LBS 2023
18th Conference on Location Based Services
November 20-22, Ghent, Belgium

Indoor Localisation through Isovist Fingerprinting from Point Clouds and Floor Plans

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LBS2023 November 20-22. Ghent, Belgium

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- LBS2021 – Online

Building Rhythms: Reopening the Workspace with Indoor Localisation

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**Esri Nederland

- LBS2023 – Offshore
  - “Offshore in USA now, 15 miles south of Martha's Vineyard Island. We are building the 1st ever wind farm in the USA.”

Presentation overview

- Key concepts definition
- Brief Introduction & Problem definition
- Relevance and motivation
- Methodology
- Implementation
- Results
- Conclusions
- Applications and Future prospect
- Reflection

Key concepts definition

Radio Map

Map which containing the according data into a database

Fingerprinting

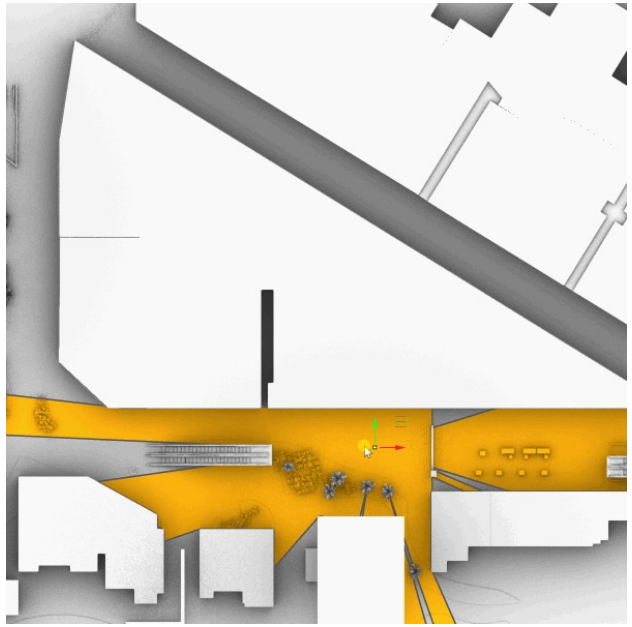
Technique used to compare the radio map with the according data produced by user

Space Syntax

Isovist is the set of all points visible from a specific vantage point in space and with respect to the environment

LiDAR

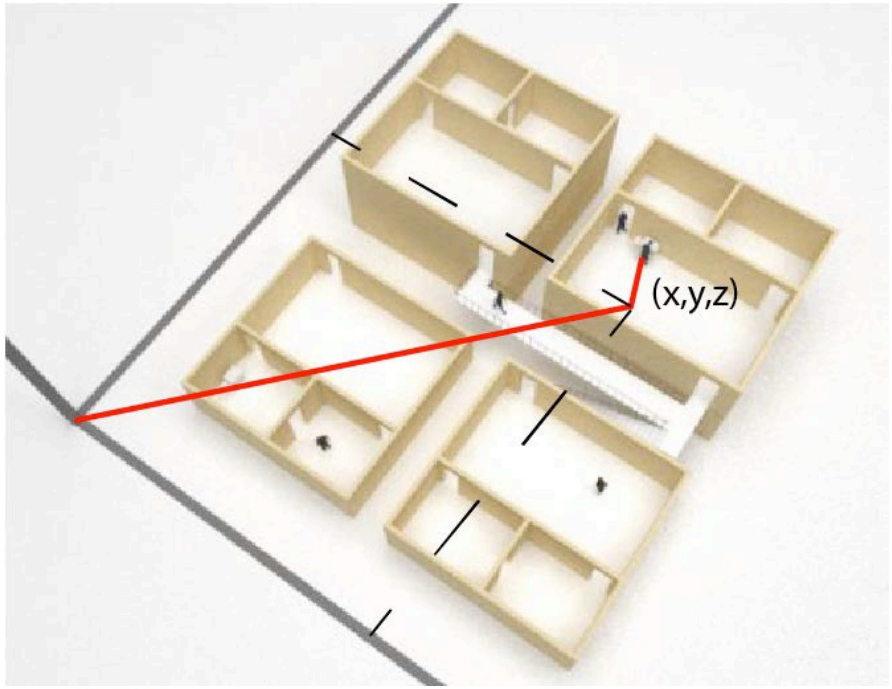
Light Detection And Ranging. Using Laser Beams to create 3D representation of the environment

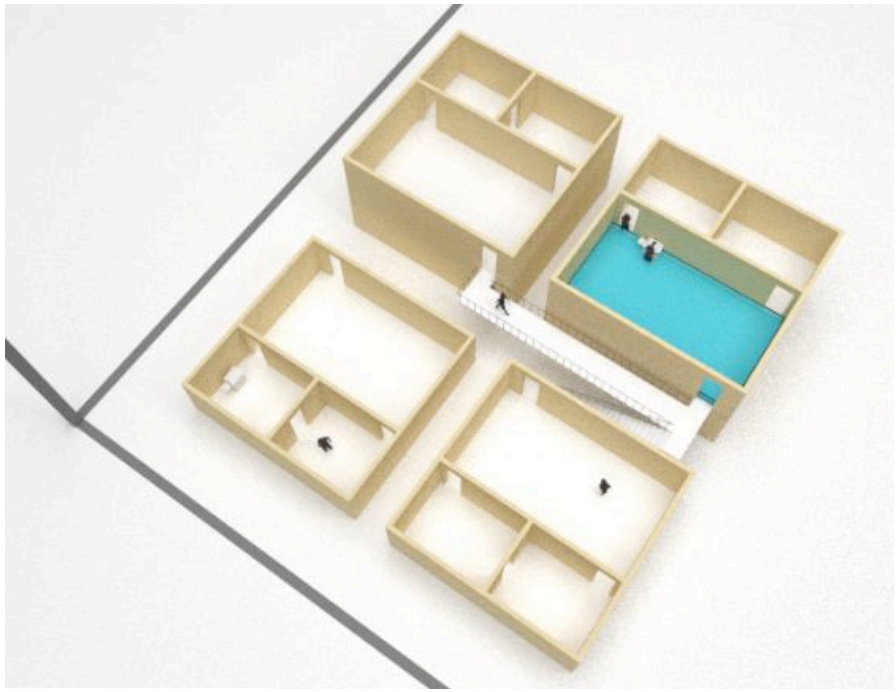


https://toolbox.decodingspaces.net/tutorial-2d-and-3d-isovists-for-visibility-analysis/

Position versus Location

- We specify a location referring to the smallest physically defined space in a building.
- These can be rooms, corridors, stairs, hall etc





ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume III-4, 2016
XXIII ISPRS Congress, 12–19 July 2016, Prague, Czech Republic

POSITION, LOCATION, PLACE AND AREA: AN INDOOR PERSPECTIVE

George Sithole[a*], Sisi Zlatanova[b]

WHY INDOOR LOCALISATION?

- People spend most of their time indoors
- Easy to lose orientation
  (complex buildings, absence of significant landmarks)
- Bad GNSS reception
- Emergency situations
- Efficient management

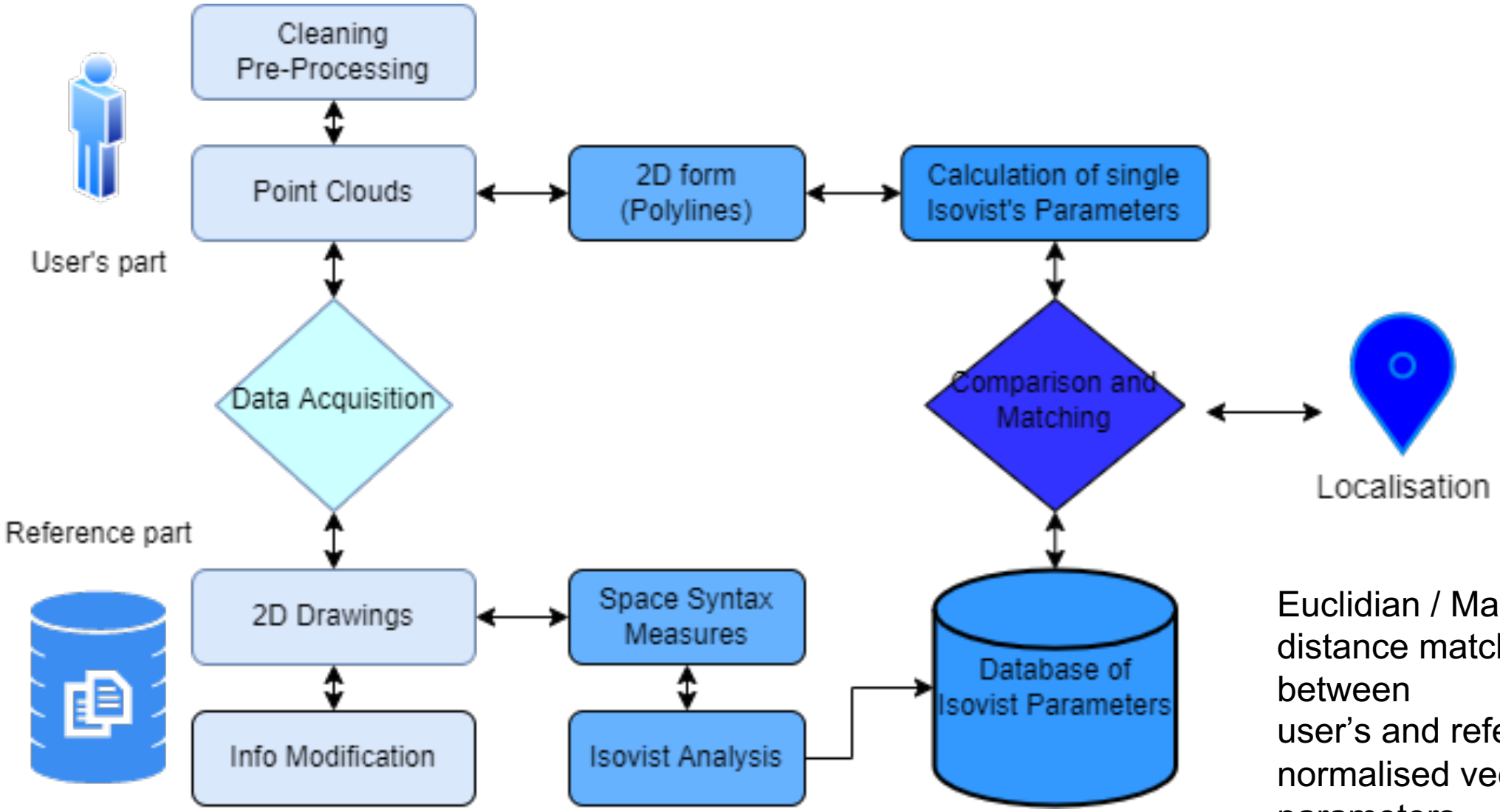
Why isovist?

- No need of locally deployed infrastructure
- Lower Cost than other methods (Wi-Fi, Bluetooth)
- Basis for navigation **WITH** better Visibility
- LiDAR on smartphones makes it more accurate & approachable

Assumptions and limitations

- Proof of concept for Isovist Fingerprinting
- Does not end to a fully integrated and functional application
- Cannot and will not become the “Silver Bullet”
- No automatic integration between all the steps
- It is mainly manually implemented now with some small automation and prospect to fully automation in future
- It tests and concludes important information regarding all related factors of the topic

Methodology



Euclidian / Manhattan distance matching between user's and reference normalised vector parameters

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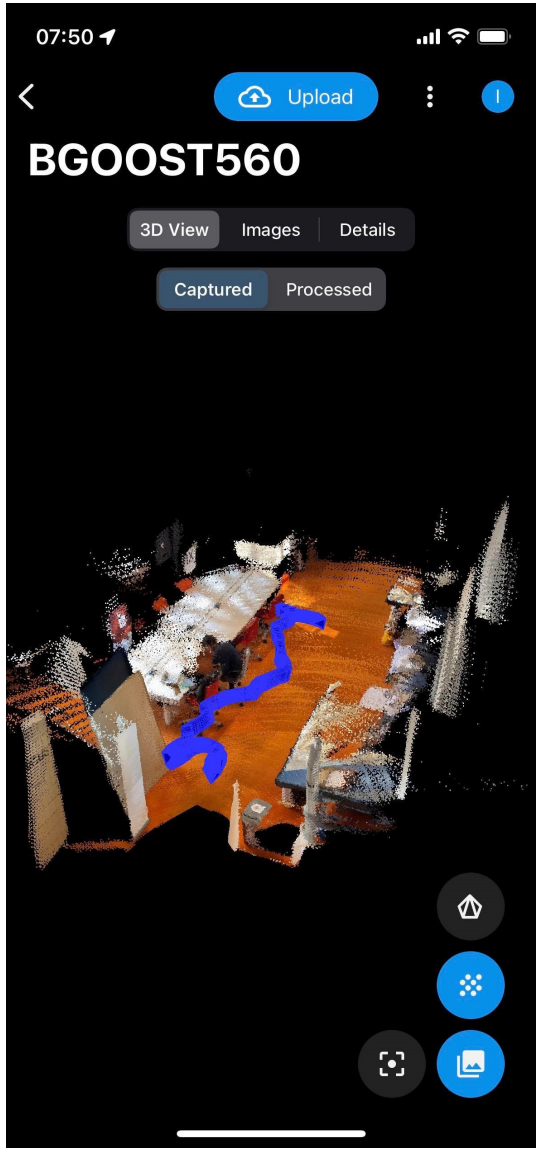
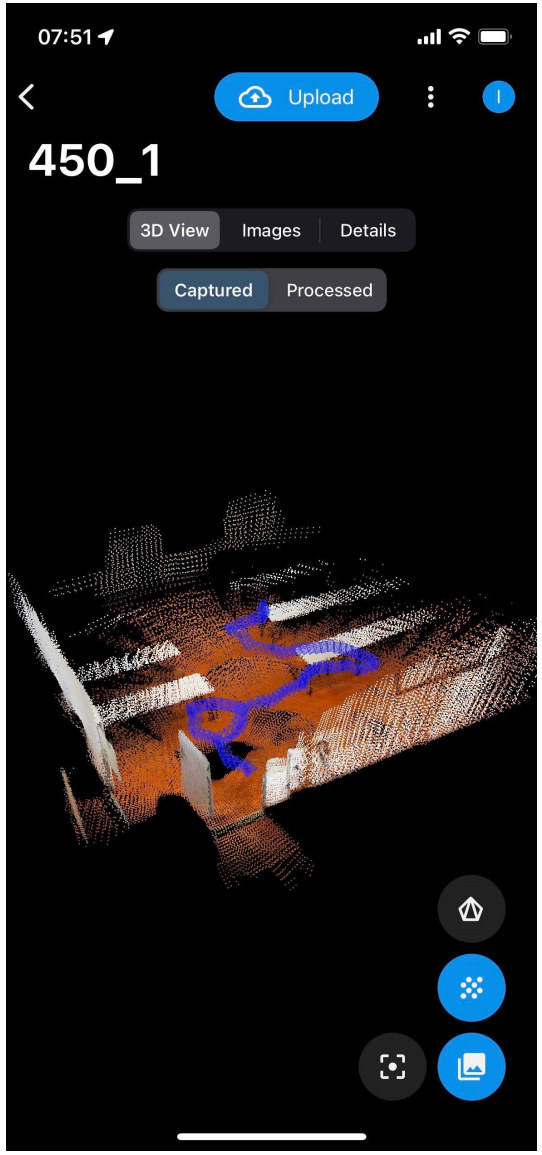
Data acquisition and manipulation

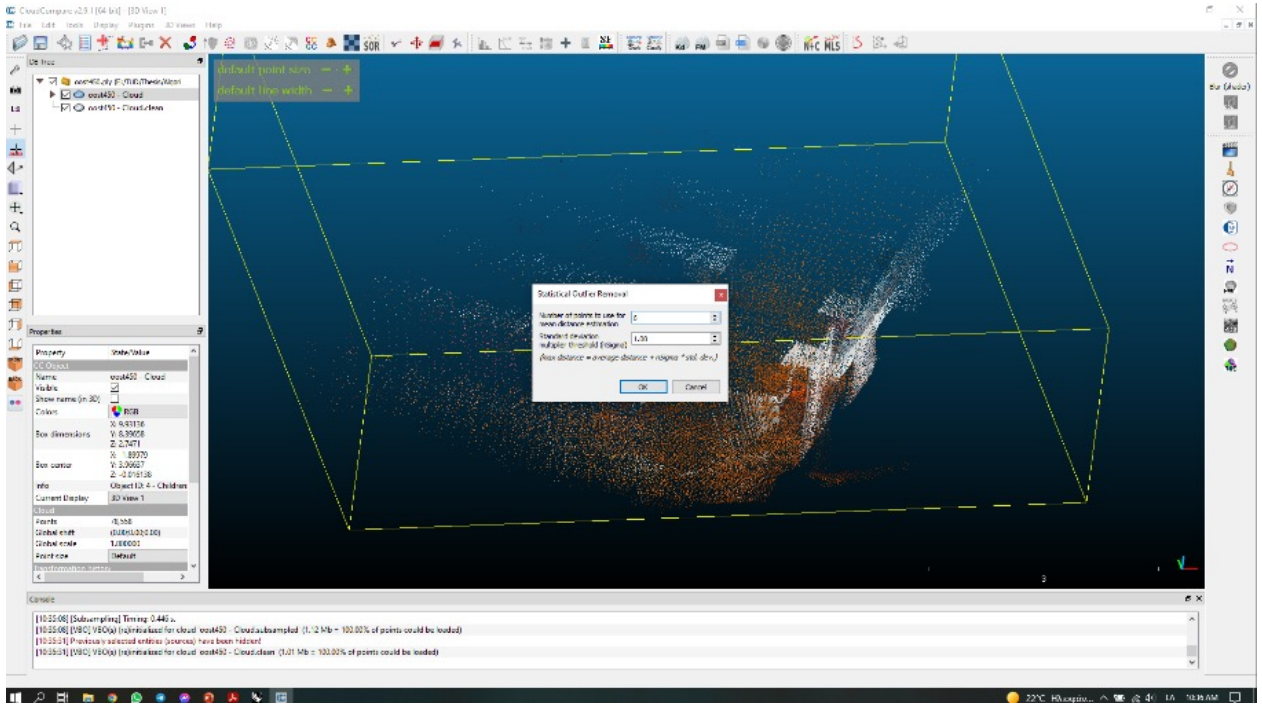
- Point Clouds
  - iPhone 12 Pro with LiDAR sensor for the user part
- Assumption
  - Point Cloud must be gathered from entrance of the room mainly

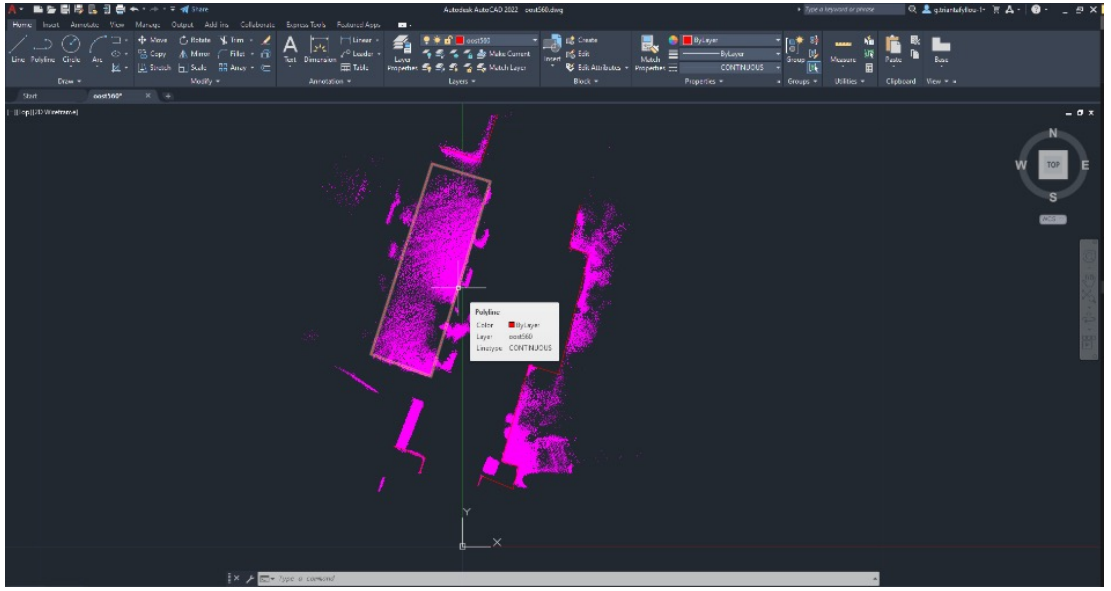




Data acquisition and manipulation
From Point Cloud to 2D – Manual Implementation

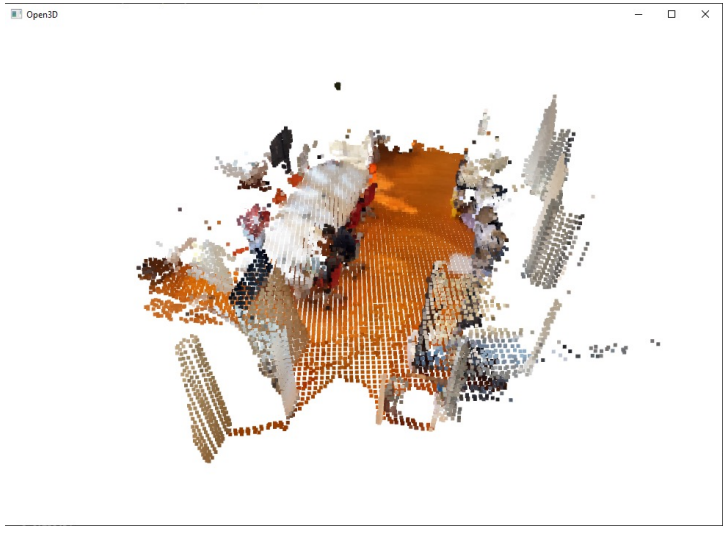
- Import to Cloud Compare
- Statistical Outliers Removal
- Slicing in height
- Export in .dxf and drawing the objects in AutoCad





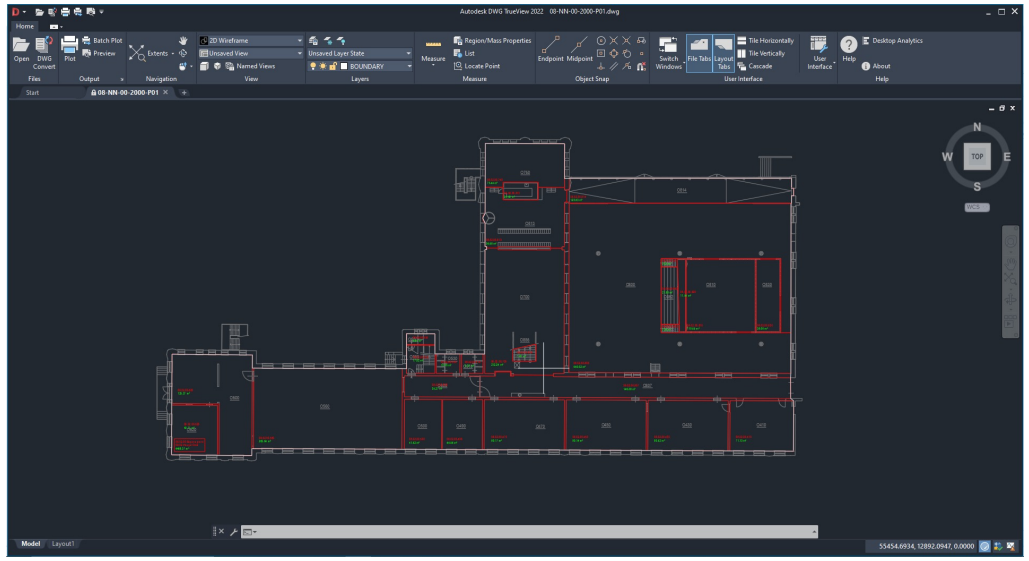
Data acquisition and manipulation
From Point Cloud to 2D - Algorithmic Implementation

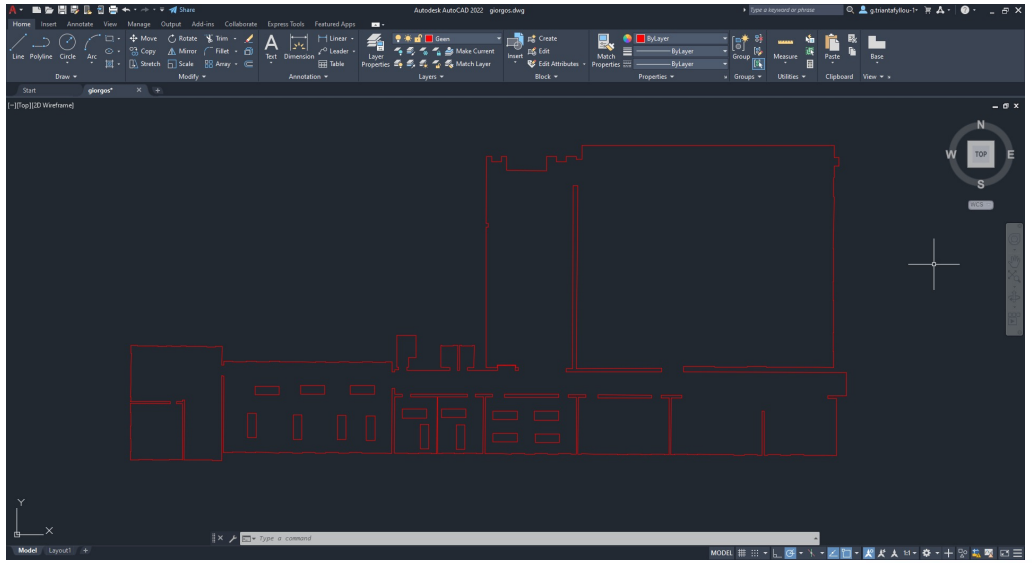
- Voxel downsampling of the point cloud
- Statistical outlier removal
- Conversion of point cloud into 3D array



Data Acquisition and Manipulation

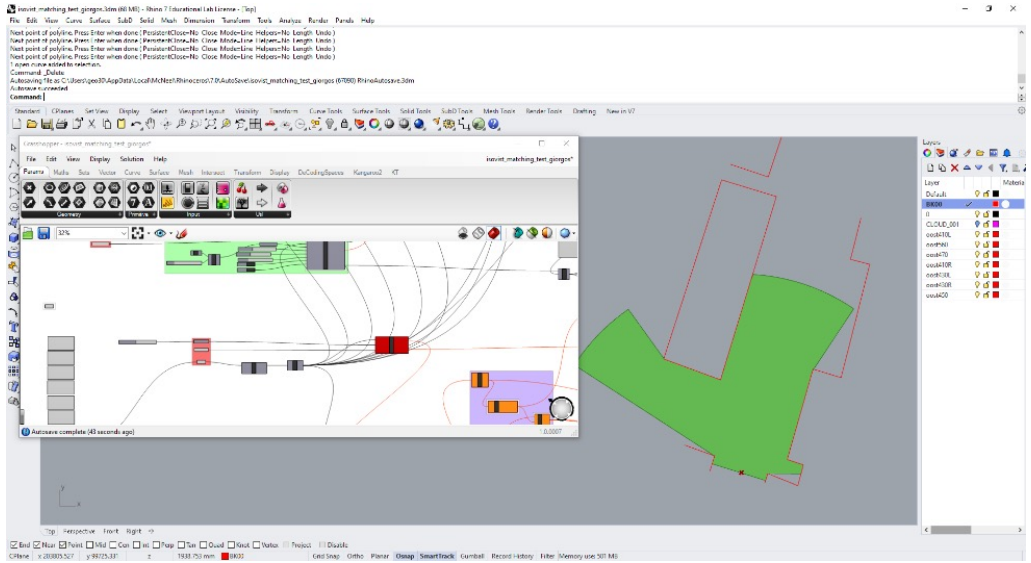
- 2D Drawings (AutoCAD)
  - Acquire floorplans and creation of one united curve
    Faculty of Architecture and the Built Environment
  - Specific Layer allocation to simplify the data
  - Addition of furniture and other unique characteristics – to make the Isovist more unique





Space syntax measures

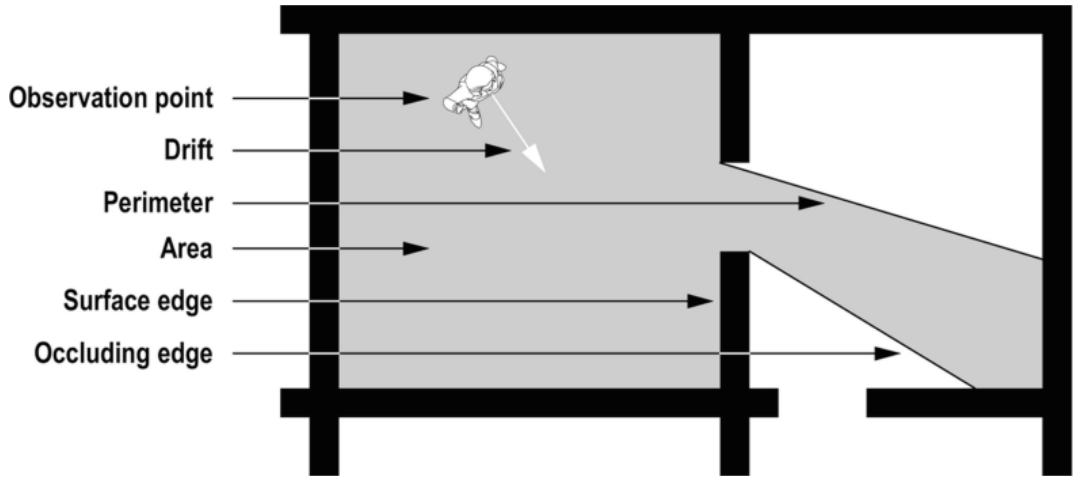
- Isovist Analysis in DeCodingSpaces Toolbox for Grasshopper of Rhino7
- Assumptions:
  - User's point chosen manually in the entrance of the rooms in the 2D info extracted by the point clouds
  - Direction, Range and other factors are also chosen manually



Area	4.7197e+7
Area (Dist Weighted)	4.7197e+7
Perimeter	45844.733289
Compactness	0.282191
Circularity	1.161382
ConvexDeficiency	0.58718
Occlusivity	13446.133648
Min Radial	0
Max Radial	10000.0
Mean Radial	4177.042493
Standard Deviation	1.1275e+6
Variance	4.5791e+9
Skewness	1.325e+13
Dispersion	-1.1233e+6
Elongation	0.417704
Drift Magnitude	4961.374764
Drift Angle	-0.021586

Isovist parameters

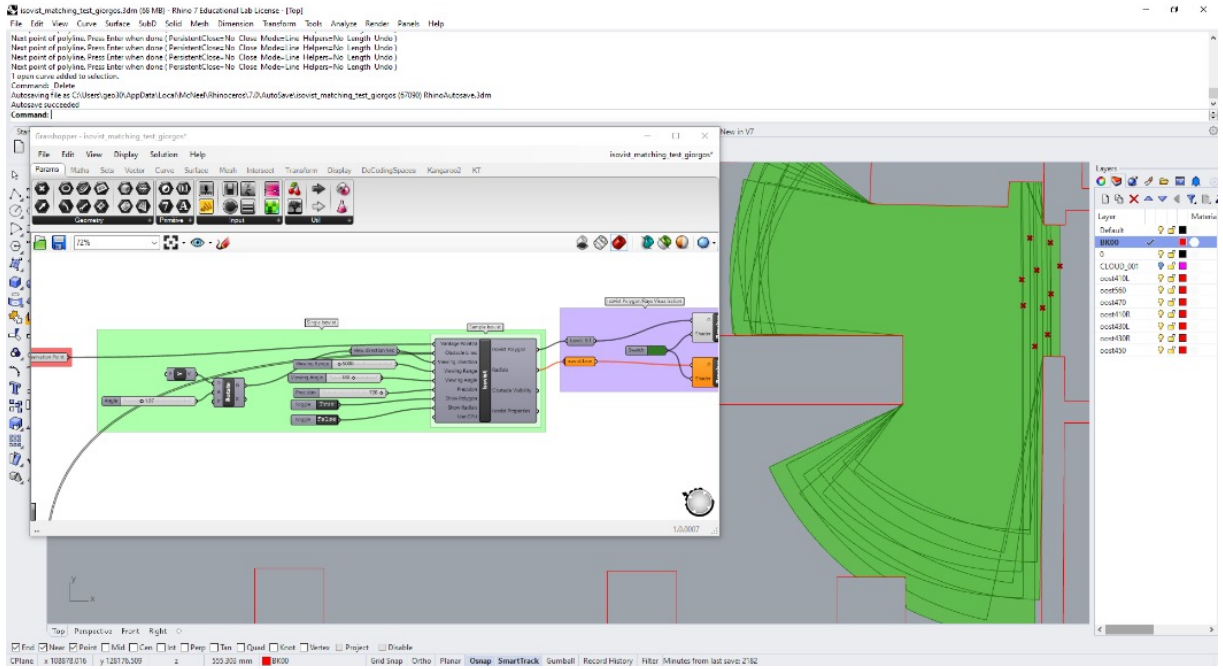
- Area: Expresses the area of all space visible from a vantage point in space
- Perimeter: Expresses the length of the edge of all space visible from a location
- Drift: Expresses the distance from a subject point to the center of gravity of its isovist
- Compactness: Expresses the shape property (relative to a circle) of all space visible from a location.



Source : Ostwald, M. J. and Dawes, M. J. (2018). Isovists: Spatio-Visual Mathematics in Architecture, pages 1–13. Springer International Publishing, Cham.

Space syntax measures

- Import the modified 2D drawings (Building's floorplans & Point Clouds)
- Grasshopper algorithm/script for Isovist analysis
  - Calculation of Isovist Polygons and 17 Parameters
  - Visualising the Isovist Polygon
  - Normalising the data of Isovist Parameters



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Isovist matching

1. Creation of a grid to the whole area & calculation of thousands isovists for the area (One Isovist per grid cell)

2. Calculation of 10 sets of Isovist on each entrance of rooms of interest

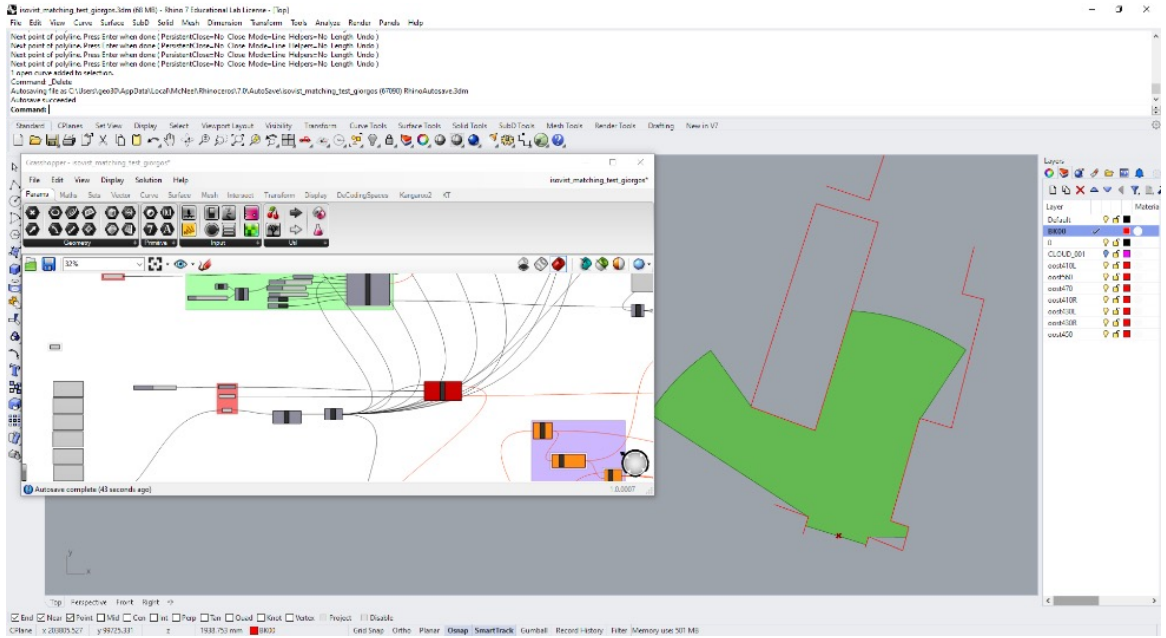
1. Calculation of one isovist each time from a moving vantage point in space

2. Calculation of one Isovist on the entrance of rooms by acquired Point Clouds

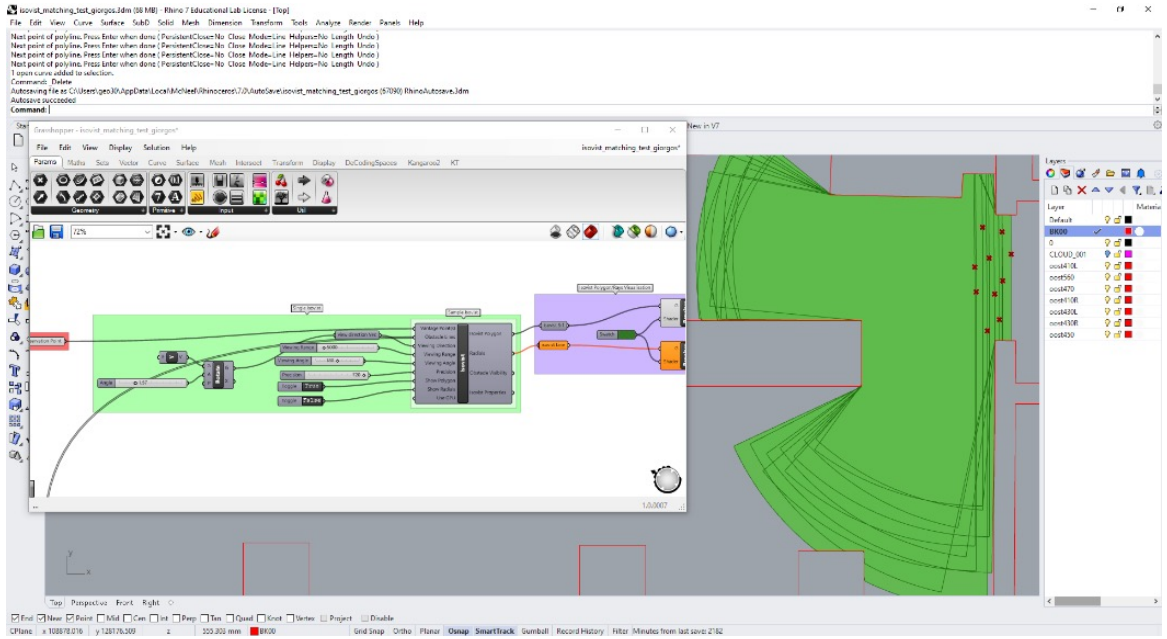
Analysing and Normalising the set of 17 Isovist parameters

Matching the single Isovist with the database by using Distance algorithm

Isovist matching

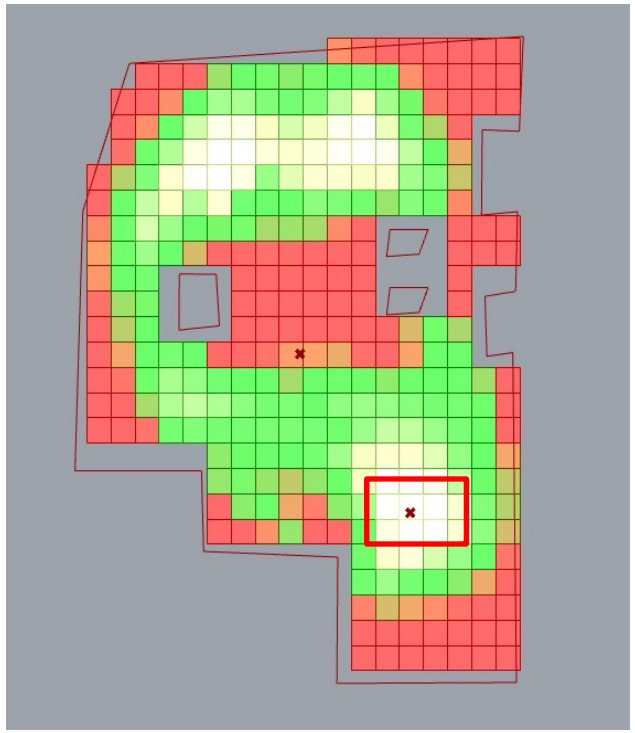


Single Isovist from Point-Cloud

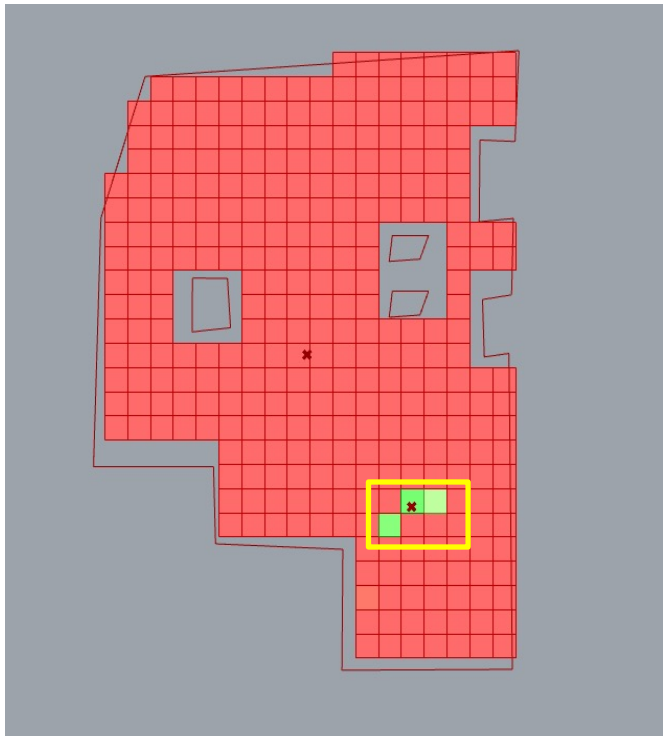


Set of 10 Isovists of an Entrance

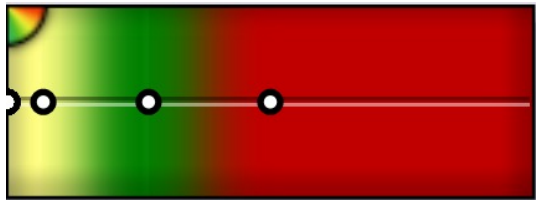
Isovist Matching



14 parameters 360°



17 parameters 360°



Best -----> Worst

Applications and future prospect

- Promising method for the future especially in combination with other methods
- Basis for navigation by using better visibility options
- Locating expensive machines (Hospitals, Factories)
- Use lidar for continuous update of the database

Thank you for your attention
TU Delft