

ISOVIST FINGERPRINTING AS NEW WAY OF INDOOR LOCALISATION

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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

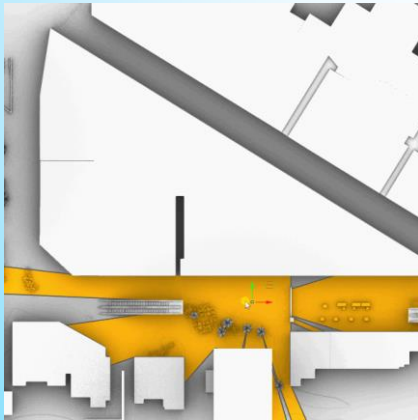
Technique used to compare the radio map with the according data produced by user

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



INTRODUCTION & PROBLEM DEFINITION

Ancient times

- Relative position based on stars (Sailors)
- Relative position based on what visible around



<http://www.weems-plath.com/About/History-of-Navigation.html>

Today

- GNSS provides exact position with coordinates
- Outdoors: Mostly accurate
- Indoors: No signal and bad reception

Positioning VS Localisation

- Exact position with coordinates
- Approximate and Contextual information



<https://leica-geosystems.com/nl-nl/products/gnss-systems>

INDOOR LOCALISATION

TERRA INCOGNITA TO BE DISCOVERED

- ▶ There is not one 'silver bullet'

- ▶ "We now use the term 'silver bullet' to refer to an action which cuts through complexity and provides an immediate solution to a problem. The allusion is to a miraculous fix, otherwise portrayed as 'waving a magic wand'."

- ▶ There is a need for indoor localisation.

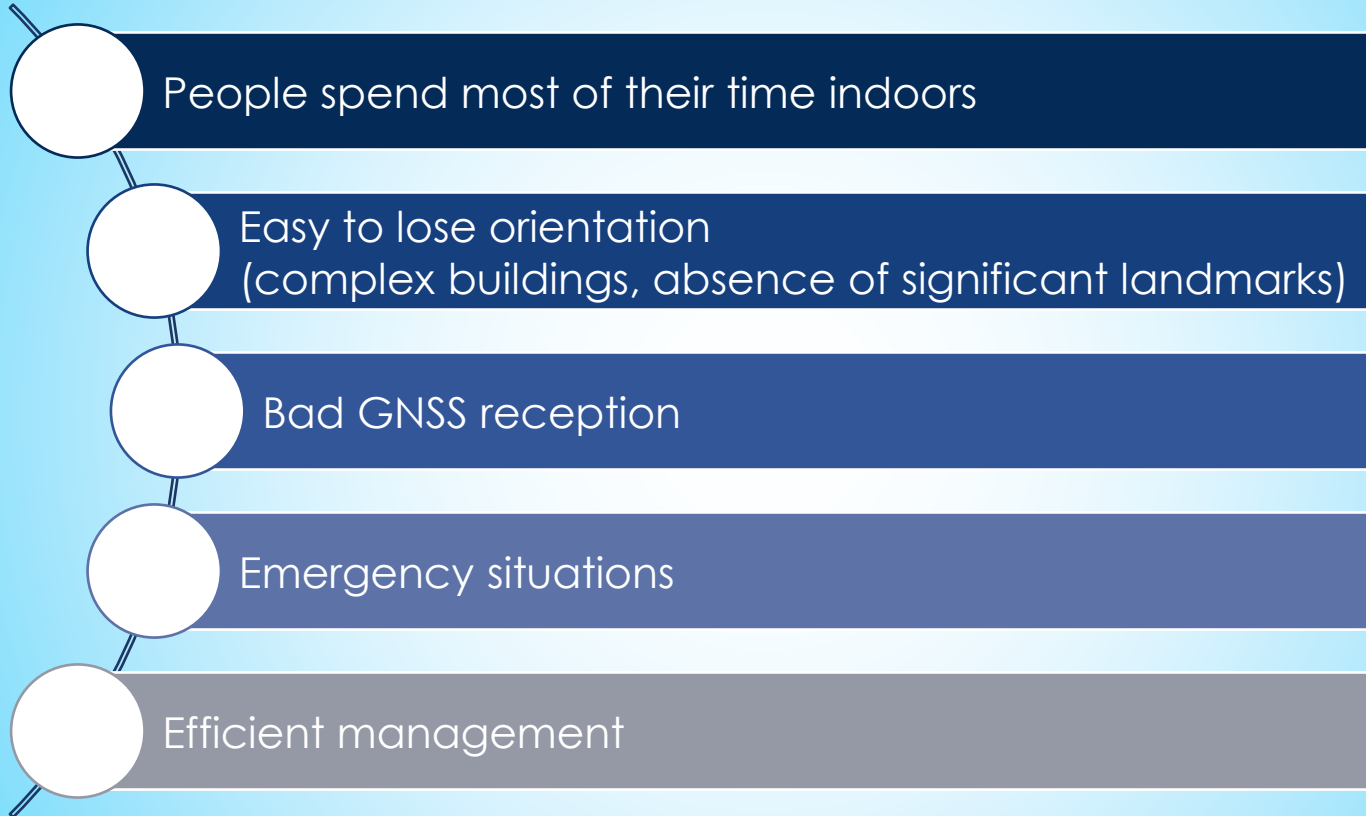
- ▶ Not only 'point positioning' but meaningful 'place localisation':

- "Where am I?"

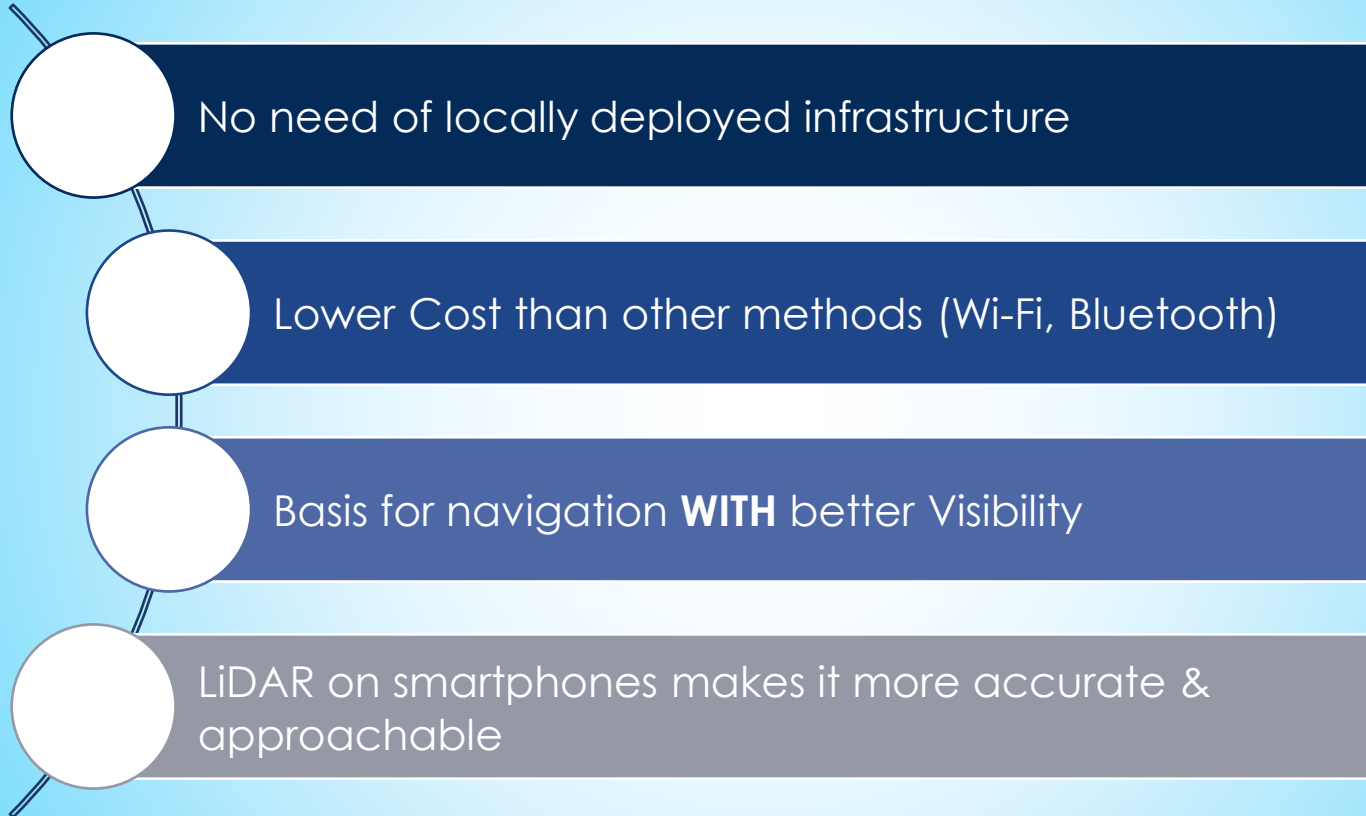
- ▶ Also meaningful indoor '3D mapping':

- "I am here".

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

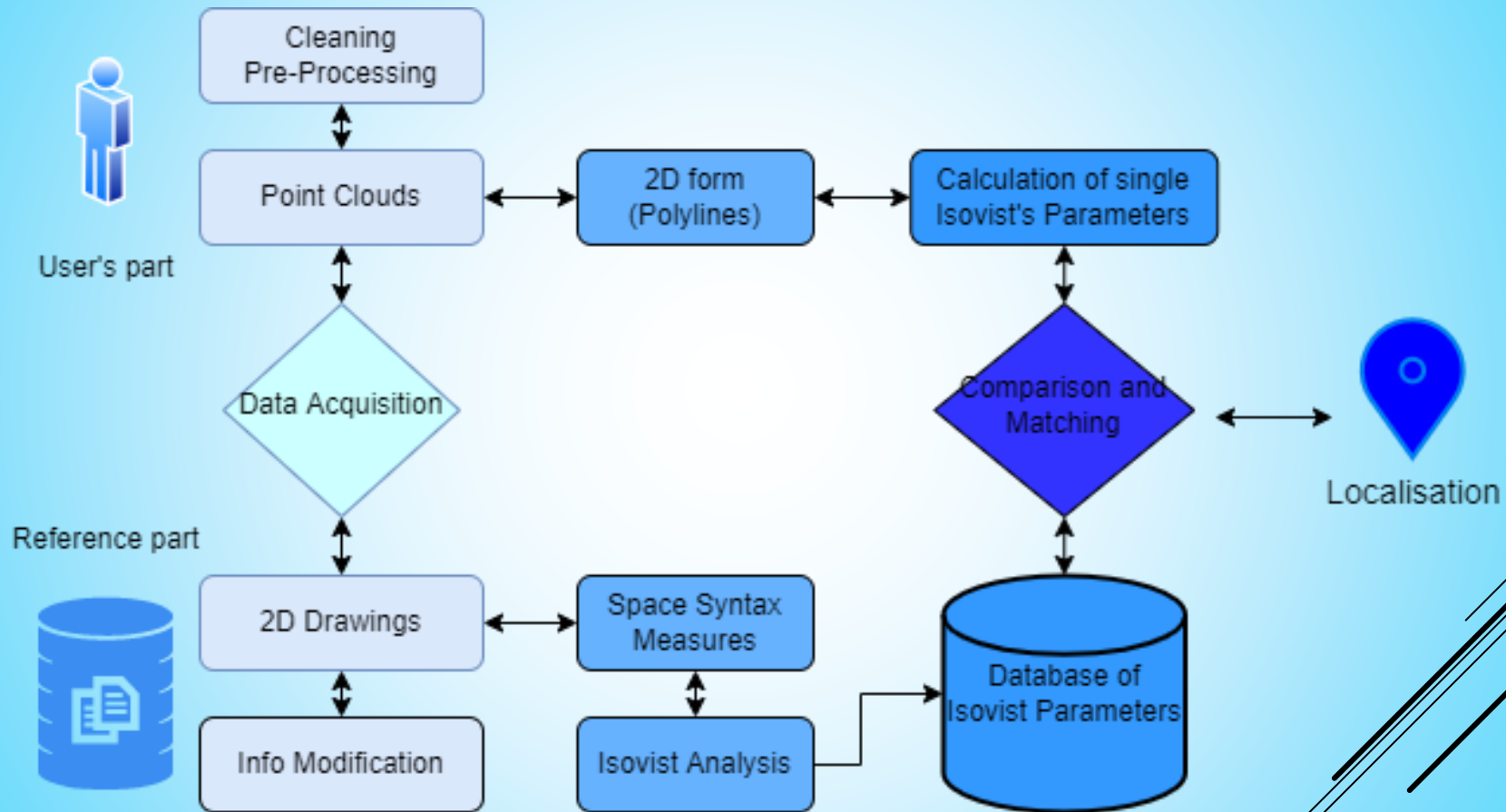
WHY ISOVIST?

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

ASSUMPTIONS AND LIMITATIONS

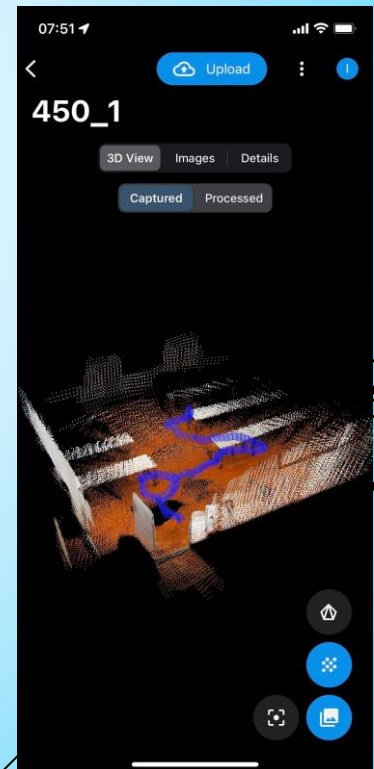
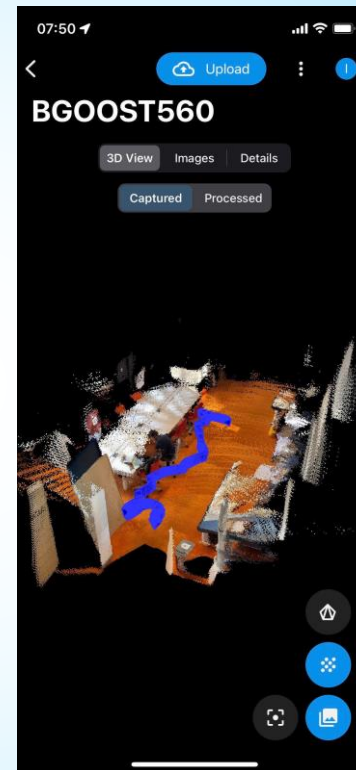
- ▶ This research topic it is just an initial investigation to form a proof of concept for Isovist Fingerprinting
- ▶ Does not end to a fully integrated and functional application
- ▶ Cannot and will not become the “Silver Bullet”
- ▶ No automatic integration between all the steps
- ▶ It is mainly manually 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



DATA ACQUISITION AND MANIPULATION

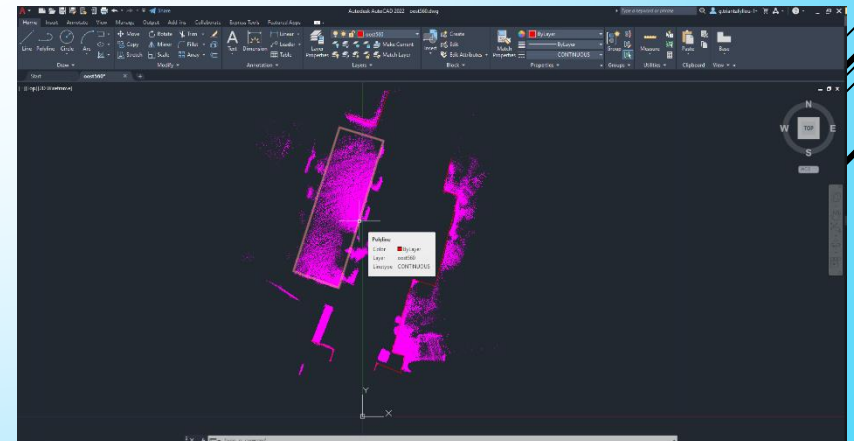
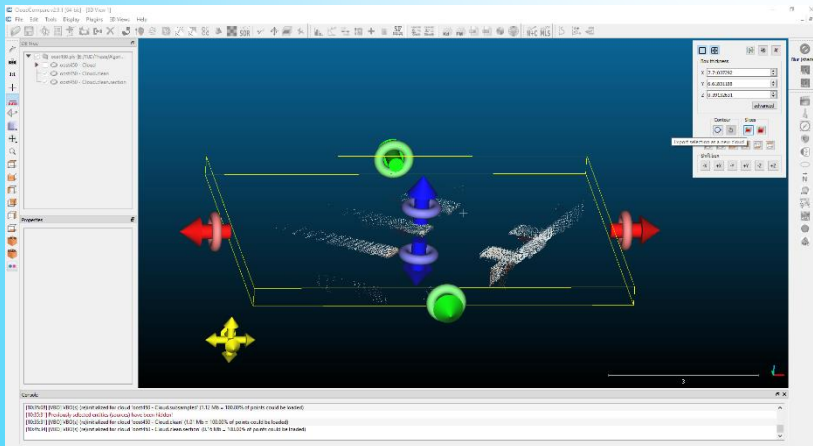
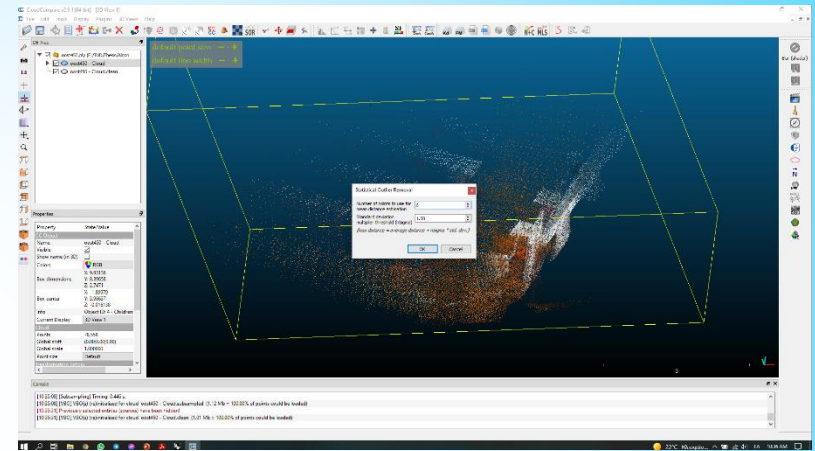
- Point Clouds
 - iPhone 12 Pro with LiDAR sensor for the user part
 - PIX4Dcatch app used with iPhone
- Assumption
 - Point Cloud must be gathered from entrance of the room mainly



DATA ACQUISITION AND MANIPULATION

Point Cloud to 2D drawing

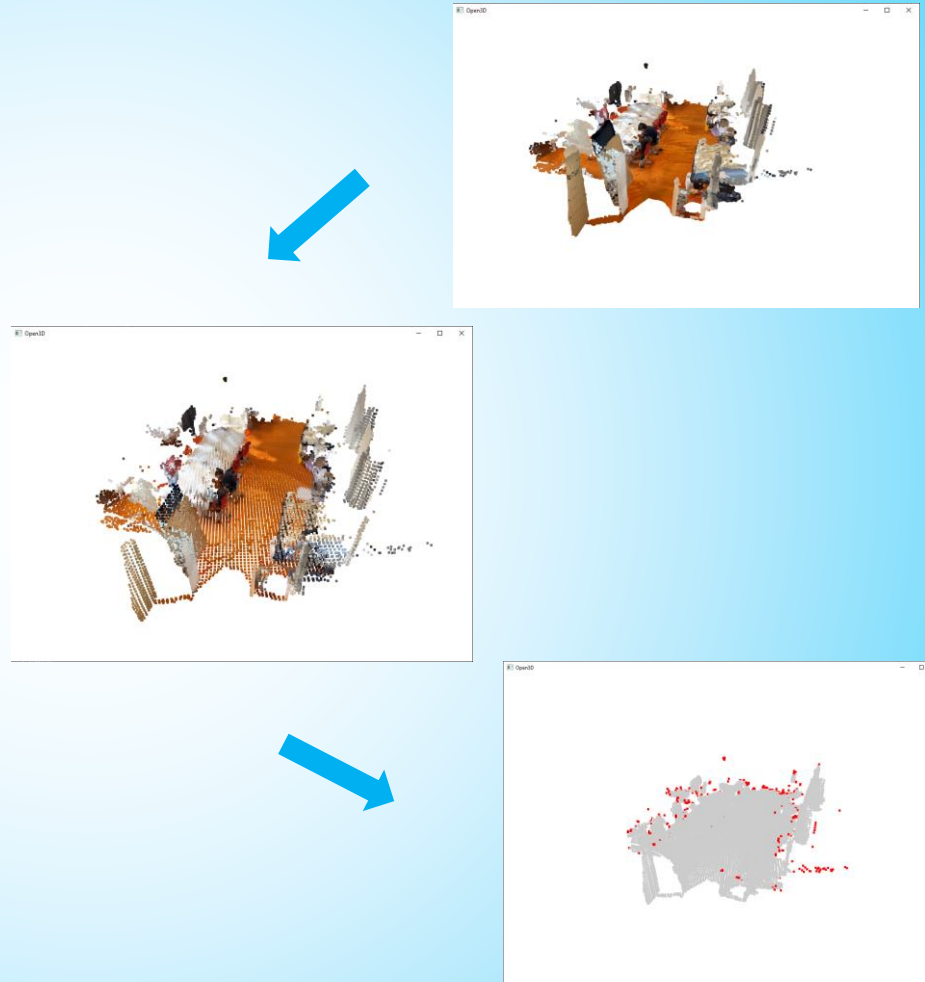
- Manual Implementation
 - Import to Cloud Compare
 - Downsampling (3.88 cm distance between points)
 - Statistical Outliers Removal
 - Slicing in height with most objects (60-120 cm)
 - Export in .dxf and drawing the



DATA ACQUISITION AND MANIPULATION

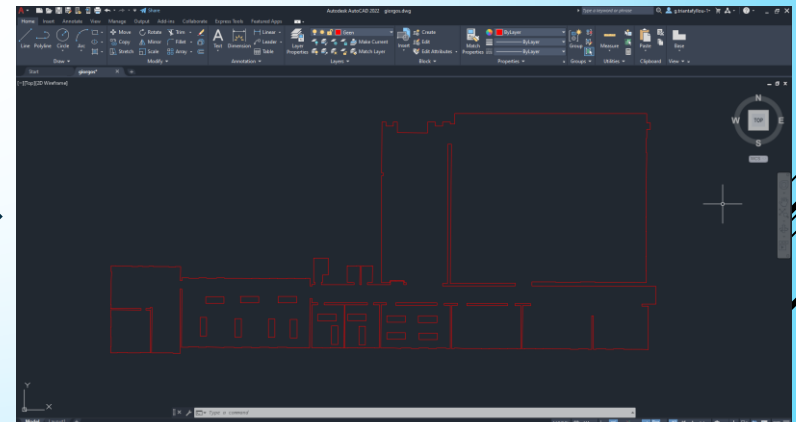
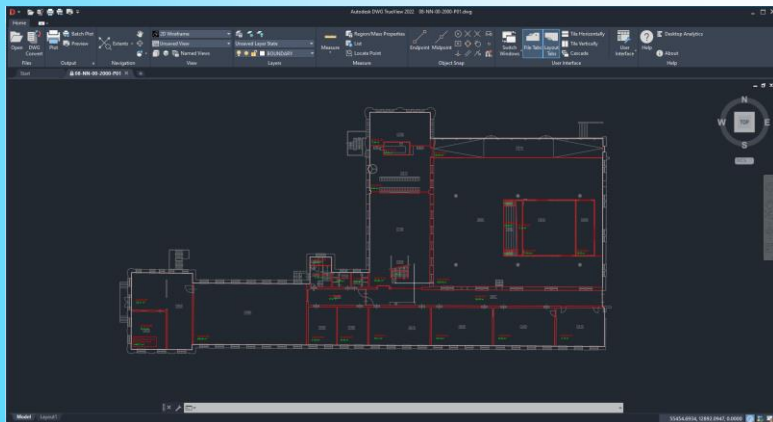
Point Cloud to 2D drawing

- Algorithmic Implementation
 - Reading and loading the point cloud in .ply format
 - Voxel downsampling of the point cloud
 - Statistical outlier removal
 - Conversion of point cloud into 3D array



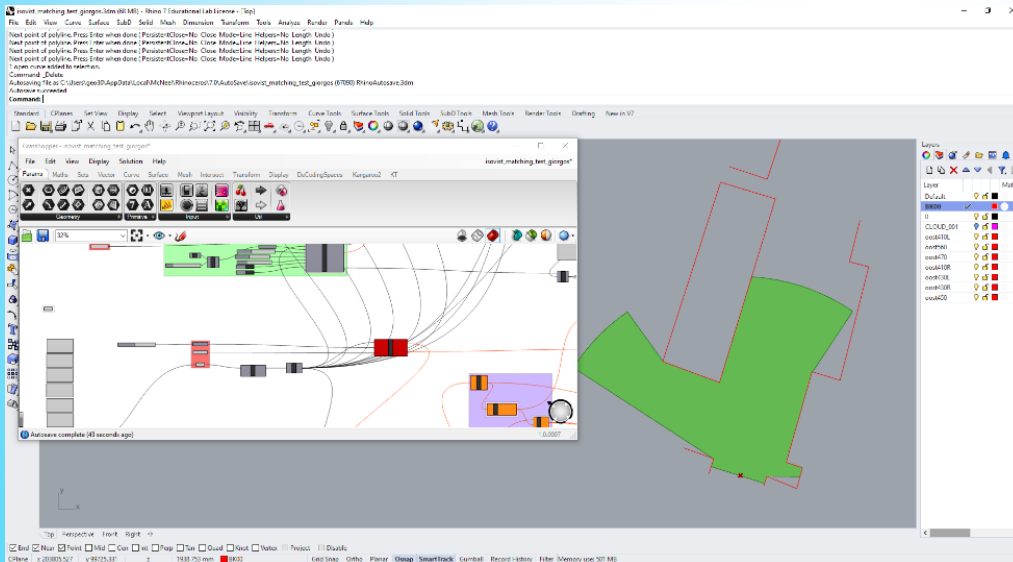
DATA ACQUISITION AND MANIPULATION

- 2D Drawings (AutoCAD)
 - Acquire of BK floorplans (Synthesis Project 2021" Building rhythms: Reopening the workspace with indoor localization"
 - Modification of BK floorplans and creation of one united curve
 - Specific Layer allocation to simplify the data
 - Addition of furniture and other unique characteristics



SPACE SYNTAX MEASURES

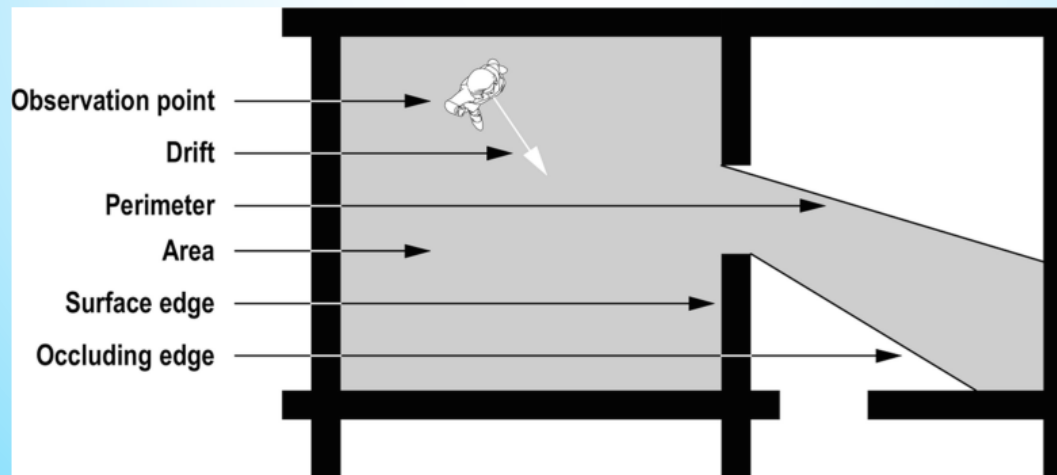
- Isovist Analysis in DeCodingSpaces Toolbox for Grasshopper of Rhino7
- Assumptions:
 - User's point chosen manually in the entrance of the rooms in the 2D info extracted by the point clouds
 - Direction, Range and other factors are also chosen manually



✓ 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

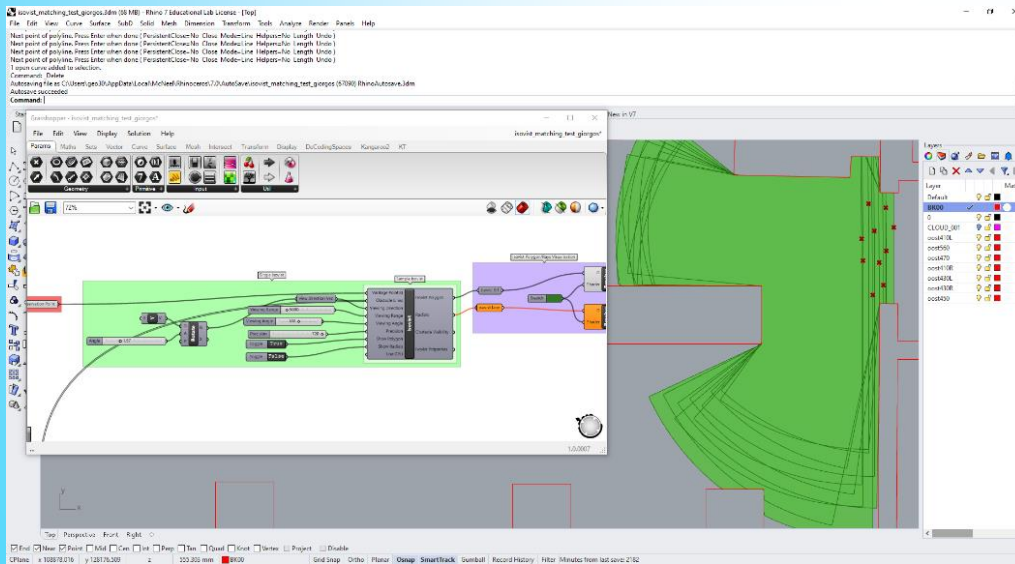
- **Area** : Expresses the area of all space visible from a vantage point in space
- **Perimeter** : Expresses the length of the edge of all space visible from a location
- **Drift** : Expresses the distance from a subject point to the center of gravity of its isovist
- **Compactness** : Expresses the 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
 - Distance Algorithm between the user's Isovist Parameters and the Database ones
 - Localisation visualisation
 - Storing and exporting the Calculations in .csv



Area	4.7197e+7
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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

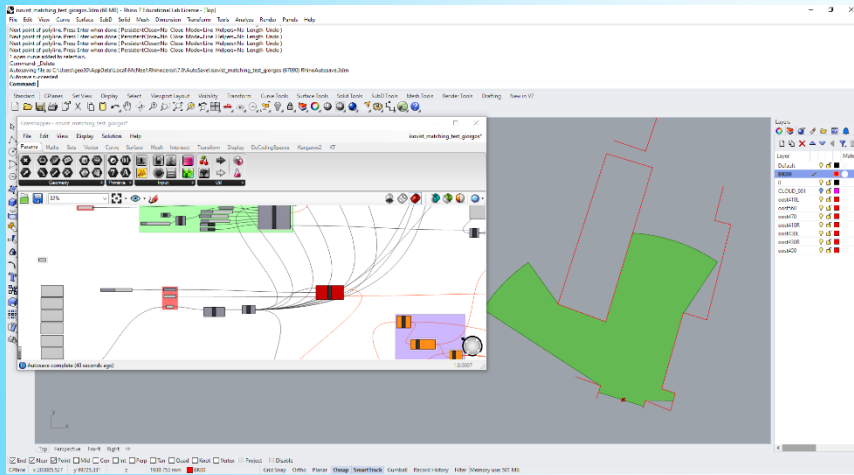


Analysing and Normalising the set of 17 Isovist parameters

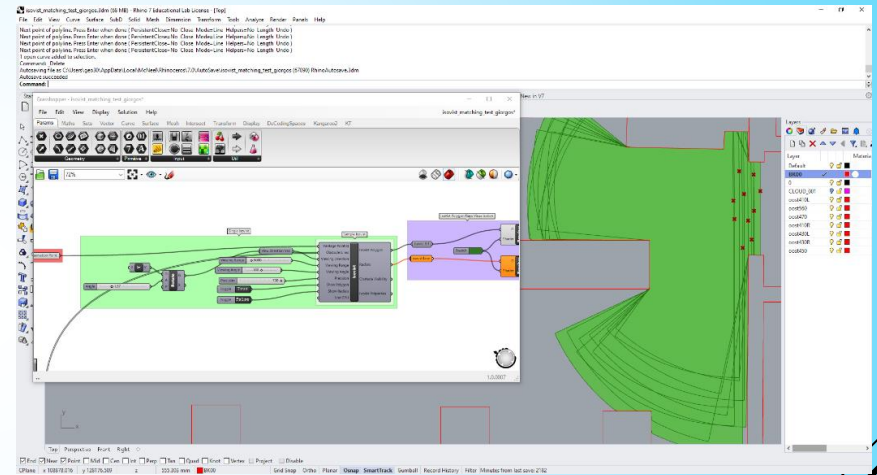


Matching the single Isovist with the database by using Distance algorithm

ISOVIST MATCHING



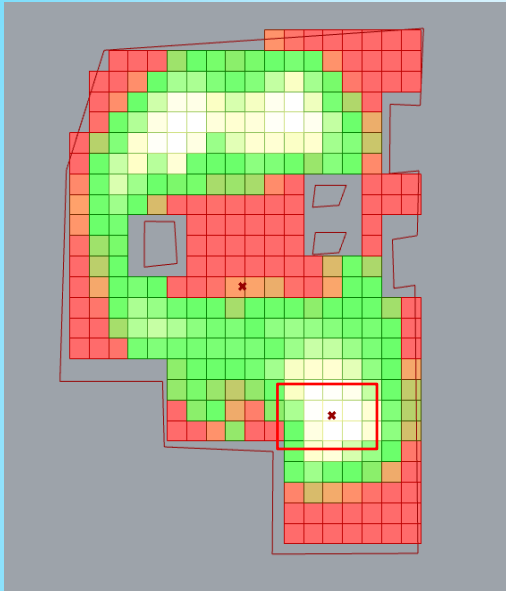
Single Isovist from Point-Cloud



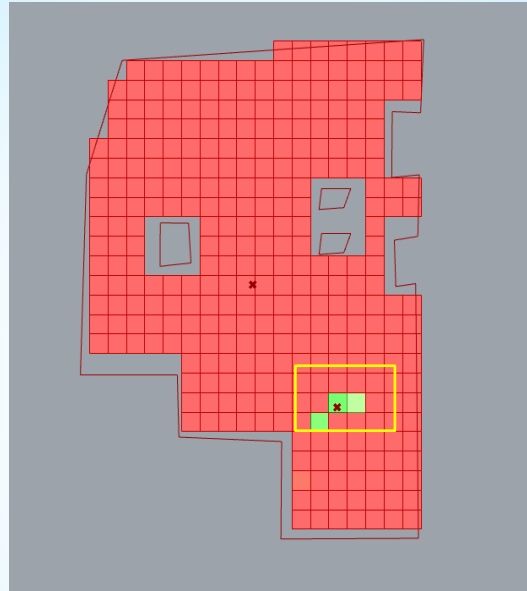
Set of 10 Isovists of an Entrance

TEST RESULTS

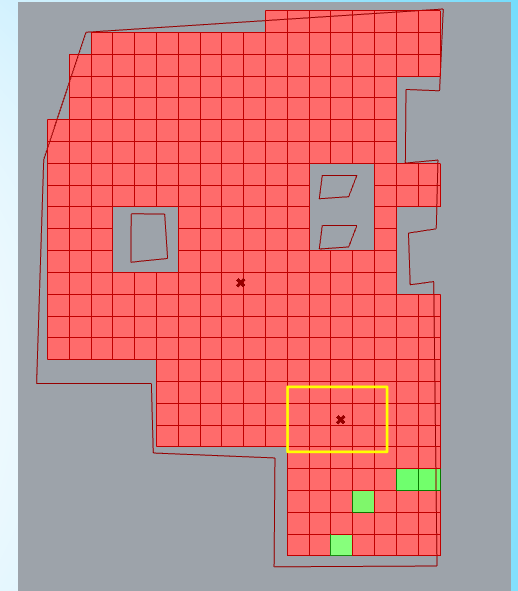
Isovist Parameters Analysis



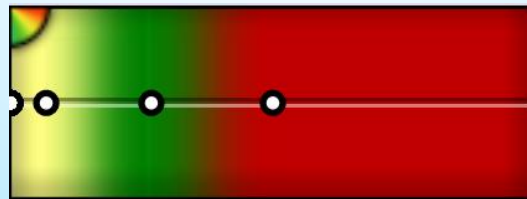
14 parameters 360°



17 parameters 360°



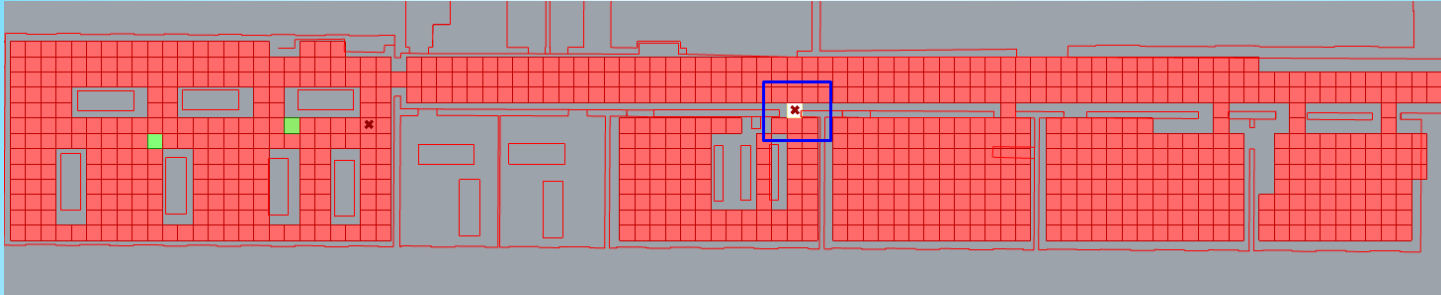
15 parameters 180°



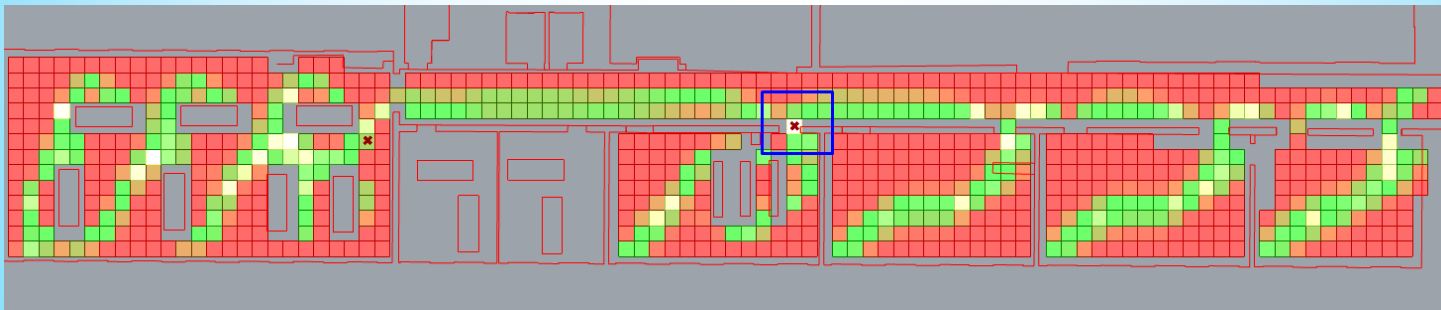
Best -----> Worst

TEST RESULTS

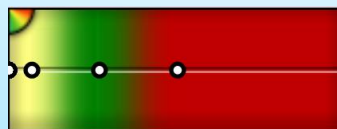
Distance Algorithms Testing



Euclidean Distance Algorithm



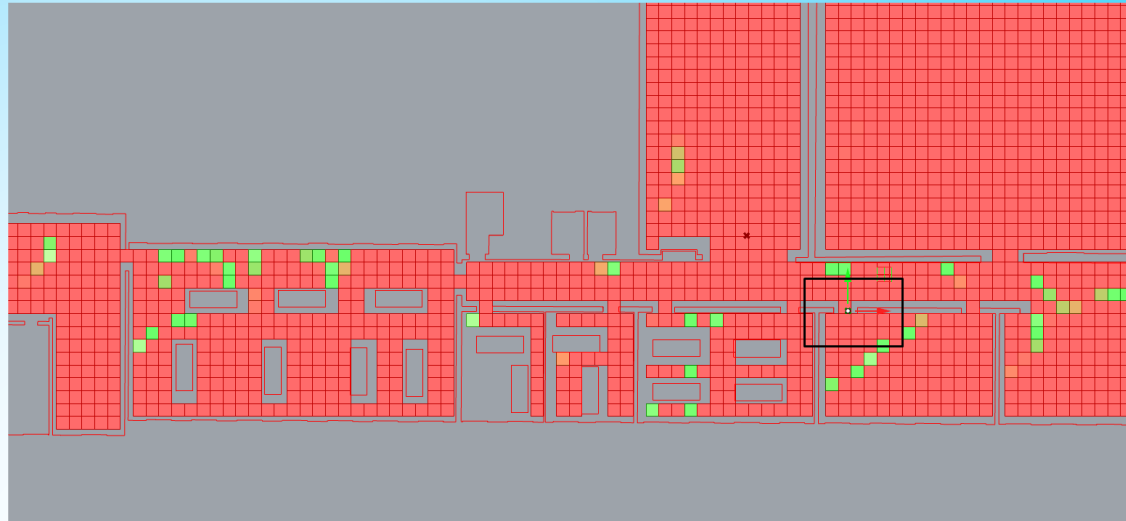
Manhattan Distance Algorithm



Best -----> Worst

TEST RESULTS

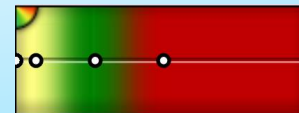
Localisation Tests



Empty room



With Furniture Room



Best ----> Worst

CONCLUSIONS

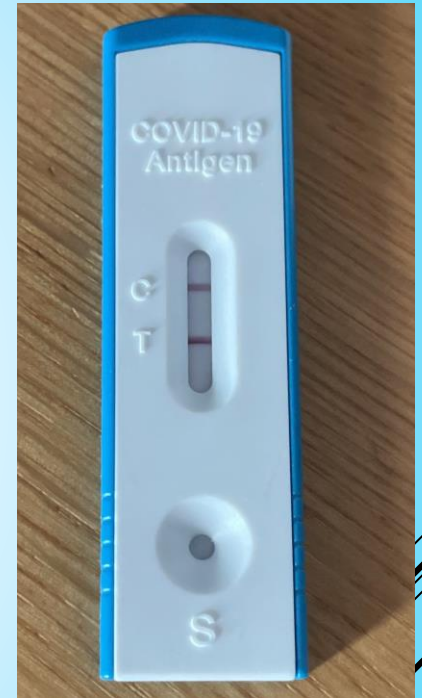
- ▶ Data Acquisition with smartphone supporting LiDAR were great accuracy for the topic's purpose
- ▶ Rhino's capabilities gave big space for testing
- ▶ Area, Perimeter and Drift Angle Highest importance
- ▶ Variance and Skewness is the least
- ▶ Euclidean Distance better choice
- ▶ Depending the environment results are not good
- ▶ Can support Indoor Localisation

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 them for continuous update of the database

REFLECTION

- ▶ Topic can extend fields of Geomatics and Indoor Localisation
- ▶ High impact in society
- ▶ Lots of work and research still needs to be done
- ▶ Not the best time management
- ▶ Learned a lot during the process
- ▶ **Covid-19 Pandemic Limitation**
- ▶ Keep Going!



Thank you for your attention !!!

