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REC Summer Programme

Geospatial Analysis in Land Development

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Department of Real Estate and Construction
The University of Hong Kong
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Open office hour: 9:30-10:30 am, Fridays

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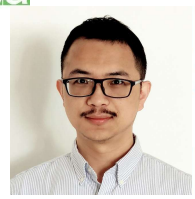
About me



- 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

- 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.

ESI Top 1% Researcher
World Top 2% Scientist

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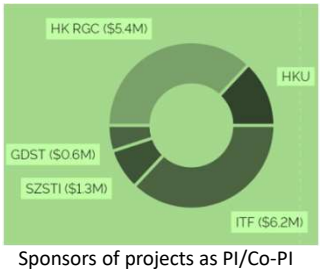
Frank's research projects

- 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?

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



Sponsors of projects as PI/Co-PI

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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)

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Part I Introduction to Land Development

(L1)

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I. Urbanization, a global trend

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

A

B

Scan or click to join

Chance to win a gift!

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I. Urban Development Cycle

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

7 Harbor 1960s 2020s

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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

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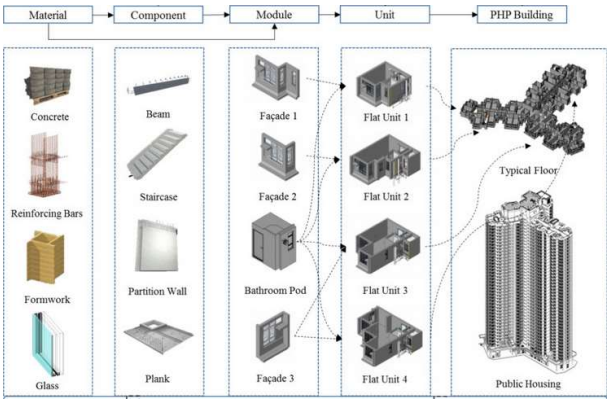
I.2 Construction stage

(Source: HK Housing Society)

- 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

- Prefabricated construction tech. 模塊化



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

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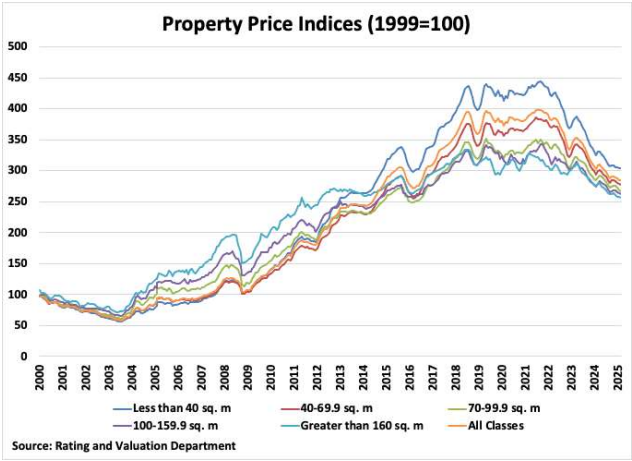
I.2 Marketing and Facility Management



- 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

Geospatial Analysis in UD

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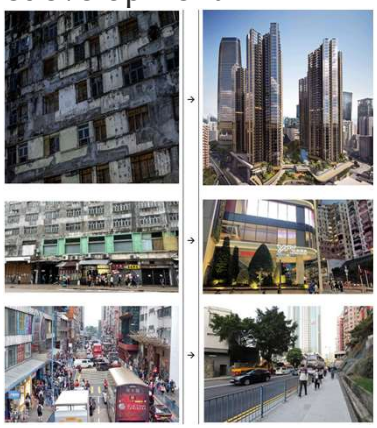
I.3 Conservation and renewal

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

Peak tram 1960s 2020s

- Renewal/redevelopment
  - Pros
  - Cons



Redevelopment (Kwun Tong) before after

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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

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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

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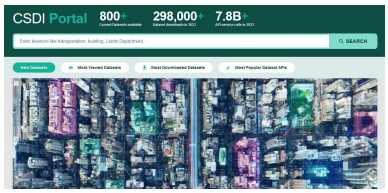
Summary and Opportunity

- Land Development
  - Project-scope, long cycle, lengthy and complex
  - Both Secondary and Third industries (第二 + 第三产业)
- 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



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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"

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Part II
Geospatial analysis

(L1)

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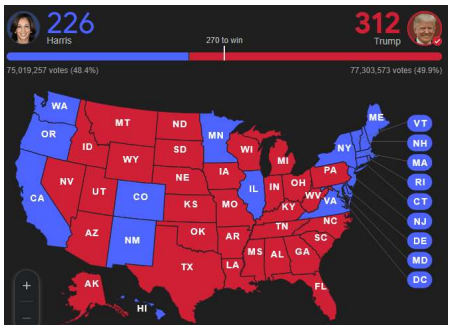
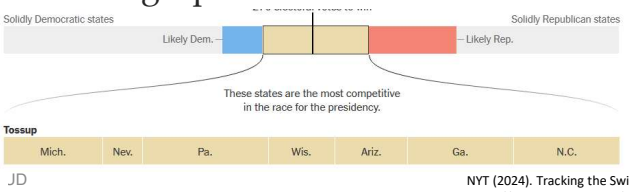
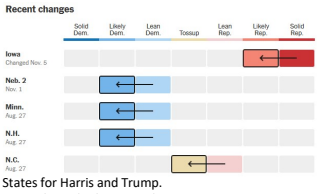
II. Warming up

- Today, DJ Trump swears in as US's 47th 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?

(Source: AP)







JD

NYT (2024). Tracking the Swing States for Harris and Trump. https://www.nytimes.com/interactive/2024/us/elections/presidential-election-swing-

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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

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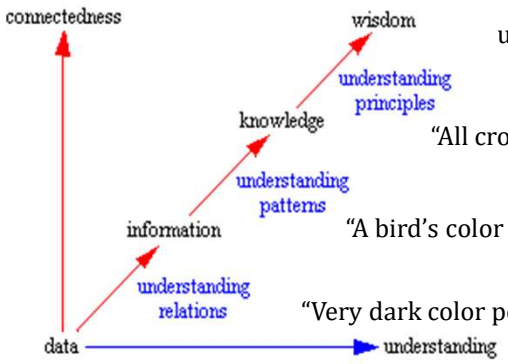
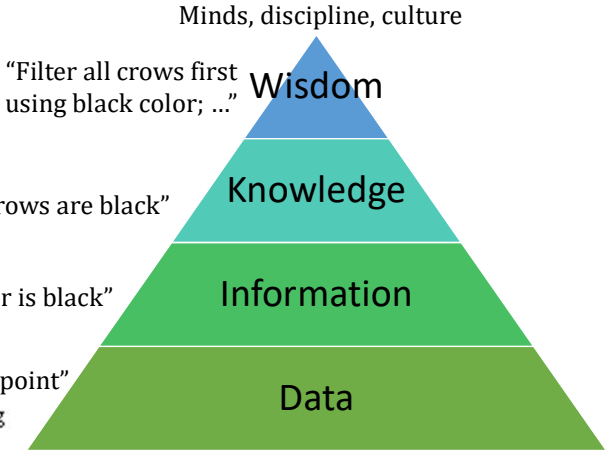
II.1 Data, information, or knowledge?

- The DIKW pyramid



DIKW and understanding
(Source: system-thinking.org; Author: Bellinger et al.)



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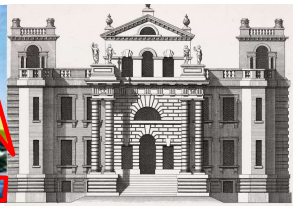
II.1 An example of campus photo

- 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, ...

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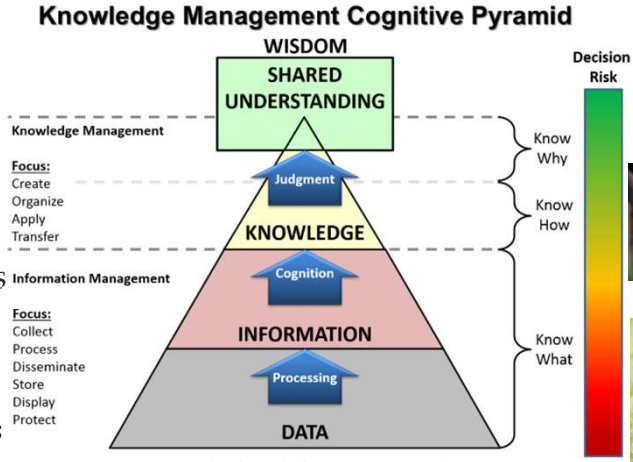
II.1 Data, information, or knowledge? (cont.)

- 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



DIKW pyramid in knowledge management/engineering
(*Source: Wikipedia.org; Author: Matthew.viel*)

Jungle crow

Hooded crow

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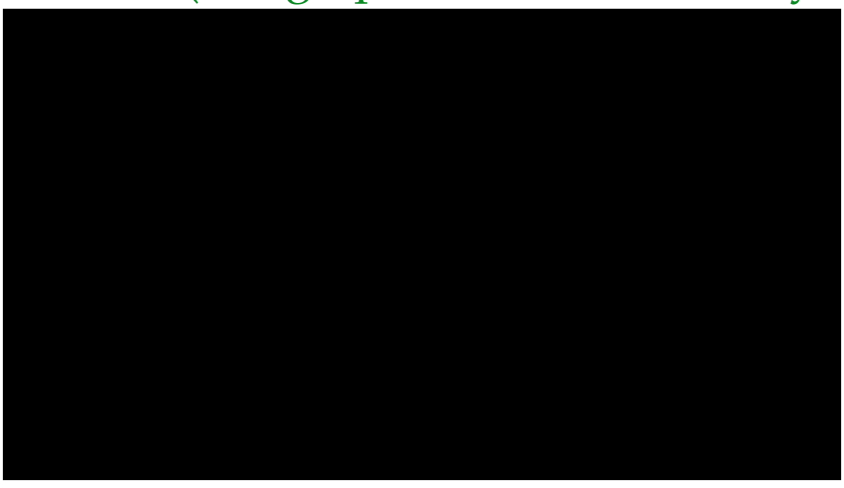
II.2 GIS (Geographical Information System)



Esri's definition of GIS
(*Source: https://www.youtube.com/watch?v=-ZFmAAHBfOU; Author: Esri*)

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

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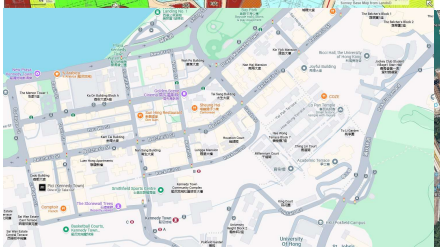
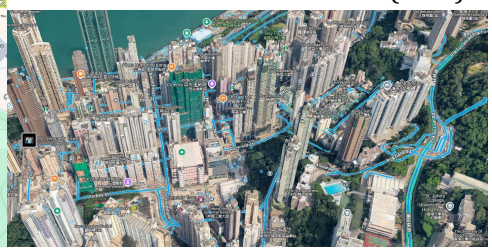
II.2 Site suitability analysis in GIS





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

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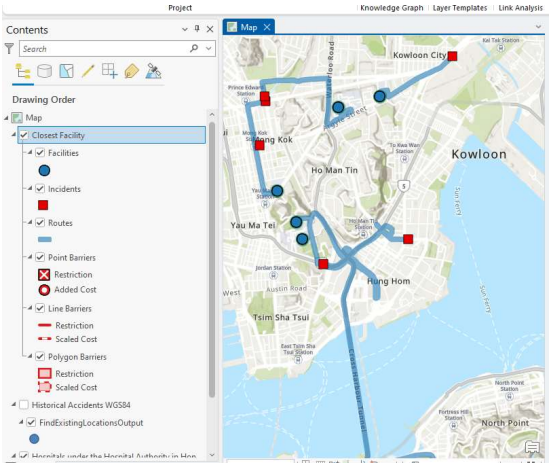
II.2 Proximity/Accessibility Analysis

- 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

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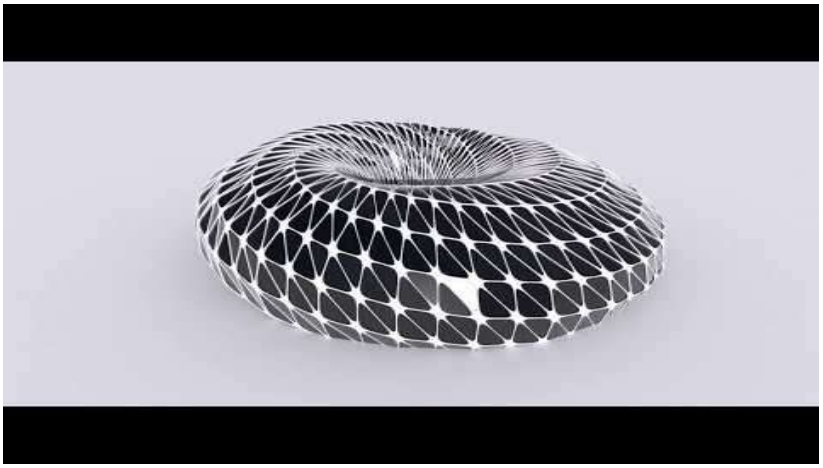
II.2 BIM (building information modeling)



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

- 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

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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

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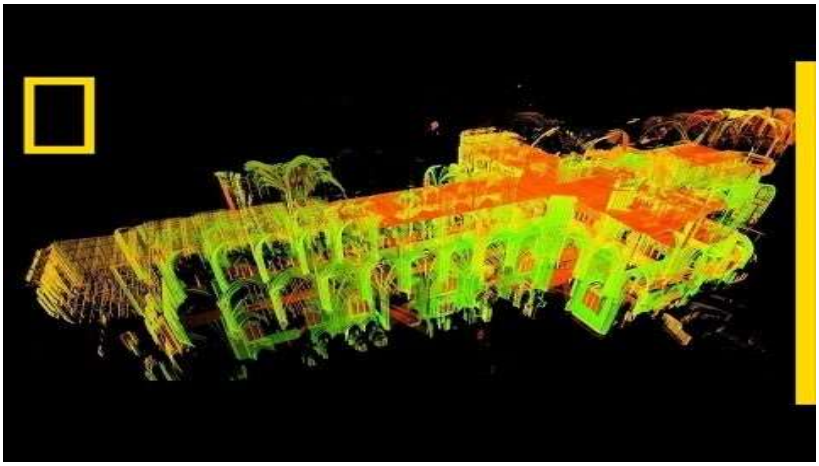
II.2 Laser scanning



Laser Scanning (total station)
(*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

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II.2 Laser scanning

Laser Scanning (hand-held)
(*Source: https://www.youtube.com/watch?v=L2IvXb7uTUQ; Author: Sensor Canvas*)

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

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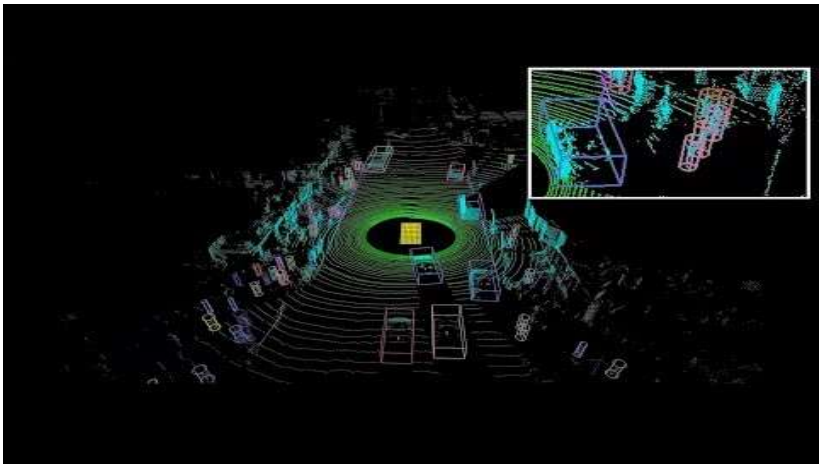
II.2 Laser scanning (extension)



Laser Scanning (auto vehicle)
(*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

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II.2 Positioning

BLE based indoor positioning
(*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

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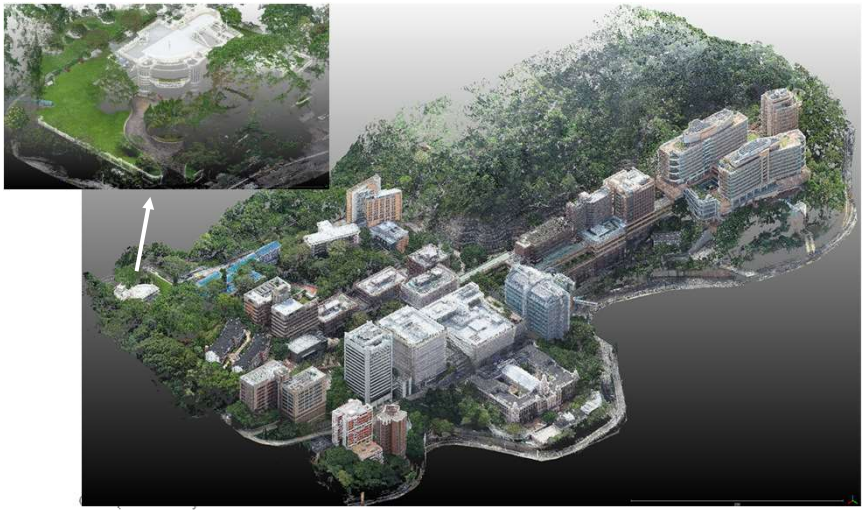
II.2 UAV (drones)



- 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

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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
(*Source: https://www.youtube.com/watch?v=0dGcNWZ3vaA; Author: scanways*)

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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?

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Part III
A Taste of ArcGIS

(L3)

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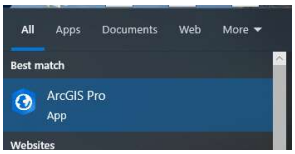
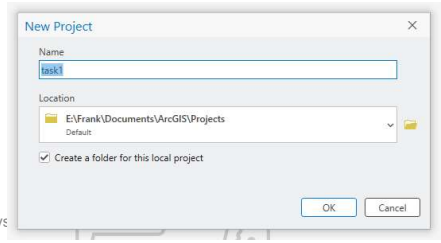
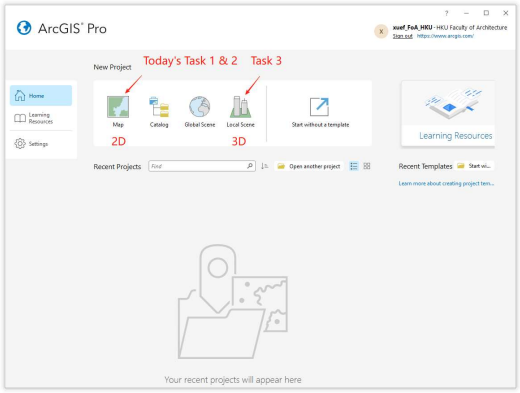
III.1 Task 1 Viewing historical maps



- 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"





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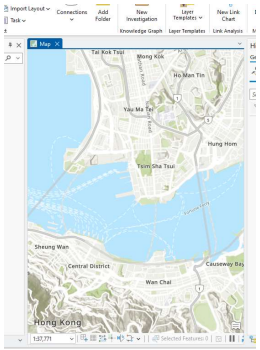
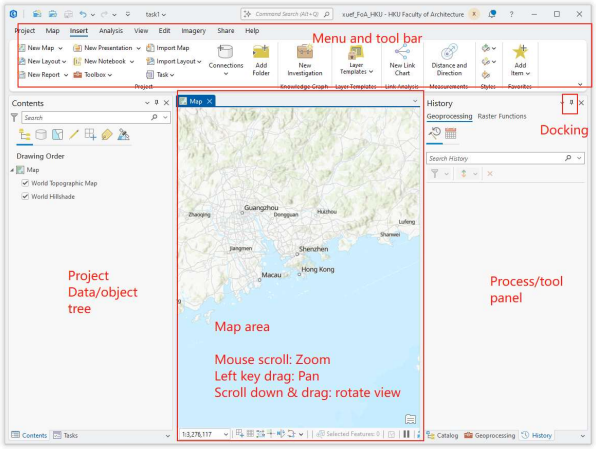
III.1 Zooming

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





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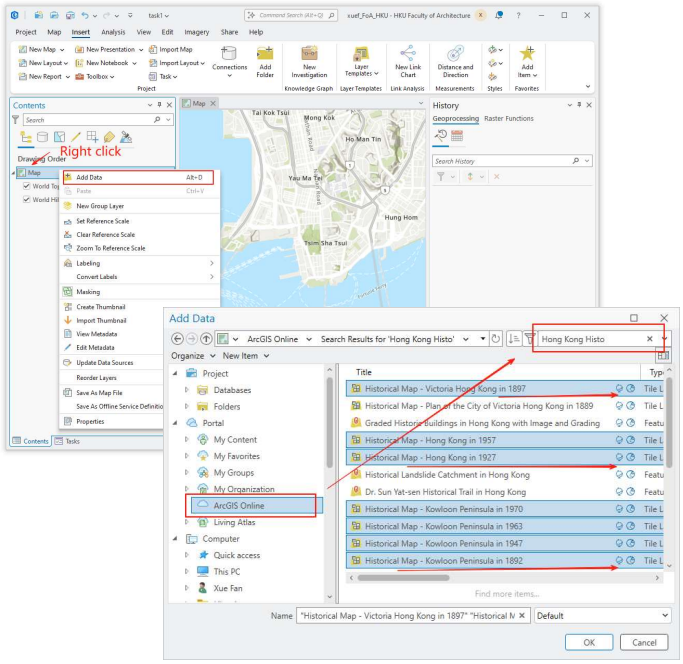
III.1 Add more data

- 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



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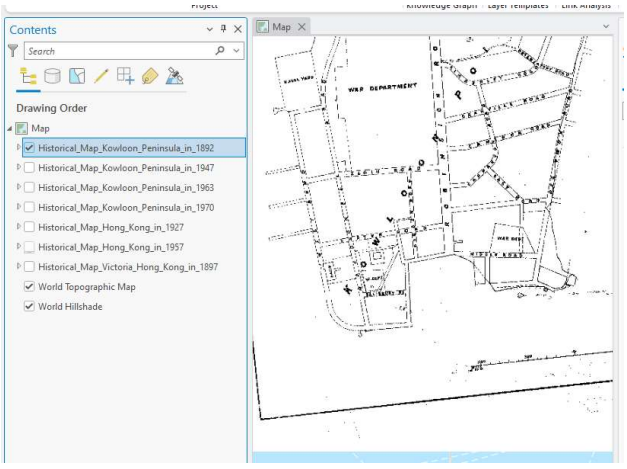
III.1 Exploring by selecting maps to view

- 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



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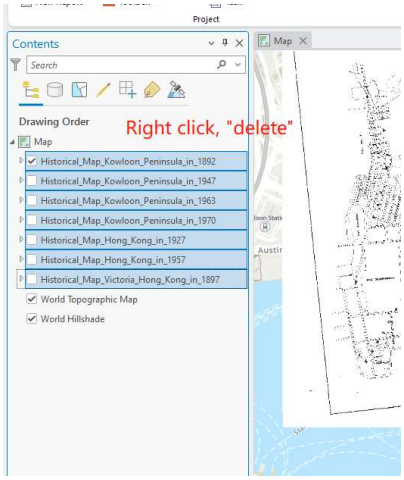
III.1 Remove data and maps

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



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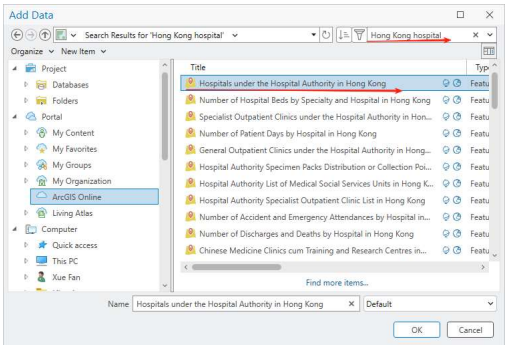
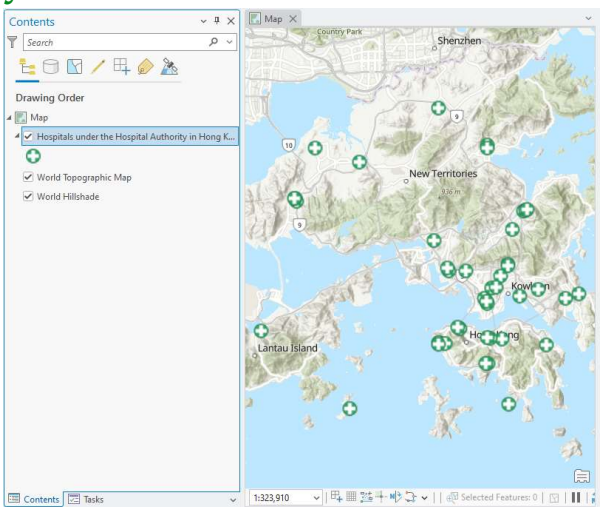
III. Task 2. Network analysis

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





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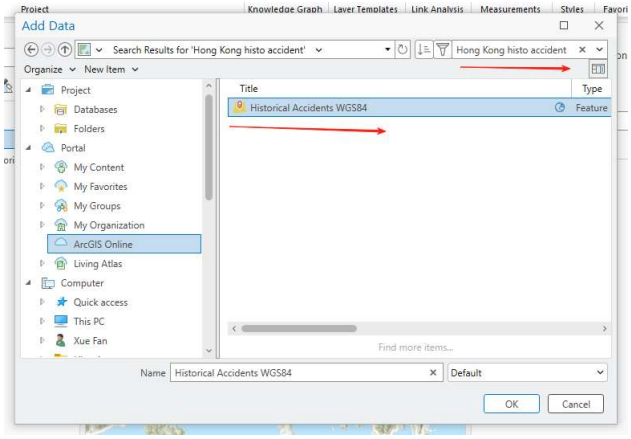
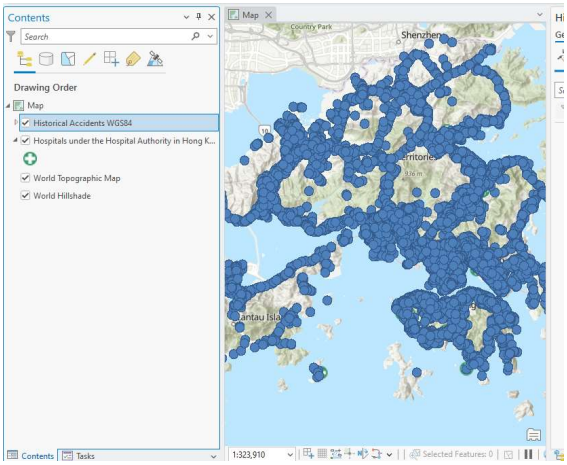
III.2 Add data

- Add the result data of
  - "Hong Kong histo accident"





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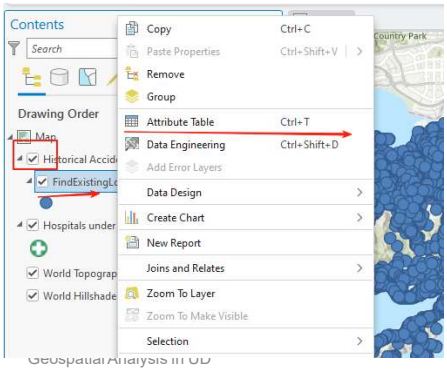
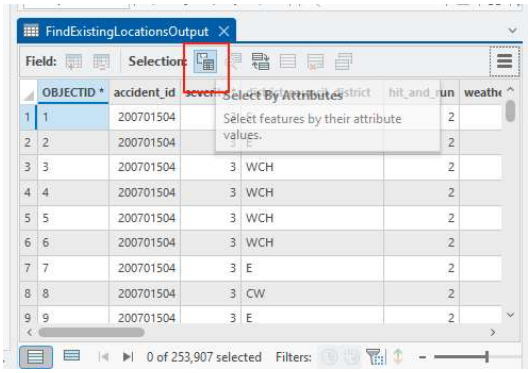
III.2 Select a few sample from data

- Too many accidents!
- Select data in "Historical …"
  - Click "Attribute table", them "Select by Attribute"





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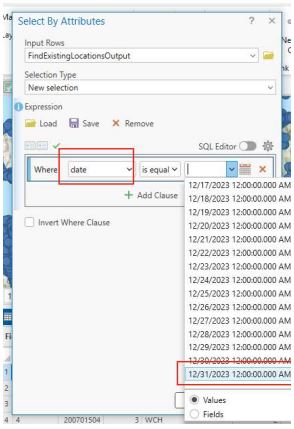
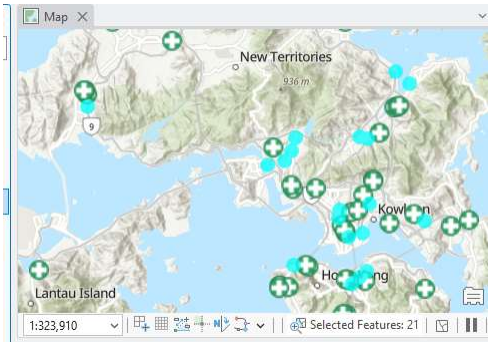
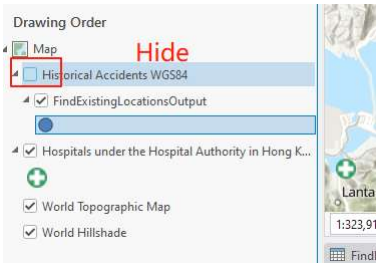
III.2 Select data

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







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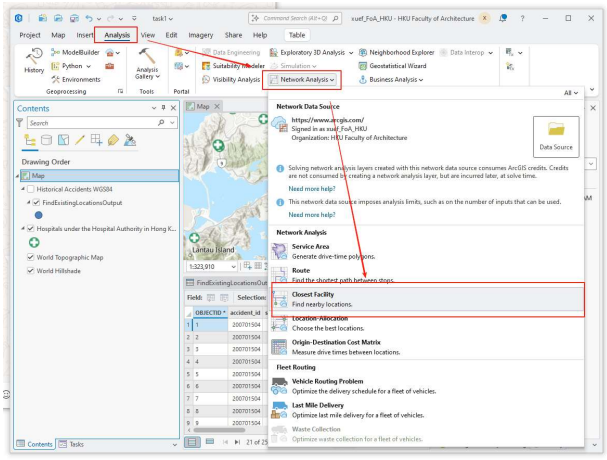
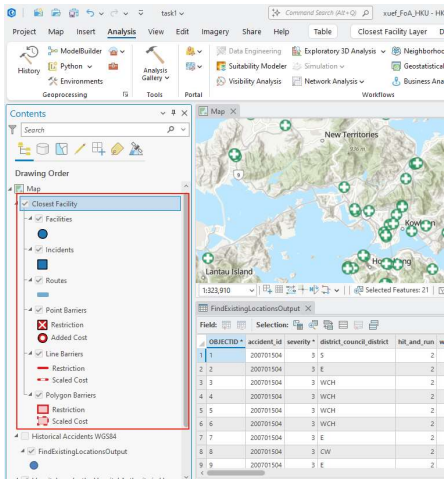
III.2 Network – closest facility





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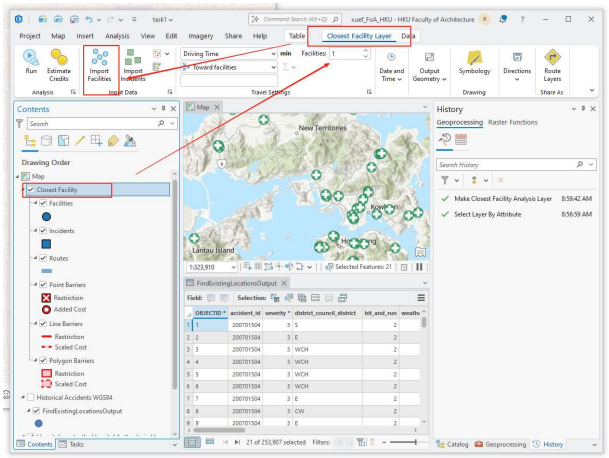
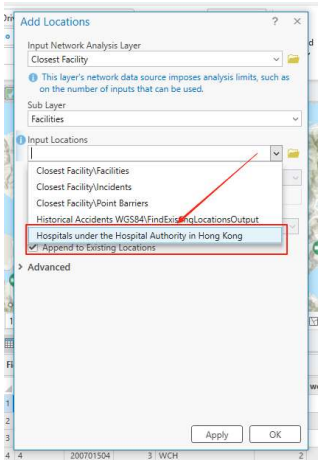
III.2 Add facility





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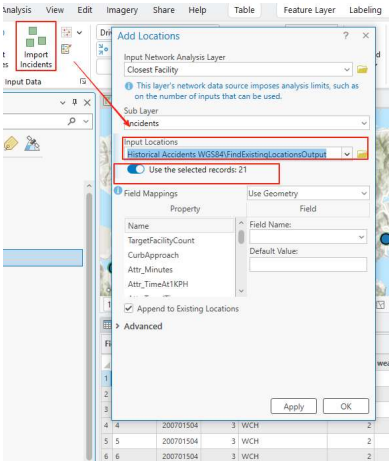
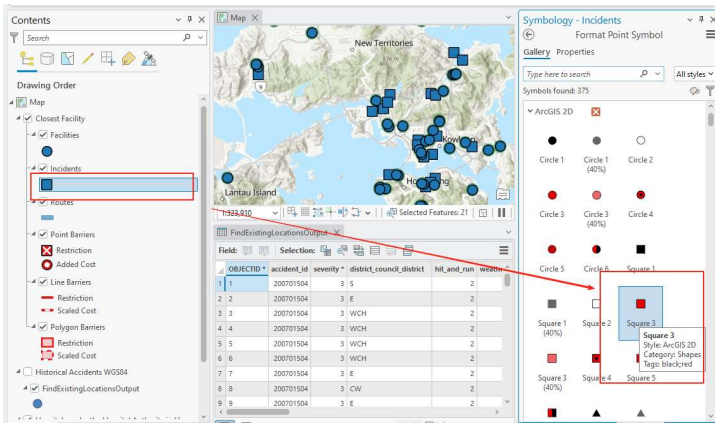
III.2 Add incidents



- Change a style for incidents



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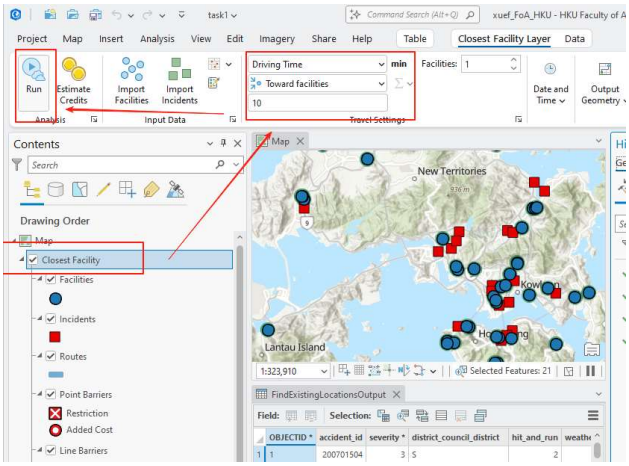
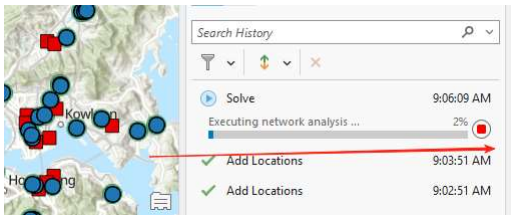
III.2 Analyze



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



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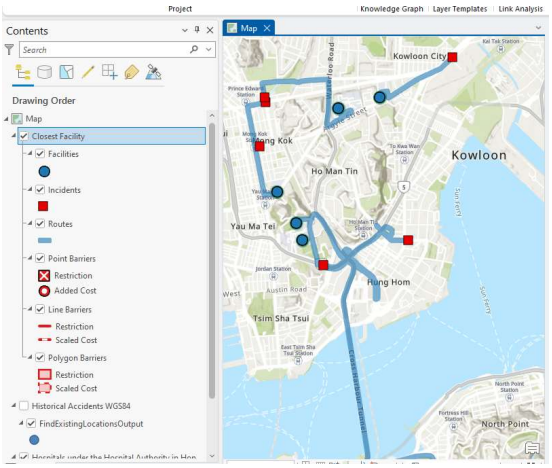
III.2 Network analysis

- 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?



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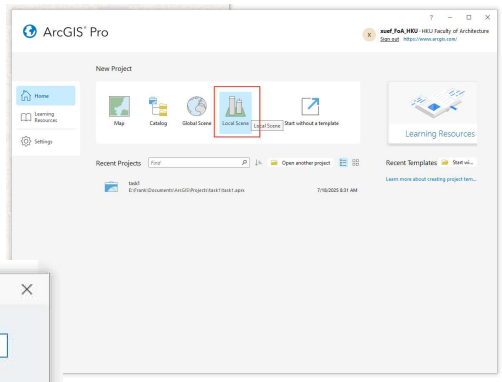
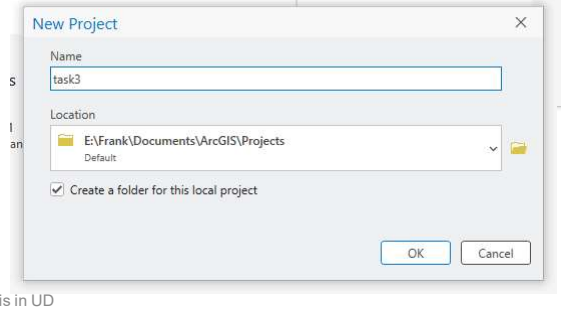
III. Task 3: 3D scene

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





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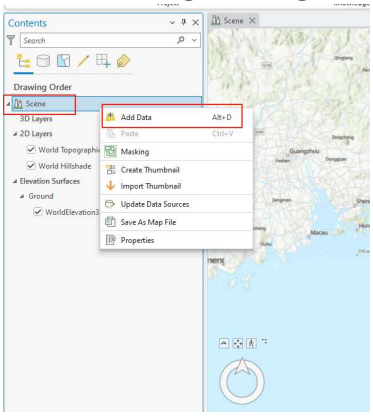
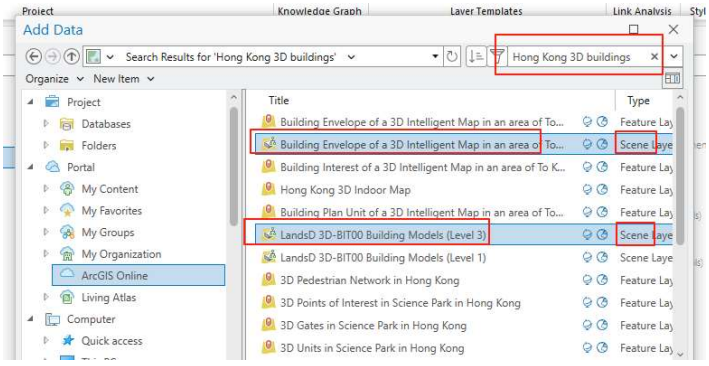
III.3

- Add data
- Add using "Hong Kong 3D buildings"





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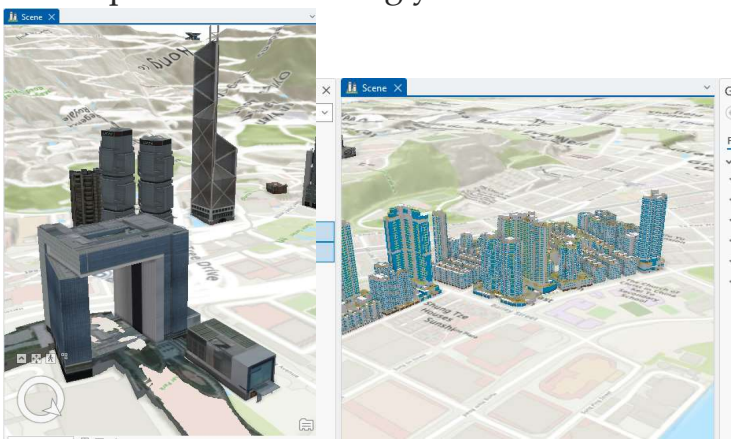
III.3 3D views

- Explore around using you mouse control



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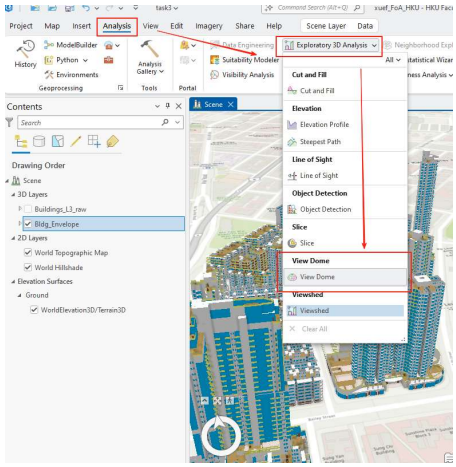
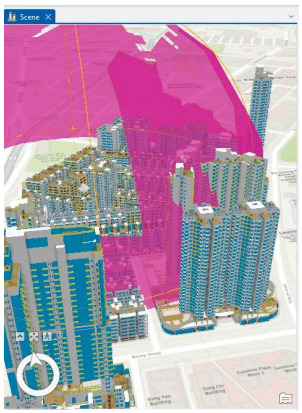
III.3 Very simple view dome/shed analysis



- From low-level window, high-level



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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?

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REC Summer Programme

Keep awesome !