

PhD and Postdoc research

OVERVIEW OF BUILDING RESEARCH AT THE APPLIED GEOTECHNOLOGIES

Lucía Díaz Vilariño

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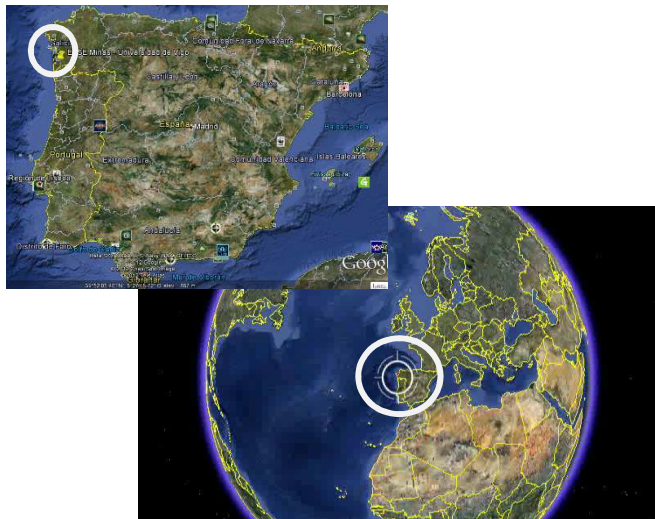
- The Applied Geotechnologies Research Group
- PhD research: from point clouds to gbxml.
- Postdoc research: point clouds for accessibility diagnosis and path planning in indoors/outdoors.

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- **The Applied Geotechnologies Research Group**
- PhD research: from point clouds to gbxml.
- Postdoc research: point clouds for accessibility diagnosis and path planning in indoors/outdoors.

The Applied Geotechnologies Research Group

Grupo de Investigación
en Xeotecnoloxías Aplicadas
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- The Applied Geotechnologies Research Group
- **PhD research: from point clouds to gbxml.**
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From point clouds to gbXML

PhD Research

- PhD Thesis (2015): **Geomatic techniques for the generation of semantically-rich building models for energy analysis purposes**

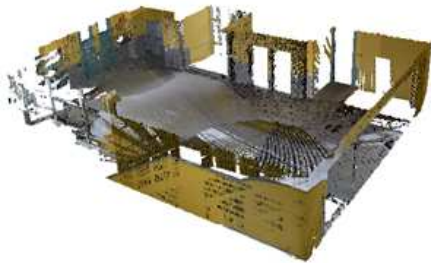
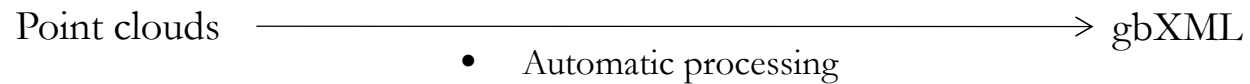


Figure. Point cloud

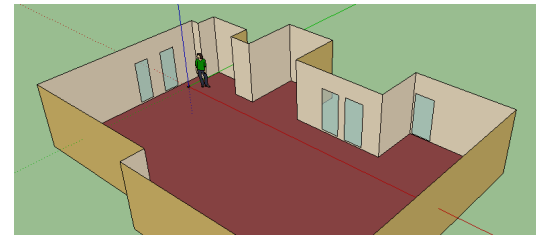


Figure. Resulting model imported in Sketchup.

Why gbXML?

PhD Research



‘The Green Building XML schema, or "gbXML", was developed to facilitate the transfer of **building information** stored in **CAD-based building information models**, enabling interoperability between disparate building design and **engineering analysis software tools**.’(<http://www.gbxml.org/>).

NEWS

August 1, 2016

Over 40 BIM and Building Analysis Software Tools Worldwide Now Support gbXML

(Autodesk, Trimble, Graphisoft, Bentley, etc)
(TAS, Energy Plus, etc.)

Why gbXML?

PhD Research

Geometry

- Geometry highly simplified
- Building elements as Surfaces
- Each surface defined by 4 boundary points (Cartesian Coordinates)
- Curved surfaces solved as a set of planar surfaces
- Openings as rectangles perfectly oriented
- A building as a set of enclosed spaces.

Topology

- Spaces Adjacency
- Interior Building Elements Adjacency
- Openings are Contained by Walls

Semantics

- To energy analysis purposes: materials, heating systems, weather, orientation, etc.

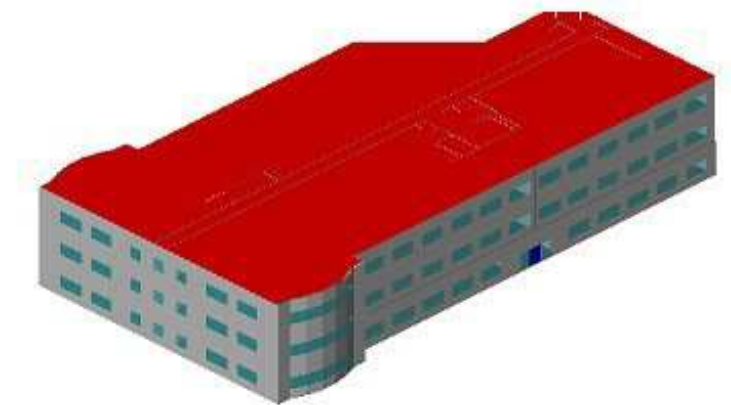


Figure. gbXML model Karlsruhe Institute of Technology

Point cloud processing

PhD Research

Point clouds —————> gbXML

- Envelope Reconstruction
- Opening Reconstruction
- Space reconstruction

Envelope reconstruction

PhD Research

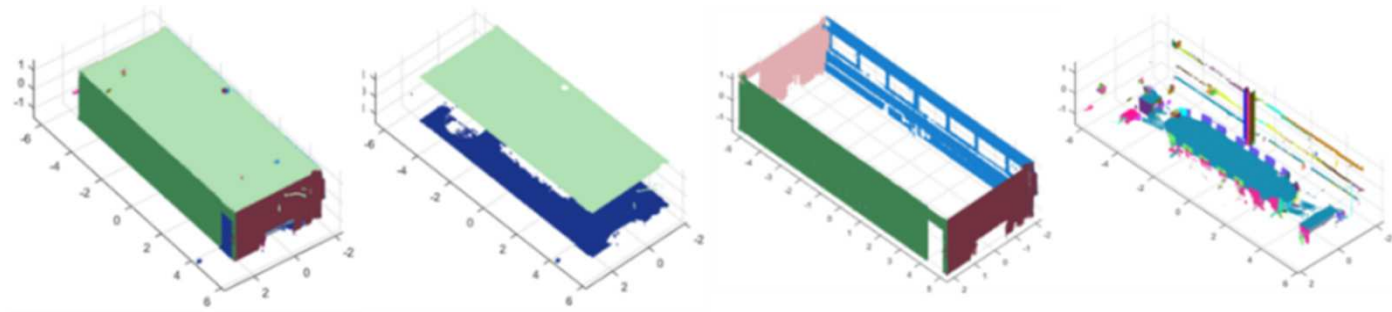
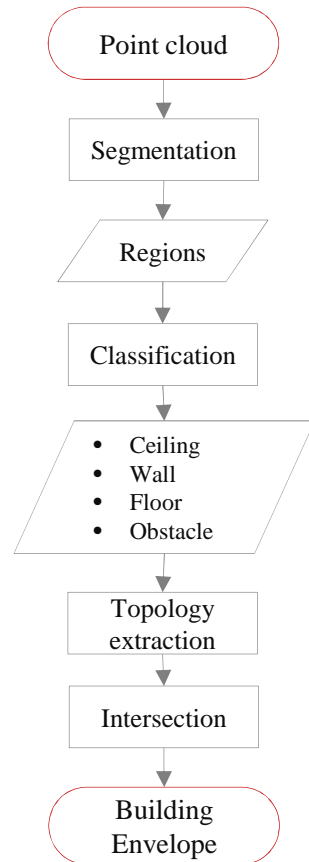


Figure: a) all segmented regions, b) ceiling and floor, c) walls, d) Obstacle class

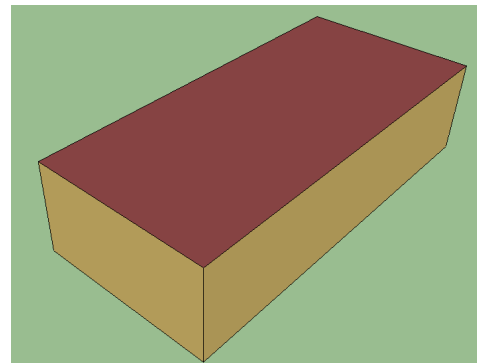


Figure: Parametric model of the envelope after topology extraction and intersection

Opening reconstruction

PhD Research

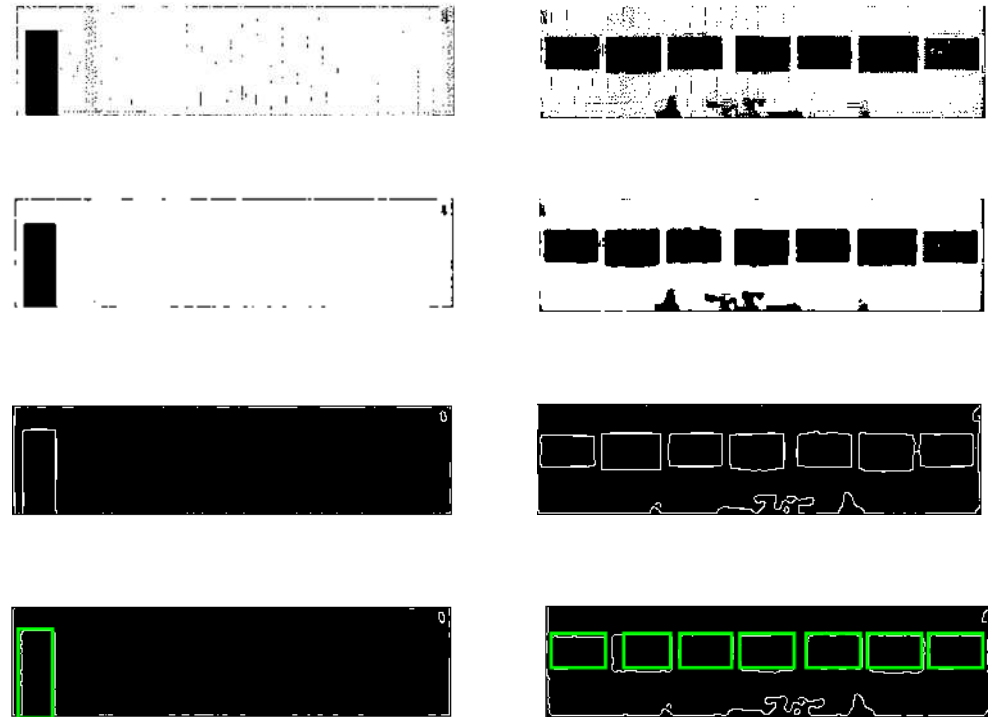
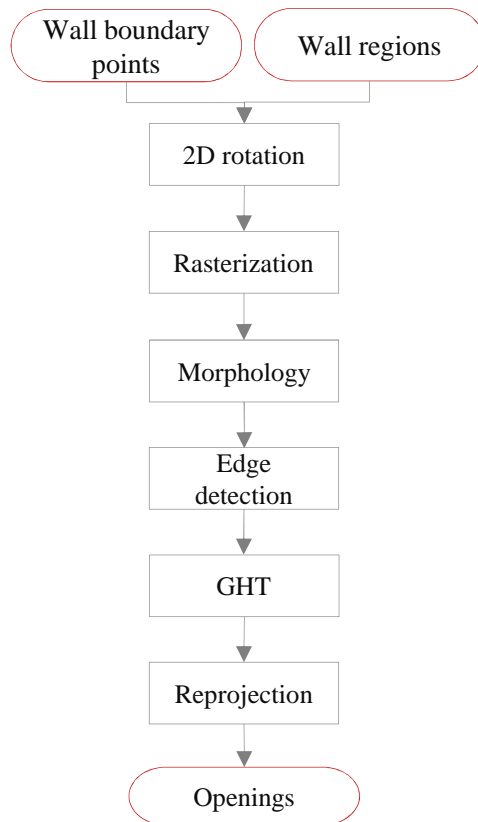


Figure: Results of window (right) and door (left) detection. From up to down: raster image, raster submitted to salt and pepper filter and edge image, and edge image with openings in green.

Resulting models

PhD Research

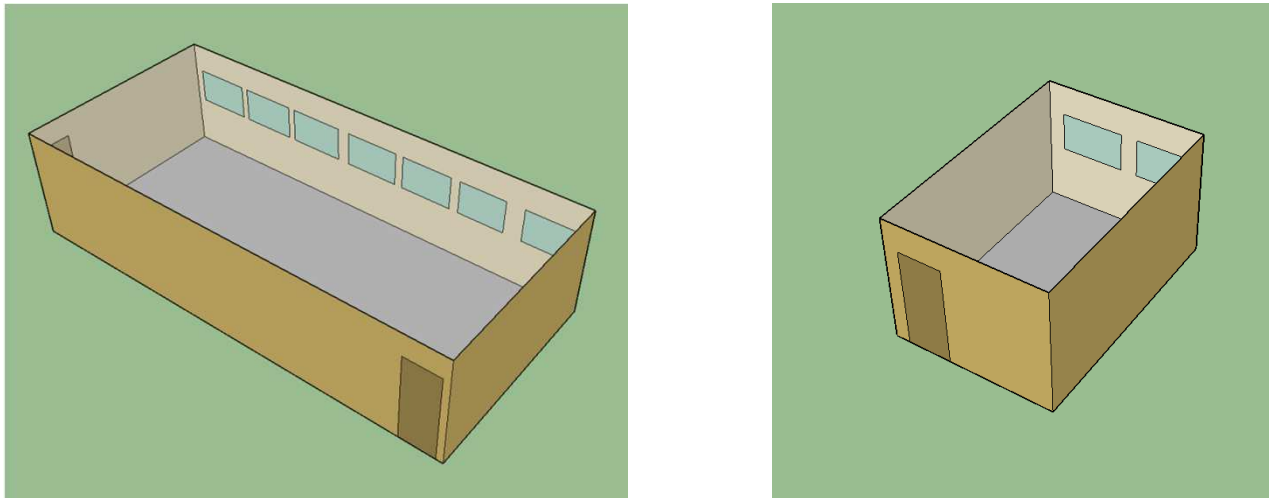


Figure: gbXML models visualized in Sketchup (EnergyPlus plugin)

Closed doors as a special case

PhD Research

- Applying the previous methodology to **orthoimages**.
- Distinguishing doors from other objects with the same size and shape

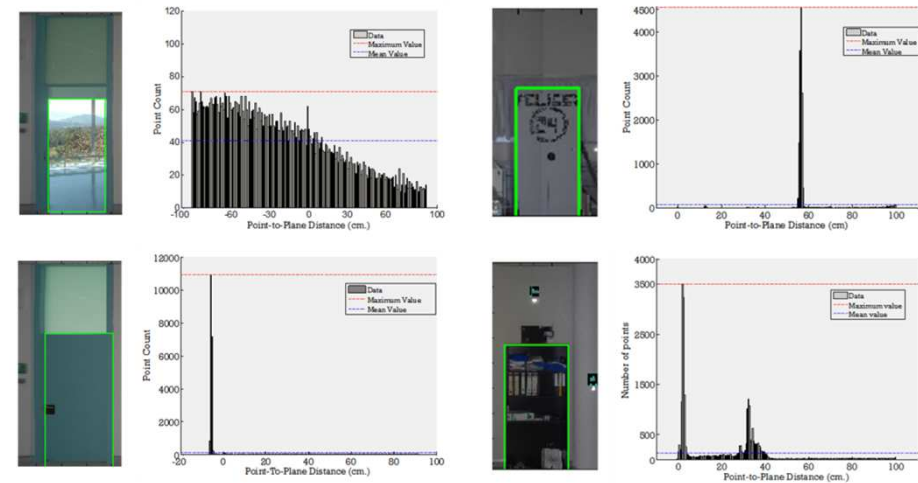
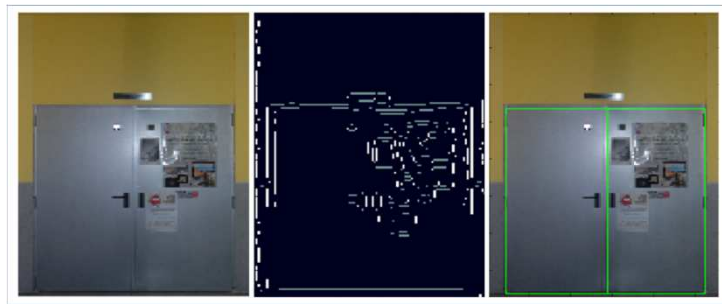


Figure: Histograms point-to-plane

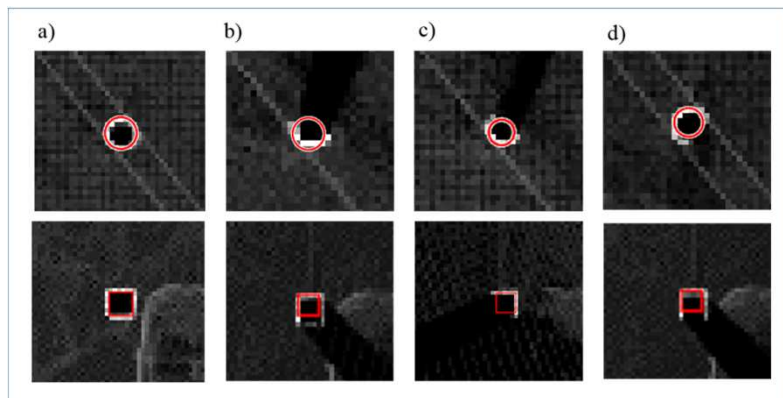
From: Díaz-Vilariño, L., Khoshelham, K., Martínez-Sánchez, J., Arias, P. 3D modeling of building indoor spaces and closed doors from imagery and point clouds (2015) *Sensors*, 15 (2), pp. 3491-3512

From: Díaz-Vilariño, L., Martínez-Sánchez, J., Lagüela, S., Armesto, J., Khoshelham, K. 2014. Door recognition in cluttered building interiors using imagery and LiDAR data. *ISPRS Archives*, 40 (5), 203-209

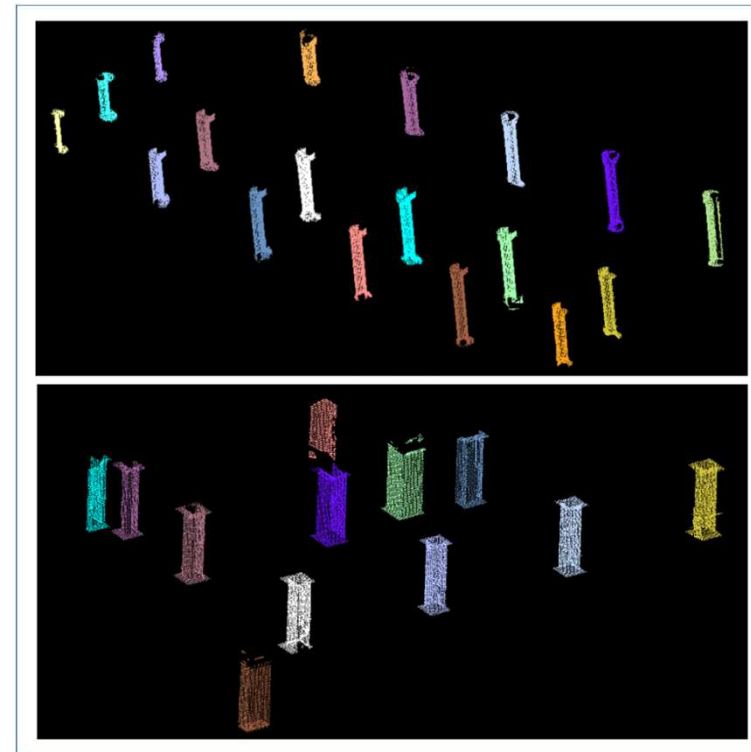
Column segmentation

PhD Research

- To segment round-cross section and rectangular cross-section columns under different conditions of data completeness (not interesting for energy analysis purposes)



From: Díaz-Vilariño, L., Conde, B., Lagüela, S., Lorenzo, H., 2015. Automatic Detection and Segmentation of Columns in As-Built Buildings from Point Clouds. Remote Sensing, 7, pp.15651-15667



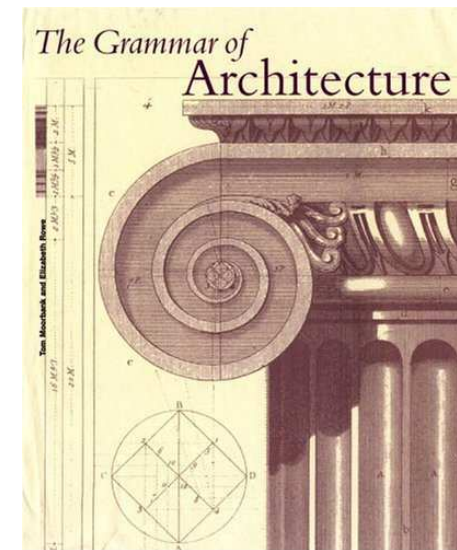
Indoor space reconstruction: grammar-based

PhD Research

Grammar is the set of **rules** governing the **composition** of elements from simpler units.



Linguistics: phrases, words, etc.



Architecture: columns, façades, etc.

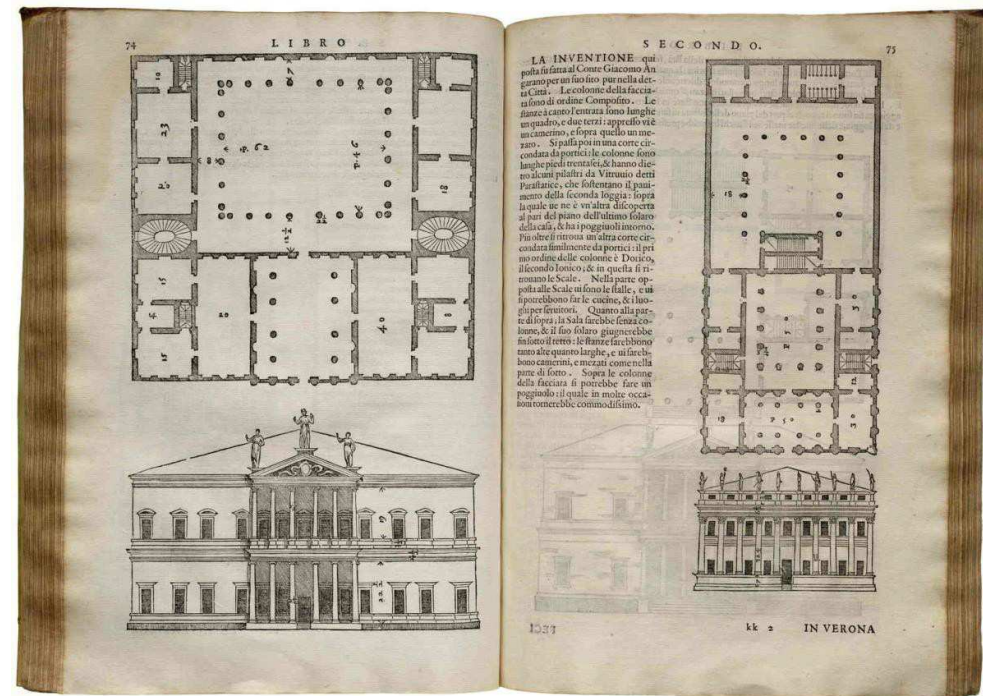
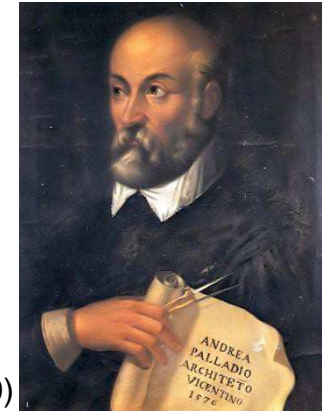
Indoor space reconstruction: grammar-based

PhD Research

- Example: Palladian indoor designs
- Characterized by:

Repetition
Regularity
Creativity

Andrea Palladio (1508 –1580)



Indoor space reconstruction: grammar-based

PhD Research

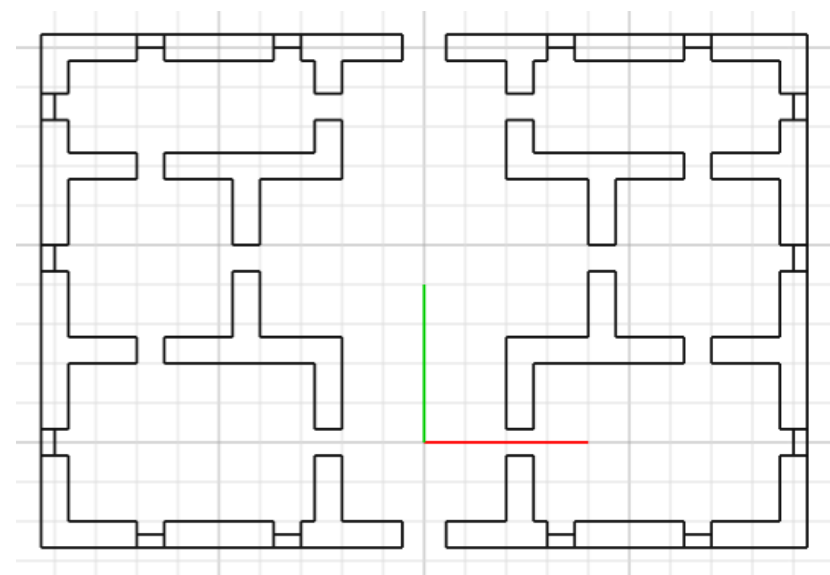
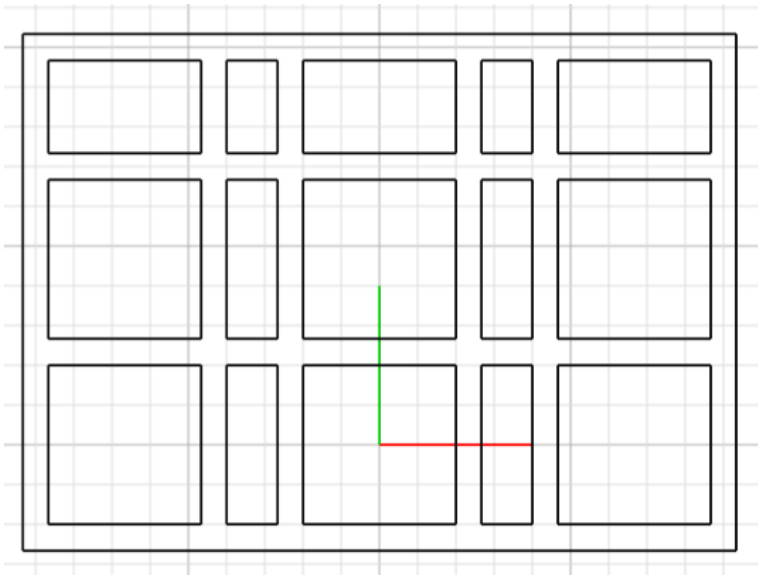
- Rule 1: Make a grid of rectangular spaces

Repetition

Regularity

- Rule 2: Collapse some of the walls

Creativity

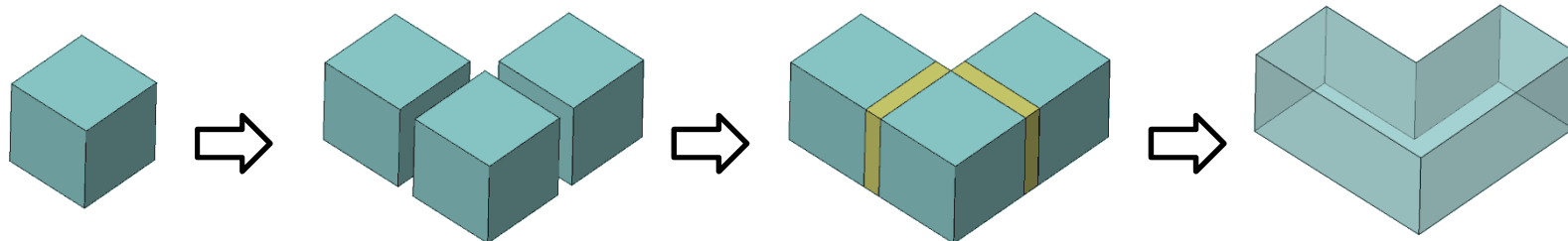
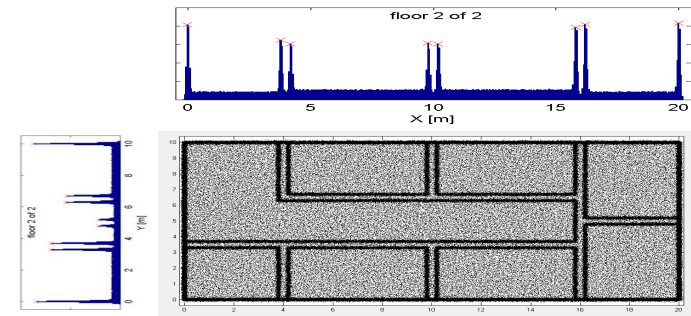


Indoor space reconstruction: grammar-based

PhD Research

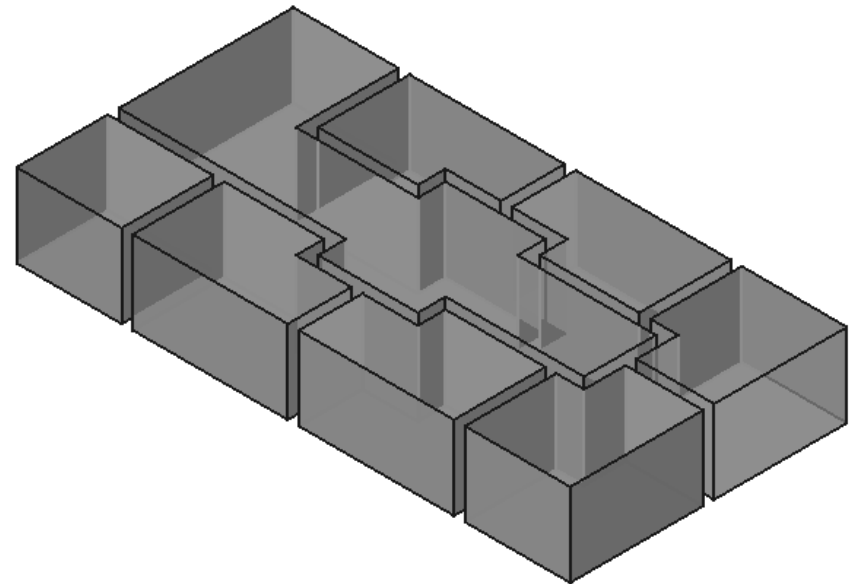
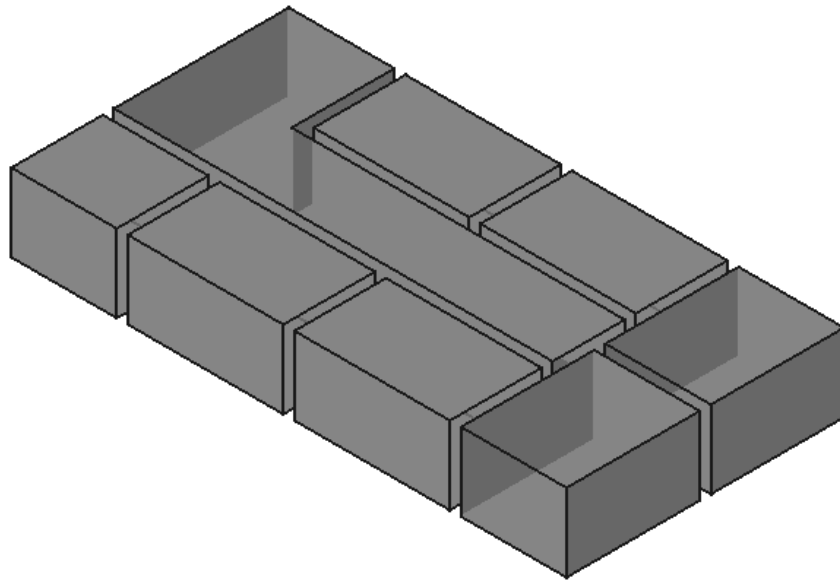
Manhattan-World Structures

- Rule 1: place a cuboid
If there are points on its ceiling
- Rule 2: connect two cuboids
If they are not separated by a wall
- Rule 3: merge two cuboids
If they have a common face



Indoor space reconstruction: grammar-based

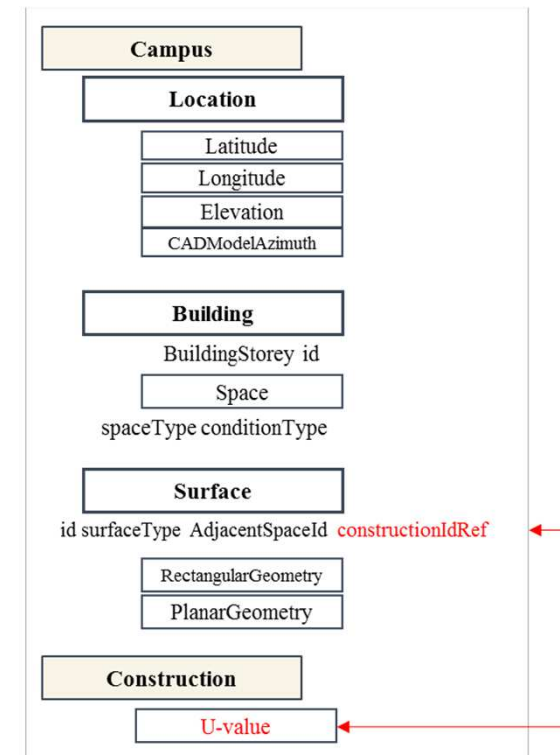
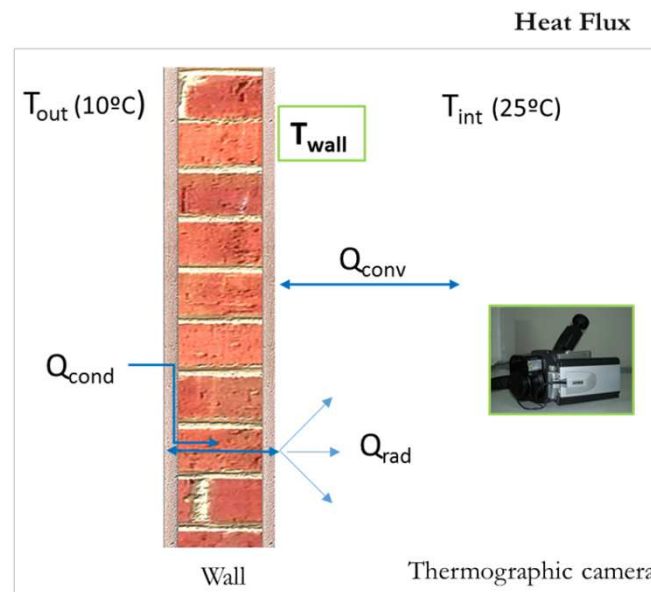
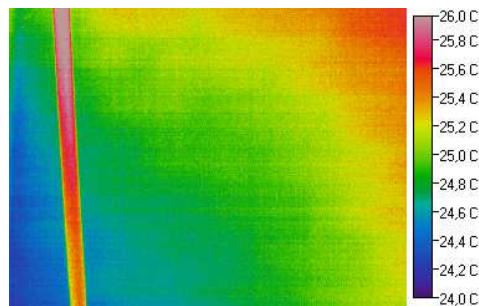
PhD Research



Enriching models with thermal data

PhD Research

- Use **infrared thermography** for the calculation of **U-values** of the enclosure in a non-destructive way.
- Integrate semantic and geometric information into a model, validated according to gbxml specifications.



PhD research: point clouds for energy analysis

PhD Research

H2020-FTIPilot-2015-1

ENGINEENCY A Holistic System for Building Inspection and Energy Efficiency
Management (Fast Track to Innovation pilot)



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Postdoc Research

Concept

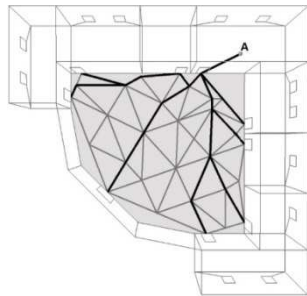
- Postdoc Project (2016-2019): **Accessibility diagnosis and path planning in indoor/outdoor scenes from point clouds**

Point clouds

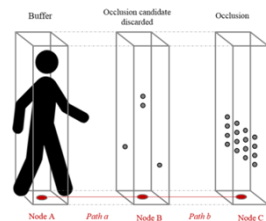
→ Building models

- Automatic processing

- Semantic modelling for different purposes



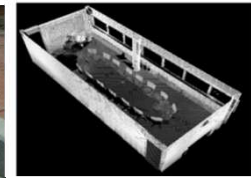
- Different geometry of interest



- Different meaning

semantic

- Extension to indoors and outdoors



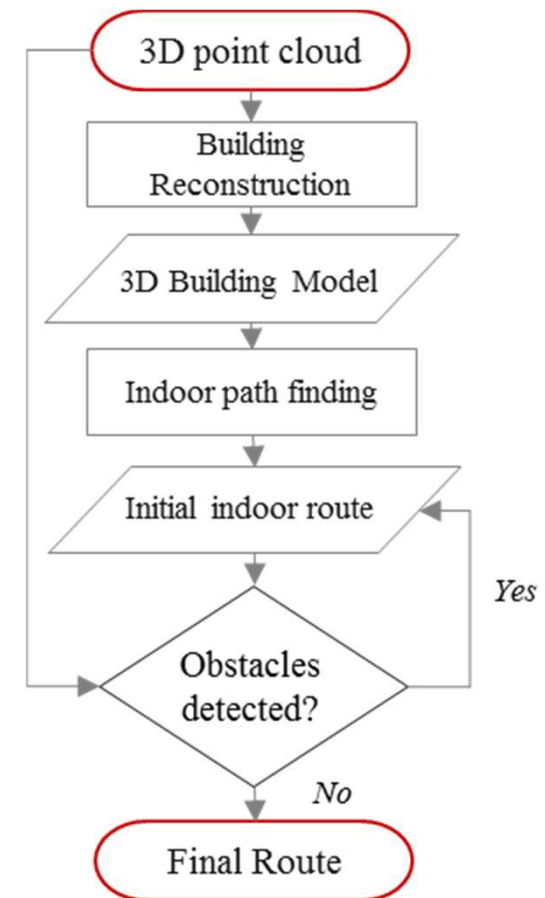
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Indoors

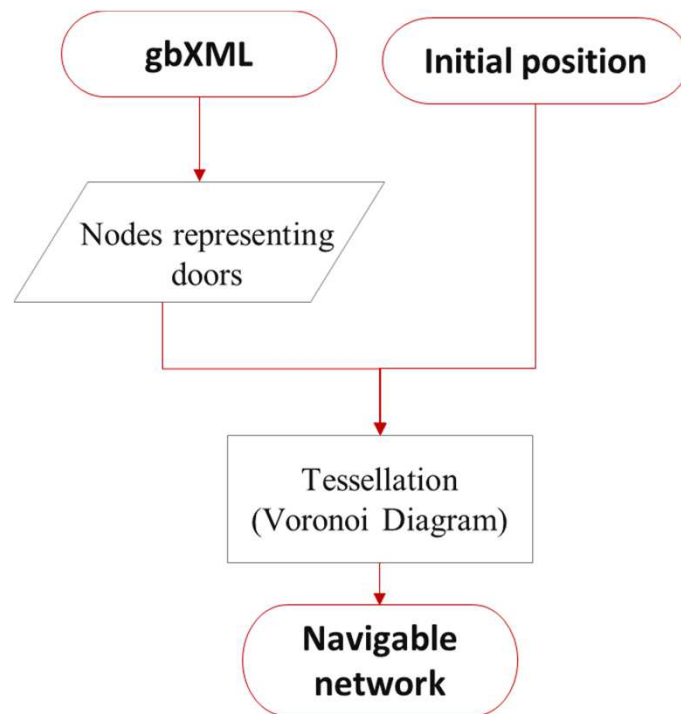
Postdoc Research

Díaz-Vilariño, L., Boguslawski, P., Khoshelham, K., Lorenzo, H., and Mahdjoubi, L. **Indoor navigation from point clouds: 3D modelling and obstacle detection**, ISPRS Archives, 2016, XLI-B4, 275-281



Indoors

Postdoc Research



Initial position

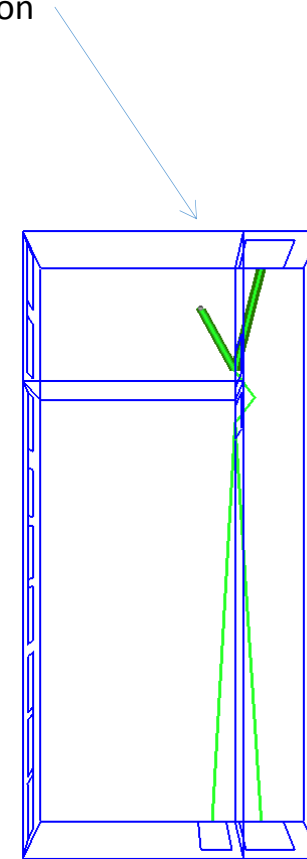
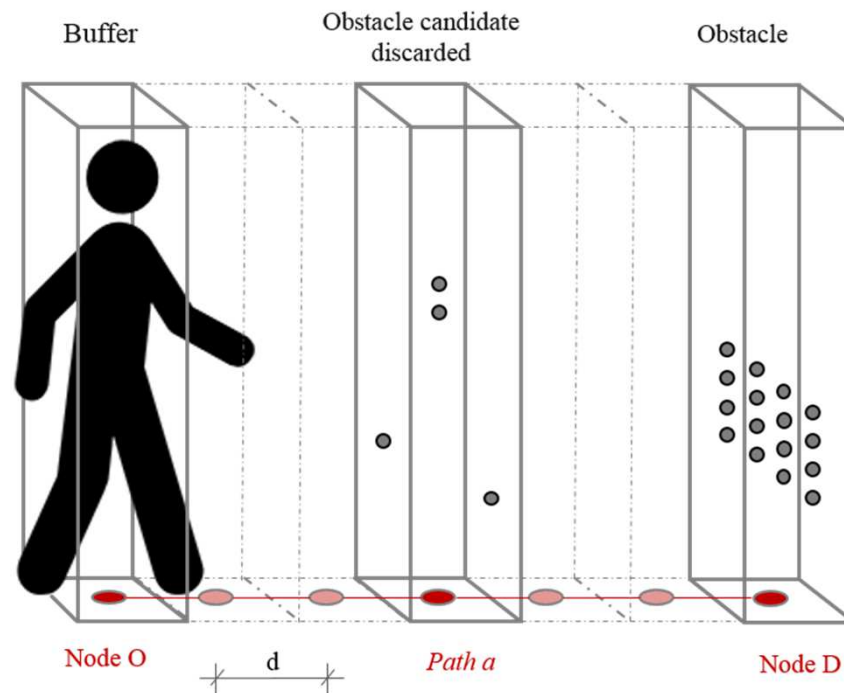


Figure: Example of an initial network in a three-room building with 5 doors.

Indoors

Postdoc Research

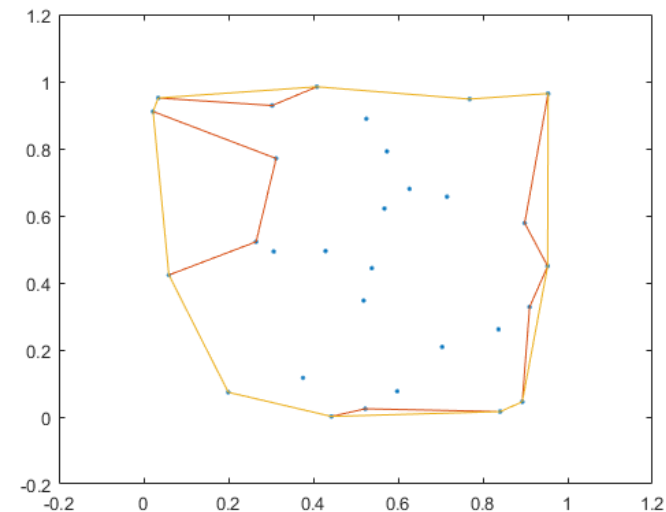
- An **obstacle** is defined by the existence of a **set of 3D points** interrupting the trajectory defined by a path.



Indoors

Postdoc Research

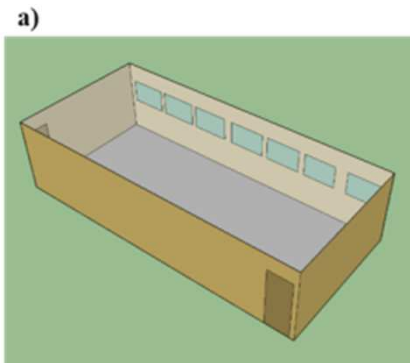
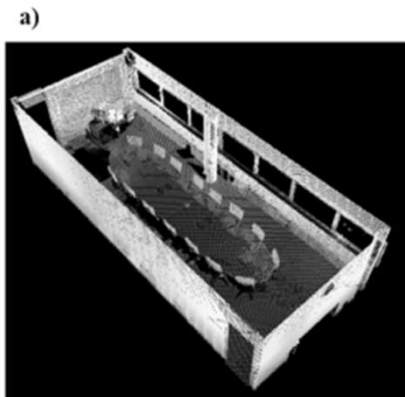
- Dijkstra algorithm is used for path-finding: the shortest-route.
- Routes are submitted to obstacle detection.
- When an **obstacle is detected**, the boundary polygon is **added to the navigable network** and **excluded** from navigation.
- Links inside the polygon area are excluded from navigation.
- **The process iterates until no obstacles are found.**



From: <https://nl.mathworks.com/help/matlab/ref/boundary.html>

Case study: an academic room from University of Vigo

Postdoc Research



Videoconference room (a)			
Origin node	X (m)	Y (m)	Destination node
Node A	-2.236	-2.405	Closest door
Node B	0.913	-4.601	

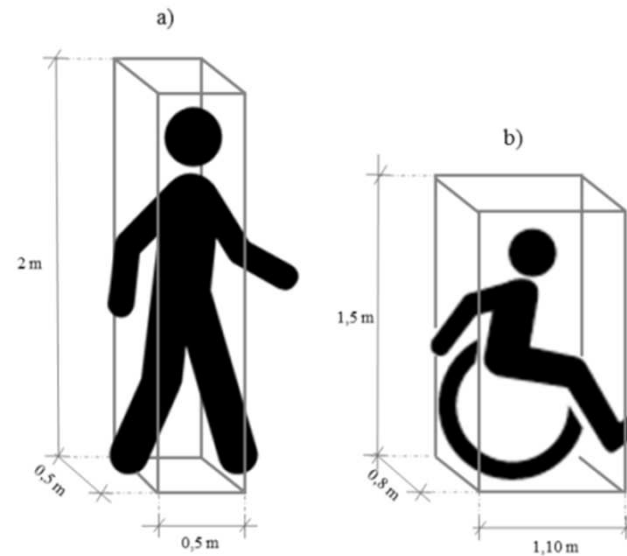
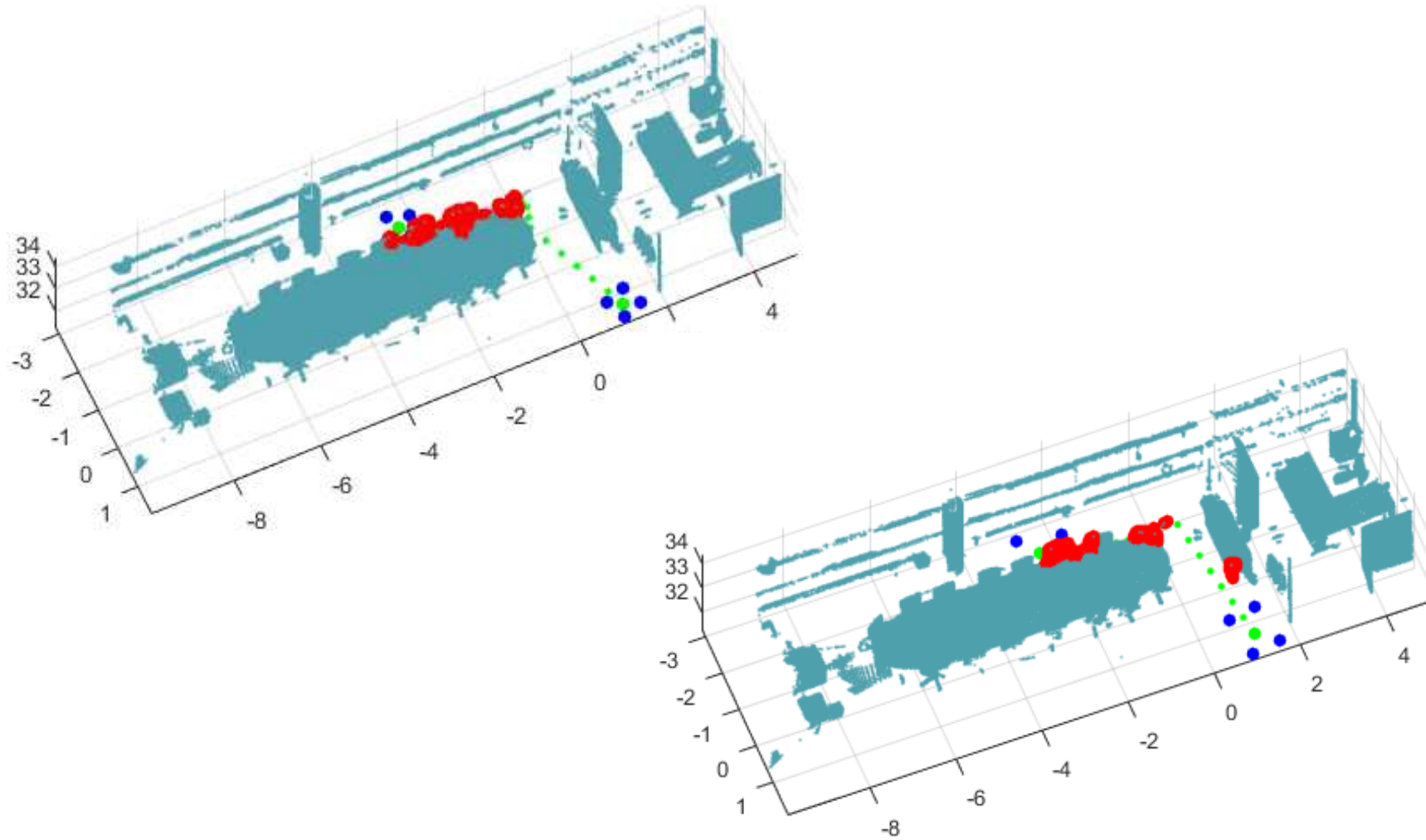


Figure: Buffer size for (a) non-disabled and (b) wheelchair people.

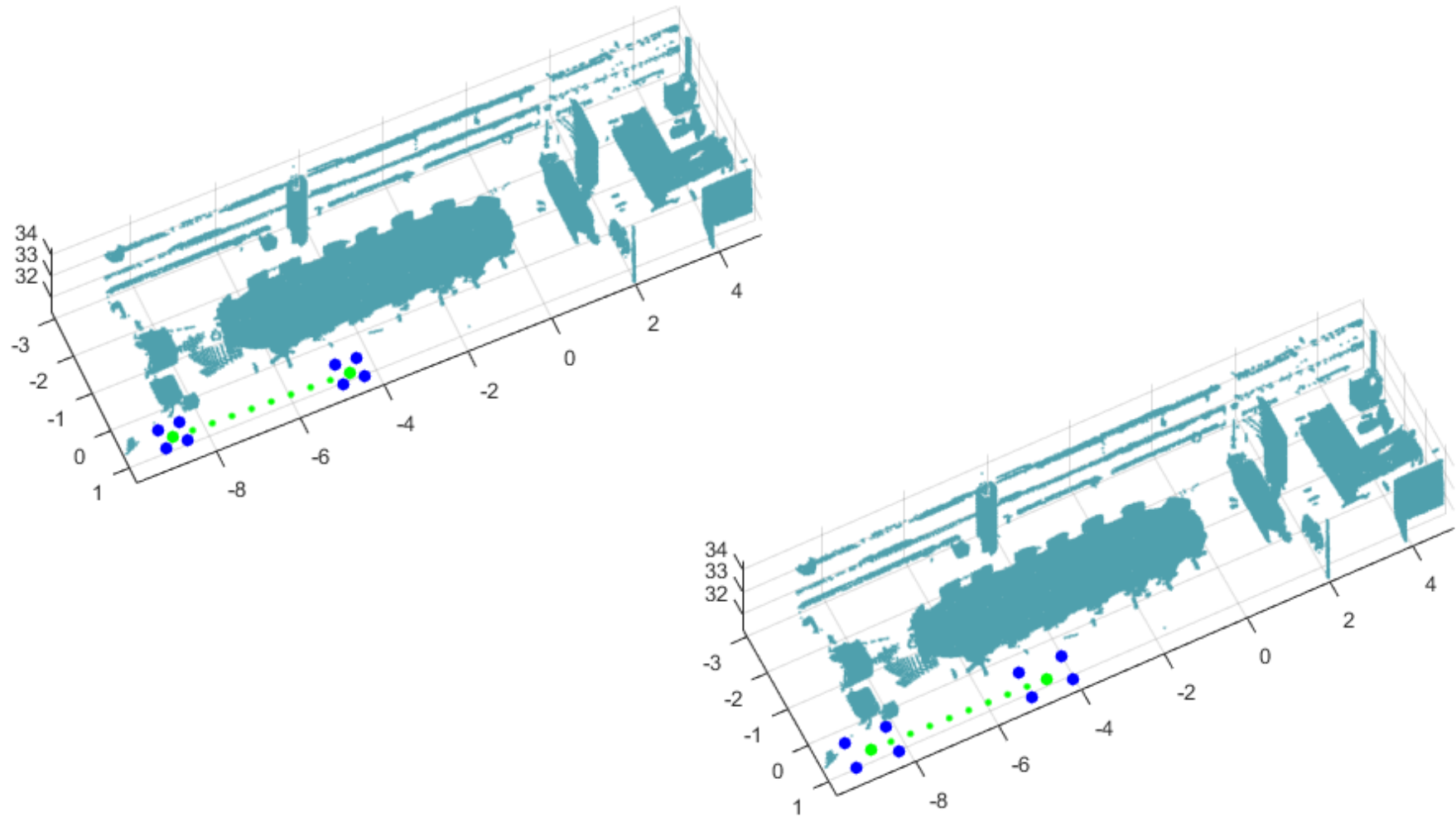
Results

Postdoc Research



Results

Postdoc Research



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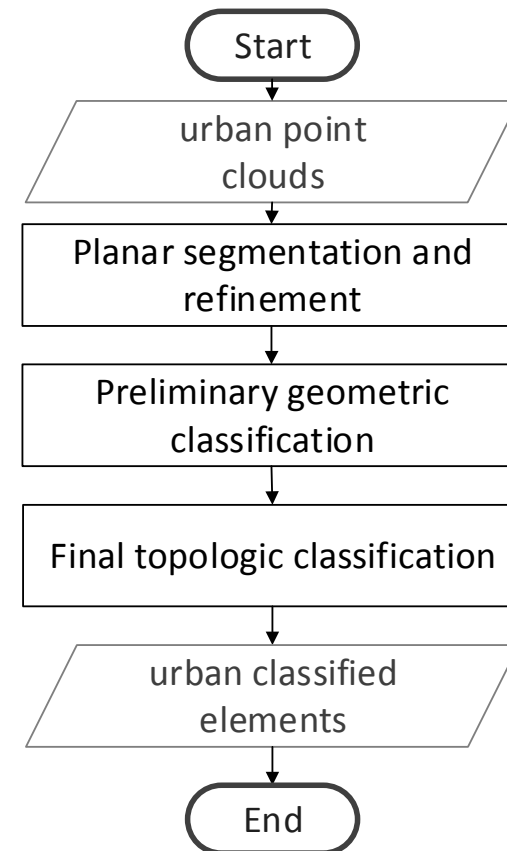
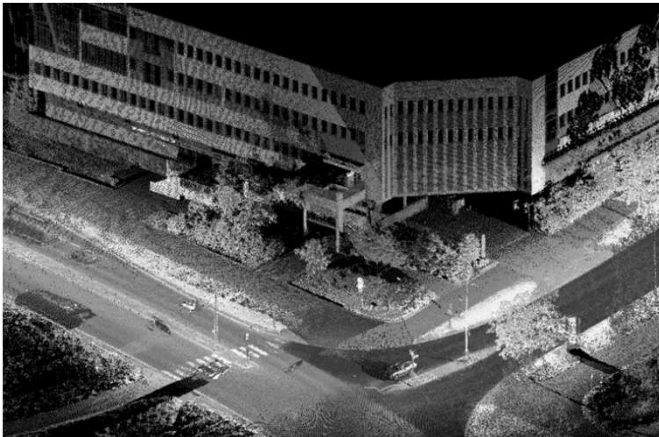
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Outdoors

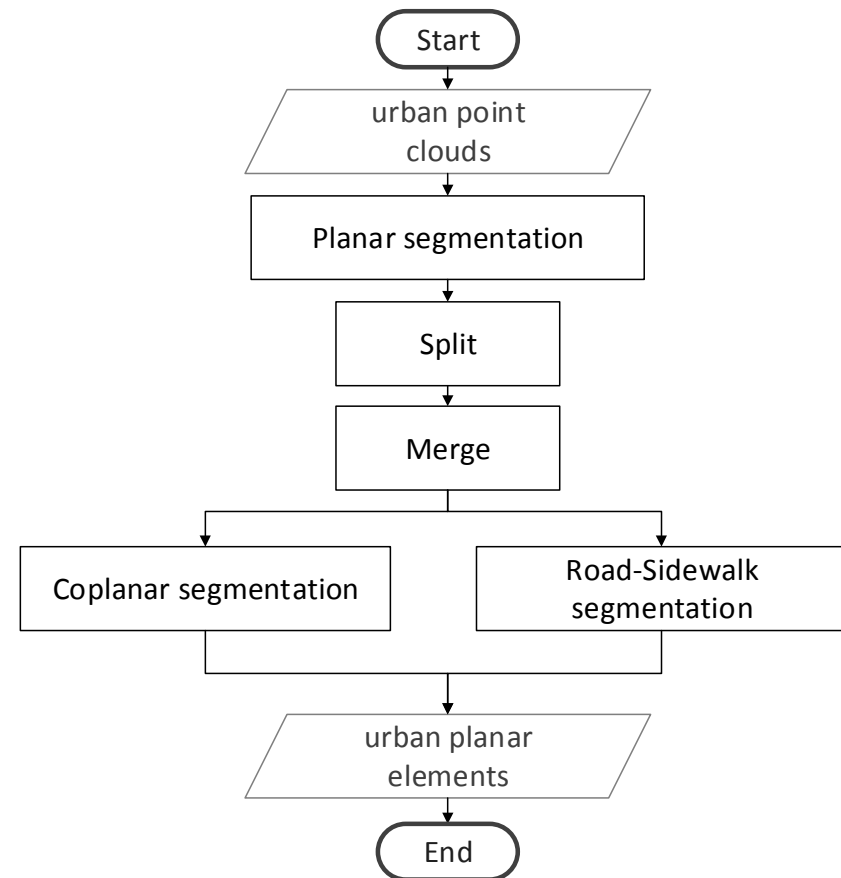
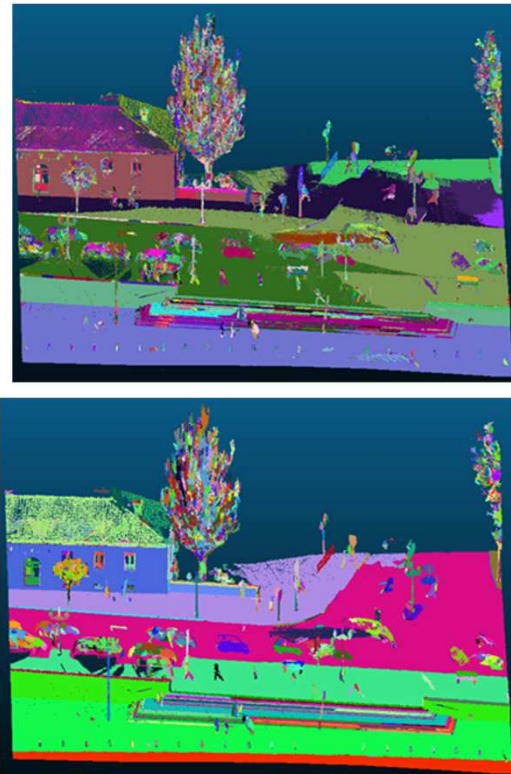
Postdoc Research

An approach for automatic classification of urban ground elements from 3D point clouds.



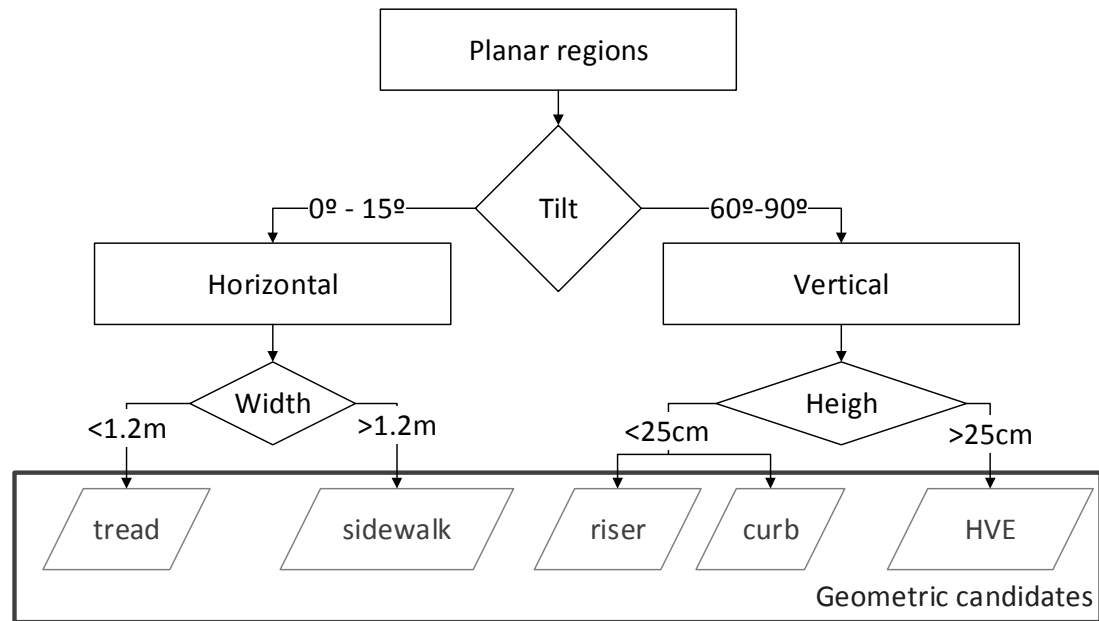
Segmentation

Postdoc Research



Geometric preliminary classification

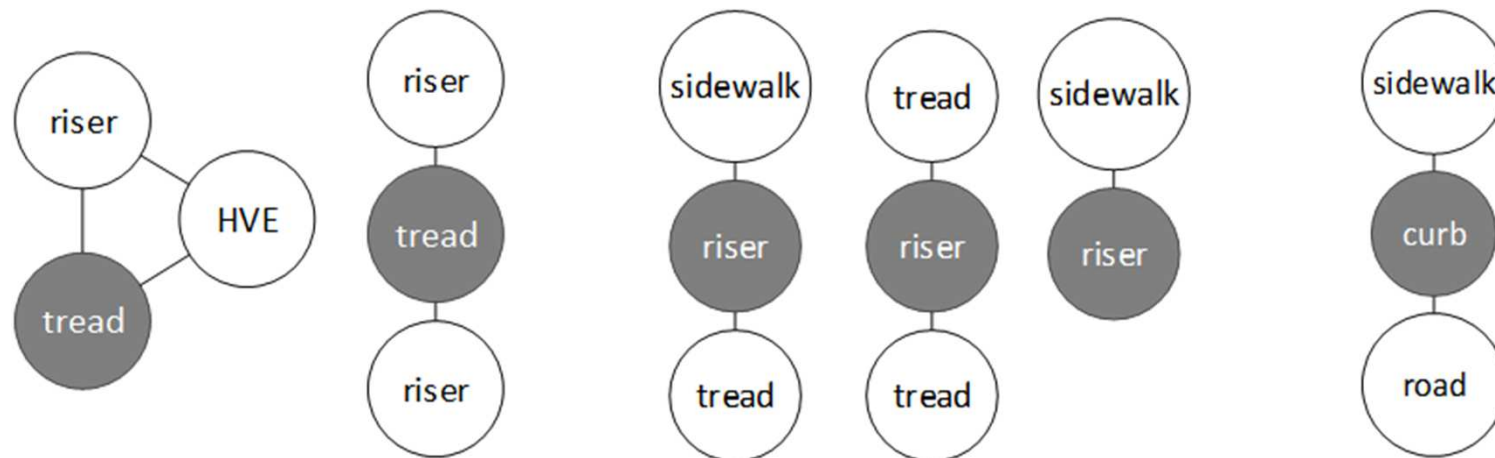
Postdoc Research



Outdoors

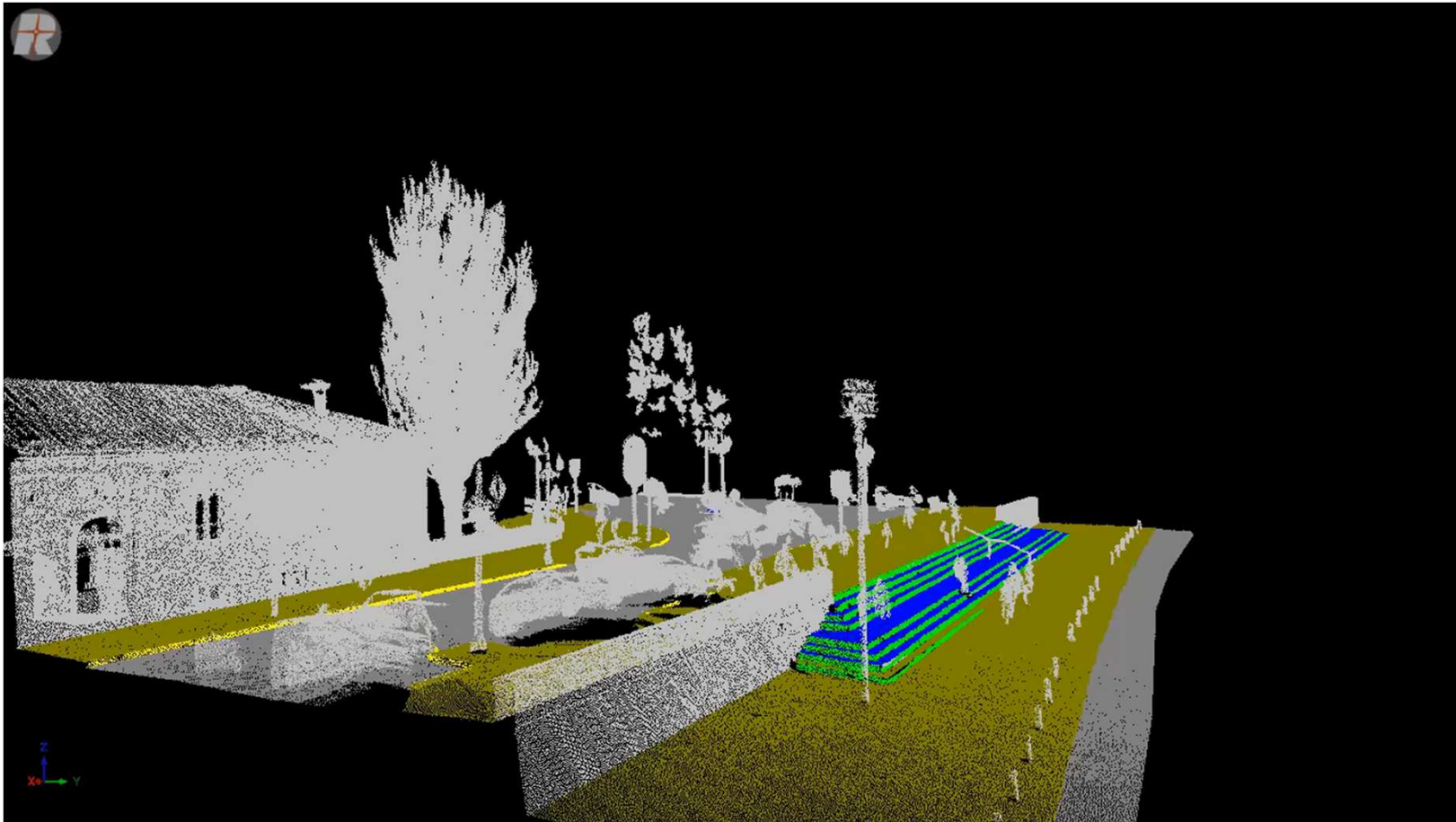
Postdoc Research

Adjacency analysis
Comparison with a graph dictionary



Results

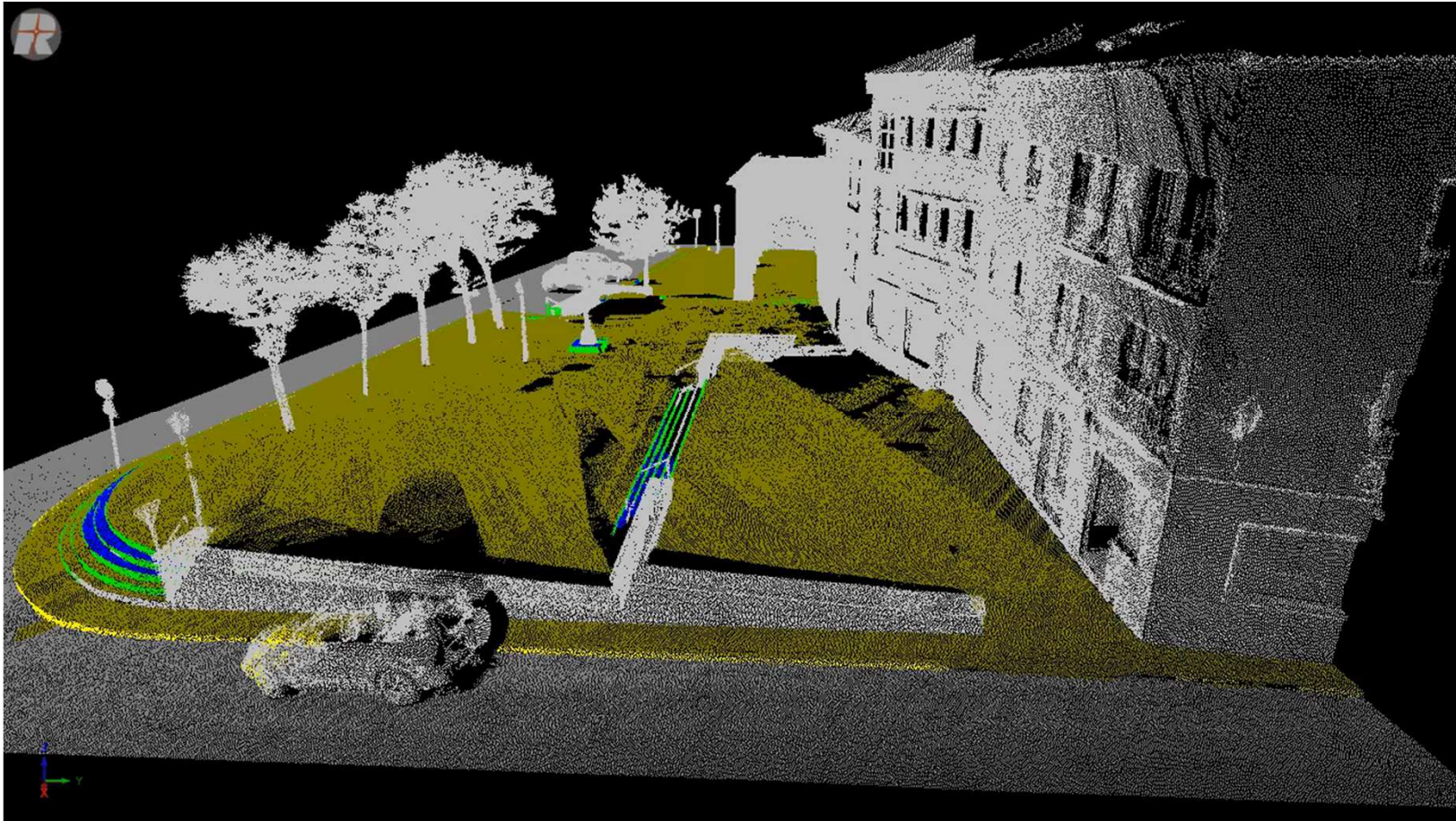
Postdoc Research



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Results

Postdoc Research



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References

- K Khoshelham, L Díaz-Vilariño, **3D Modelling of interior spaces: Learning the language of indoor architecture**, 2014, ISPRS Archives, XL.5: 321-326
- S Lagüela, L Díaz-Vilariño, J Armesto, P Arias, **Non-destructive approach for the generation and thermal characterization of an as-built BIM**, 2014, Construction and Building Materials 51, 55-61
- L Díaz-Vilariño, K Khoshelham, J Martínez-Sánchez, P Arias, **3D modeling of building indoor spaces and closed doors from imagery and point clouds**, 2015, Sensors 15 (2), 3491-3512
- L Díaz-Vilariño, B Conde, S Lagüela, H Lorenzo, **Automatic Detection and Segmentation of Columns in As-Built Buildings from Point Clouds**, 2015, Remote Sensing 7 (11), 15651-15667
- Indoor navigation from point clouds: 3D modelling and obstacle detection
- L. Díaz-Vilariño, P. Boguslawski, K. Khoshelham, H. Lorenzo, L. Mahdjoubi, **Indoor navigation from point clouds: 3D modelling and obstacle detection**, 2016, ISPRS Archives, XLI-B4, 275-281

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