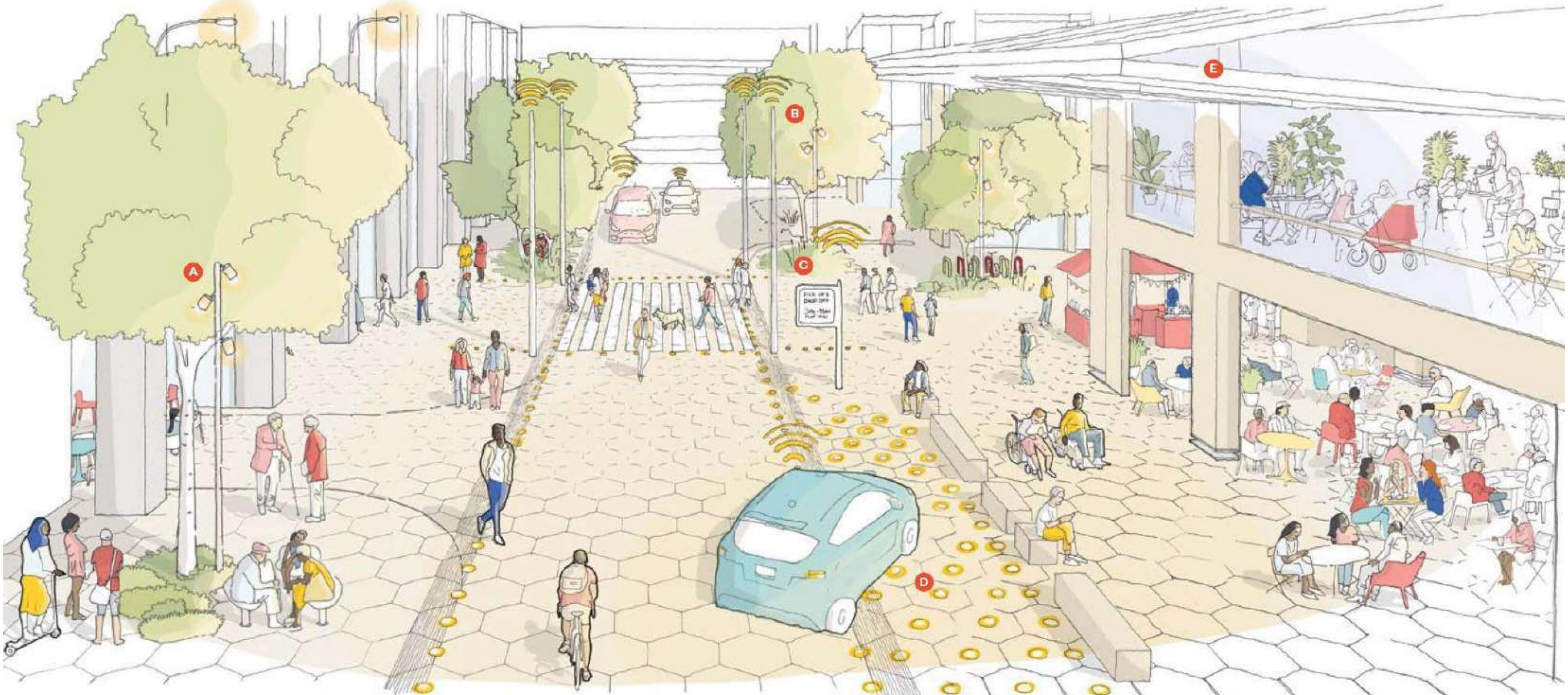
Korea Research Institute for Human Settlements

The Future of Urban AI: Implementations and challenges

The purpose of this presentation is to reveal the relationship between AI technology and urban space, and to propose policy directions by analyzing the data, technology, and decision-making methods needed to implement Urban AI. For this purpose, we researched cases in each field where Urban AI has been introduced to see how AI technology is applied to cities, what differentiates them from similar digital businesses, and identified four elements necessary for Urban AI. These four elements are urban data, AI infrastructure, AI industry ecosystem, and governance, which must be included when we establish an AI strategy at the city level and aim to implement Urban AI.



The Future of Urban AI: Implementations and challenges

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KRIHS 국토연구원

Contents

Chapter 1

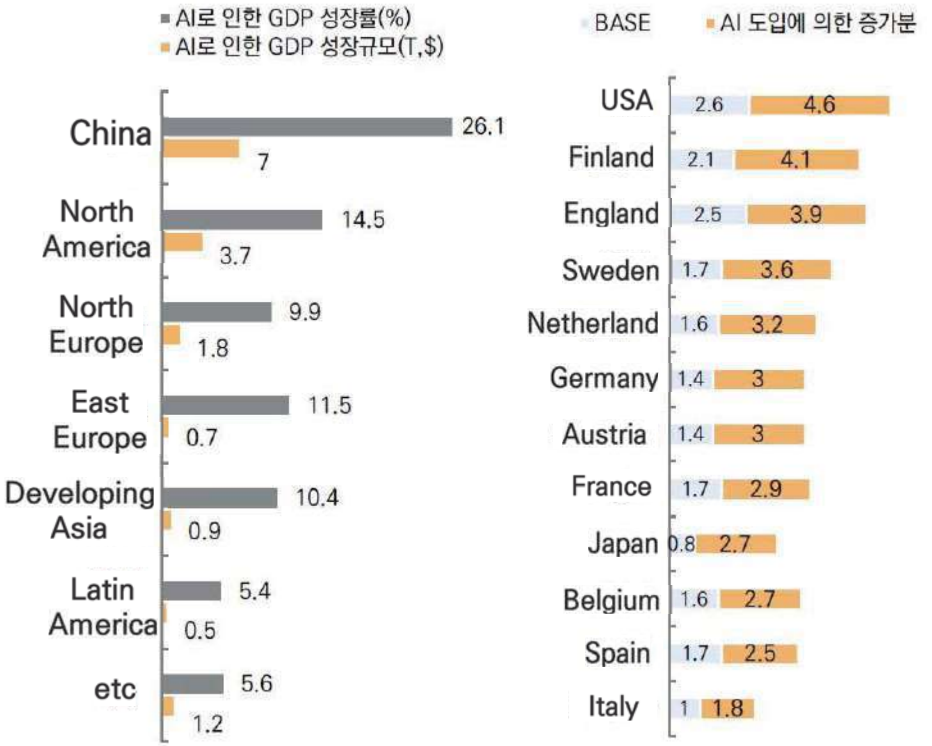
Urban and Tech: Urban AI

Image source : https://eandt.theiet.org/content/articles/2021/11/ai-takes-on-city-design/

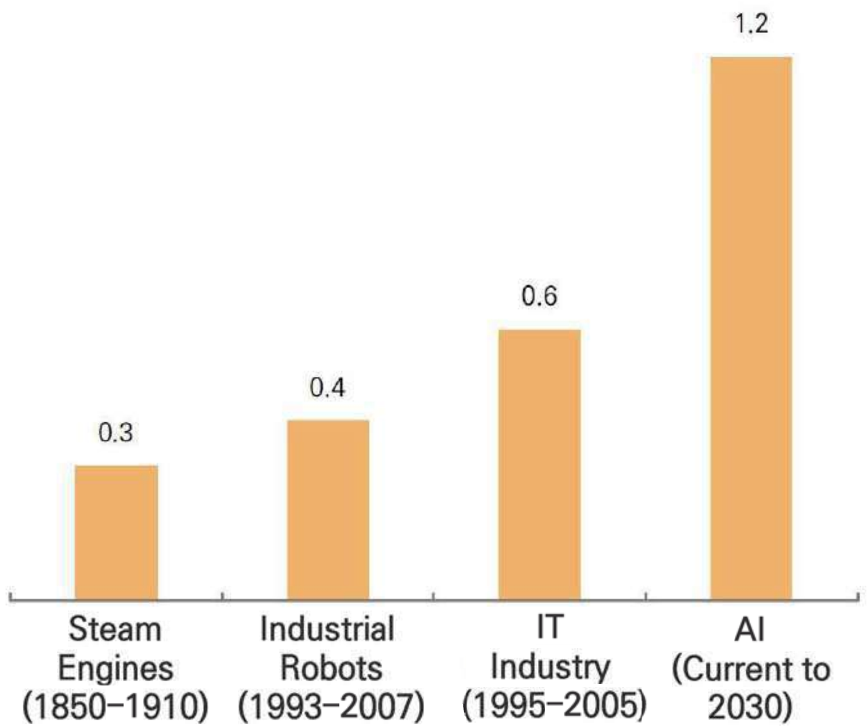
1-1. AI Tech Trends

- Global AI industry market size will be 4.6 times larger than today ($407 billion), with GDP growth of 5-26% by 2035
- Productivity gains from AI are more than double those of past IT revolutions (1.2% CAGR)
- Post-generative AI, global GDP grows by 7% per year (over 10 years) and nearly 300 million jobs become more productive

Impact of AI on global GDP and GVA in 2030-35 (in %)



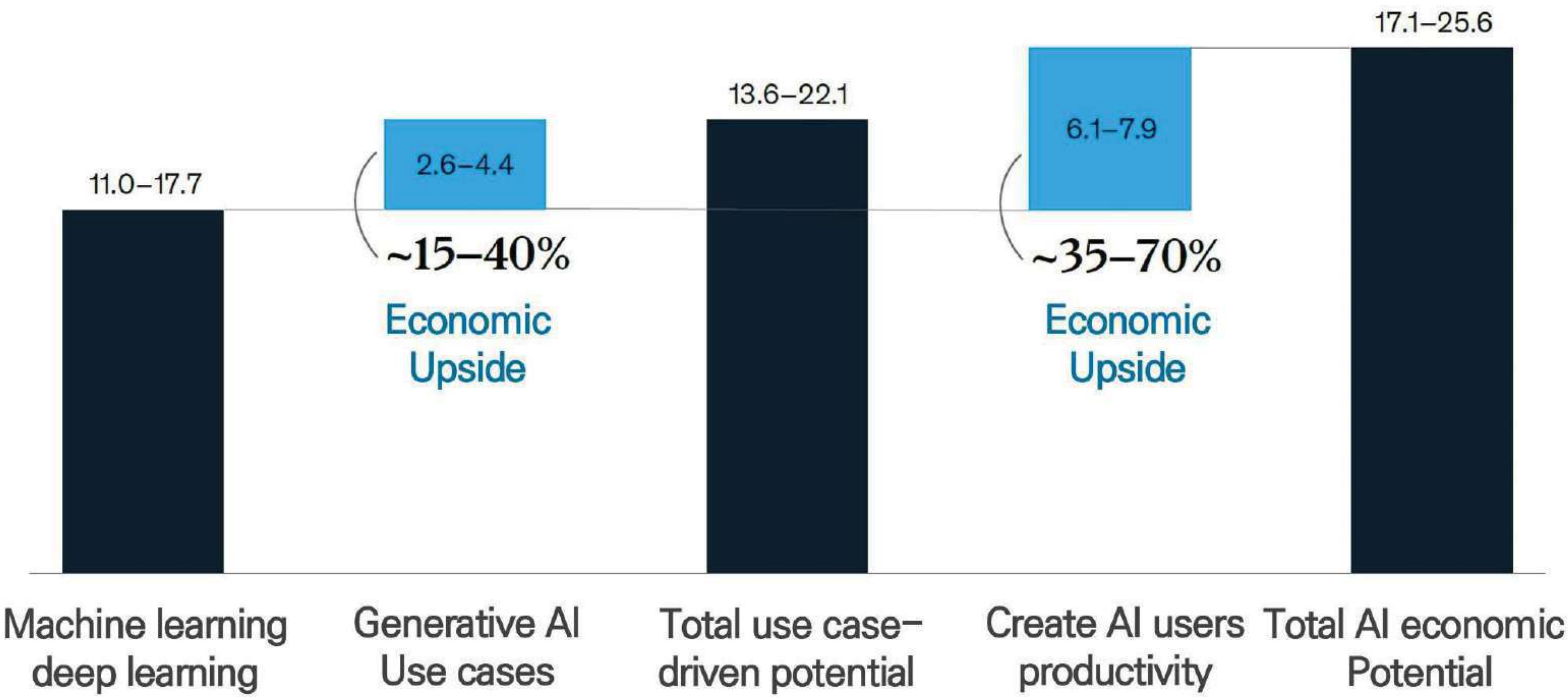
Productivity gains driven by tech innovation (CAGR, %)



Data source : Article by Mirae Asset Securities Digital Research Team using data from PwC, Accenture, and McKinsey

1-1. AI Tech Trends

- AI has been projected to have an economic value of around $11 trillion to $11.7 trillion even in its early machine learning(ML) stages, but the economic value is expected to increase by another 15-40% in about a year after the advent of generative AI.



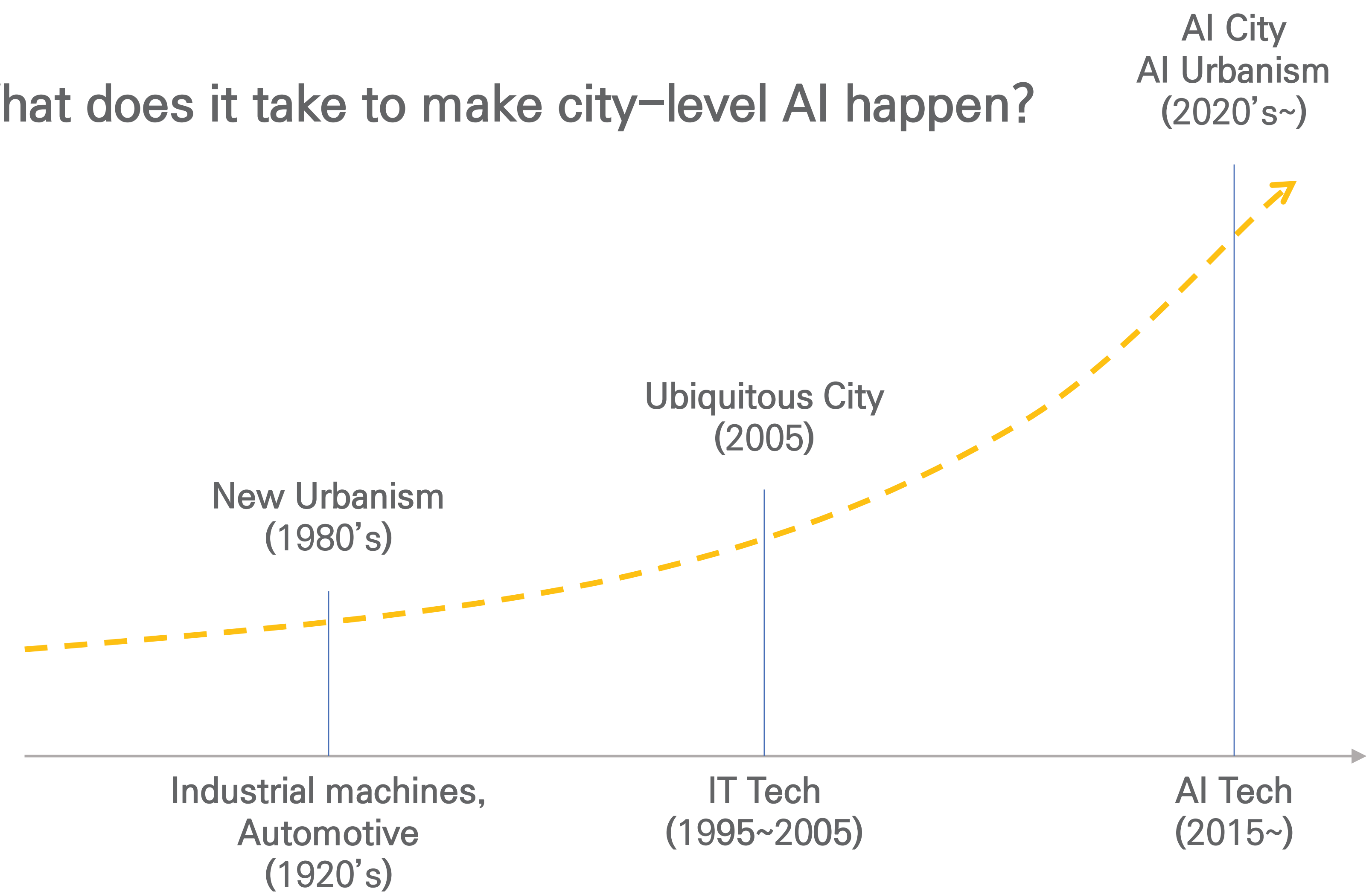
Data source : McKinsey & Company. 2023. p.10.

1-2. Urban and Tech

"Urbanize Technology"

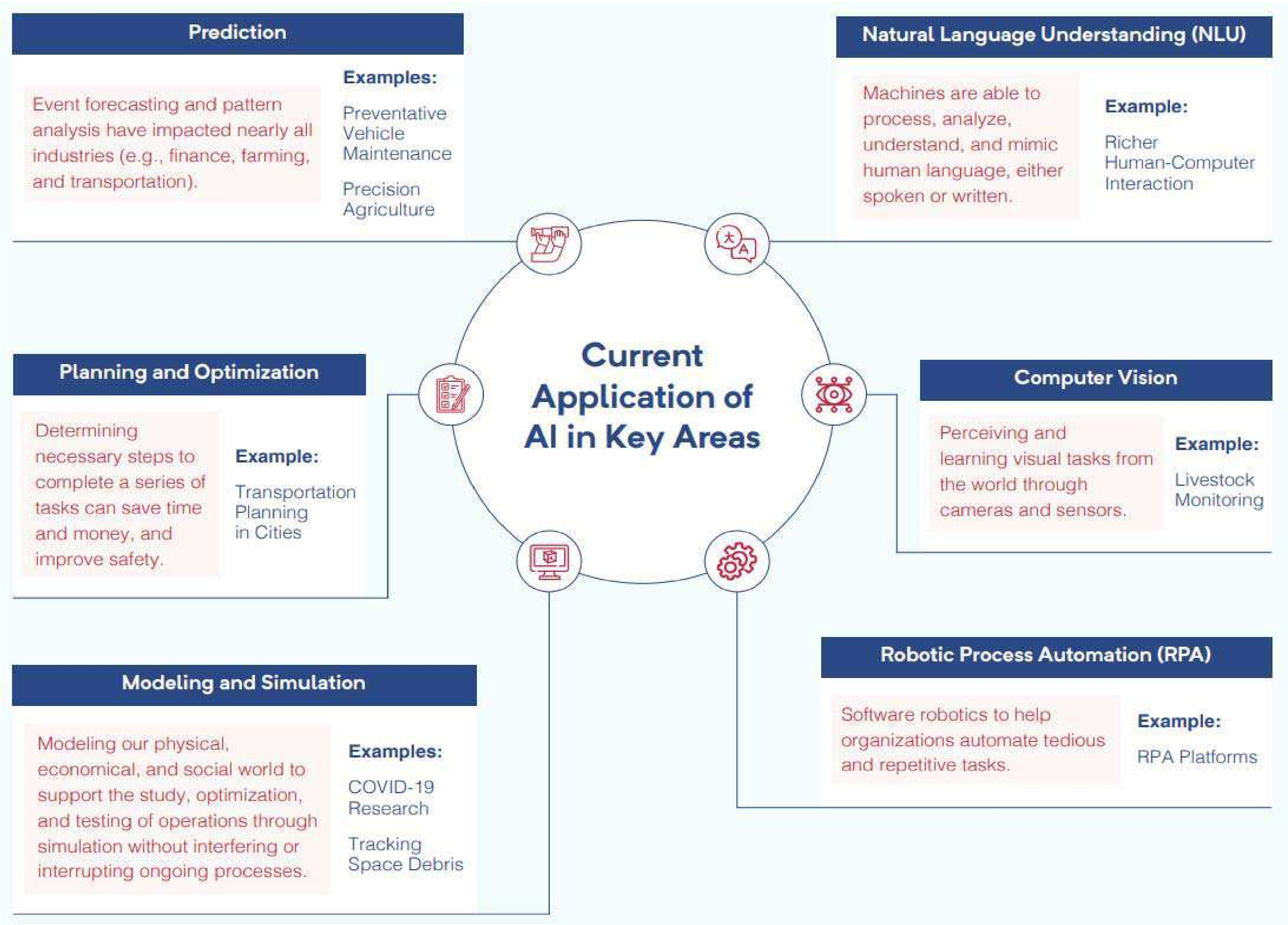
"Cities are already built and run on technology, and cities that don't work are unsustainable."

Q. What does it take to make city-level AI happen?



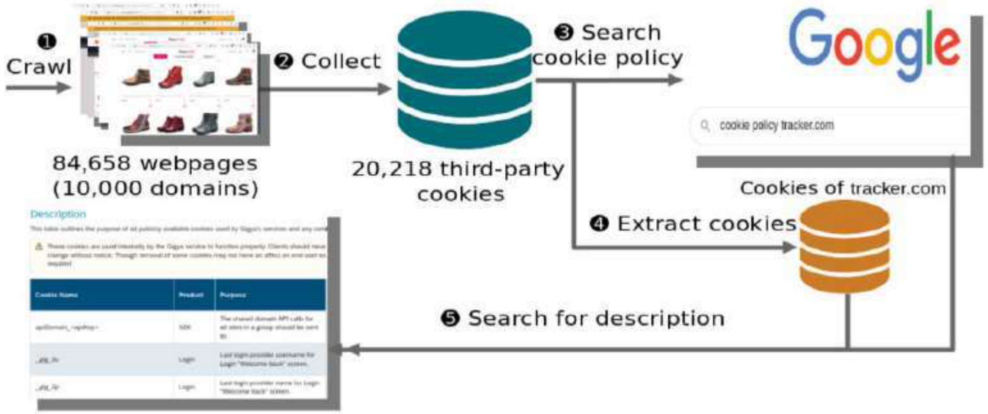
1–2. Urban and Tech

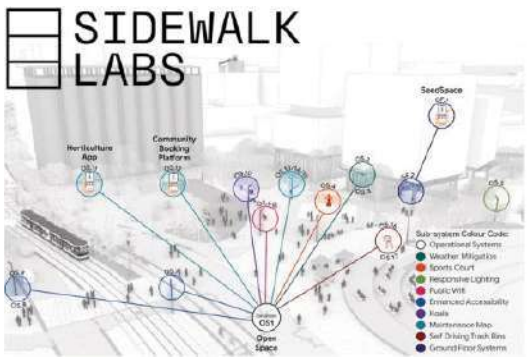
NSCAI, AI Policy Report

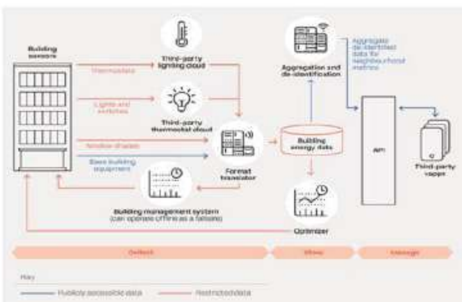


Data source : NSCAI. 2021. National Security Commission on Artificial Intelligence Final report. p.33.

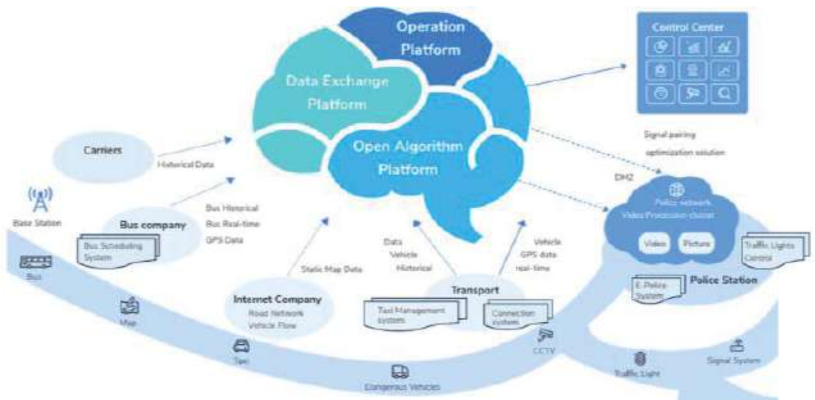
"Just as Google collects data from the Internet to develop its AI platform,
do big techs want to collect Urban Data from cities to develop an Urban AI platform?"







Alibaba Cloud, ET City Brain



Data source : https://www.sidewalklabs.com/toronto

1-3. Urban AI

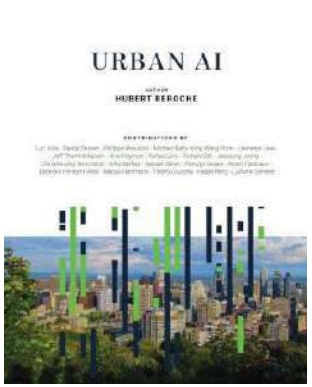
"Urban AI" is the crossroads between AI and the notion of "Smart Cities."

"Can AI help us build sustainable cities? "

In other words, dynamic cities, inclusive and respectful of the environment.

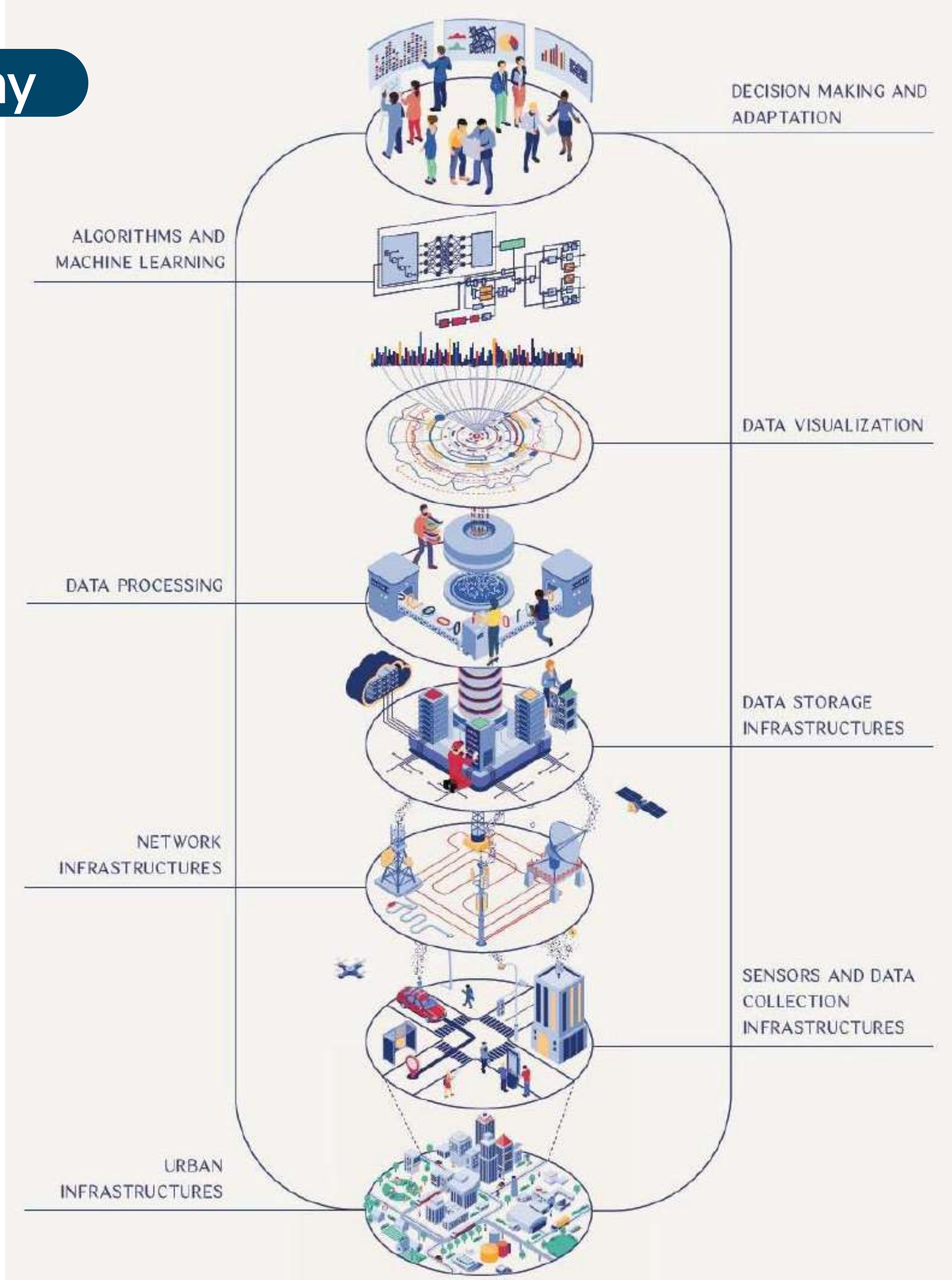
1. Ontology: Transforming urban data into knowledge of the territory, infrastructures and uses.

2. Robotics: Creating robots that are capable of movement in an urban context and that can carry out one or several predefined tasks.



Data source : https://urbanai.fr/education-programs/workshops/

Urban AI Anatomy

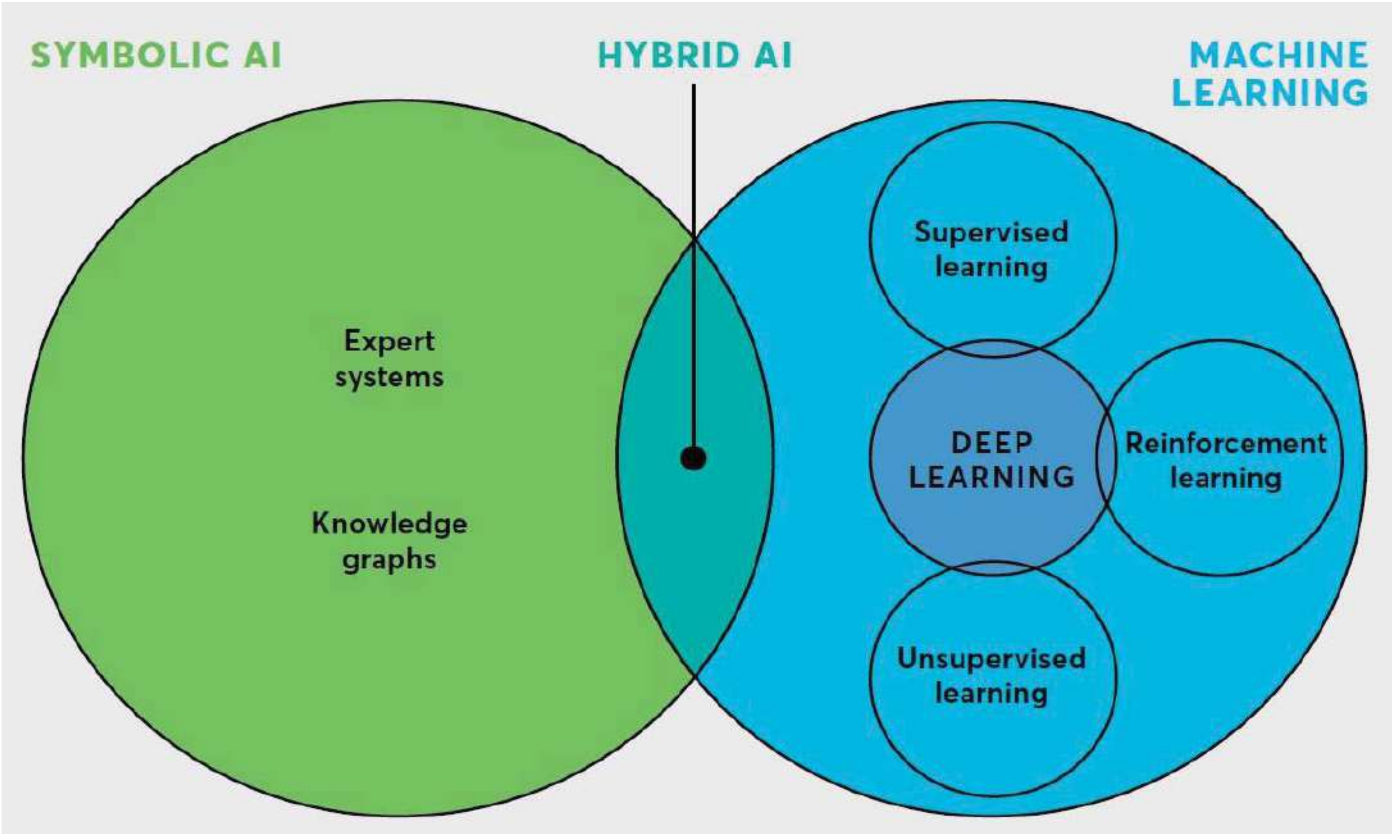


Data source : Popelka, S., Zertuche, L., & Beroche, H. (2022). Urban AI guide. p.46.

1-3. Urban AI

UN-Habitat & Mila(2022). 'AI and Cities'

"There are symbolic and statistical approaches to AI.
The AI that cities need is a hybrid, an intersection of the two."



Data source : UN-Habitat & Mila. 2022. AI and Cities. 13p.

Chapter 2

Use Case and Policies Studies

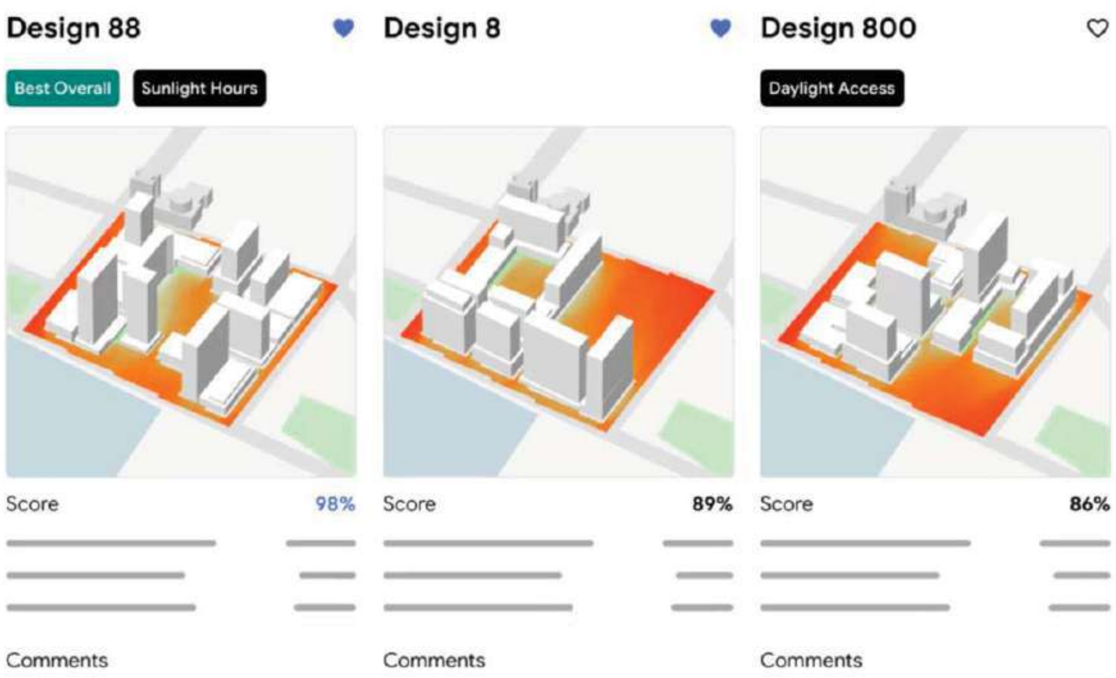
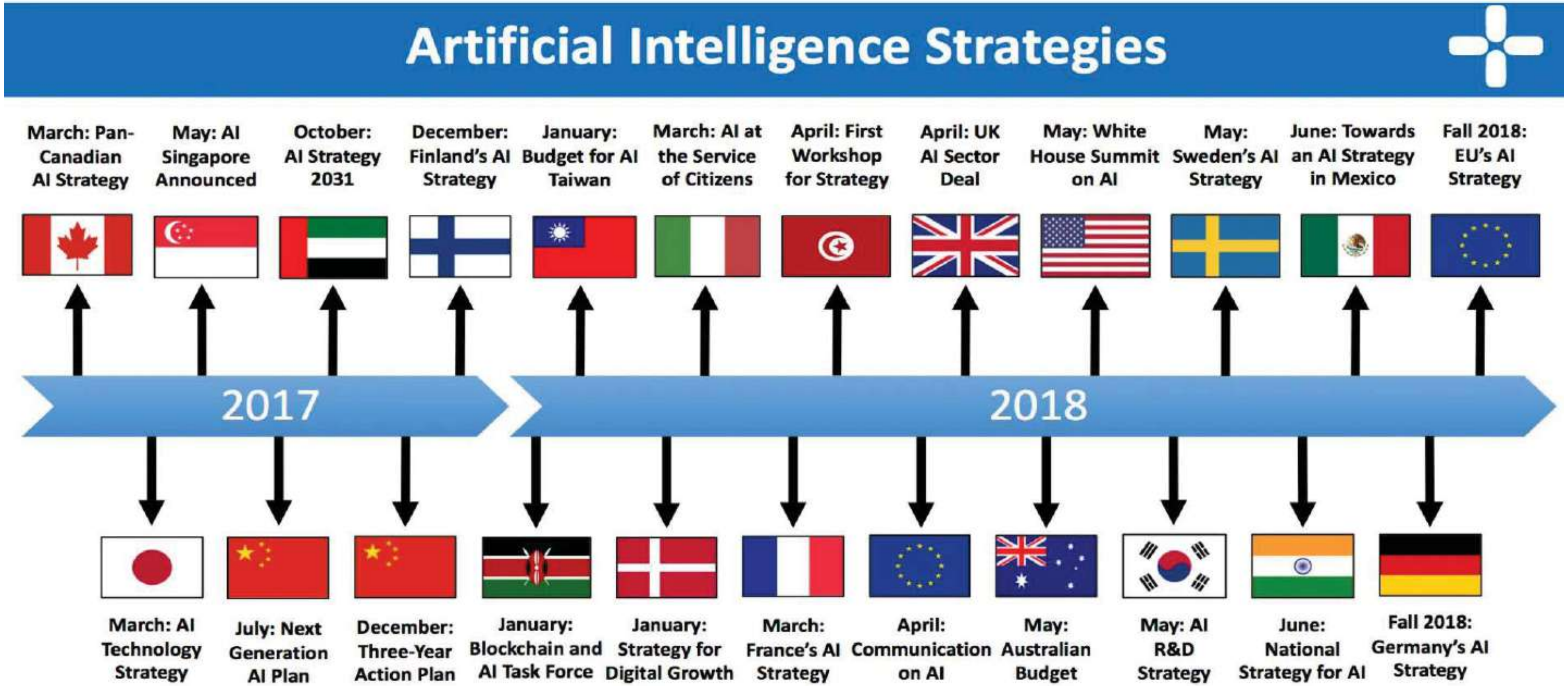


Image source : https://www.aecplustech.com/tools/delve

Overview of National AI Strategic Planning



Data source : https://medium.com/politics-ai/an-overview-of-national-ai-strategies-2a70ec6edfd

Differences in AI Strategic Plans across countries

- Established the first National AI Strategy in 2017
- Research Ecosystem Centered on AI Research Institutions
- AI-based supply chain Super Cluster(Scale AI)
- Establishing a legal framework for Responsible AI
- Developing an Algorithmic Impact Assessment (AIA)

- "Preparing for the Future of AI" and "National AI R&D Strategic Plan" in 2016
- Enactment of the National AI Initiative Act of 2020
- the National Council on AI (NSCAI) report, 2021
- AI R&D Strategic Plan 2023

- National AI Strategy in 2021
- Long-term investment in the AI ecosystem
- Regional and sectoral AI Growth (Benefits)
- Effective AI governance
- Tech Nation

- Manufacturing and Physical capital ➔ AI Strategy
- National AI Strategy shifting its AI strategy to a human rights-respecting and inclusive approach in 2020

〈National AI Strategy in 2019〉

- 9 strategies in 3 areas, 100 top actions
- 10 projects announced to bring AI to the people

〈Smart City Master Plan〉

- 3rd Master Plan identifies AI as one of the leading technologies of the future
- Toward a Cyber Physical System (CPS) that combines Digital Twin and AI

2-2. AI Strategy Plan

Seoul Plan 2040

"Urban Planning with Big Data and AI"

구 분		7대 목표	주요 내용
어디서나 누릴 수 있는 "삶의 질"	1	걸어서 누리는 다양한 일상, '보행일상권 조성'	주거 일자리 여가문화 상업 등 다양한 일상생활을 도보 30분 내에서 향유
	2	수변 공간의 잠재력 발굴, '수변 중심 공간 재편'	물길의 잠재력을 이끌어내 지역과 시민생활 중심으로 재편
	3	새로운 도시공간의 창출, '기반시설 입체화'	도심 속 새로운 공간 창출을 위한 사람 중심의 기반시설 입체화 추진
서울의 성장 견인 "도시경쟁력"	4	미래성장거점 육성·연계 '중심지 기능 혁신'	서울의 도시경쟁력을 높이기 위한 중심지 기능 고도화 및 신성장 산업 기반 마련
	5	기술발전에 선제적 대응, '미래교통 인프라 구축'	신 교통수단의 효율적인 정착을 위한 미래교통 기반시설 마련
대전환시대 미래 서울의 "가치와 방향"	6	미래위기를 준비하는, '탄소중립 안전도시 구축'	탄소중립 도시를 위한 공간계획의 주요 원칙, 기후변화 및 신종 대형재난에 대응하는 지속가능한 서울로의 전환
	7	도시의 다양한 모습 구현, '도시계획 대전환'	미래 도시변화에 대응하기 위한 유연한 도시계획체계로의 전환

Seoul Smart City Plan

"Urban management and operations with AI"

Seoul AI Strategy Plan

"Finding AI services for Seoul and establishing a Master Plan"

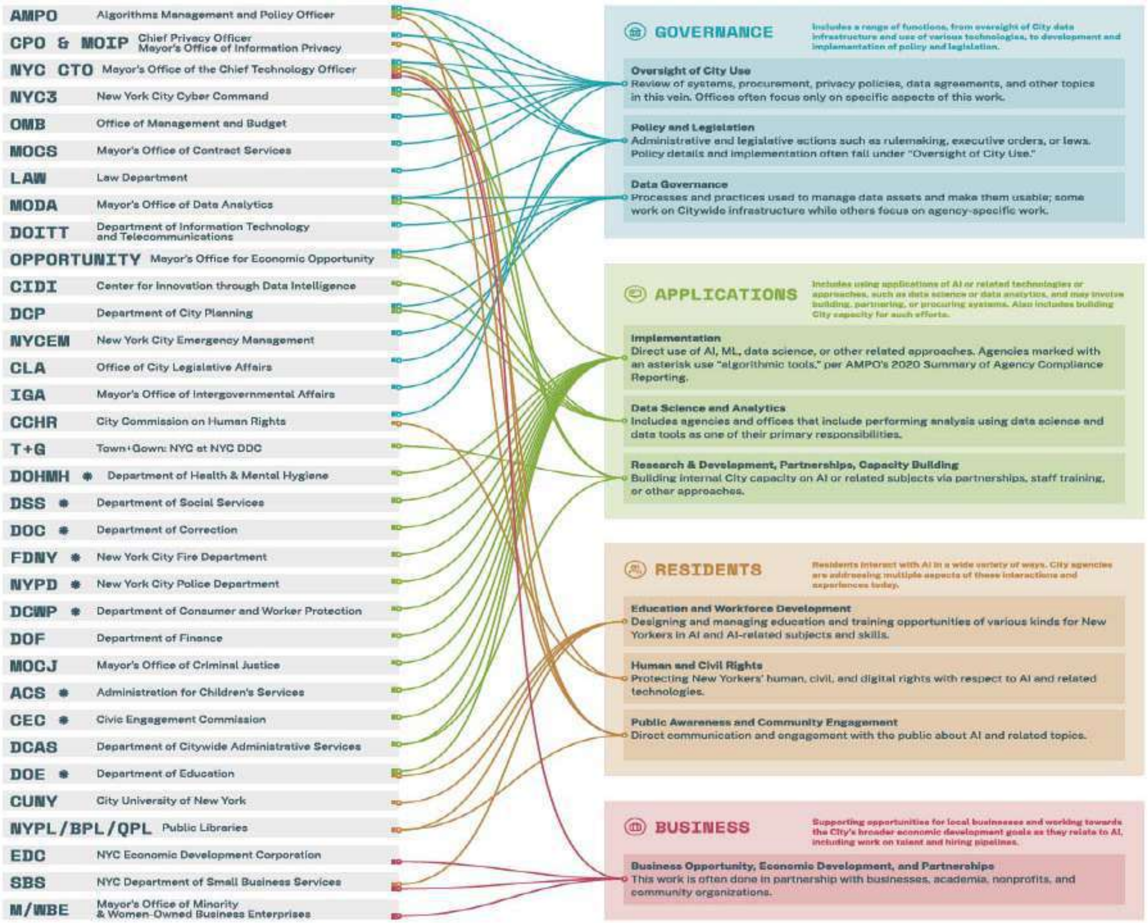
?

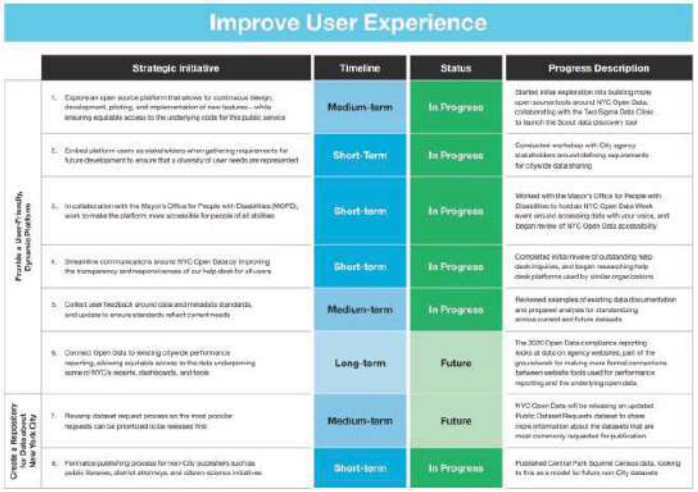
연번	서비스명	관련부서	검토사항
1	(신규) 주택불법 거래 감지 시스템	주택정책실	- 데이터 수집·확보사항 - 개인정보 유무
2	(신규) 따릉이 수요 분석을 위한 적정 배치 시스템	서울시설공단	- 데이터 수집·확보사항 - 개인정보 유무
3	건축공사장 위험요소 관제	주택정책실 (지역건축안전센터)	- 추진현황,고도화 계획
4	도시변화탐지 시스템	디지털정책관 (공간정보담당관)	- 추진현황,고도화 계획
5	인공지능 회의록 지원 시스템	디지털정책관 (정보시스템담당관)	- 추진현황,고도화 계획
6	RPA기반 업무자동화	디지털정책관 (정보시스템담당관)	- 추진현황,고도화 계획
7	인공지능 기반 보안관제 플랫폼	디지털정책관 (정보통신보안담당관)	- 추진현황,고도화 계획
8	개인정보 접속기록AI 관제 시스템	디지털정책관 (정보시스템담당관)	- 추진현황,고도화 계획
9	중요멀티미디어 기록 디지털 활용기반 구축	디지털정책관 (서울기록원)	- 추진현황

자료: 서울시 원문정보 2023.「서울시AI서비스 발굴 검토 설명회 개최」p.3 인용

NYC AI Strategy Plan

"Urban Data, Applications, Governance, Partnerships, Equity"

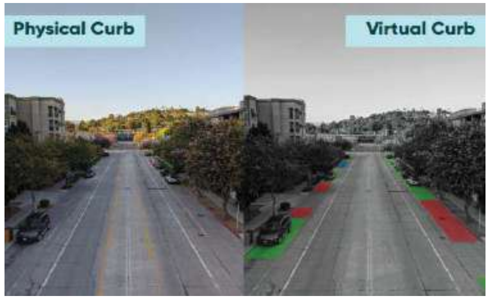


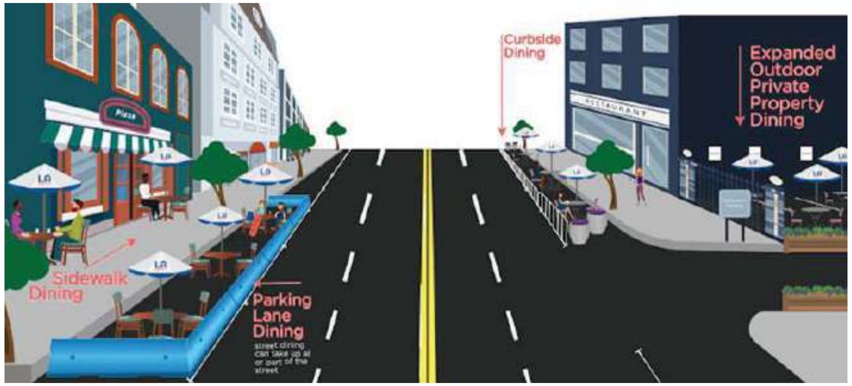


Data source : https://www.nyc.gov/assets/cto/downloads/ai-strategy/nyc_ai_strategy.pdf

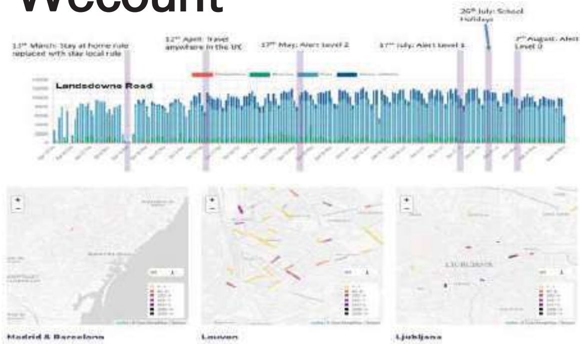
Urban AI Use case

LA, CurbIQ

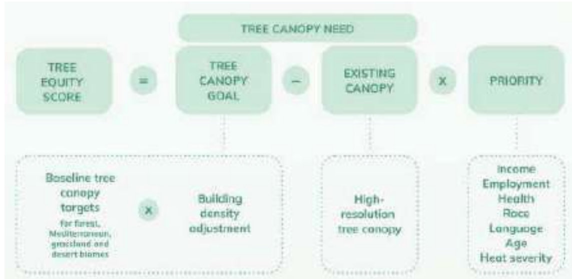




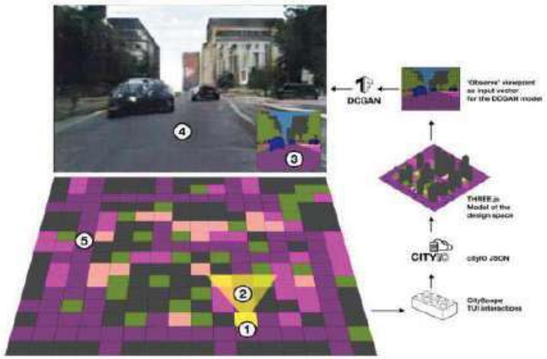
Wecount

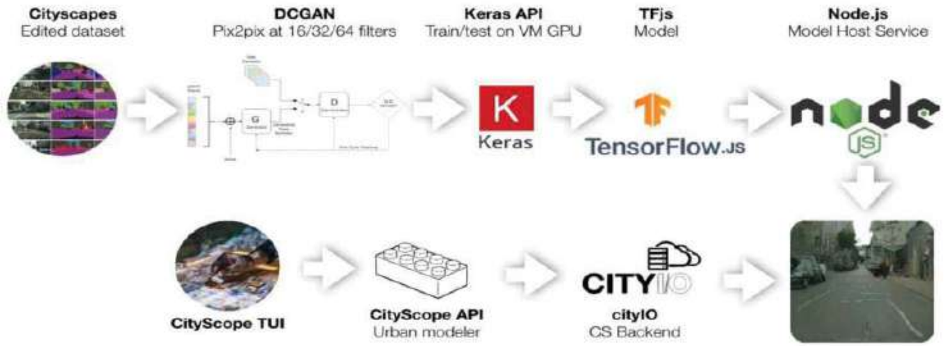


Tree Equity Score



MIT, DeepScope





2-3. Urban AI Use case

Classify cases by Urban AI area and derive key content

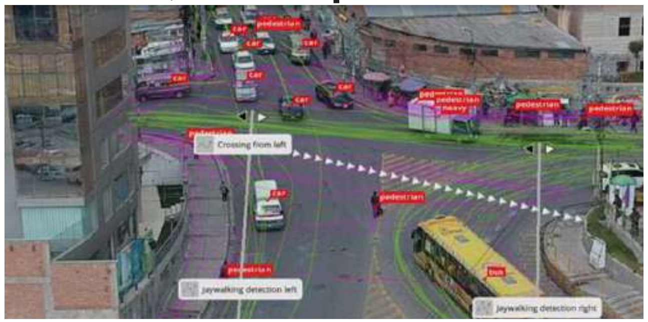
	Optimize	Ontology	Sharing·Connect	Augmented	Multi-Use
Mobility ▪ 영역별 고른 분포 ▪ AI적용 사례 다수 ▪ 문제인식 명확 ▪ 의사결정에 즉시 반영 가능	· (NY) VIA - 온디멘드 자율주행 - 스쿨버스, 교통 Net 최적화 · (SG) S-Nation - 온디멘드 자율주행 - 교통 Net 최적화 · TOMTOM - AI 적용(EL-GAN) - HD맵(자율주행)	· (EU) Wecount - 크라우드소싱데이터 - 실시간 교통량 집계 · (MTL) Trajet App - 여행자 데이터 취득 - 몬트리올 공간계획 · (BOS) UNA - 보행자 데이터 취득 - 도시연결분석	· V2X - 네트워크, 인프라 - 자율주행 연결 기술 · MaaS - 교통네트워크 통합 연계 - Sidewalk Labs, 카카오	· (SG) FASTER - 교통 시뮬레이션 - 긴급상황 대응 솔루션	· (LA) Code THE Curb - 연석공간 데이터 - Curbside 공간관리계획 · (NY) BlankSpace - 도로 공용공간 모델링 - 모빌리티(Live LAIDAR)
Cities / Architecture ▪ 도시의 복잡성 ▪ 개별 문제 대응 ▪ 계획수립(참여) 위해 증강 필요 ▪ 설계 최적화 도입	· (MTL) MAXEN - 딥러닝, HVAC - 스마트 빌딩(공기) · (QC) CANN Forecast - 파이프코호트, 수압 - 수도파이프 관리체계	· (NY) SONYC - 소음 센서, NYC311 - 소음 공해 민원 대응		· MIT, CityScope - ABM, AR, DCGAN - 참여형 도시계획 · (SG) H3 Dynamics - 드론 3D, 영상데이터 - 태양열/농장/생산 등 · (SG) CKG, Ideas - 디지털 지식관리 플랫폼 - 탄종파가 시뮬레이션	· Wework - IoT, 공간사용, ML - 건물 공간사용분석 · (BCN) SDI지수 - 건축형태, 이민자데이터 - 건축형태와 사회통합
Resources / Environment ▪ 자원 최적화 ▪ (수자원) 안전 연계 ▪ 환경 센서, 영상 등 데이터 확장	· (WPG) MyUtility - 물관리 데이터, ITRON - AI 물관리체계 · (FRA) CanForecast - 수질 관리(대장균), 예측 - 수질관리 플랫폼 · Max AI - 쓰레기 자동분류 객체탐지 - 재활용, 폐기물 관리 로봇 · Tastry - 소비자 미각, 와인샘플 - 소믈리에 앱(음식, 와인추천)	· The Quantified Canopy - 수목 분류 데이터셋 - Tree Equity Score 플랫폼 · (VNO) Breeze Tech - 실내/실외/산불 대기센서 - 대기질과 MaaS와 연계 · (BER) CityLAB - 개방형 수목데이터, 크라우드소싱 - 도시 숲 나무 관리 플랫폼 · (LON) HogWatch - 야생동물 종 분류 영상 - 도시 야생동물 다양성 조사		· (TOR) Oscar Zero-Waste - 폐기물 분류/인식, 얼굴 인식 - 폐기물 관리 플랫폼	

2-3. Urban AI Use case

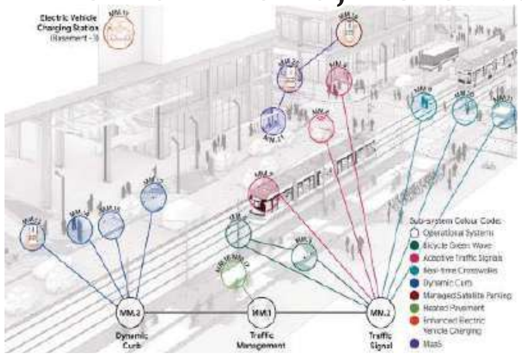
Implications of City level AI Use case

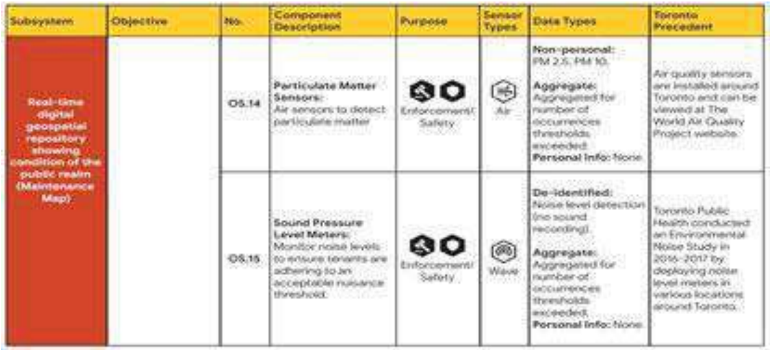
Alibaba, City Brain

NVIDIA, Metropolis



Sidewalk Labs, Toronto

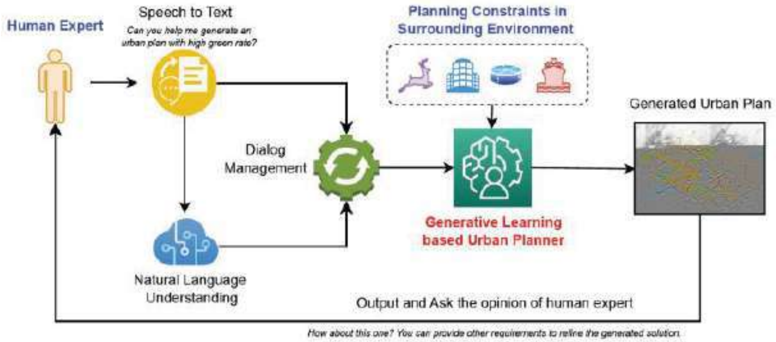




Subsystem	Objective	No.	Component Description	Purpose	Sensor Types	Data Types	Toronto Precedent
Real-time digital geospatial repository showing condition of the public realm (Maintenance Map)		05.14	Particulate Matter Sensors: Air sensors to detect particulate matter	Enforcement/ Safety	Air	Non-personal: PM 2.5, PM 10. Aggregate: Aggregated for number of occurrences thresholds exceeded. Personal Info: None	Air quality sensors are installed around Toronto and can be viewed at The World Air Quality Project website.
		05.15	Sound Pressure Level Meters: Monitor noise levels to ensure tenants are adhering to an acceptable nuisance threshold	Enforcement/ Safety	Wave	De-identified: Noise level detection (no sound recording). Aggregate: Aggregated for number of occurrences thresholds exceeded. Personal Info: None	Toronto Public Health conducted an Environmental Noise Study in 2016-2017 by deploying noise level meters in various locations around Toronto.

Mila

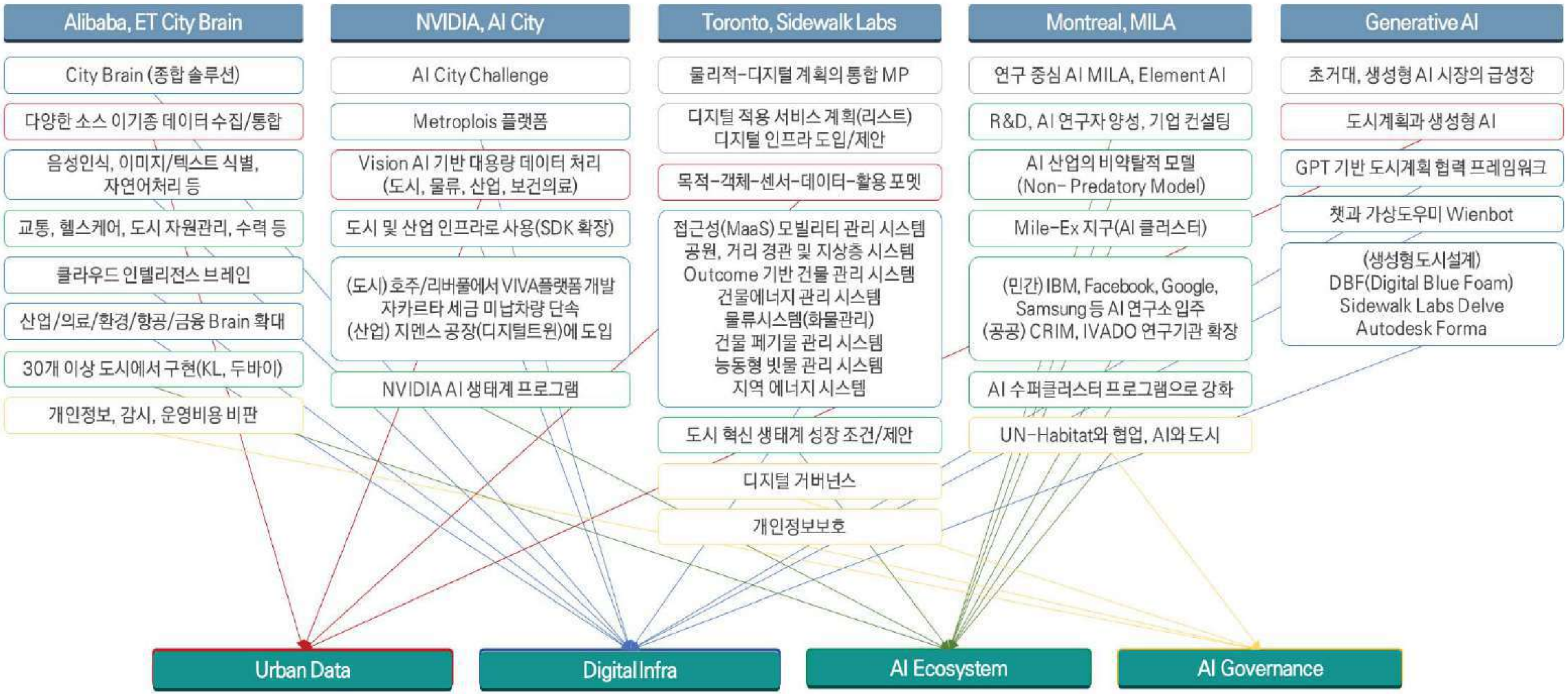
Urban Planning and Generative AI



Sidewalk Labs, Delve

2-3. Urban AI Use case

Implications of city-level AI cases



- 다양한 소스, 이기종 데이터 수집
- 대용량 데이터 처리
- (물리적-디지털) 데이터 모델 규정
- 생성형 AI 데이터 모델

- City Brain(클라우드 인텔리전스브레인)
- NVIDIA Metropolis
- 물리적-디지털 인프라 계획
- 생성 AI(초거대 AI)

- ET City Brain, Nvidia 생태계 확대
- MILA의 비 약탈적 모델
- AI 클러스터

- AI 기본법·제도
- Responsible AI(개인정보 등)
- 데이터 공유 전략, 알고리즘 평가
- 시민참여

Chapter 3

Implementations and Challenges

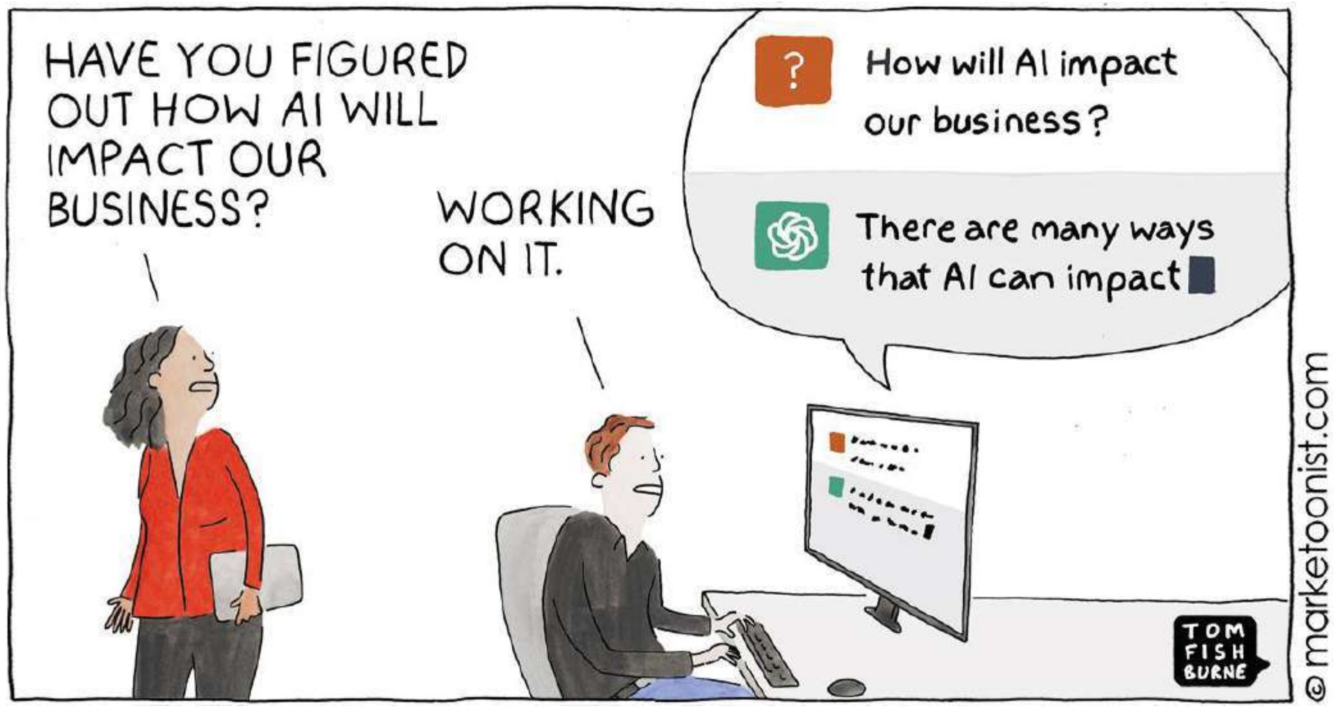
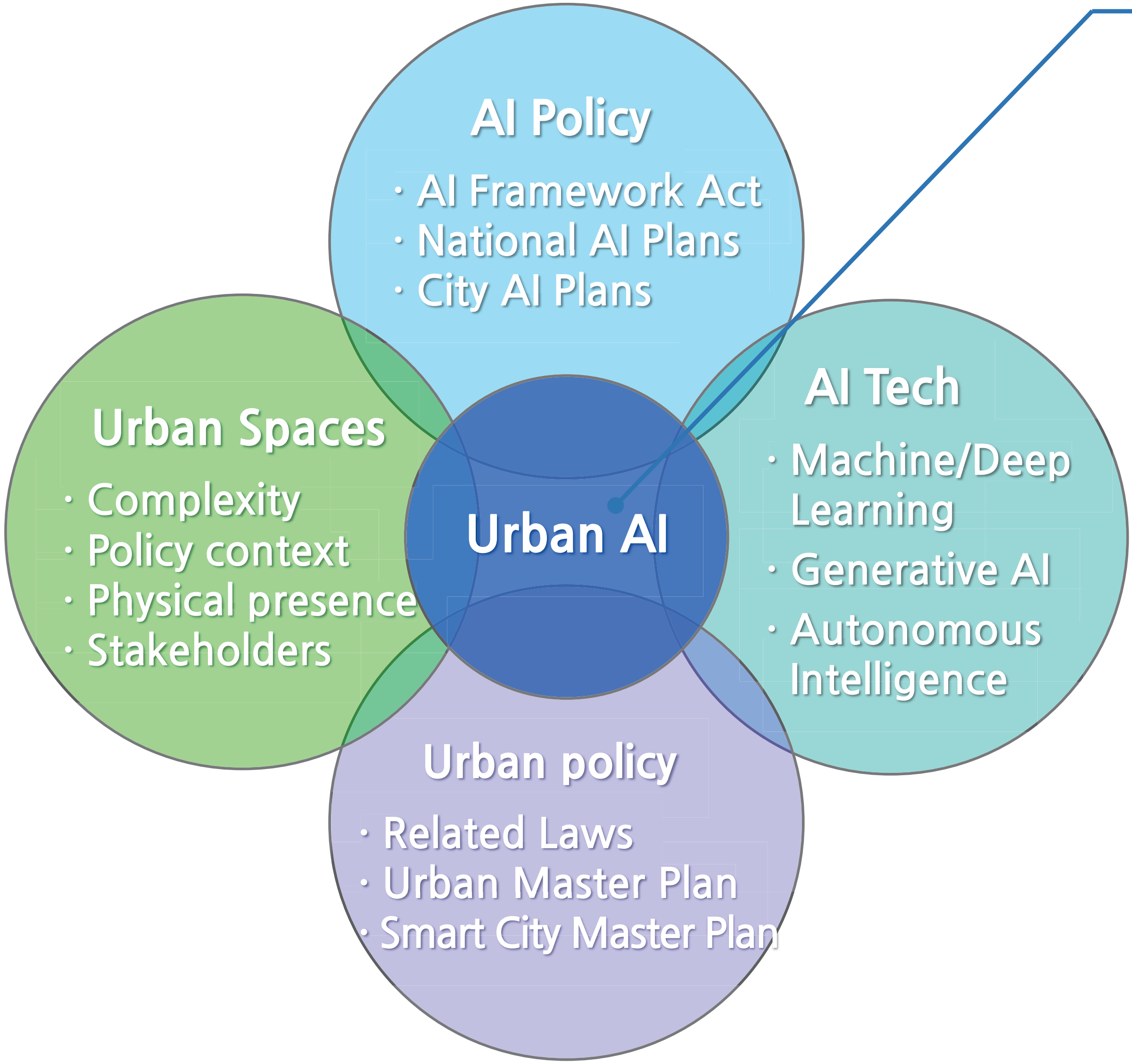


그림 출처: https://marketoonist.com/2023/01/ai-tidal-wave.html

3-1. Definition of Urban AI

Definition of Urban AI



Elements for implementing Urban AI

- Urban Data (Machine Readable)
- AI Infrastructure
- AI Ecosystem
- Urban AI Governance

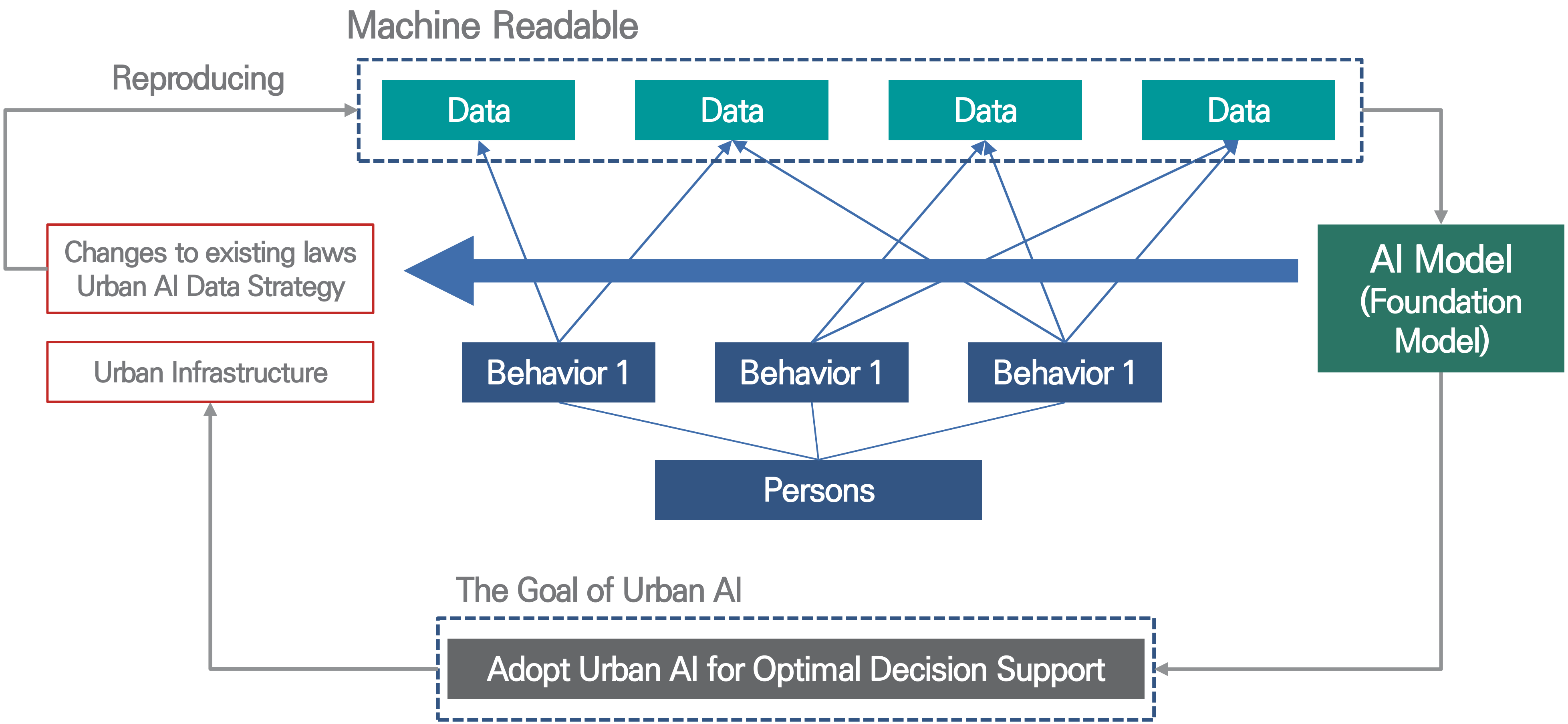
What is Urban Data for AI?

Degree of digitisation of plans

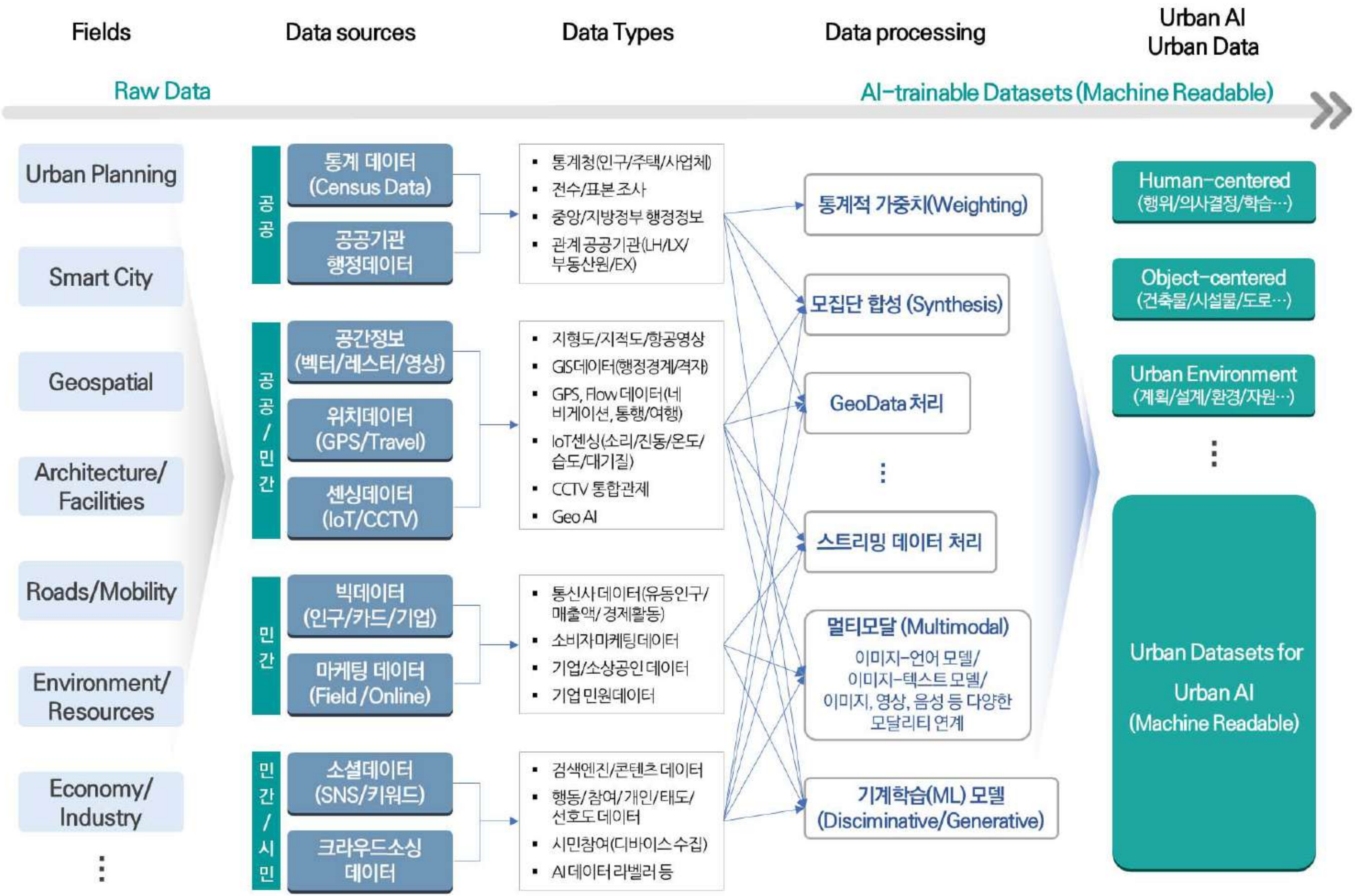
Data source : ESPON(2021), DIGIPLAN – Final report「Evaluating spatial planning practices with digital plan data」

3–2. Urban Data for AI

How do we create Urban Data for Urban AI?

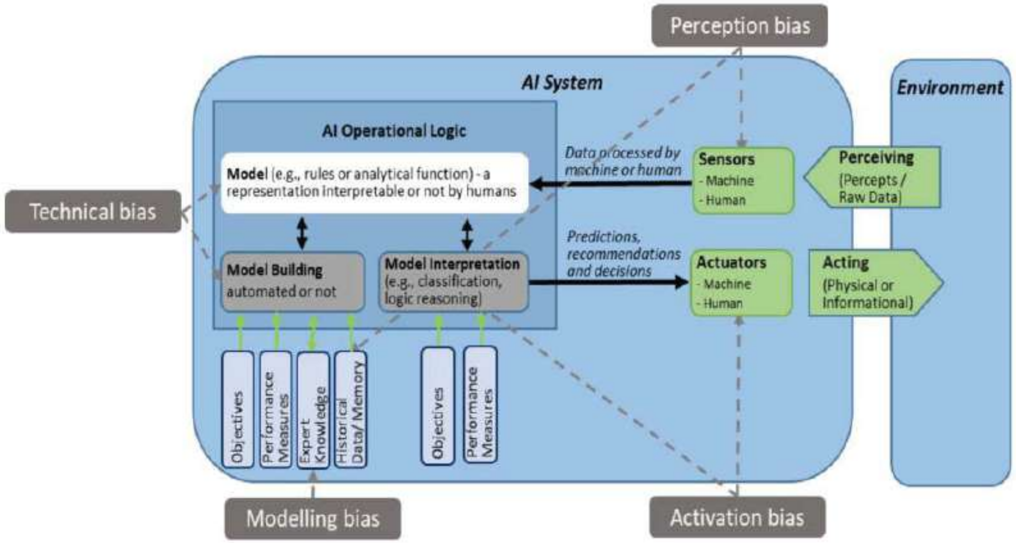


3-2. Urban Data for AI

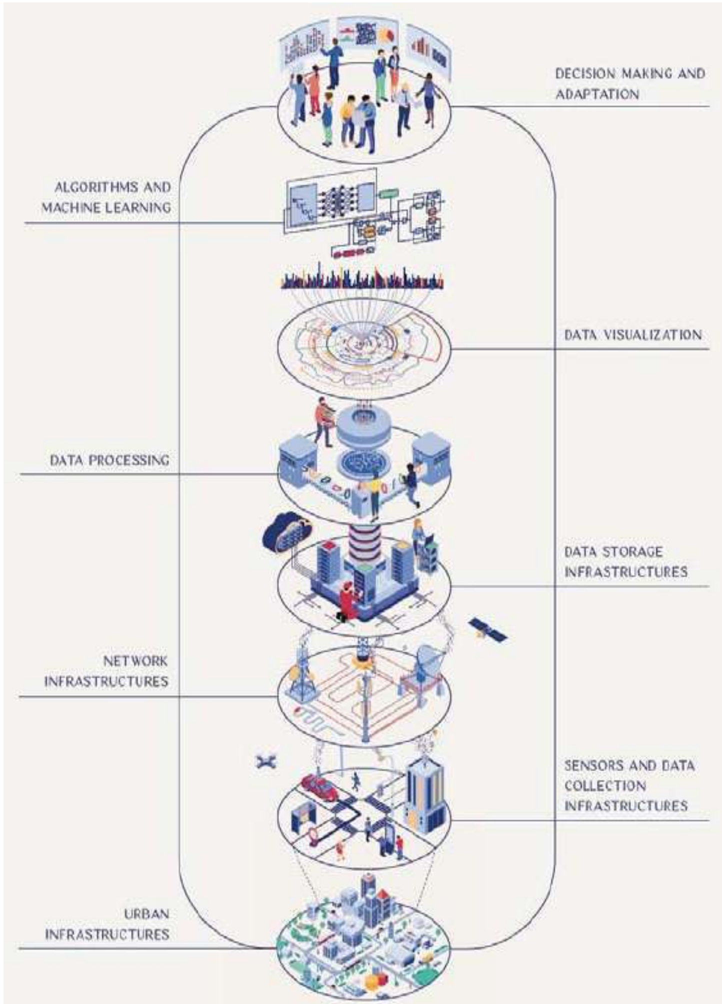


What is Urban Infra for AI?

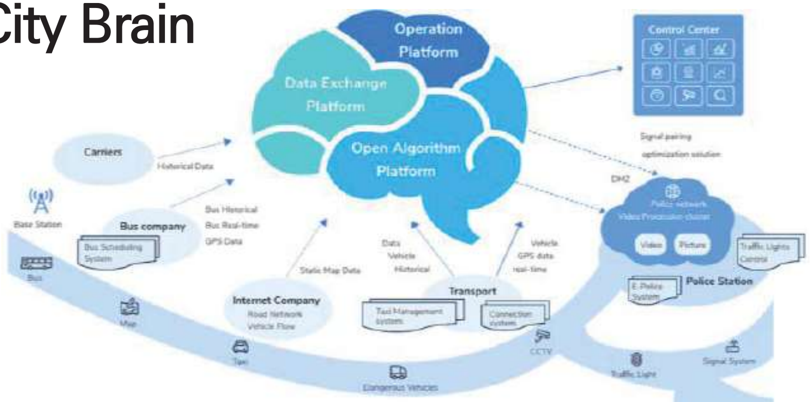
OECD, AI System



Urban AI



City Brain

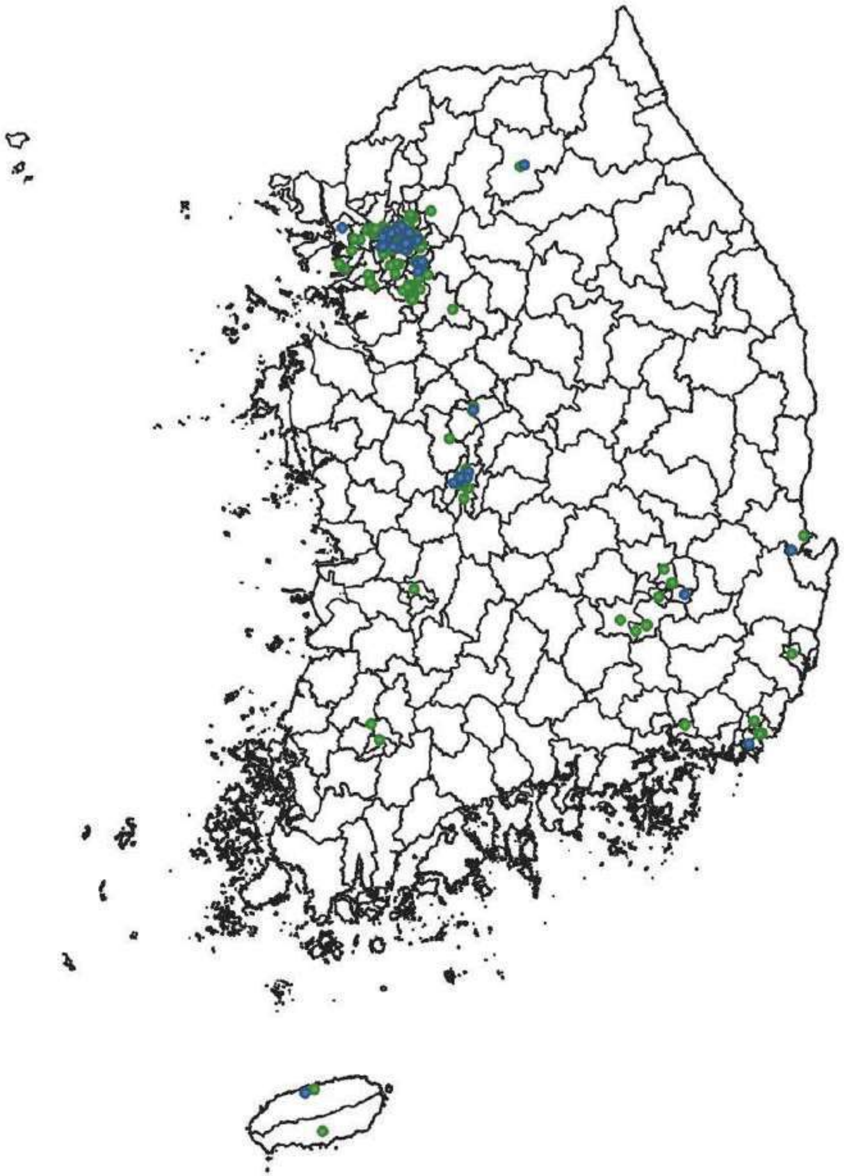


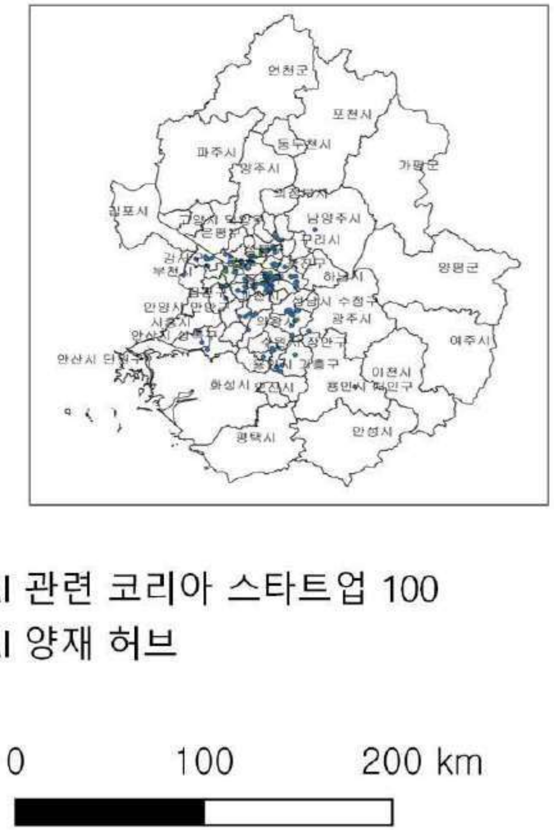
Data source : https://doi.org/10.1787/d62f618a-en

3-4. AI Cluster

Where are the AI clusters in South Korea?

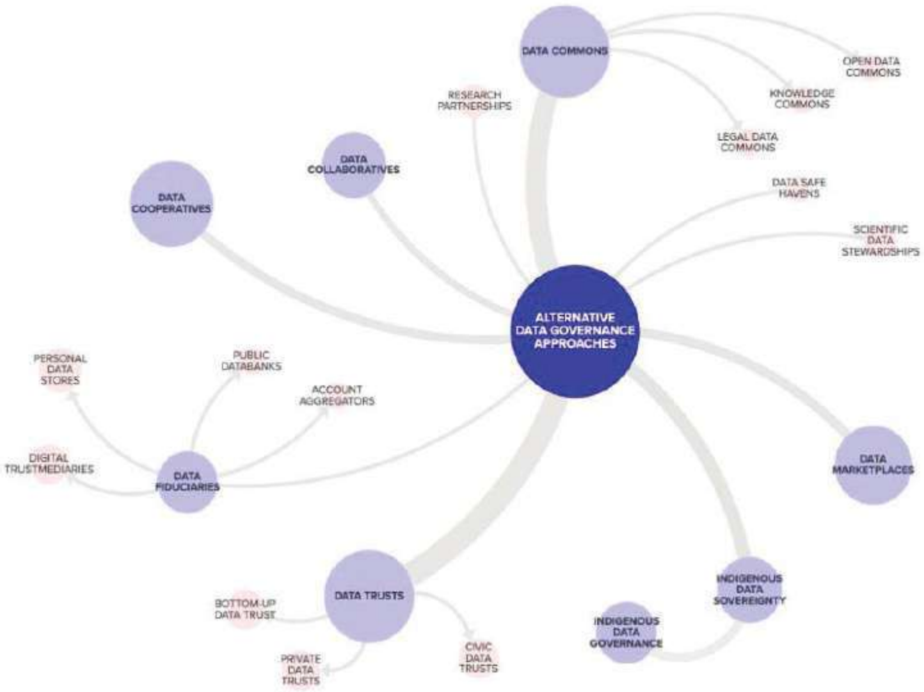
Super Cluster(Scale AI)





Responsible AI

Data Governance



AIA, Algorithmic Impact Assessment

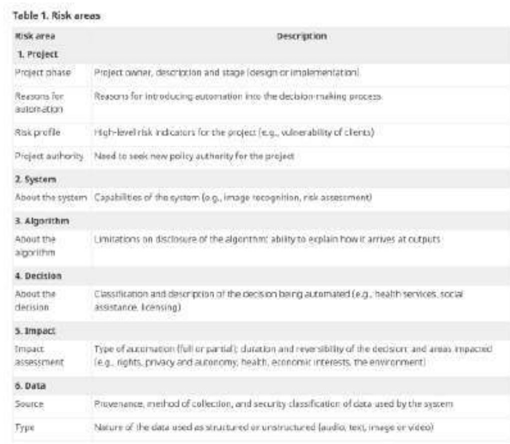
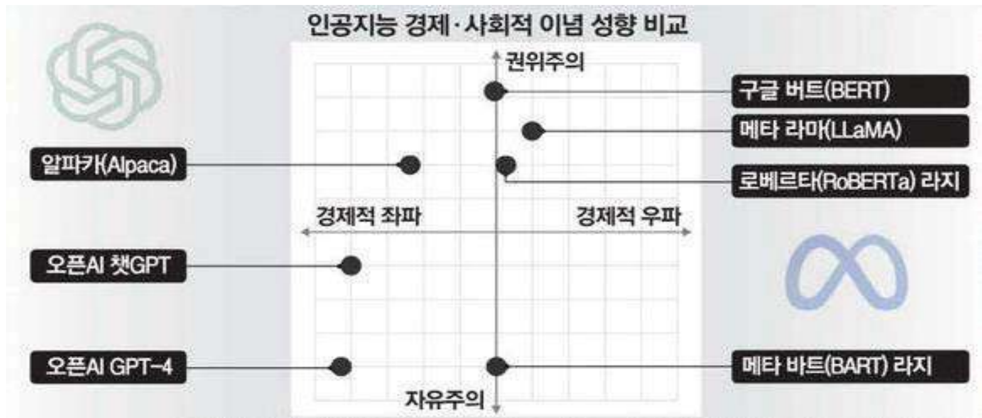


Table 1. Risk areas

Risk area	Description
1. Project	
Project phase	Project owner, description and stage (design or implementation)
Reasons for automation	Reasons for introducing automation into the decision-making process
Risk profile	High-level risk indicators for the project (e.g., vulnerability of clients)
Project authority	Need to seek new policy authority for the project
2. System	
About the system	Capabilities of the system (e.g., image recognition, risk assessment)
3. Algorithm	
About the algorithm	Limitations on disclosure of the algorithm; ability to explain how it arrives at outputs
4. Decision	
About the decision	Classification and description of the decision being automated (e.g., health services, social assistance, licensing)
5. Impact	
Impact assessment	Type of automation (full or partial); duration and reversibility of the decision; and areas impacted (e.g., rights, privacy and autonomy, health, economic interests, the environment)
6. Data	
Source	Provenance, method of collection, and security classification of data used by the system
Type	Nature of the data used as structured or unstructured (audio, text, image or video)

AI Ethics



Q & A

KRIHS 국토연구원

PANEL DISCUSSION

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