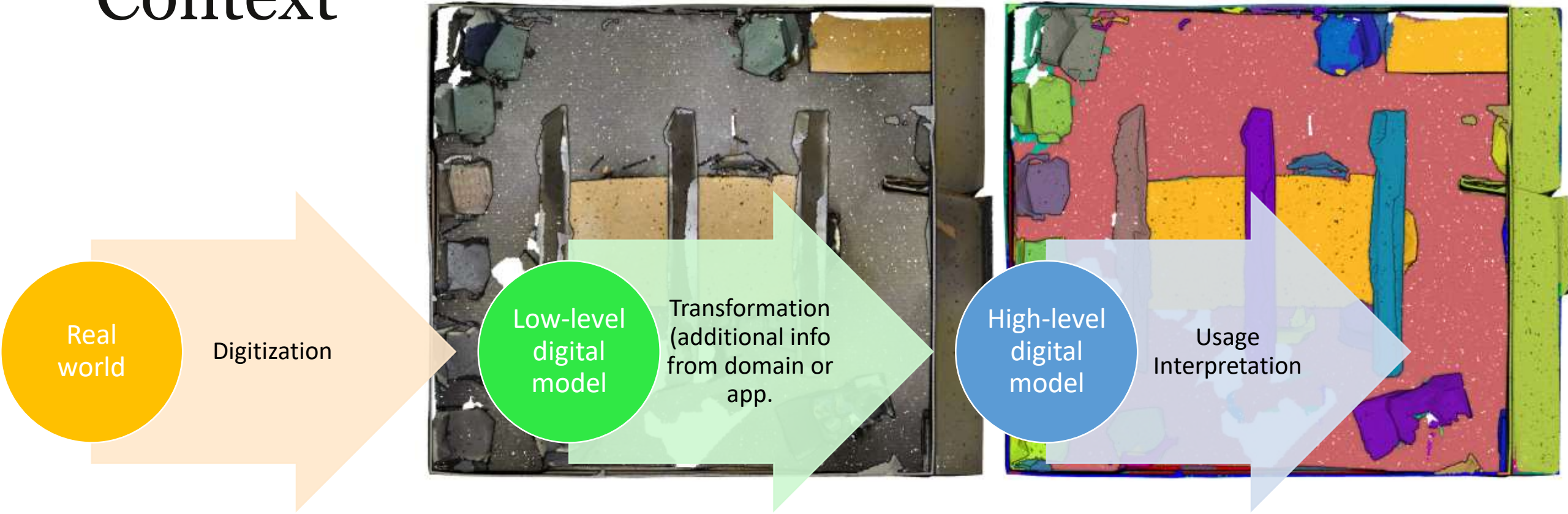


The Smart Point Cloud Model Integration of point intelligence

Florent Poux

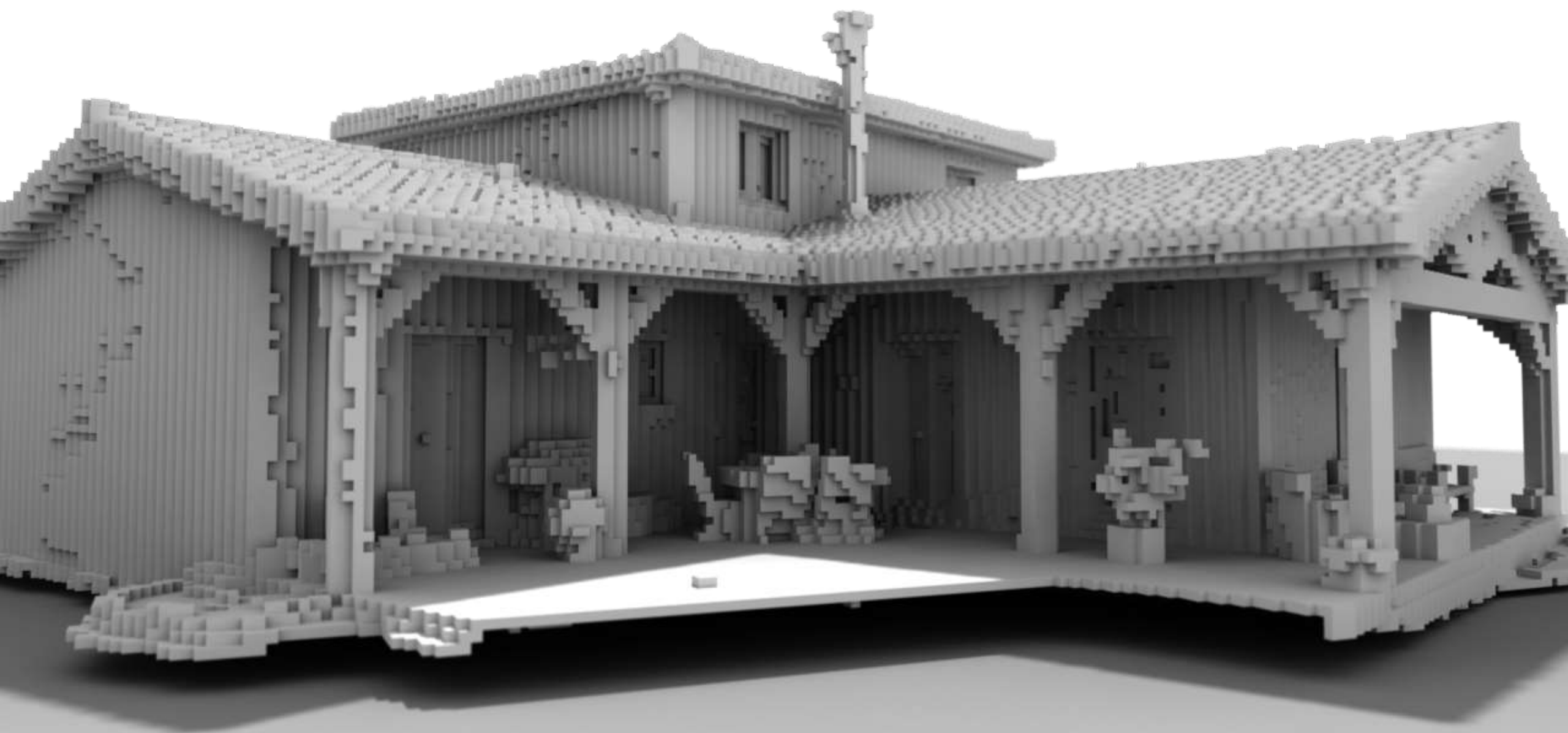
Context

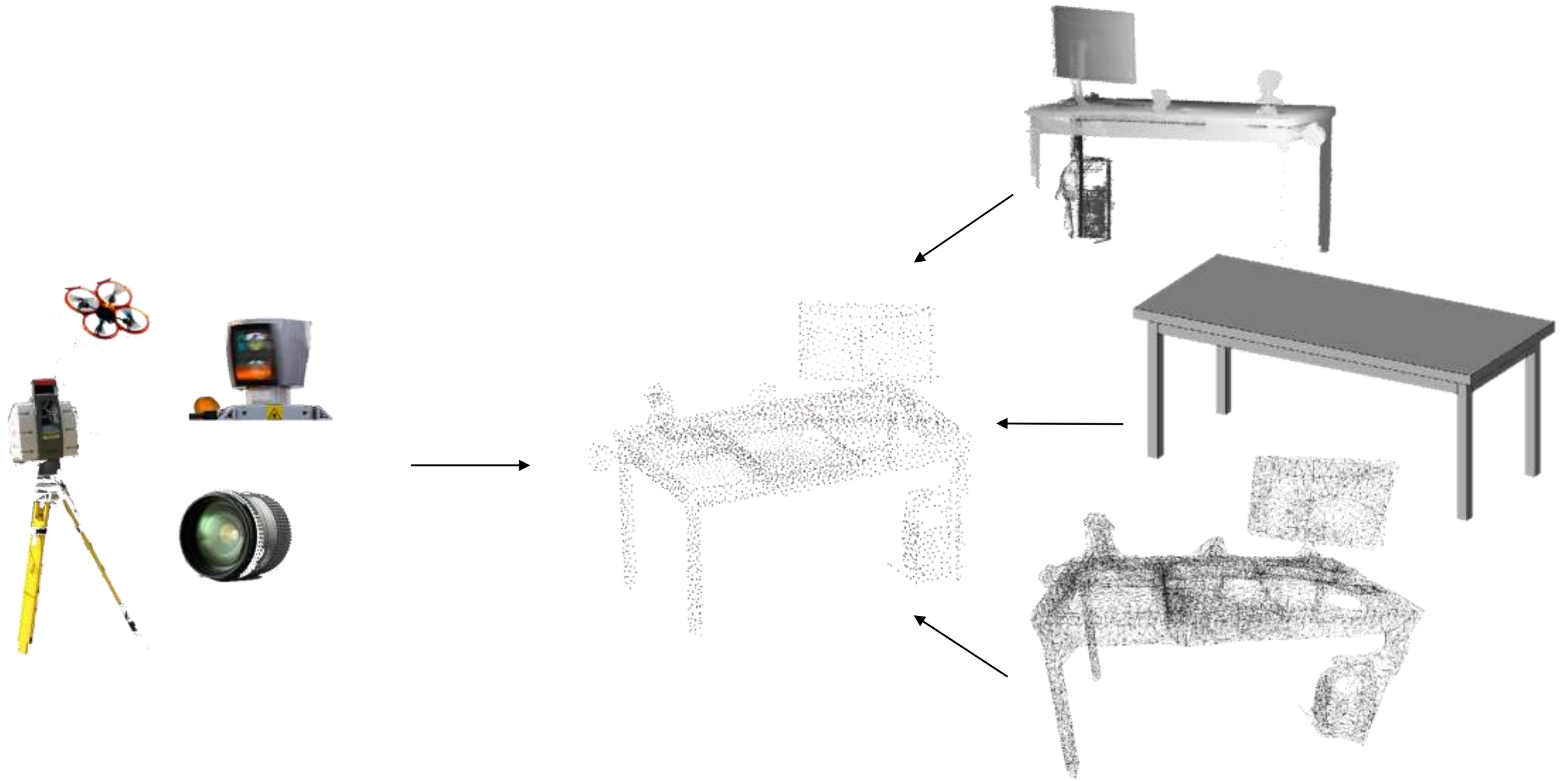


3D Point Cloud Specificities



Representation & Structuration





Automation

1 Acquisition

2 Pre-processing

3 Registration

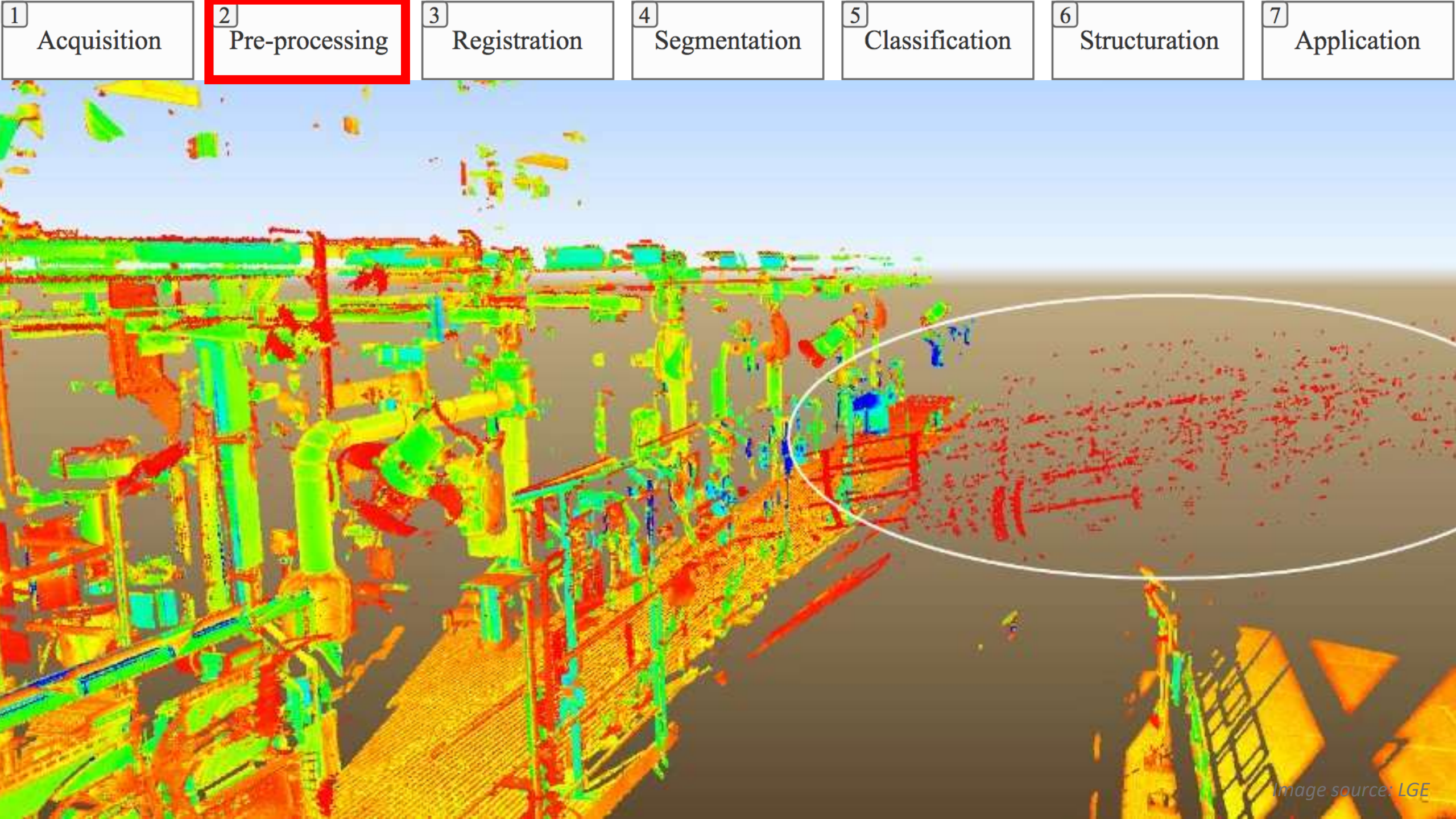
4 Segmentation

5 Classification

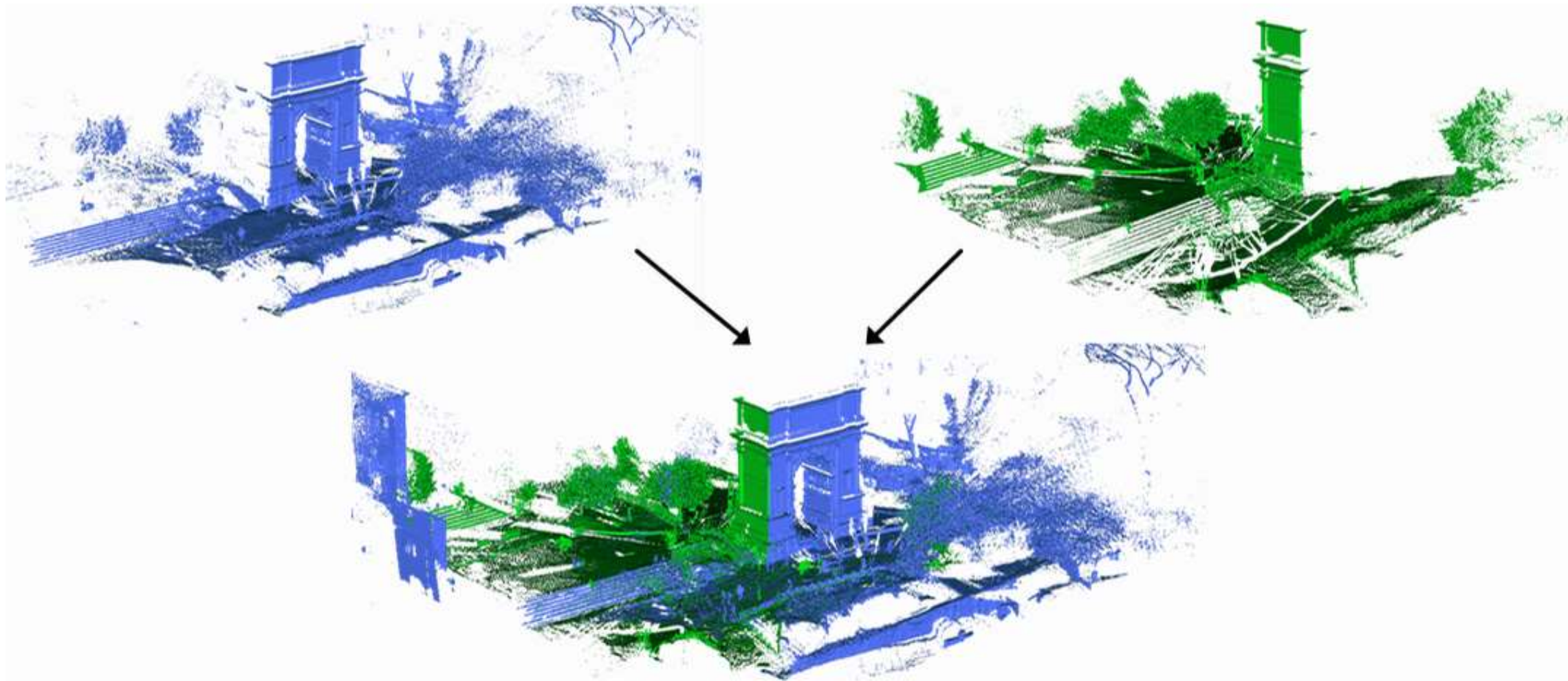
6 Structuration

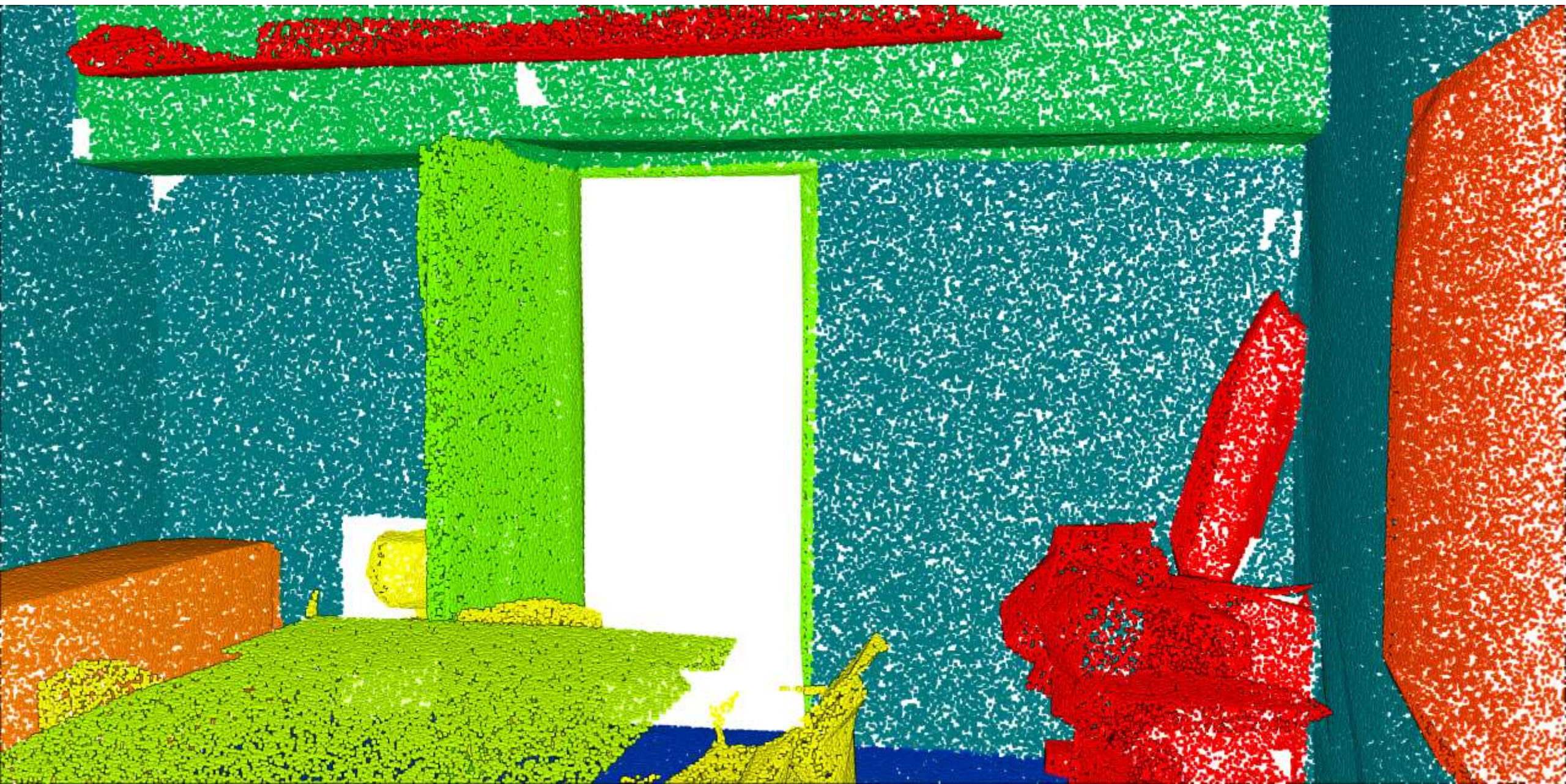
7 Application

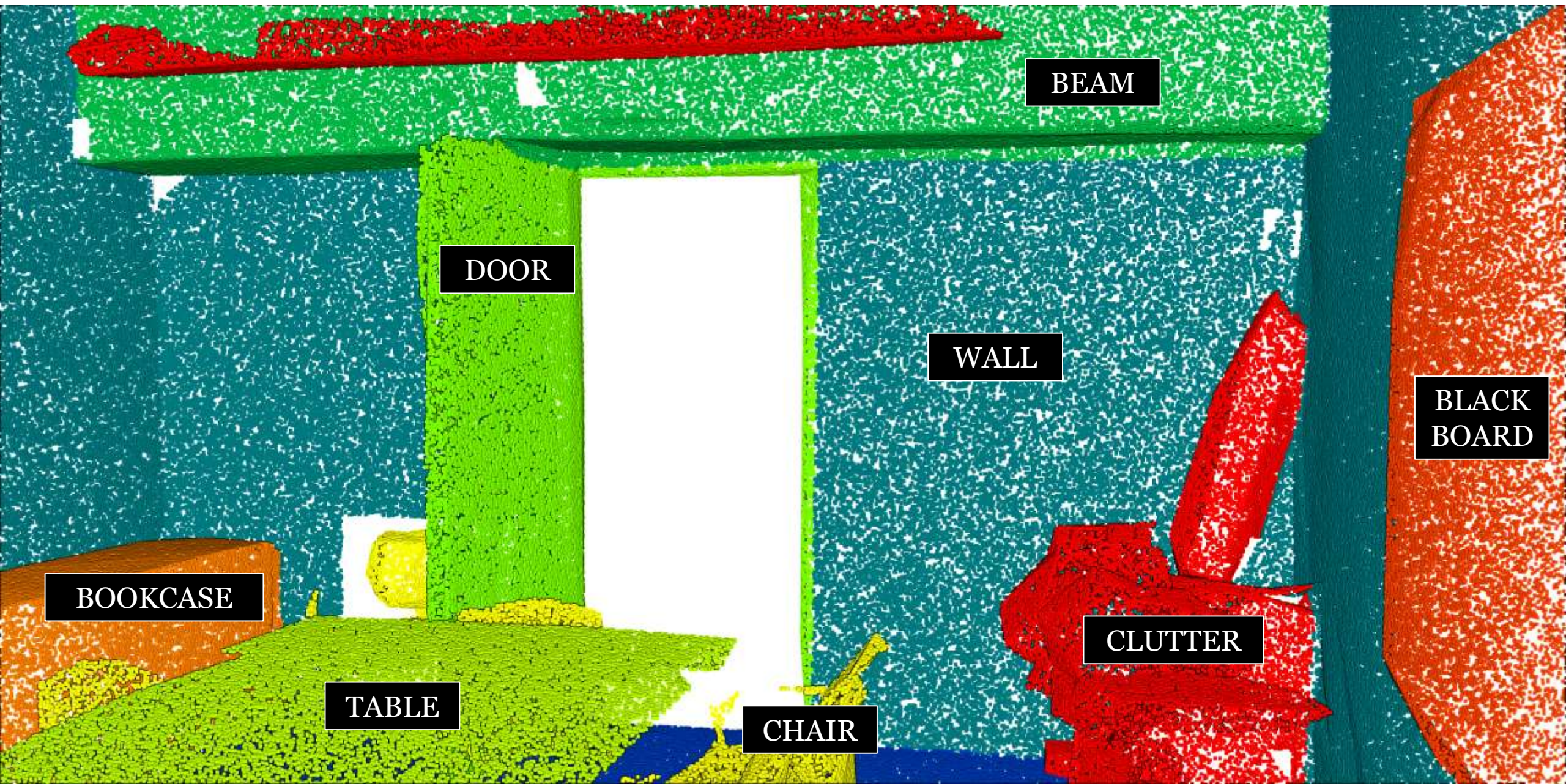




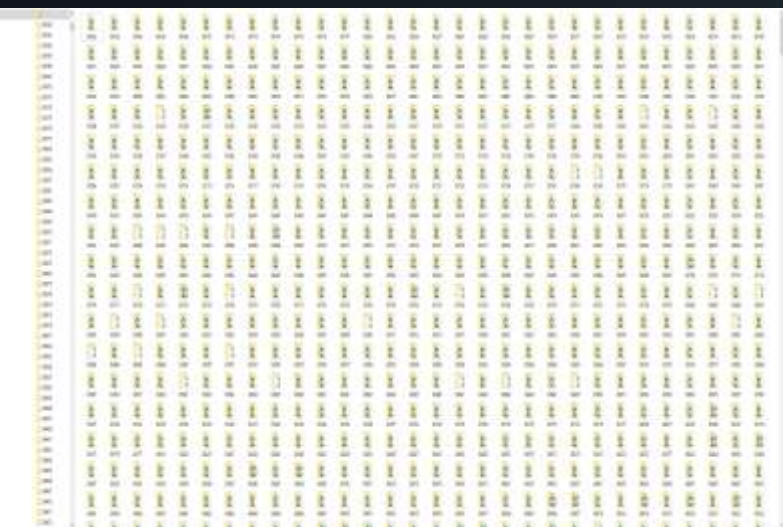
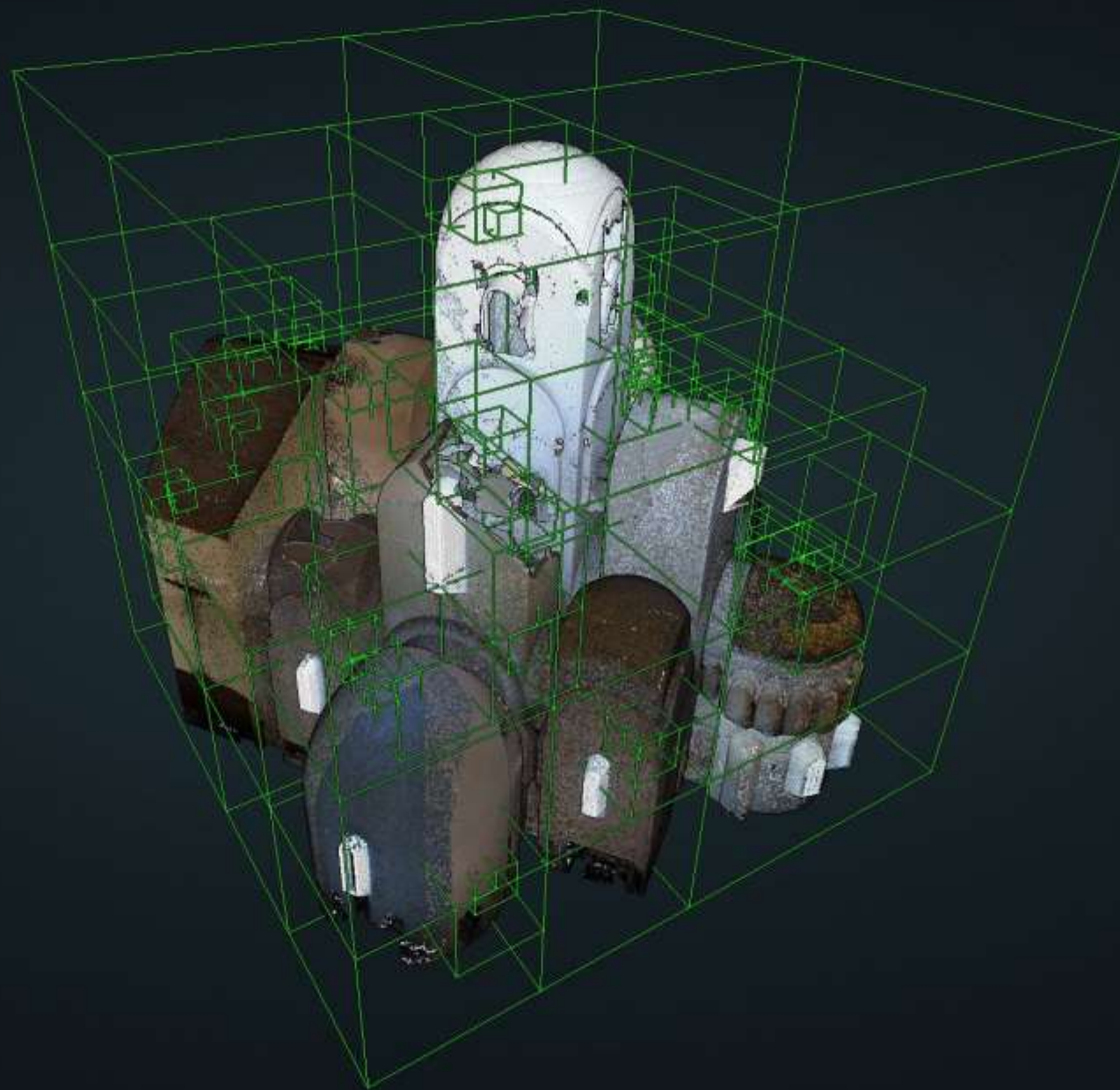
- 1 Acquisition
- 2 Pre-processing
- 3 Registration
- 4 Segmentation
- 5 Classification
- 6 Structuration
- 7 Application

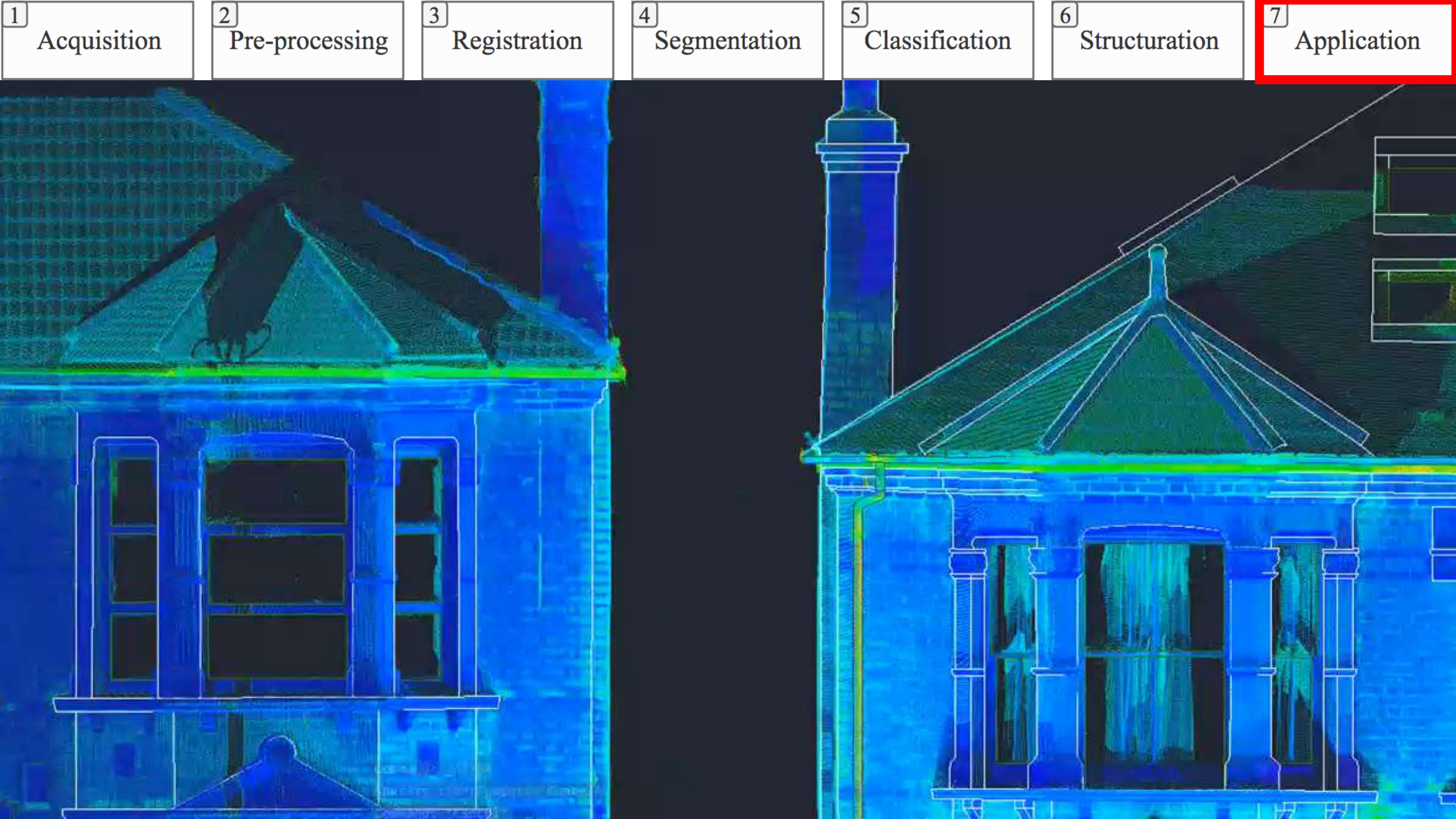






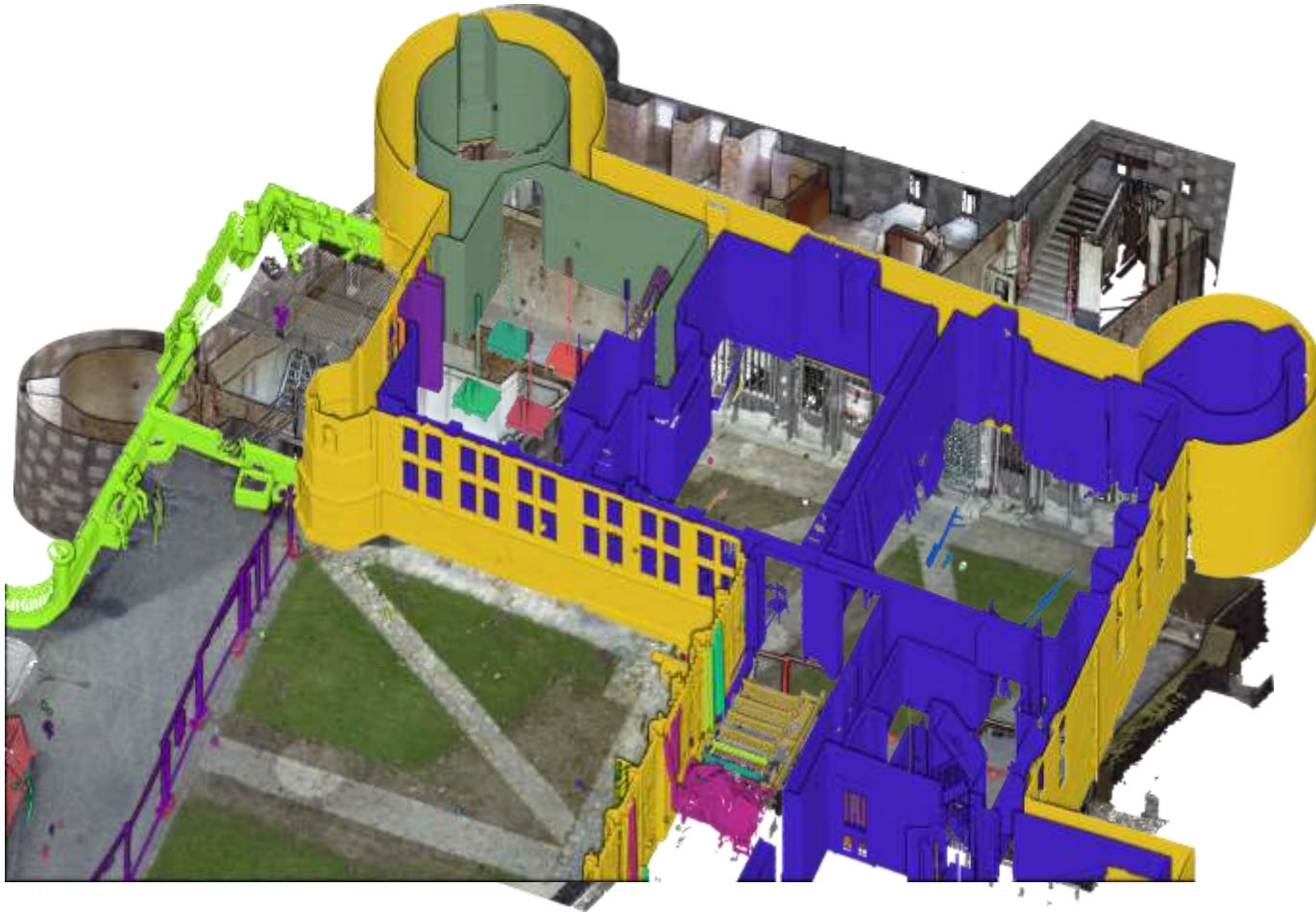
1	Acquisition	2	Pre-processing	3	Registration	4	Segmentation	5	Classification	6	Structuration	7	Application
---	-------------	---	----------------	---	--------------	---	--------------	---	----------------	---	---------------	---	-------------



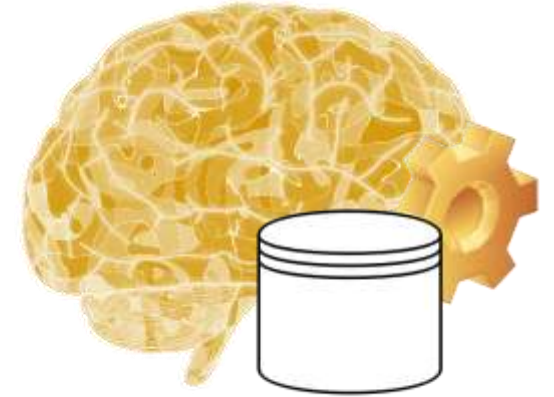


- 3D Point Cloud Specificities
- Representation & Structuration
- Automation

Semantics & Knowledge Integration



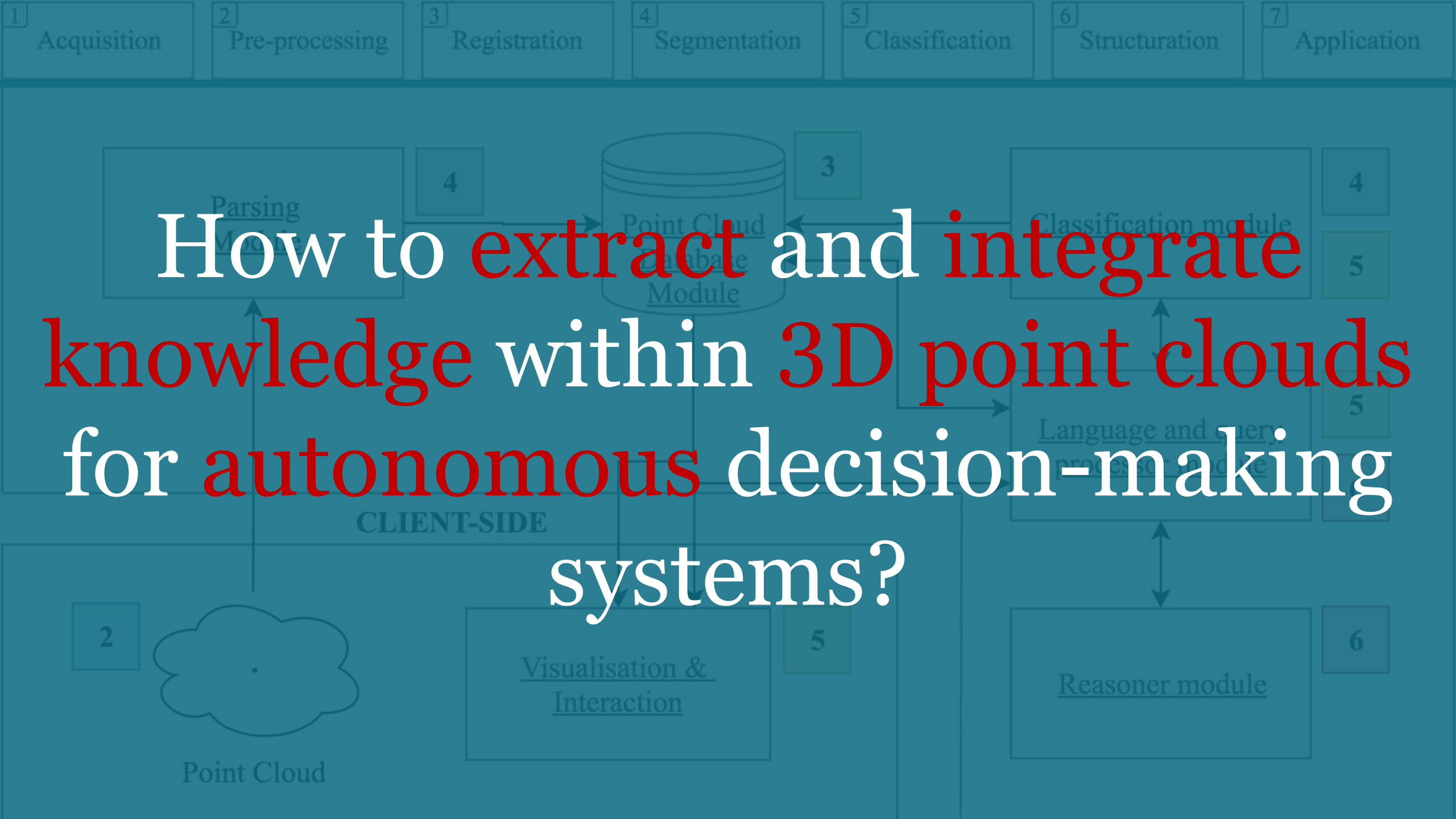
TODAY
←→
WHAT WE WANT



KNOWLEDGE



DELIMITATION
EXTRACTION, ...
SIMULATION, ...



How to extract and integrate knowledge within 3D point clouds for autonomous decision-making systems?

Acquisition

Pre-processing

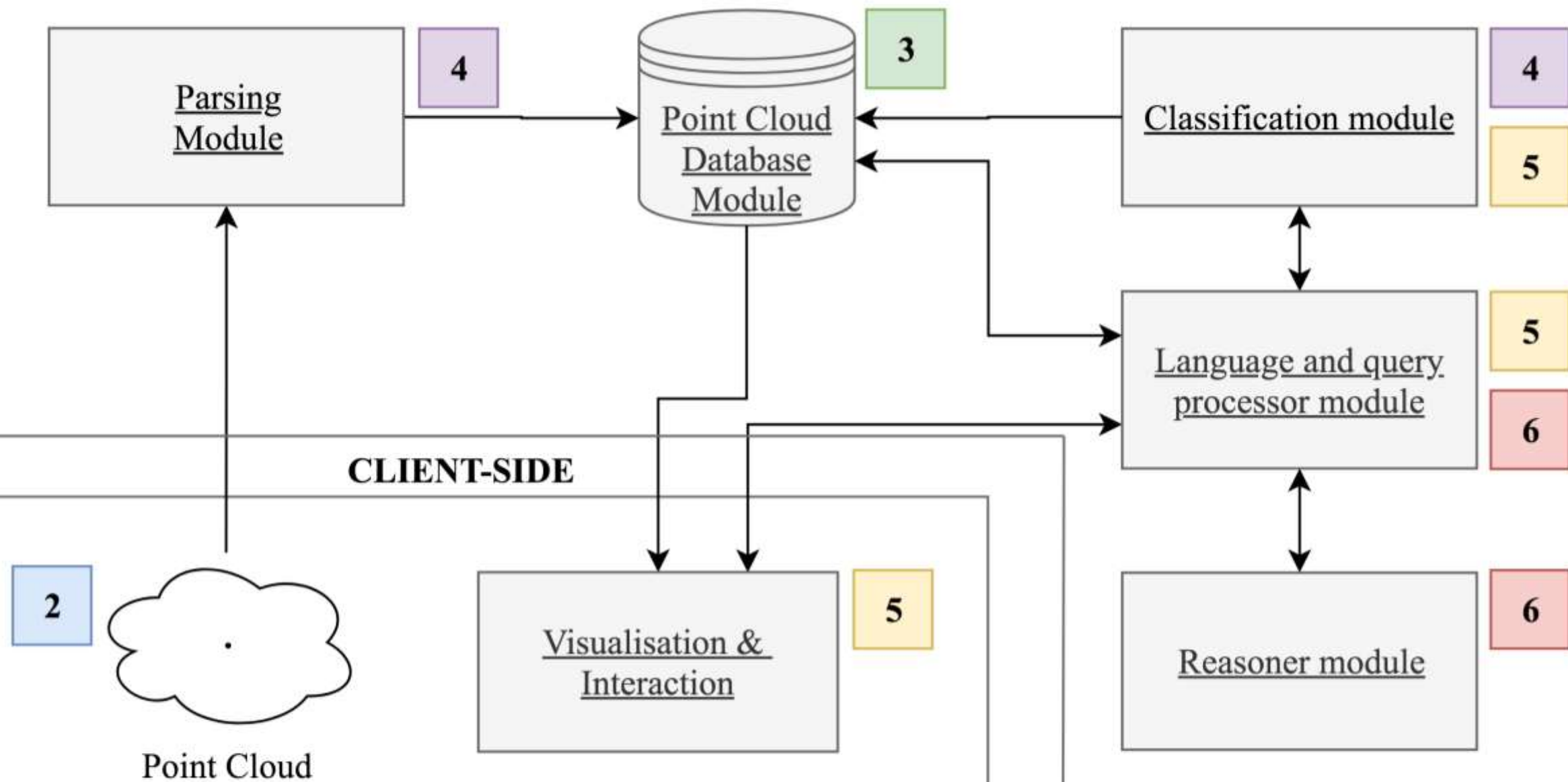
Registration

Segmentation

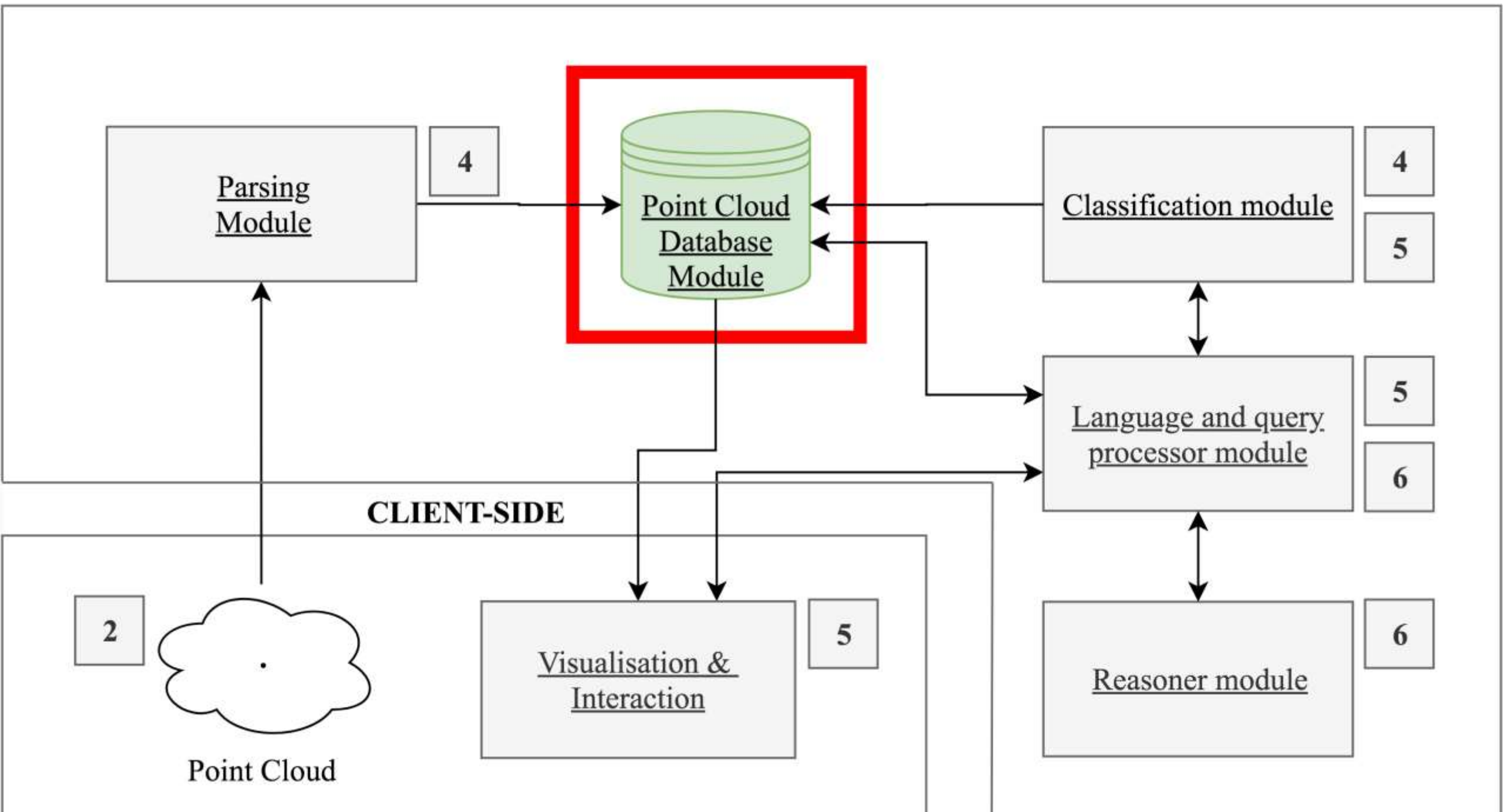
Classification

Structuration

Application

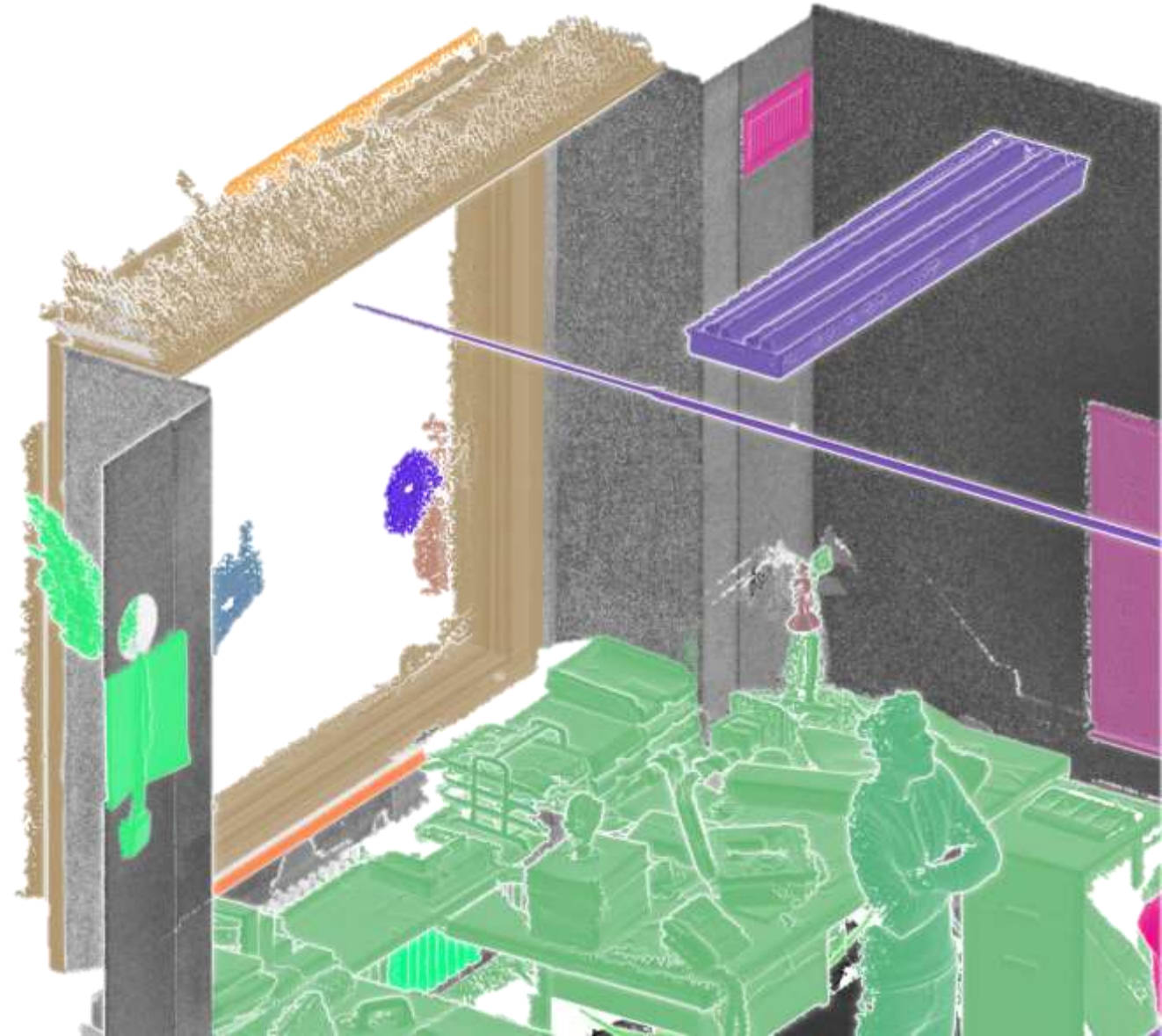
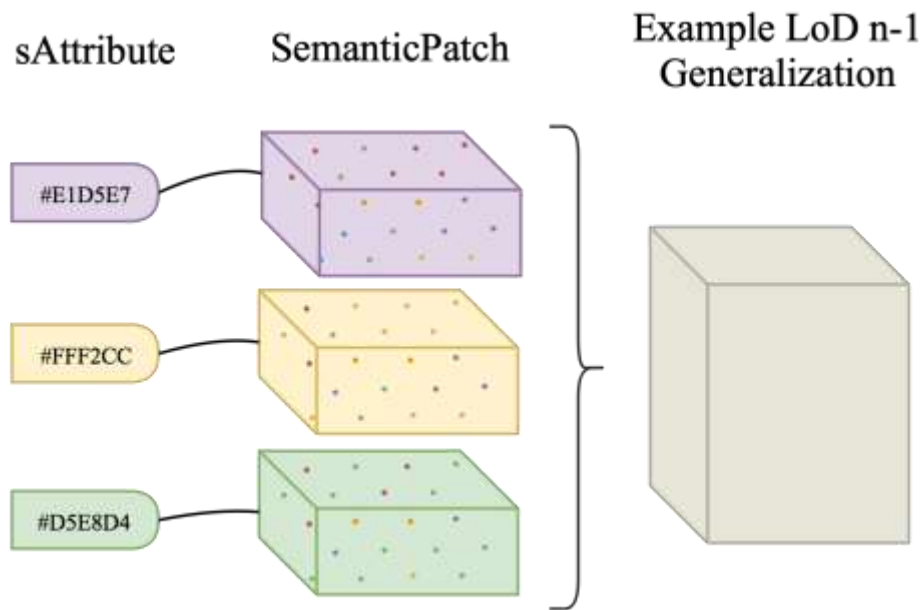


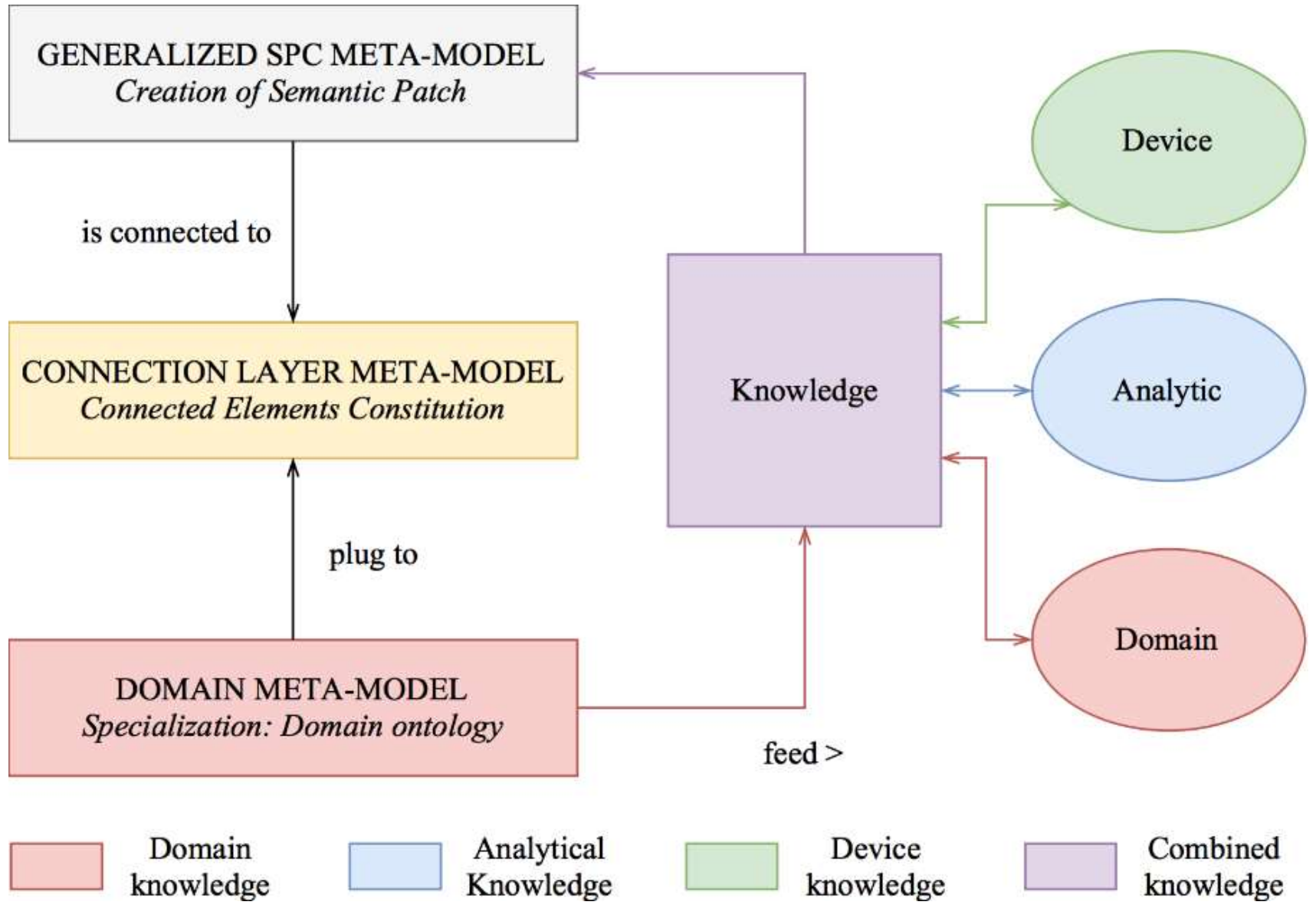
SERVER-SIDE



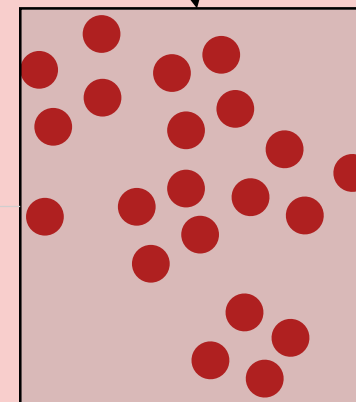
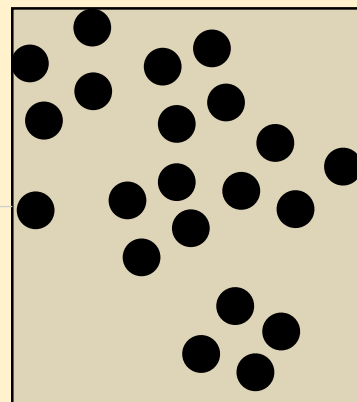
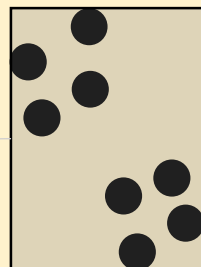
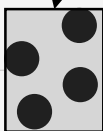
Point Cloud Specificity

Unstructured and too sparse for DBMS per-row insertion





Knowledge



Point

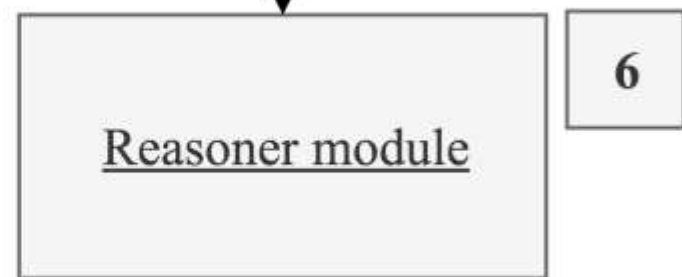
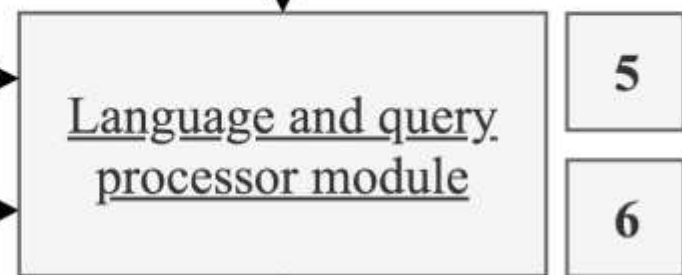
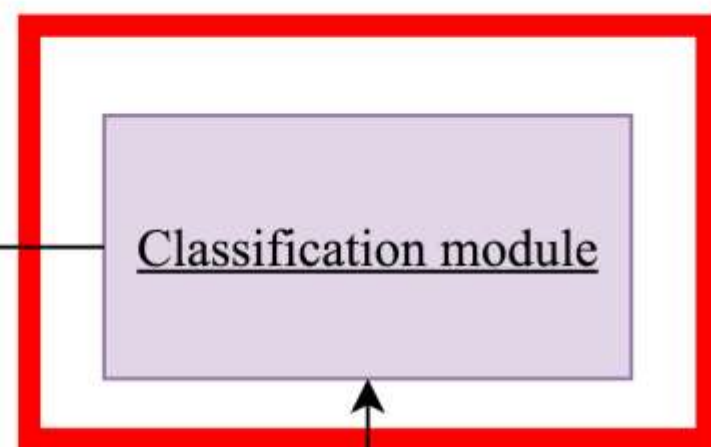
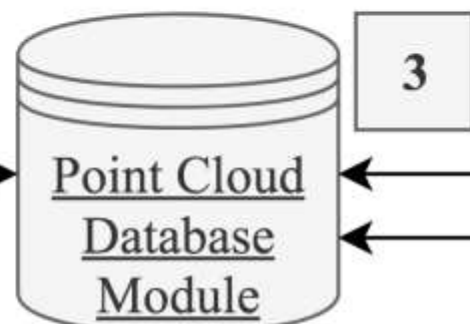
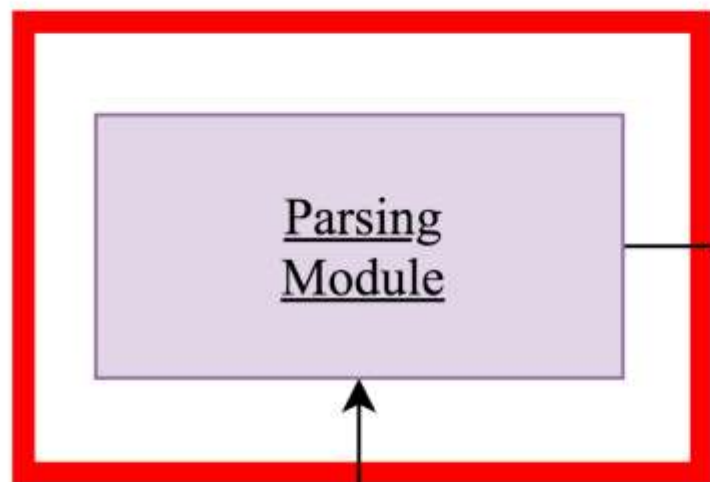
Semantic
Patch

Connected
Element

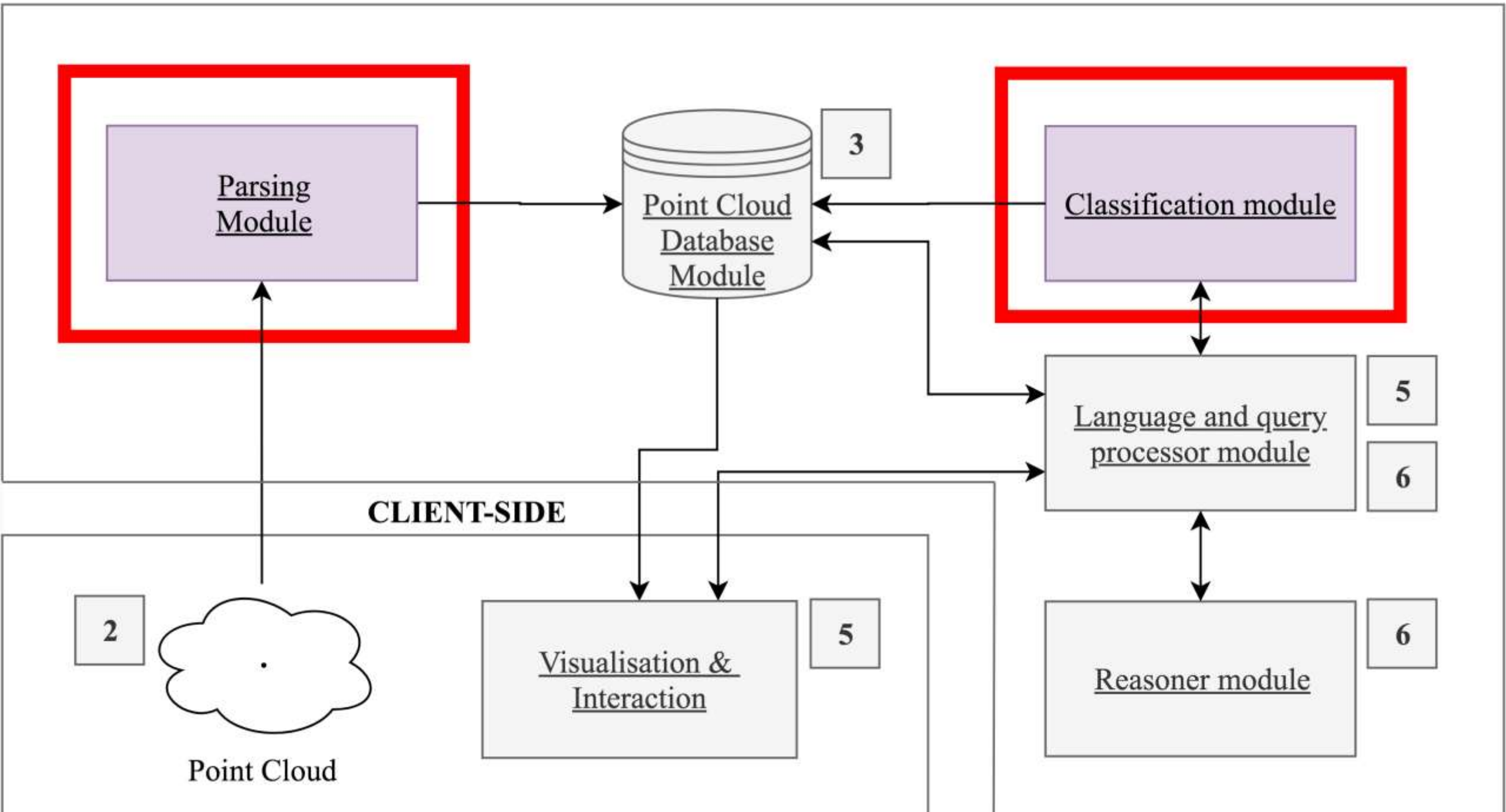
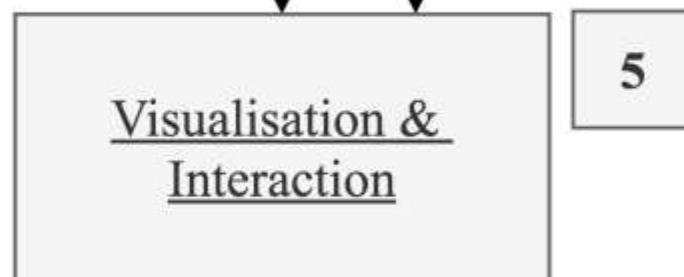
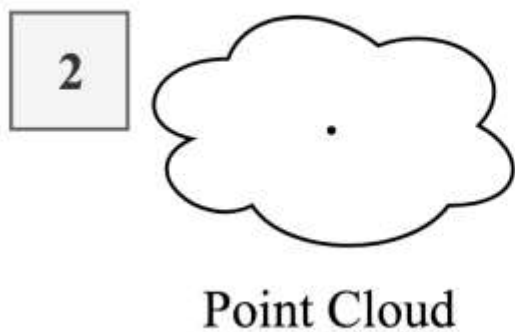
Aggregated
Element

Class
Instance

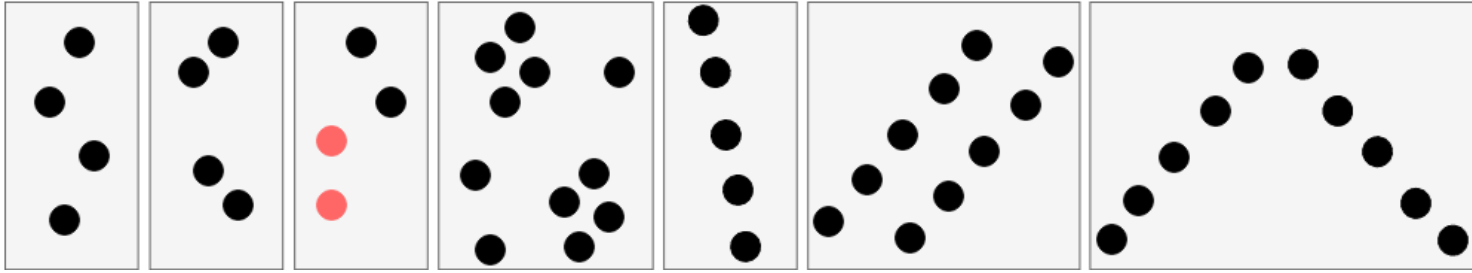
SERVER-SIDE



CLIENT-SIDE



Gestalt's theory



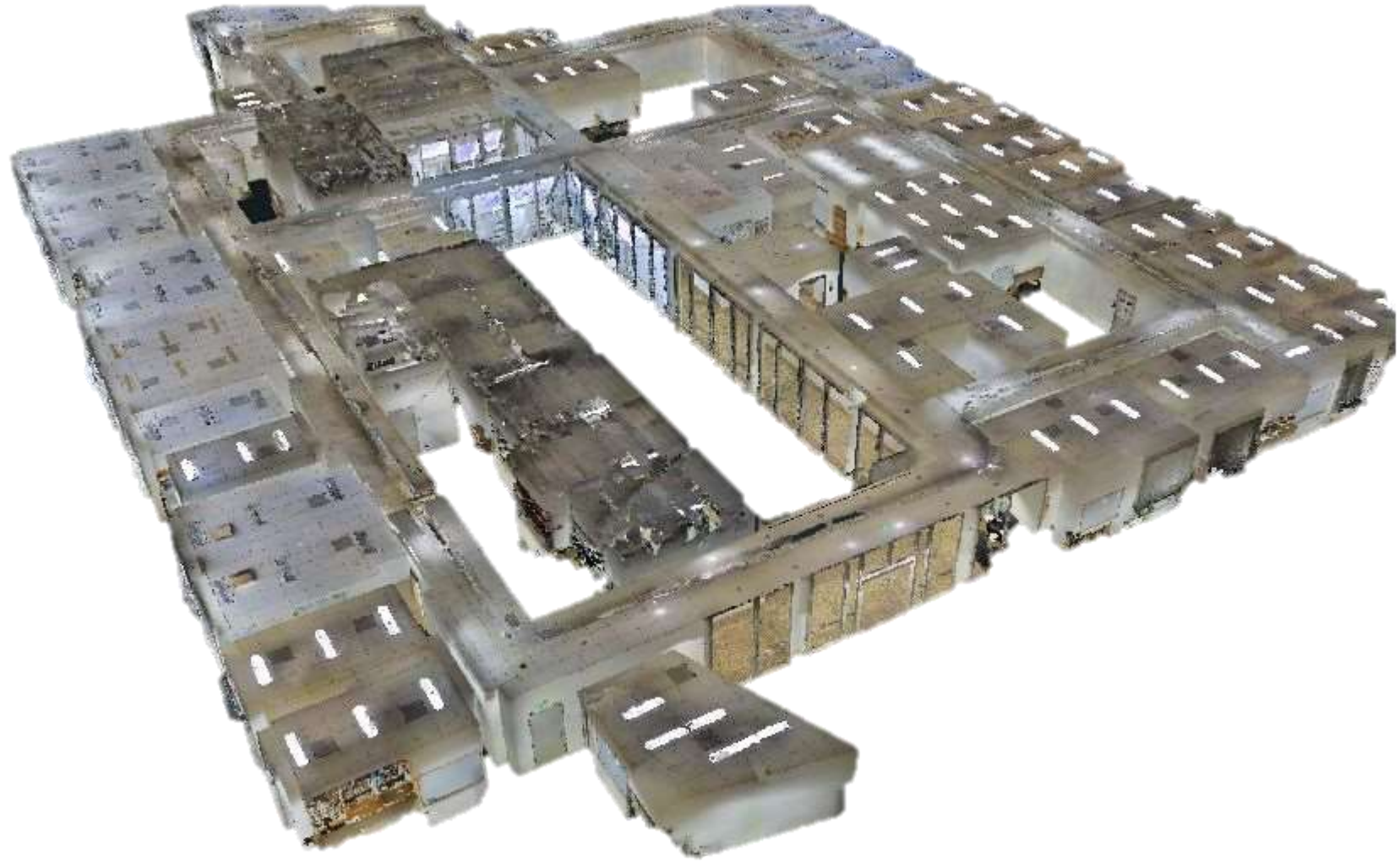
Visual patterns on points



Deep learning > feature-engineering

Visual patterns of points

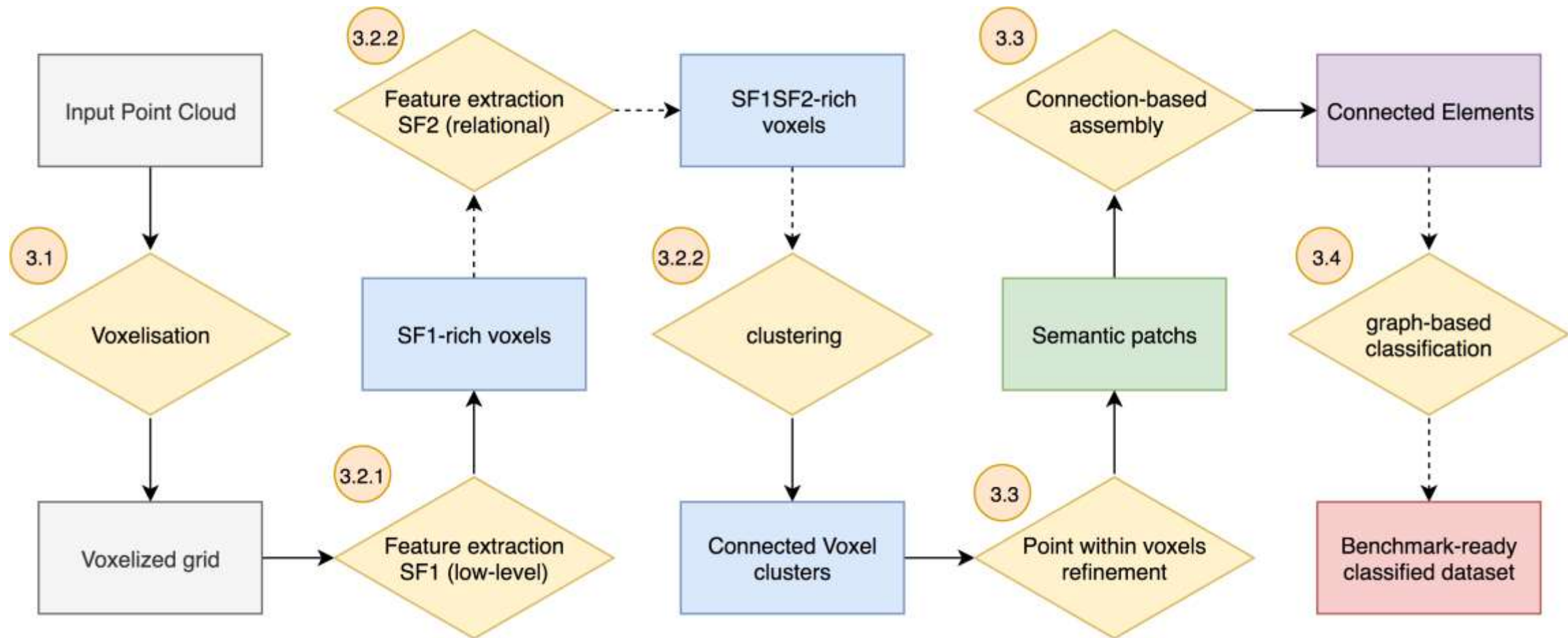
Point Cloud Datasets

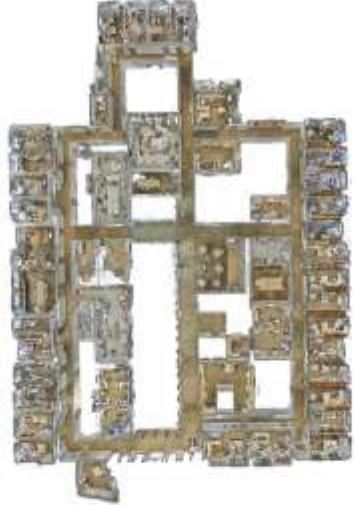
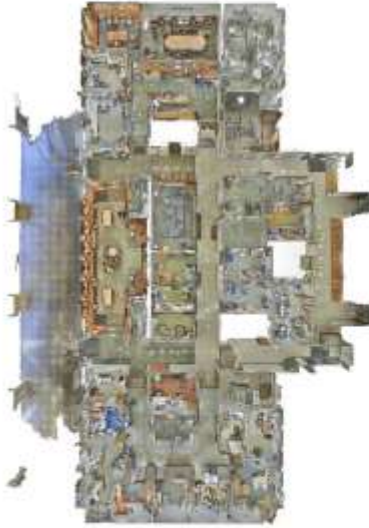
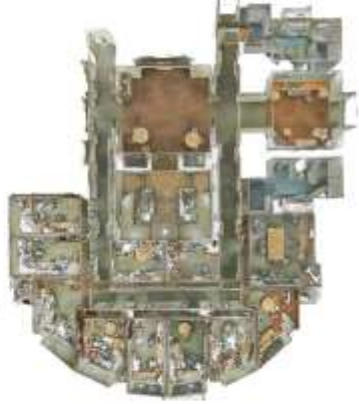


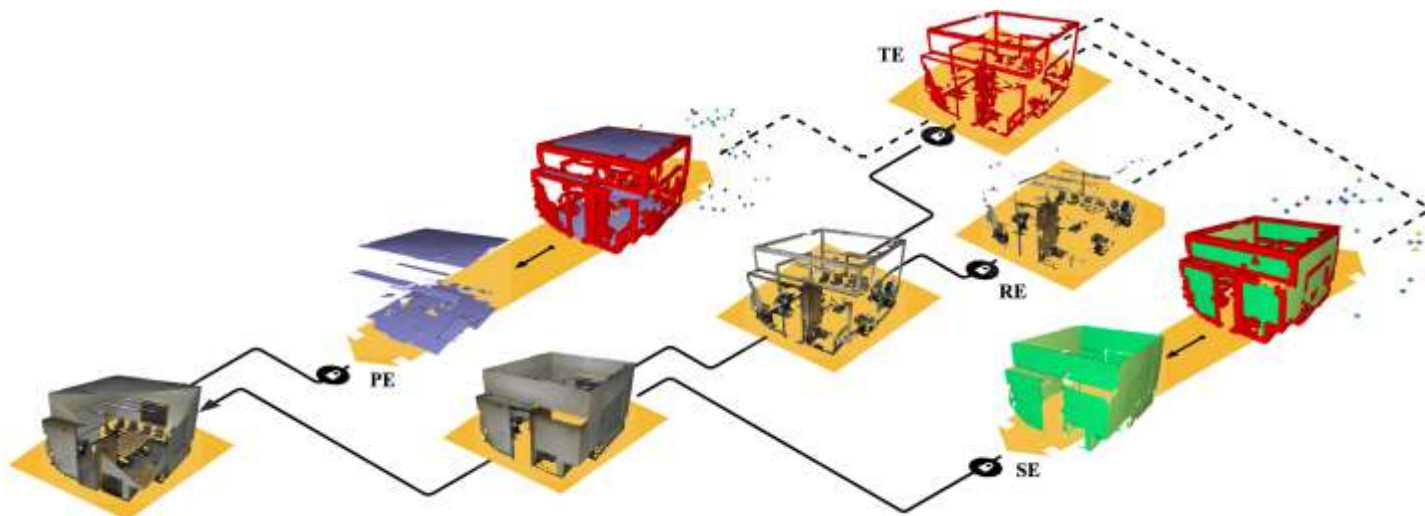
Point Cloud Dataset

Deep learning < feature-engineering

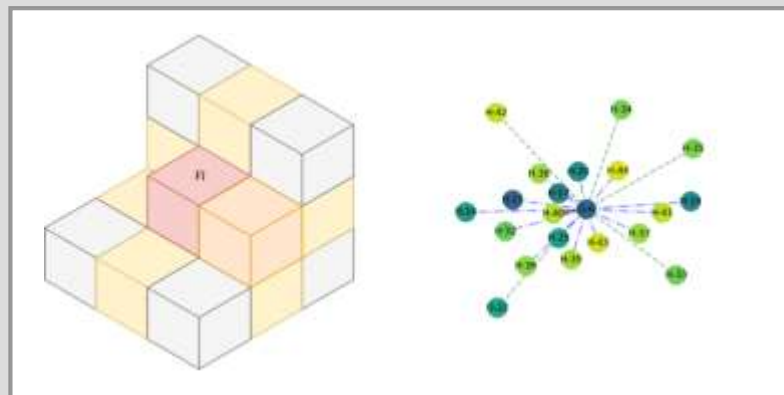
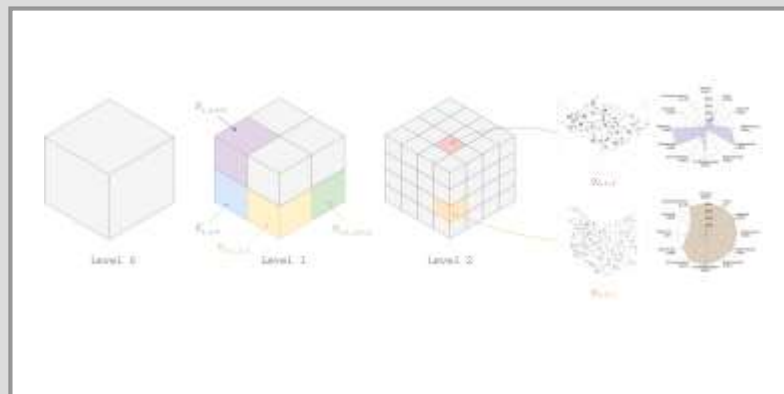
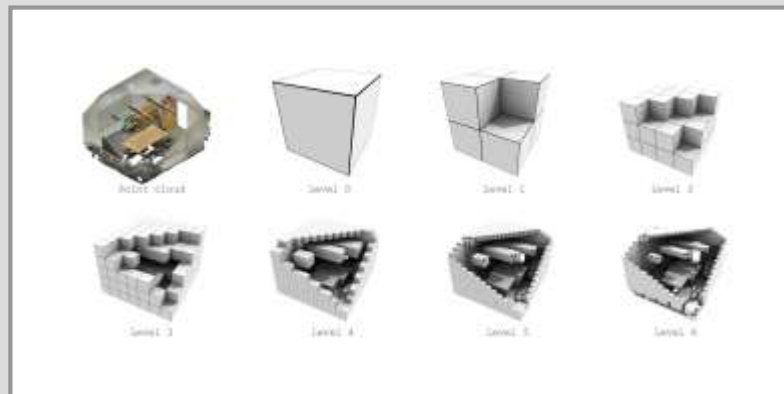
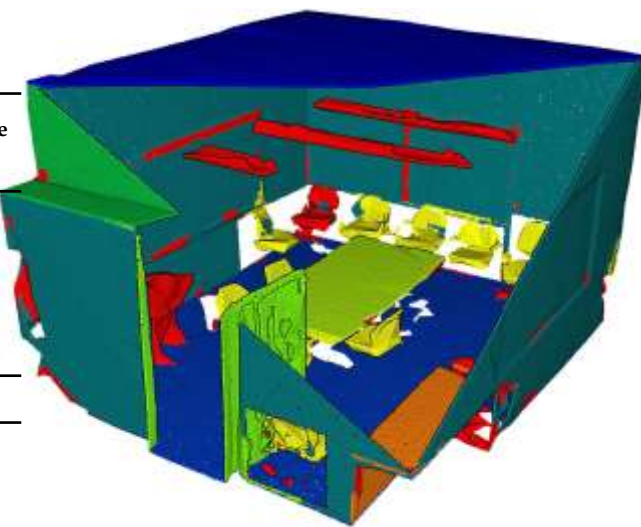








Overall Precision	Ceiling	Floor	Wall	Beam	Door	Table	Chair	Bookcase
Baseline (no colour) [16]	0.48	0.81	0.68	0.68	0.44	0.51	0.12	0.52
Baseline (full) [16]	0.72	0.89	0.73	0.67	0.54	0.46	0.16	0.55
Ours	0.94	0.96	0.79	0.53	0.19	0.88	0.72	0.2



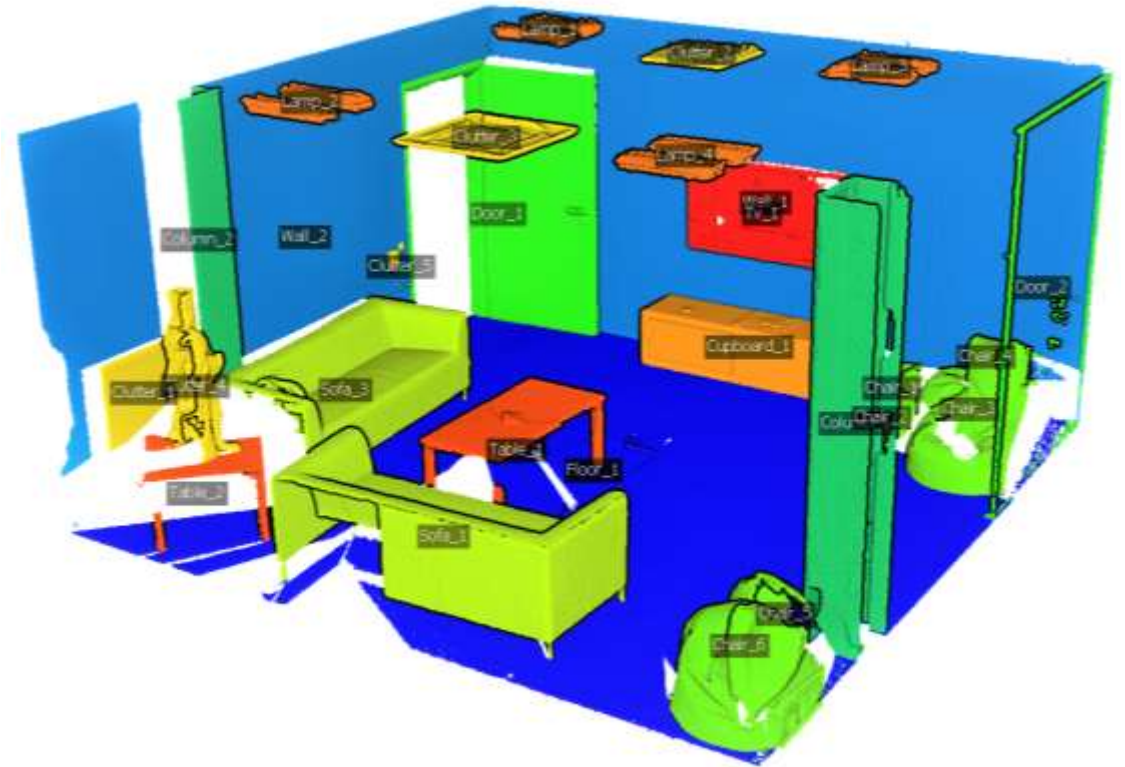
1.5 million points / minute

Overall	Ceiling	Floor	Wall	Beam	Door	Table	Chair	Bookcase
Precision	0	1	2	3	6	7	8	10
Baseline (no colour) [16]	0.48	0.81	0.68	0.68	0.44	0.51	0.12	0.52
Baseline (full) [16]	0.72	0.89	0.73	0.67	0.54	0.46	0.16	0.55
Ours	0.94	0.96	0.79	0.53	0.19	0.88	0.72	0.2

Name	Number of points	Attribute	Sensor	Size Go
CHÂTEAU_JEHAY	2.300.247.428	RGB, intensity	Leica P30	69.636
PCID10_RTWH_Exterior	312.710.687	RGB, intensity	TLS	4,907
PCID11_RTWH_CHAIR	259.101.028	RGB, intensity	TLS	4,807
PCID2_ULG_B5a	115.190.236	RGB, intensity	TLS	3,824
PCID8_NAAVIS_1	44.847.540	RGB	NavVIS	0,657
PCID6_REVO	53.800.194	Without	REVO	0,630
PCID9_NAAVIS_2	4.244.416	RGB	NavVIS	0,062

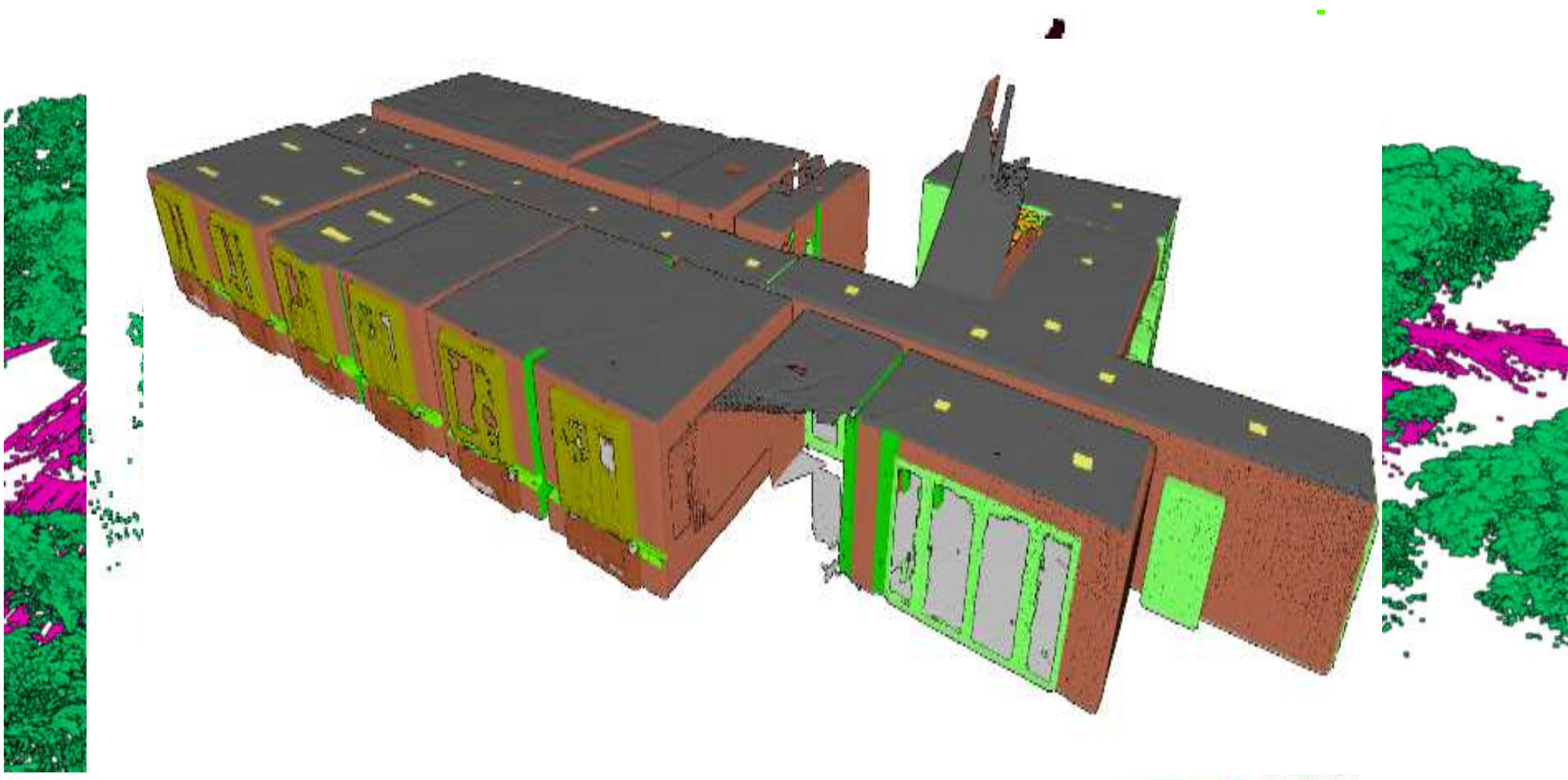


Indoor		Outdoor	
0	Floor	30	road_Sign
1	Ceiling	31	advertisingBoard
2	Wall	32	banc
3	Beam	33	bicycle
4	Column	34	bicycleStation
5	Window	35	Building_facades
6	Door	36	busStation
7	Table	37	car
11	Board	41	Humains
...

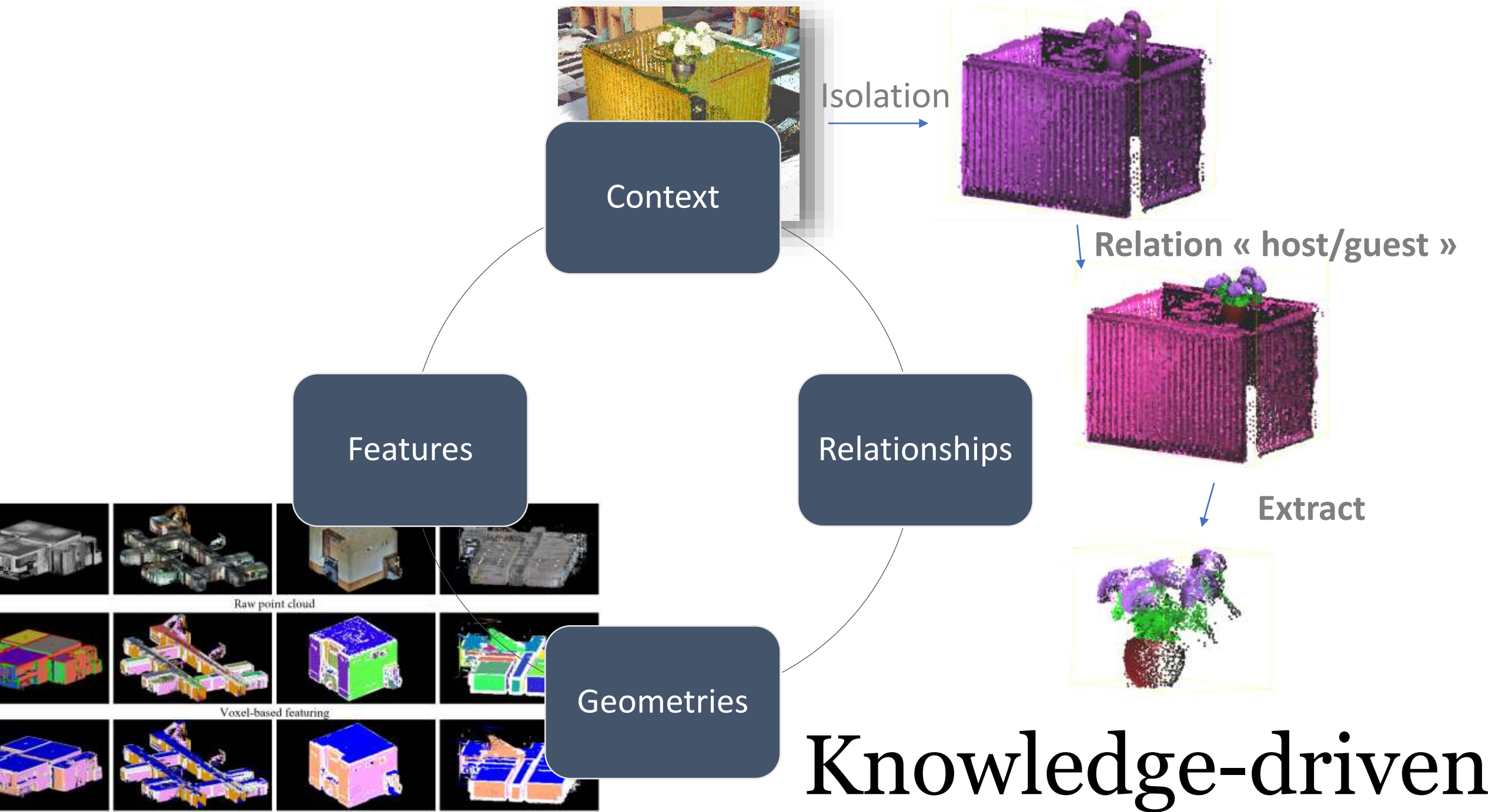


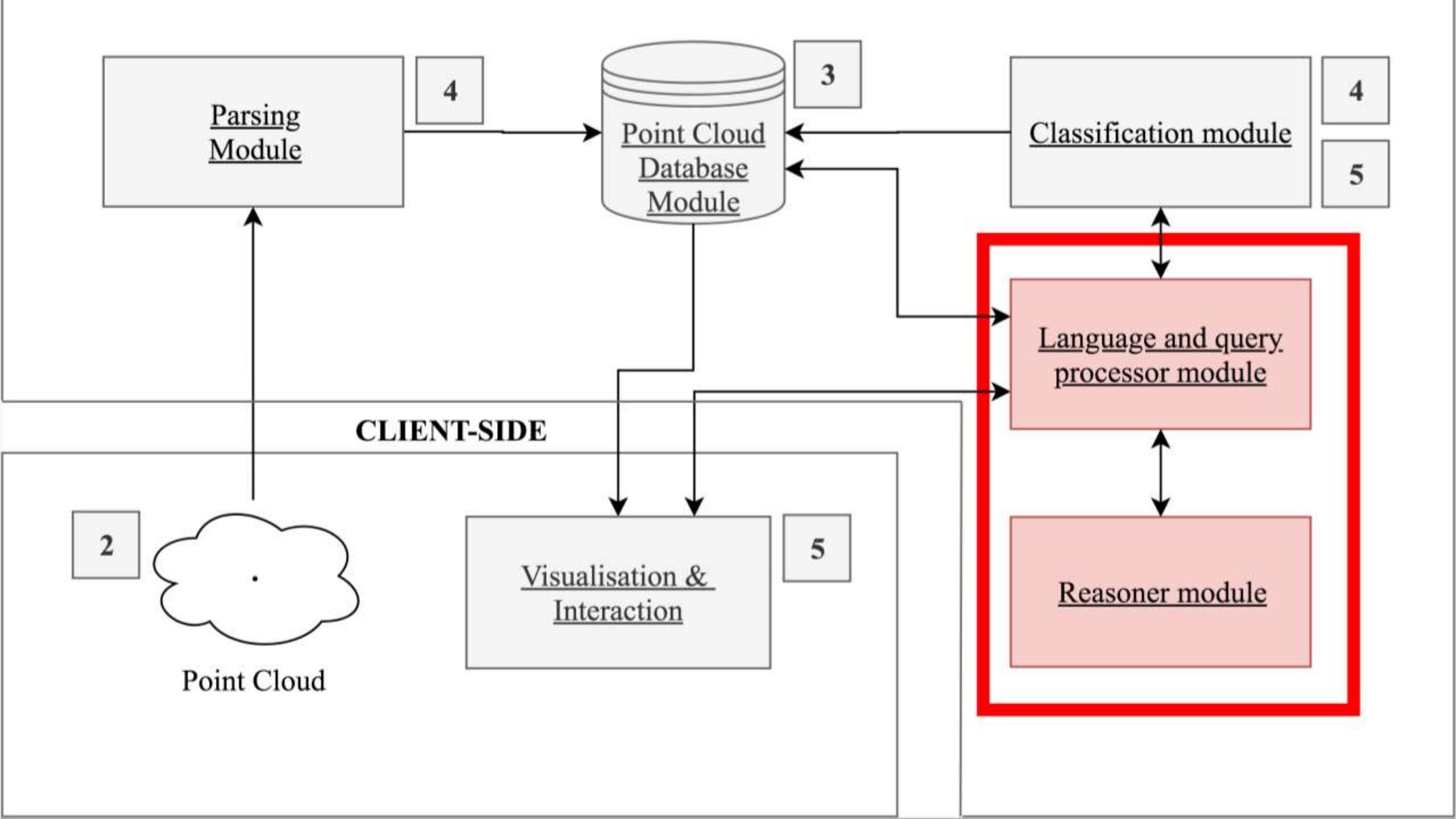
Format .LAS, ou bien .LAZ
Format specification .LAS version 1.2

Example after classification



Perencanaan Arsitektur





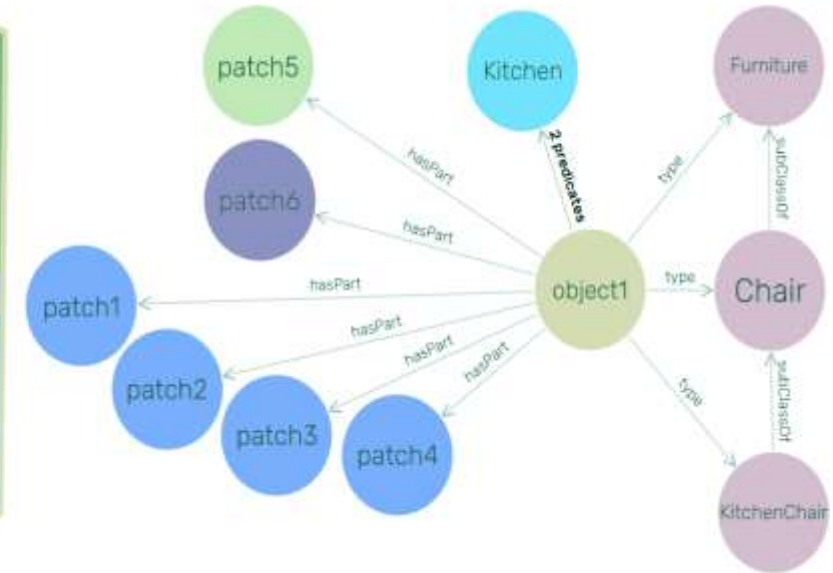
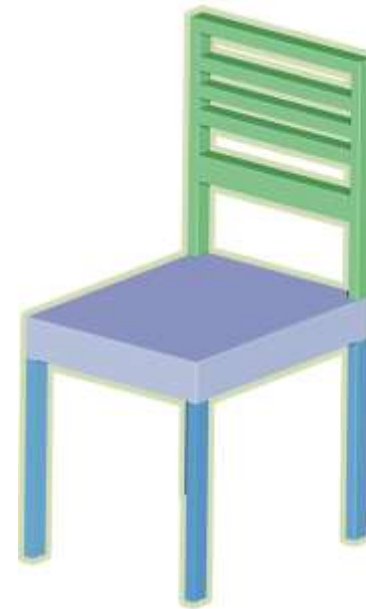
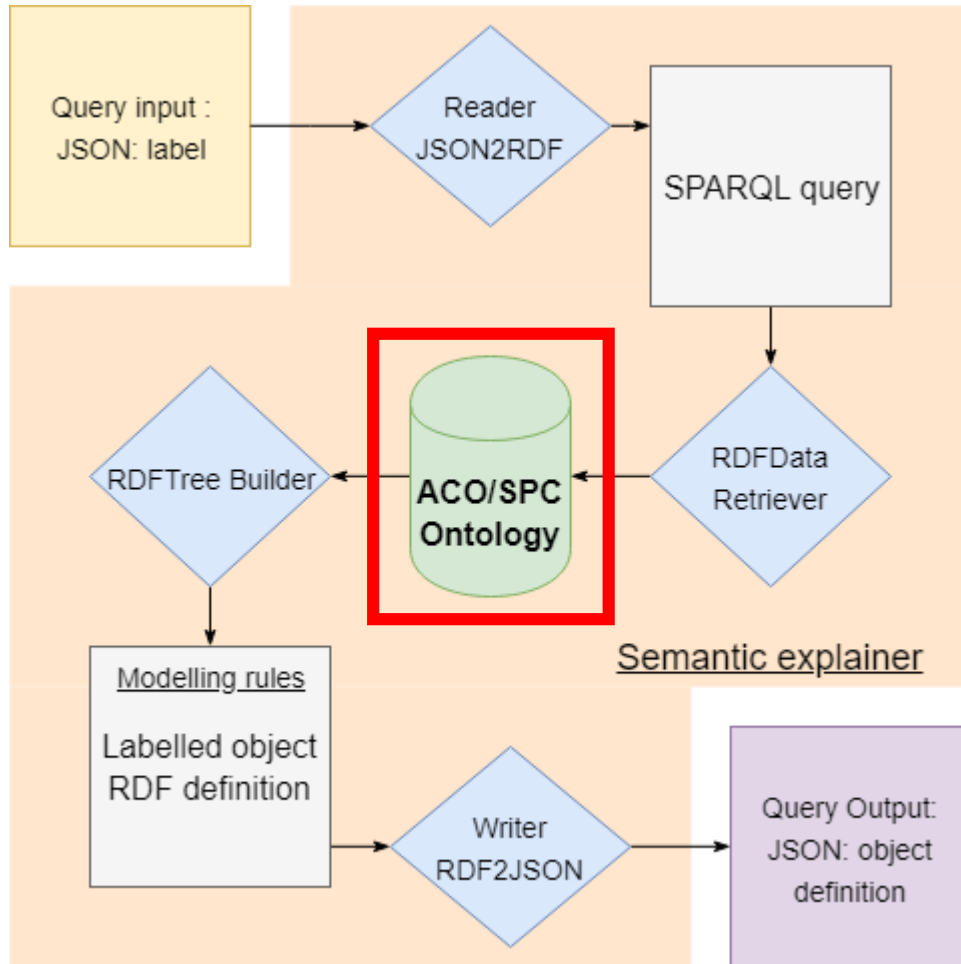




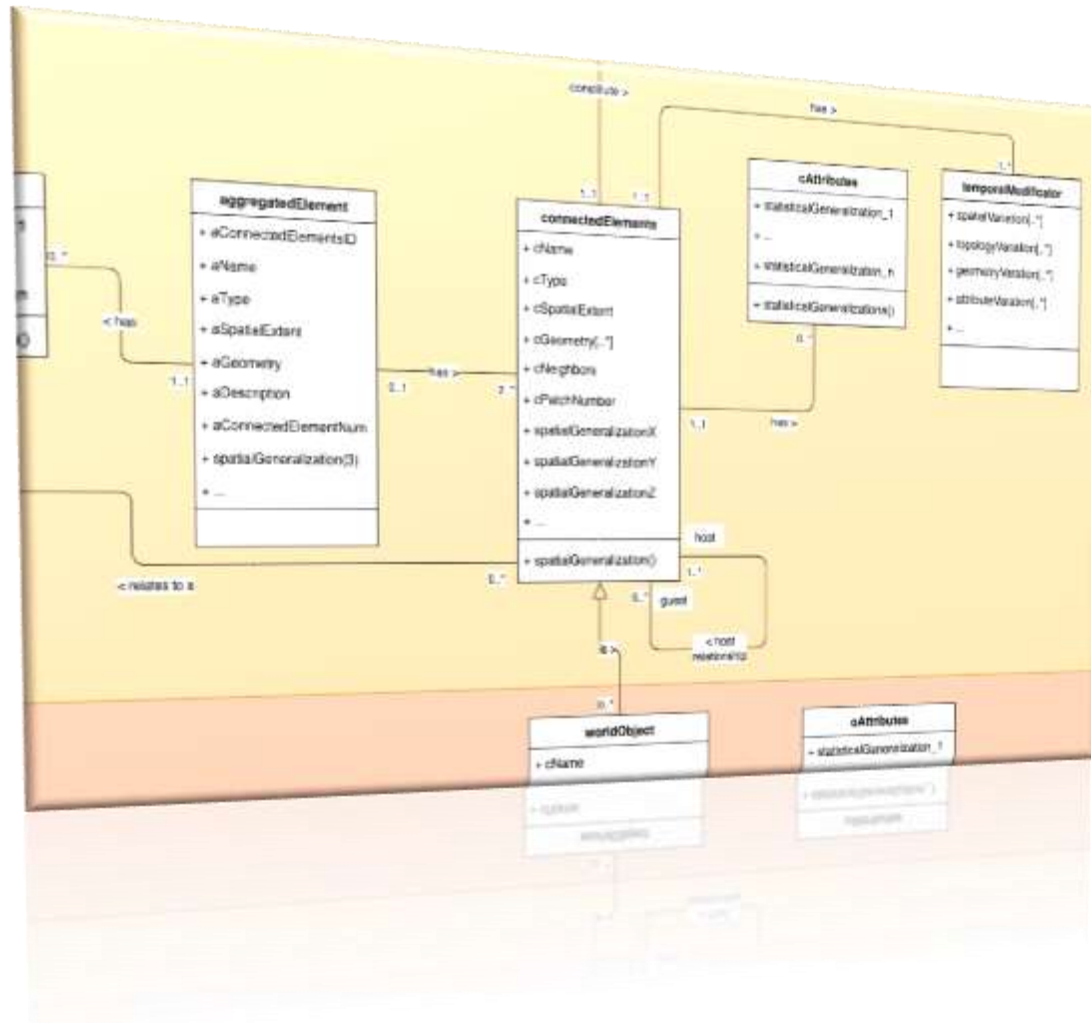
A classified entity



chair



Connected Elements



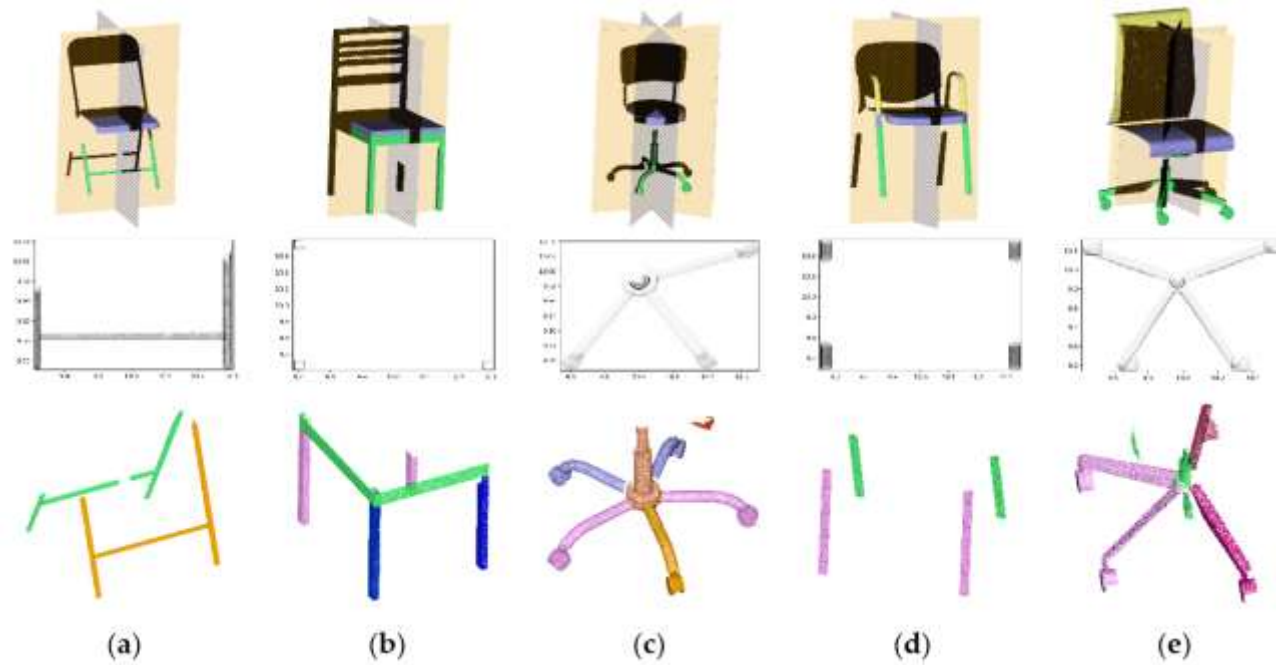
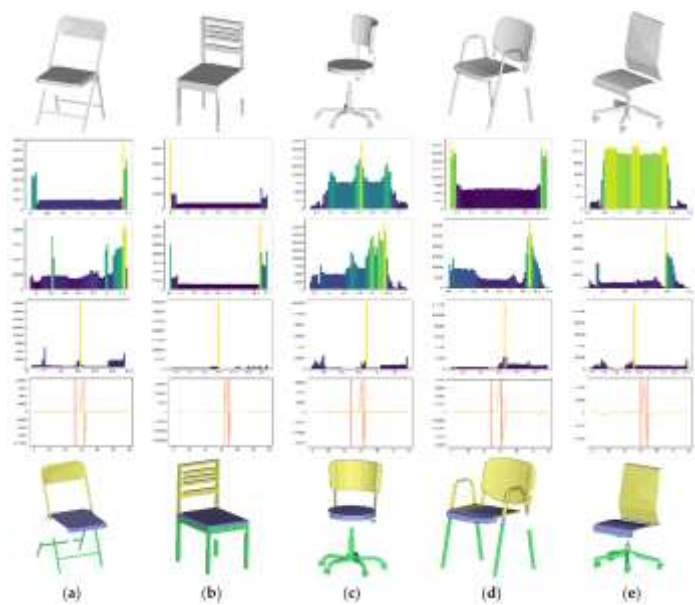
- Aggregated-Element
- Normal-Element
- Sub-Element



Chair = AE

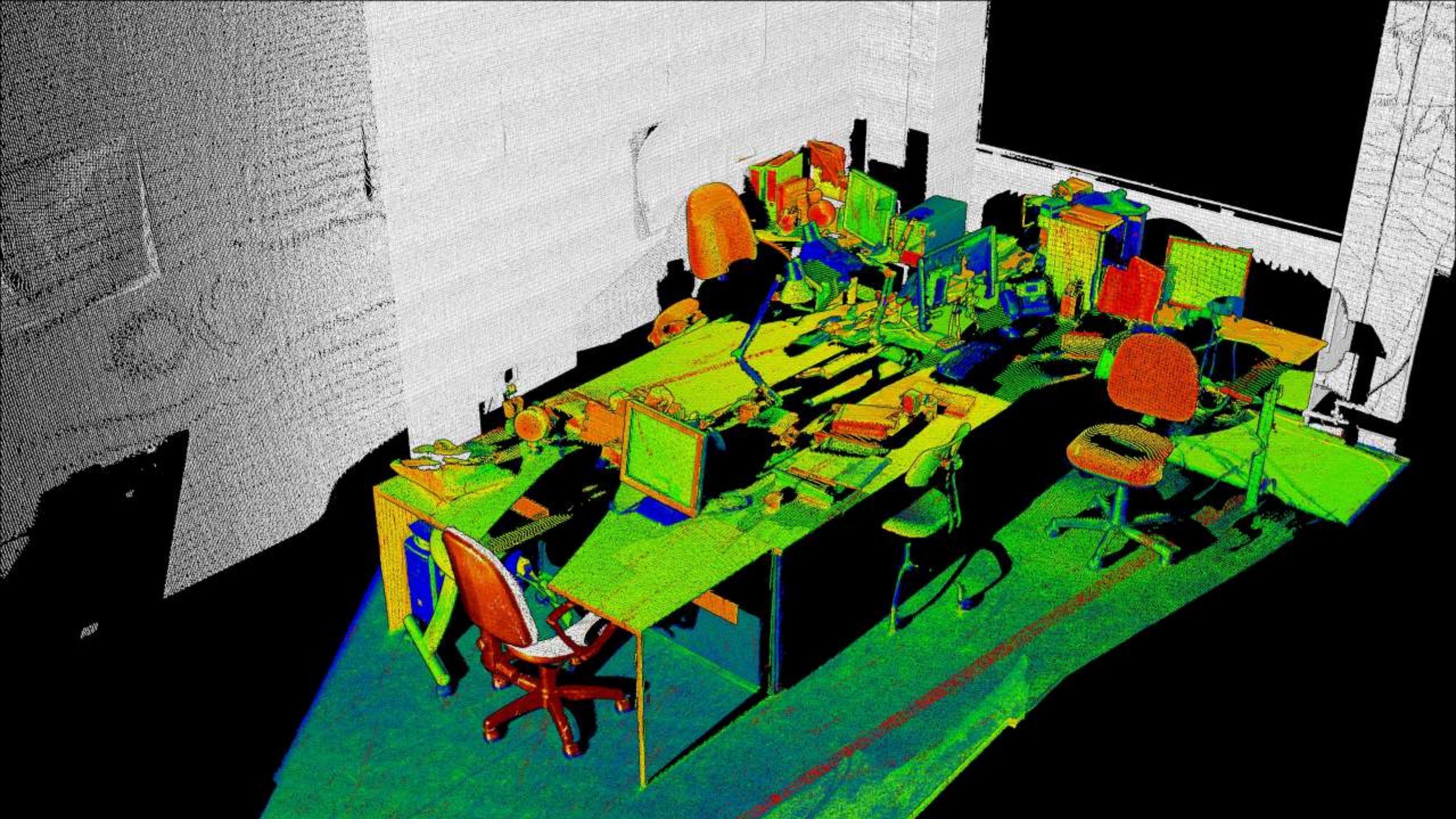


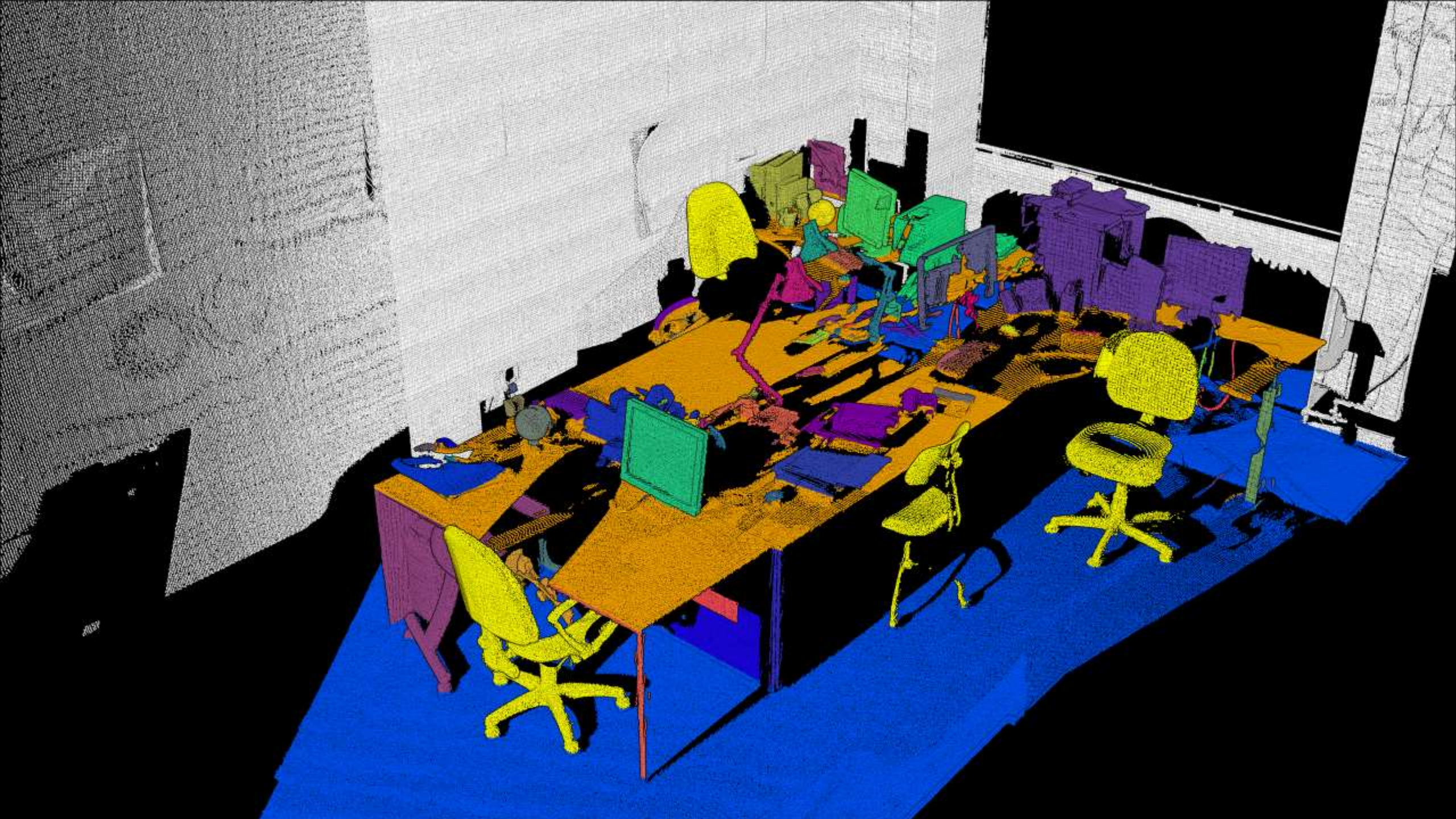
Part segmentation

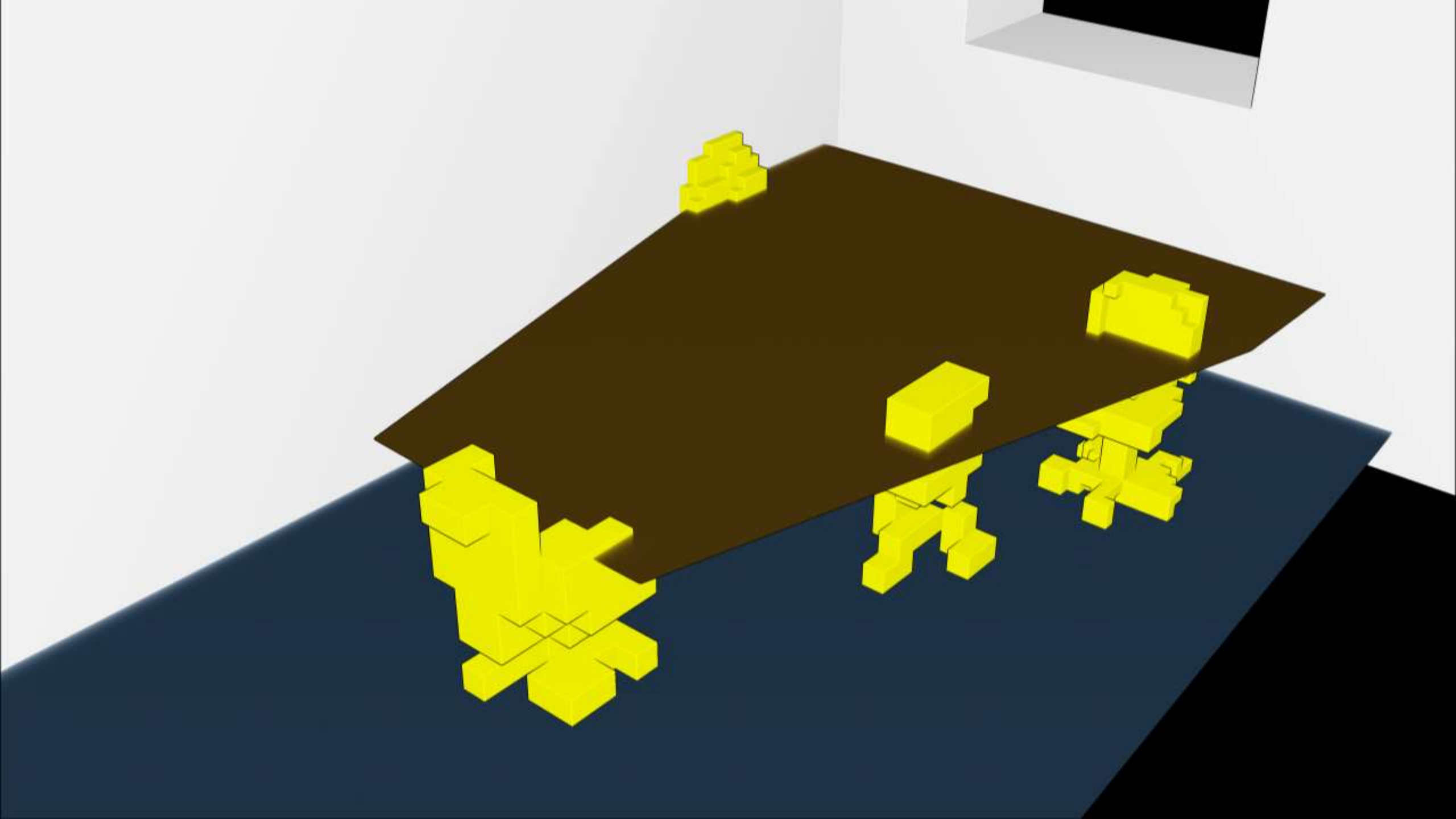




Characterization refinement







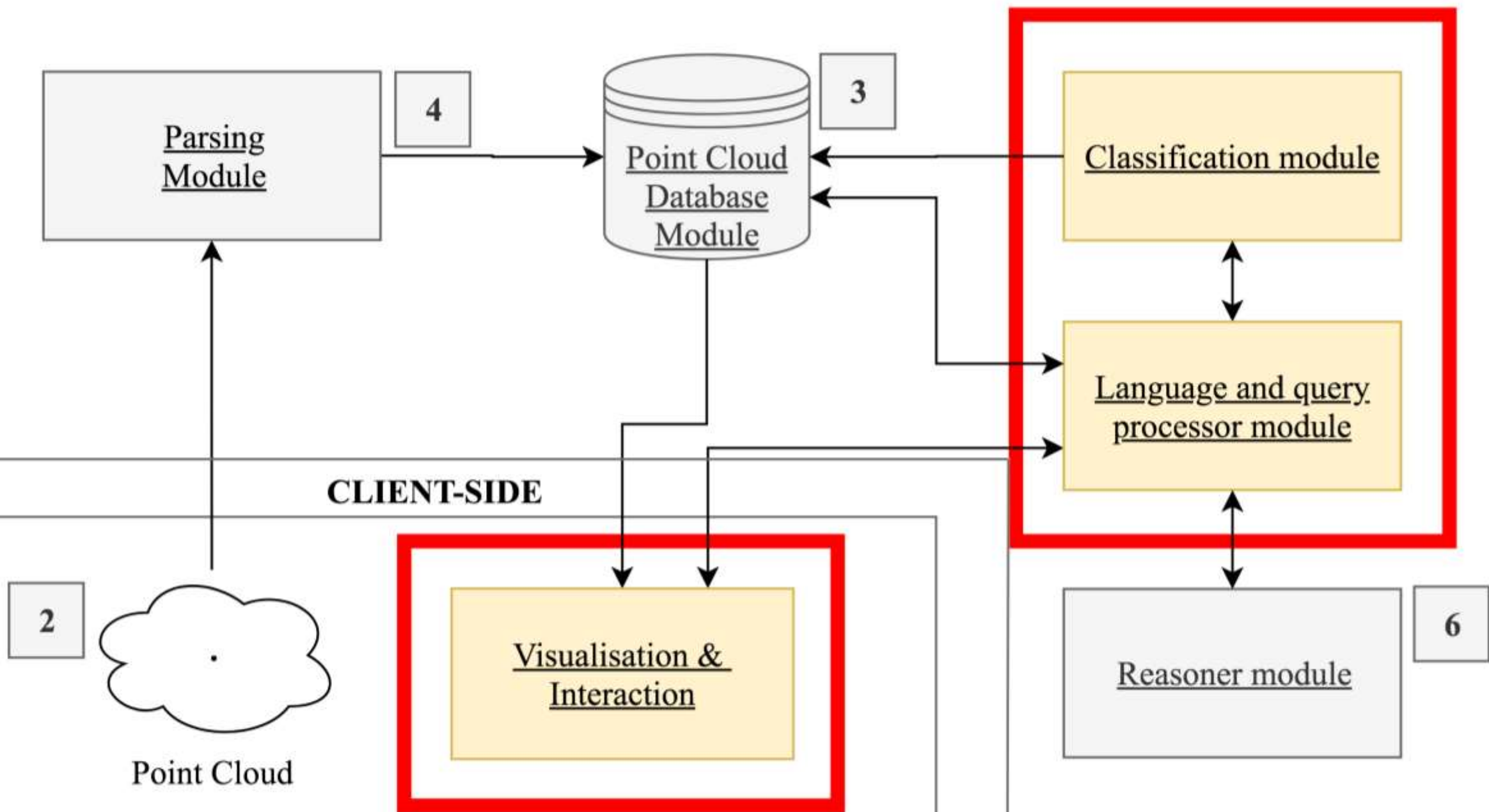
Semantic Representation

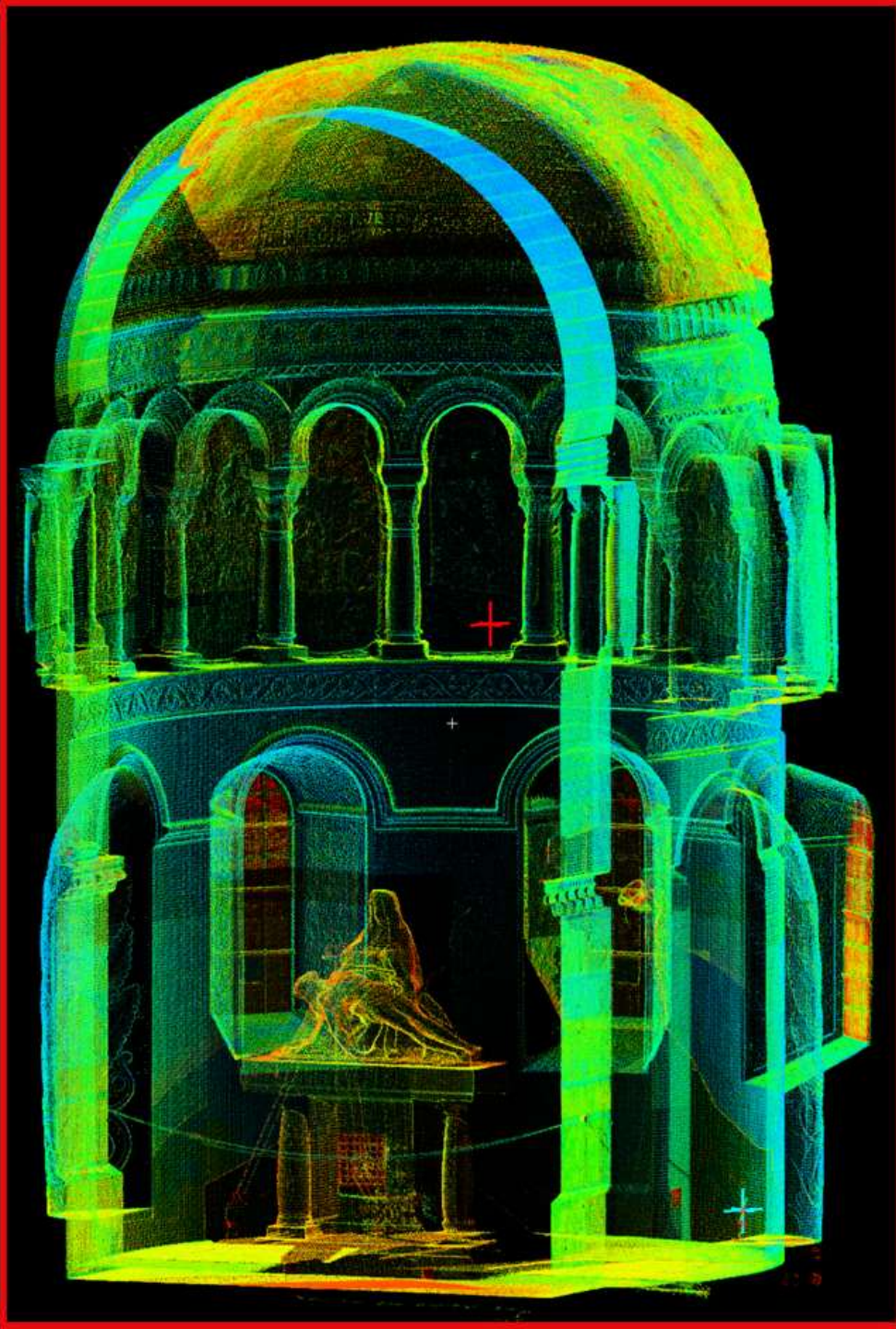
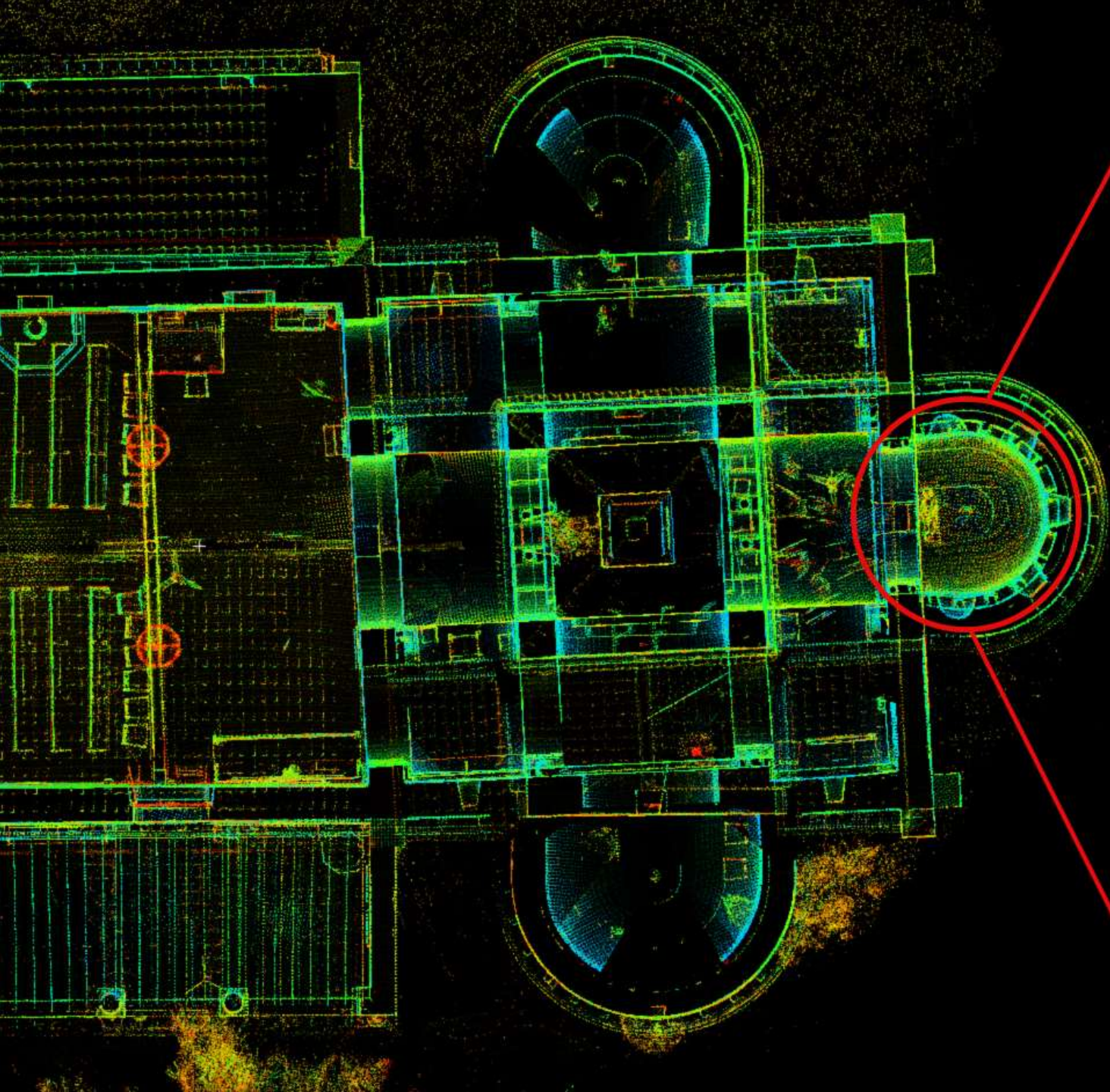
A 3D visualization of a desk and office environment. The scene is rendered in a semi-transparent, teal-blue style. The desk is a dark, flat surface. On the desk, there are several objects represented by colored blocks and outlines: a computer monitor, a keyboard, a mouse, a lamp, and various other office supplies. The desk is supported by four legs, also represented by colored blocks. In the background, there are more office furniture items like a chair and a filing cabinet. The overall scene is a simplified, block-based representation of a real-world office space.

How to **extract** and **integrate**
knowledge within **3D** point clouds
for **autonomous** decision-making
systems?

1. Using a multi-level conceptual structure
2. Parsing PC at the lowest possible level
3. Plug a domain formalization through an ontology of classification
4. Generate a modular semantic representation

... Automatically ...







INITIAL

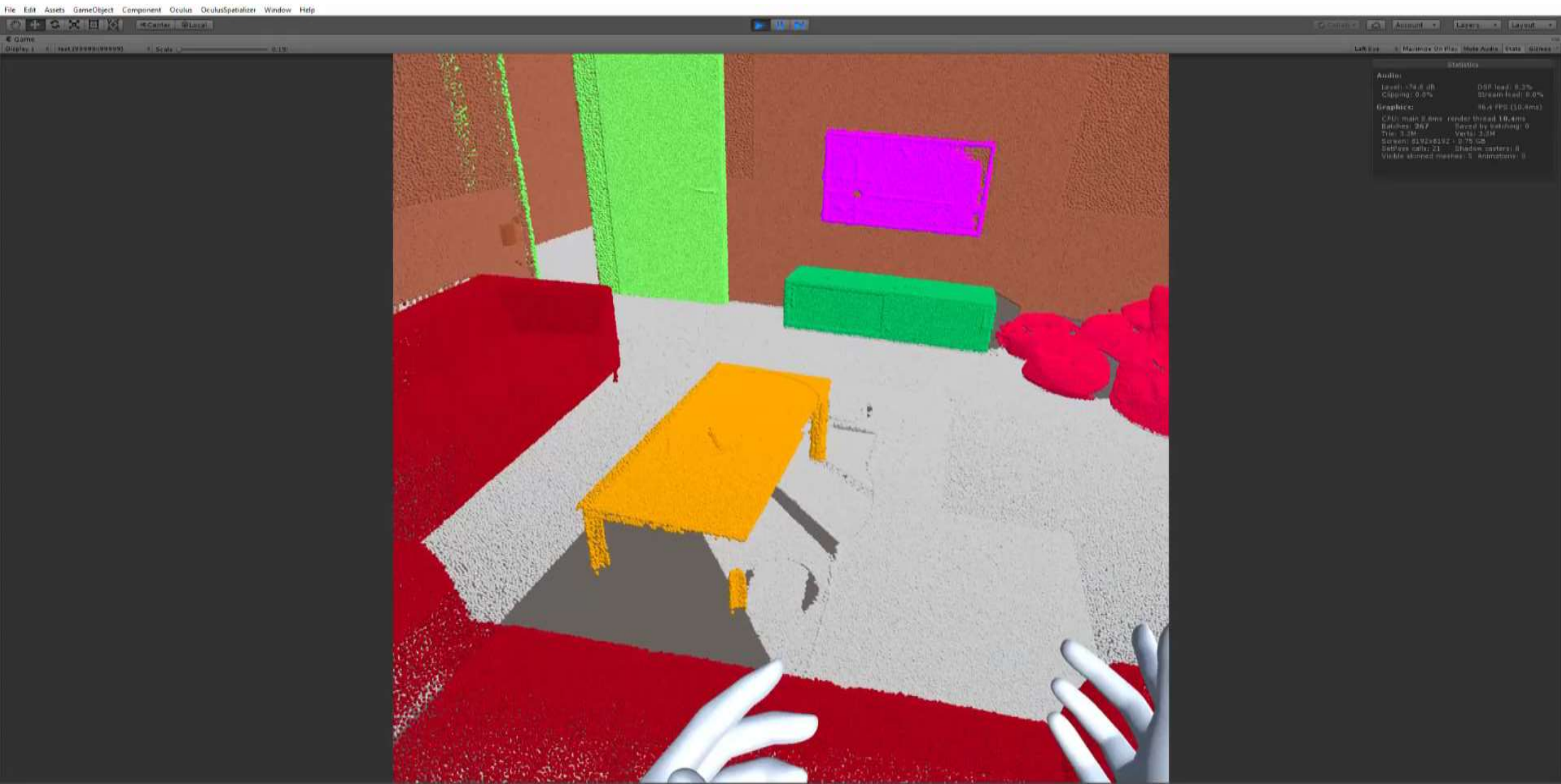
GOLD

FAIENCE

SILVER



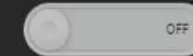
VR APPLICATION



The SPC in 5 points

Double right-click to select a point.

Activate selection mode :



MINI SELECTOR

VALIDATE

- Interoperable point cloud data structure...
- ... leveraged for automated object detection...
- ... providing a large domain connectivity...
- ... unsupervised and robust to variability...
- ... modular and efficient.

Loading Octree of LAS files

Double right-click to select a point.

Activate selection mode :

OFF

MULTIPLE SELECTION

Query Form

(c) Florent POUX - Smart Point Cloud - BUILD PRE-ALPHA

- Define powerful SPC-based AI Agents
- Increase generalization / specialization
- Dynamic data and LoD management
- Enhance unsupervised segmentation
- Enhance classification
- Integrate natural processes





LIÈGE université
Sciences

References

1. Poux, F. The Smart Point Cloud: Structuring 3D intelligent point data, Liège, 2019.
2. Poux, F.; Billen, R. Voxel-Based 3D Point Cloud Semantic Segmentation: Unsupervised Geometric and Relationship Featuring vs Deep Learning Methods. *ISPRS Int. J. Geo-Information* **2019**, *8*, 213.
3. Poux, F.; Neuville, R.; Van Wersch, L.; Nys, G.-A.; Billen, R. 3D Point Clouds in Archaeology: Advances in Acquisition, Processing and Knowledge Integration Applied to Quasi-Planar Objects. *Geosciences* **2017**, *7*, 96.
4. Poux, F.; Billen, R. Smart point cloud: Toward an intelligent documentation of our world. In Proceedings of the PCON; Liège, 2015; p. 11.
5. Poux, F.; Neuville, R.; Hallot, P.; Billen, R. Point clouds as an efficient multiscale layered spatial representation. In Proceedings of the Eurographics Workshop on Urban Data Modelling and Visualisation; Vincent, T., Biljecki, F., Eds.; The Eurographics Association: Liège, Belgium, 2016.
6. Poux, F.; Neuville, R.; Hallot, P.; Van Wersch, L.; Jancsó, A.L.; Billen, R. Digital investigations of an archaeological smart point cloud: A real time web-based platform to manage the visualisation of semantical queries. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci. - ISPRS Arch.* **2017**, *XLII-5/W1*, 581–588.

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7. Poux, F.; Neuville, R.; Hallot, P.; Billen, R. MODEL FOR SEMANTICALLY RICH POINT CLOUD DATA. *ISPRS Ann. Photogramm. Remote Sens. Spat. Inf. Sci.* **2017**, IV-4/W5, 107–115.
8. Poux, F.; Neuville, R.; Billen, R. POINT CLOUD CLASSIFICATION OF TESSERAE FROM TERRESTRIAL LASER DATA COMBINED WITH DENSE IMAGE MATCHING FOR ARCHAEOLOGICAL INFORMATION EXTRACTION. *ISPRS Ann. Photogramm. Remote Sens. Spat. Inf. Sci.* **2017**, IV-2/W2, 203–211.
9. Poux, F.; Neuville, R.; Nys, G.-A.; Billen, R. 3D Point Cloud Semantic Modelling: Integrated Framework for Indoor Spaces and Furniture. *Remote Sens.* **2018**, 10, 1412.
10. Poux, F.; Billen, R. A Smart Point Cloud Infrastructure for intelligent environments. In *Laser scanning: an emerging technology in structural engineering*; Lindenbergh, R., Belen, R., Eds.; ISPRS Book Series; Taylor & Francis Group/CRC Press: United States, 2019 ISBN in generation.
11. Poux, F.; Hallot, P.; Neuville, R.; Billen, R. SMART POINT CLOUD: DEFINITION AND REMAINING CHALLENGES. *ISPRS Ann. Photogramm. Remote Sens. Spat. Inf. Sci.* **2016**, IV-2/W1, 119–127.
12. Poux, F. Vers de nouvelles perspectives lasergrammétriques : optimisation et automatisation de la chaîne de production de modèles 3D Florent Poux To cite this version : HAL Id : dumas-00941990. **2014**.
13. Novel, C.; Keriven, R.; Poux, F.; Graindorge, P. Comparing Aerial Photogrammetry and 3D Laser Scanning Methods for Creating 3D Models of Complex Objects. In *Proceedings of the Capturing Reality Forum*; Bentley Systems: Salzburg, 2015; p. 15.