FIG WORKING WEEK 2025
AND Locate25 THE NATIONAL GEOSPATIAL CONFERENCE
Collaboration, Innovation and Resilience: Championing a Digital Generation
FIG Geospatial Council of Australia
Brisbane, Australia 6–10 April

Big Data and Smart Cities

Trends and Challenges

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PLATINUM SPONSORS Australian Government CHCNAV esri THE SCIENCE OF WHERE Leica Geosystems HD Meter Surveyors Australia

The most relevant SDGs related to theme of this session

1st relevant SDG

2nd relevant SDG

3rd relevant SDG

SUSTAINABLE DEVELOPMENT GOALS

International Federation of Surveyors supports the Sustainable Development Goals

Big Data and Smart Cities *Trends and Challenges*

- 2D Smart City to 3D Smart City
- Sensors and Big Data
- Digital Twins and AI

Big Data and Smart Cities *Trends and Challenges*

- **2D Smart City to 3D Smart City**
- Sensors and Big Data
- Digital Twins and AI

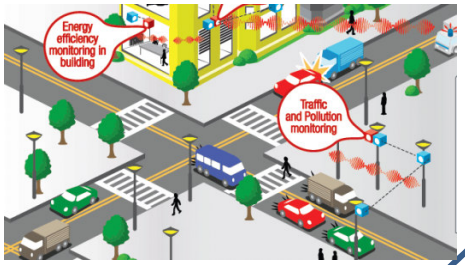
Use of ICT

Govt & Firms

1986 HK Land Information Centre
1987 Guangzhou Urban Planning Automation Centre
1994 National Geospatial Information Center

Digital Cities

Govt & Firms People



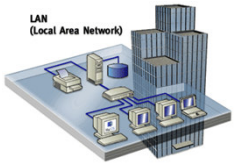
Intelligent Cities

Smart Cities

Govt & Firms People Anytime, Anywhere

Smart City v?

5G， IoT, Web 3.0
AI - Artificial Intelligence
AV – Autonomous Vehicle



Computers and LAN

Internet and Sensors

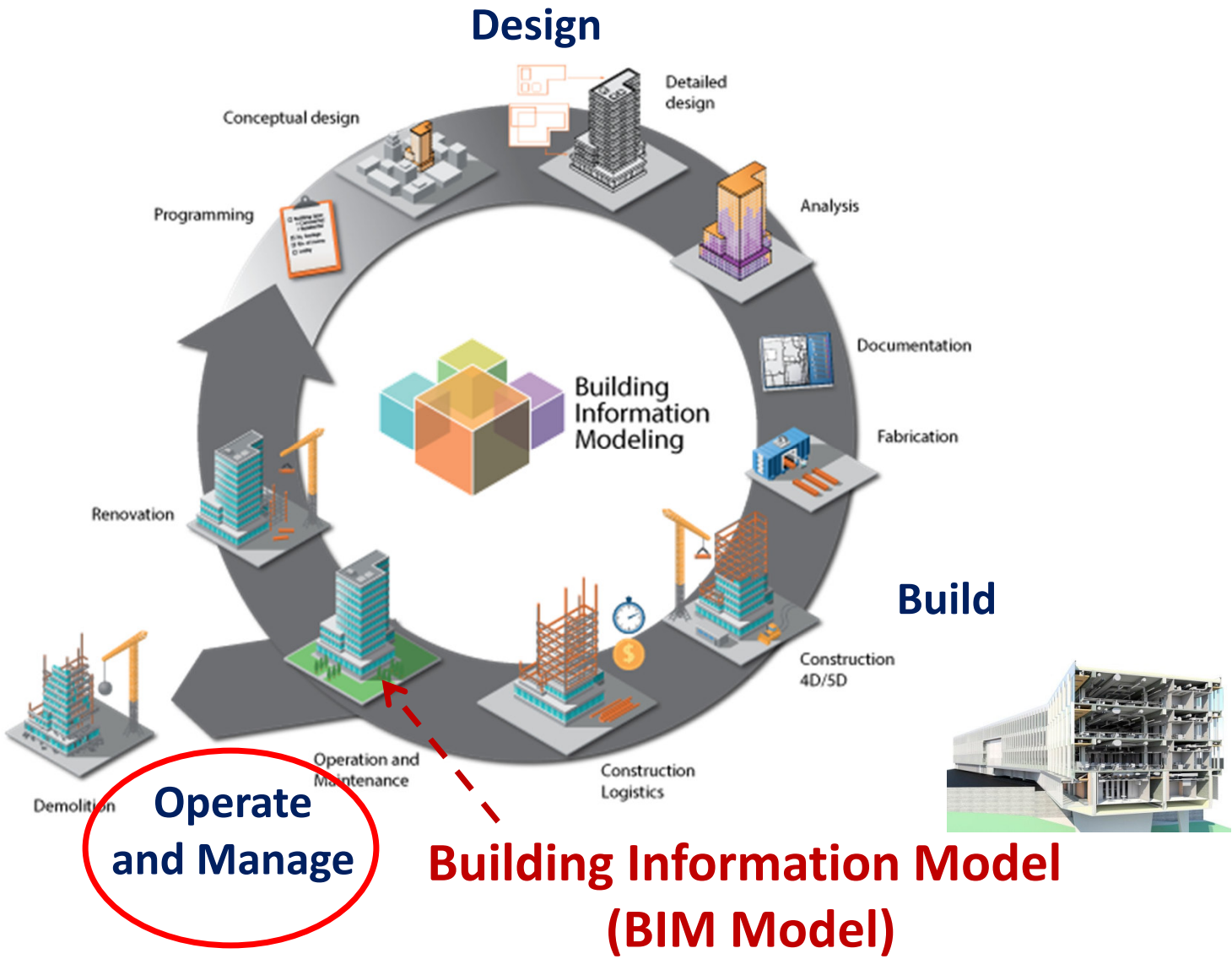
Smart Phones with Sensors, Wi-Fi, IoT

1985 - 1995 1995 - 2010 2010 -

Backbone of Smart Cities = GIS + Sensors + ICT + WiFi

City is 3D – GIS should be 3D

Building Information Modeling (BIM)



From BIM to DIM and CIM

BIM technology is evolving from **District Information Modeling (DIM)** to **City Information Modeling (CIM).** DIM and CIM are similar to how we modeling buildings and infrastructure.

DIM is the 3D modeling at the **District level**; while **CIM** aims to model the smart city at the **City level**.

A **CIM** model could enable city-wide simulation (for architects and planners) of various aspects such as traffic, congestion, energy, impact of natural disasters such as earthquakes or hurricanes, flood control, etc.

BIM → DIM → CIM

From BIM Model to DIM Model and CIM Model

BIM of Old Buildings (over 90% in city)

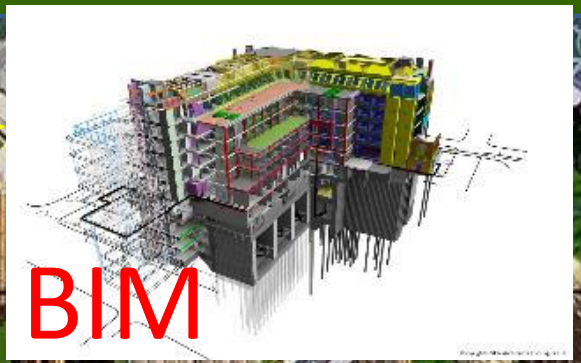
3D GIS

Common Spatial Data Infrastructure(CSDI) 2021

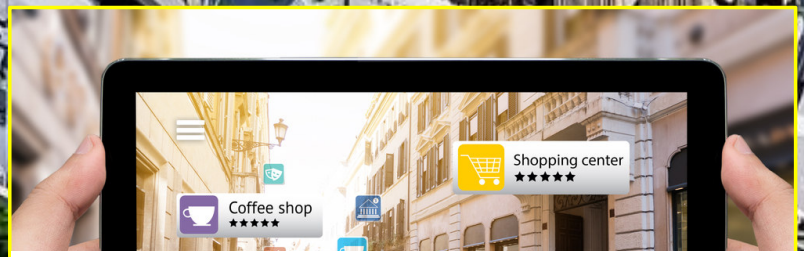
China National Geospatial Information Center 实景三维

Integration of 3D GIS and BIM
(Virtual Reality & Augmented Reality)

3D GIS



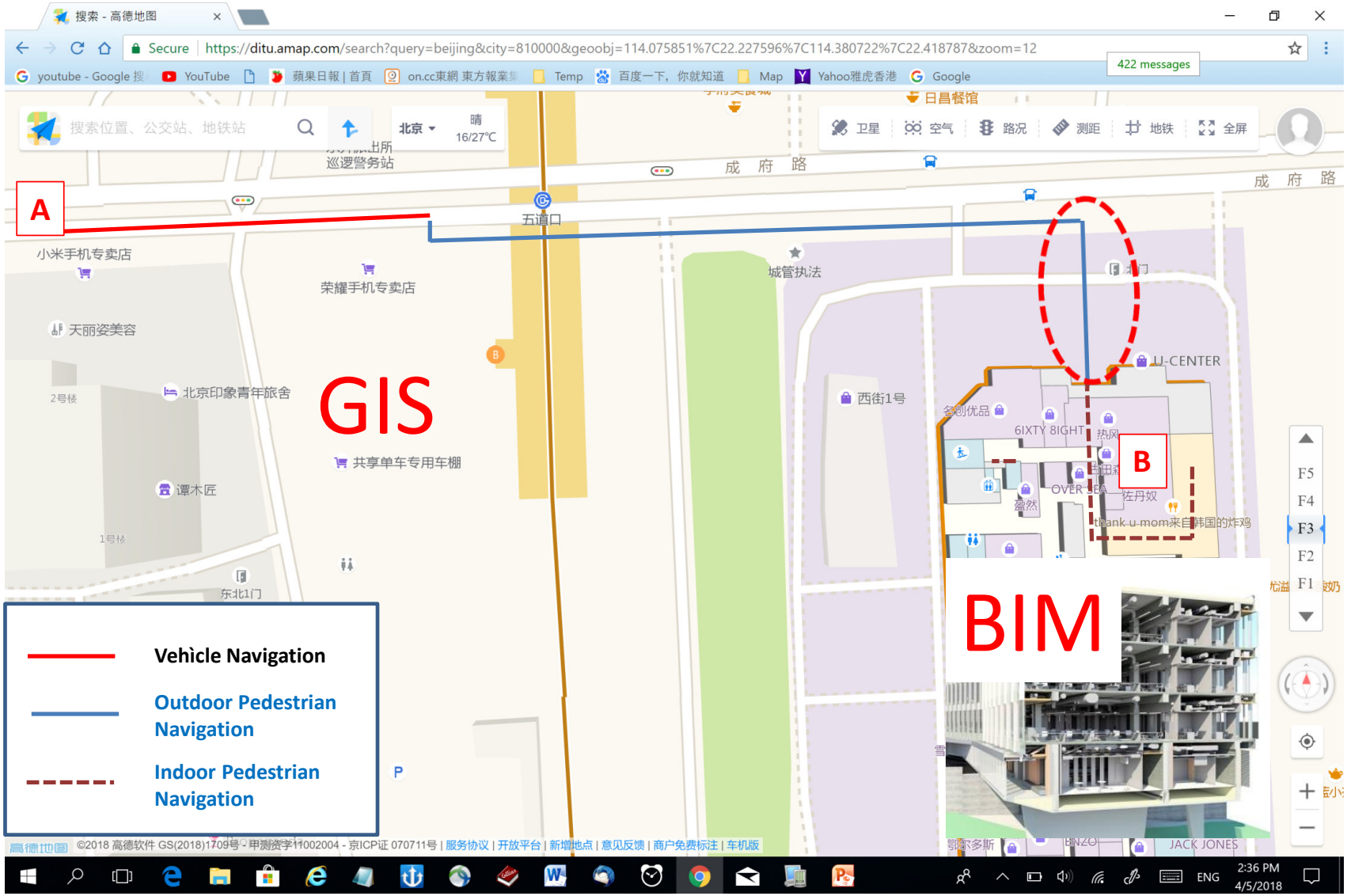
BIM



The development of 3D-GIS is more complicated than 2D-GIS

The work has just started, we still have a long way to go

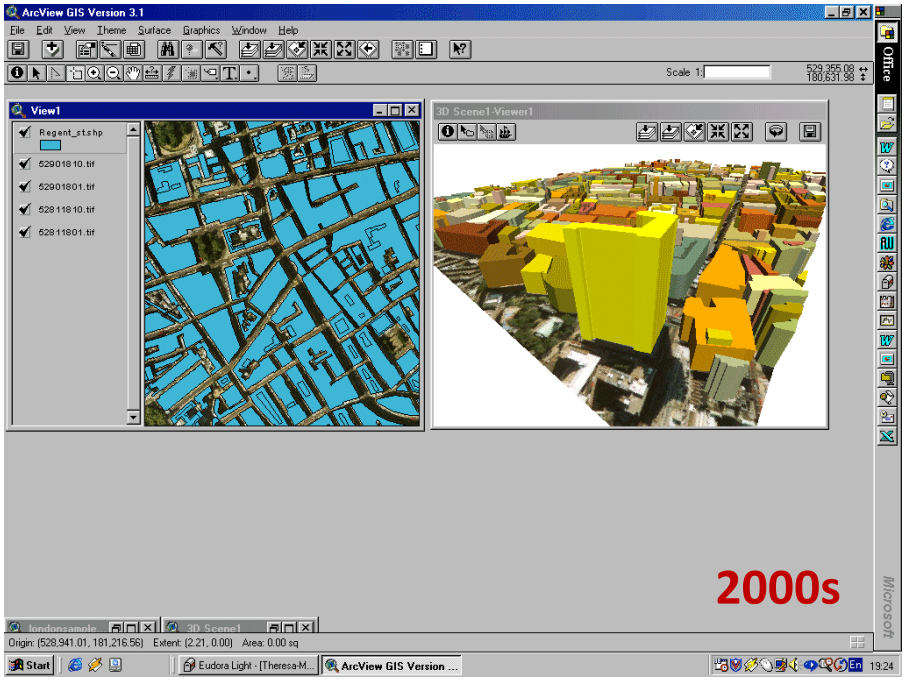
Integration of 2D GIS and BIM in Pedestrian Navigation

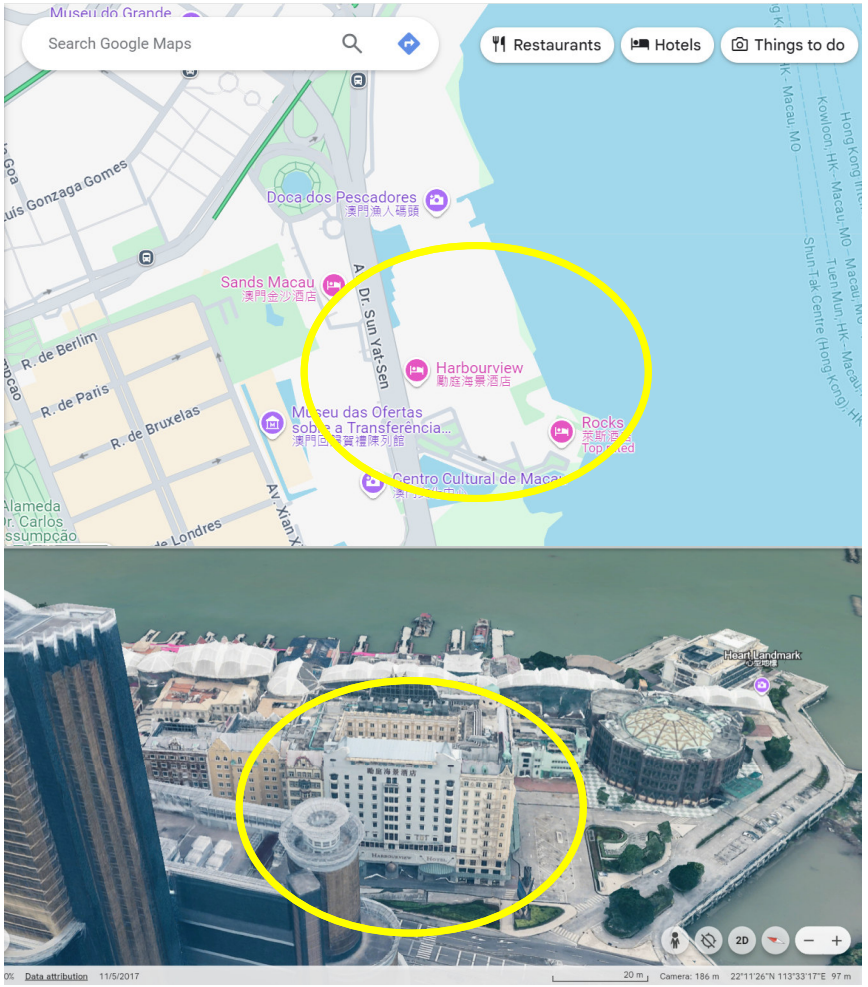


Applications of 3D GIS in Smart City

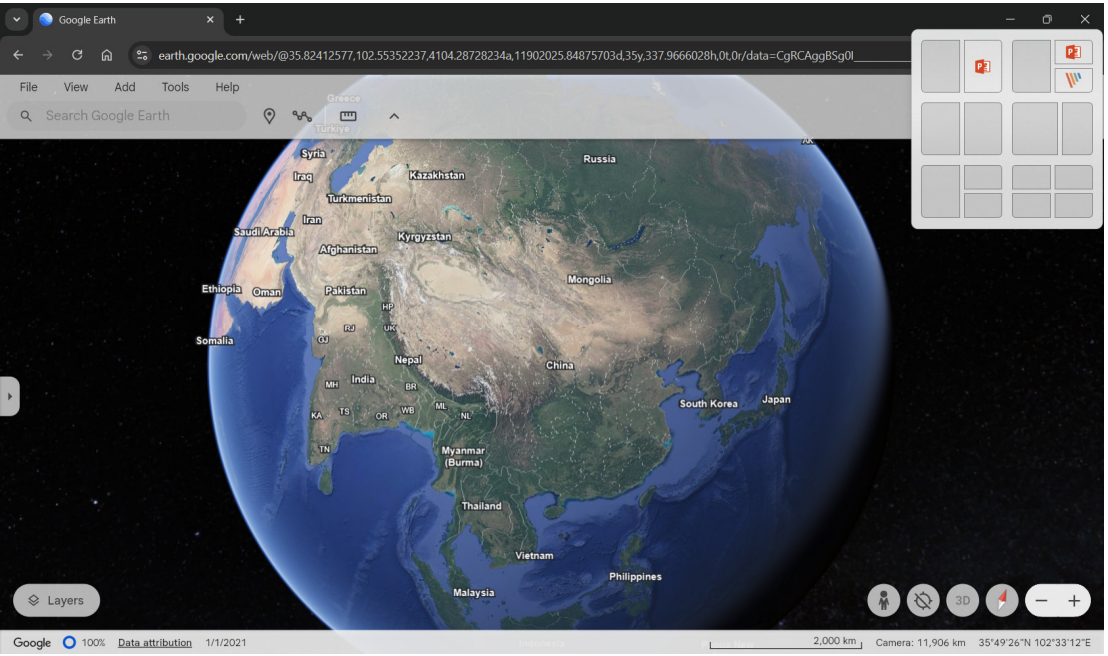
Yesterday's Technology, Today's Applications

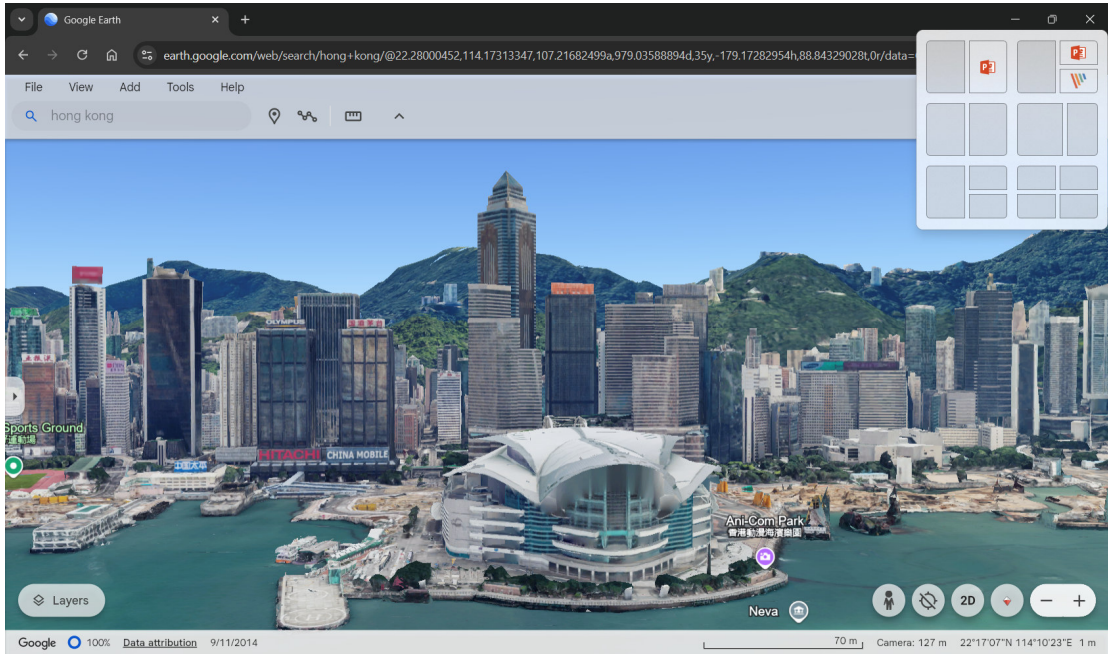
- **3D Map and Visualization**



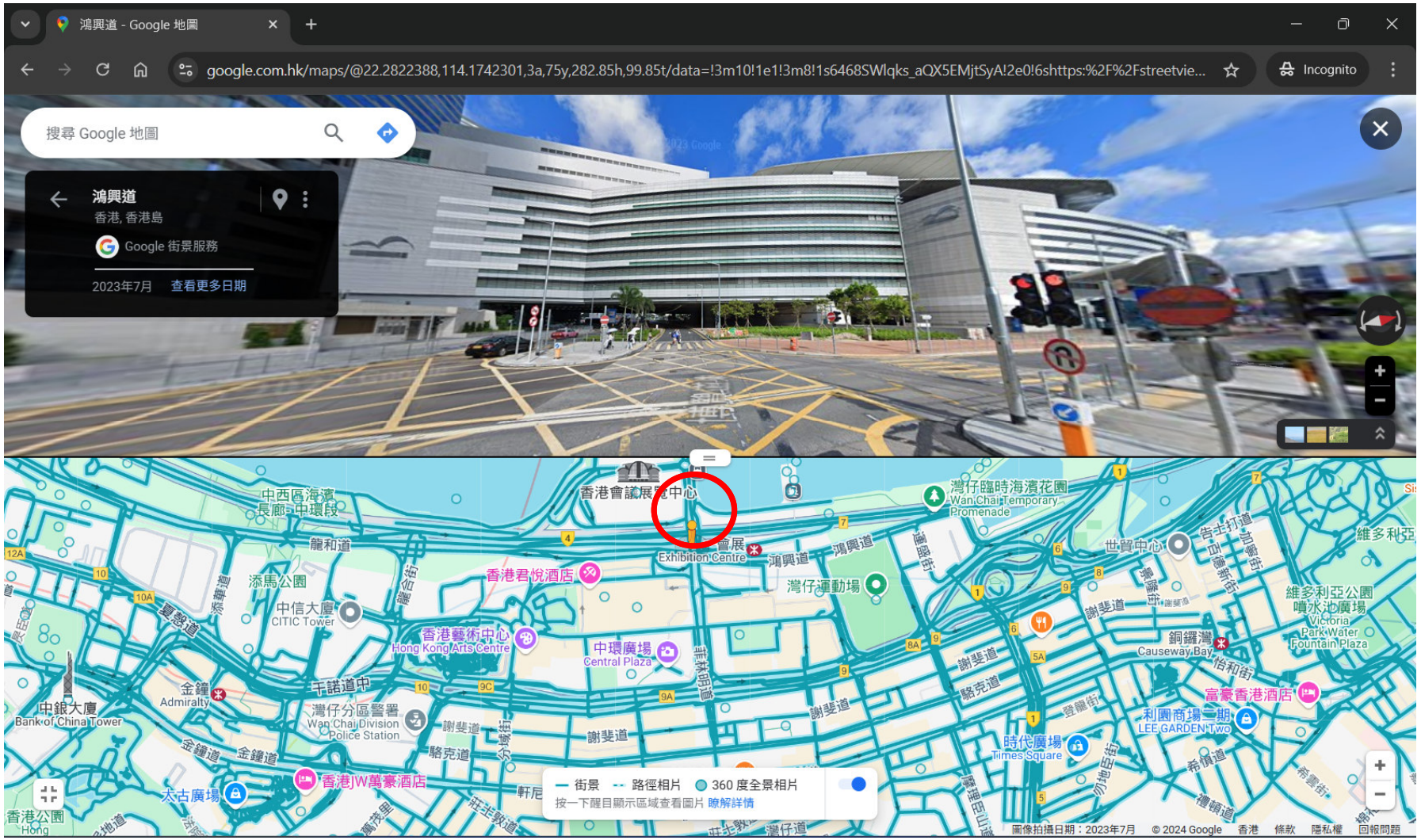


Google Earth 2005

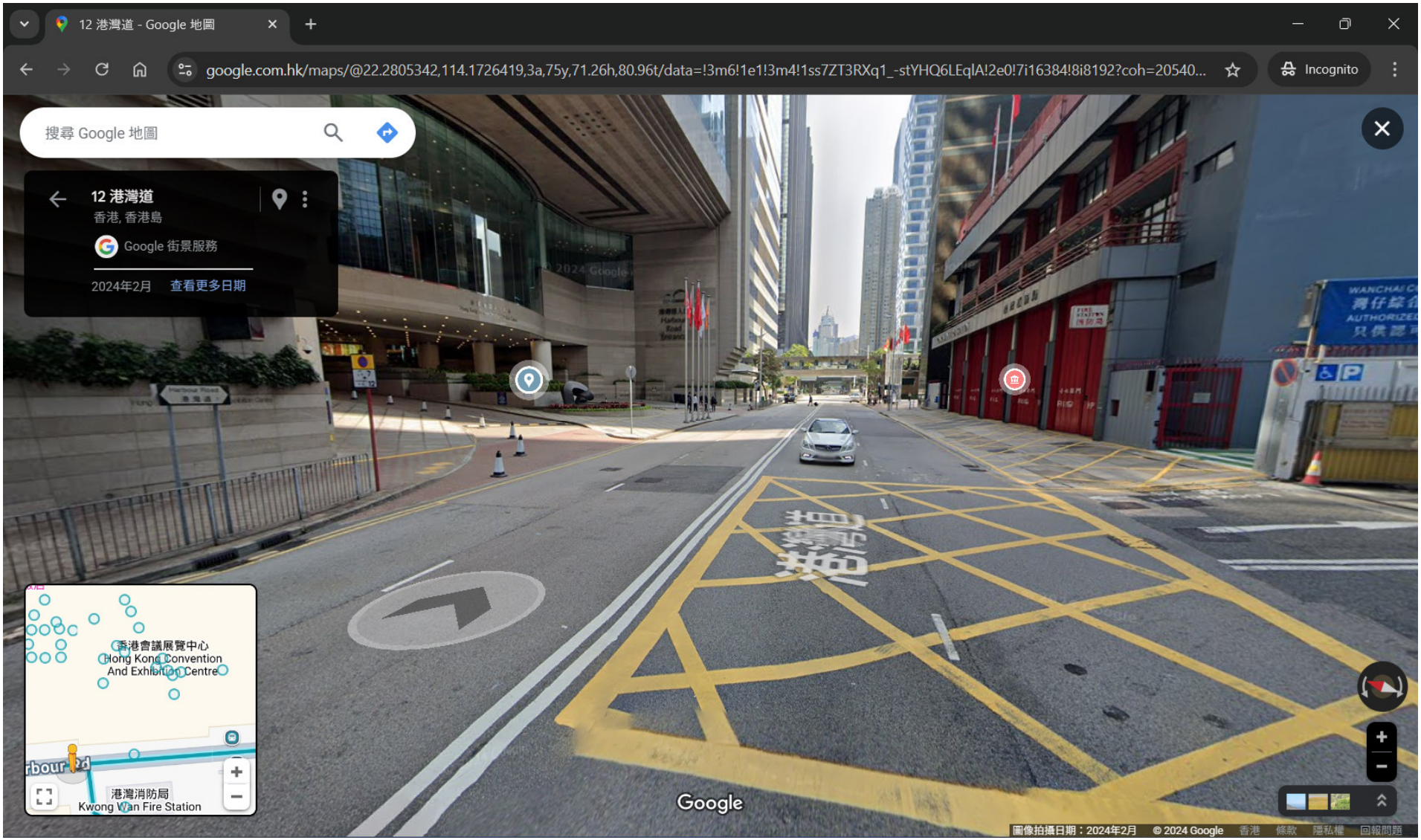




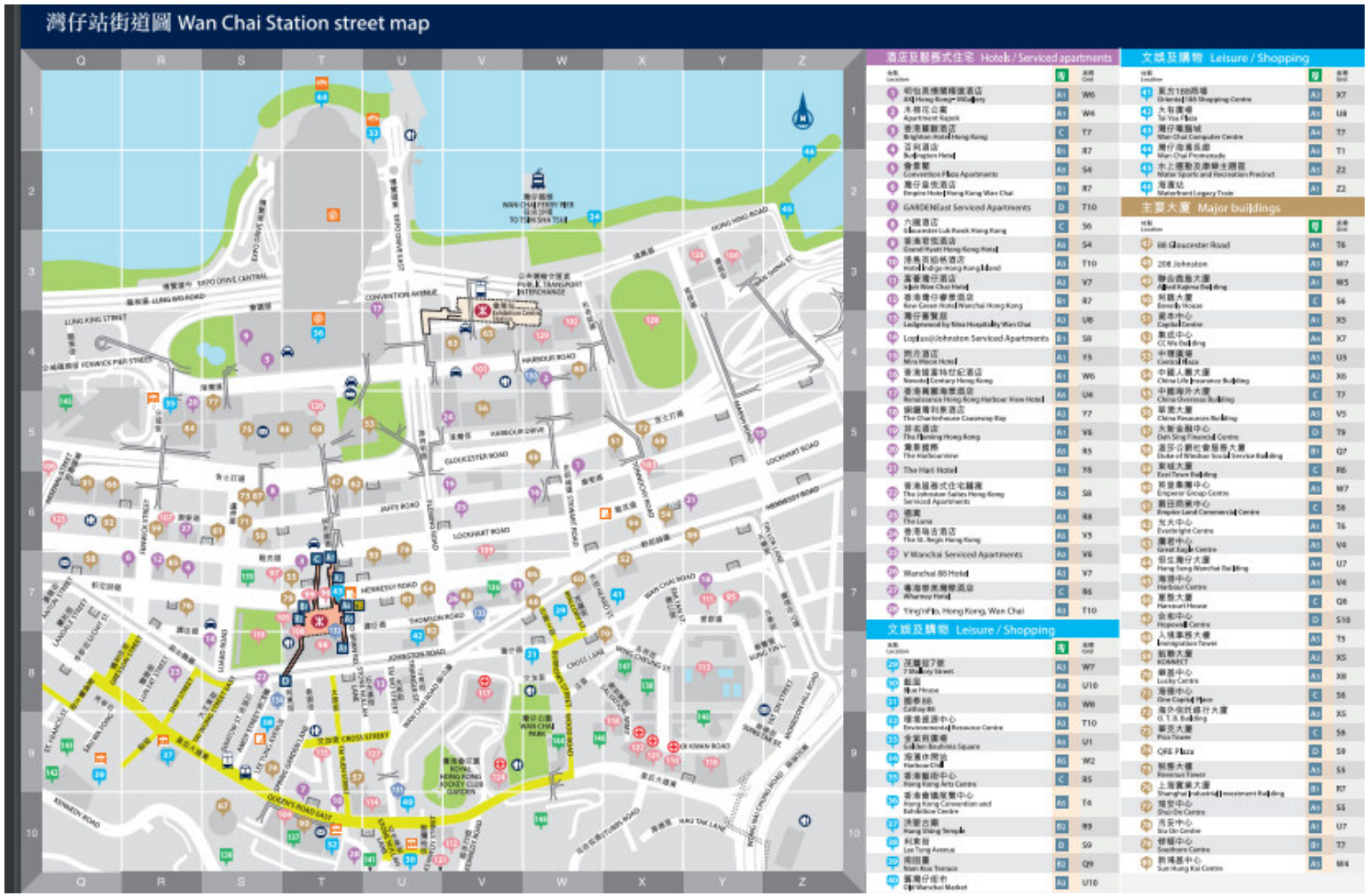
Google Street View 2007



Visual 3D Street View Navigation



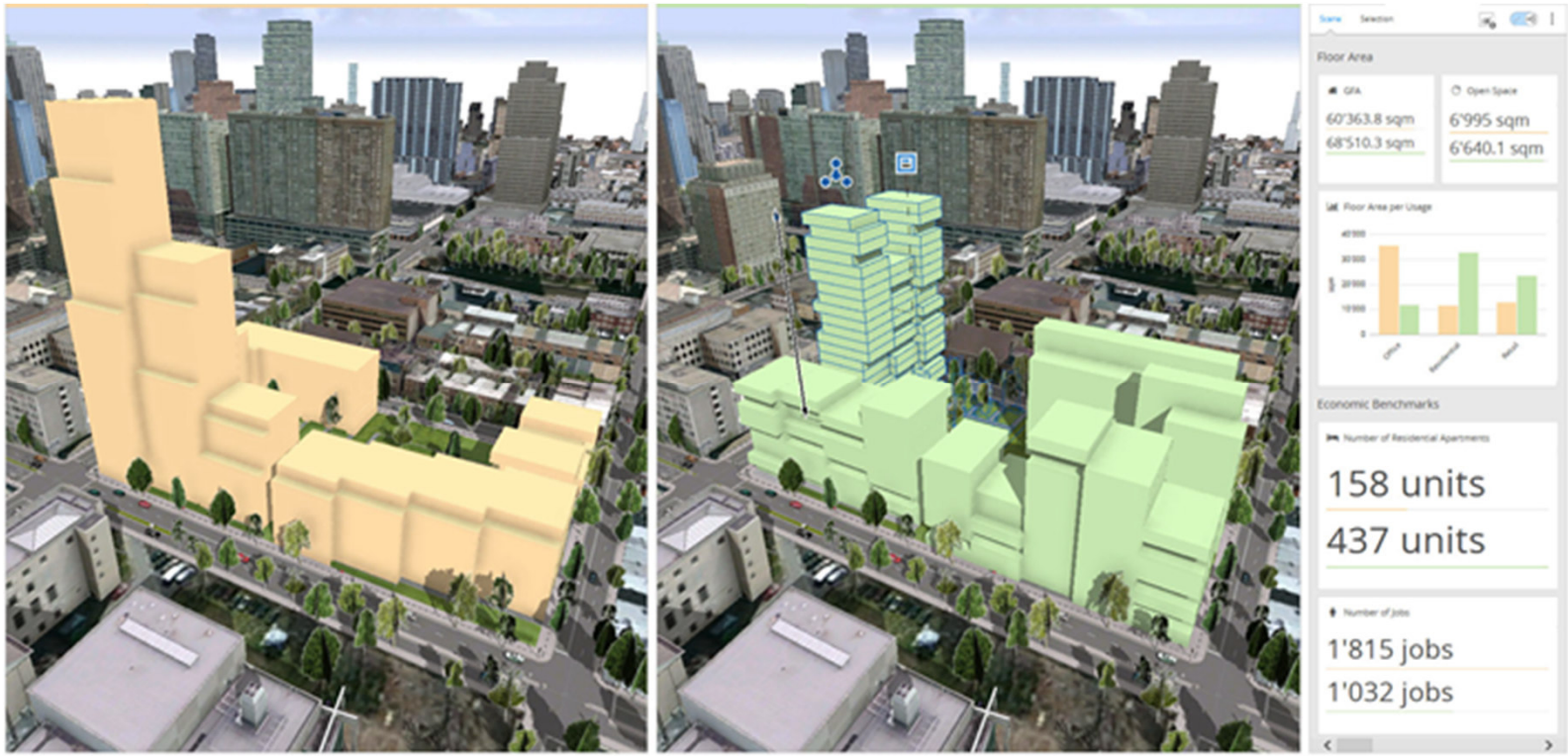
MTR Location Map (2D)



Dongguan MTR Location Map (2023 – 2.5D)

Urban Design and Planning

BIM-based Analysis, Visualization, Planning and Management:



https://www.shelidon.it/?p=8298

Before Redevelopment

Old Buildings Demolished

Proposed Development

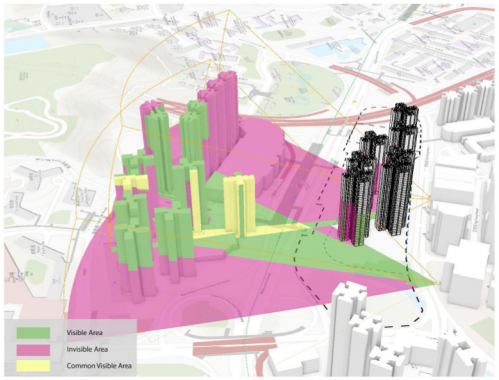
Urban Design and Planning

Viewshed

Overall viewshed of Cheong Hung Court

Viewshed at Choi Hung Road

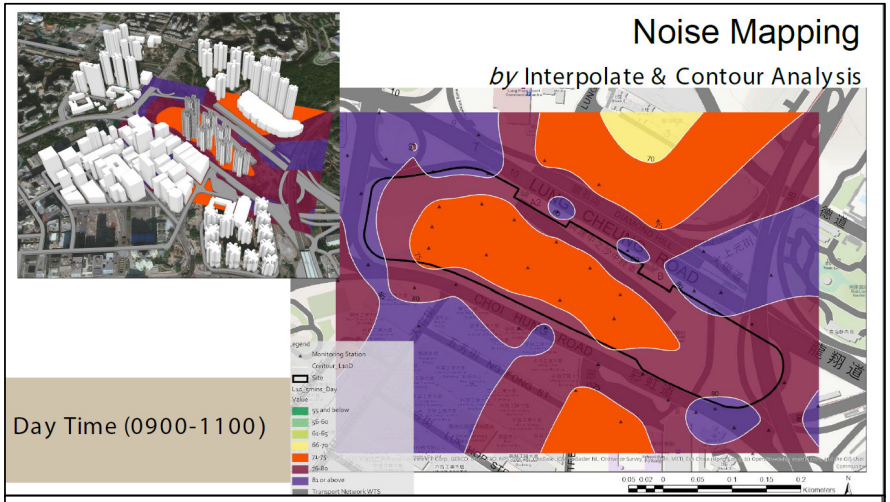
- Cheong Hung Court might block the view of the pedestrian facing Hollywood Plaza and its surrounding buildings



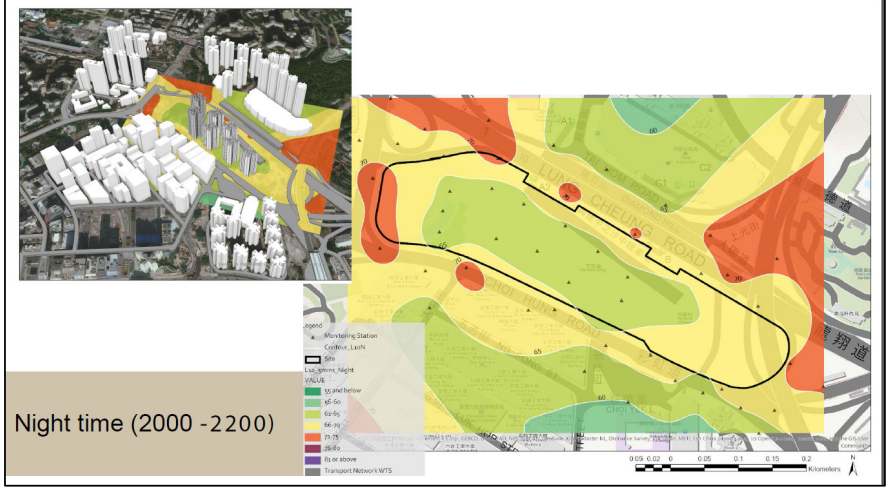
Noise

Noise Mapping

by Interpolate & Contour Analysis

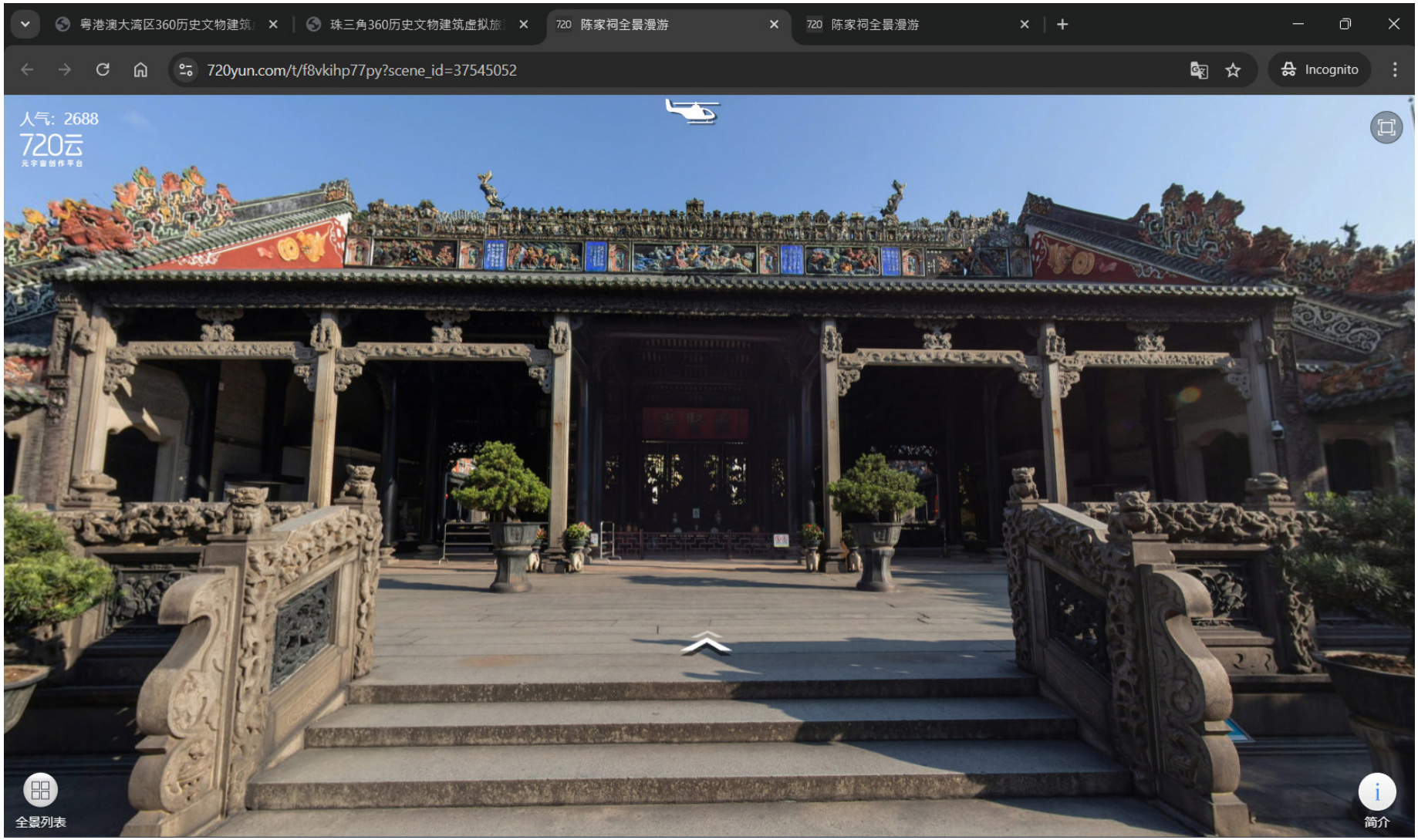


Day Time (0900-1100)



Night time (2000 -2200)

Virtual Tour of Chen Clan Ancestral Hall, Guangzhou

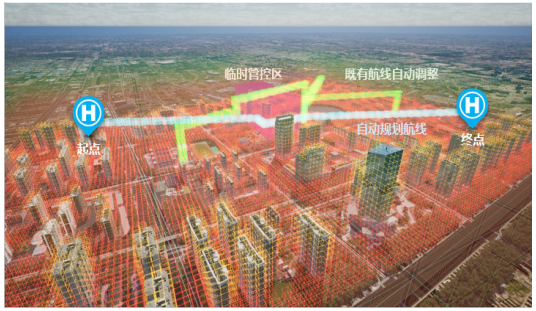


3D Photorealistic Multimedia Games

ow Altitude Economy（Planning & Mgt)

New Industry

去年年底中央经济工作会议将低空经济列为三大战略新兴产业之一，今年又首次写入政府工作报告，被认为是“万亿级风口”、新质生产力。

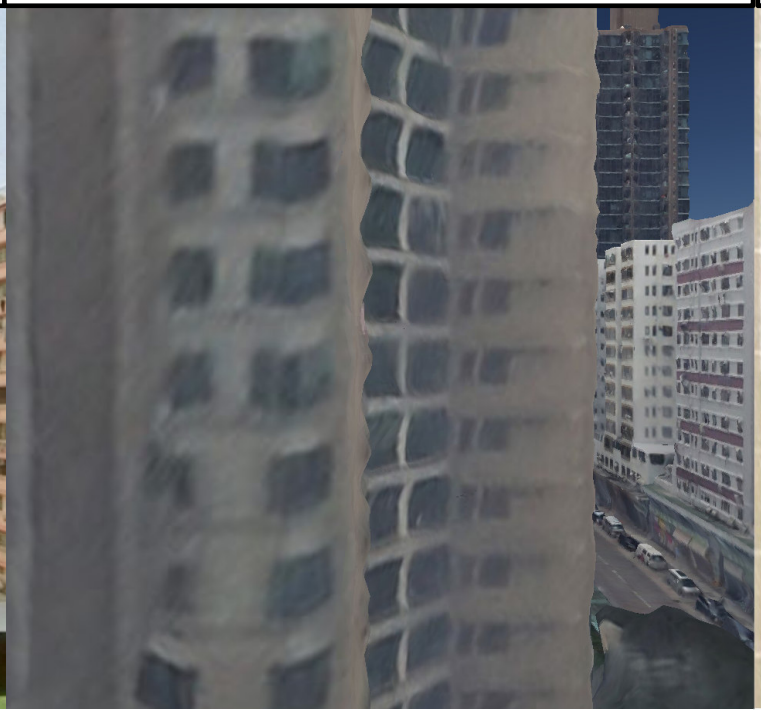


Up Stream			Mid-Stream		Down Stream	
研发	CAx	EDA	载荷	摄像机	飞行审批	低空经济+物流
	PLM	其他		传感器		
关键原材料	钢材	铝合金		云台		低空经济+农业
	工程塑料	陶瓷基材		其他		
	碳纤维	玻璃纤维	低空产品	无人机	空域管控	低空经济+旅游
	树脂基材	复合材料		航空器		
零部件	芯片	板卡		高端装备		低空经济+消防
	电池	电机		配套产品		
	陀螺	其他		低空保障		低空经济+应急
				综合服务		
			地面系统	遥控监测	其他	低空经济+其他
				系统监控		
				数据处理		
				起降系统		
				辅助设备		
				指挥系统		

低空经济产业链结构 来源：新华网

New Growth Engine

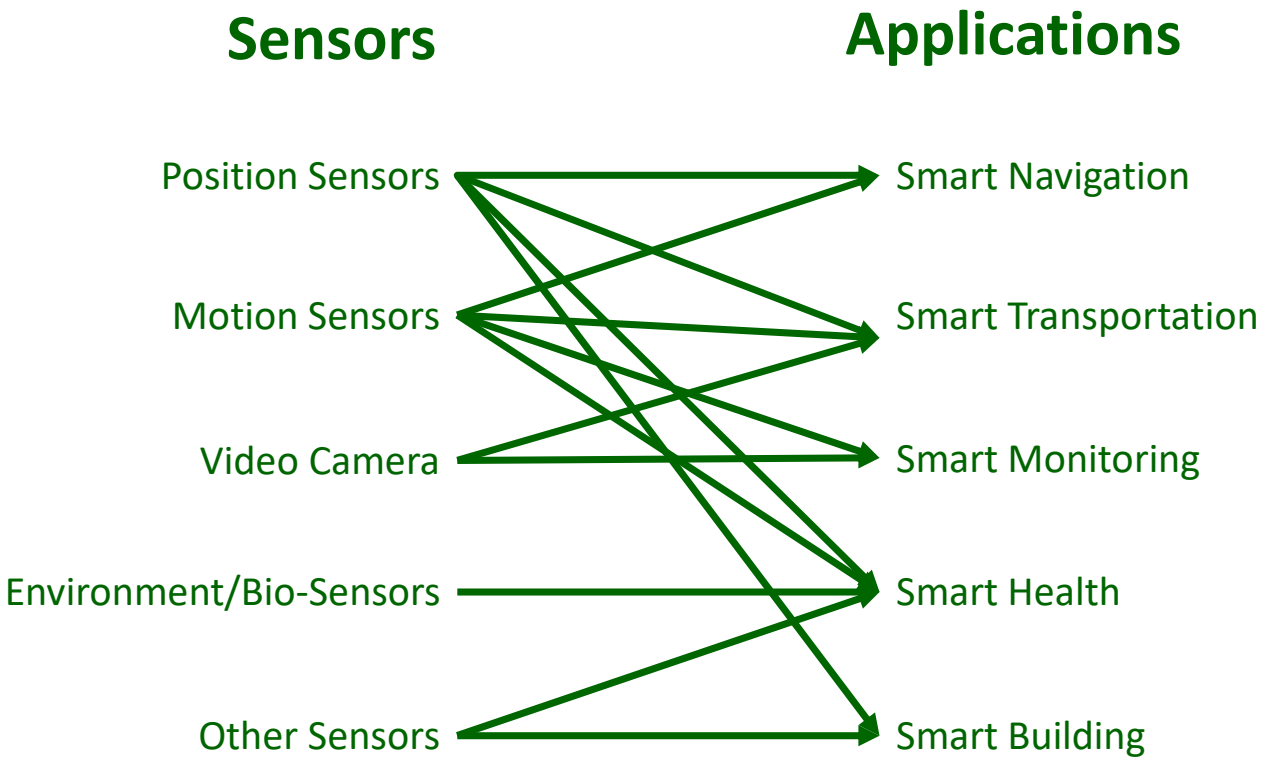
3D-GIS Resolution

Real window view	Generated window view (PlanD, 2020)	Generated window view (LandsD, 2022)
		

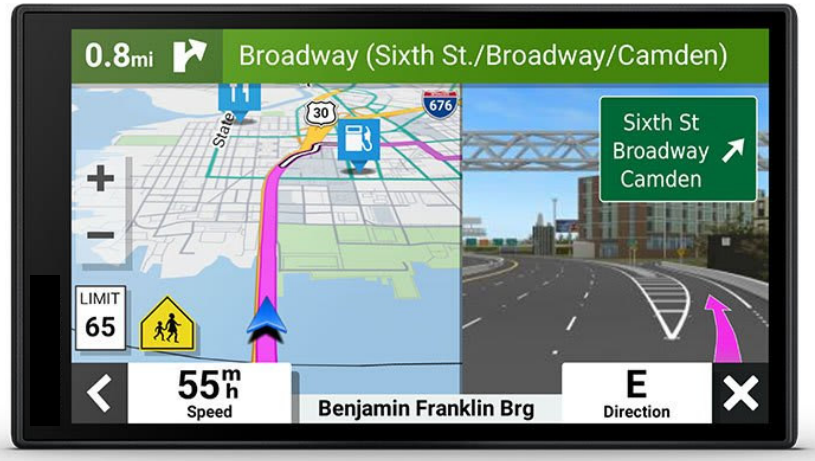
Big Data and Smart Cities *Trends and Challenges*

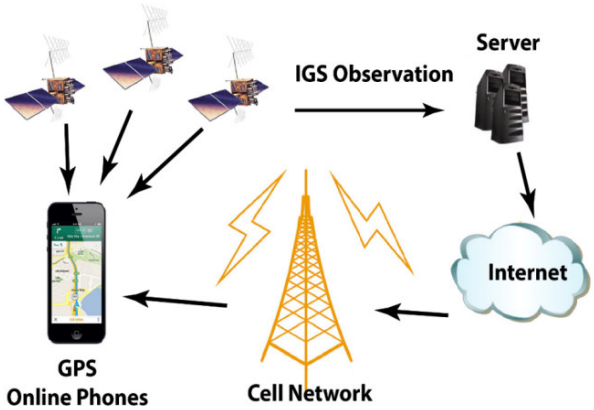
- 2D Smart City to 3D Smart City
- **Sensors and Big Data**
- Digital Twins and AI

Sensors, Information and Related IT and Applications is the Heart of Smart Cities



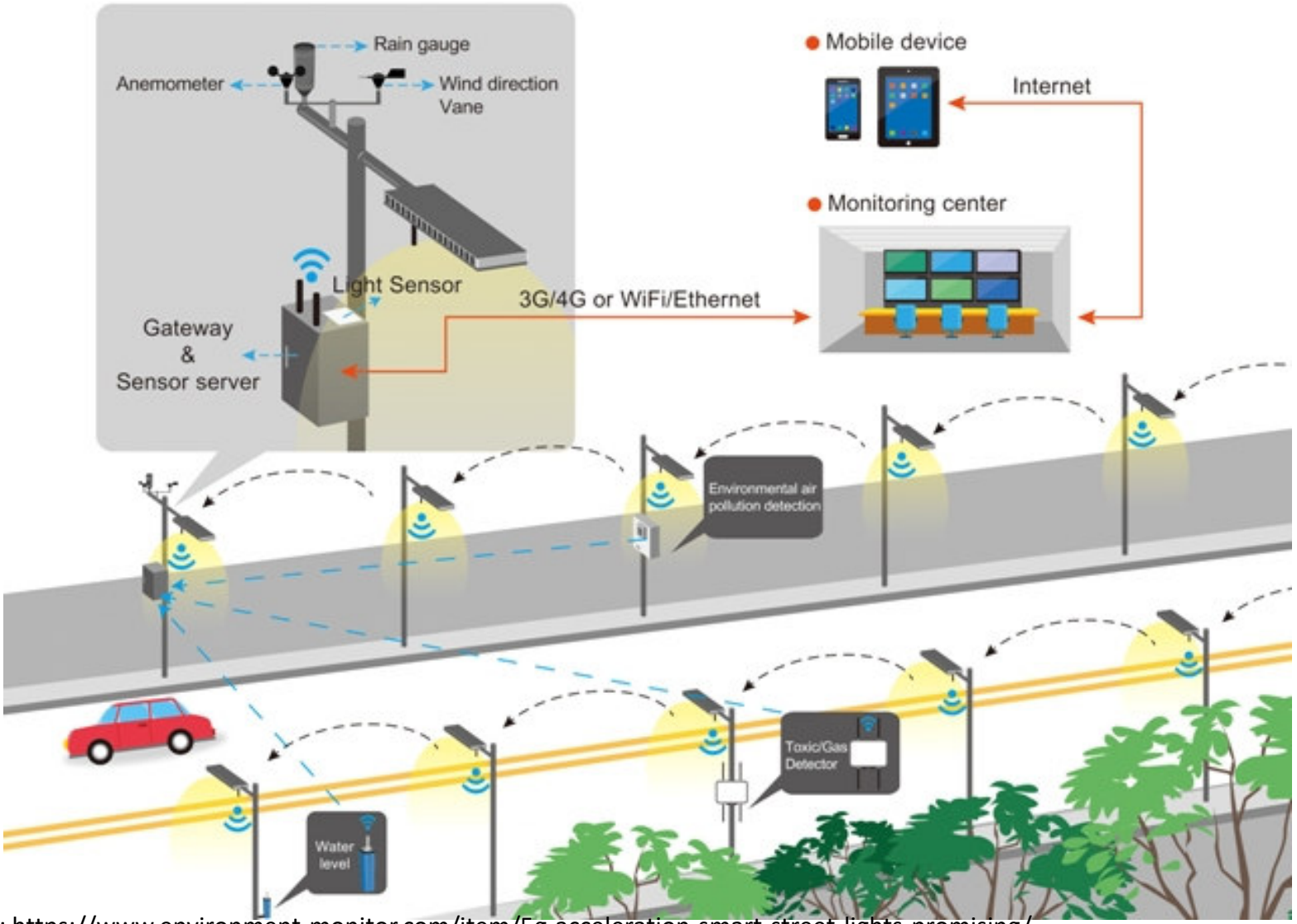
Sensors in Smart Mobility





Global Navigation Satellite Systems (GNSS)

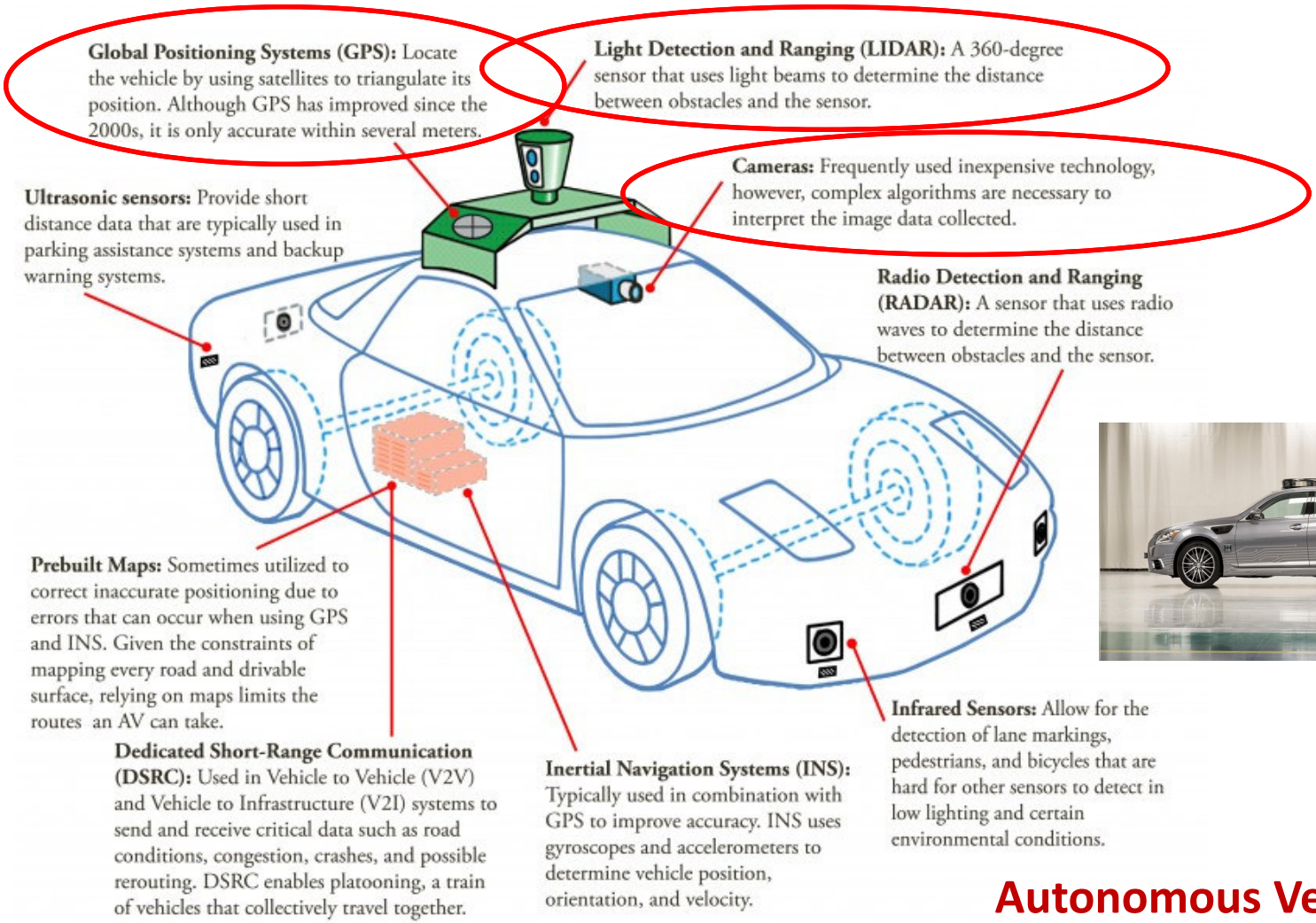
Smart Street Lamp Posts



Source: https://www.environment-monitor.com/item/5g-acceleration-smart-street-lights-promising/

Car Camera

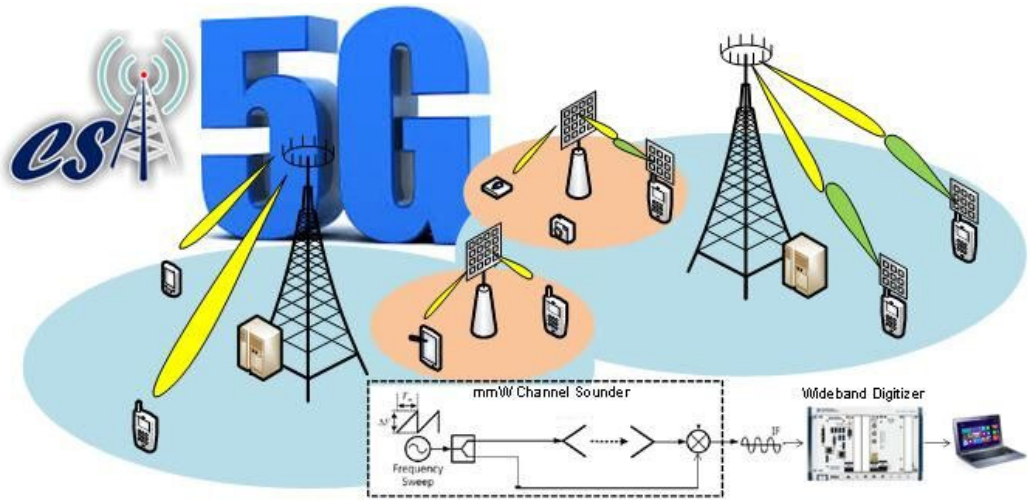
Sensors in Smart Mobility



Autonomous Vehicle

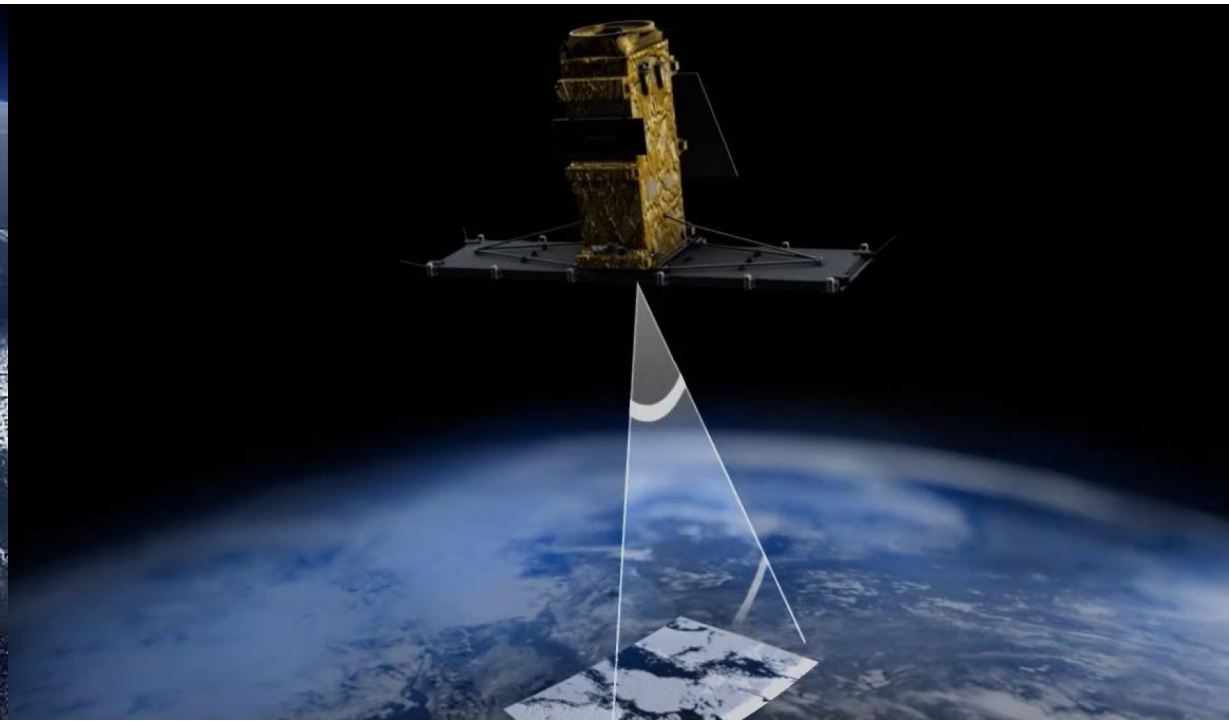
5G Positioning

- 5G Cellular Grid + Mobile Phone
- Density of Base Station
- Accuracy : cm to m



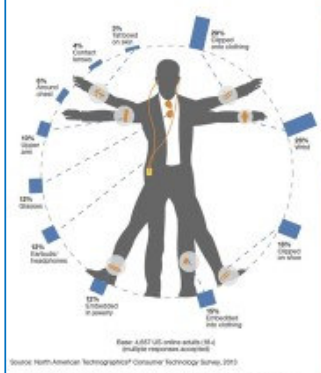
Source:
ieeemy.org

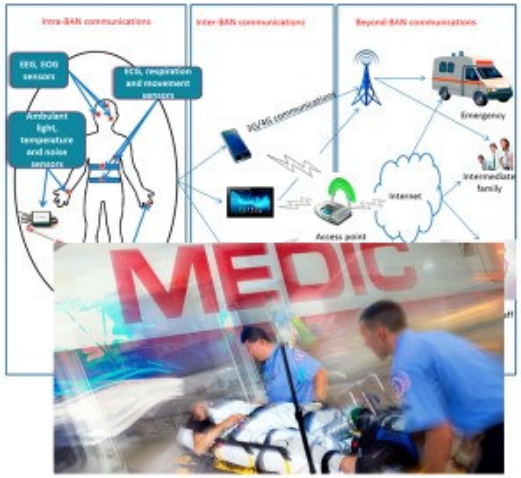
Satellite



UAV Unmanned Aerial Vehicle (Drone)

Smart Heath





Wearable Health Care Sensors
(Source: North American Technographics® Consumer Technology Survey).

Smart Home and Living

Samsung

Google

Smart Environment

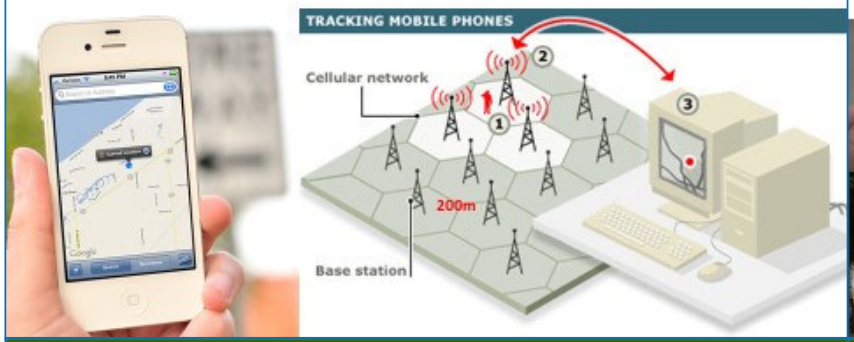
Monitoring of Air and Water Quality

Smart Green Building

Green Living and Sustainable Development
Reduce Energy Consumption

Mobile Phone Data

Mobile data have been widely applied in human mobility pattern and behavioral research.



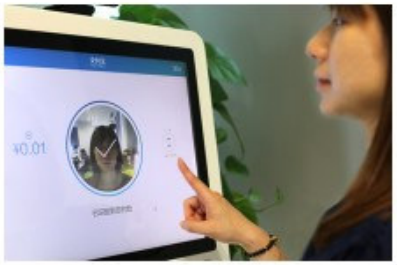
Smart Card Data/Smart Pay

Smart card data/smart pay have been used to identify commuting pattern. This data can also be used to study city spatial structure.

Smart Business

E-Pay

- Cashless
- QR Code
- Face Recognition



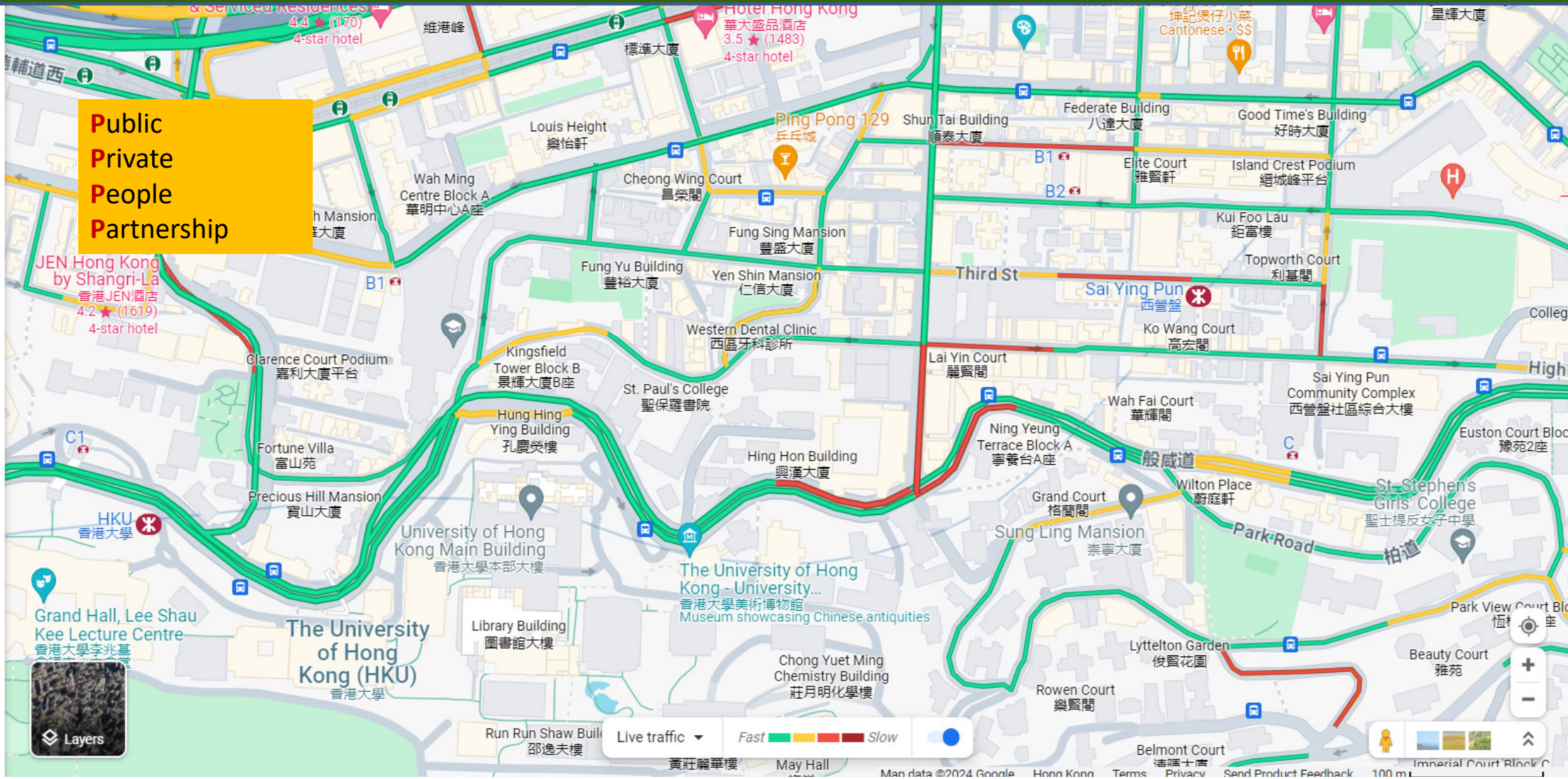
Smart Shopping

E-Shopping

- E-shopping
- Unmanned Shops : Amazon Go、BingoBox、Taobao

User Supplied (Crowd Sourcing) Traffic Information

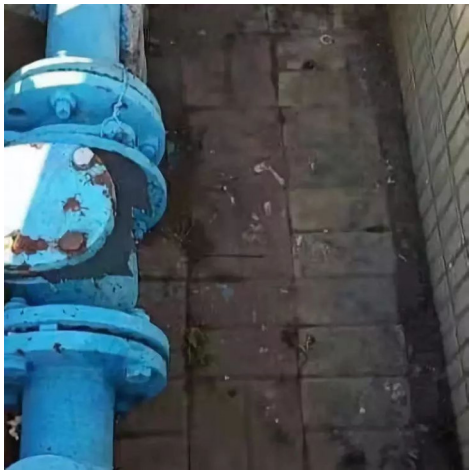
(Google/Gaode Map)



Smart Government – Crowd Sourcing *(Participation in Urban Management)*

- **Report Location：** xxDistrict, yy Street, No. zz
- **Report Problem：** rubbish in public area
- **Work Done：** Urban Service Department has cleared the rubbish on DD/MM/YEAR at xx time.

Before Reporting



After Reporting

Traditional Big Data Sources

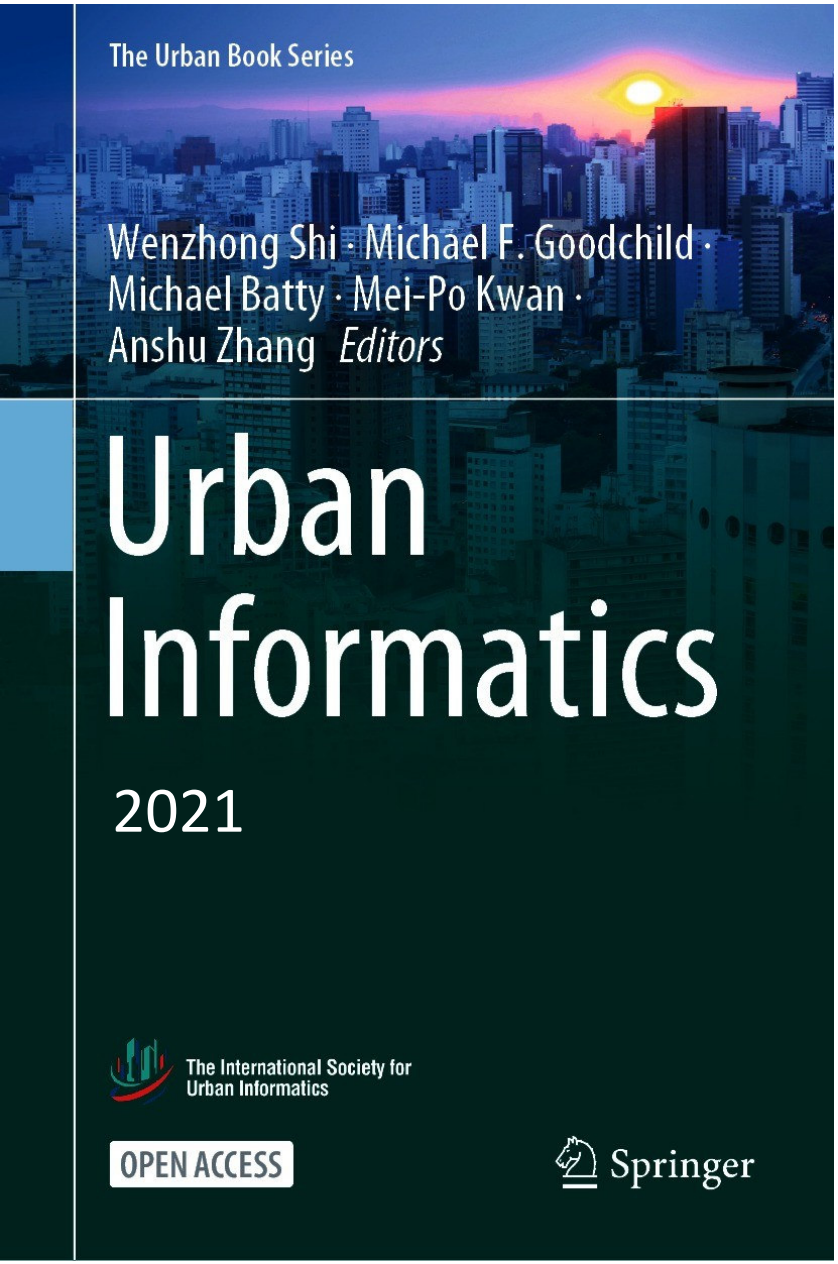
- **Remote Sensing** – land use, land use changes
- Census Data – social area analysis, residential mobility, target marketing
- Telephone Directories – location and spatial distribution, firm births and closures
- Credit Card Data – consumer behaviour, target marketing, consumer profiling, human mobility

Smart Cities – New Data Sources

New Big Data

- **Spatial-Temporal Data**: GPS trajectory, mobile phone data, Smart Card etc.
- **Smart Grid and Sensor Data**: car sensor, oil pipes, Internet of Things (IoT)
- **Social Media Data**: Facebook, WeChat, Twitter, Instagram, etc.
- **Web Data**: page views, searches, purchasing, etc.
- **Text Data**: email, news, etc.

Urban Informatics → Urban Analytics

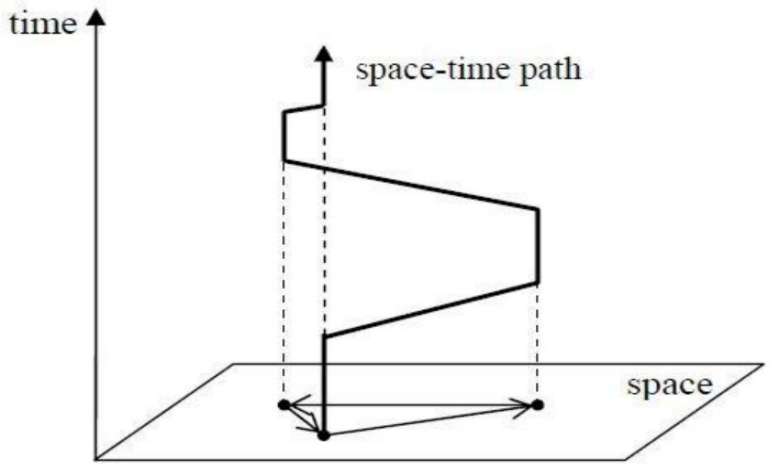


https://link.springer.com/book/10.1007/978-981-15-8983-6

Spatial-Temporal Big Data

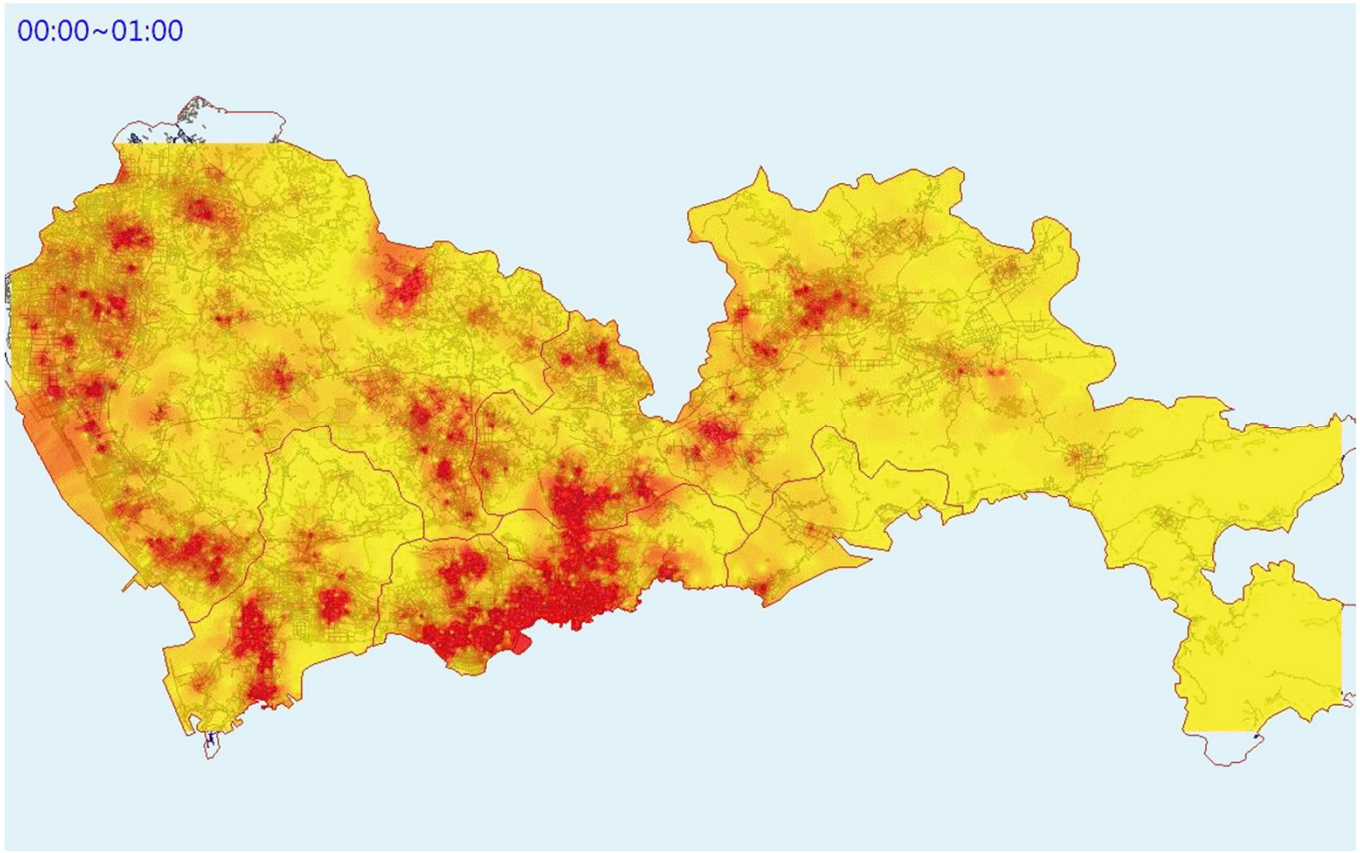
- Higher Resolution (Spatial)
- Higher Granularity (Time)
- Real Time

Space-Time Prism



Swedish Torsten Hagerstrand's Time Geography (1970)

Mobile Phone Location Data – Big Data



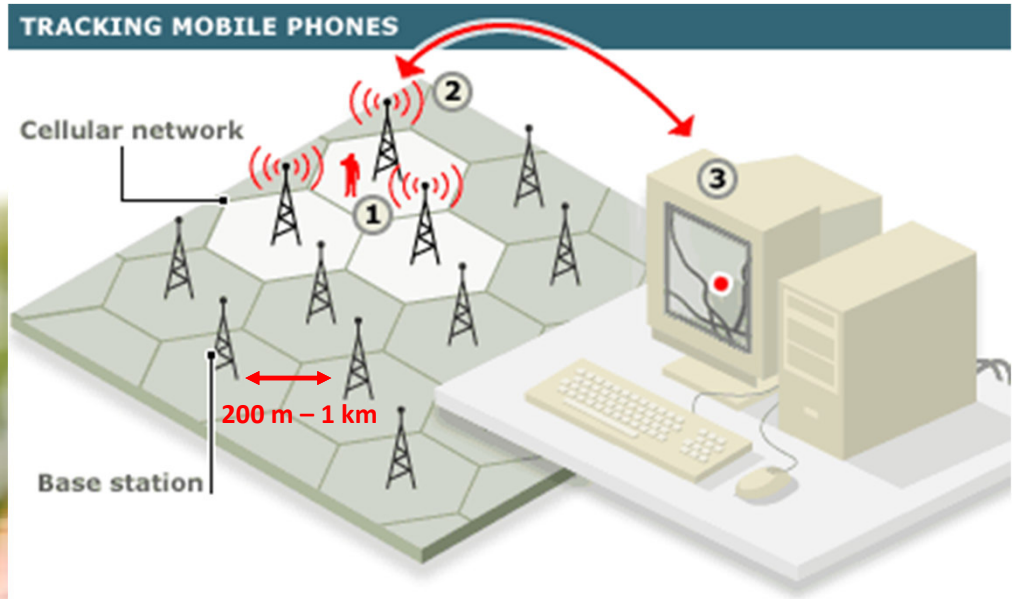
Activity intensity in Shenzhen within 24 hours - 2011

Mobile Phone Data

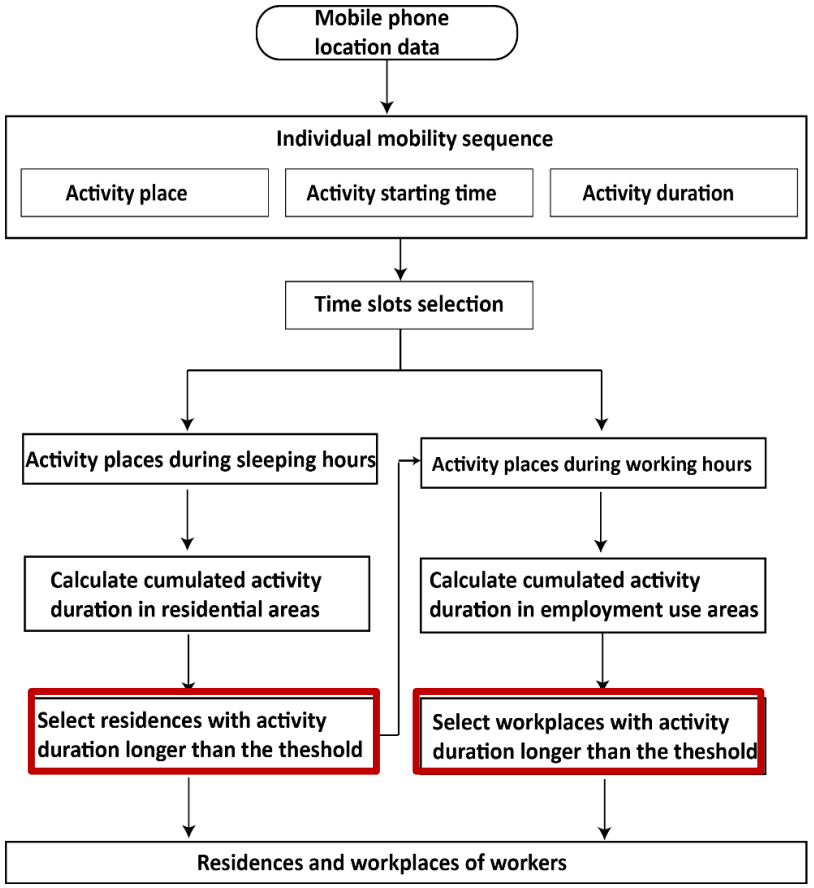
Mobile phone data have been widely applied in human mobility pattern and behavioral research.

Mobile Phone User ID	Date	Time	Latitude	Longitude
A	2011/8/1	20:34:33	22.53133	114.0658
B	2011/8/1	20:34:59	22.53133	114.0658
C	2011/8/1	20:46:16	22.53133	114.0658
D	2011/8/1	14:21:38	22.56144	114.0902
E	2011/8/1	14:21:30	22.56144	114.0902

Mobile Phone Tracking



Big Data processing with GIS



Identification of mobile phone users' residences and workplaces

Big Data

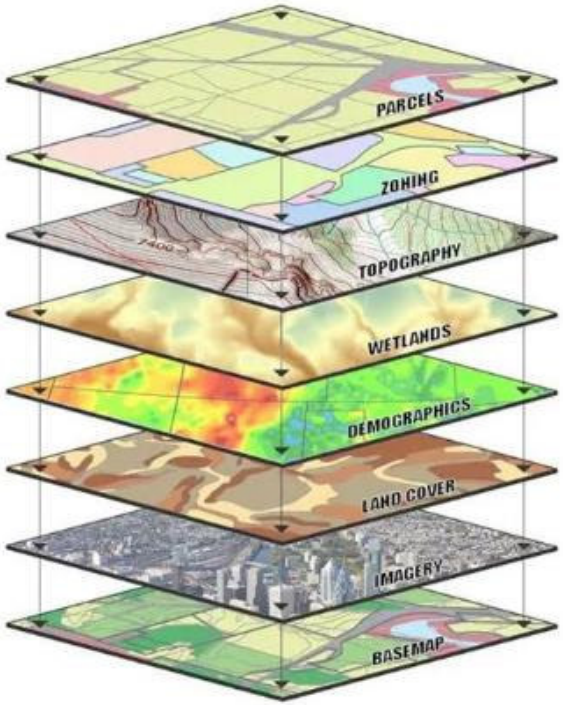
Residents

Jobs

Space-Time

Distribution

Survey
Small Data
Field Work



Adminstrative Boubdaries

Census and Economic Data

POI

Services and Facilities

Land Use

Transport Network

Public Space

etc.

GIS - Geographical Context

Big Data and Smart Cities *Trends and Challenges*

- 2D Smart City to 3D Smart City
- Sensors and Big Data
- **Digital Twins and AI**

Digital Twin City

Physical Real City

Intelligent Urban Management and Maintenance

Operation Mgt

Maintenance Mgt

Traffic & Environment Information & Prediction

Building & Facility Information & Prediction

Digital Cyber City

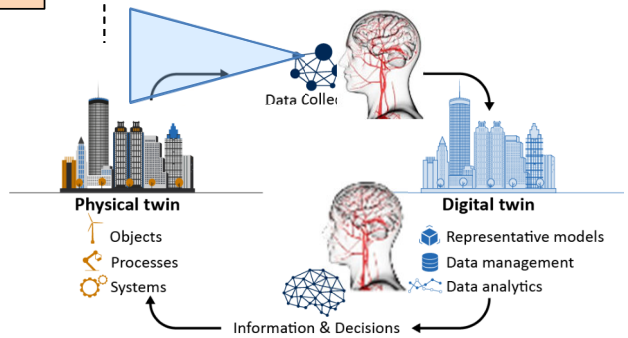
AI Operation and Management System

Digital GIS + BIM

Real Time Sensing, Monitoring and Feedback Control System

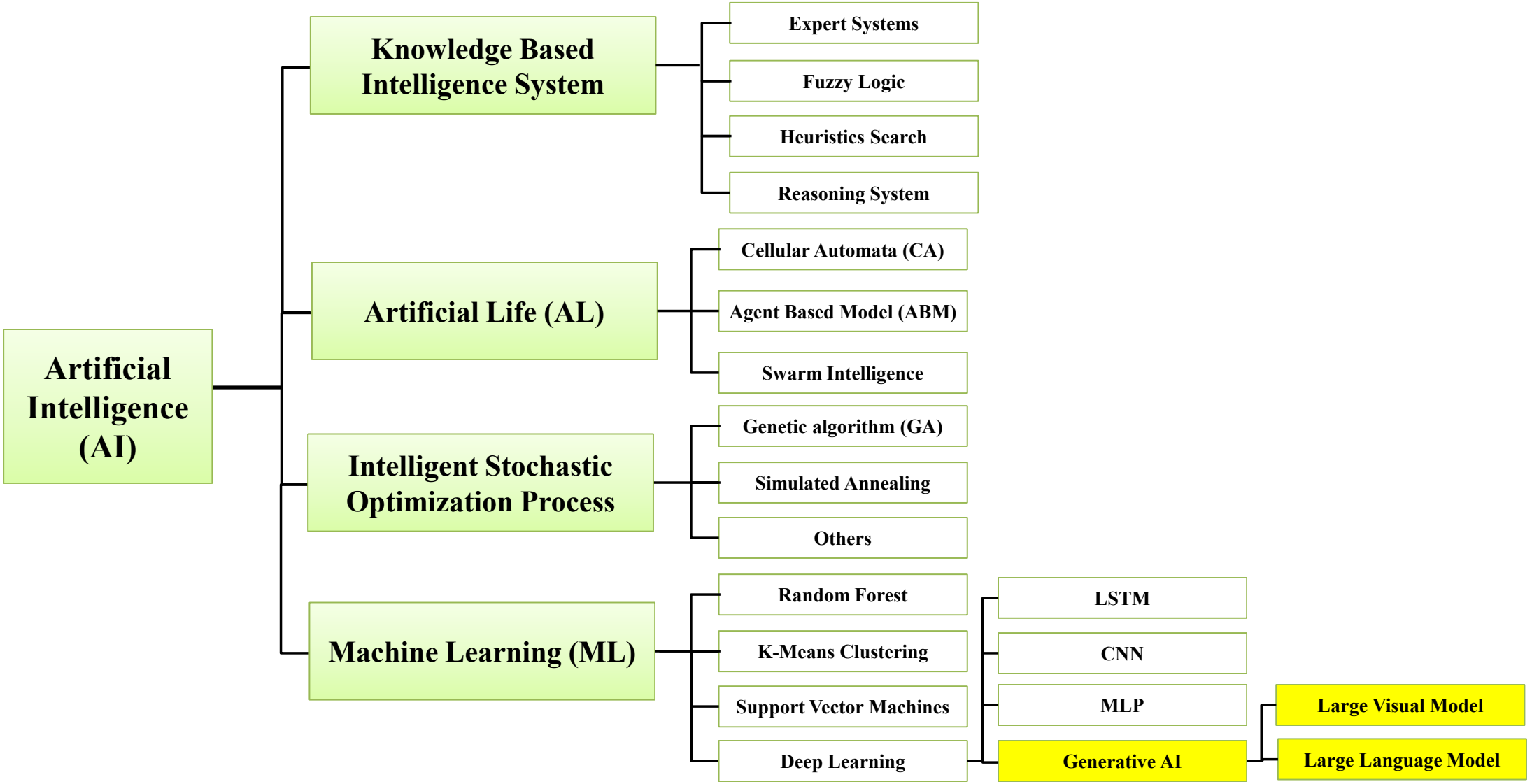
Sensors

Real World Photorealistic Visualization

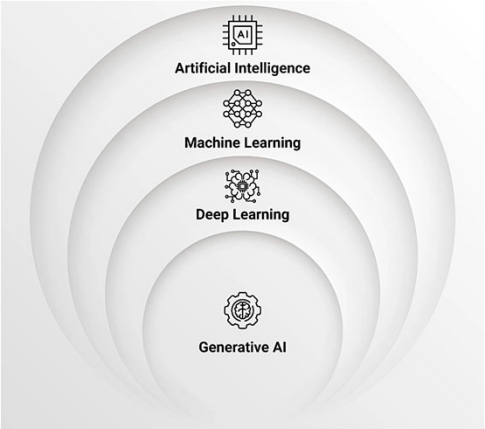


Sources: GAO; ladoga/stock.adobe.com. | GAO-23-106453

Urban Informatics → Urban Analytics

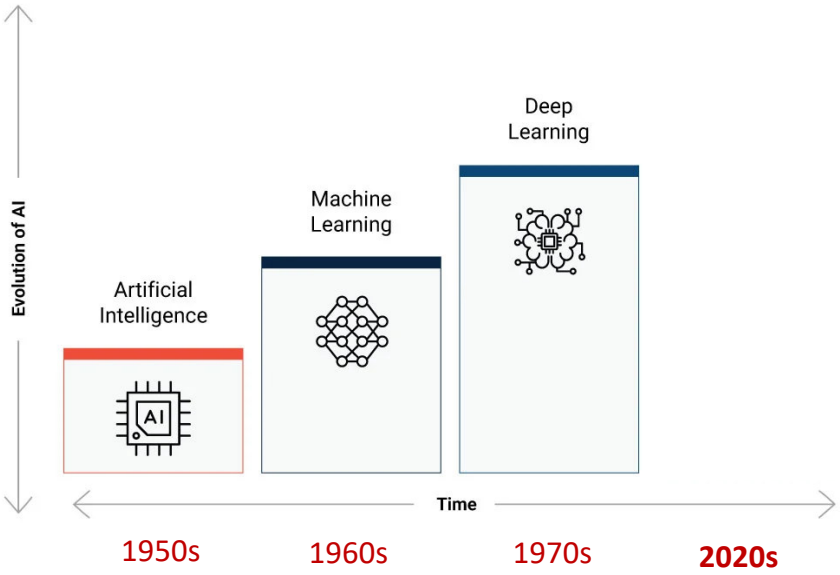


AI Definition



- **Artificial Intelligence** originated around **1950s**. It represents simulate intelligence in machines. It is a subset of data science. Its aim is to build machines which are capable of thinking like humans.
- **Machine Learning** originated around **1960s**. It is the practice of getting machines to make decisions without machines to make decisions without being programmed. It is a subset of AI & Data Science. Its aim is to make machines learn through data so that they can solve problems.
- **Deep Learning** originated around **1970s**. It is the process of using artificial neural networks to solve complex problems. It is a subset of Machine Learning, AI & Data Science. Its aim is to build neural networks that automatically discover patterns for feature detection.

- **Generative AI** surged around **2020s**. It is advanced from using the Transformer-based deep neural networks. It is a subset of Deep Learning. Its aim is to generate different types of content – such as text, imagery, audio, video – based on what has learnt from existing content.



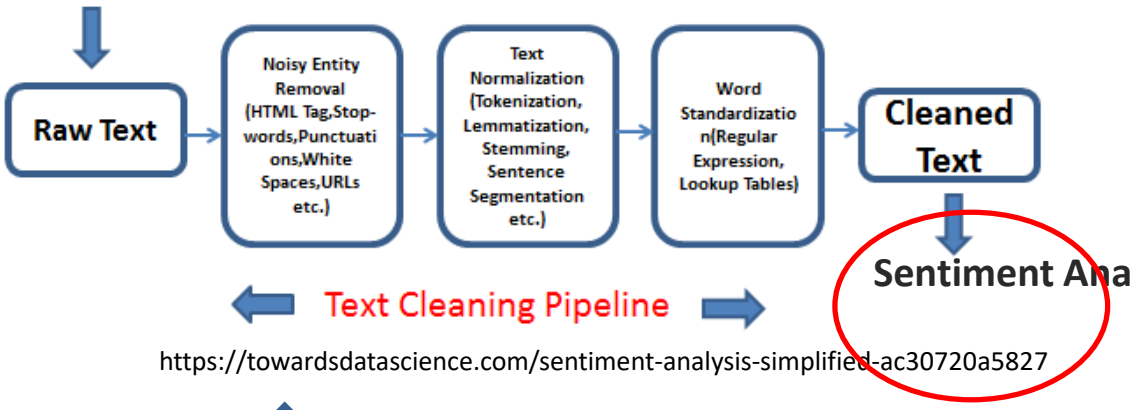
Mapping Slums and the Dynamics of the Deterioration in Cities

- With the growth of the fields of deep learning and computer vision, understanding cities through the eyes of a computer opens the door for analysing missing attributes of city dynamics.
- Large-scale analysis of digital images and patterns of captured features that may not be recognised of significance by human eyes can potentially enable various urban issues to be identified and collected.
- AI-based tool of deep convolutional neural networks could extract rich geospatial data such as slums, transport modes, and pedestrians in cities from street view images.

Ibrahim, M. R., Haworth, J., & Cheng, T. (2021). URBAN-i: From urban scenes to mapping slums, transport modes, and pedestrians in cities using deep learning and computer vision. *Environment and Planning B: Urban Analytics and City Science*, *48*(1), 76-93.

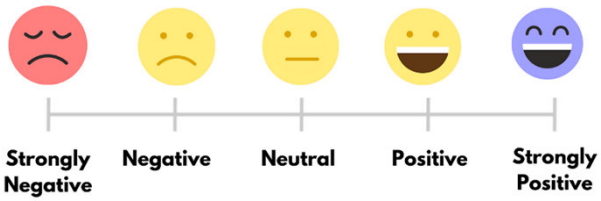
Generative AI – Large Language Model

Natural Language Processing for Public Participation

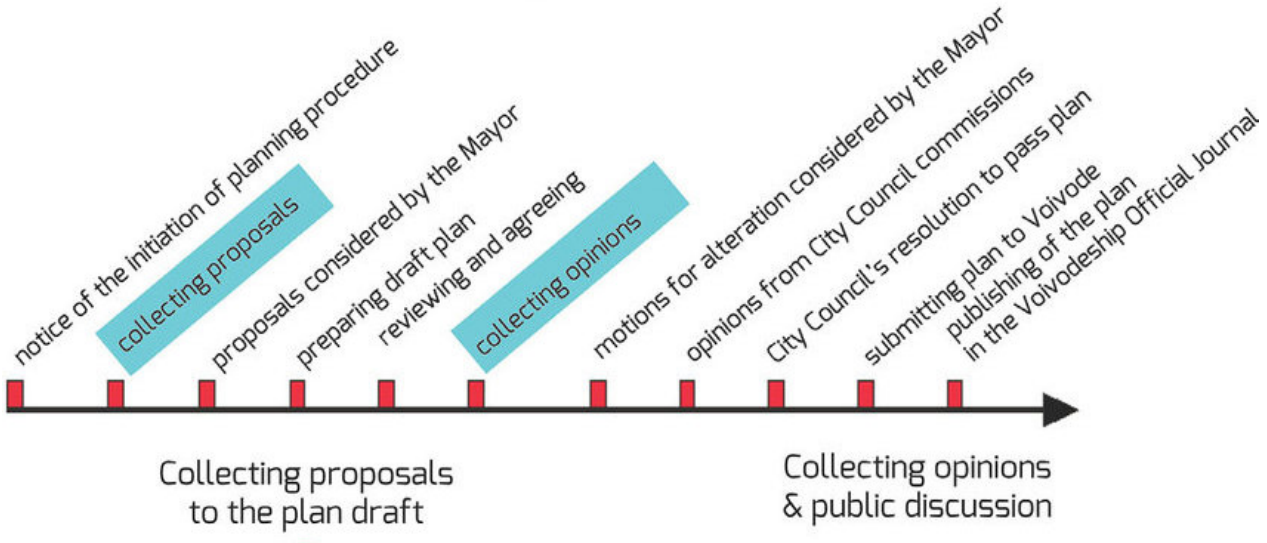


https://towardsdatascience.com/sentiment-analysis-simplified-ac30720a5827

Comment1: Build more public housing for HK people.
Comment2: We will lose the surrounding greeneries.



Representations & Comments in Plan-making Process

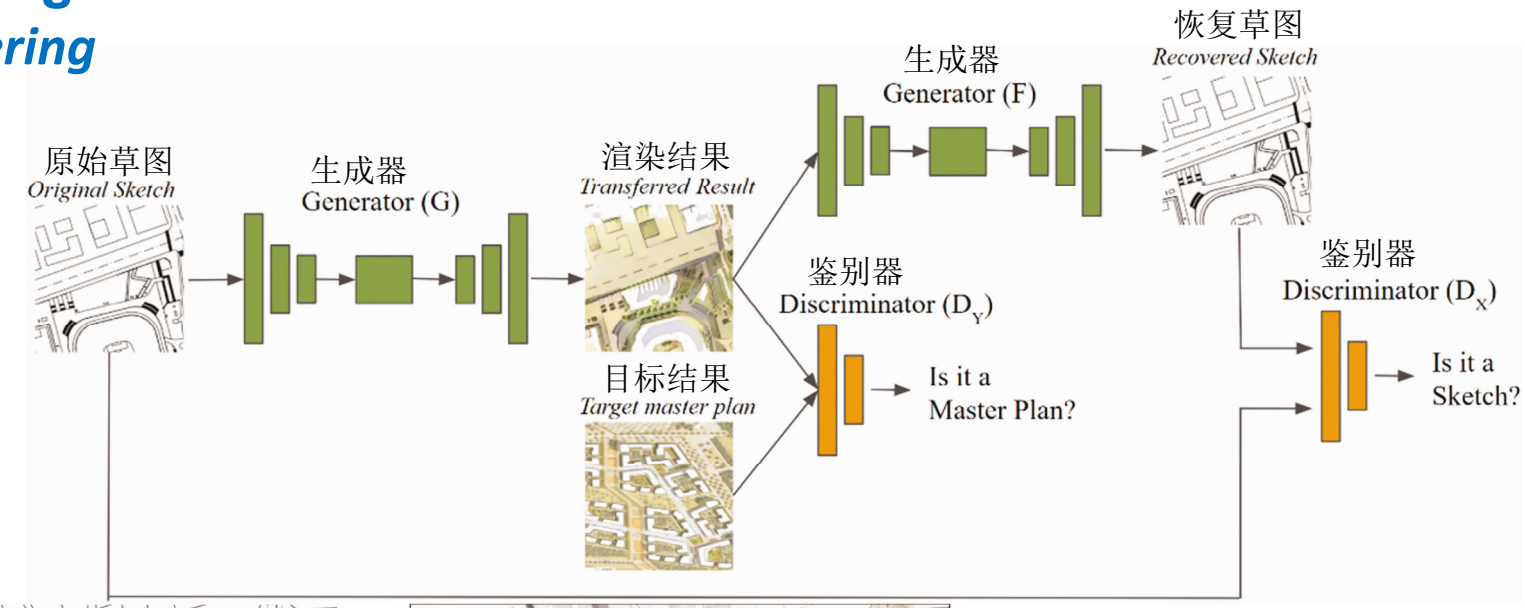


Haklay, M., Jankowski, P., & Zwoliński, Z. (2018). Selected modern methods and tools for public participation in urban planning–a review. Quaestiones Geographicae, 37(3).

Generative AI – Large Visual Model

Urban Design Rendering

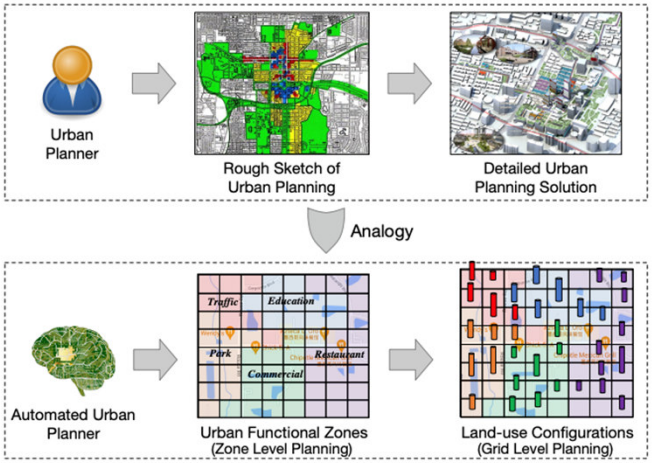
MasterplanGAN



Source: Ye, X., Du, J., & Ye, Y. (2022). MasterplanGAN: Facilitating the smart rendering of urban master plans via generative adversarial networks. *Environment and Planning B: Urban Analytics and City Science*, 49(3), 794-814.

Generative AI – Large Visual Model

Automated Urban Planning



- The essential task of urban planning is to generate the optimal land-use configuration of a target area.
- This study proposes a land-use configuration generation framework, namely LUCGAN, which can generate a land-use configuration automatically for an empty geographical area based on surrounding contexts.

Wang, D., Fu, Y., Wang, P., Huang, B., & Lu, C. T. (2020, November). Reimagining city configuration: Automated urban planning via adversarial learning. In *Proceedings of the 28th international conference on advances in geographic information systems* (pp. 497-506).

Smart Technology, Big Data, AI and Urban Analytics

- **Make cities more efficient and sustainable – A Very Valuable Tool**
  - **New Smart Technology - *Better real time survey, information, and monitoring***
  - **Crowd Sourcing – *Public participation in sustainable urban management***
  - **Digital Twin with AI – *More efficient and timely urban management***
- **Changes in Surveying Education - *have to learn more skills and technologies***
- **What new knowledge CAN we**
  learn from Big Data, AI and Urban Analytics ?

Thank You