

 THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系



REC Summer Programme

# Geospatial Analysis in Land Development

Prof Fan Xue (Frank)  
Associate Professor  
Department of Real Estate and Construction  
The University of Hong Kong  
[xuef@hku.hk](mailto:xuef@hku.hk)  
<https://frankxue.com>  
Open office hour: 9:30-10:30 am, Fridays

 THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## About me

- Xue, Fan (Frank)
- Edu. background
  - BEng in **Automation**
  - MSc in **Computer Science**
  - PhD in **System Engineering, PolyU**
  - PDF/RAP/AP in **Construction IT**
- Research interests
  - Urban sensing and computing
  - As-built BIM and digital twin
  - Automation/IT in construction
  - Applied operations research, ML
  - Blockchain applications in construction




2000  
2004  
2007  
2013

→



ESI Top 1% Researcher  
World Top 2% Scientist

- Engineering
  - CEM, ISE, EIE
- Computer Science
  - AI, OR, ML
- Professional
  - MACM, SMCGS, SMIEEE, MACM, MISDE
  - Vice-Chair ACM-HK, Com. CGS-BIM, Com. ASC-Smart Const.

Geospatial Analysis in UD

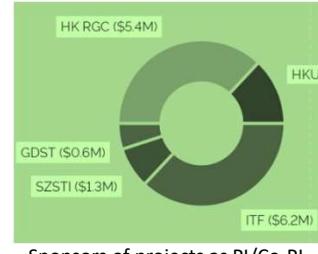


## Frank's research projects

- As PI:
  - HK RGC GRF/ECS ([17201717](#), [17200218](#), [27200520](#),  
[17200221](#), [17200123](#), [17201325](#)),
  - HKU-Tsinghua SPF ([20300083](#)), HKU (\* 9 projects)
  - SZ-HK-MC TRP-C ([#SGDX202011...02](#))
- As PC:
  - ITF ([ITP/004/23LP](#))
- As Co-PI:
  - HK RGC TRS ([T22-504/21-R](#)), Key R&D Guangdong ([2019B010151001](#)), ITF ([ITP/029/20LP](#)), HKU PTF ([102009741](#))
- **Q: Which city are you from?**

Talk 1 - Introduction

- Keywords
  - BIM/CIM
  - 3D point cloud
  - Derivative-free optimization
  - Urban semantics



3



## What We'll Learn Today

- Upon the completion of this session, you should be able to
  - 1) Explain the concept of urban development;
  - 2) Contrast geospatial analysis technologies in Urban Development; and
  - 3) Try ArcGIS, a Geographic Information System
    - 1) Relate to yesterday's sessions on surveying and
    - 2) digital maps

Frank's legend of level	Acknowledge (Level 1)	Analysis (Level 2)	Application (Level 3)
-------------------------	-----------------------	--------------------	-----------------------

Geospatial Analysis in UD



# Part I

## Introduction to Land Development

(L1)

Geospatial Analysis in UD



### I. Urbanization, a global trend

- Warming-up: Guess cities.
- Why people gather to form cities?



Geospatial Analysis in UD



B



Scan or  
click [to  
join](#)

Chance  
to win  
a gift!

A



## I. Urban Development Cycle

- Securing land and funds
  - Construction
  - Marketing & FM
  - Renewal & Regeneration



7 Harbor 1960s

2020s



## I.2 Securing land, funds, and plans

- “Location, location, location”
    - Vital from the beginning of urban development
  - Zoning plan (城市規劃圖)
    - Area west to HKU
  - Money raising
    - Bank loans
    - Equity financing, etc.
  - Planning
    - Scope, schedule
    - Get permits, control risks



Geospatial Analysis in UD

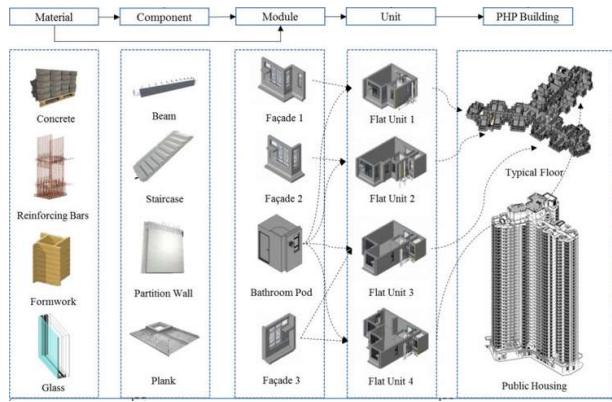
THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## I.2 Construction stage

- Pre-construction
  - Tendering 招投標
  - Contract award/Main contractor
- Construction
  - Site works, foundations
  - Construction start (Main contractor)
  - Subcontractor tendering 分包
  - [Commenced]
- Post-construction
  - Inspection (defects), documentation
  - Securing occupancy permits

(Source: HK Housing Society) 



```

graph LR
    Material[Material] --> Component[Component]
    Component --> Module[Module]
    Module --> Unit[Unit]
    Unit --> PHPBuilding[PHP Building]
    
```

The diagram illustrates the hierarchical assembly of a building. It starts with 'Material' (Concrete, Reinforcing Bars, Formwork, Glass, Beam, Staircase, Partition Wall, Plank) which are combined into 'Component' (Façade 1, Façade 2, Façade 3, Bathroom Pod, Plank). These components are further assembled into 'Module' (Flat Unit 1, Flat Unit 2, Flat Unit 3, Flat Unit 4). Finally, multiple modules are integrated into a 'Typical Floor', which is part of a larger 'Public Housing' building.

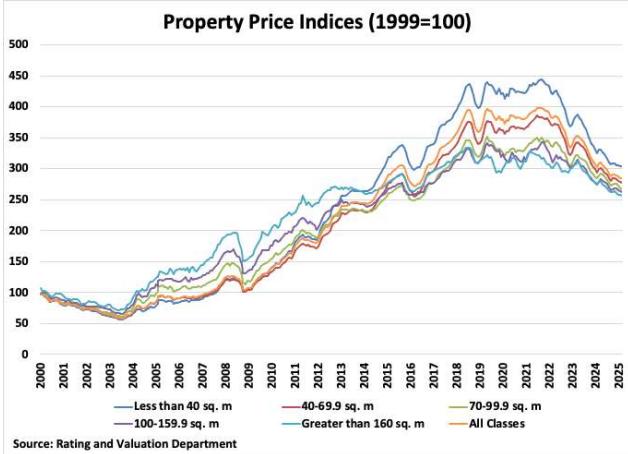
Geospatial Analysis in UD

Li, X., Shen, G. Q., Wu, P., & Yue, T. (2019). Integrating building information modeling and prefabrication housing production. *Automation in Construction*, 100, 46-60.

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## I.2 Marketing and Facility Management



**Property Price Indices (1999=100)**

Year	Less than 40 sq. m	40-69.9 sq. m	70-99.9 sq. m	Greater than 160 sq. m	All Classes
2000	100	100	100	100	100
2001	105	105	105	105	105
2002	100	100	100	100	100
2003	95	95	95	95	95
2004	105	105	105	105	105
2005	115	115	115	115	115
2006	130	130	130	130	130
2007	145	145	145	145	145
2008	180	180	180	180	180
2009	170	170	170	170	170
2010	220	220	220	220	220
2011	250	250	250	250	250
2012	280	280	280	280	280
2013	290	290	290	290	290
2014	300	300	300	300	300
2015	320	320	320	320	320
2016	340	340	340	340	340
2017	360	360	360	360	360
2018	400	400	400	400	400
2019	380	380	380	380	380
2020	360	360	360	360	360
2021	380	380	380	380	380
2022	350	350	350	350	350
2023	330	330	330	330	330
2024	280	280	280	280	280
2025	250	250	250	250	250

Source: Rating and Valuation Department

Geospatial Analysis in UD

- Pre-marketing
  - Market research, feasibility
  - Branding, pricing strategy
- Presale market 預售
  - Consent from gov.
  - Marketing
- Spot sale
  - Occupation permits, certificates
- Post-sales services
  - Land registration



## I.3 Conservation and renewal

- Heritages preserved/conserved

- E.g., HKU's several old buildings
- Tin Tin Car (叮叮車), Peak tram



Peak tram 1960s  
Geospatial Analysis in UD



2020s

- Renewal/redevelopment

- Pros
- Cons



→



→



Redevelopment before  
(Kwun Tong)

after

## I.3 Needs: Major themes and projects

- In Hong Kong

- Hong Kong Zhuhai Macao bridge
- Northern Metropolis
- Lantau Tomorrow
- Smart City 3.0
- Carbon Neutral@HK
- And more



北部都會區  
Northern Metropolis



12




**THE UNIVERSITY OF HONG KONG 香港大學**  
**faculty of architecture 建築學院** 
  
 Department of Real Estate and Construction  
 房地產及建築系

## I.3 Challenges

- Securing land and funds
  - Land supply shortage
  - High capital requirements
- Construction
  - Aging and shortage in labor force
  - Low productivity
  - High cost
- Marketing
  - Intense competition
  - FM: High-level service demand
- Conservation and renewal



Geospatial Analysis in UD


**THE UNIVERSITY OF HONG KONG 香港大學**  
**faculty of architecture 建築學院** 
  
 Department of Real Estate and Construction  
 房地產及建築系

## Summary and Opportunity

- Land Development
  - Project-scope, long cycle, lengthy and complex
  - Both Secondary and Third industries (第二 + 第三產業)
- Geospatial IT is useful
  - Collection, processing, management, analysis, and visualization of geospatial data (HKIS 2024)
  - Examples
    - Geographic Information Systems (GIS),
    - Remote sensing from satellites, planes, ground, phones,
    - BIM with 3D environment models
  - Resources
    - Digital map, 3D city model, buildings data



14



## After-class questions open to you

- In a land-scarce city like Hong Kong, how should policymakers **balance** between conservation, development, and community needs during land conversion?
- Think of a redevelopment project in your city—what **stages** did it go through? What challenges did it face?
- Who **benefits** and who **loses** in typical urban land conversions?



“When your city runs out of space...  
 time to get geospatial”



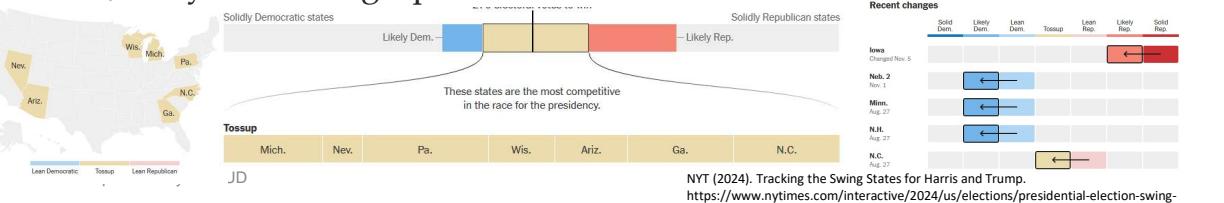
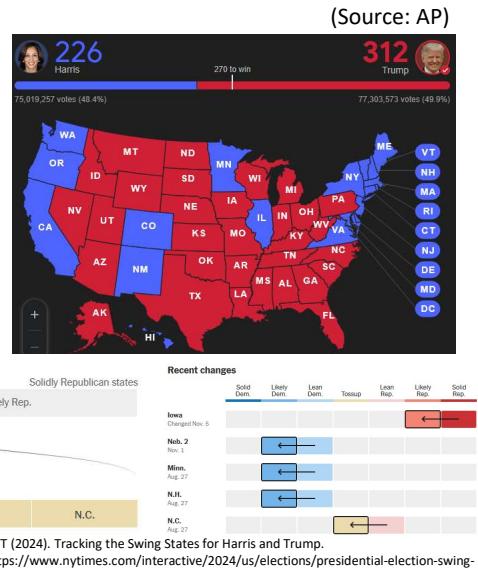
## Part II Geospatial analysis

(L1)



## II. Warming up

- Today, DJ Trump swears in as US's 47<sup>th</sup> president (mid-night HK time)
    - After winning the election against K Harris
    - Including all 7 “swing states”
  - Countered many predictions
    - E.g., the NYT’s November 5th’s swing-states-based prediction.
  - Q: Why are tossing-up states so vital?



## II. What is information

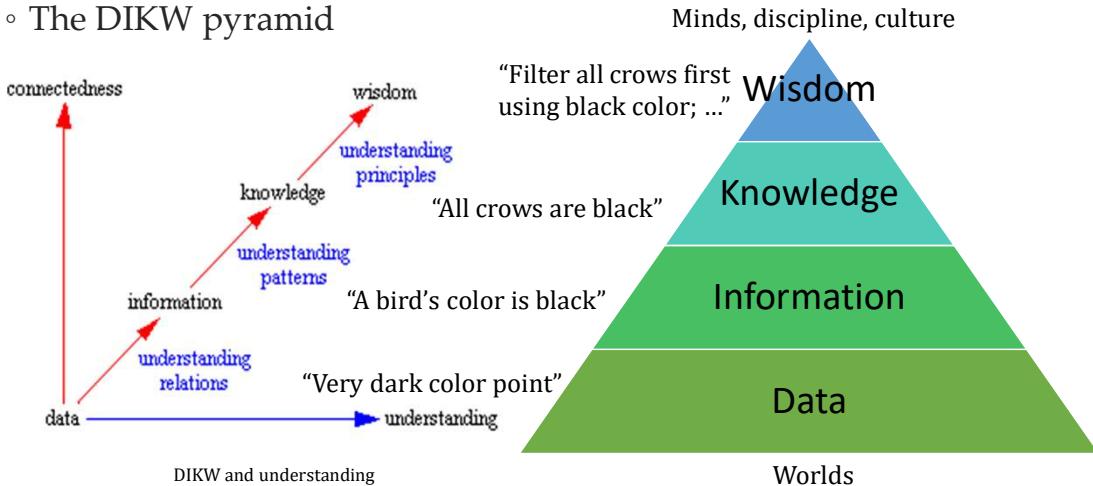
- Definition
    - Information is the resolution of uncertainty (Tentative)
  - Three features
  - 1 Associated with data and knowledge
    - I.e., involving numeric values and ontology
  - 2 Answering questions “Is it ...?” or “What is ...?”
    - How many questions? How much information
  - 3 Can be coded

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建設系

## II.1 Data, information, or knowledge?

- The DIKW pyramid



The diagram illustrates the DIKW pyramid, a conceptual model for understanding data. It consists of four levels arranged vertically:

- Wisdom** (top): "Filter all crows first using black color; ..."
- Knowledge**: "All crows are black"
- Information**: "A bird's color is black"
- Data** (bottom): "Very dark color point"

Arrows indicate the flow from Data to Knowledge, and from Knowledge to Wisdom. The arrow from Data to Knowledge is labeled "understanding relations". The arrow from Knowledge to Wisdom is labeled "understanding principles". A vertical red arrow on the left is labeled "connectedness". A horizontal blue arrow at the bottom is labeled "understanding".

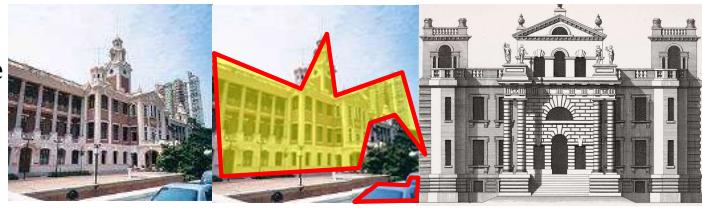
DKIW and understanding  
Geospatial Analysis in UD (Source: system-thinking.org; Author: Bellinger et al.)

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建設系

## II.1 An example of campus photo

- Data
  - RGB pixels (a lot of) with noise
- Information
  - Buildings, two cars, trees
- Knowledge
  - An Edward Baroque building
  - Campus age
  - Cultural background
  - Cultural heritage
  - Has features like ...
- Wisdom
  - Worthy for a conservation



Data: Digital pixels (0~255 R, G, B)  
Information: Car, building, tree, ...  
Knowledge: Baroque building, rough campus ages, historical background, ...

49 49 99 40 17 81 18 57 60 87  
61 49 31 73 55 79 14 29 93 71  
52 70 95 23 04 60 11 42 49 24  
22 31 16 71 51 67 63 89 41 92  
24 47 32 60 99 03 45 02 14 75  
32 98 61 28 64 23 67 10 26 38  
67 26 20 68 02 62 12 20 98 63  
24 95 50 05 66 73 99 26 97 37

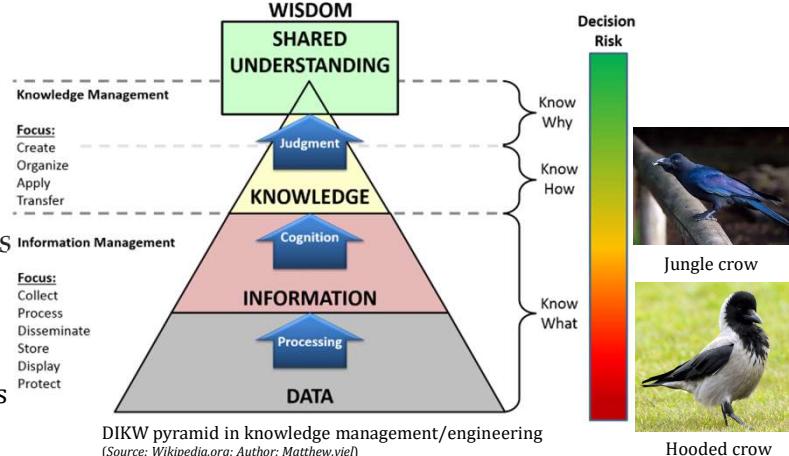
Geospatial Analysis in UD



## II.1 Data, information, or knowledge? (cont.)

- KM/KE perspective
- Focuses
  - Lower level → higher
- Uncertainty and risks
  - Higher → lower
  - “Not all crows ...”
- Why geospatial analysis in urban development
  - Less **risk**
  - more **info** & **knowledge**
  - About location and objects

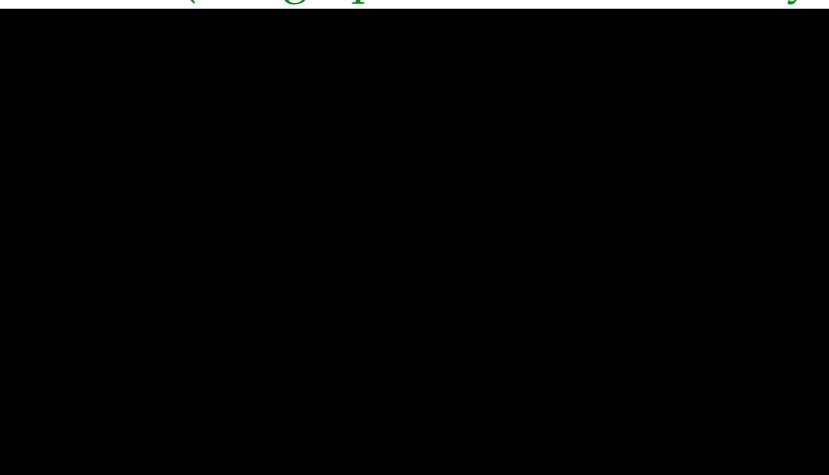
**Knowledge Management Cognitive Pyramid**



Geospatial Analysis in UD



## II.2 GIS (Geographical Information System)



Geospatial Analysis in UD

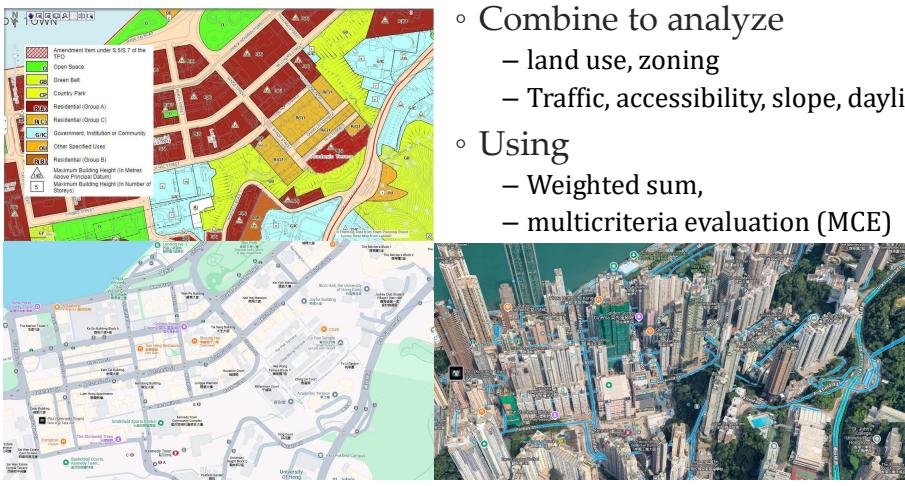
Esri's definition of GIS  
(Source: <https://www.youtube.com/watch?v=ZFmAAHBjOU>; Author: Esri)

- Esri's view
  - Geoinformation **decision-making** tools
  - Not only map
- Many datasets
  - In same coordinates
  - Calibrated
- And many analysis tools

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## II.2 Site suitability analysis in GIS



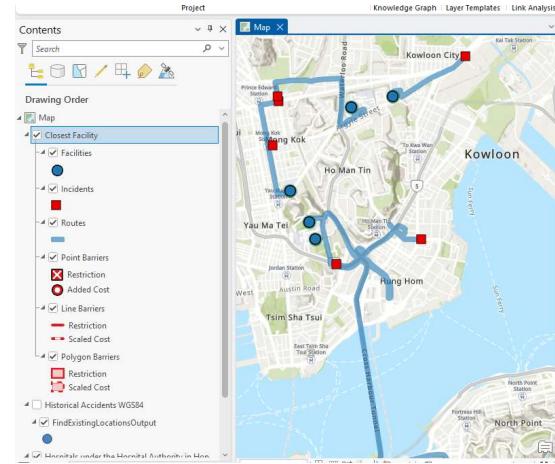
Geospatial Analysis in UD

- Combine to analyze
  - land use, zoning
  - Traffic, accessibility, slope, daylight, sea view
- Using
  - Weighted sum,
  - multicriteria evaluation (MCE)

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## II.2 Proximity/Accessibility Analysis

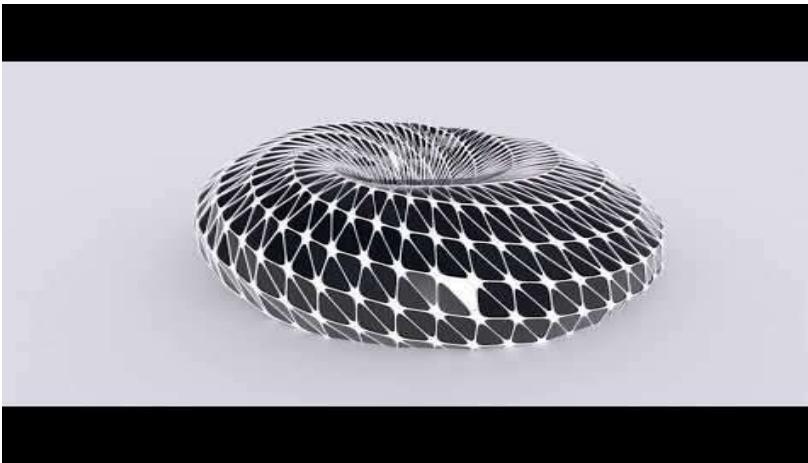


- Nearest facilities
  - MTR/bus stations
  - Hospitals, wet market
  - Sea side, park
- HKU café accessibility
- Urban vegetation management
  - Watering
  - Services, etc.
- Etc.

Geospatial Analysis in UD



## II.2 BIM (building information modeling)



- Evolution from 1960s to present
- Autodesk's view
- BIM is a
  - Digital process transformation &
  - Shared knowledge database for decision making
- Difference with GIS: sale, objects

Autodesk's BIM  
(Source: <https://www.youtube.com/watch?v=gsm15cawHbY>; Author: Autodesk)



## II.2 3D surveying bridging the two

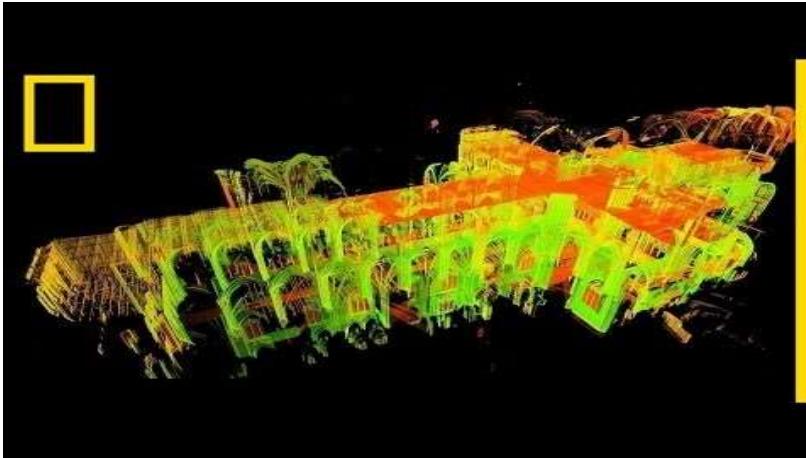
- Site survey
  - Inspection of property's condition
  - For identifying risks and possible expenditure
  - E.g., for progress, building quality, appropriate retrofitting, or maintenance
- Challenges in
  - Time
  - Complex geometry, conditions
  - Weather, season
  - Matter of as-built



Geospatial Analysis in UD



## II.2 Laser scanning



Laser Scanning (total station)

Geospatial Analysis in (Source: <https://www.youtube.com/watch?v=jAi29udFMKw>; Author: National Geographic)

- Laser scanning on a tripod
  - Accurate
  - Dense
  - 3D
- Cons
  - No color
  - Low information
  - Need registration one by one sphere cloud
  - Still time-consuming



## II.2 Laser scanning



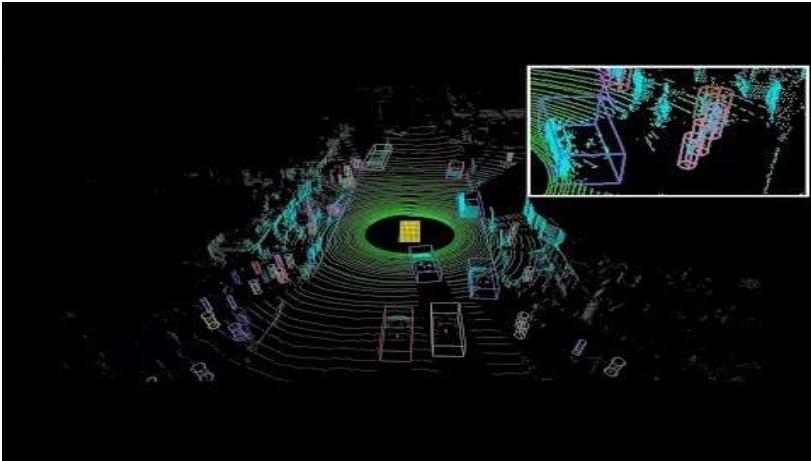
Laser Scanning (hand-held)

Geospatial Analysis in (Source: <https://www.youtube.com/watch?v=L2lvXb7uTUQ>; Author: Sensor Canvas)

- Mobile laser (LiDAR + cam) scanning
  - Fast
  - Accurate
  - Versatile
  - Colorful
  - No registration required
- Cons
  - Low information
  - Huge size



## II.2 Laser scanning (extension)



Laser Scanning (auto vehicle)  
Geospatial Analysis in (Source: <https://www.youtube.com/watch?v=T7w-ZCVVUgM>; Author: NVIDIA)

- 3D sensing and understanding
  - Not only for construction
  - Also auto cars
  - Deserves a bright future



## II.2 Positioning



BLE based indoor positioning  
Geospatial Analysis in (Source: <https://www.youtube.com/watch?v=cnjDWUwtD3w>; Author: RICAL lab at Georgia Tech)

- GPS is great
- Indoor is vital, too
  - Wifi
  - BLE (Bluetooth low energy)
  - UWB (Ultra-wideband)
  - LiFi
  - SLAM (simultaneous localization and mapping), the mobile case
  - 3D space network



## II.2 UAV (drones)



- UAV
  - Unmanned aerial vehicle
- Photogrammetry
  - Camera photos
  - Triangulated by key feature points
  - Example: HKU campus (2019)
- Or LiDAR
  - Laser point clouds
  - Registered on-the-fly



## II.2 UAV (drones)



- Photos triangulated
  - Camera poses
  - Key points
- 3D point cloud
- Then, semi-automatic work
  - Fully auto in future ?
- 3D model done

Drone scanning, to as-built 3D model  
Geospatial Analysis in Source: <https://www.youtube.com/watch?v=OdGcNWZ3vaA>; Author: scanways



## II.3 Summary and after-class questions

- Geospatial analysis
  - For decision making, with less risks and more knowledge
  - GIS and BIM focused on urban/buildings scales
- Qs:
  - What are the main differences and similarities between GIS and BIM?
  - How would you use GIS to choose the best location for a new housing development?
  - What are the benefits of integrating GIS and BIM in a smart city or urban redevelopment project?
  - Imagine a future city in 2035. How could geospatial analysis in GIS and BIM help make it smarter, greener, and more livable?



Geospatial Analysis in UD



## Part III A Taste of ArcGIS (L3)

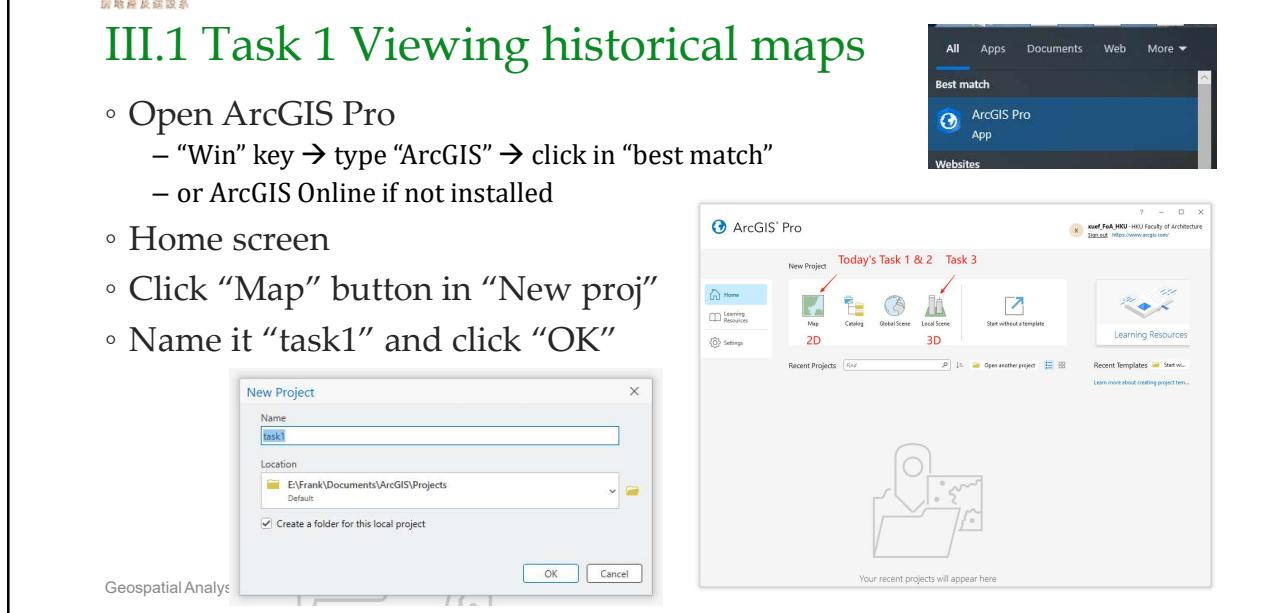
Geospatial Analysis in UD

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## III.1 Task 1 Viewing historical maps

- Open ArcGIS Pro
  - “Win” key → type “ArcGIS” → click in “best match”
  - or ArcGIS Online if not installed
- Home screen
- Click “Map” button in “New proj”
- Name it “task1” and click “OK”



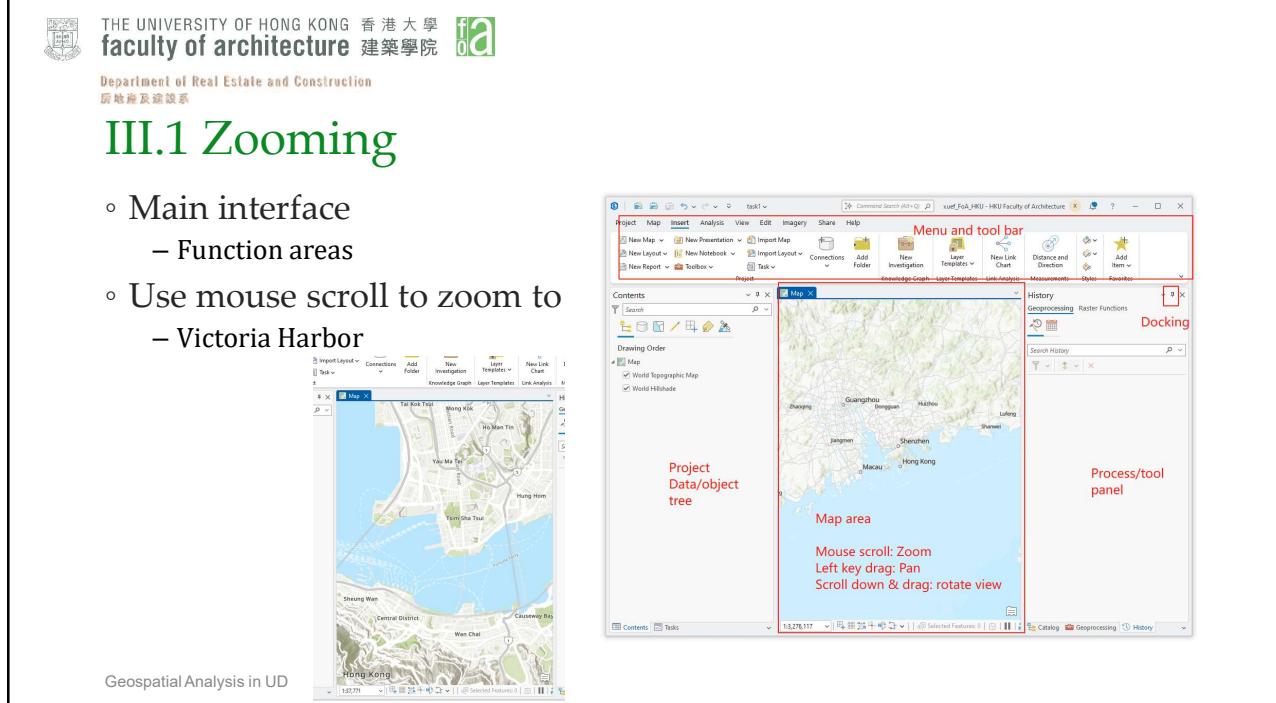
The screenshot shows the ArcGIS Pro application window. On the left, a 'New Project' dialog box is open, prompting for a project name ('task1') and location ('E:\Frank\Documents\ArcGIS\Projects'). On the right, the main ArcGIS Pro interface is visible, featuring a 'Home' tab and various project creation options like 'Map', 'Catalog', 'Global Scene', 'Local Scene', and '3D'. A red arrow points to the 'Map' button. The status bar at the bottom indicates 'Geospatial Analysis'.

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## III.1 Zooming

- Main interface
  - Function areas
- Use mouse scroll to zoom to
  - Victoria Harbor



The screenshot displays the ArcGIS Pro workspace. A map of Hong Kong is centered on Victoria Harbor. Several interface components are highlighted with red boxes: the 'Project Data/object tree' on the left, the 'Map area' in the center, and the 'Process/tool panel' on the right. A callout box in the bottom right corner provides instructions: 'Mouse scroll: Zoom', 'Left key drag: Pan', and 'Scroll down & drag: rotate view'.

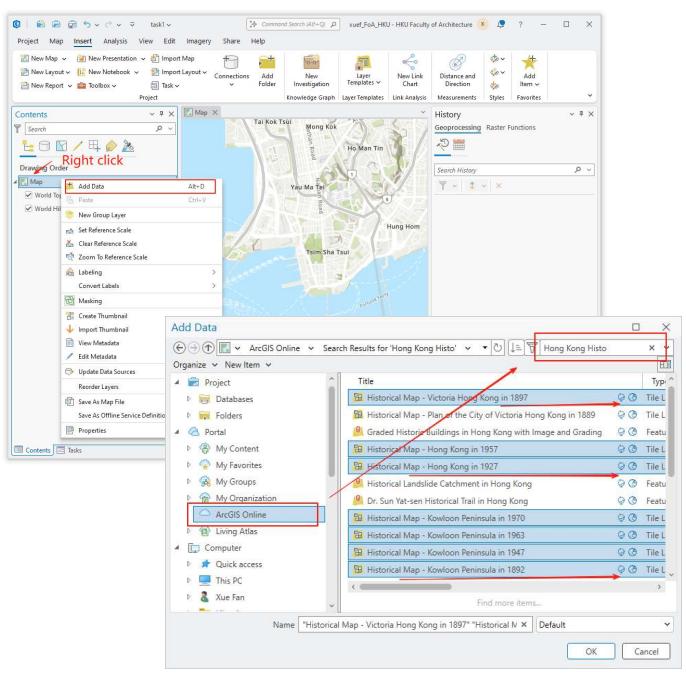
THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## III.1 Add more data

- Right click “Map”
- Add Data
  - Select “ArcGIS Online”
  - Type “Hong Kong histo” in filter
  - “Ctrl” + mouse select 7 maps in
    - 1897
    - 1957
    - 1927
    - 1970
    - 1963
    - 1947
    - 1892
- Cheers. Wait for loading

Geospatial Analysis in UD



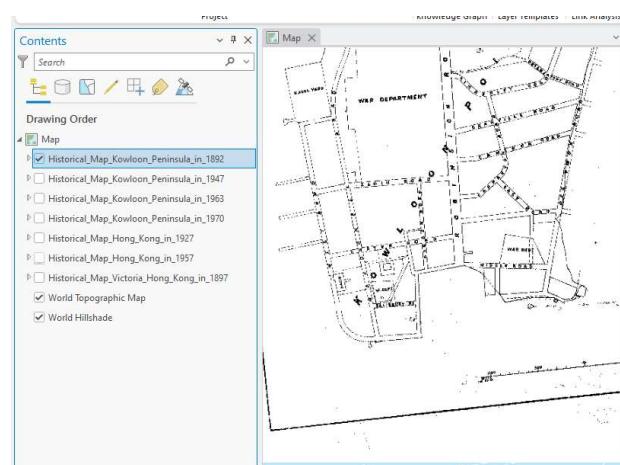
THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## III.1 Exploring by selecting maps to view

- What was Kowloon like
  - In 1892?
  - Why the name *Tsim Sha Tsui* (尖沙咀) indicates 尖(sharp) & 咀(mouth)
  - But today it is not sharp and mouth like
- How about the land reclamation areas in HK and Kowloon?
  - Find your evidence
- More open topics for you

Geospatial Analysis in UD

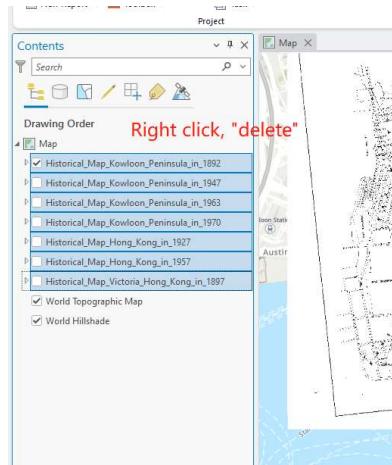


THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## III.1 Remove data and maps

- Select
- Right click
- Click “Remove” the historical maps
  - From project tree



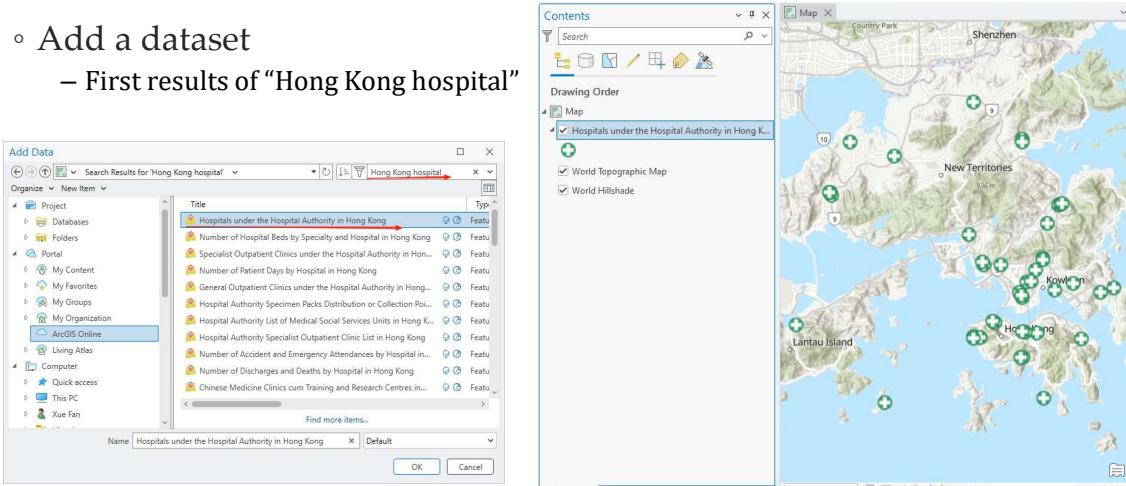
Geospatial Analysis in UD

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## III. Task 2. Network analysis

- Add a dataset
  - First results of “Hong Kong hospital”



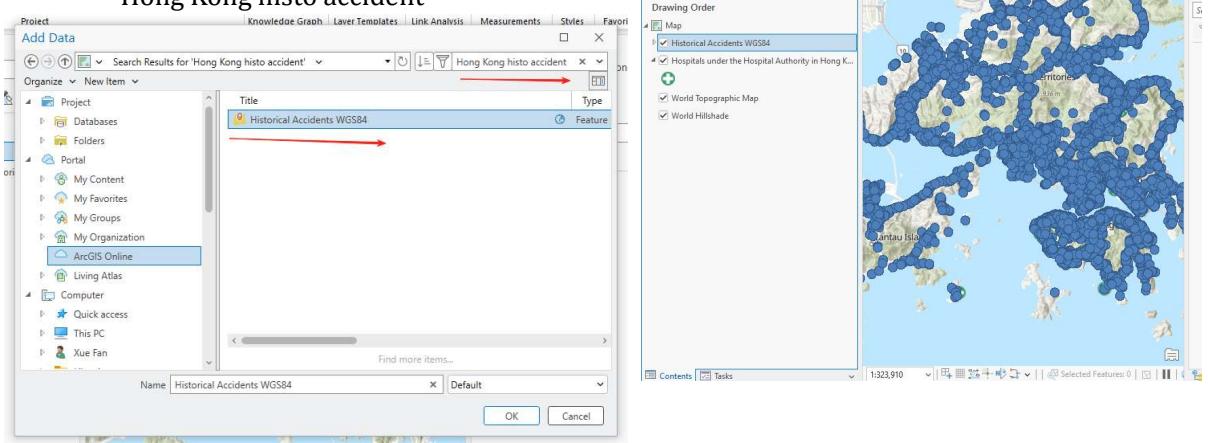
Geospatial Analysis in UD

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## III.2 Add data

- Add the result data of
  - “Hong Kong histo accident”



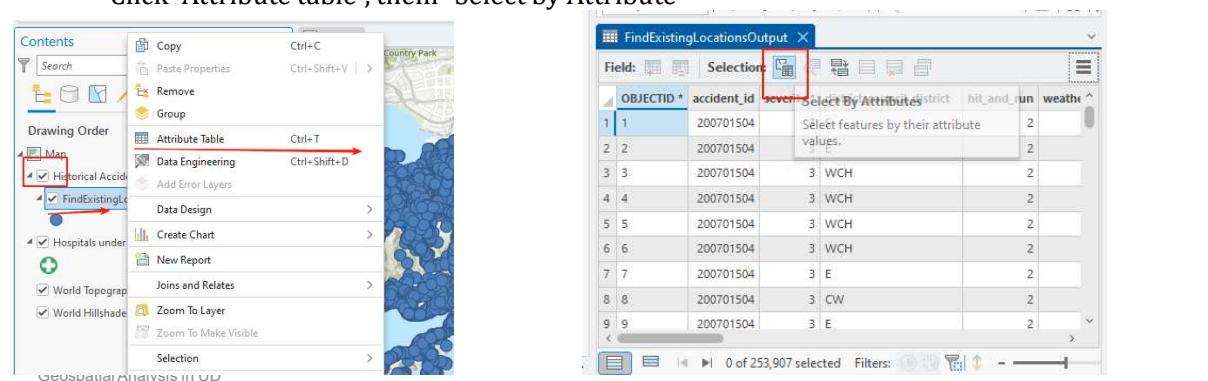
The screenshot shows the 'Add Data' dialog in ArcGIS Pro. In the 'Title' field, 'Historical Accidents WGS84' is entered. The 'Type' dropdown is set to 'Feature'. The 'Drawing Order' pane shows 'Historical Accidents WGS84' is checked. On the right, a map of Hong Kong displays a dense cluster of blue circular features representing historical accidents. The map includes labels for 'Country Park', 'Shenzhen', 'Lantau Island', and 'Hong Kong Island'.

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## III.2 Select a few sample from data

- Too many accidents!
- Select data in “Historical ...”
  - Click “Attribute table”, them “Select by Attribute”



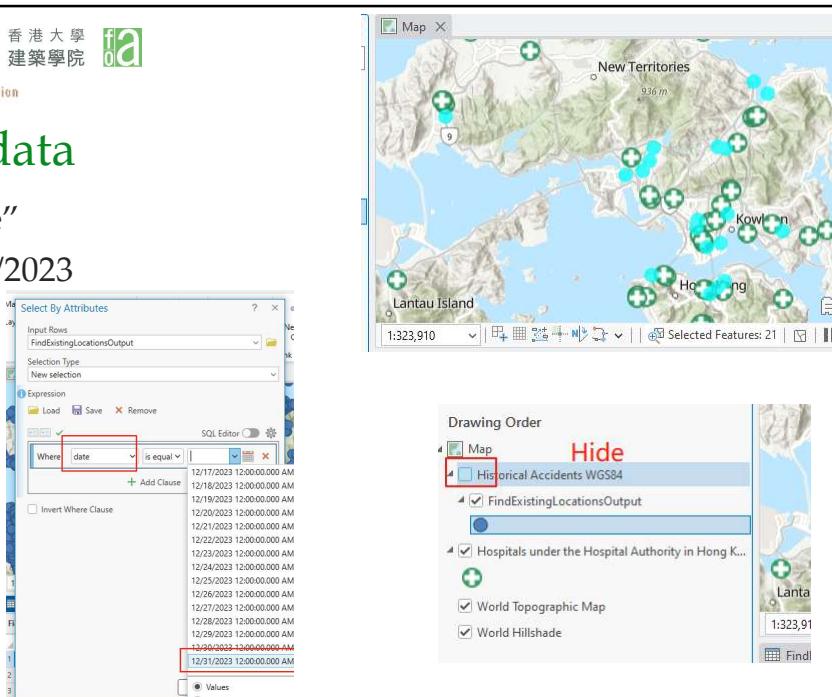
The screenshot shows the 'FindExistingLocationsOutput' attribute table in ArcGIS Pro. The 'Selection' tool icon is highlighted with a red box. The table lists 9 rows of data, each with an OBJECTID, accident\_id, search, select\_by\_attributes, hit\_and\_un, and weather values. The first row has accident\_id 200701504 and select\_by\_attributes value 'values.'.

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## III.2 Select data

- Filter by “Date”
- Equal to 12/31/2023
- Hide all

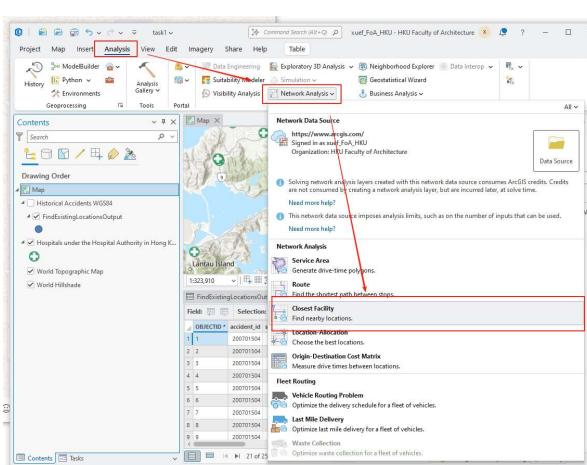
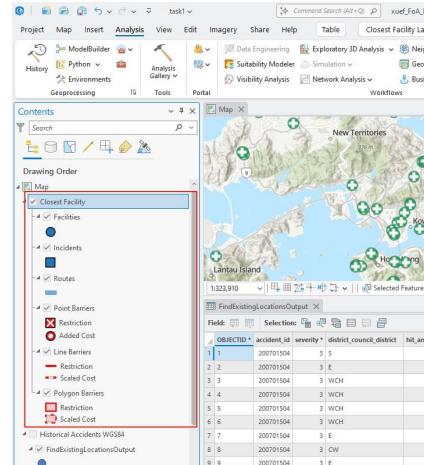


Geospatial Analysis in UD

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## III.2 Network – closest facility

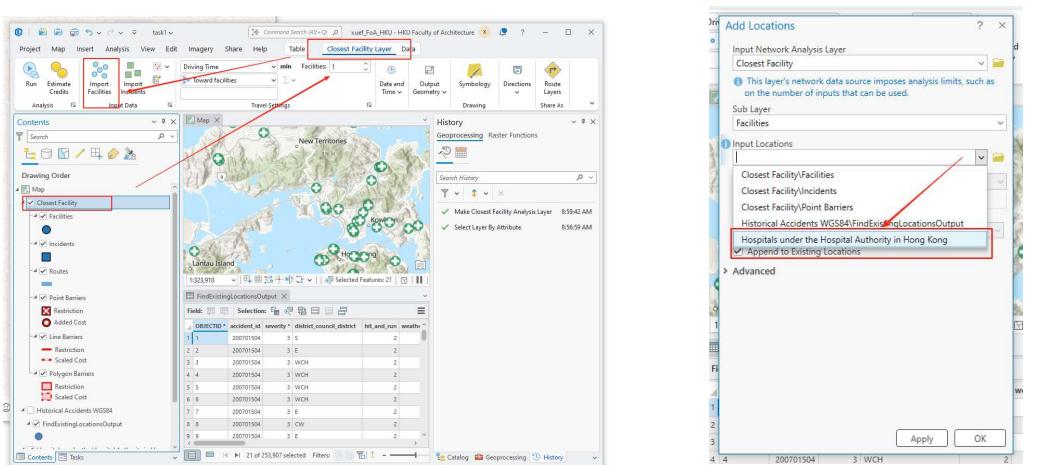



Geospatial Analysis in UD

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建設系

## III.2 Add facility

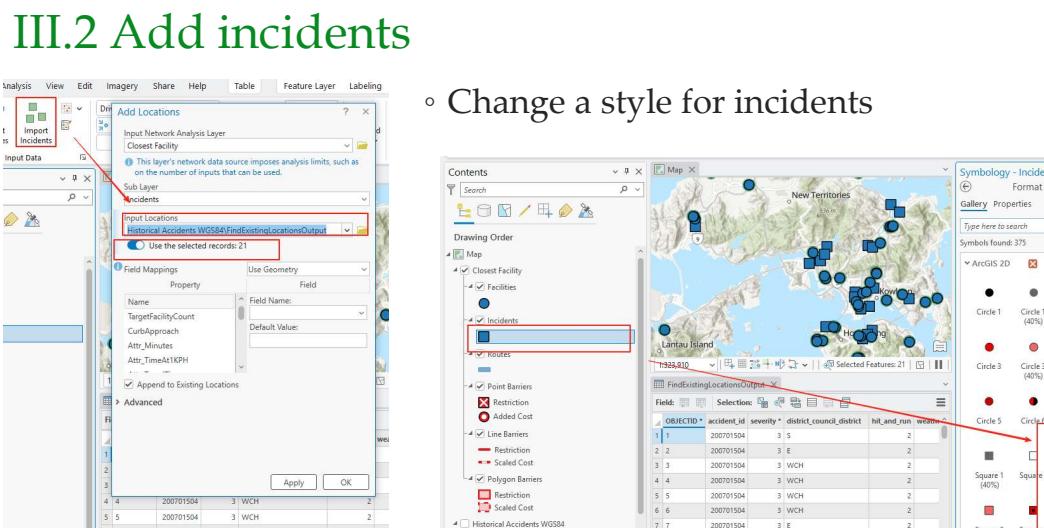


Geospatial Analysis in UD

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建設系

## III.2 Add incidents



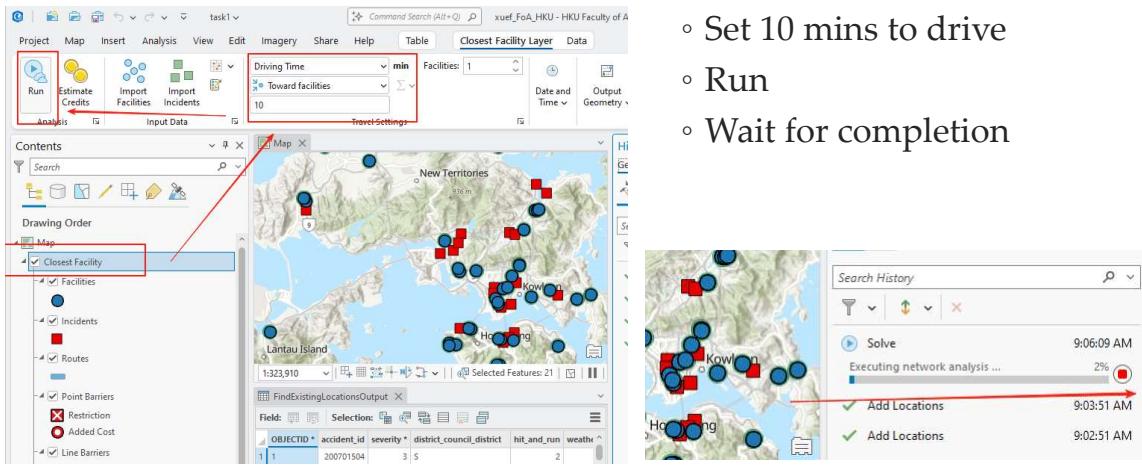
- Change a style for incidents

Geospatial Analysis in UD

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## III.2 Analyze



Geospatial Analysis in UD

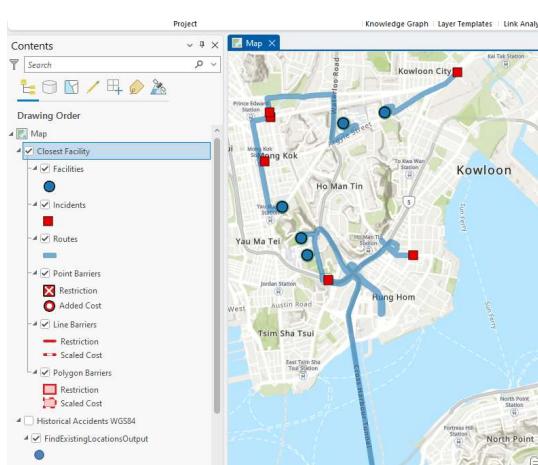
- Set 10 mins to drive
- Run
- Wait for completion

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

## III.2 Network analysis

- Well done!
- Pleased to know every incident could arrive a hospital in <10 mins
- Think about:
  - What if the time is >10 or >30 mins?
  - What applications in housings and urban development can use this analysis?



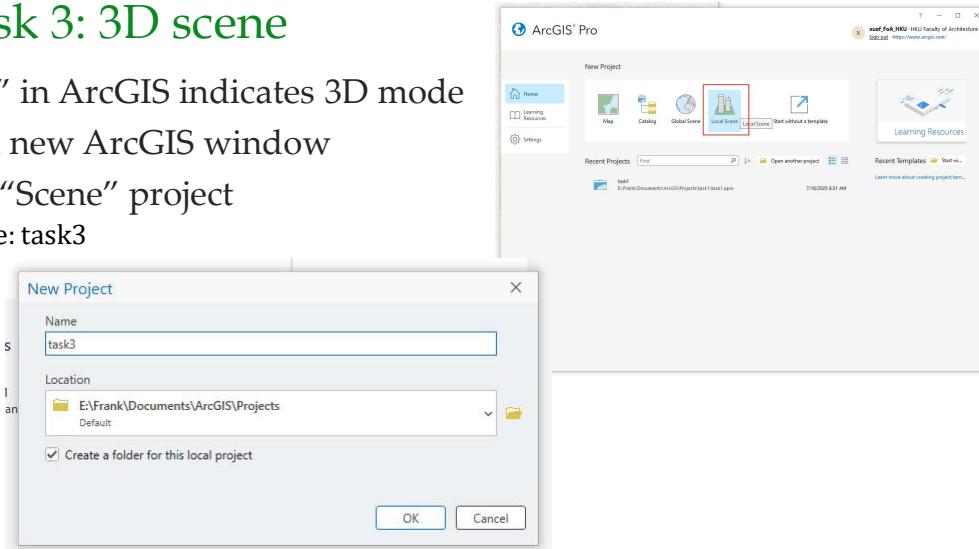
Geospatial Analysis in UD

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

### III. Task 3: 3D scene

- “Scene” in ArcGIS indicates 3D mode
- Open a new ArcGIS window
- Create “Scene” project
  - Name: task3



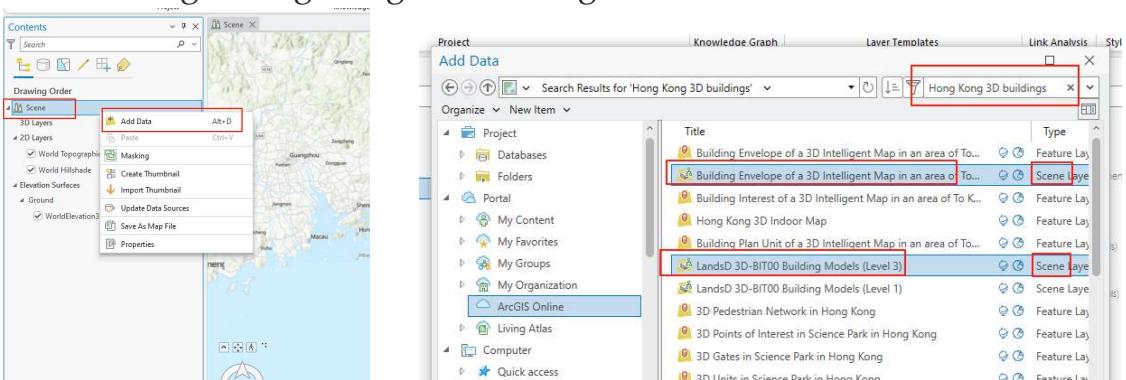
Geospatial Analysis in UD

THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

### III.3

- Add data
- Add using “Hong Kong 3D buildings”

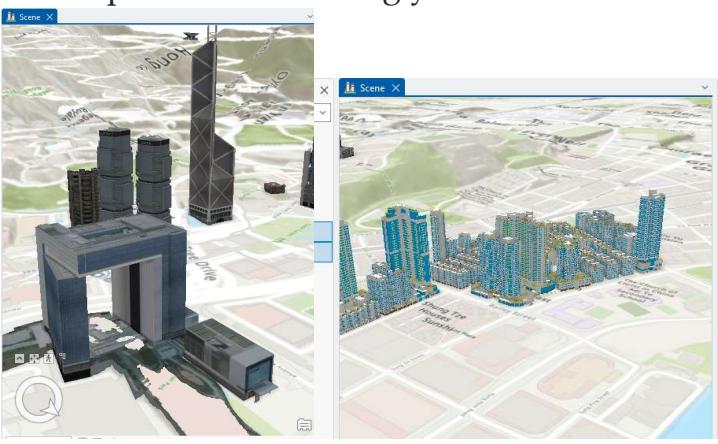


THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

### III.3 3D views

- Explore around using your mouse control



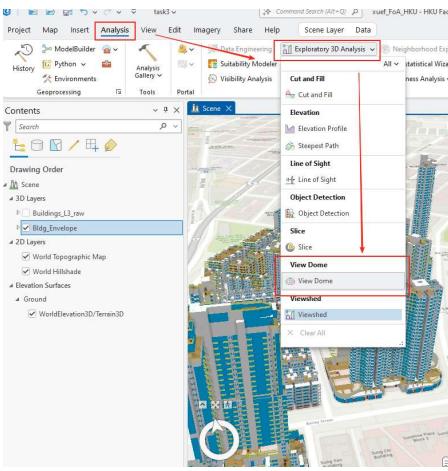

Geospatial Analysis in UD

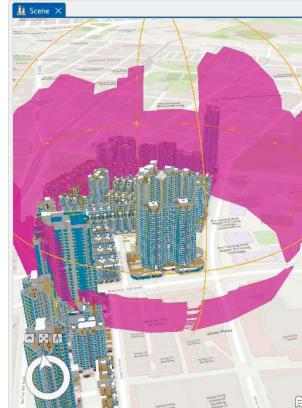
THE UNIVERSITY OF HONG KONG 香港大學  
faculty of architecture 建築學院 

Department of Real Estate and Construction  
房地產及建築系

### III.3 Very simple view dome/shed analysis

- From low-level window, high-level





Geospatial Analysis in UD



### III.4 Summary and after-class thinking

- Well done!
- 3 tasks
  - Viewing
  - 2D geospatial analysis
  - 3D geospatial analysis
- Questions to discuss with your friends:
  - How does 2D analysis help in identifying patterns such as **density, proximity, or accessibility?**
  - In what types of projects is **3D analysis** more appropriate or necessary than 2D? (say, Road, buildings, tunnels, etc.)
  - What factors do you need to consider when creating maps or 3D models intended for public presentations or reports?

Geospatial Analysis in UD



REC Summer Programme

Keep awesome !