Application of GIS in Research and International Institution

Koichi Ito: SUA Class of 2019

THE WORLD BANK

SUA
ES concentration (c/o 2019)

World Bank
Poverty and Equity Global Practice

UN/World Bank or Academia

2019 — Now — 2026?~

2021 — 2022

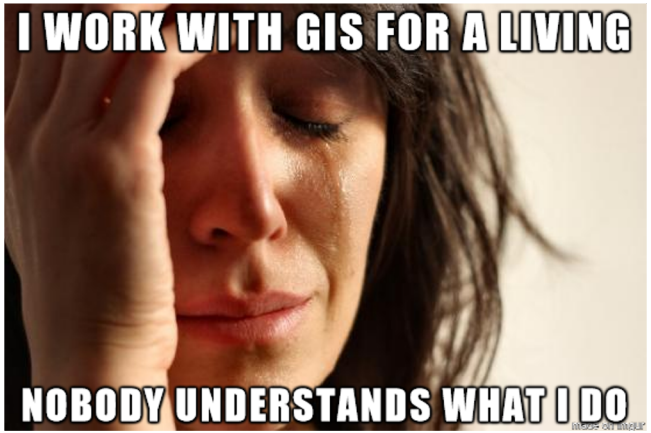
National University of Singapore
Master of Urban Planning

PhD
Urban Analytics

Who am I?

Today's objectives

1. Get students more excited about GIS
2. Give some tips I wish I knew before
3. Show an example of a GIS related path after Soka (i.e., my path so far)



Outline of this talk

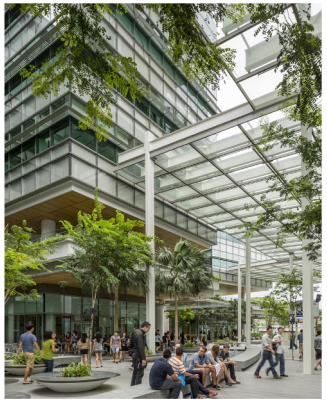
1. My master's program
2. Research on street view imagery: literature review
3. Research on street view imagery: bikeability
4. Work at the World Bank
5. Q&A

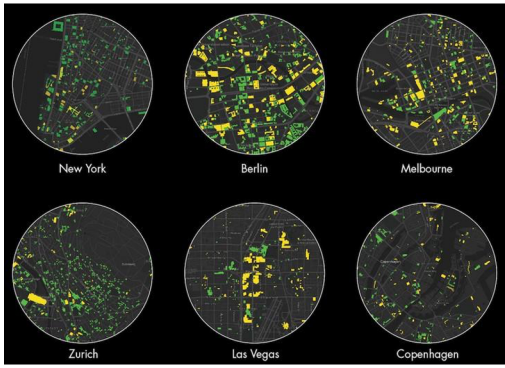
My master's program

Master of urban planning
@ the National University of Singapore

Tip: Don't be scared of technical stuff
(if you like GIS)

Urban analytics lab





Tip: Get to know multiple profs
(I didn't do this...)

Street view imagery in urban analytics and GIS: A review

(Biljecki & Ito, 2021)

My first-ever publication

Contents lists available at ScienceDirect

Landscape and Urban Planning

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

Review Article

Street view imagery in urban analytics and GIS: A review

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HIGHLIGHTS

- Street-level imagery became ingrained as an important urban data source.
- Most comprehensive review on street view imagery in geospatial and urban studies.
- We have screened 619 papers to identify the state of the art, focusing on applications.
- 250 studies are classified into 10 application domains and span dozens of use cases.

ARTICLE INFO

Keywords:
Urban data science
Urban planning
Built environment
Deep learning
Remote sensing
Ground-level

ABSTRACT

Street view imagery has rapidly ascended as an important data source for geospatial data collection and urban analytics, deriving insights and supporting informed decisions. Such surge has been mainly catalysed by the proliferation of large-scale imagery platforms, advances in computer vision and machine learning, and availability of computing resources. We screened more than 600 recent papers to provide a comprehensive systematic review of the state of the art of how street-level imagery is currently used in studies pertaining to the built environment. The main findings are that: (i) street view imagery is now clearly an entrenched component of urban analytics and GIScience; (ii) most of the research relies on data from Google Street View; and (iii) it is used across myriads of domains with numerous applications – ranging from analysing vegetation and transportation to health and socio-economic studies. A notable trend is crowdsourced street view imagery, facilitated by services such as Mapillary and KartaView, in some cases furthering geographical coverage and temporal granularity, at a permissive licence.

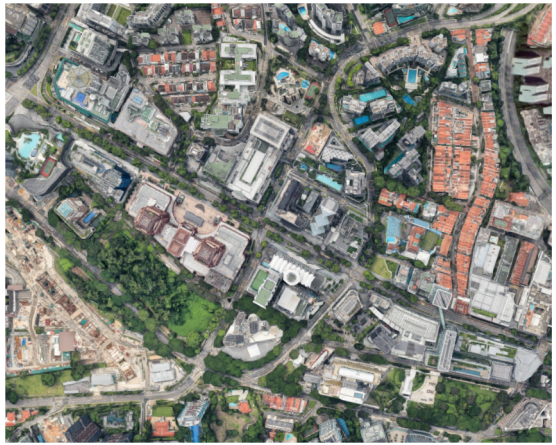
(a) Aerial perspective. (b) Street-level point of view.

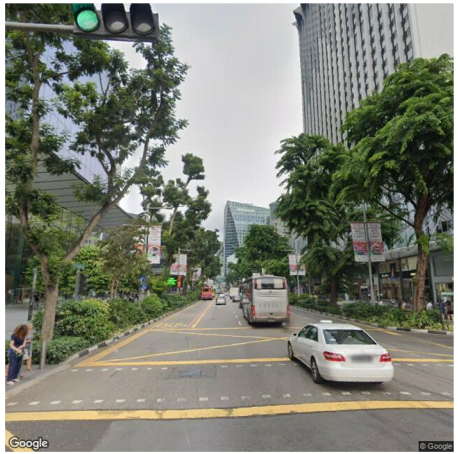
Fig. 1. Illustration indicating the edge street view images have over those derived from aerial/satellite platforms, which have been used traditionally to extract spatial information. SVI pivoted the usual perspective from vertical to horizontal, enabling new insights into the built environment and facilitating new applications.

Fig. 5. Sources of SVI identified in our study.

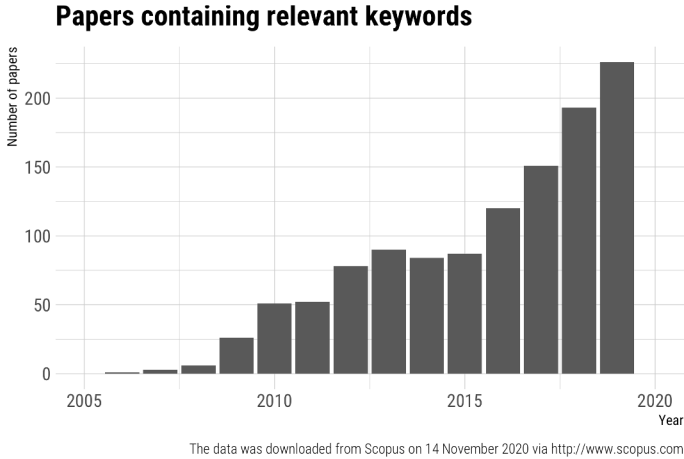
Fig. 10. Semantic segmentation is the predominant computer vision technique that is used in calculating the amount of greenery from street-level imagery. It is also frequent in studies in other thematic categories. The image in Fig. 1b was segmented using DeepLab, a deep learning model for semantic image segmentation and was trained on the Cityscapes dataset (Chen et al., 2018; Cordts et al., 2016). The green portion of the overlayed mask represents the vegetation that is detected in the original image, facilitating the quantification of indicators such as the GVI.

Aerial image vs Street view image (SVI)





Rapidly growing field because...
Expanding SVI coverage + Better AI



SVI can capture what people see on the street. It's a new frontier in GIS.

Why is street view imagery a thing?

Method: systematic review

Search for papers → Screen #1 → Screen #2 → Classify/Analyze

1300 papers

Search on Scopus with keywords: ‘street view’ & ‘street-level image’

650 papers

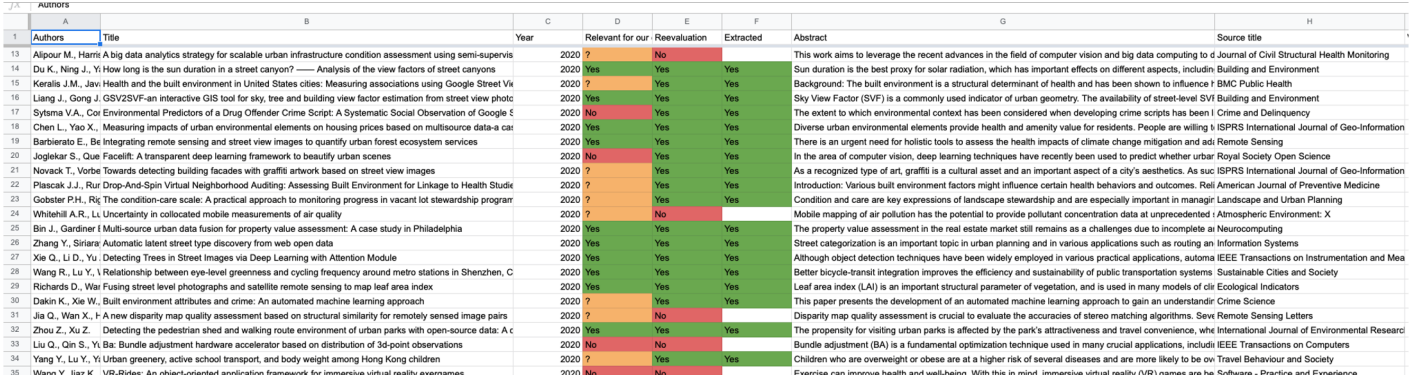
Only include papers published in the past 3 years

250 papers

Only Include papers related to urban studies

10 categories

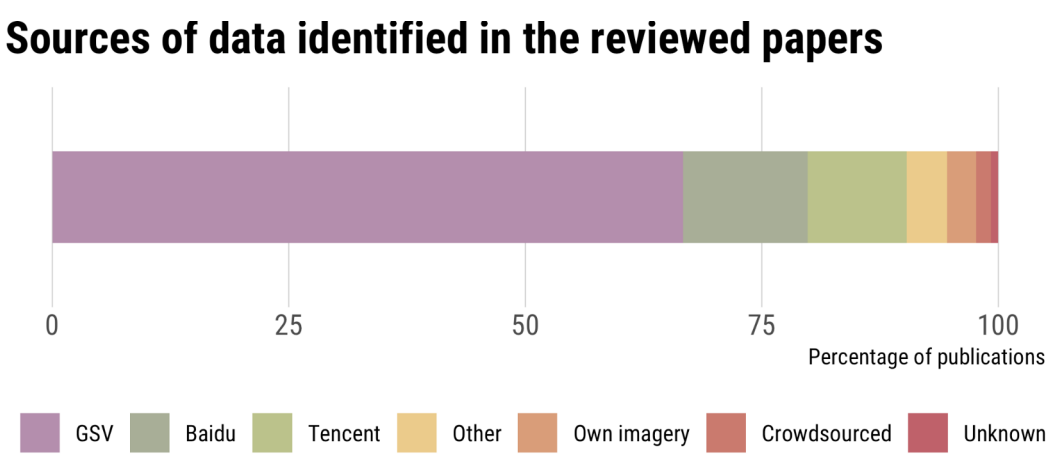
Read each paper and categorize/analyze them

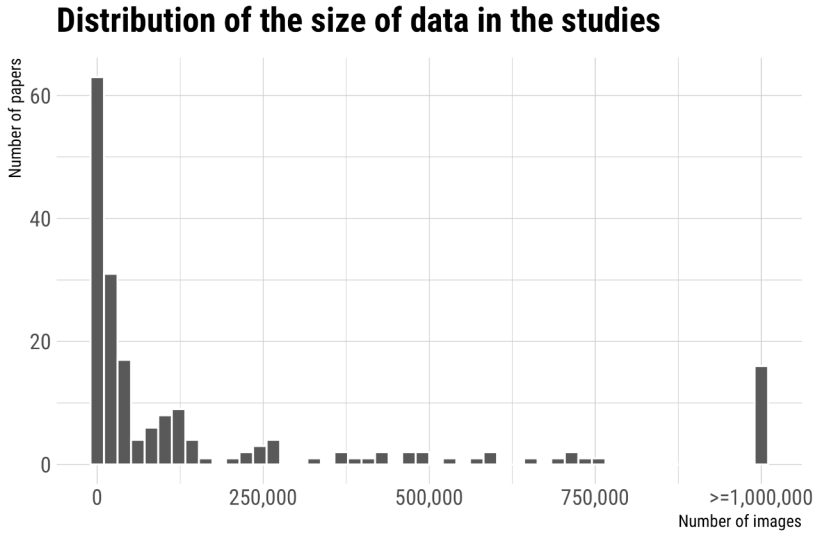


	A	B	C	D	E	F	G	H
1	Authors	Title	Year	Relevant for our	Reevaluation	Extracted	Abstract	Source title
13	Alipour M., Harris	A big data analytics strategy for scalable urban infrastructure condition assessment using semi-supervis	2020	?	No		This work aims to leverage the recent advances in the field of computer vision and big data computing to d	Journal of Civil Structural Health Monitoring
14	Du K., Ning J., Yi	How long is the sun duration in a street canyon? —— Analysis of the view factors of street canyons	2020	Yes	Yes	Yes	Sun duration is the best proxy for solar radiation, which has important effects on different aspects, includin	Building and Environment
15	Keralis J.M., Javi	Health and the built environment in United States cities: Measuring associations using Google Street Vie	2020	?	Yes	Yes	Background: The built environment is a structural determinant of health and has been shown to influence h	BMC Public Health
16	Liang J., Gong J.	GSV2SVF-an interactive GIS tool for sky, tree and building view factor estimation from street view photo	2020	Yes	Yes	Yes	Sky View Factor (SVF) is a commonly used indicator of urban geometry. The availability of street-level SVI	Building and Environment
17	Sytsma V.A., Cor	Environmental Predictors of a Drug Offender Crime Script: A Systematic Social Observation of Google S	2020	No	Yes	Yes	The extent to which environmental context has been considered when developing crime scripts has been l	Crime and Delinquency
18	Chen L., Yao X.,	Measuring impacts of urban environmental elements on housing prices based on multisource data-a cas	2020	Yes	Yes	Yes	Diverse urban environmental elements provide health and amenity value for residents. People are willing t	ISPRS International Journal of Geo-Information
19	Barbierato E., Be	Integrating remote sensing and street view images to quantify urban forest ecosystem services	2020	Yes	Yes	Yes	There is an urgent need for holistic tools to assess the health impacts of climate change mitigation and ad	Remote Sensing
20	Joglekar S., Que	Facelift: A transparent deep learning framework to beautify urban scenes	2020	No	Yes	Yes	In the area of computer vision, deep learning techniques have recently been used to predict whether urbar	Royal Society Open Science
21	Novack T., Vorbe	Towards detecting building facades with graffiti artwork based on street view images	2020	?	Yes	Yes	As a recognized type of art, graffiti is a cultural asset and an important aspect of a city's aesthetics. As suc	ISPRS International Journal of Geo-Information
22	Plascak J.J., Rur	Drop-And-Spin Virtual Neighborhood Auditing: Assessing Built Environment for Linkage to Health Studie	2020	?	Yes	Yes	Introduction: Various built environment factors might influence certain health behaviors and outcomes. Reli	American Journal of Preventive Medicine
23	Gobster P.H., Riç	The condition-care scale: A practical approach to monitoring progress in vacant lot stewardship program	2020	?	Yes	Yes	Condition and care are key expressions of landscape stewardship and are especially important in managir	Landscape and Urban Planning
24	Whitehill A.R., Li	Uncertainty in collocated mobile measurements of air quality	2020	?	No		Mobile mapping of air pollution has the potential to provide pollutant concentration data at unprecedented s	Atmospheric Environment: X
25	Bin J., Gardiner I	Multi-source urban data fusion for property value assessment: A case study in Philadelphia	2020	Yes	Yes	Yes	The property value assessment in the real estate market still remains as a challenges due to incomplete a	Neurocomputing
26	Zhang Y., Siriara	Automatic latent street type discovery from web open data	2020	Yes	Yes	Yes	Street categorization is an important topic in urban planning and in various applications such as routing an	Information Systems
27	Xie Q., Li D., Yu	Detecting Trees in Street Images via Deep Learning with Attention Module	2020	Yes	Yes	Yes	Although object detection techniques have been widely employed in various practical applications, automa	IEEE Transactions on Instrumentation and Mea
28	Wang R., Lu Y., \	Relationship between eye-level greenness and cycling frequency around metro stations in Shenzhen, C	2020	Yes	Yes	Yes	Better bicycle-transit integration improves the efficiency and sustainability of public transportation systems	Sustainable Cities and Society
29	Richards D., War	Fusing street level photographs and satellite remote sensing to map leaf area index	2020	Yes	Yes	Yes	Leaf area index (LAI) is an important structural parameter of vegetation, and is used in many models of clir	Ecological Indicators
30	Dakin K., Xie W.,	Built environment attributes and crime: An automated machine learning approach	2020	?	Yes	Yes	This paper presents the development of an automated machine learning approach to gain an understandir	Crime Science
31	Jia Q., Wan X., H	A new disparity map quality assessment based on structural similarity for remotely sensed image pairs	2020	?	No		Disparity map quality assessment is crucial to evaluate the accuracies of stereo matching algorithms. Seve	Remote Sensing Letters
32	Zhou Z., Xu Z.	Detecting the pedestrian shed and walking route environment of urban parks with open-source data: A c	2020	Yes	Yes	Yes	The propensity for visiting urban parks is affected by the park's attractiveness and travel convenience, whe	International Journal of Environmental Researcl
33	Liu Q., Qin S., Yi	Ba: Bundle adjustment hardware accelerator based on distribution of 3d-point observations	2020	No	No		Bundle adjustment (BA) is a fundamental optimization technique used in many crucial applications, includi	IEEE Transactions on Computers
34	Yang Y., Lu Y., Yi	Urban greenery, active school transport, and body weight among Hong Kong children	2020	?	Yes	Yes	Children who are overweight or obese are at a higher risk of several diseases and are more likely to be ov	Travel Behaviour and Society
35	Wang Y., Jiao K.,	VR-Rides: An object-oriented application framework for immersive virtual reality exergames	2020	No	No		Exercise can improve health and well-being. With this in mind, immersive virtual reality (VR) games are be	Software - Practice and Experience

Objective findings

Which SVI services are used? How many images are used?

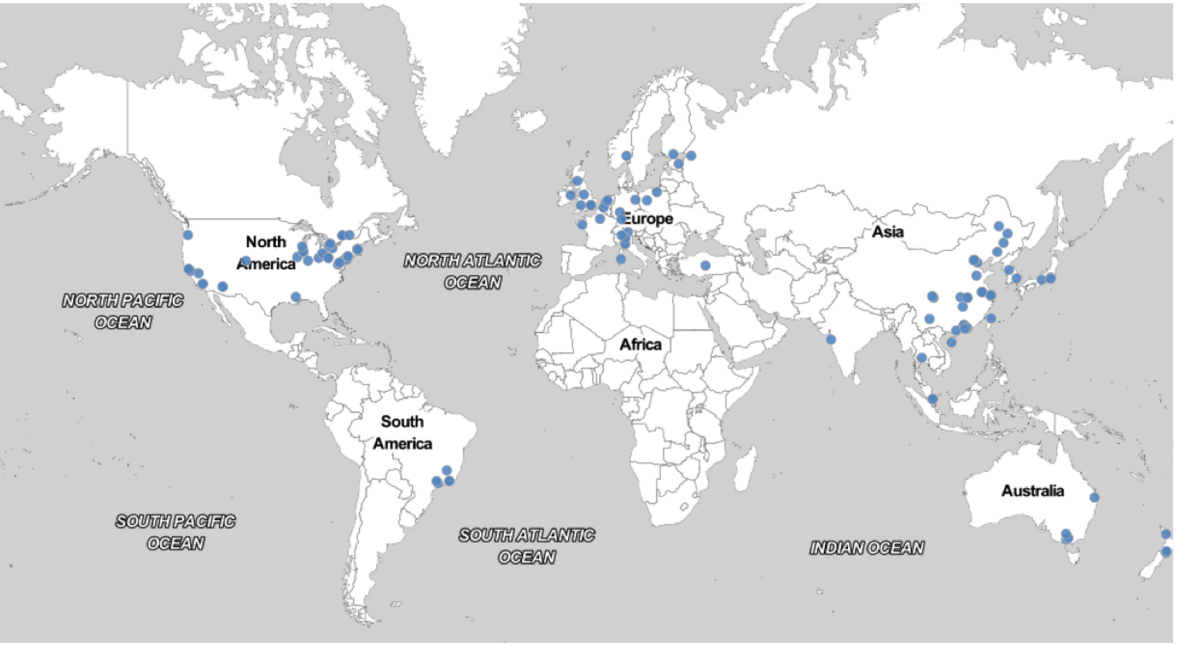




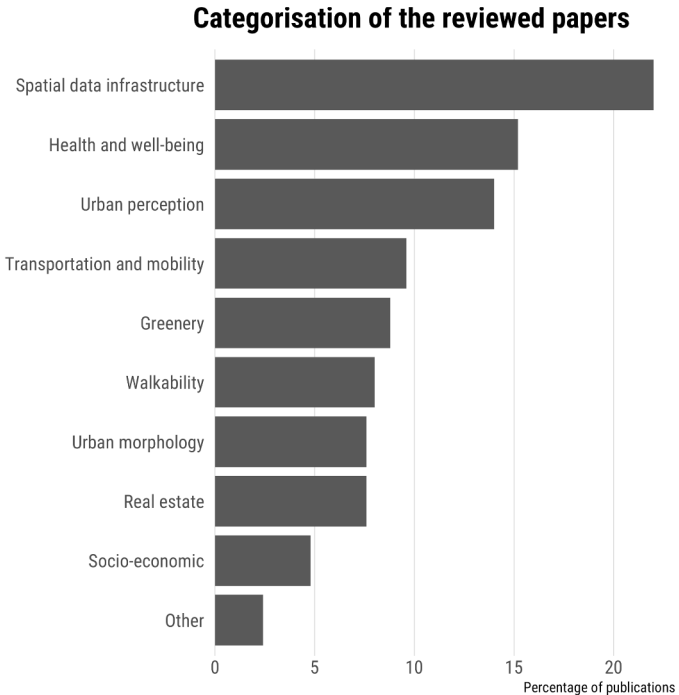
Google street view (GSV) dominates the field.
Many papers used more than 1 million images for analysis.

Objective findings

Study areas are concentrated in the US, Europe, and East Asia



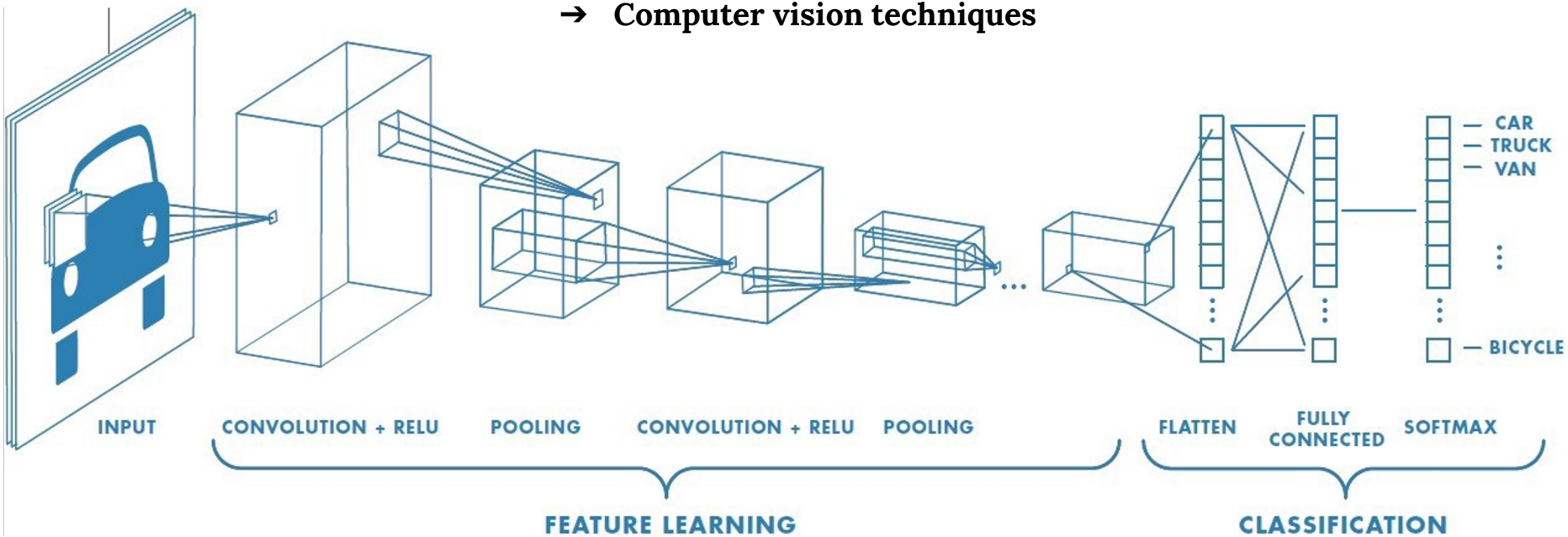
Spatial data infrastructure is saturated



Before we get into details...
how do we get information from images?

➔ **Computer vision techniques**

RGB layers

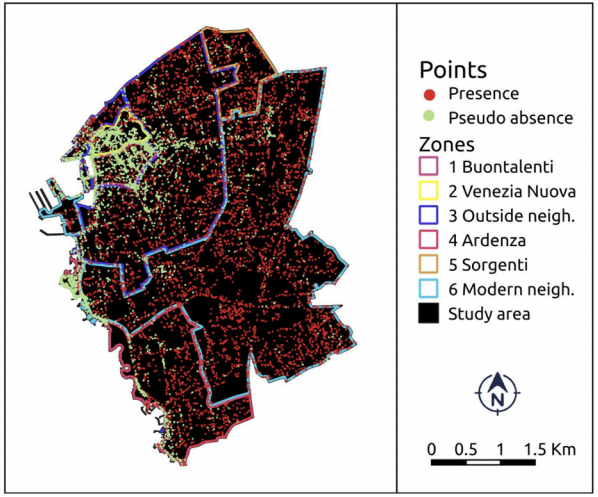


(Normal Neural Network)

Well, convolutional neural network is a lot to explain in 1 slide, but it's basically stretching an image into a series of numbers that computers can process

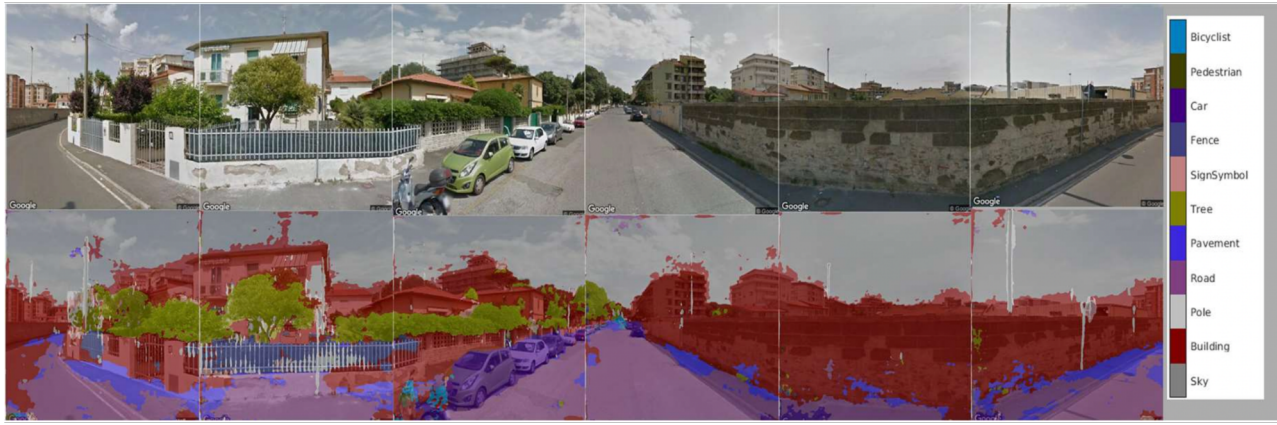
Research example #1:
Urban perception

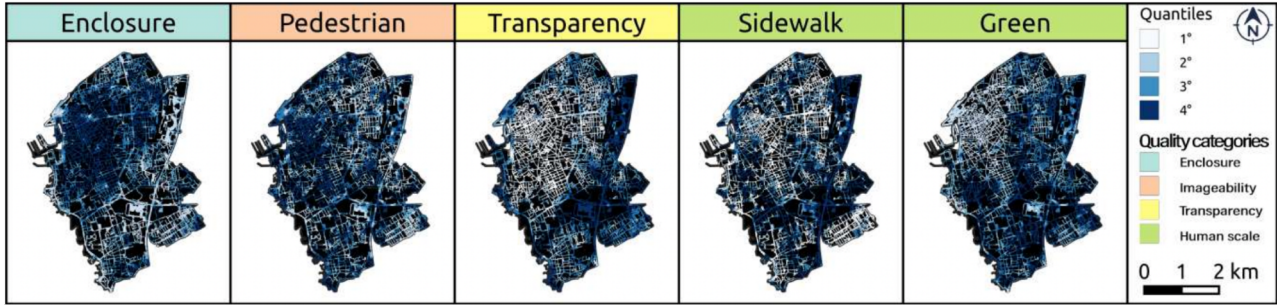
Urban niche assessment: An approach integrating social media analysis, spatial urban indicators and geo-statistical techniques (Bernetti et al., 2020)



Prediction of popular locations in a city

➔ Semantic segmentation to quantify visual elements



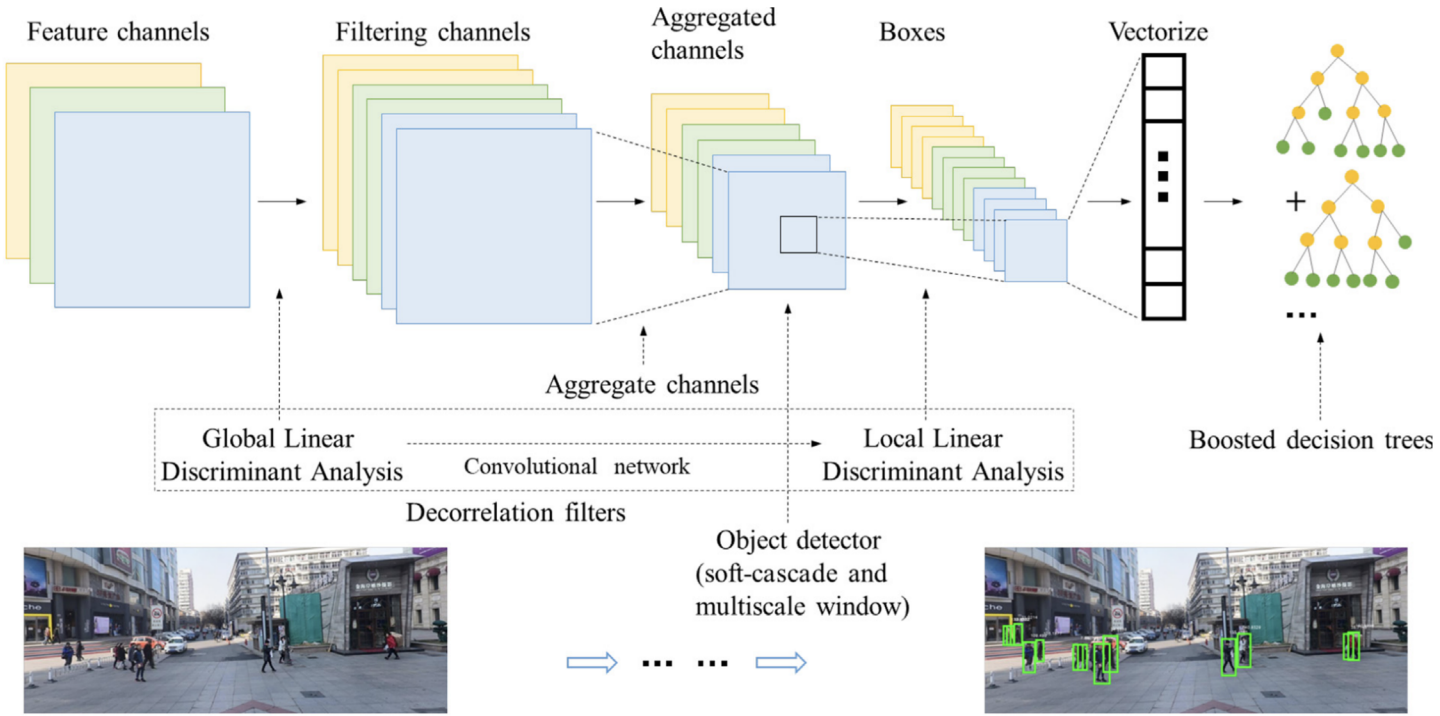


Research example #2:
Transportation and mobility

Estimating pedestrian volume using Street View images: A large-scale validation test (Chen et al., 2020)

Estimation of pedestrian counts

➔ Object detection to find and count pedestrian in images

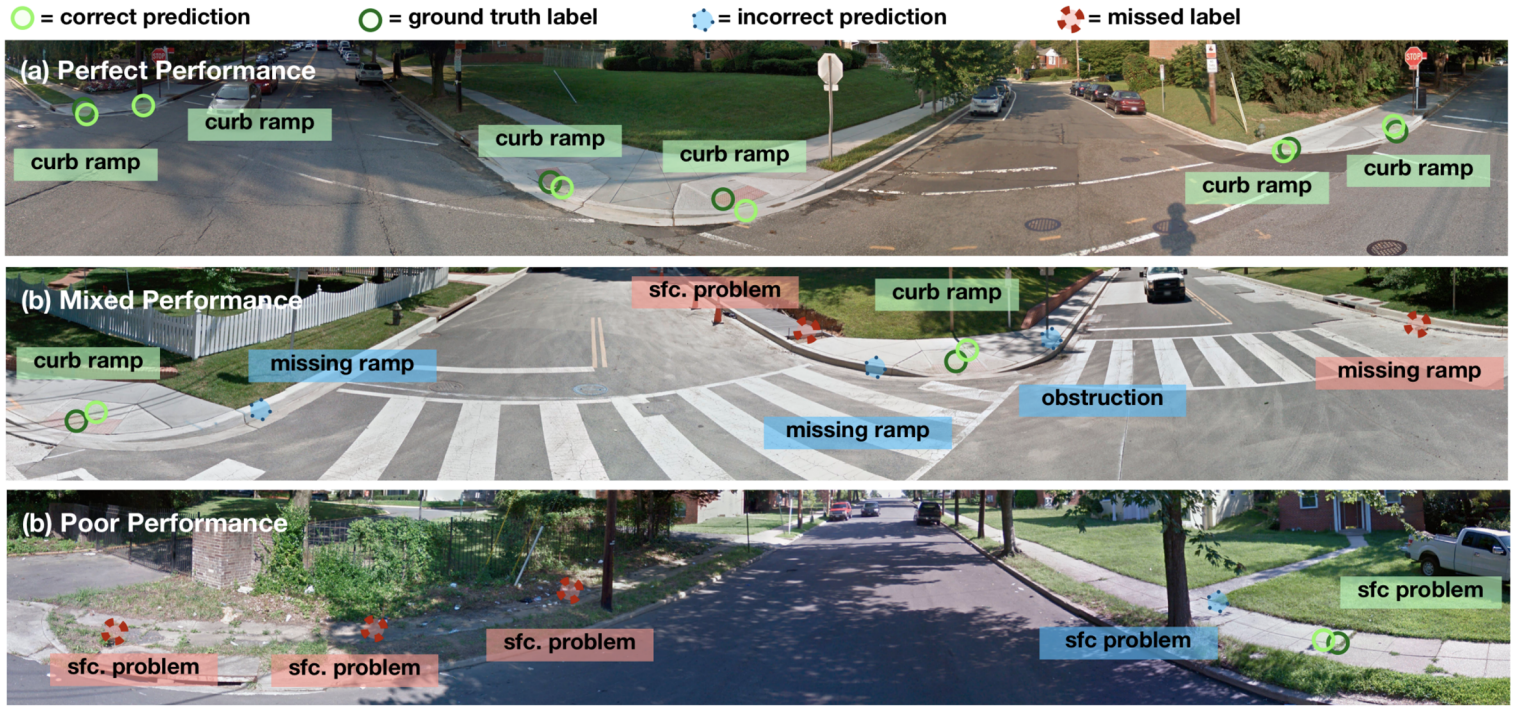


Research example #3:
Walkablity

Deep Learning for Automatically Detecting Sidewalk Accessibility Problems Using Streetscape Imagery (Weld et al., 2019)

Assessment of street condition

➔ Object detection to find good and bad street features



Many more cool papers in our paper!

Please google ***Street view imagery in urban analytics and GIS: A review***

(I found my master thesis topic from our paper)

Assessing bikeability with street view imagery and computer vision
(Ito & Biljecki, 2021)

My master thesis

Contents lists available at ScienceDirect

Transportation Research Part C

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

Assessing bikeability with street view imagery and computer vision

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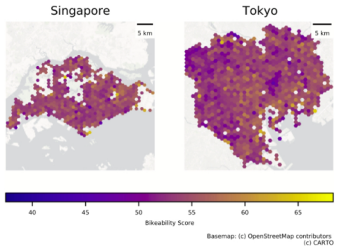
ARTICLE INFO

Keywords:
Urban planning
Deep learning
GIS
OpenStreetMap
Bicycles
Google Street View

ABSTRACT

Studies evaluating bikeability usually compute spatial indicators shaping cycling conditions and conflate them in a quantitative index. Much research involves site visits or conventional geo-spatial approaches, and few studies have leveraged street view imagery (SVI) for conducting virtual audits. These have assessed a limited range of aspects, and not all have been automated using computer vision (CV). Furthermore, studies have not yet zeroed in on gauging the usability of these technologies thoroughly. We investigate, with experiments at a fine spatial scale and across multiple geographies (Singapore and Tokyo), whether we can use SVI and CV to assess bikeability comprehensively. Extending related work, we develop an exhaustive index of bike-ability composed of 34 indicators. The results suggest that SVI and CV are adequate to evaluate bikeability in cities comprehensively. As they outperformed non-SVI counterparts by a wide margin, SVI indicators are also found to be superior in assessing urban bikeability and potentially can be used independently, replacing traditional techniques. However, the paper exposes some limitations, suggesting that the best way forward is combining both SVI and non-SVI approaches. The new bikeability index presents a contribution in transportation and urban analytics, and it is scalable to assess cycling appeal widely.

Fig. 1. Illustration of an urban setting together with one of the corresponding street-level views, highlighting several aspects that may indicate bikeability. The method presented in this paper takes advantage of a substantial number of visual features that may be extracted automatically from street view images and engage them to generate a composite index that suggests cycling appeal at a fine spatial scale and across multiple cities.



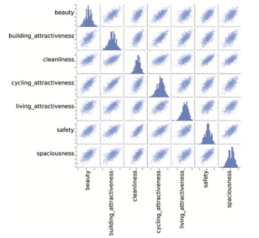


Fig. 4. A scatter plot matrix of the perception scores obtained from the survey.

Background

Bicycles make cities environmentally sustainable, healthy, and economically vibrant

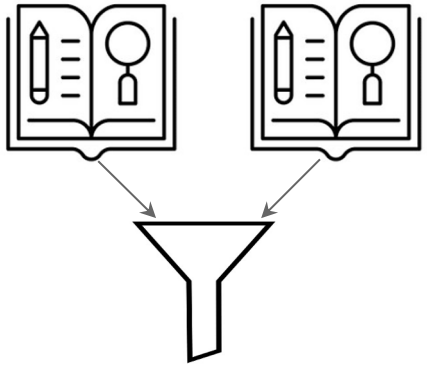
What is bikeability?

- It is the extent to which cycling is facilitated

So, can we use computer vision techniques and SVI to assess bikeability?

➔ No study has done it.
Let’s see how to do it.

Method: preparation



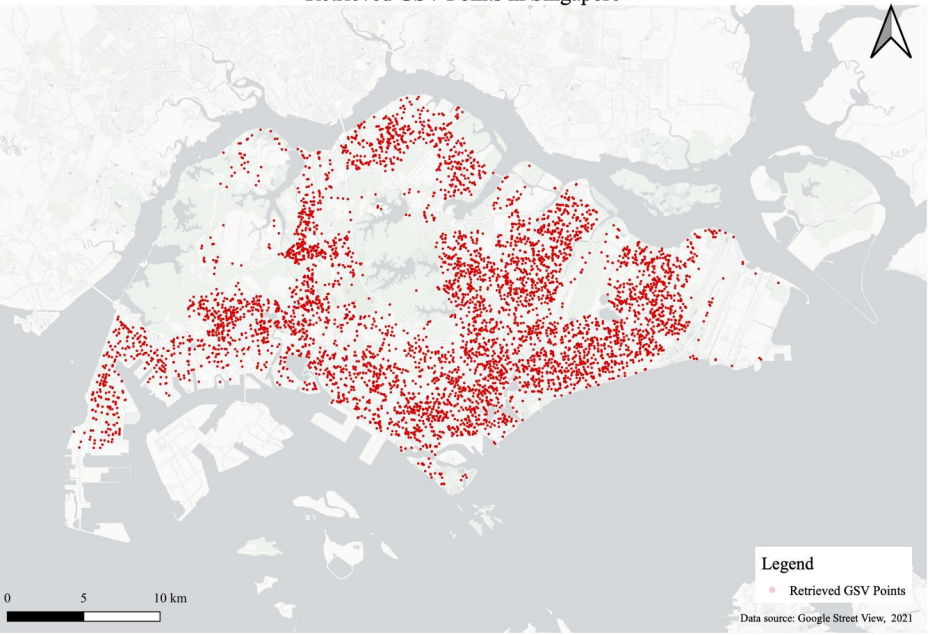
Identification of bikeability indicators through literature review

OpenStreetMap

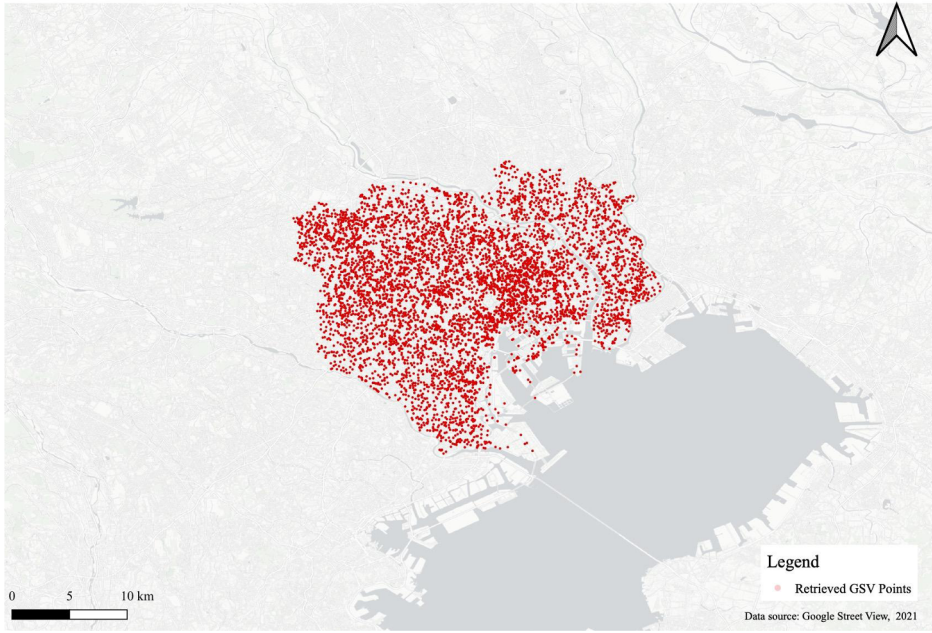
python

Get sample points in Tokyo and Singapore

Retrieved GSV Points in Singapore



Retrieved GSV Points in Tokyo



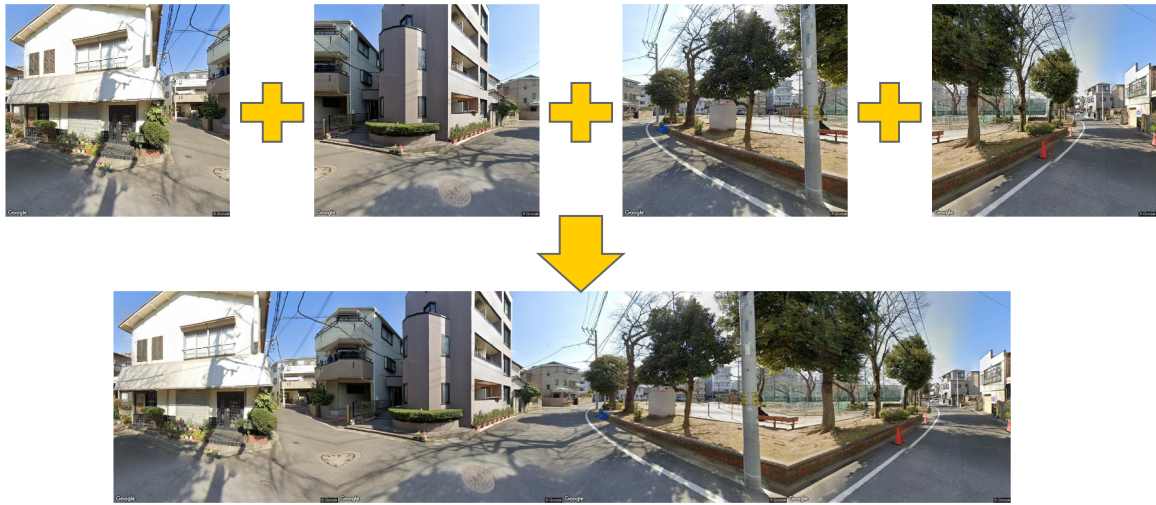
Method: data retrieval

Download street view images from Google Street View API for each sample point

Google Maps Platform

python

Stitch 4 images into 1 panorama
(*you can't download a panorama from API)



Method:
objective indicator extraction

Extract objective indicators: greenery, bike lanes, potholes, etc

➔ Use semantic segmentation

Method: subjective indicator extraction

Training data collection

On a scale of 0-10, how **beautiful** do you think this streetscape is?

On a scale of 0-10, how **safe** would you feel if you were cycling on this street?

On a scale of 0-10, how **attracted** would you feel to cycle on this street?

On a scale of 0-10, how **clean** do you think this street is?

On a scale of 0-10, how **attractive** do you think **buildings** in this image are on average?

On a scale of 0-10, how **spacious** do you think this street is?

Show an image →
and ask the questions above ↑

Conduct a survey

➔ 7 perceptions
➔ 800 images
➔ 8 different participants for each image

Method: subjective indicator extraction
Modeling

High-level features

Detection

Segmentation

Low-level features

Edge Detection

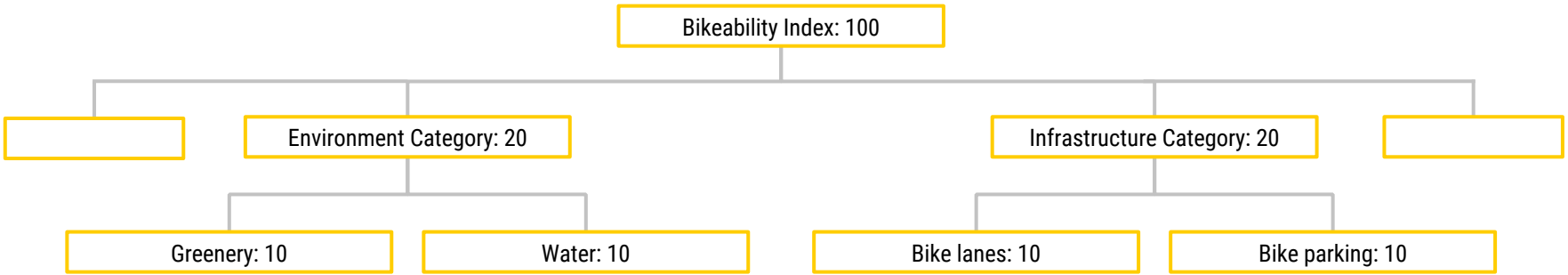
Blob Detection

Machine learning: predict perceptions
for the rest of the sample points

Method: composite index

Equally weighted index

- ➔ Total score: 100
- ➔ 5 categories
- ➔ Each category's weight: 20
- ➔ Each sub-indicator's weight is: 20/n (n is # of sub-indicators under the same category)
- ➔ Each sub-indicator is scaled into 0-1



* This is just a simplified diagram

Results: extracted indicators

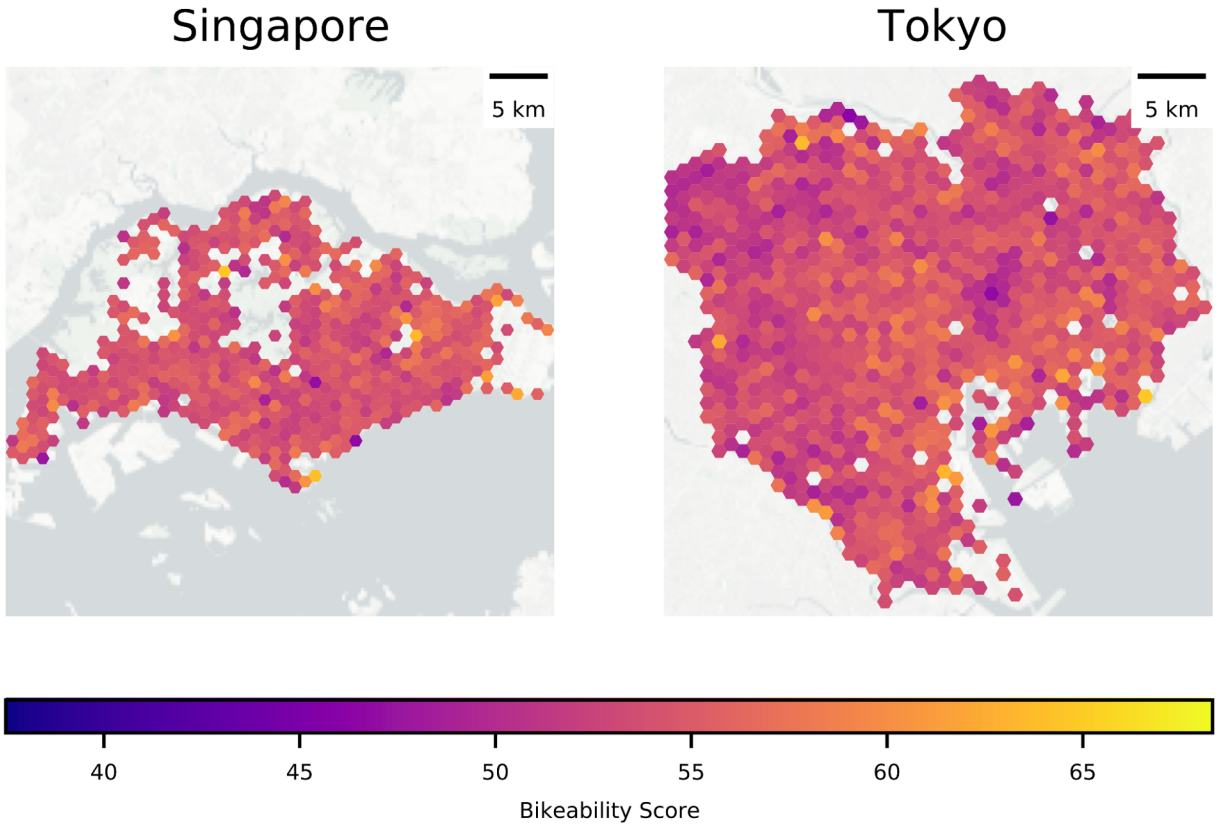
34 indicators were extracted under 5 categories

21 indicators were extracted from SVI

Category	No. of indicators	Examples of indicators from SVI
Connectivity	3	
Environment	7	Greenery, enclosure
Infrastructure	13	Bike lanes, pavement condition
Perception	7	Safety, beauty
Vehicle-Cyclist Interaction	4	Stop signs, vehicle volume

* I used data sources other than SVI (e.g., OpenStreetMap, land use, etc)

Bikeability



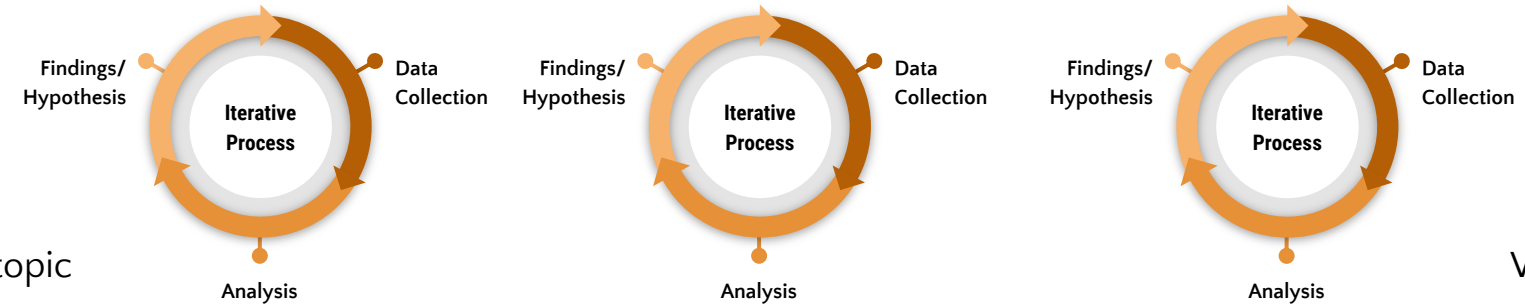
Ok, this research got published.
But was it perfect?

➔ No way near perfection (So many flaws actually)

➔ But I learned something out of this experience

Research/Publication tips

1. Find your own unique spot
   (AI + Urban planning in my case)
2. Research never goes according to the plan
3. Start small + iterative process



My career

Ok, almost the end of this talk... (2 slides left!)

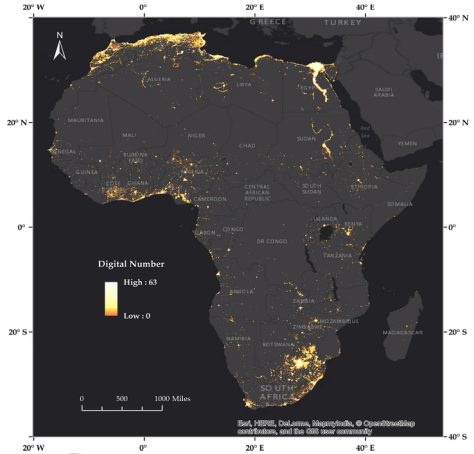
THE WORLD BANK

*None of the visualization here is my own.
As most of the projects are confidential.

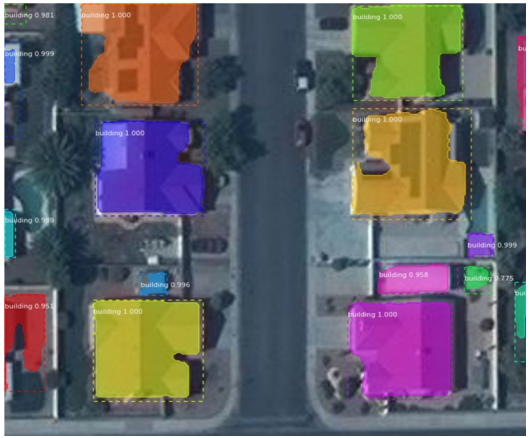
Working at the World Bank

What do I do for work...

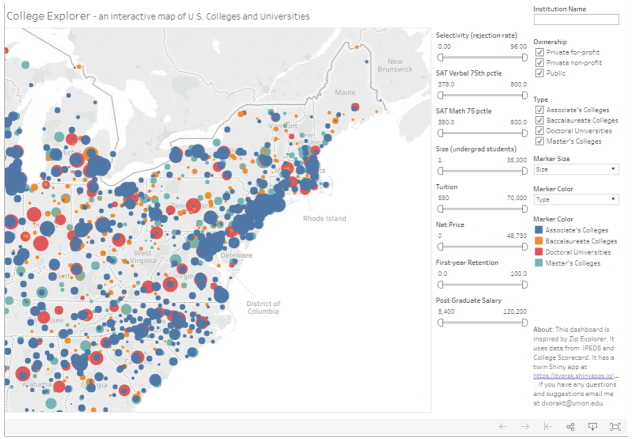
Nighttime light analysis



Building detection



Dashboard in R Shiny



python R GitHub

All of these things may seem fancy, but most of them are based on what I learned in GIS courses at Soka.

The last tip:
Use Soka alumni network for job hunting or graduate school choice. Use LinkedIn to get connected and ask for advice! They are usually super helpful!

I landed on the current job through Soka network too!
I'm currently preparing for applications for PhD programs.
So, I am happy to share the application process too! 😃

Thank you for listening!
Q & A Time!