GeoAdvances 2024

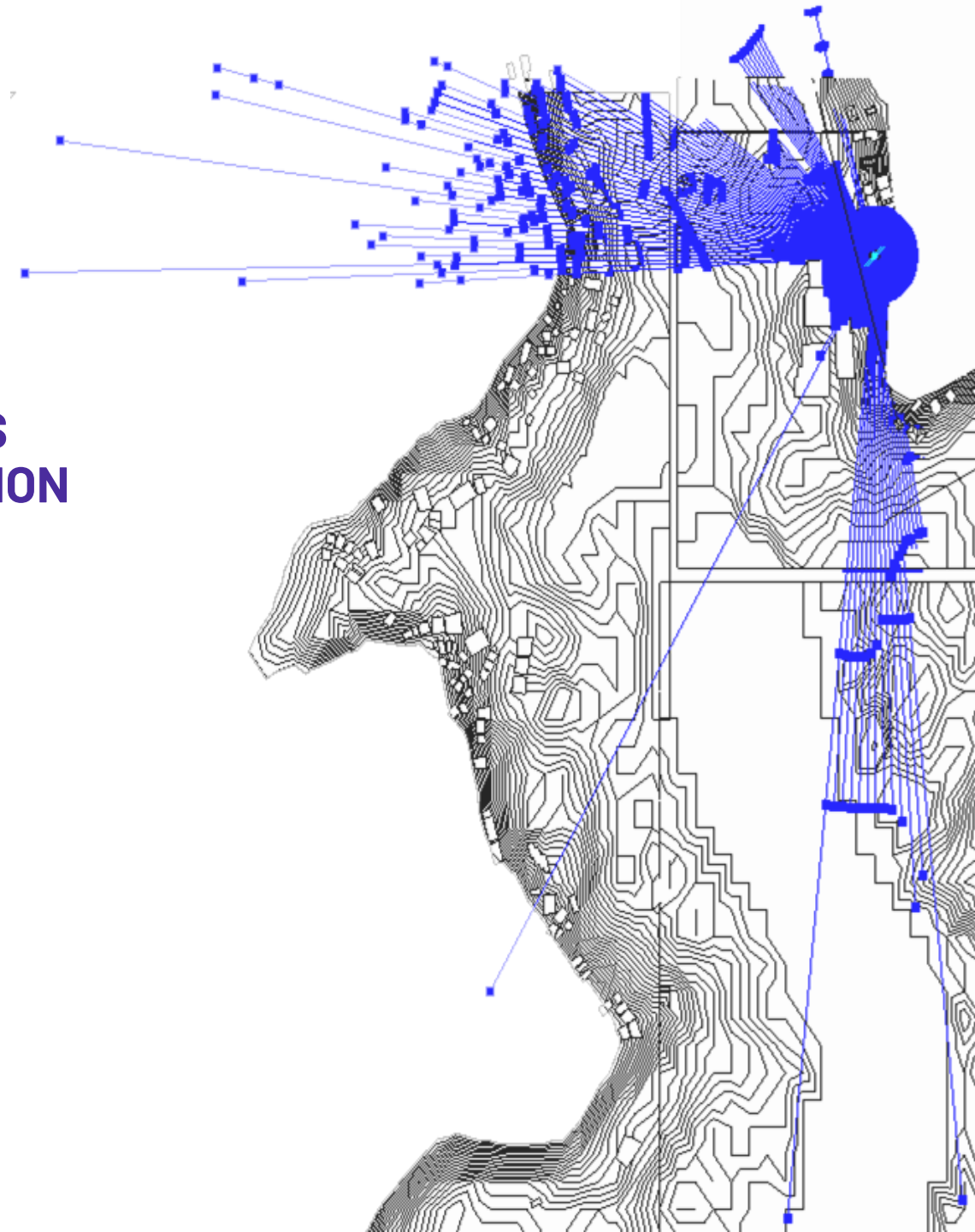
12.01.24 | Session 5-4

3D VISIBILITY ANALYSES USING BIM & GIS INTEGRATION

Prof. Dr. Ümit IŞIKDAĞ [1]

Ecenur ÇORLU [1]

MSFAU, DEPT. OF ENFORMATICS [1]



OUTLINE |

1. **Introduction**

visibility, visibility analysis, usage, problem, aim

2. **Method**

Open Data Sources, BIM –GIS Integration, 3D isovists, Study Area

3. **Results**

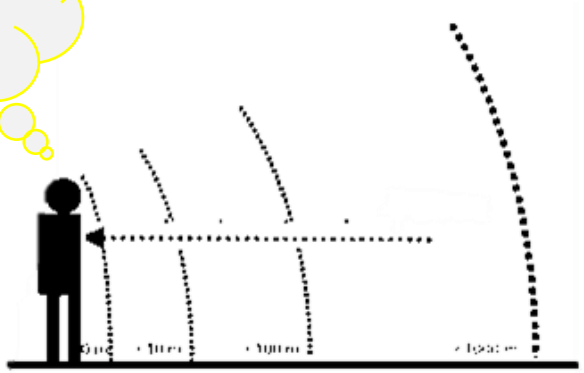
Visibility Analysis, Study Area

4. **Discussion & Conclusion**

Challenges, Contributions

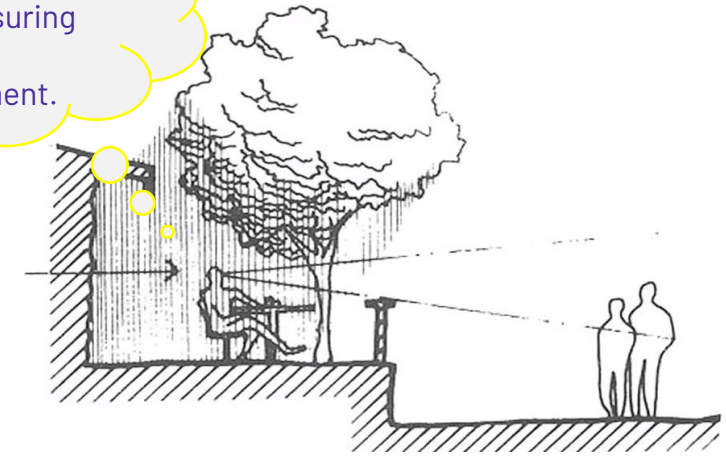
View

human perception and cognition



the state of being able to see

defining space and measuring the environment.



Building valuation

People prefer *larger view* rather than narrow view.

People prefer *visually comfortable buildings*

→ goodwill

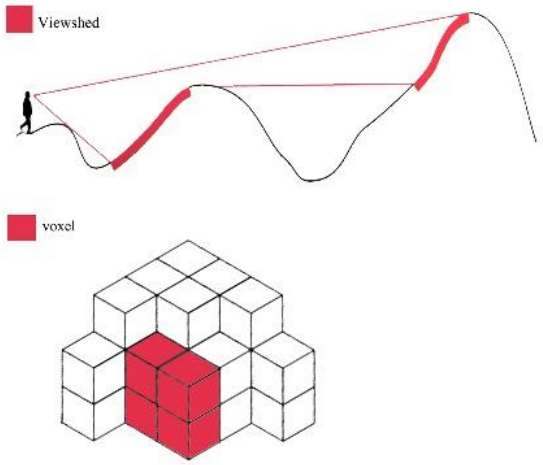
examining the current urban model and the building model simultaneously is needed.

to evaluate goodwill, creating a (3D) urban model is needed

BIM and GIS information is needed to combine for evaluating building and built environment relationships

* image sources: *https://webpages.uidaho.edu/larc453/pages/arcAndSpace.htm*

3- Visibility Usage Methods



Search - focused on

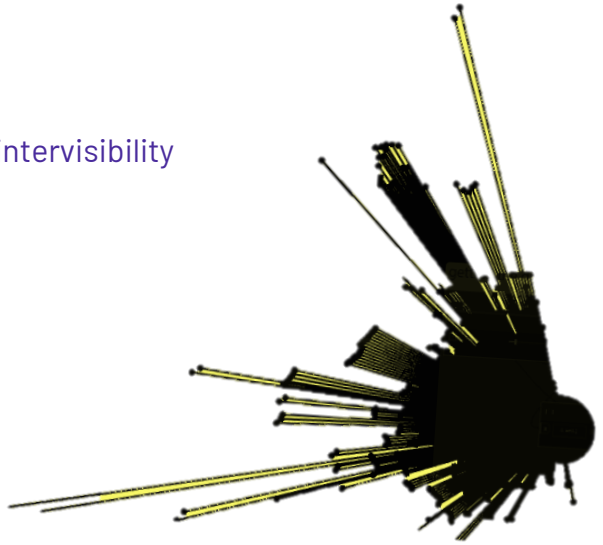
- visual openness, visual exposure, visual comfort, view clarity, and view quality, intervisibility

Method

- isovists is one of the most used visibility analysis method
- grid-based analysis using 2D grids or 3D voxels (Morello and Ratty ,2009,
- Fisher Gewirtzman,2013)
- MATLAB custom component heatmaps

Environmental data

- Environmental data is also changed for analysis such as meshes, surfaces, polygons, points, polyhedral or voxels etc.



a set of all points that is visible from a specific observer point within the environment".

4- Problem

depthMapX

DeCodingSpaces Toolbox for Grasshopper

These methods are strict and the calculation is aimed to create in BIM

- *calculation method for the isovists is strict.*
- *Visibility is analysed in different topics*
- *AEC sector professionals need calculation method in BIM*
- *Visual openness indexes need precisely calculate*

Therefore, in this study, visibility was examined through 3-dimensional (3D) isovists, which are thought to represent the human perception of vision.

View

People prefer *larger view* rather than narrow view.

* View of a narrow canal in Venice

* Large view in Venice

* image sources: *unsplash.com*

View

The *presence of* ***high-rise buildings*** and ***obstruction of view*** has negative effect on the prices of the building. Guliker et al., 2022

* Hong Kong "Architecture of Density"

**

***

**

Kowloon walled city, Hong Kong - was considered the densest settlement on earth

image sources- *Michael Wolf, Greg **Girard, ***Ian Lambot

BIM GIS INTEGRATION PROCESS

Start Process

Validate Required Data

Downloading GIS data

GIS Model Creation

- Topography Creation
- Buildings Creation
- Trees Creation

BIM Model Creation

- Facade Creation
- Elevation Creation
- Observation Elements Creation

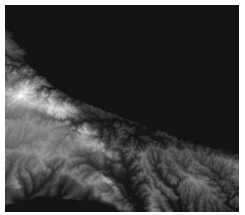
Urban Model

- Combining Models

Visibility Analysis

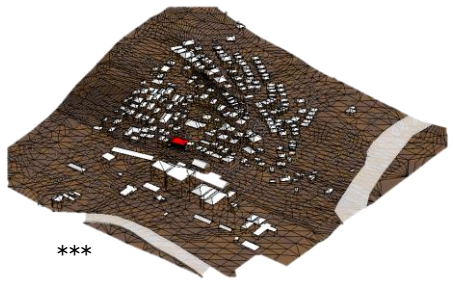
End Process

*

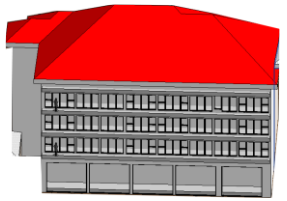


**

**

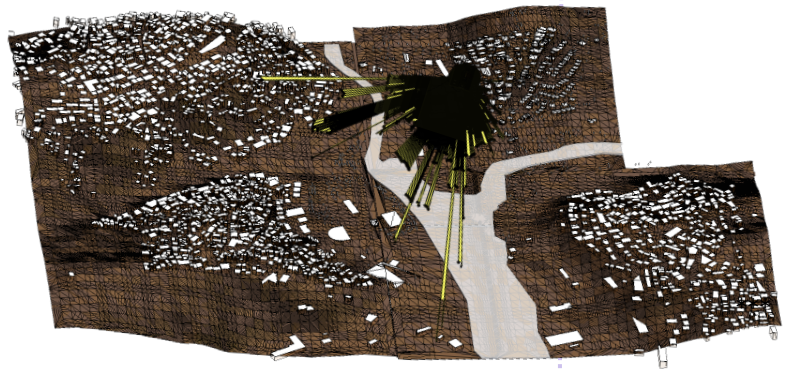


***



***

average radial of isovists and percentage of uninterrupted isovists are investigated



INFO EXCHANGE

GIS data (Building footprints, topography, borders, trees.)

Architectural Model

Models

Results

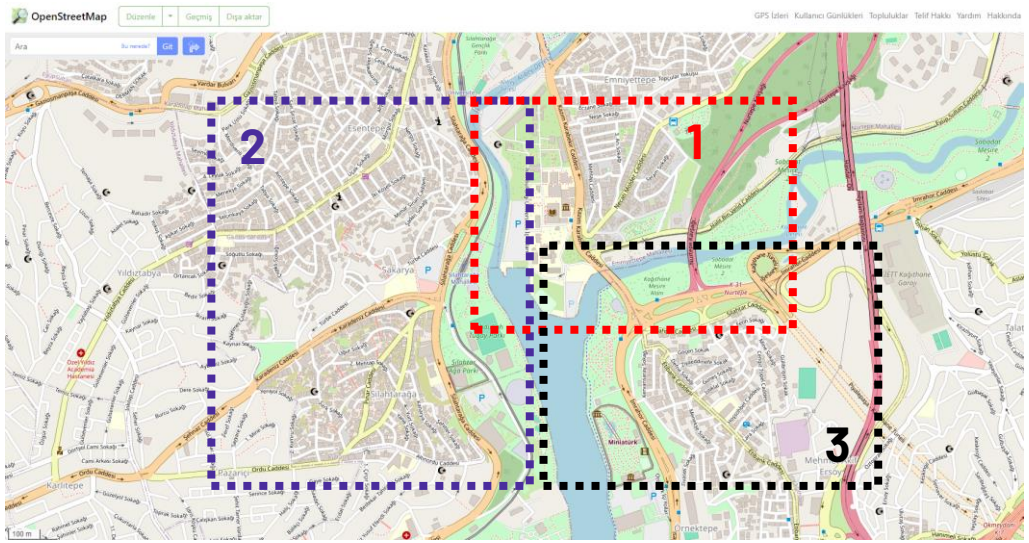
images : *openstreetmap.org , ** USGS, *** BIM Software

OPEN DATA SOURCES | CADASTRAL DATA

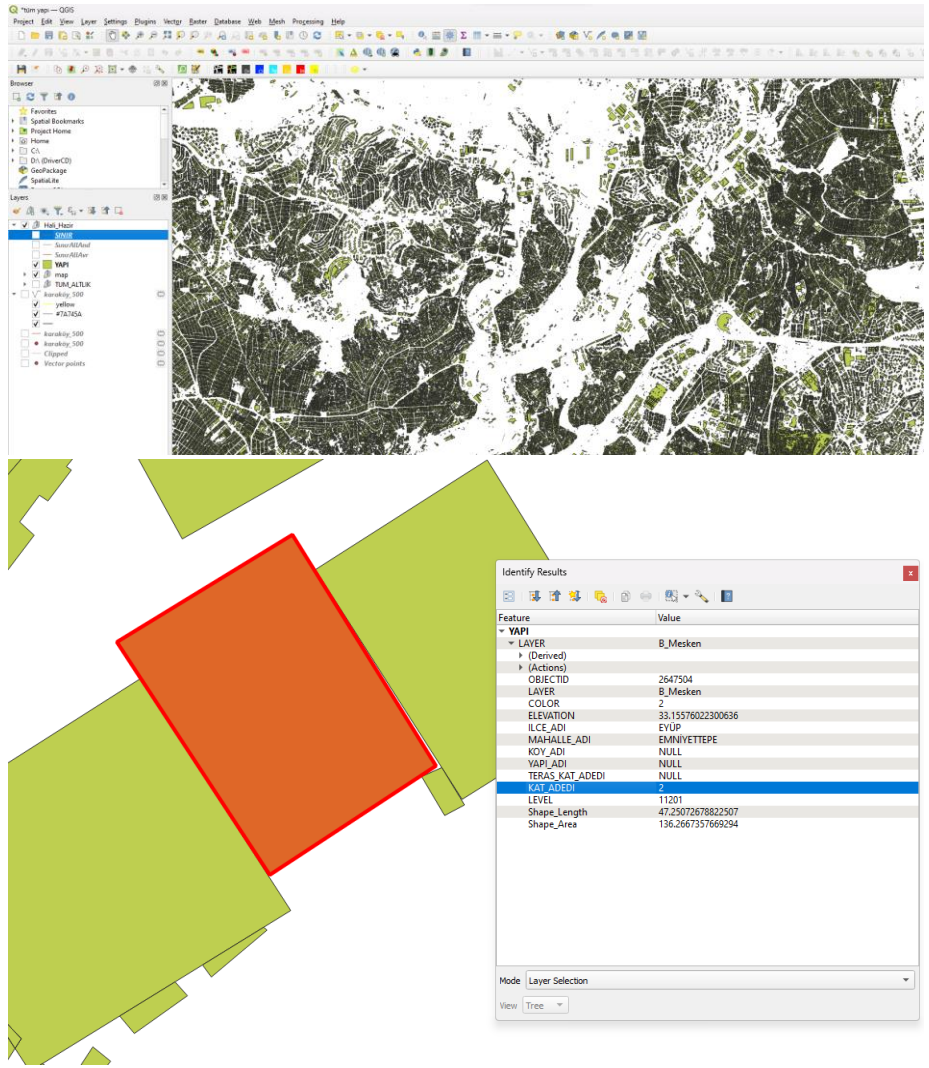
1- editing cadastral data

* trees building footprints are added manually on OSM

1- downloading cadastral data



* OSM interface

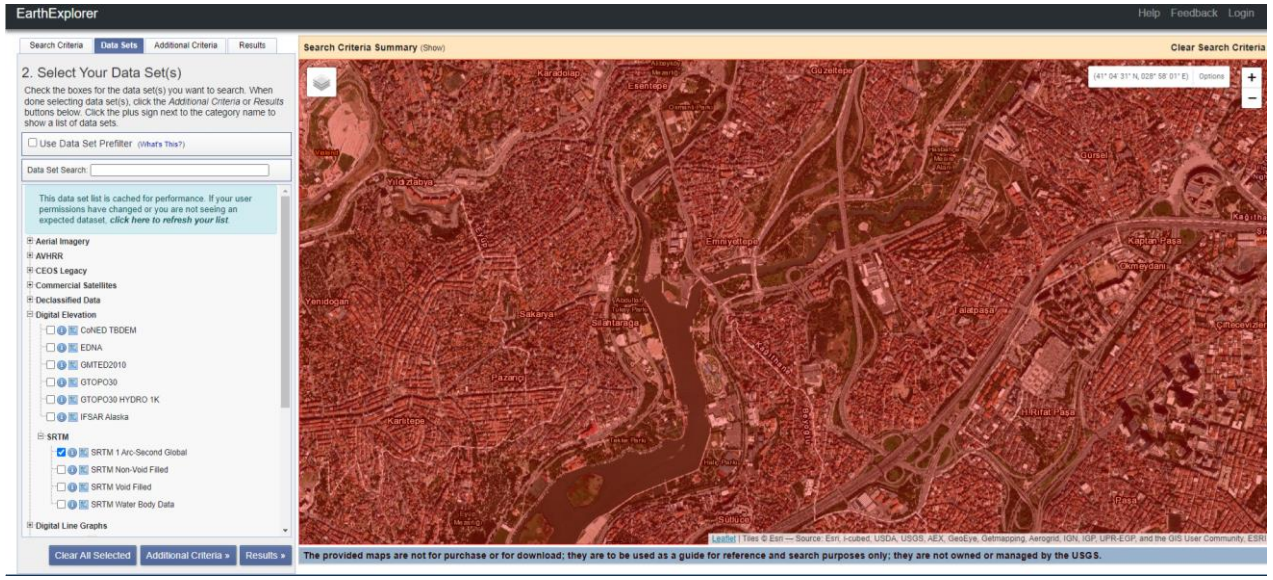


** height values are added from local sources

image sources: * openstreetmap.org , ** QGIS

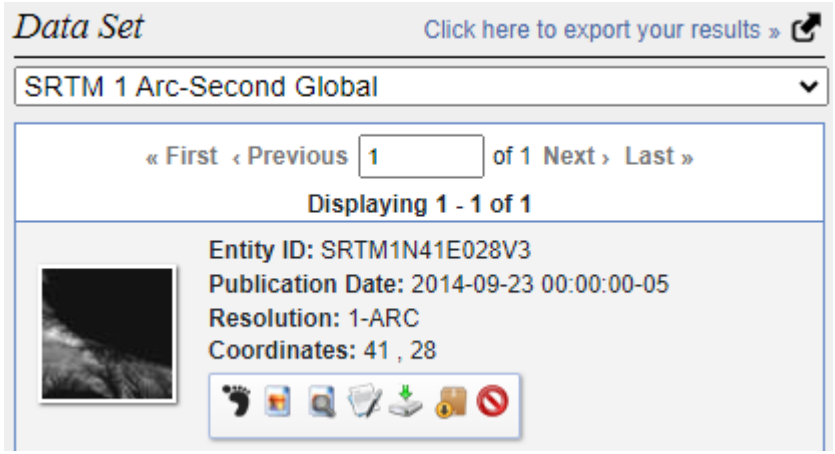
OPEN DATA SOURCES | DEM

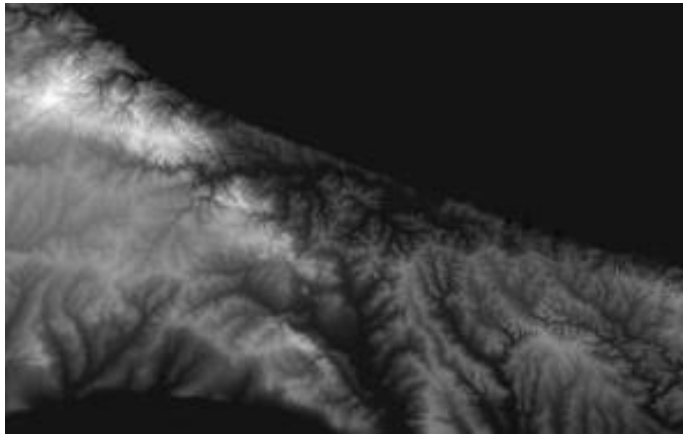
1- Digital Elevation Data



Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global over İstanbul , ~ 30 meters resolution

2- downloading dem



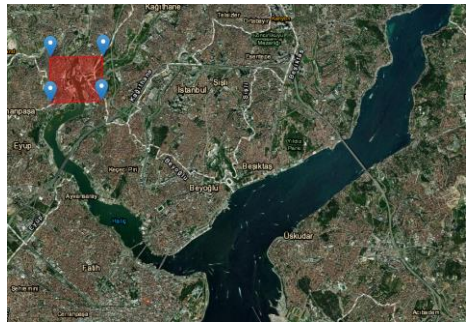


Georeferenced Tagged Image File Format (GeoTIFF)

image sources: *USGS

Study Area

Istanbul, Türkiye



Golden Horn

Study Area

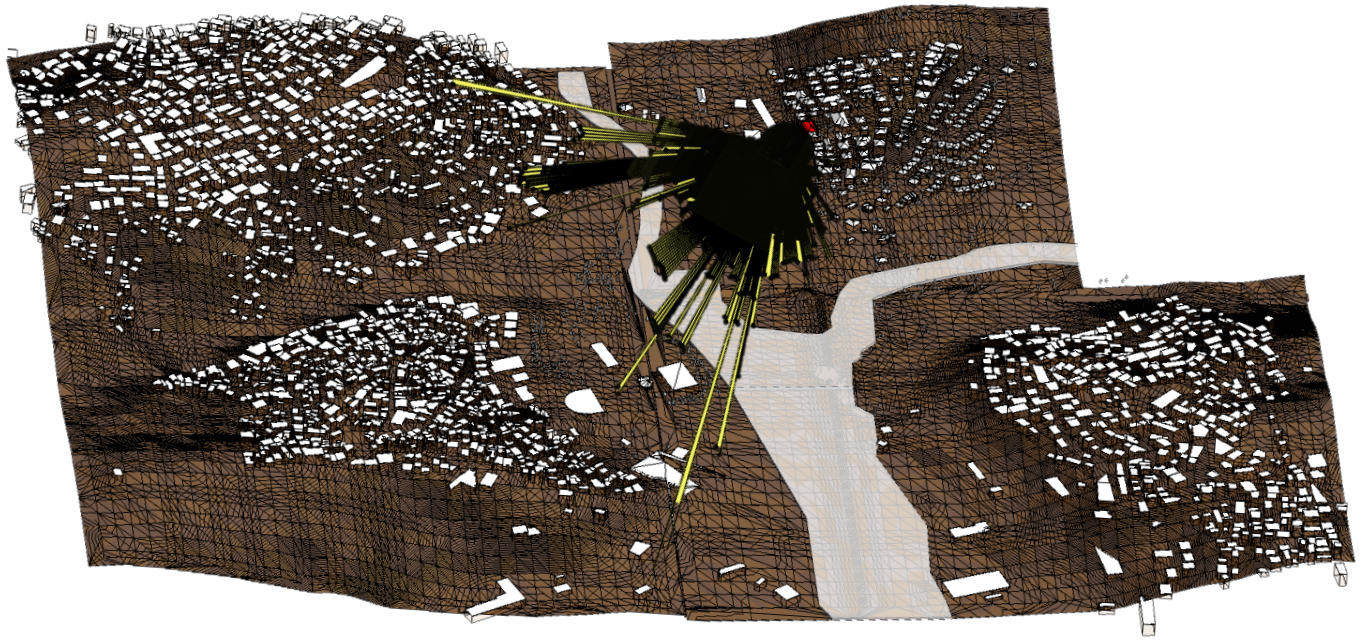
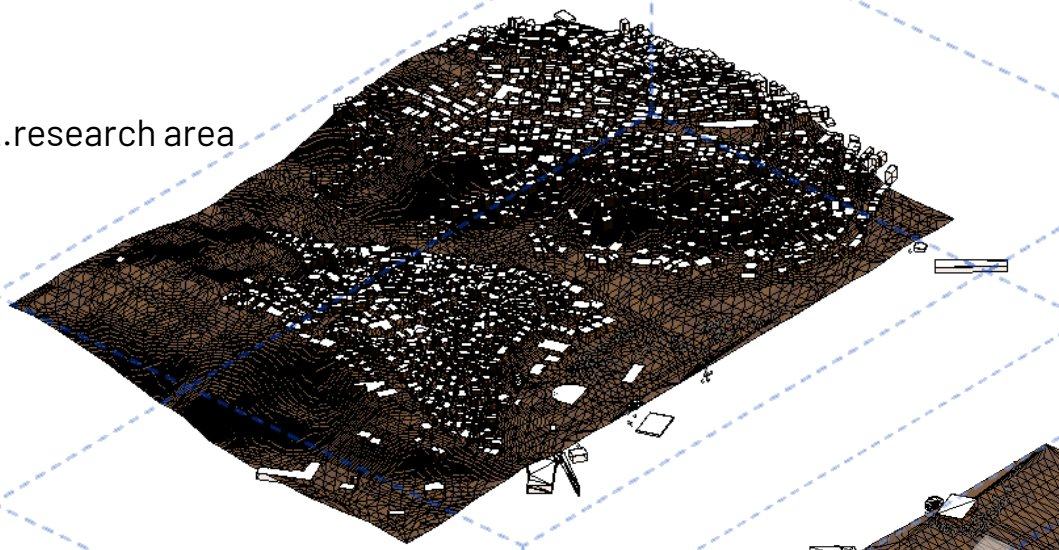


image sources- *Michael Wolf*

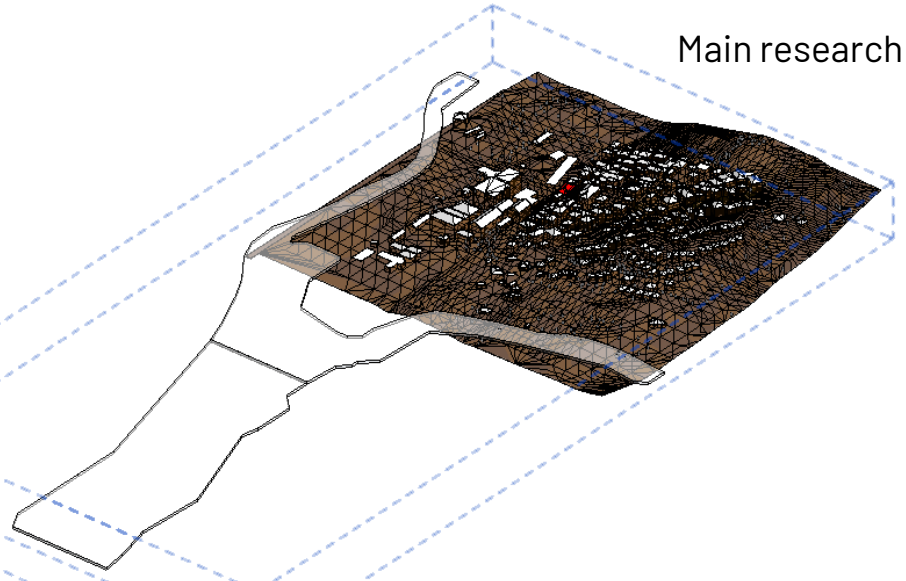
BIM | GIS INTEGRATION

Model

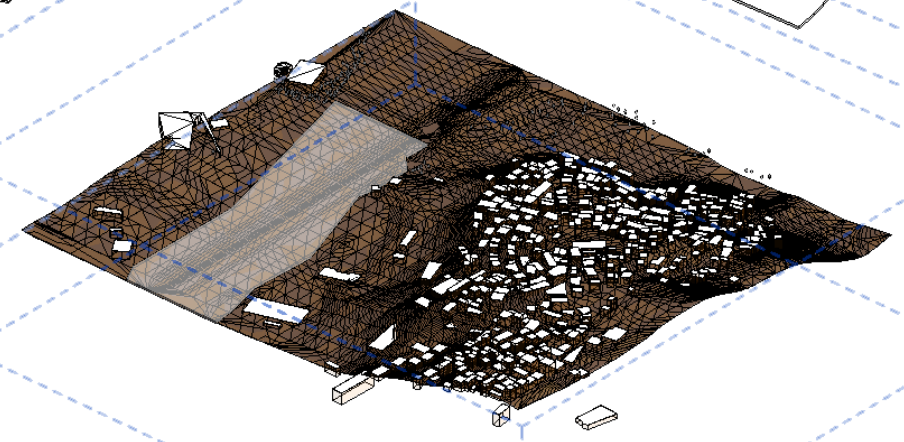
2.research area



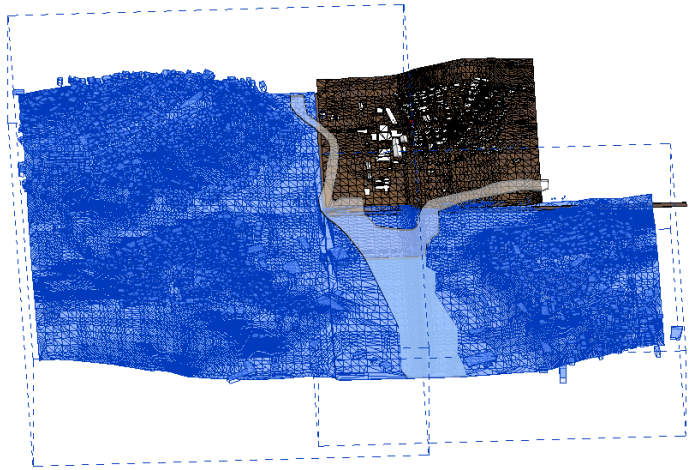
Main research area



3. research area



Combination for detailed analysis



GIS models are created separately due to heavy load data.

image : * BIM software

BIM | GIS INTEGRATION

1- Topography

*3D

*section

Code

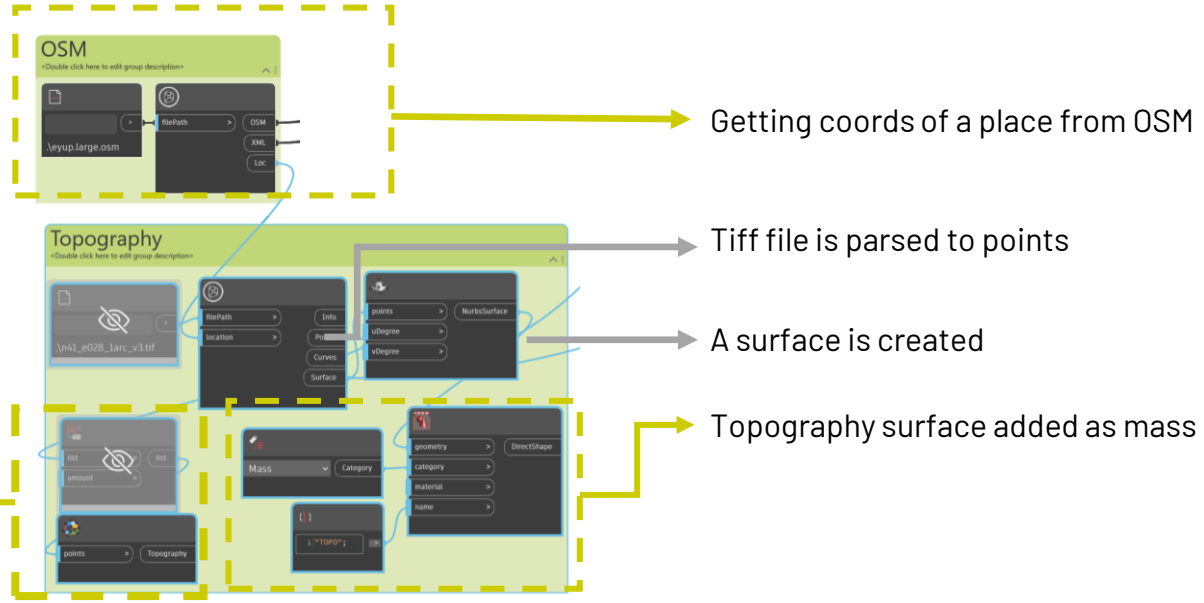
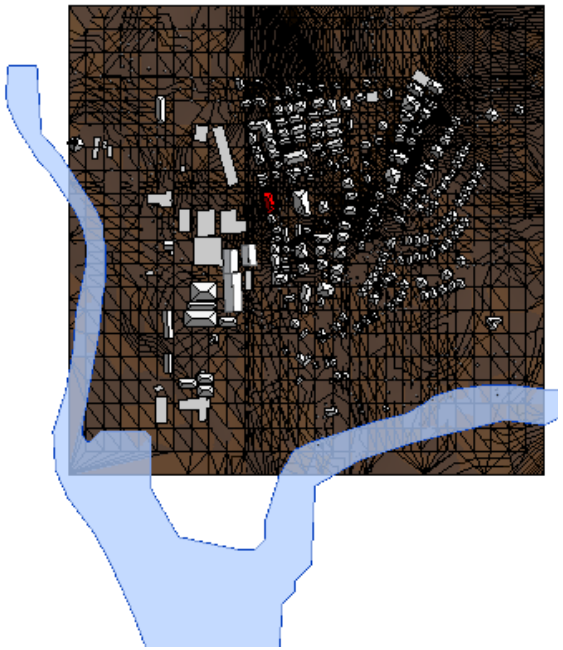


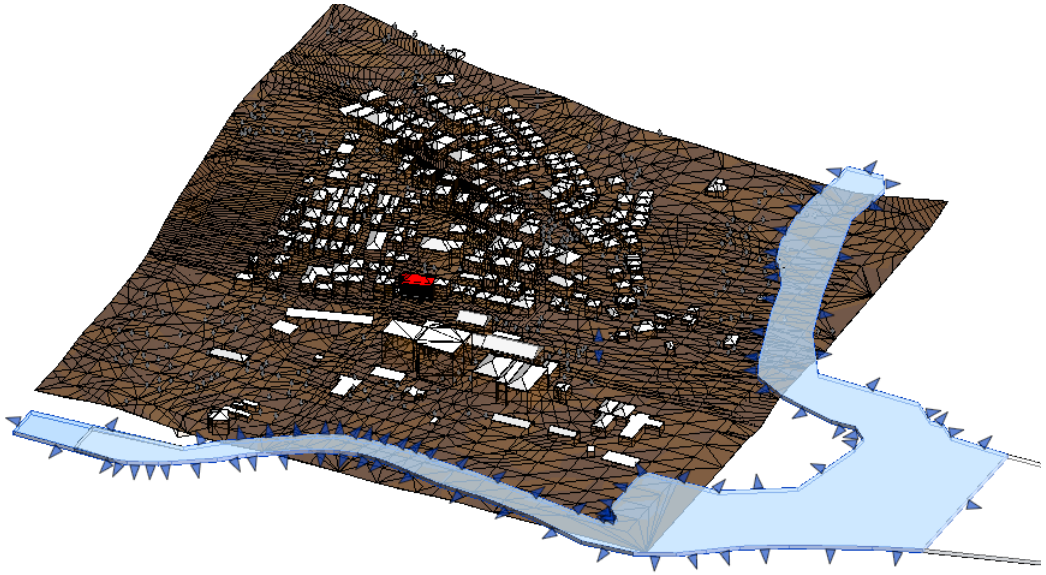
image : * BIM software

BIM | GIS INTEGRATION

2- Topography borders

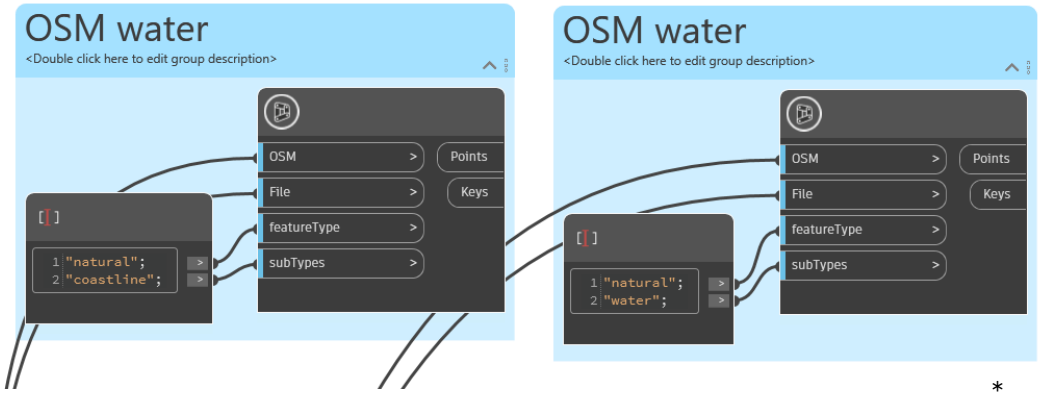


*



*

Manuel creating



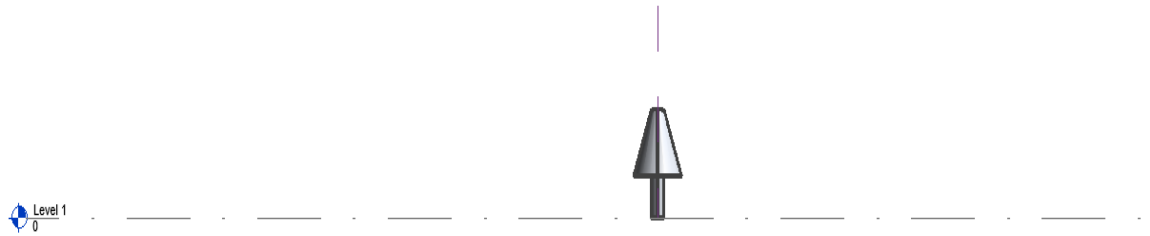
*

Points are created and a mass is drawn from that points

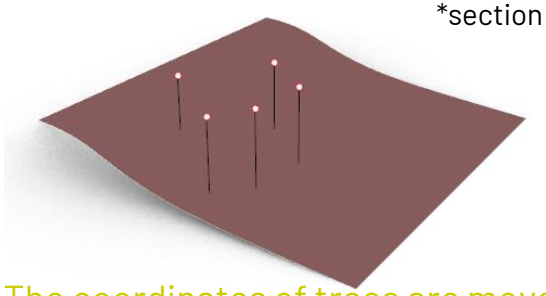
image : * BIM software

BIM | GIS INTEGRATION

3- Trees

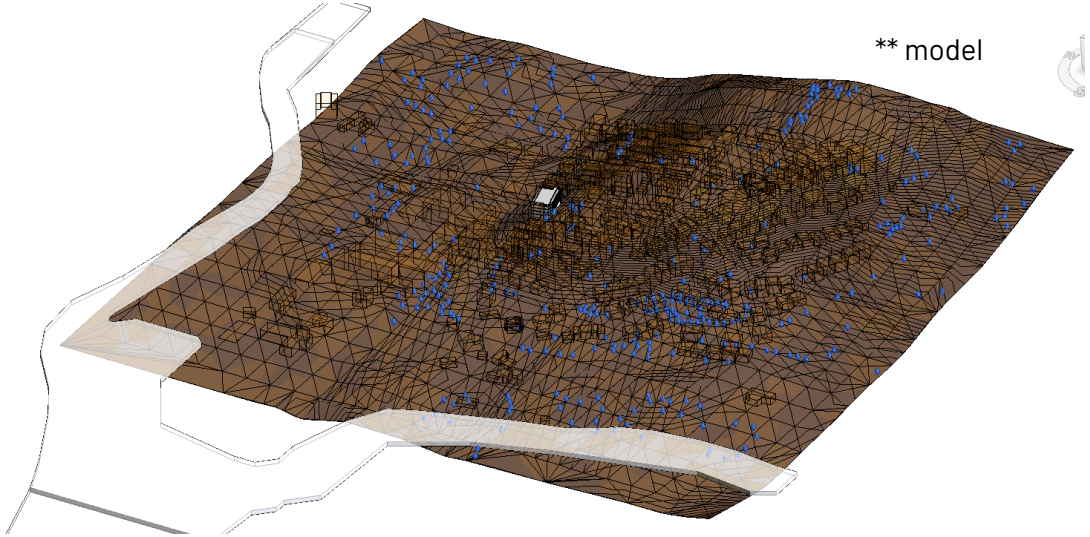


*section



The original mass to create all of the Trees

** model



Code

Trees are added in OSM under Natural tag :tree

The coordinates of trees are move upon topography and projected according to the distances between them

Trees are created from mass

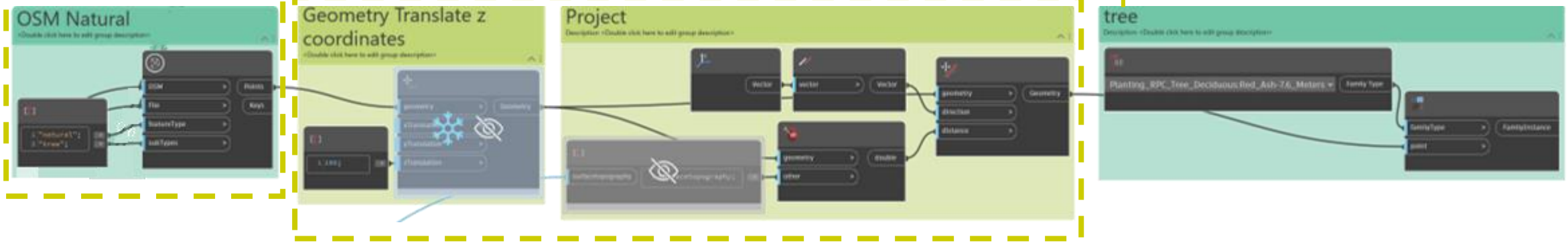
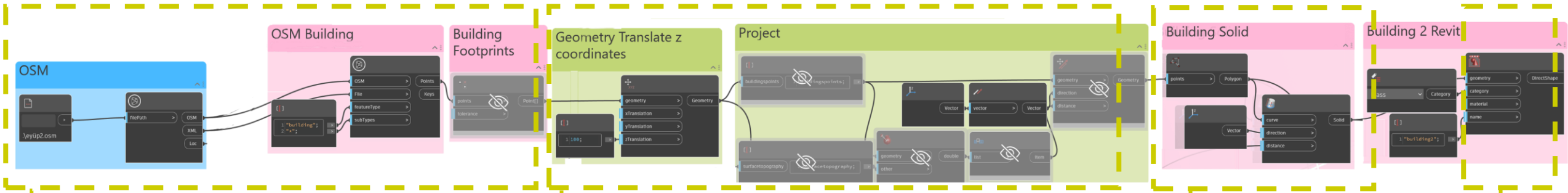


image sources: * tree model , ** BIM Software

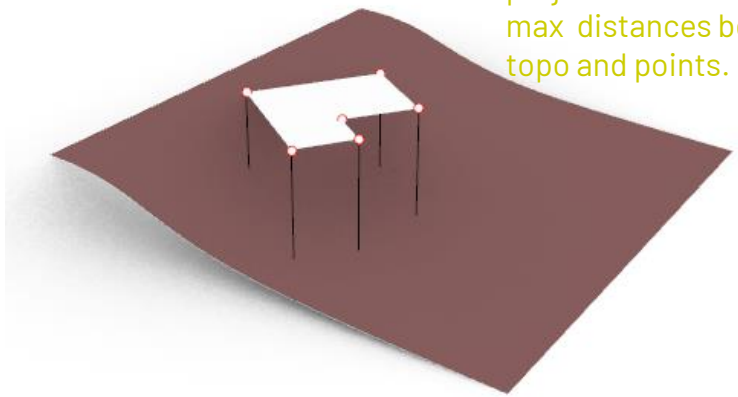
BIM | GIS INTEGRATION

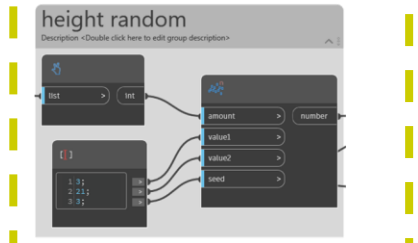
4- Creating Buildings (which located far from study area) without height



Buildings are saved in OSM under building tag

Buildings' footprints moved above topography and projected according tothe max distances between topo and points.





Buildings' heights are created randomly between 1 and 10 store.

Buildings are created from heights.

Buildings are created As a mass in BIM.

image sources: * openstreetmap.org , ** QGIS

BIM | GIS INTEGRATION

5- Creating Buildings near research area with right Height values

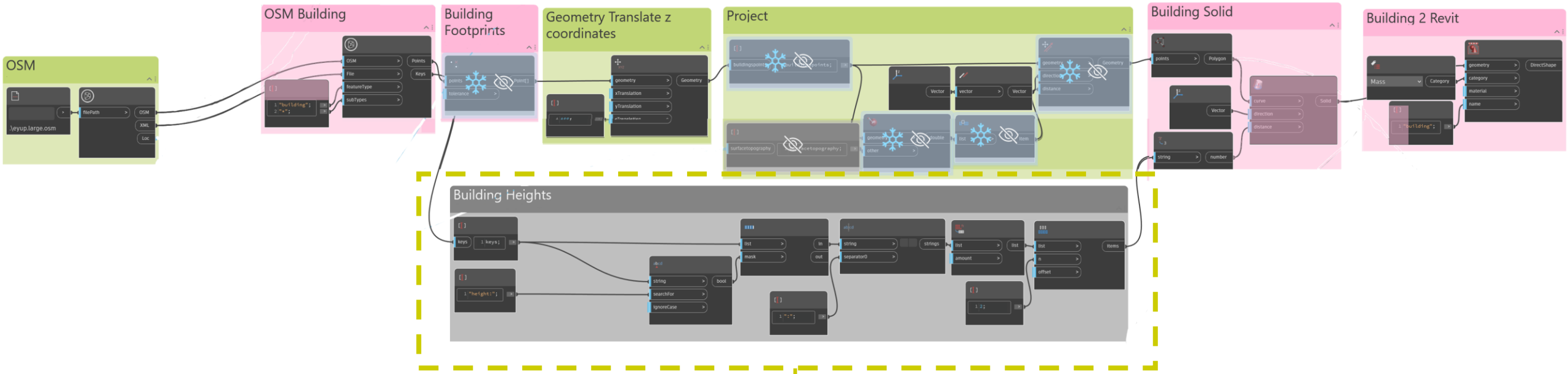
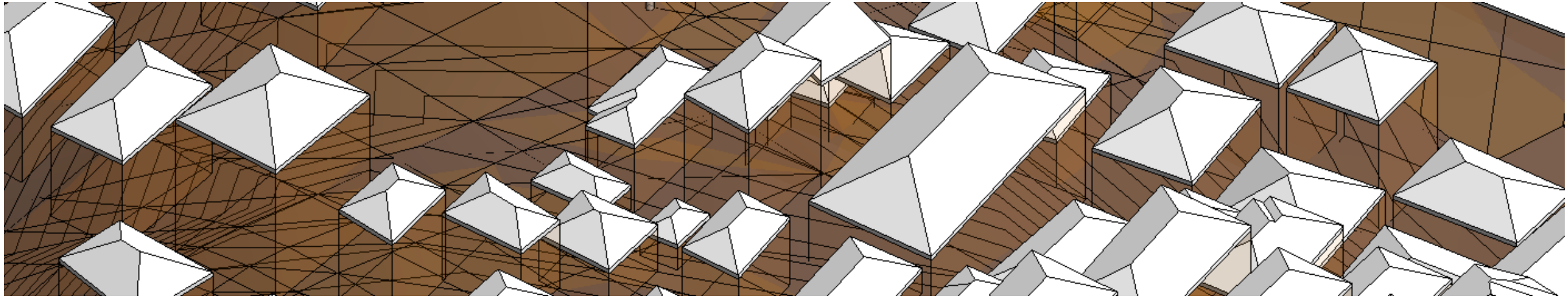
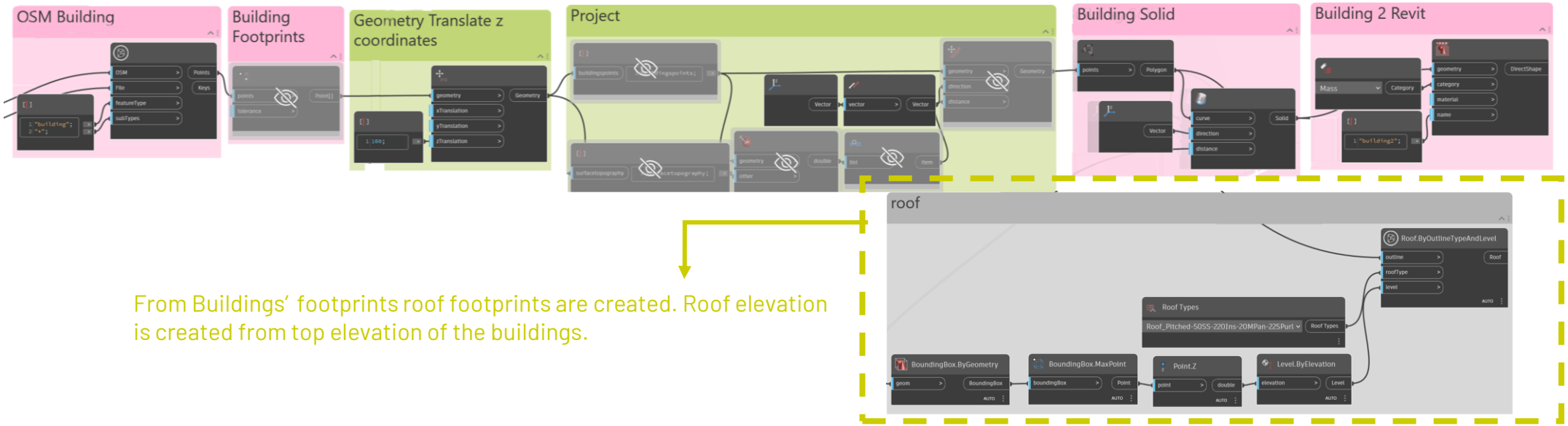


image : * BIM software

BIM | GIS INTEGRATION

1- Buildings' Roof





From Buildings' footprints roof footprints are created. Roof elevation is created from top elevation of the buildings.

*

image : * BIM software

BIM | GIS INTEGRATION

Integrated Model

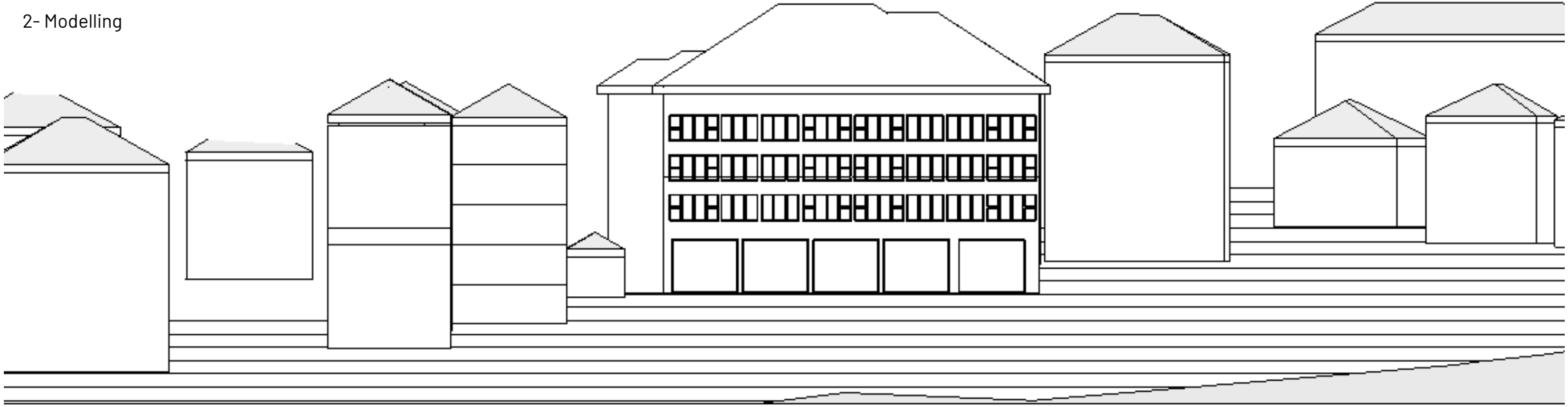
GIS models are combined.

image : * BIM software

BIM | BUILDING MODELLING

1- Buildings' Facade

2- Modelling



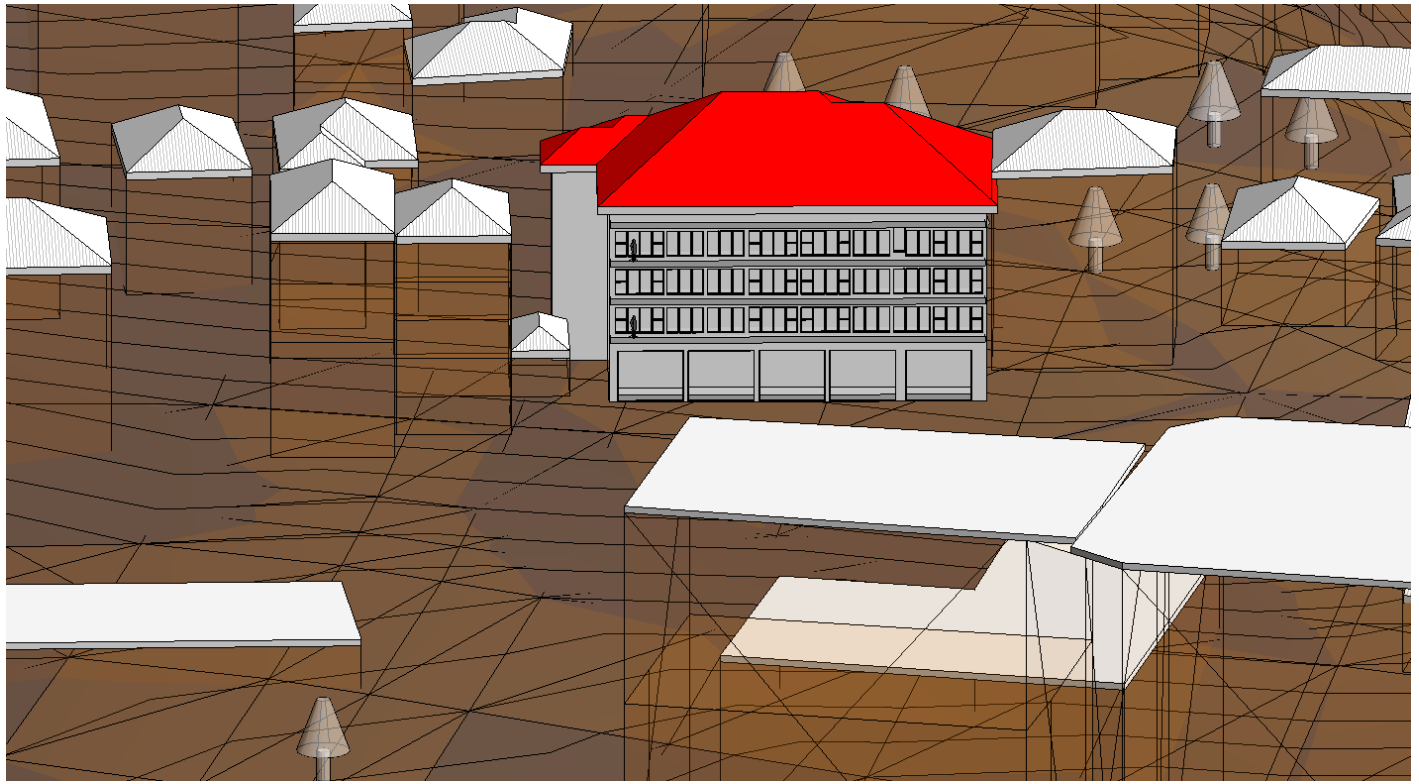
*

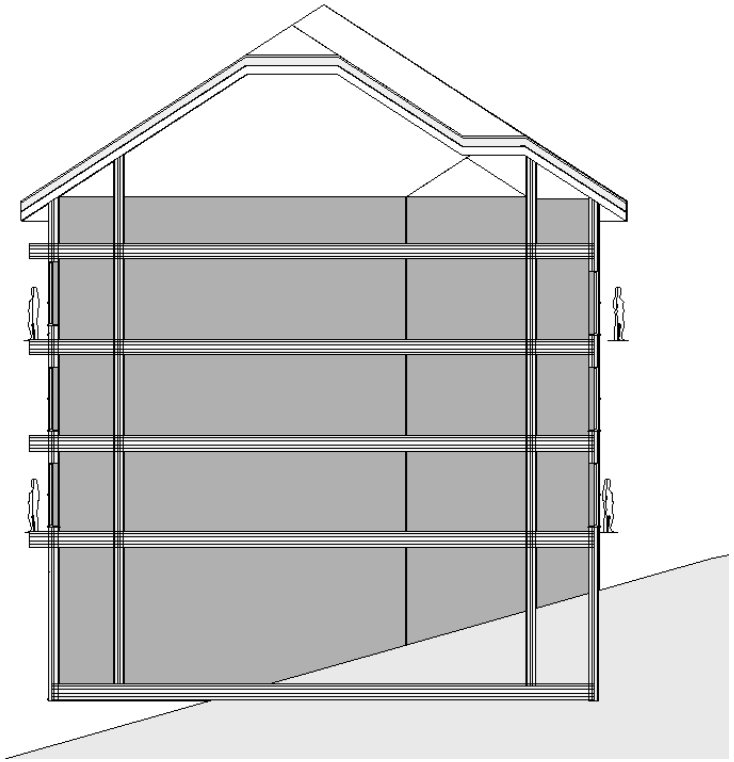
Dormitory's facade is modelled as seen in the photo in BIM.

image : *photo of building facade, ** BIM Software

BIM | Building Modelling

2- Modelling





Building was modelled in Level Of Development 200.
Window openings and elevations are added.

image : * BIM software

Visibility | Equations

1- Visual Openness 1

$$VO1 = \frac{\left(\Sigma_{i=1}^{n1} l_i + \Sigma_{i=1}^{n2} r\right)}{(n1 + n2)}$$

where

Σ = Sum

VO = Visual Openness

l = Length of isovists

r = specified distance value (maximum visible distance)

n1 = the number of isovists collided onto objects

n2 = the number of isovists that do not collide with objects (which was cropped at the specified distance)

$$\text{“ The mean of isovists' lengths ”} = \frac{\text{the sum of length of isovists that collided onto objects} + \text{the multiplication the number of isovists that don't collided on any objects by an r distance}}{\text{the total number of isovists}}$$

Visibility | Equations

2 - Visual Openness 2

What percentage of the rays do not hit an object?

$$VO2 = 100 - \frac{x}{n} \times 100\,, \quad (2)$$

where

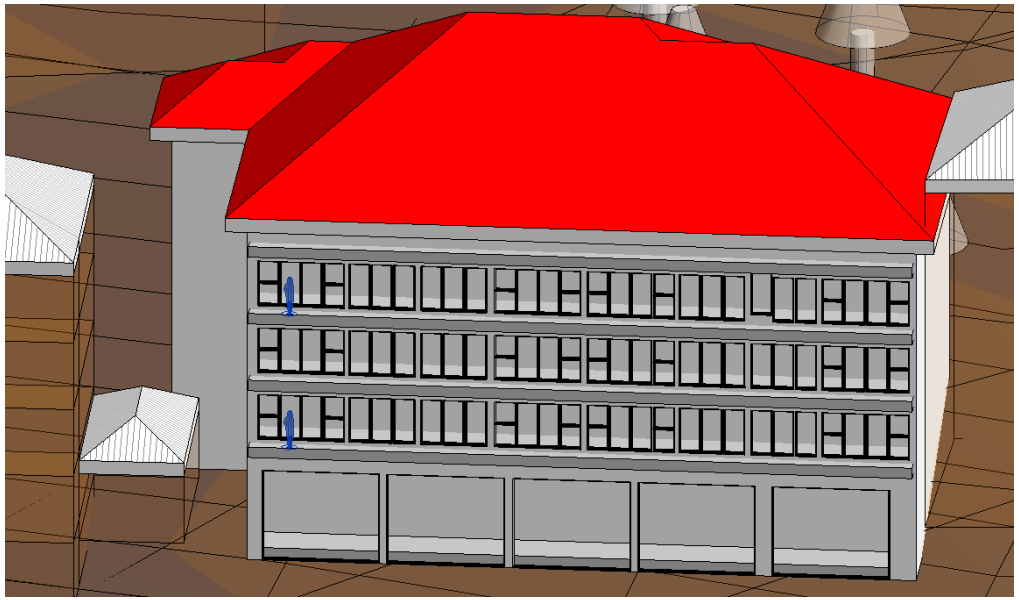
x = the number of isovists collided on built environment in a specified distance

n = the number of isovists created from vantage point

$$\text{“The percentage of non-collided isovists”} = 100 - \frac{\text{the number of isovists collided on built environment}}{\text{the total number of isovists}} \times 100$$

BIM | VISIBILITY ANALYSIS

1- Observation point



- The observer elements are seen as blue
- Front facade 2. and 4. floors

2- Choosing observer on Visual Programming

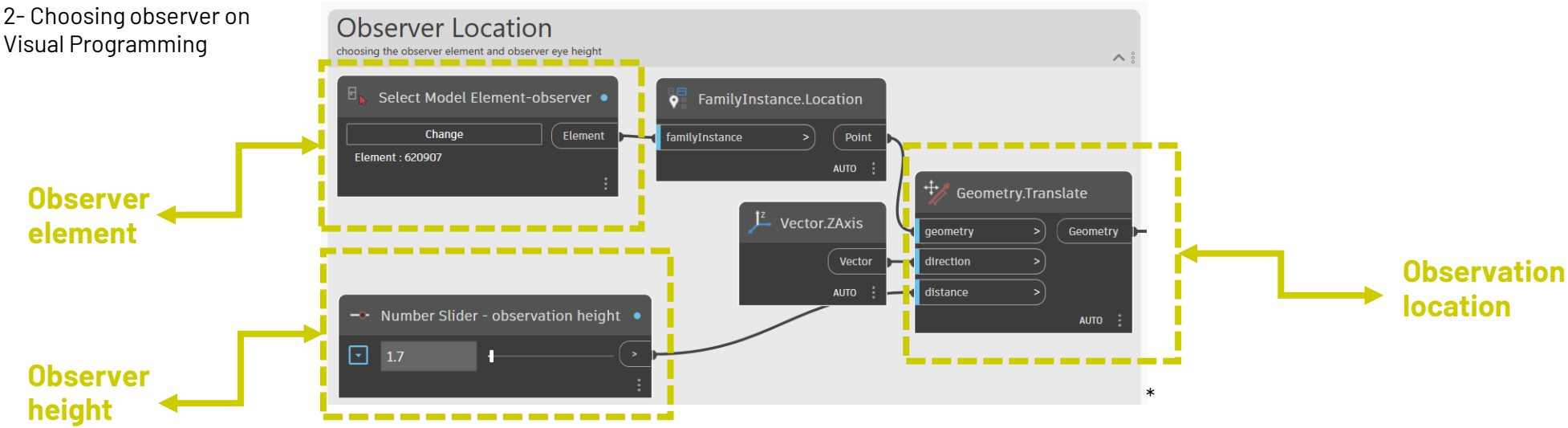


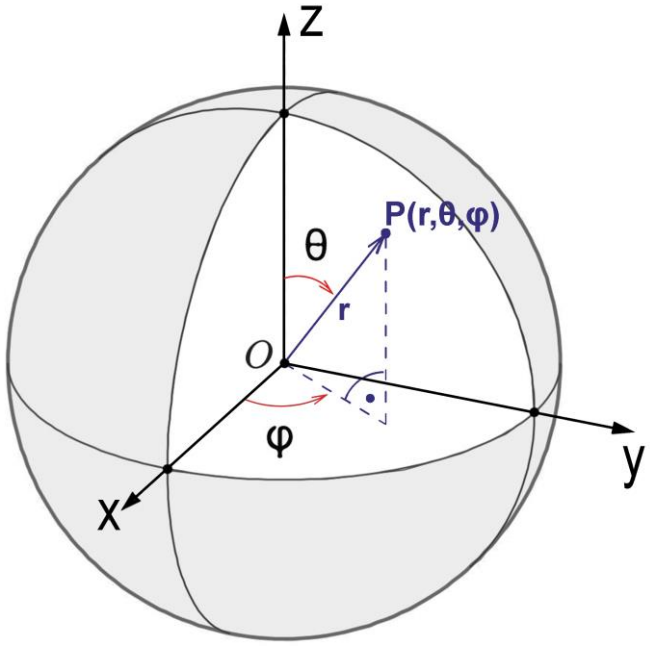
image : * BIM software

BIM | VISIBILITY ANALYSIS

1- Spherical Coordinates
To create 3D Isovists' direction

2- Creating Spherical Coordinates on Visual Programming

Good precision is reached when 64800 tracing rays created to execute analysis (Suleiman et al.,2011).



* *Higher number of points*
More accurate results.

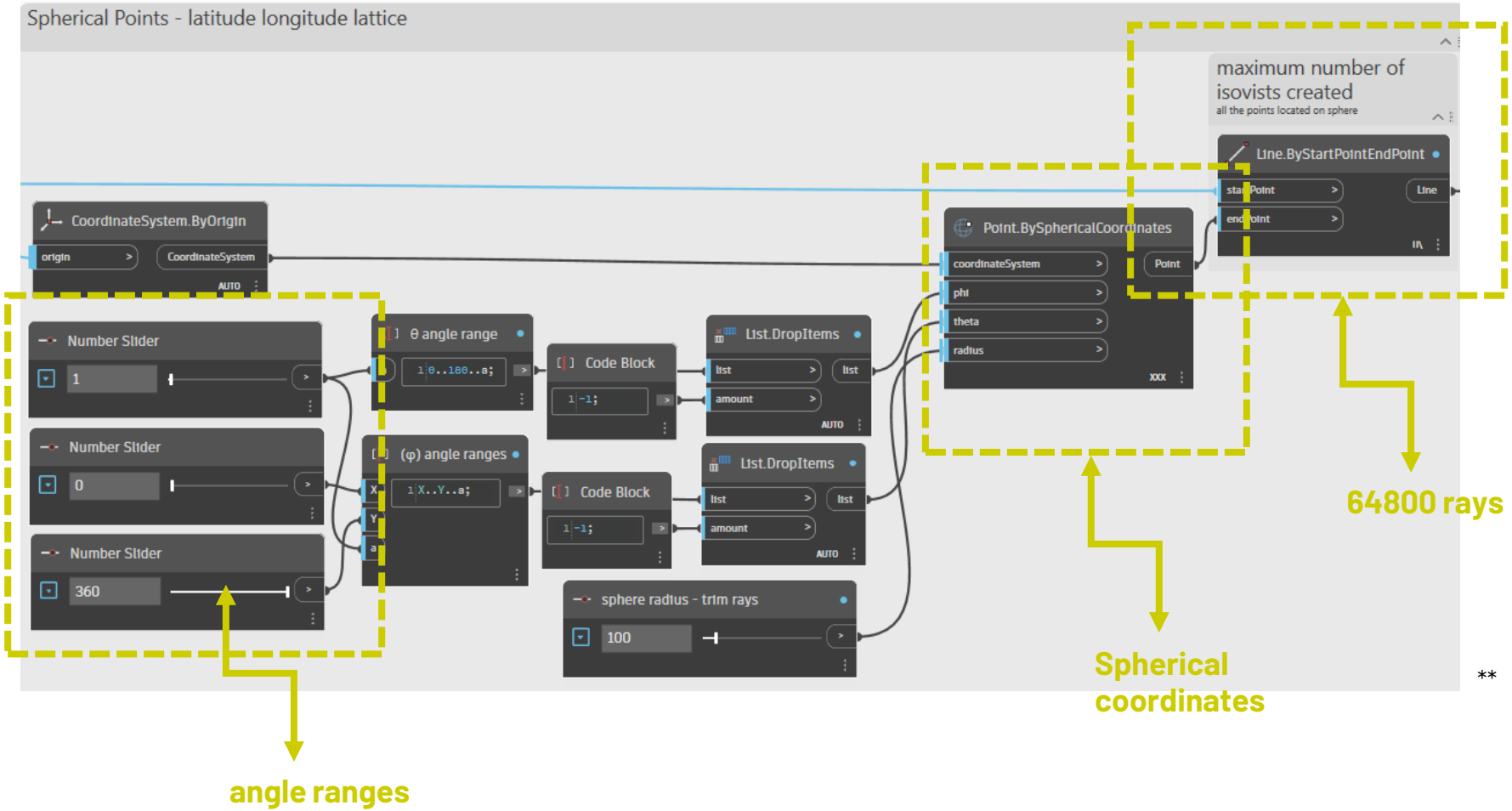


image : * drawing, ** BIM software

BIM | VISIBILITY ANALYSIS

More isovists create more precise results

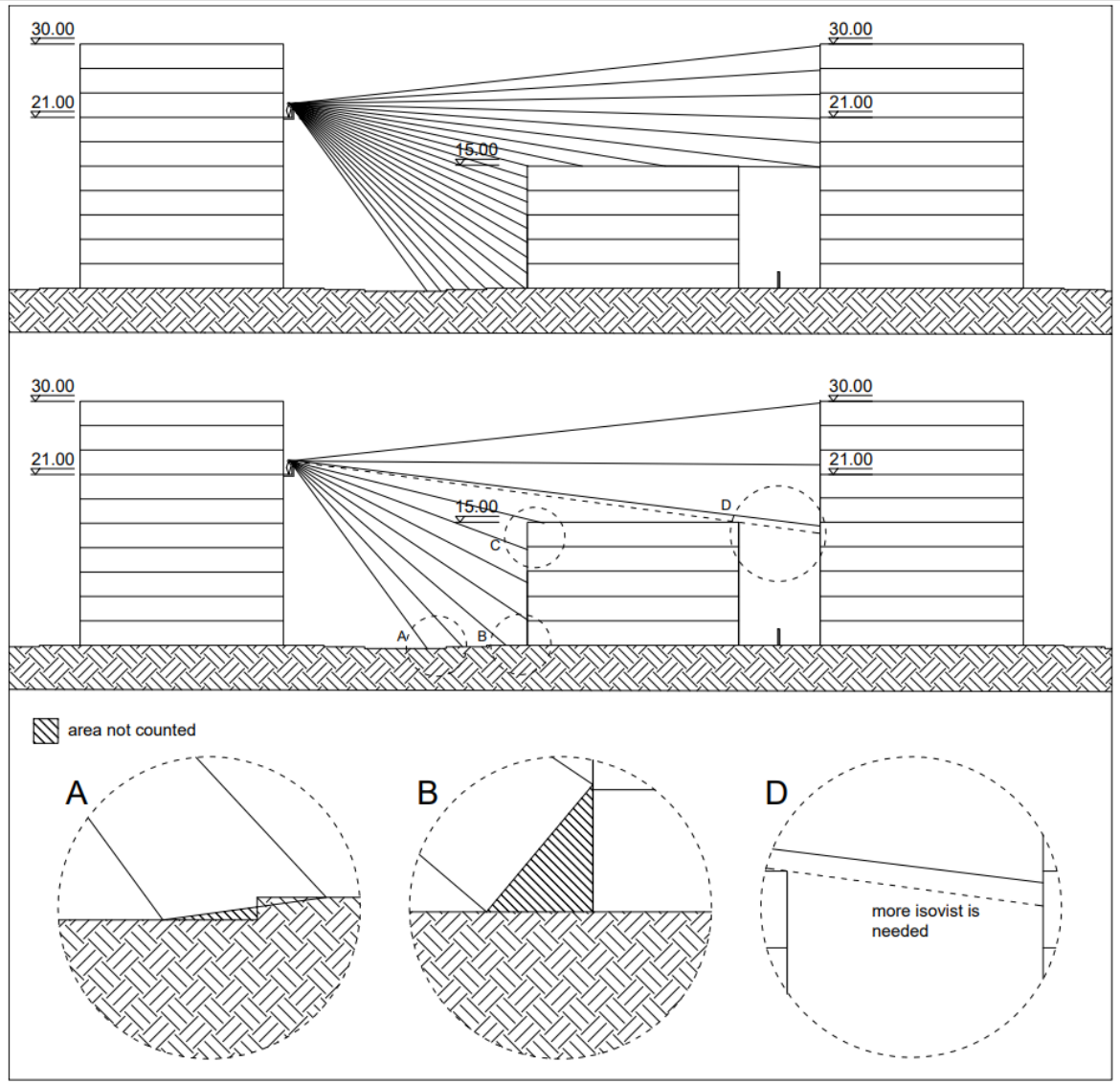
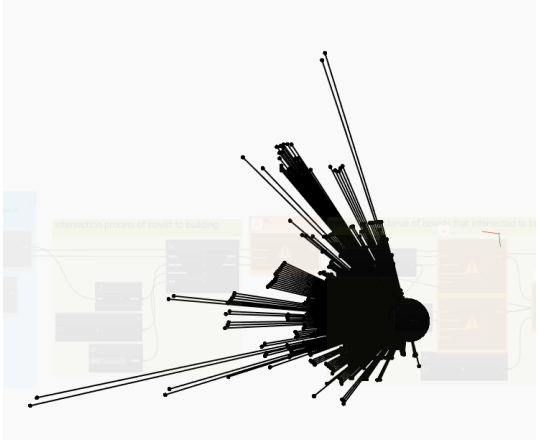
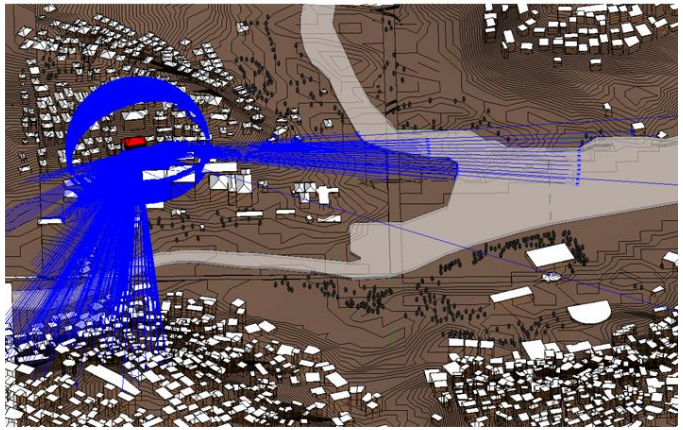


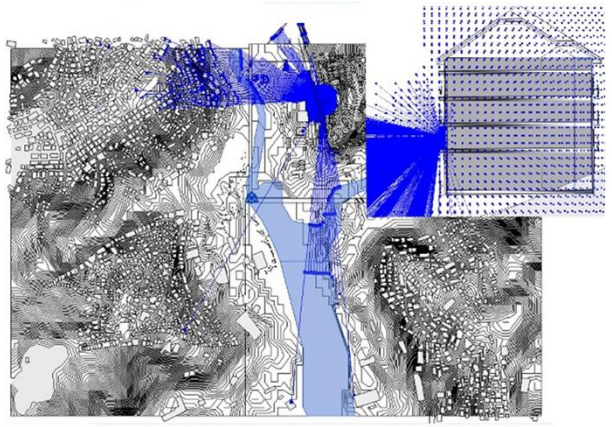
image : * drawing

BIM | VISIBILITY ANALYSIS

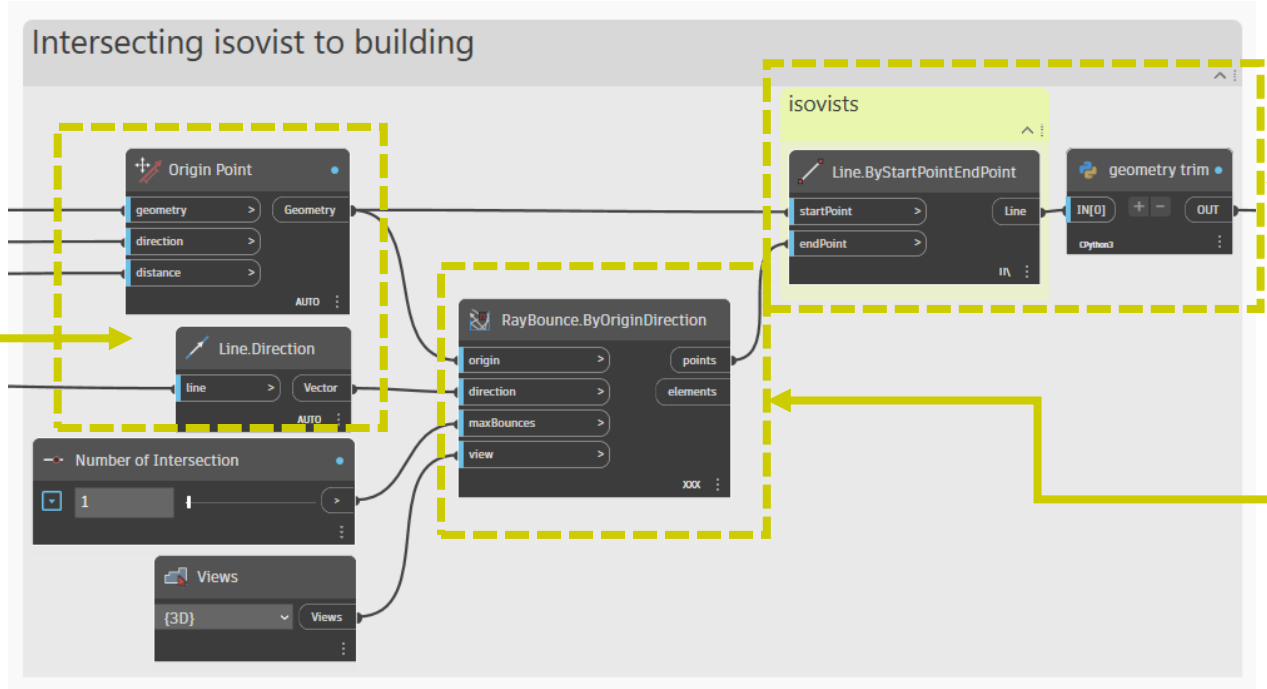
1- Isovists







2- Finding the intersection point on Visual Programming



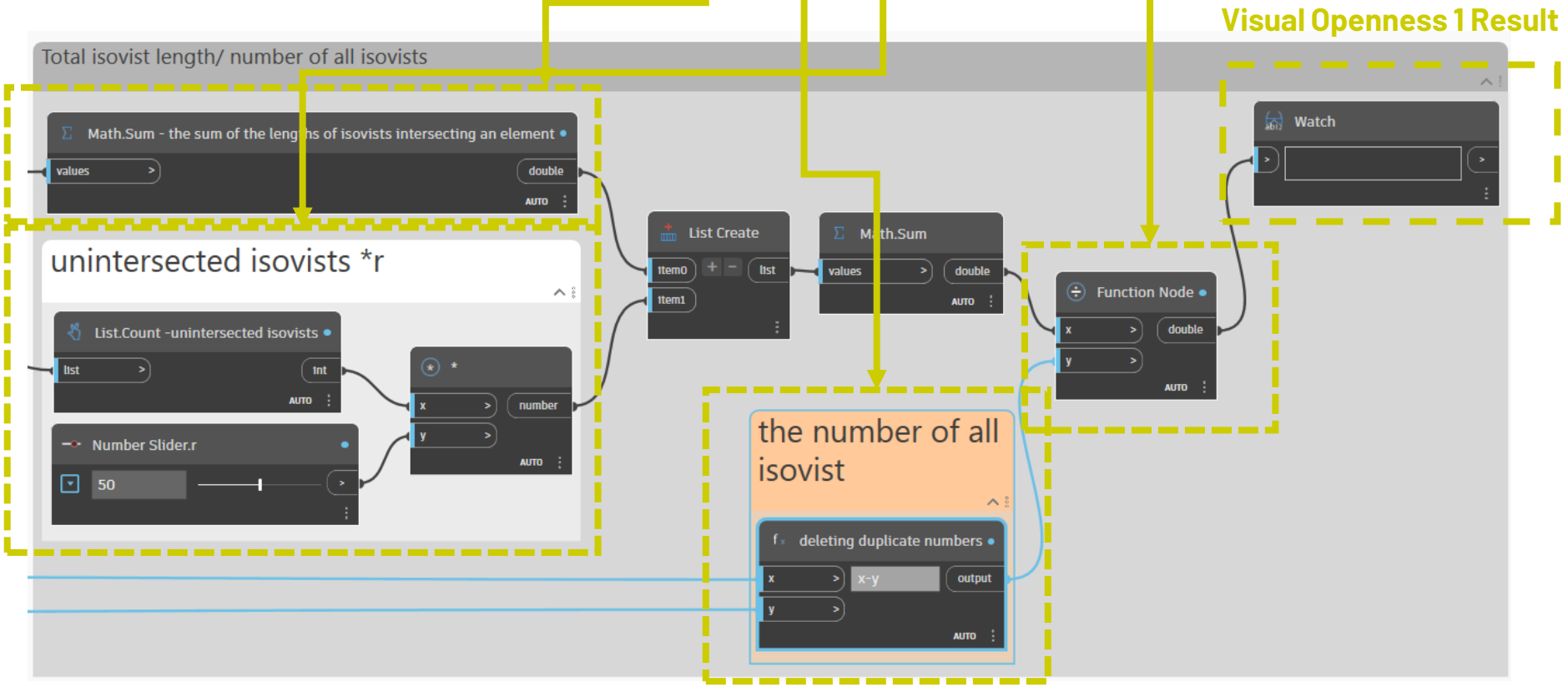
*

image : * BIM Software

BIM | VISIBILITY ANALYSIS

2- Visual Openness 1 on Visual Programming

$$VO1 = \frac{(\sum_{i-1}^{n1} l_i + \sum_{i-1}^{n2} r)}{(n1 + n2)}$$



The specified distance is given by user demand.

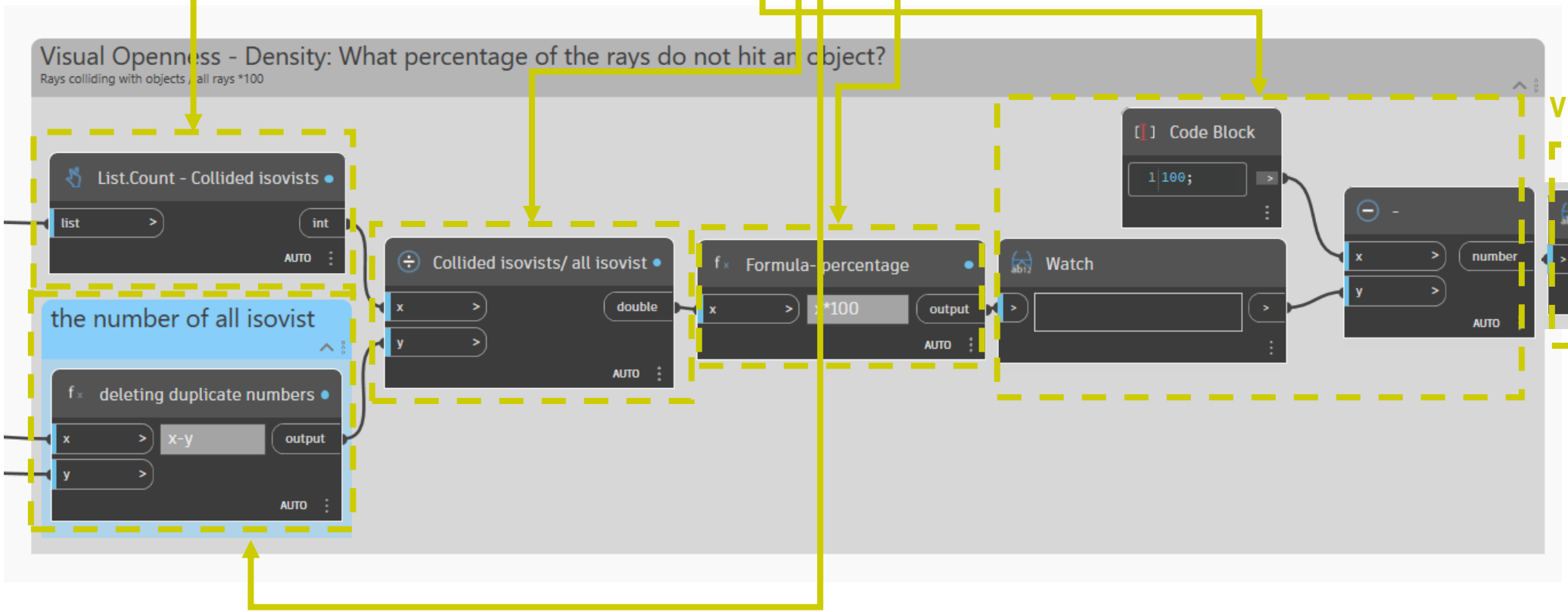
*

image : * BIM Software

BIM | VISIBILITY ANALYSIS

2- Visual Openness
2 on Visual
Programming

$$VO2 = 100 - \frac{x}{n} \times 100$$



*

image : * BIM Software

BIM | VISIBILITY ANALYSIS

Front Facade

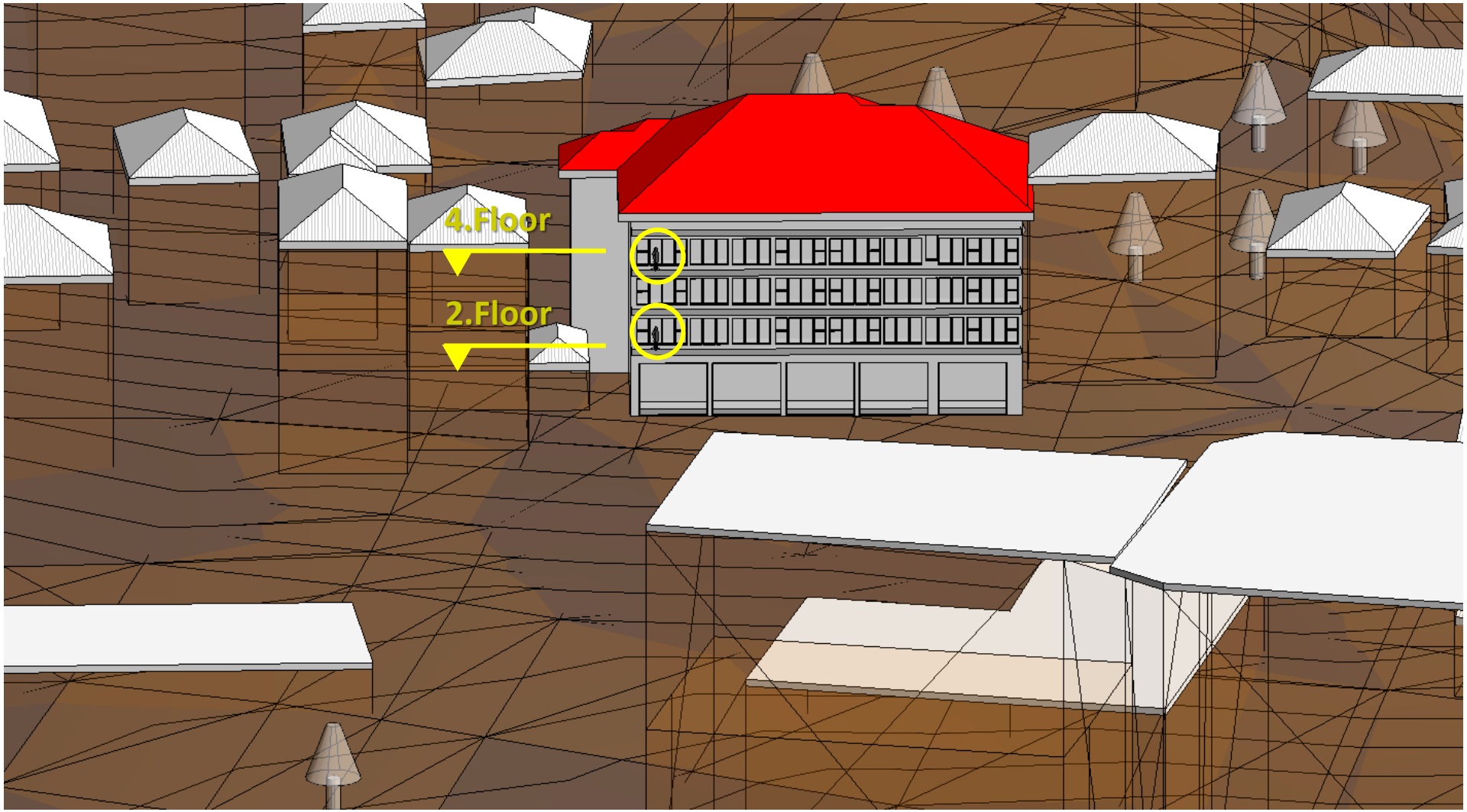


image : * BIM Software

BIM | VISIBILITY ANALYSIS

Rear Facade

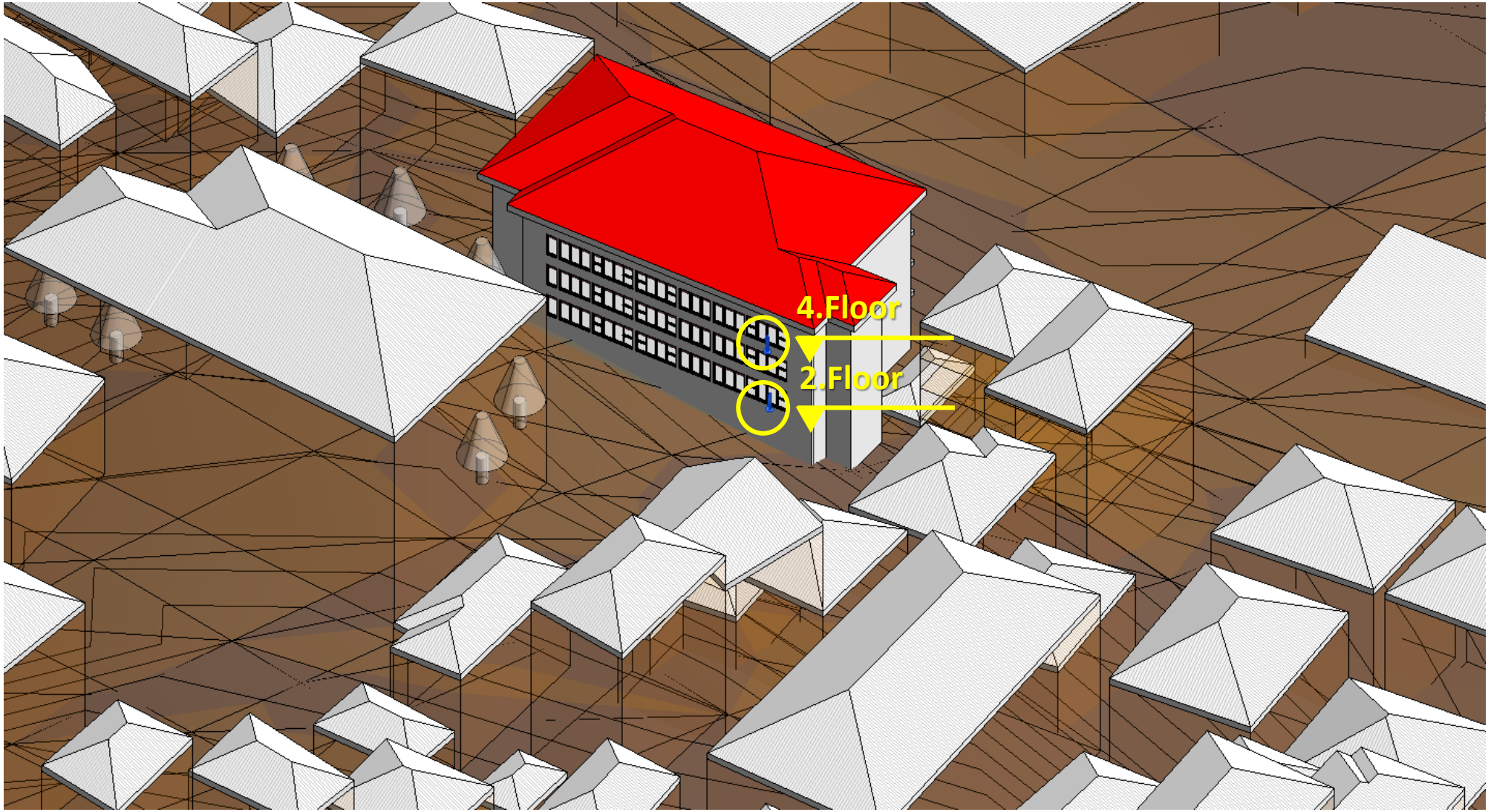
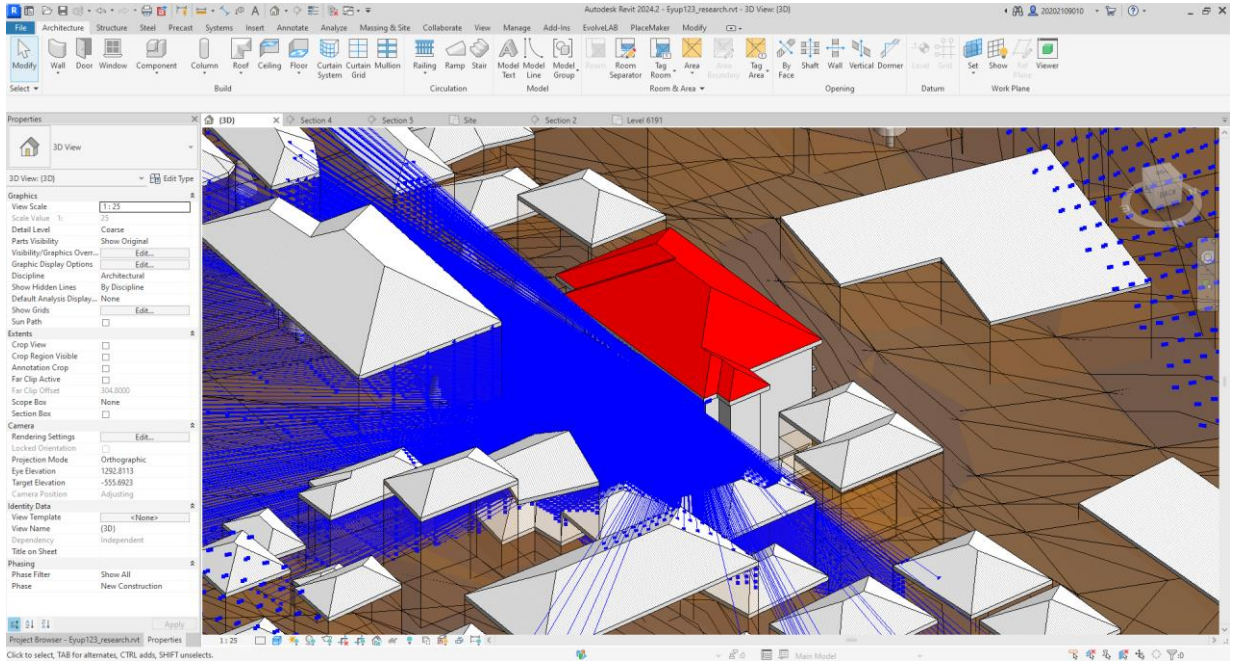
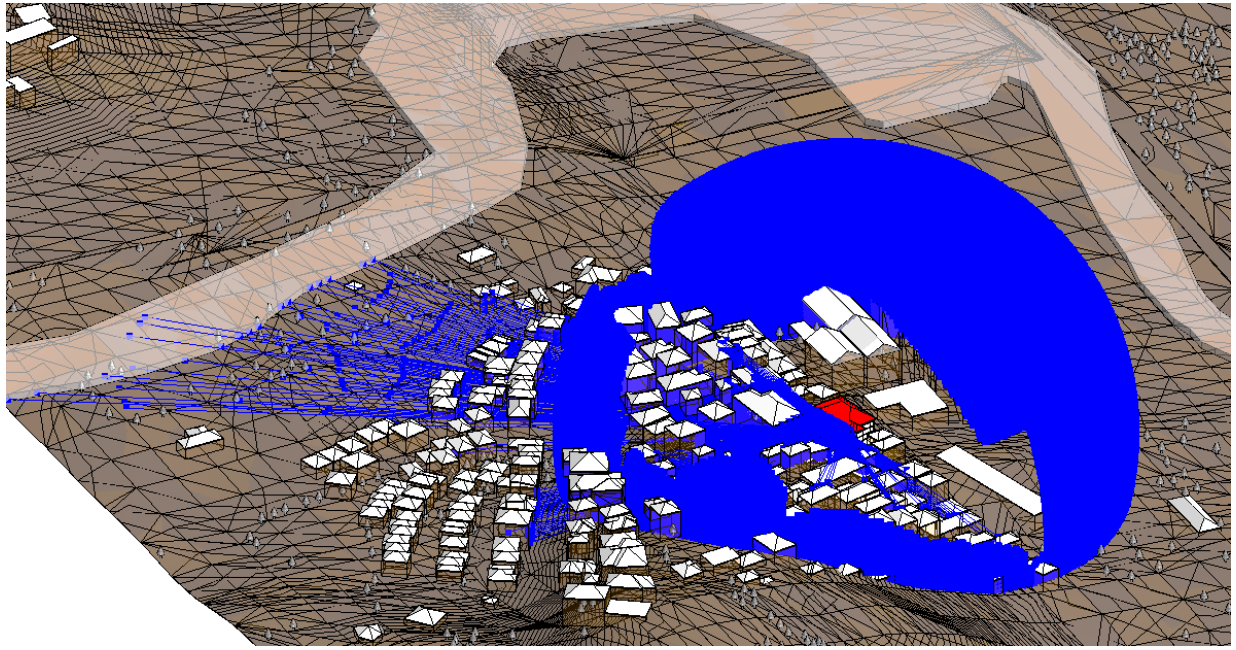


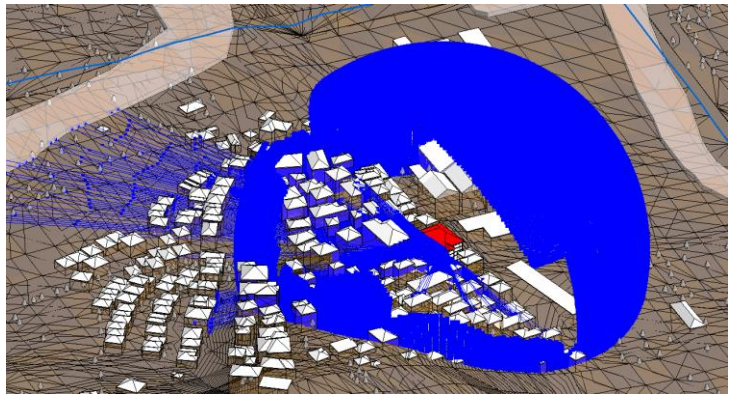
image : * BIM Software

BIM | VISIBILITY ANALYSIS

Rear facade 4th floor visibility analysis







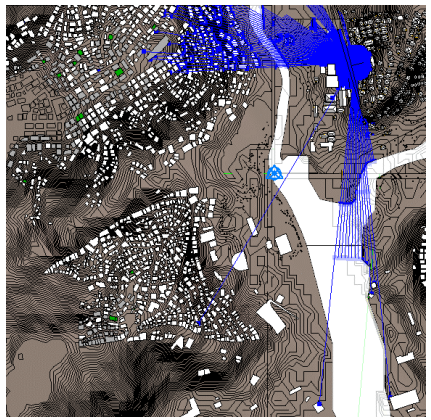


image : * BIM Software

Visibility Analysis	Visual Openness 1		Visual Openness 2
Research area	50m	150m	Limitless view
Rooms			
Front Facade Level 2	16.9851739589	38.47188612162	19.7654320988
Front Facade Level 4	18.3212858964336	40.5939256769614	20.0385802469136
Rear Facade Level 2	13.7073006160997	29.3414669437961	15.1867283950617
Rear Facade Level 4	15.6576877715483	31.8949260212159	15.6851851851852

People prefer larger view
Obtaining a higher number of visual openness index indicating that *building user comfort is higher*

Thus, achieving a higher number of visual index values can be counted as a desired feature for buildings in building appraisal

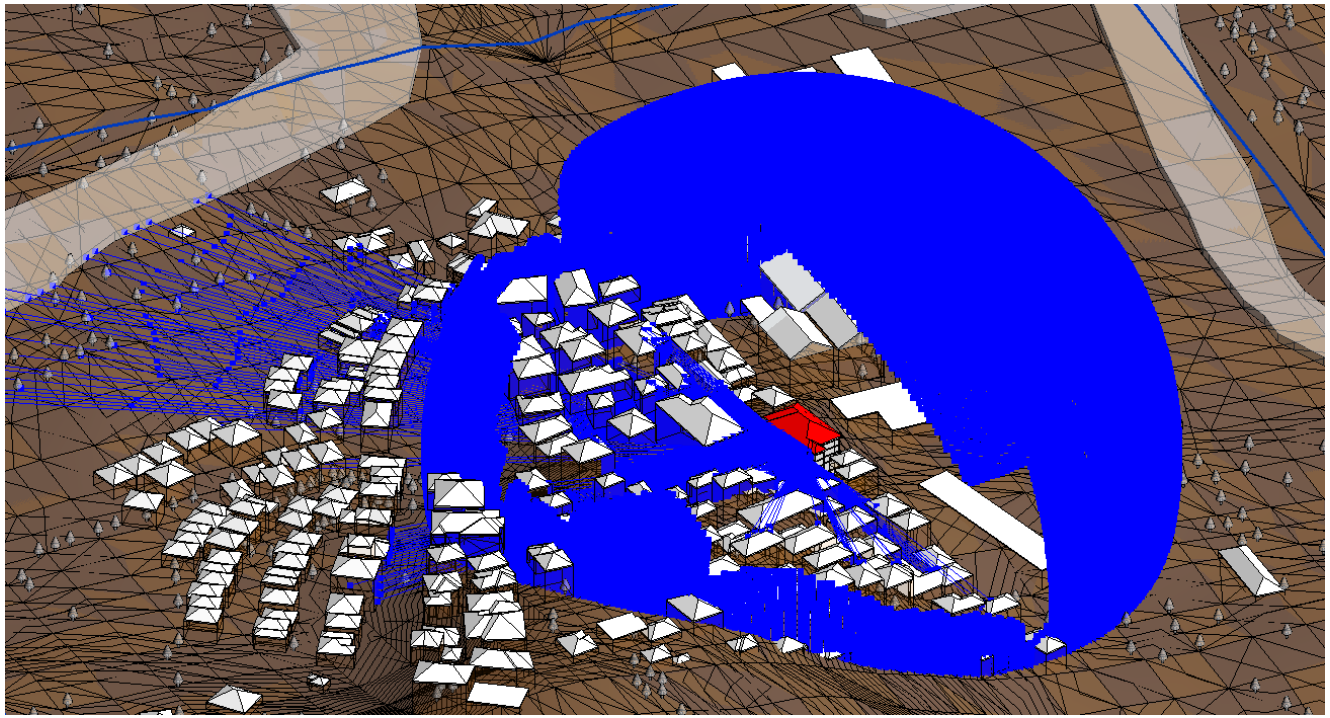
AEC sector professionals and building users can make decision from this value.

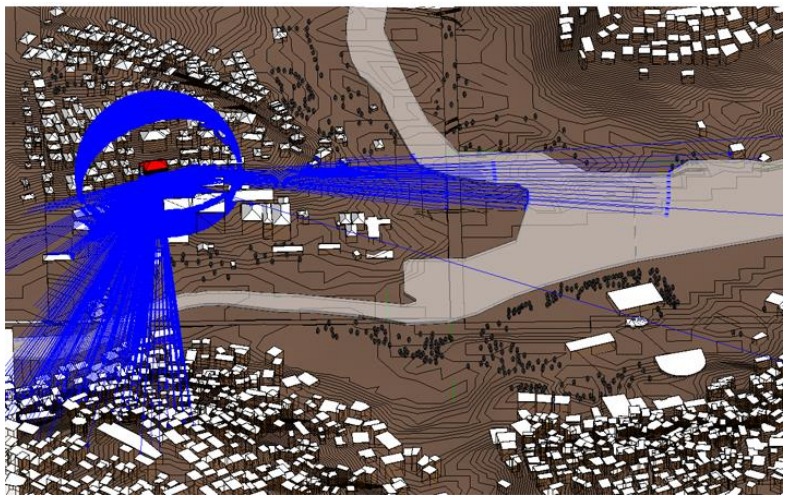
" The mean of isovists' lengths "

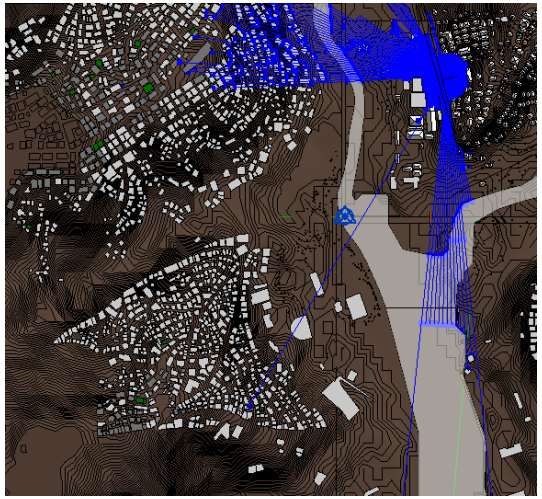
+ VO1 the longer visible area +

" The percentage of non-collided isovists"

- Non-collided isovists are reaching further and hitting objects.
- The higher number more open visible area +
- Density is less.







Contributions

workflow *3D urban model*
open-source resources *(method valid every location in the World)*
data combined on BIM software
+ 3D isovists in BIM
+ visibility evaluation method in BIM
+ digitalization in real estate evaluation + visibility
? view factor in early stages
+ BIM uses
opportunity to examine different qualities

differences

calculating the indexes in BIM
in an urban area with sloped topography

to create a sufficient result

Number of spherical coord. Points +
OSM data should increased from local sources.
DSM might be used if possible.

Cons

Long analysis period.
software upgrades
higher environment info leads crashes
in an urban area with sloped topography
100% accuracy is hardly possible – due to OSM VGI and DEM- DSM

image : * BIM Software

references

Aleksandrov, M., Zlatanova, S., Kimmel, L., Barton, J., Gorte, B., 2019. Voxel-based visibility analysis for safety assessment of urban environments, in: ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Copernicus GmbH, pp. 11–17. https://doi.org/10.5194/isprs-annals-IV-4-W8-11-2019

Al-Jameel, A.H., Al-Moula, E.K., 2023. Using Three Dimensional Isovist to Detect the Property of Surprise in Architectural Artifacts: Islamic Architecture as A Context. Eurasian Journal of Science and Engineering 9. https://doi.org/10.23918/eajse.v9i1p14

Arfken, G. 1985: *Mathematical Methods for Physicists*, Academic Press, 102-111.

Batty, M., 2001. Exploring isovist fields: Space and Shape in Architectural and Urban Morphology. Environ Plann B Plann Des 28, 123–150. https://doi.org/10.1068/b2725

Benedikt, M.L., 1979. To Take Hold of Space: Isovists and Isovist Fields. Environment and Planning B 6, 47–65.

Bernard, J., Bocher, E., Le Saux Wiederhold, E., Leconte, F., Masson, V., 2022. Estimation of missing building height in OpenStreetMap data: a French Case Study Using GeoClimate 0.0.1. Geoscientific Model Development 15, 7505–7532. https://doi.org/10.5194/gmd-2021-428

Biljecki, F., Chow, Y.S., Lee, K., 2023. Quality of crowdsourced geospatial building information: A global assessment of OpenStreetMap attributes. Build Environ 237, 110295. https://doi.org/10.1016/j.buildenv.2023.110295

De Floriani, L., Magillo, P., 2003. Algorithms for visibility computation on terrains: A survey. Environ Plann B Plann Des 30, 709–728. https://doi.org/10.1068/b12979

Evans Gary W., Lepore, S.J., Schroeder, A., 1996. The role of interior design elements in human responses to crowding. Journal of Personality and Social Psychology 70, 41–46.

Fisher-Gewirtzman, D., 2018. Integrating 'weighted views' to quantitative 3D visibility analysis as a predictive tool for perception of space. Environ Plan B Urban Anal City Sci 45, 345–366. https://doi.org/10.1177/0265813516676486

Fisher-Gewirtzman, D., Shach-Pinsly, D., Wagner, I.A., Burt, M., 2005. View-oriented three-dimensional visual analysis models for the urban environment. Urban Design International 10, 23–37. https://doi.org/10.1057/palgrave.udi.9000133

Fisher-Gewirtzman, D., Shashkov, A., Doytsher, Y., 2013. Voxel based volumetric visibility analysis of urban environments. Survey Review 45, 451–461. https://doi.org/10.1179/1752270613Y.0000000059

Fisher-Gewirtzman, D., Wagner, I.A., 2003. Spatial openness as a practical metric for evaluating built-up environments. Environ Plann B Plann Des 30, 37–49. https://doi.org/10.1068/b12861

Gibson, J., 1966. The Senses Considered As Perceptual Systems, in: Gibson, J. (Ed.), The Senses Considered As Perceptual Systems. Houghton Mifflin.

Goldstein, R., Walmsley, K., Morris, N., Tessier, A., 2023. Algorithms for Voxel-based Architectural Space Analysis, in: Nnual Modeling and Simulation Conference . Canada.

Gorte, B., 2023. Analysis of very large voxel datasets. International Journal of Applied Earth Observation and Geoinformation. https://doi.org/10.1016/j.jag.2023.103316

Guliker, E., Folmer, E., van Sinderen, M., 2022. Spatial Determinants of Real Estate Appraisals in The Netherlands: A Machine Learning Approach. ISPRS Int J Geoinf 11. https://doi.org/10.3390/ijgi11020125

Guyo, E., Hartmann, T., Ungureanu, L., 2021. Interoperability between BIM and GIS through open data standards: An overview of current literature under Creative Commons License Attribution 4.0 International (CC BY 4.0).

Kara, A., Çağdaş, V., Isikdag, U., van Oosterom, P., Lemmen, C., Stubkjaer, E., 2021. The LADM Valuation Information Model and its application to the Turkey case. Land use policy 104. https://doi.org/10.1016/j.landusepol.2021.105307

references

Ko, W.H., Kent, M.G., Schiavon, S., Levitt, B., Betti, G., 2021. A Window View Quality Assessment Framework. LEUKOS - Journal of Illuminating Engineering Society of North America. https://doi.org/10.1080/15502724.2021.1965889

Koltsova, A., Tuncer, B., Schmitt, G., 2022. Visibility Analysis for 3D Urban Environments, in: Proceedings of the 31st International Conference on Education and Research in Computer Aided Architectural Design in Europe (ECAADe) [Volume 2]. eCAADe, pp. 375–383. https://doi.org/10.52842/conf.ecaade.2013.2.375

Morello, E., Ratti, C., 2009. A digital image of the city: 3D isovists in Lynch's urban analysis. Environ Plann B Plann Des 36, 837–853. https://doi.org/10.1068/b34144t

Ofluoglu, S., Isikdag, U., 2021. Teaching BIM-enabled Performative Design, in: Proceedings of the 14th Annual AiC Conference.

Petrasova, A., Harmon, B., Petras, V., Tabrizian, P., Mitasova, H., 2018. Viewshed Analysis, in: Tangible Modeling with Open Source GIS. Springer International Publishing, pp. 127–132. https://doi.org/10.1007/978-3-319-89303-7_9

Shach-Pinsly, D., Fisher-Gewirtzman, D., Burt, M., 2011. Visual exposure and visual openness: An integrated approach and comparative evaluation. J Urban Des (Abingdon) 16, 233–256. https://doi.org/10.1080/13574809.2011.548979

Shakibamanesh, A., 2022. Investigating Mass-Space System to Reach an Optimal Model for Analyzing Visibility Among Buildings and Public Open Spaces Using Three-Dimensional Isovist. Megaron 17, 409–423. https://doi.org/10.14744/megaron.2022.33410

Tandy, C.R. V, 1967. The İsovist Method Of Landscape Survey.

Trodd, N., Underwood, J., Isikdag, U., Aouad, G., 2005. Representing 3D Building Elements using Spatial Data Structures.

Turner, A., Doxa, M., O'Sullivan, D., Penn, A., 2001. From Isovists to Visibility Graphs: A Methodology for the Analysis of Architectural Space. Environ Plann B Plann Des 28, 103–121. https://doi.org/10.1068/b2684

Ünlü, A., Edgü, E., Şalgamcioğlu, M.E., Canakcioglu, N.G., 2022. Exploring perceived openness and spaciousness: the effects of semantic and physical aspects. Archit Sci Rev 65, 162–174. https://doi.org/10.1080/00038628.2022.2039092

U.S. Green Building Council, 2020. LEED v4.1 INTERIOR DESIGN AND CONSTRUCTION.

Suleiman, W., Thierry, J., Favier, E., 2011. 3D Urban Visibility Analysis with Vector GIS Data.

Suleiman, W., Joliveau, T., Favier, E., 2013. A New Algorithm for 3D Isovist.

Wu, C., Zarrinmehr, S., Clayton, M.J., Rahmani Asl, M., Clatyon, M.J., 2019. An Automated Framework Creating Parametric BIM from GIS Data to Support Design Decisions.

Yang, P.P.J., Putra, S.Y., Li, W., 2007. Viewsphere: A GIS-based 3D visibility analysis for urban design evaluation. Environ Plann B Plann Des 34, 971–992. https://doi.org/10.1068/b32142

Yanılmaz, Z., Tavşan, F., 2021. Sürdürülebilir Eğitim Yapılarında Konfor Koşullarına İlişkin Kullanıcı Görüşleri. Mehmet Akif Ersoy Üniversitesi Fen Bilimleri Enstitüsü Dergisi. https://doi.org/10.29048/makufebed.928538

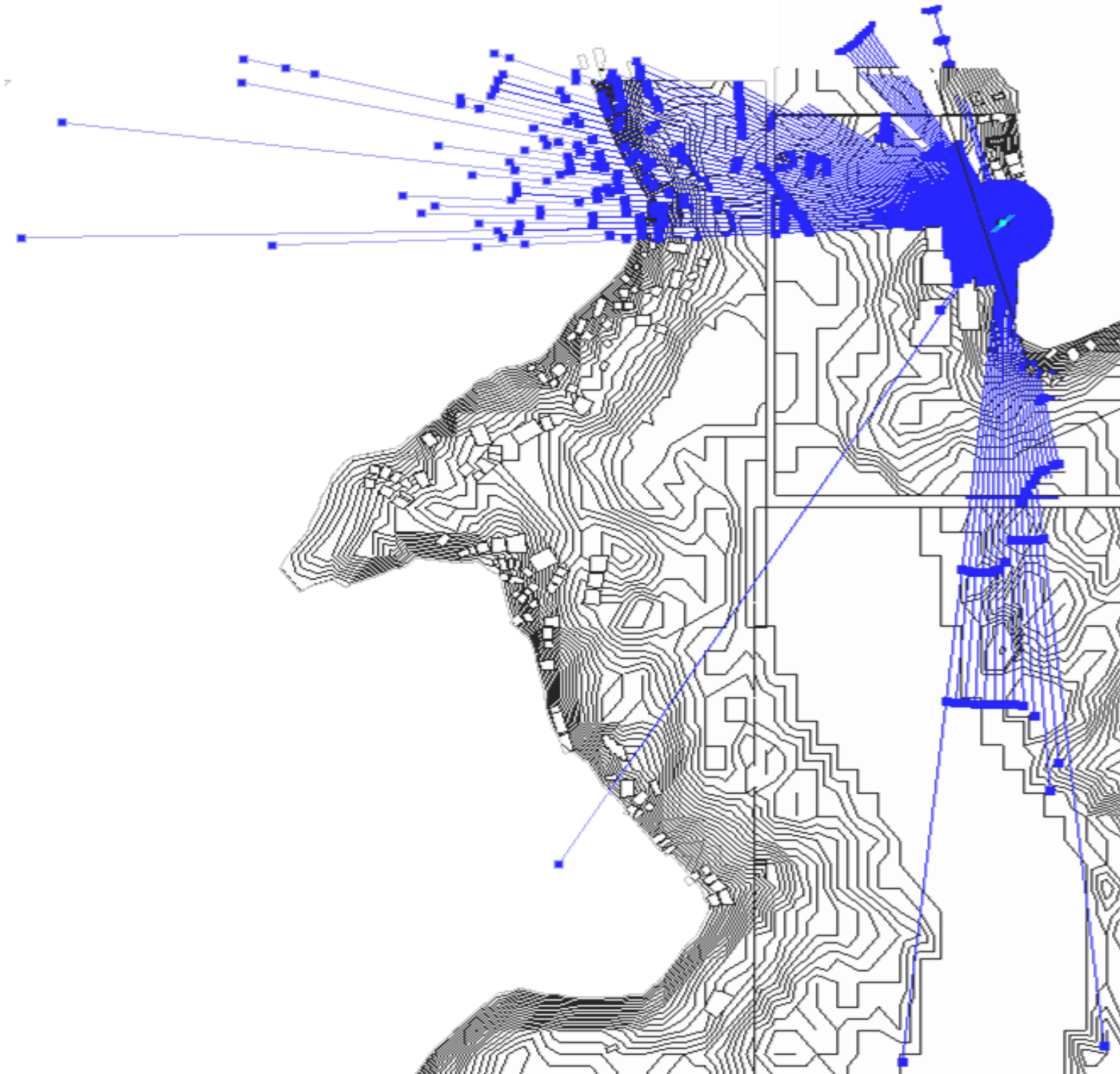
Zheng, H., Wu, B., Zhang, J., Yan, J., Wei, H., 2022. Refining the potential visual exposure index for the assessment of residential visual privacy: a three-dimensional study. Journal of Asian Architecture and Building Engineering. https://doi.org/10.1080/13467581.2022.2085724

Zlatanova, S., Isikdag, U., 2016. Building Information Modelling: Essentials and Issues The need to Integrate BIM and Geoinformation. GIM International: the worldwide magazine for geomatics 30, 27–29.

GeoAdvances 2024

12.01.24 | Session 5-4

Thank you.



Mimar Sinan
Fine Arts Universty