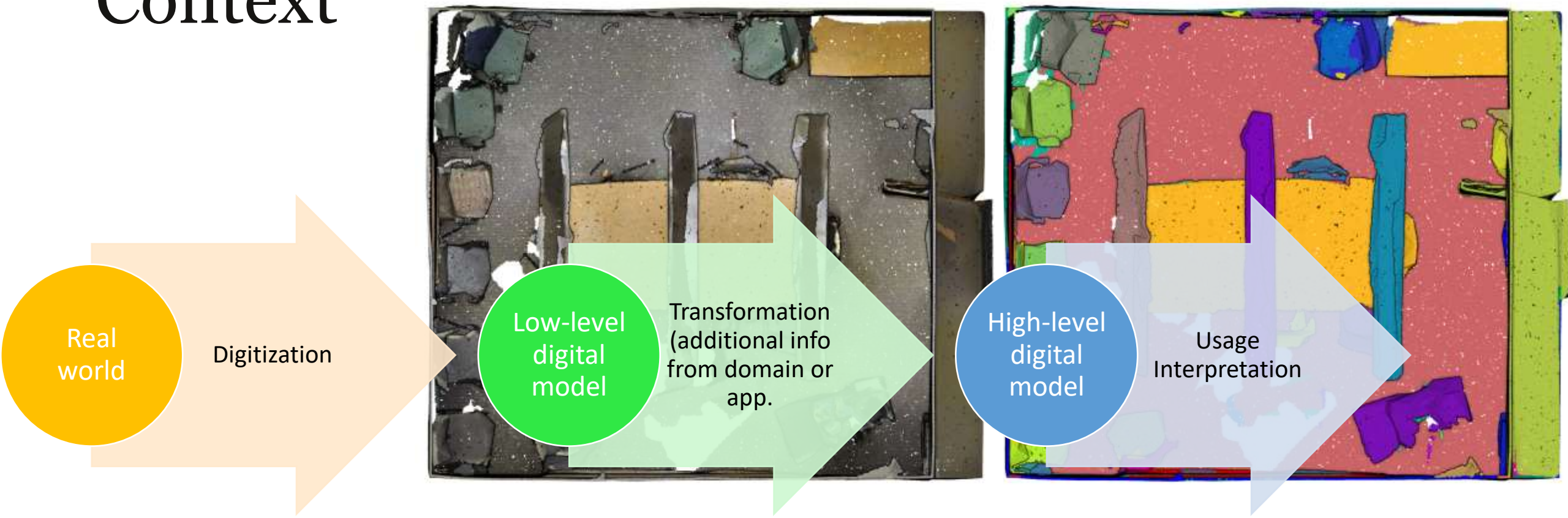
LIÈGE université
Geomatics

Point Clouds, Segments, Semantics and Automation

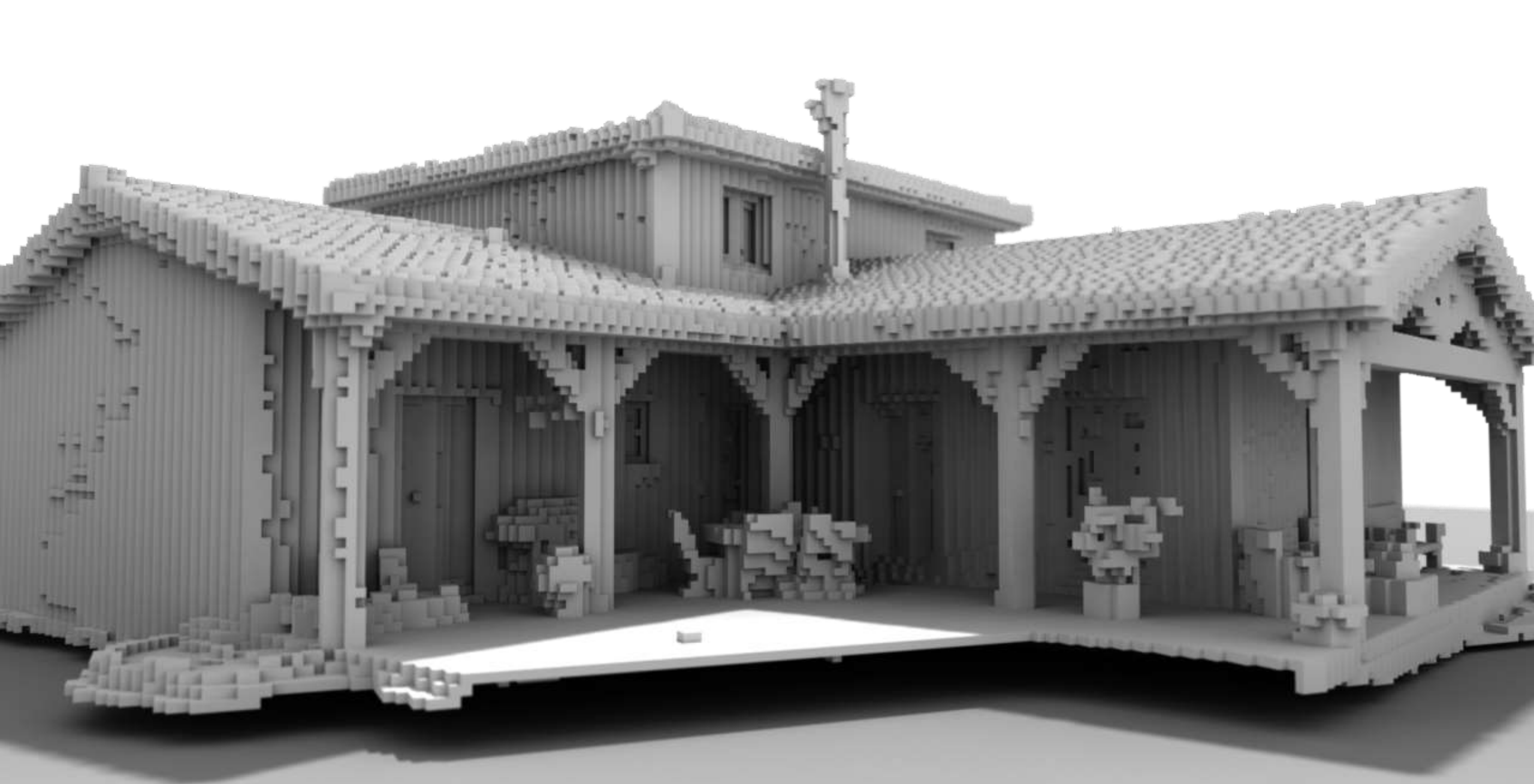
Florent Poux

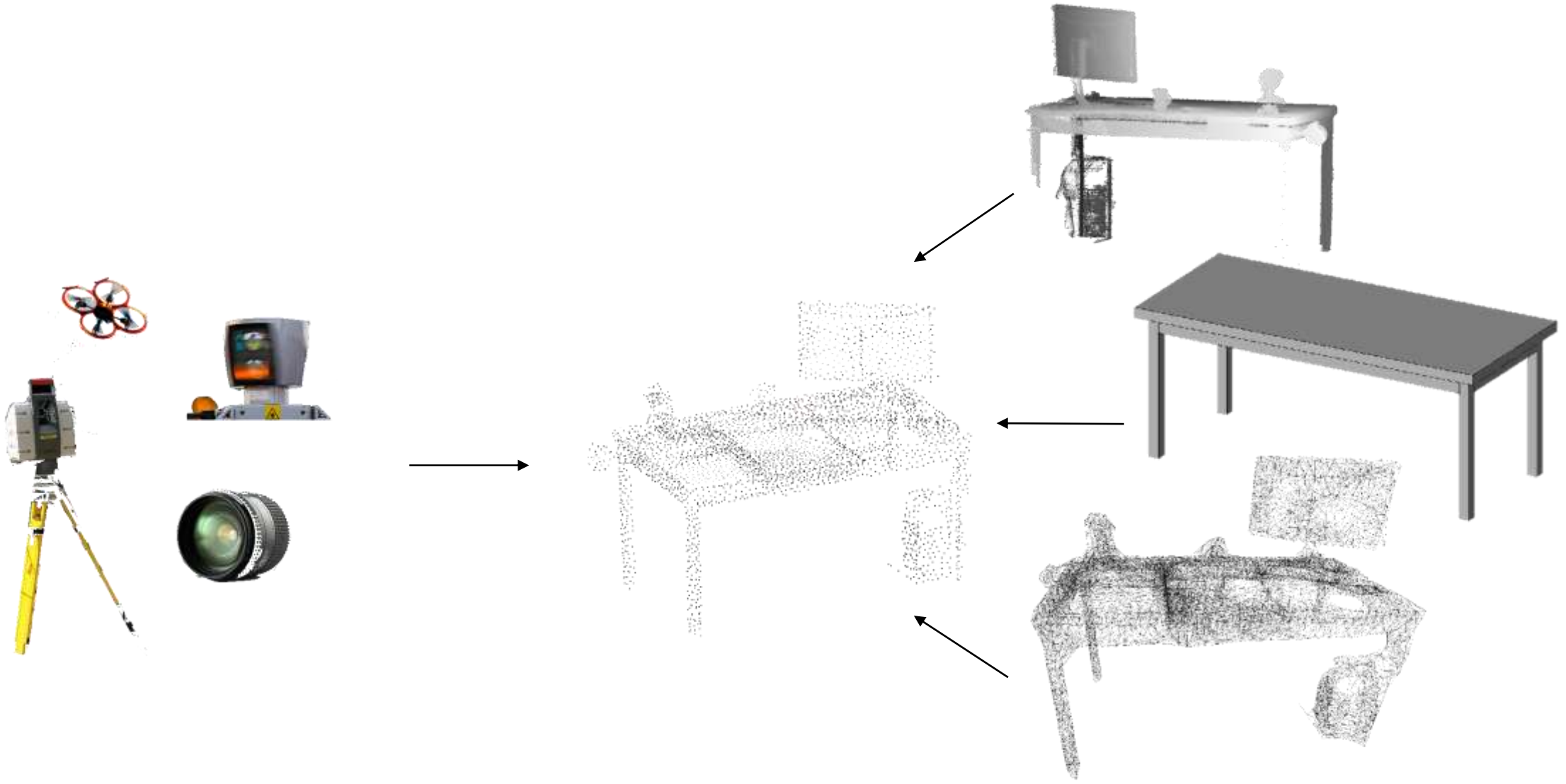
Context


Real world
Digitization
Low-level digital model
Transformation (additional info from domain or app.
High-level digital model
Usage Interpretation

3D Point Cloud Specificities

Representation & Structuration





Automation

Video Source : Emescent

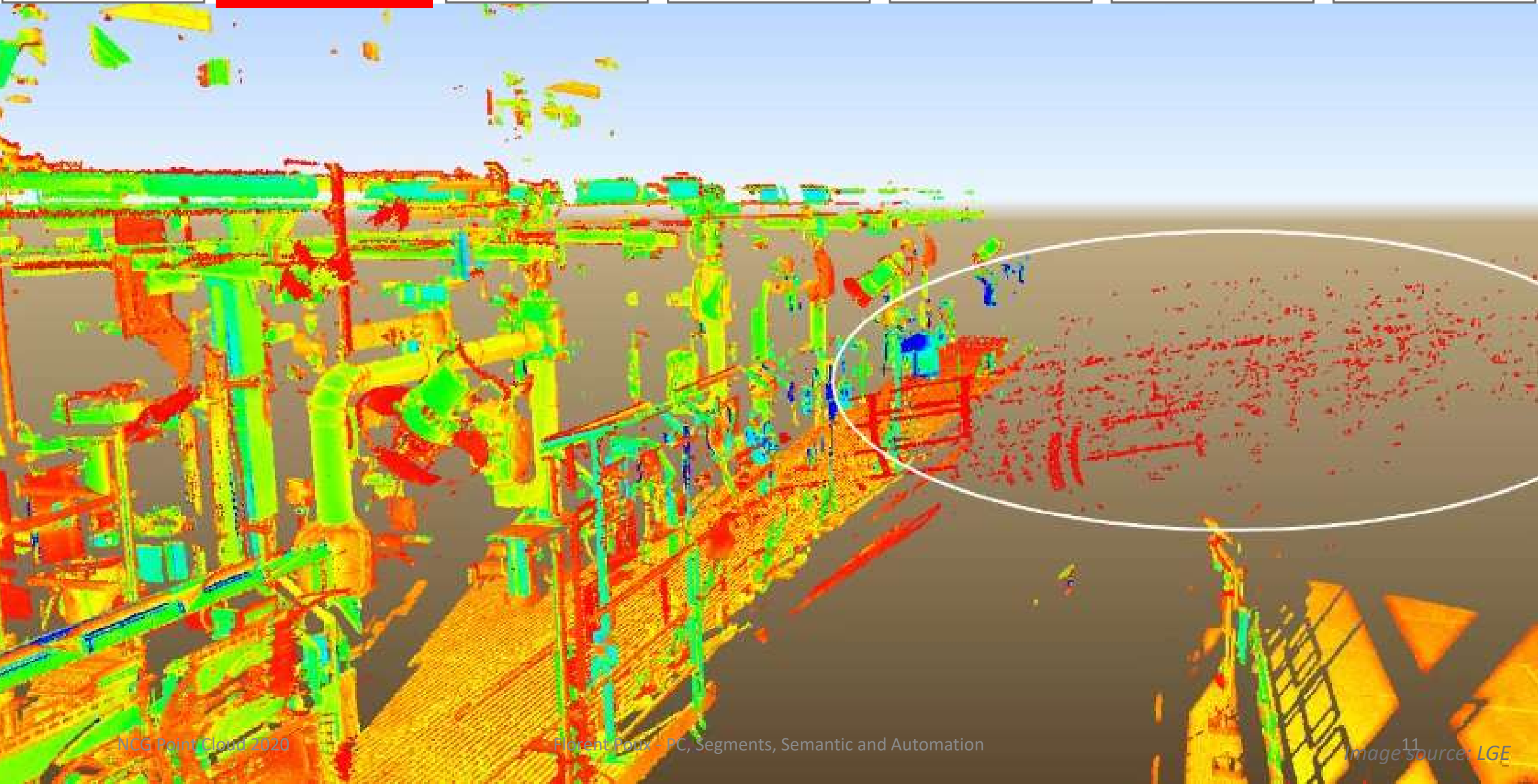


Image source: LGE

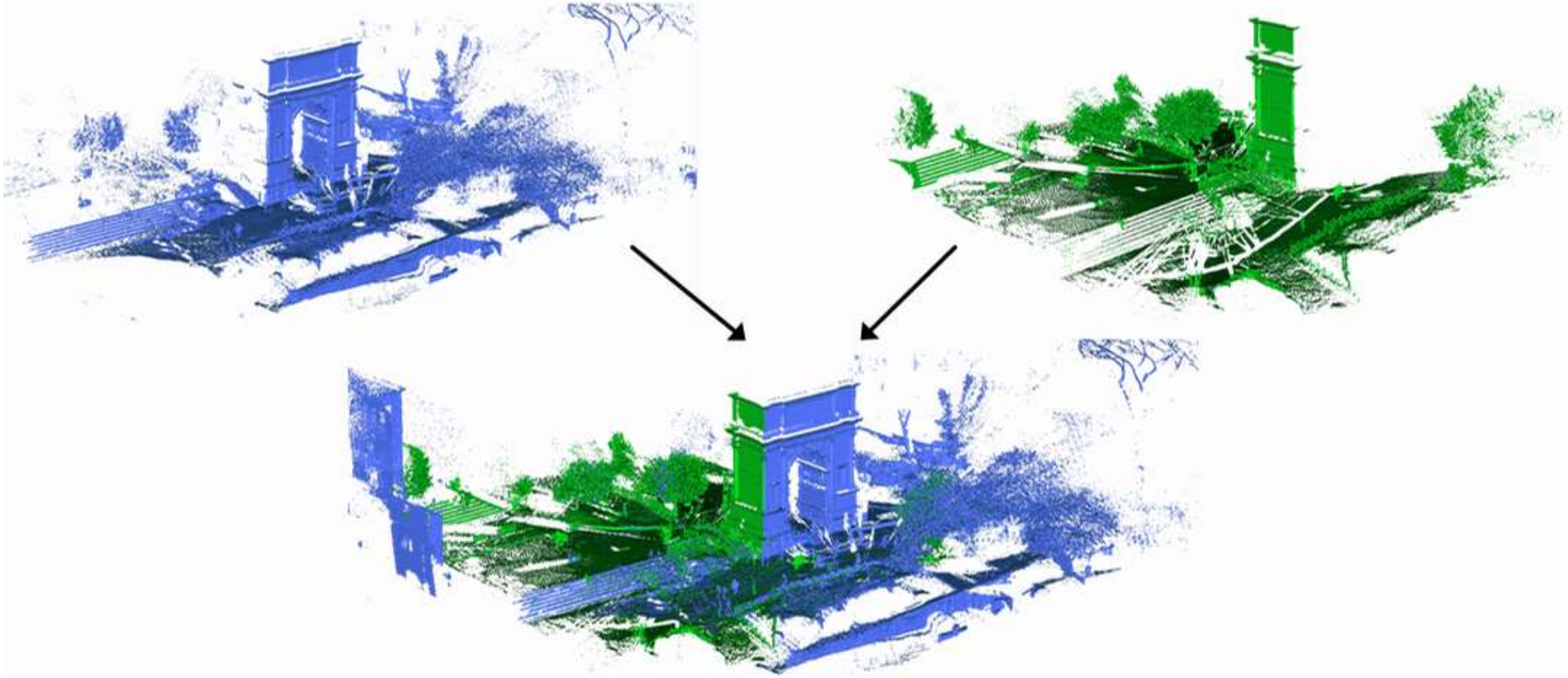
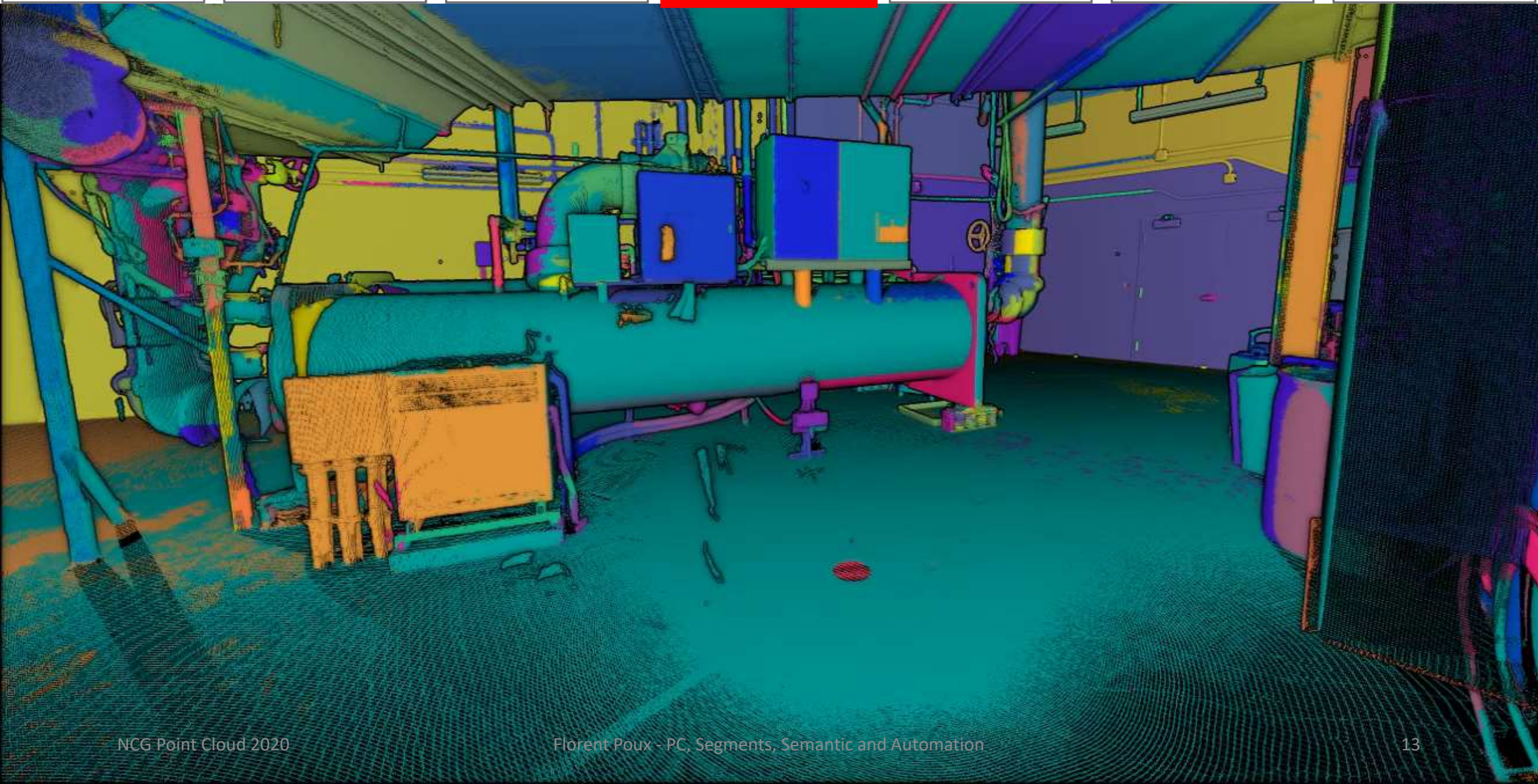
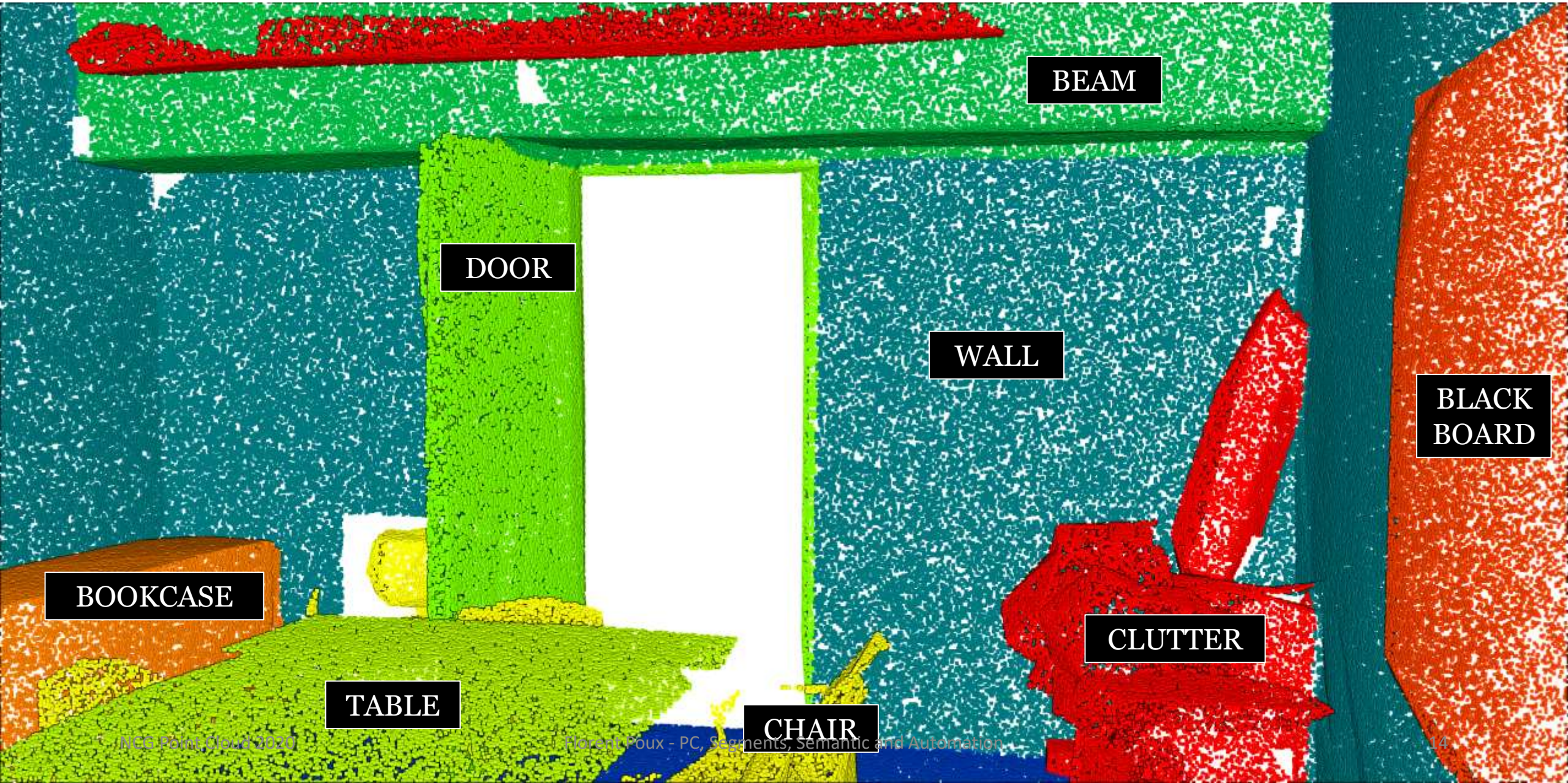
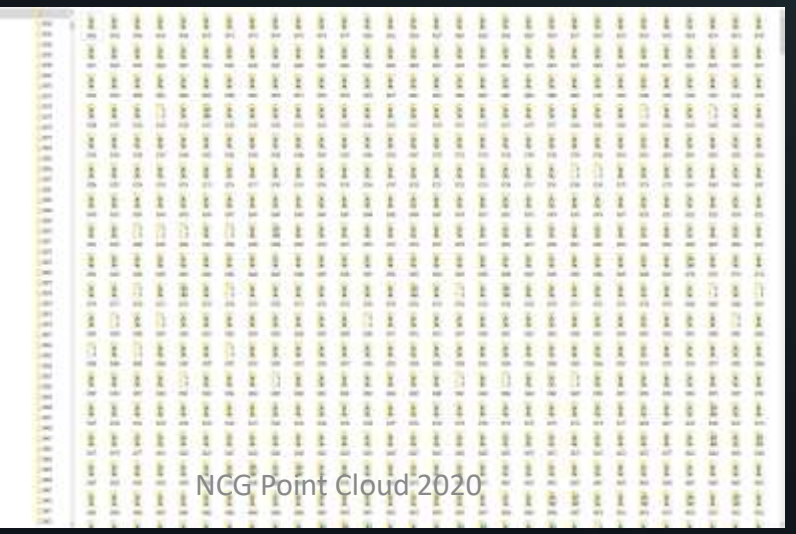


Image source: ETH Zürich

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




BEAM
DOOR
WALL
BLACK BOARD
BOOKCASE
CLUTTER
TABLE
CHAIR



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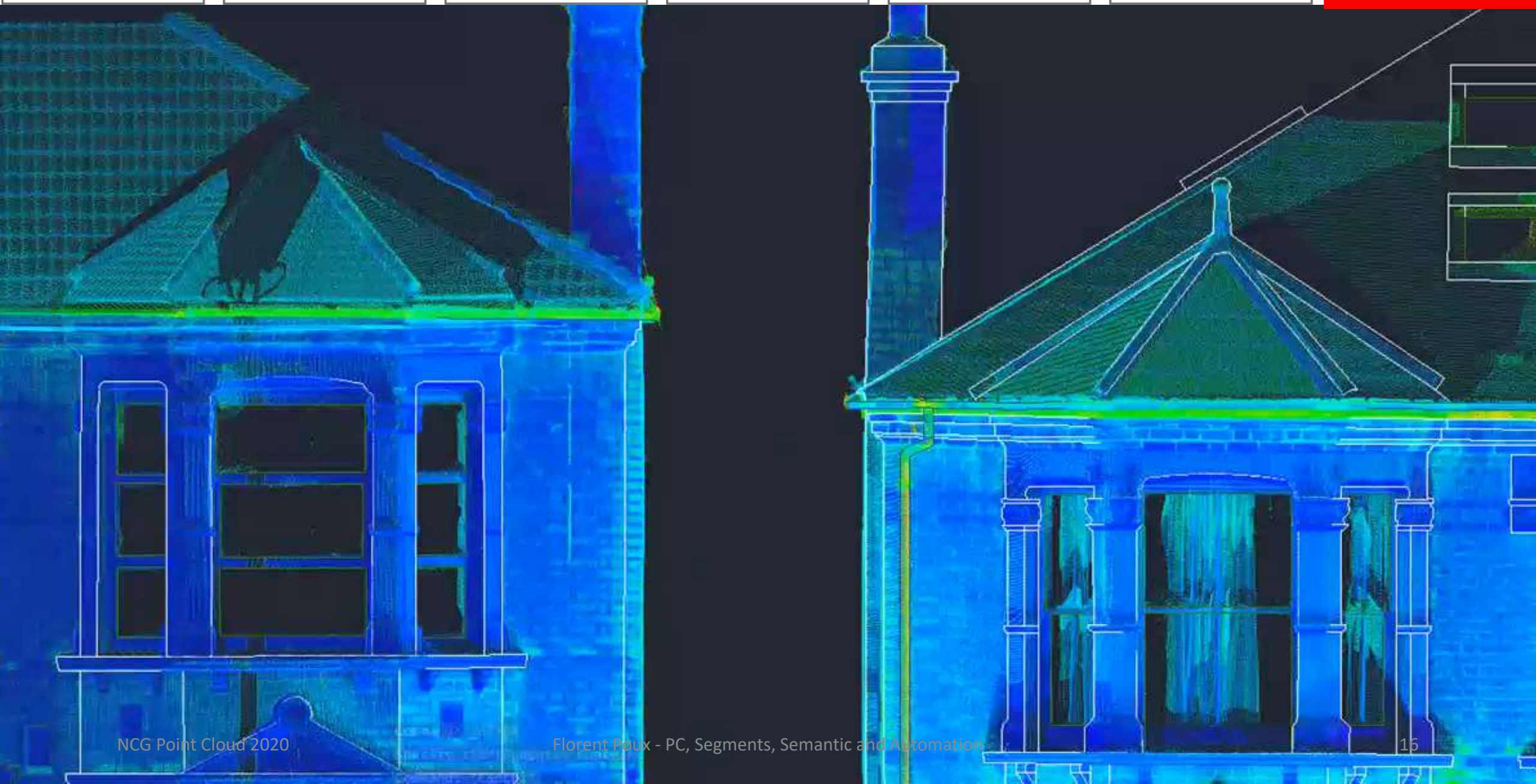
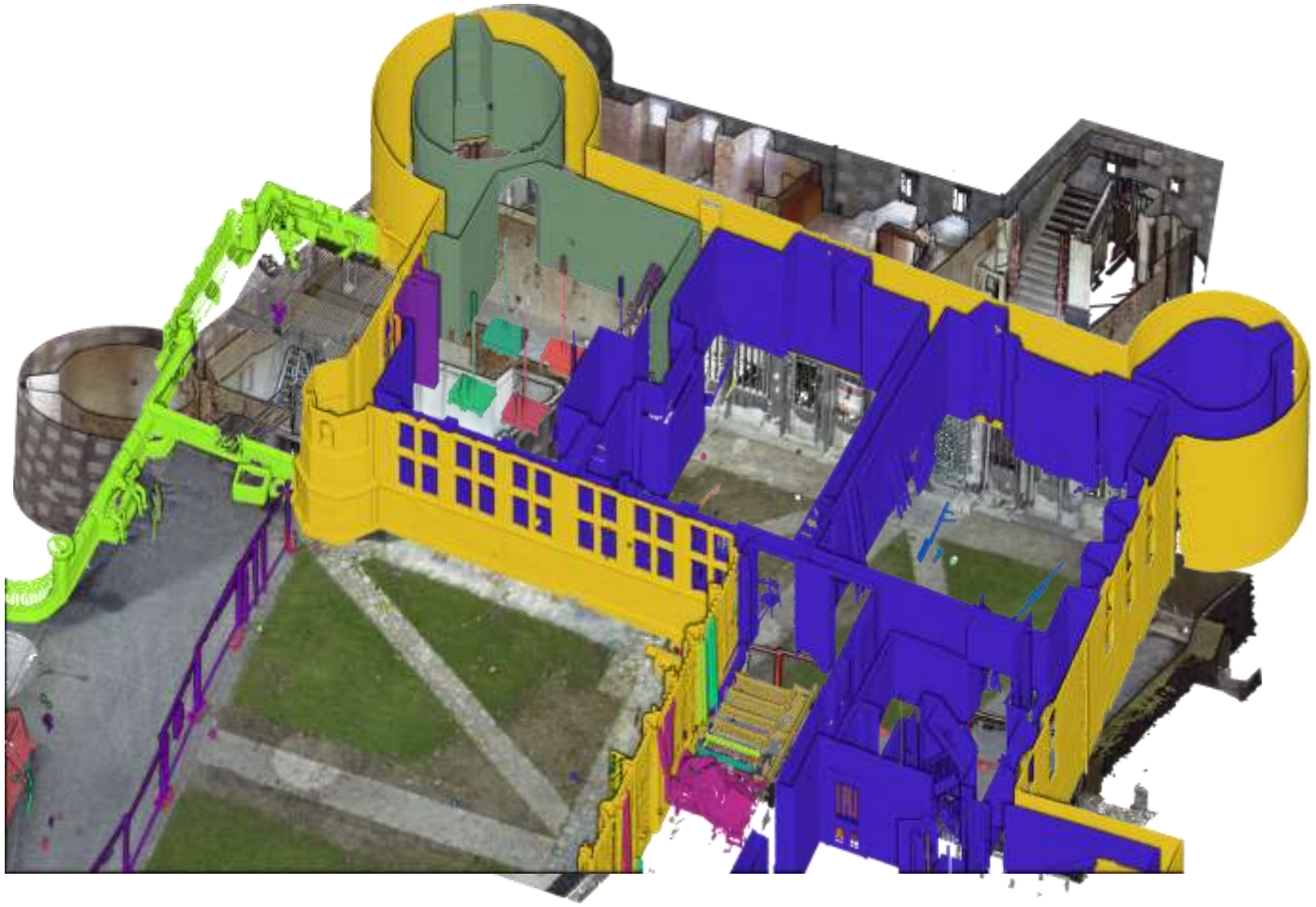


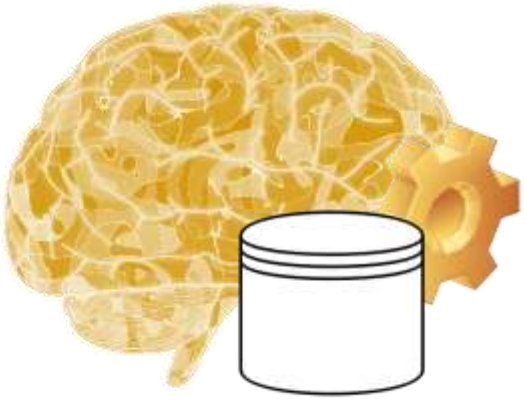
- 3D Point Cloud Specificities
- Representation & Structuration
- Automation

Semantics & Knowledge Integration



TODAY

WHAT WE WANT



KNOWLEDGE

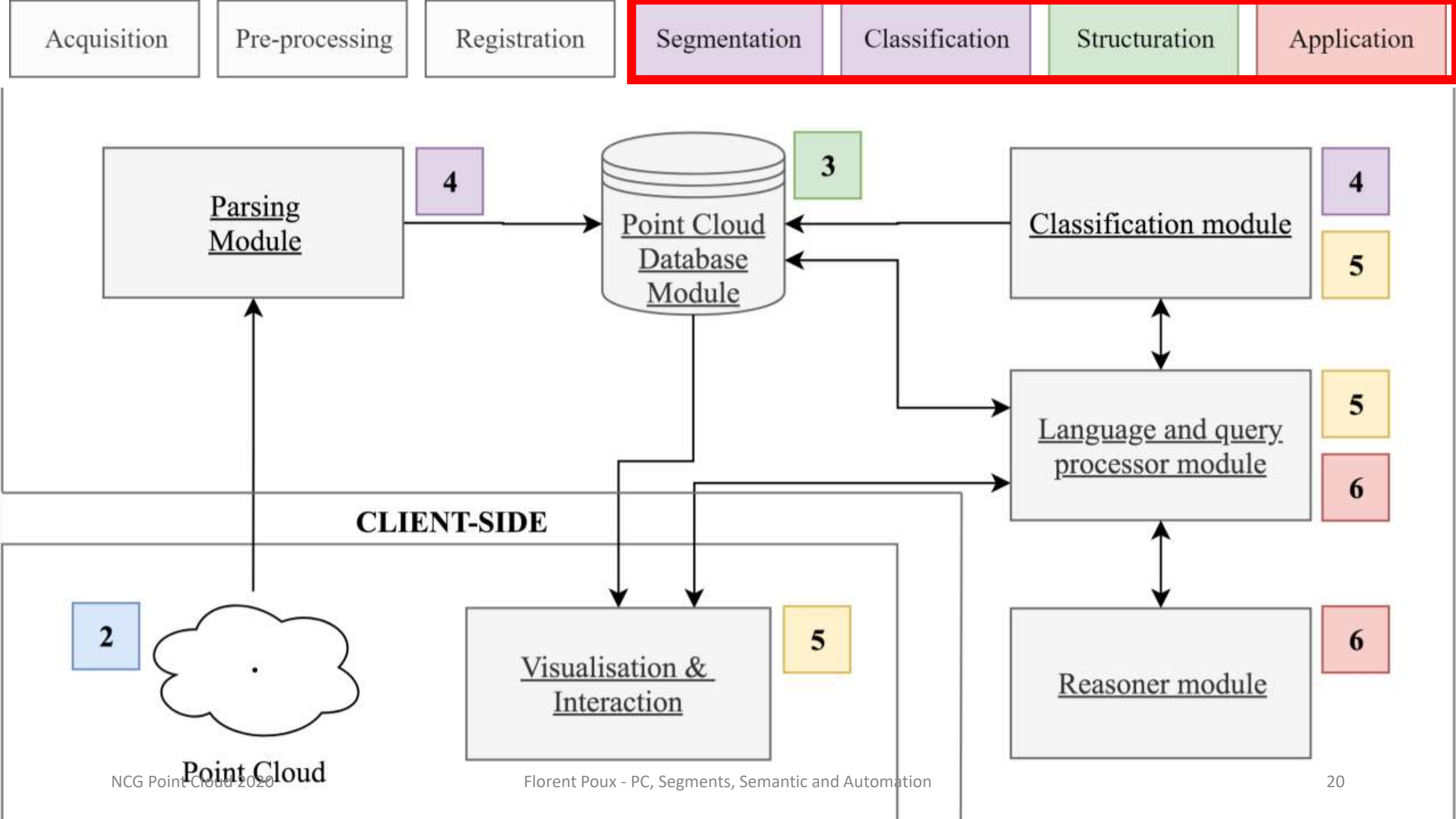
DELIVERY

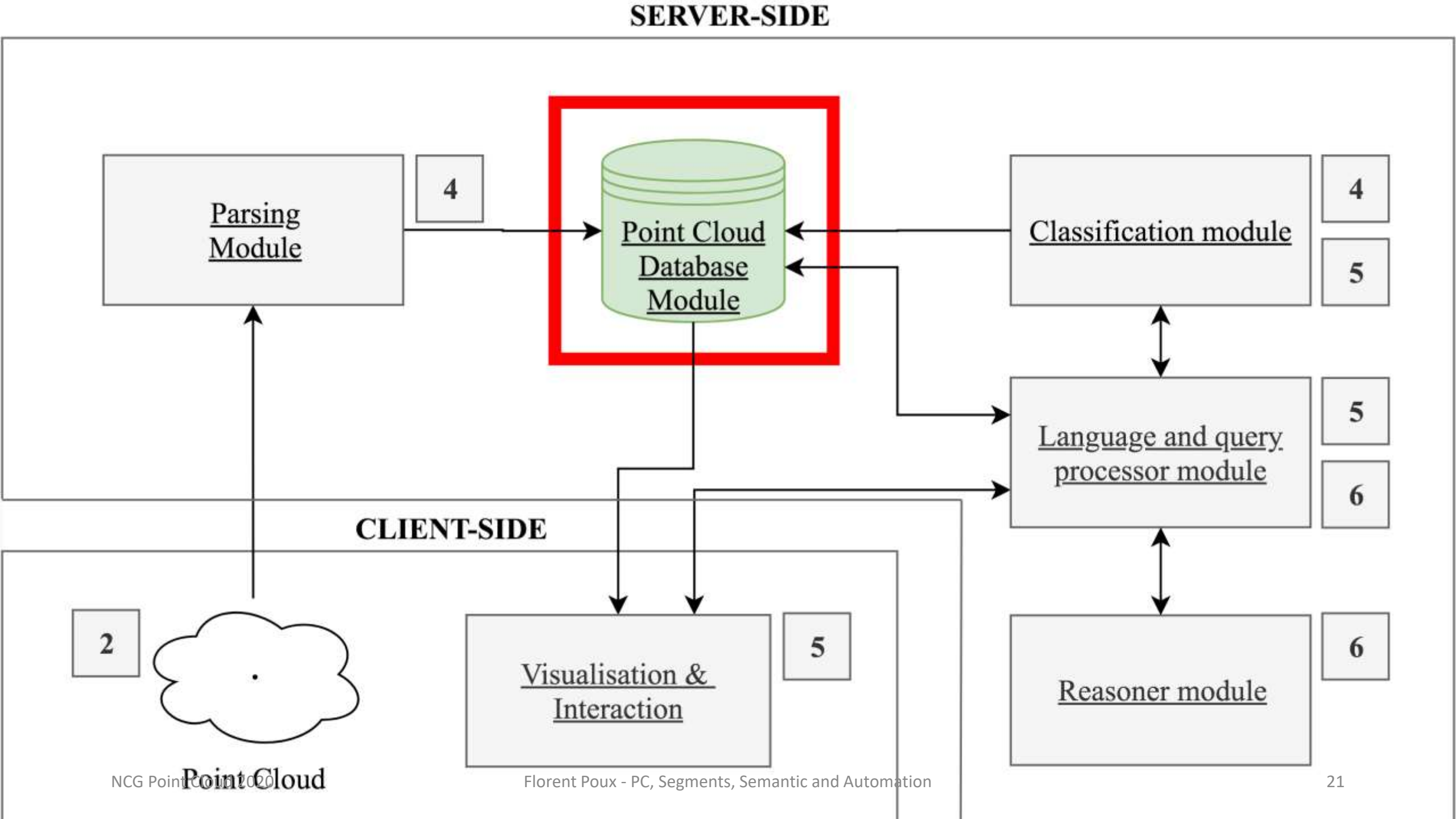
INTERPRETATION

EXTRACTION (Meshed...)

SIMULATION, ...

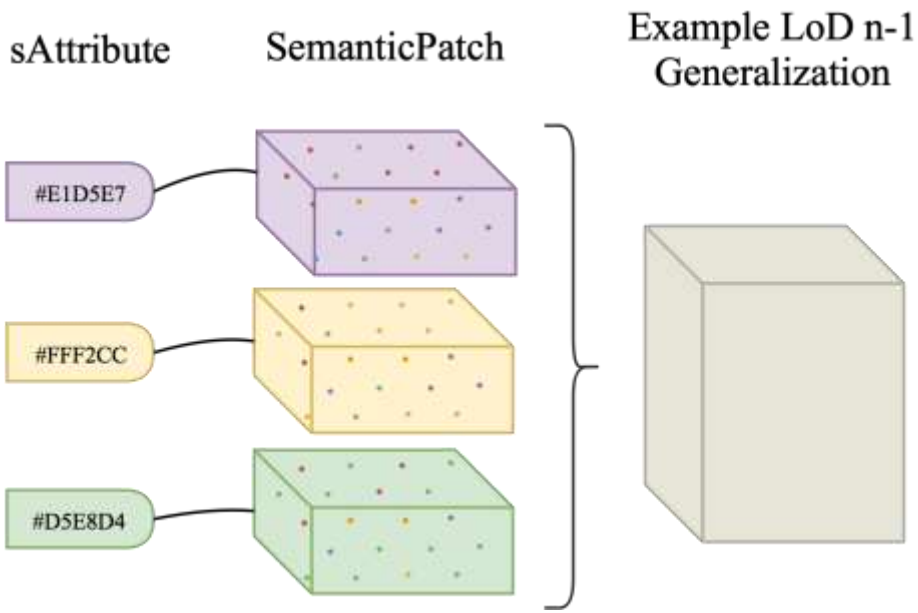
How to extract and integrate knowledge within 3D point clouds for autonomous decision-making systems?

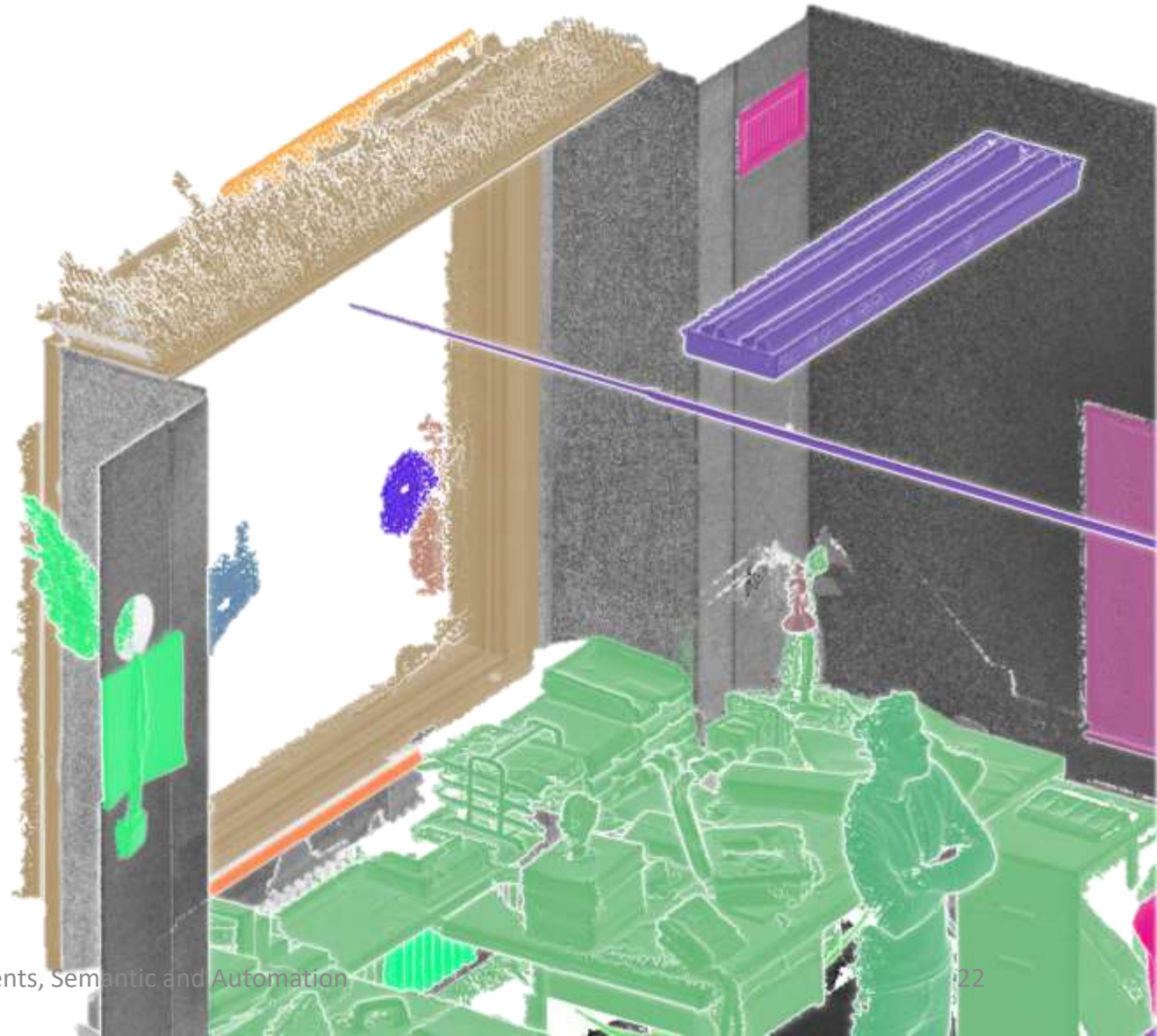

Acquisition
Pre-processing
Registration
Segmentation
Classification
Structuration
Application
Parsing Module
4
Point Cloud Database Module
3
Classification module
4
5
Language and query processor module
5
6
CLIENT-SIDE
2
Point Cloud
Visualisation & Interaction
5
Reasoner module
6

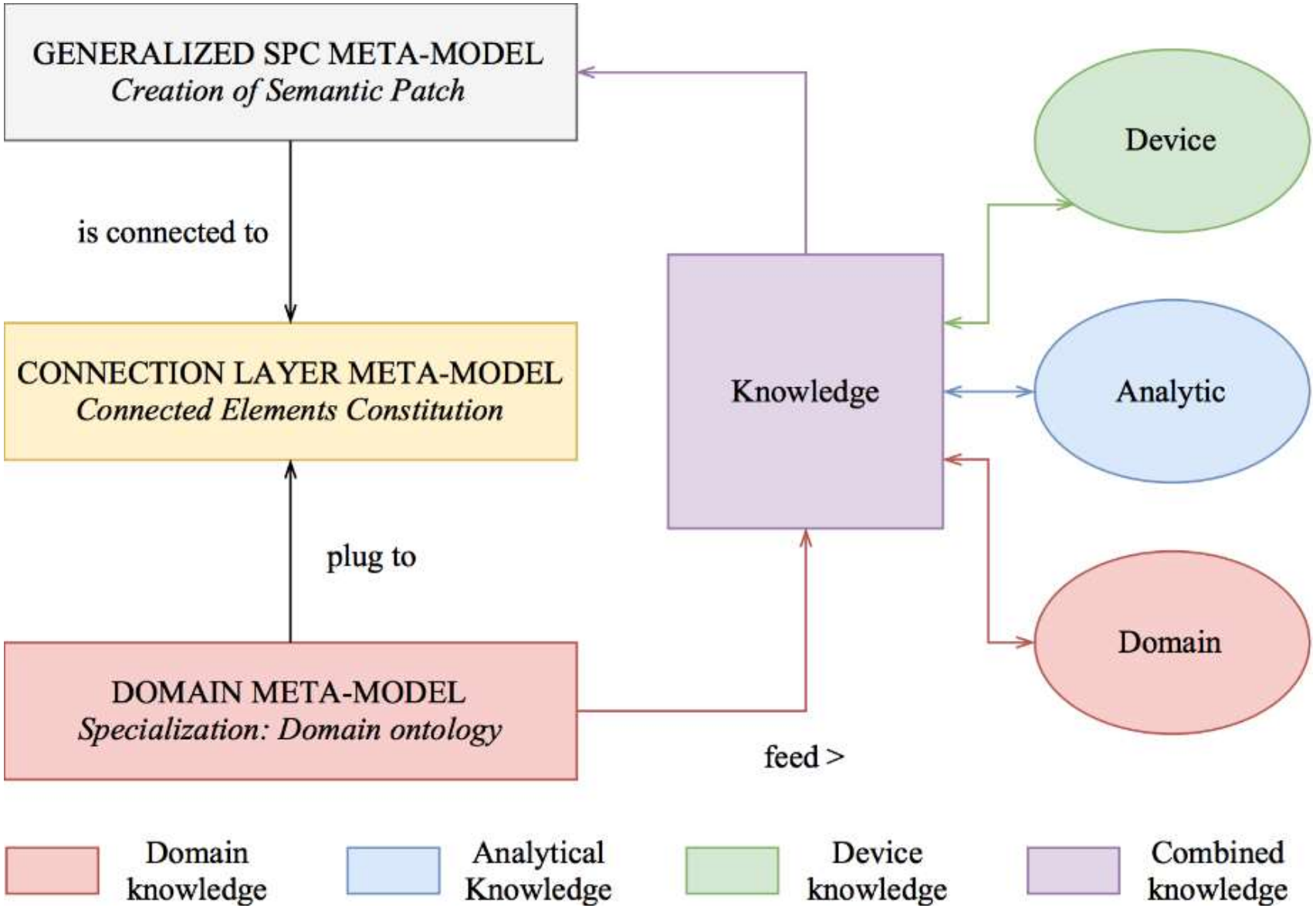

SERVER-SIDE
Parsing Module
4
Point Cloud Database Module
Classification module
4
5
Language and query processor module
5
6
Reasoner module
6
CLIENT-SIDE
2
Point Cloud
Visualisation & Interaction
5

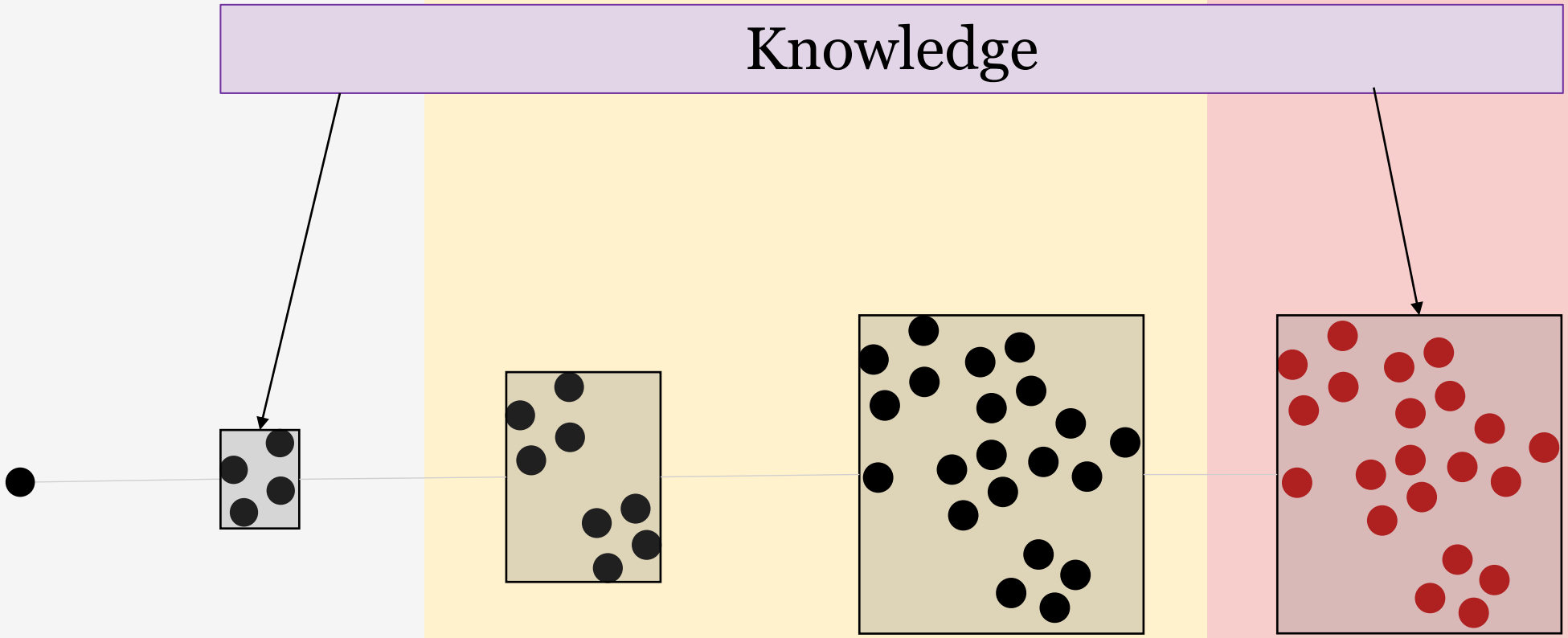
Point Cloud Specificity

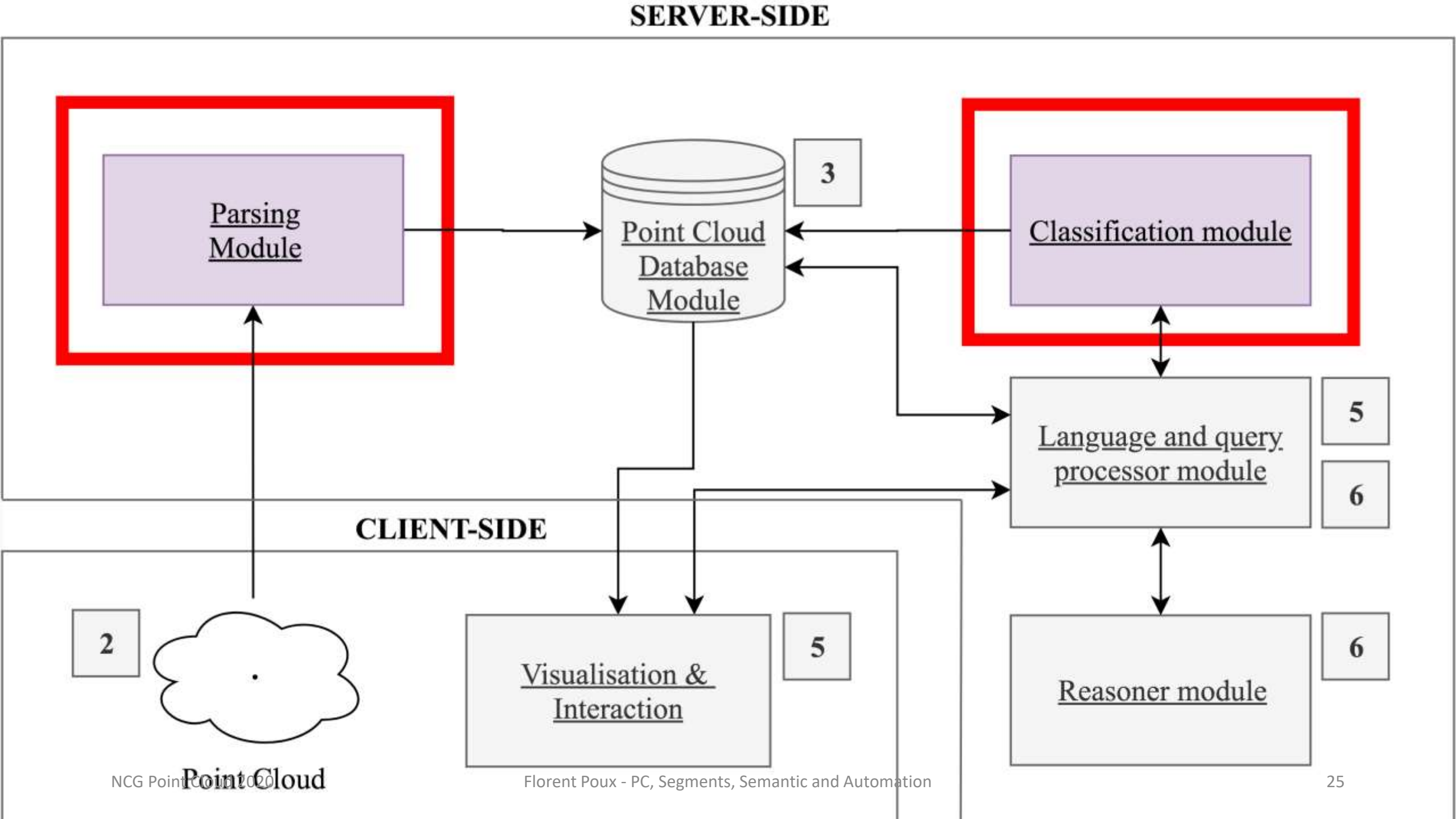
Unstructured and too sparse for DBMS per-row insertion






GENERALIZED SPC META-MODEL
Creation of Semantic Patch
is connected to
CONNECTION LAYER META-MODEL
Connected Elements Constitution
plug to
DOMAIN META-MODEL
Specialization: Domain ontology
feed >
Knowledge
Device
Analytic
Domain
Domain knowledge
Analytical Knowledge
Device knowledge
Combined knowledge


Knowledge
Point
Semantic Patch
Connected Element
Aggregated Element
Class Instance


SERVER-SIDE
Parsing Module
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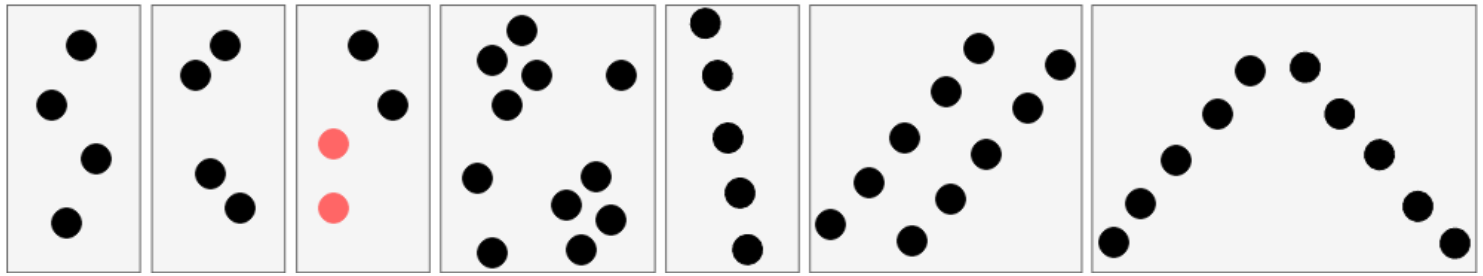
Gestalt's theory

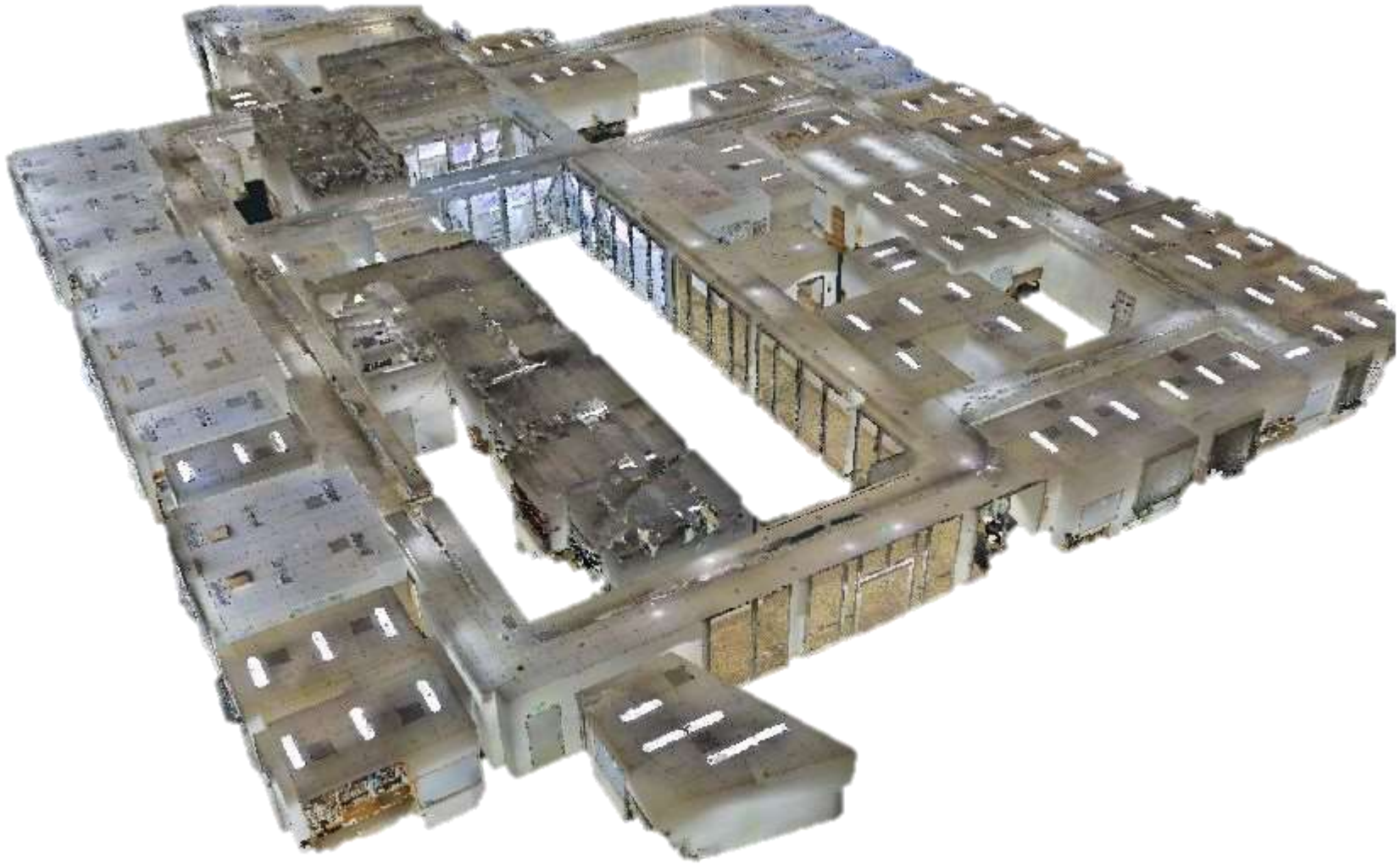


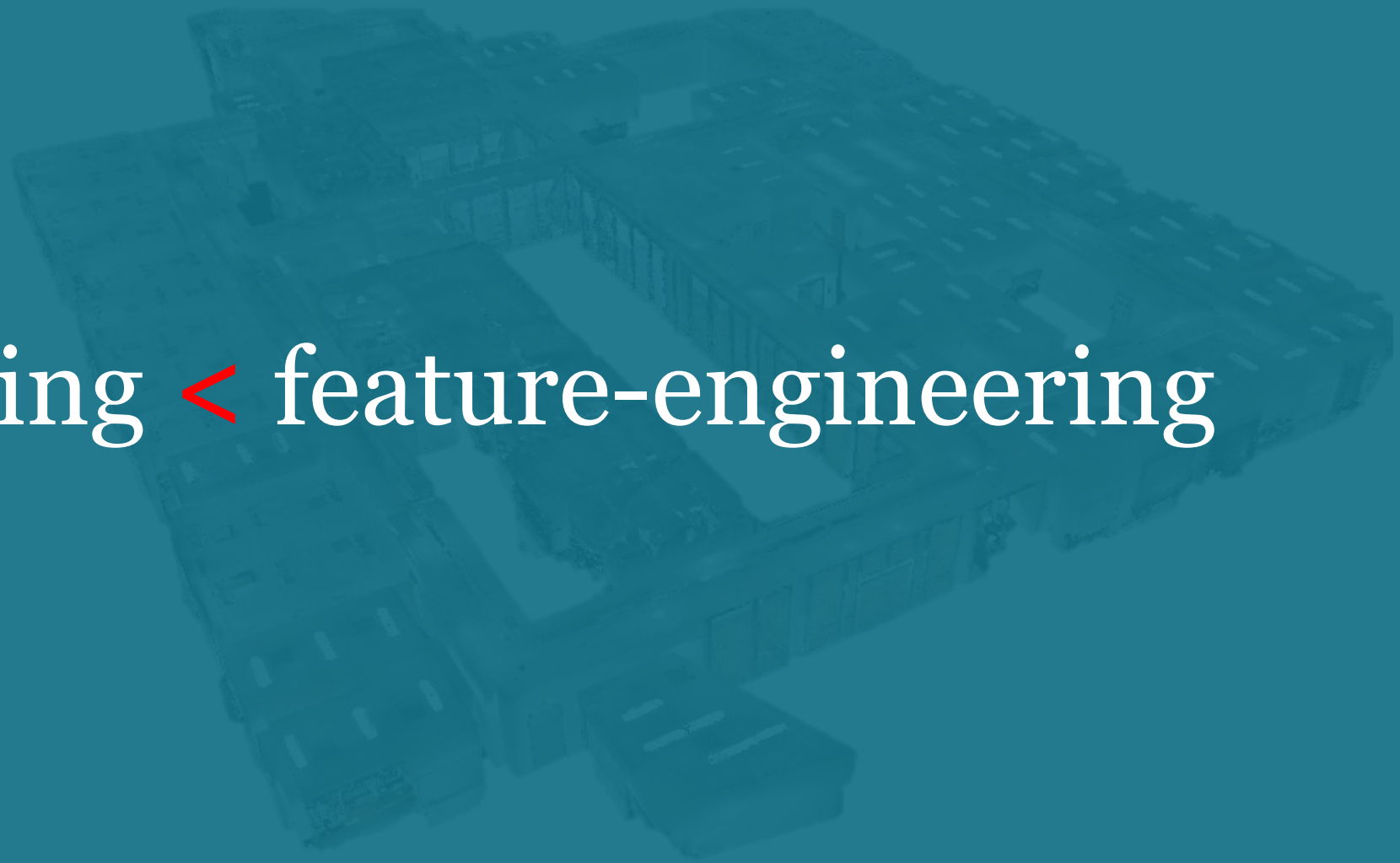
Visual patterns on points

Deep learning > feature-engineering

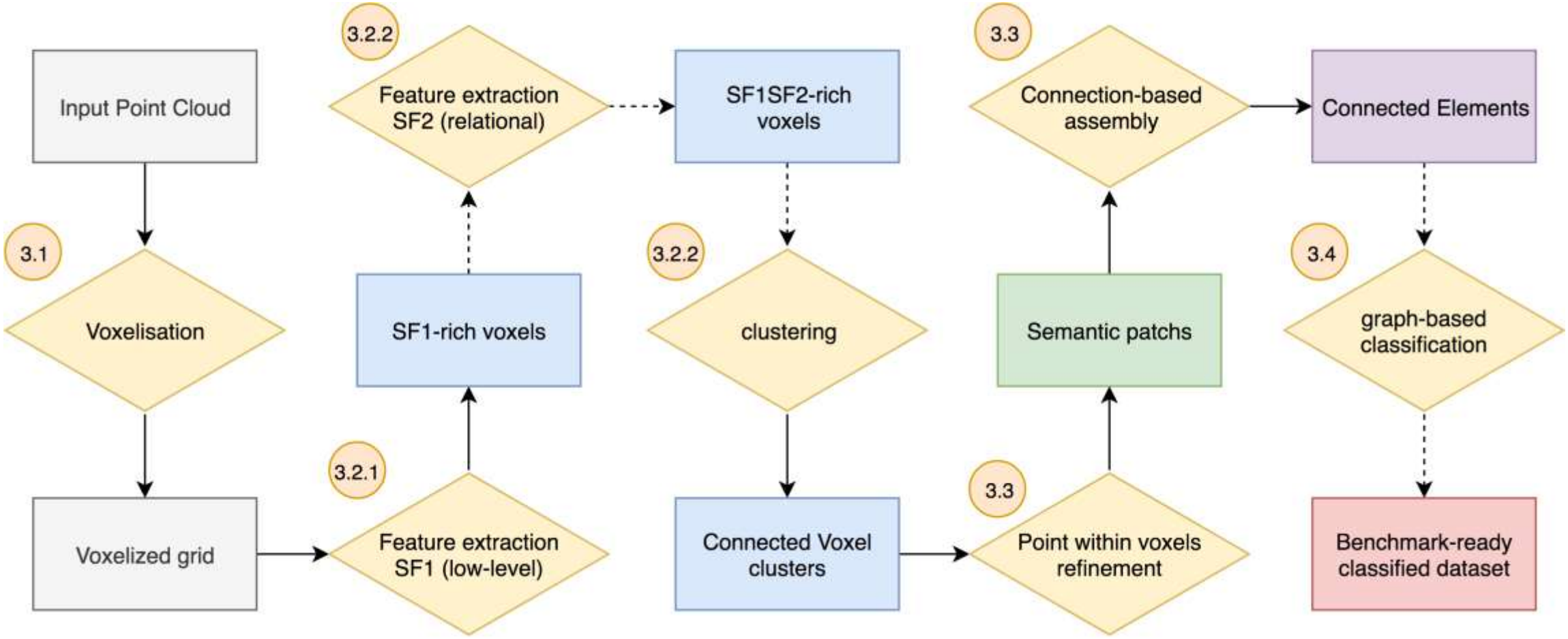
Visual patterns on points

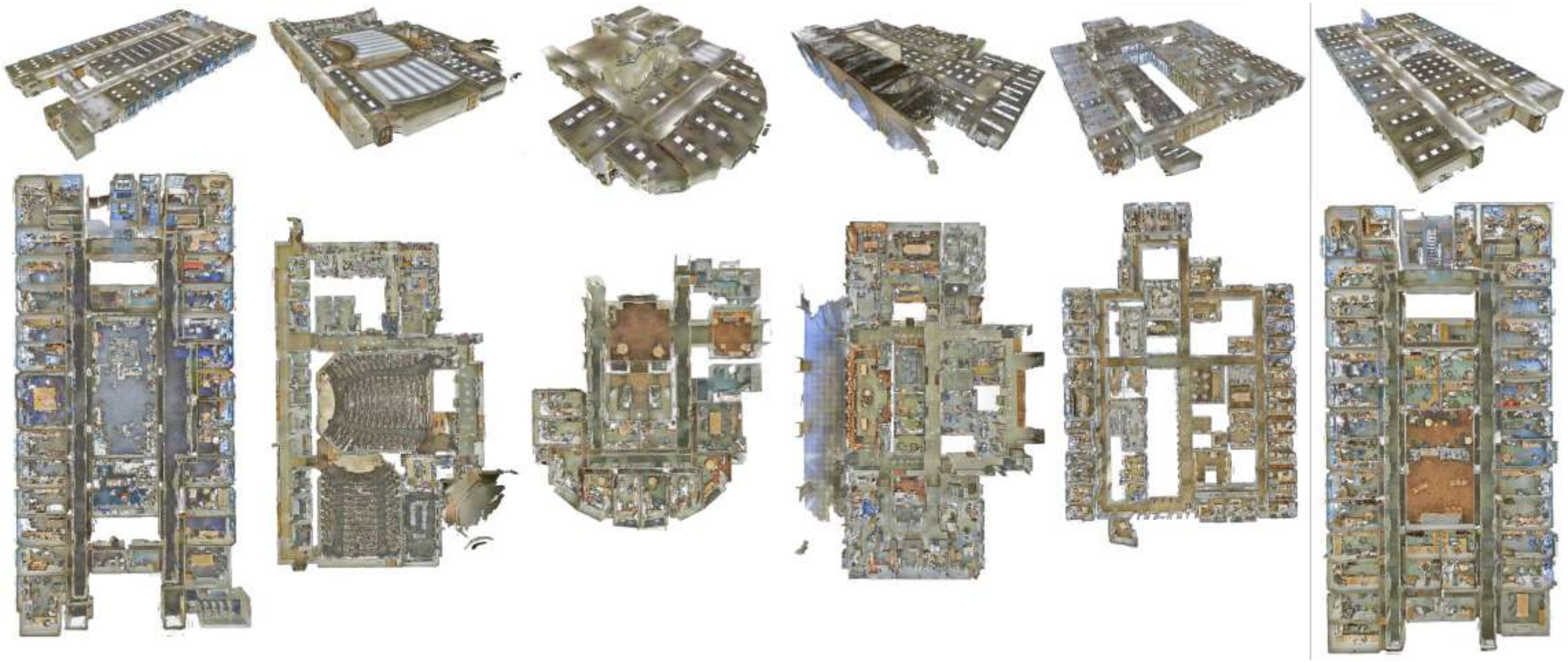
Point Cloud Datasets

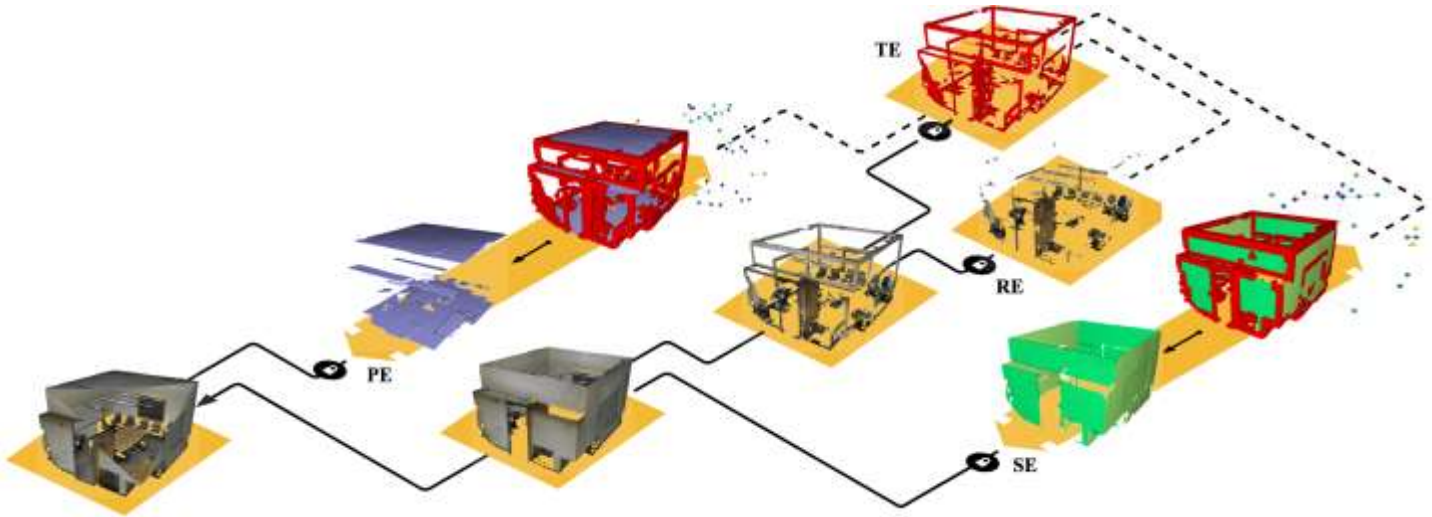




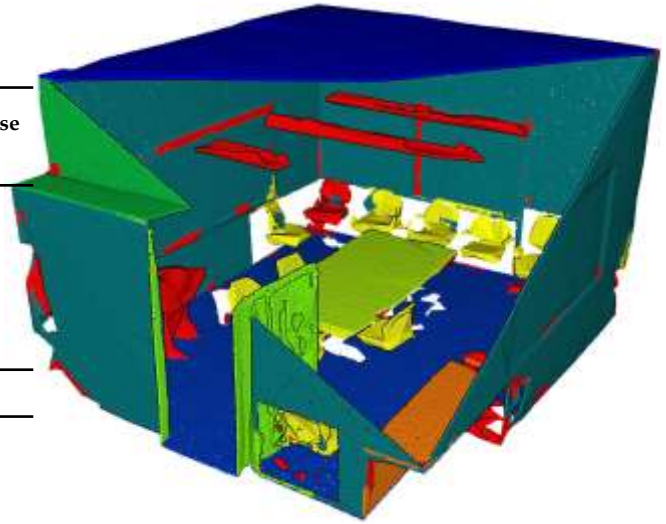
Deep learning < feature-engineering

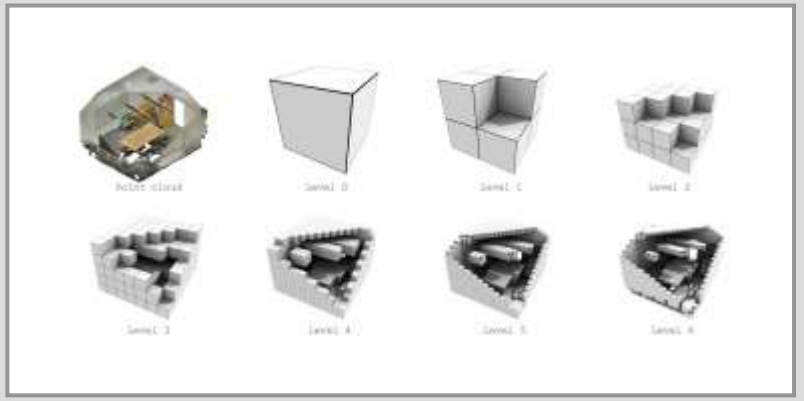

Input Point Cloud
3.1
Voxelisation
Voxelized grid
3.2.1
Feature extraction SF1 (low-level)
SF1-rich voxels
3.2.2
Feature extraction SF2 (relational)
SF1SF2-rich voxels
3.2.2
clustering
Connected Voxel clusters
3.3
Point within voxels refinement
Semantic patchs
3.3
Connection-based assembly
Connected Elements
3.4
graph-based classification
Benchmark-ready classified dataset

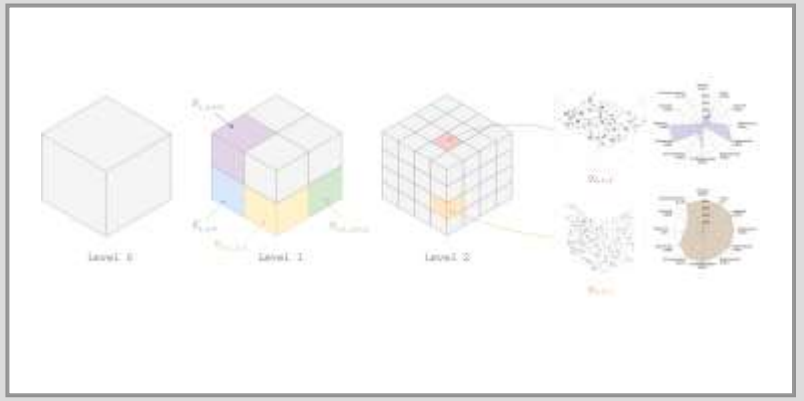


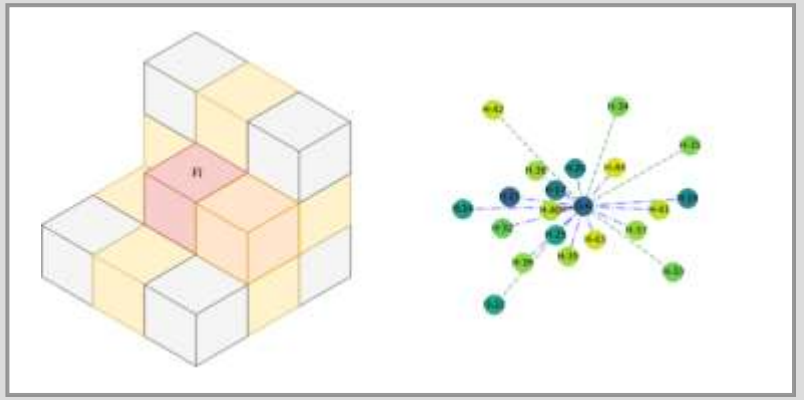


Overall Precision	Ceiling 0	Floor 1	Wall 2	Beam 3	Door 6	Table 7	Chair 8	Bookcase 10
Baseline (no colour) [16]	0.48	0.81	0.68	0.68	0.44	0.51	0.12	0.52
Baseline (full) [16]	0.72	0.89	0.73	0.67	0.54	0.46	0.16	0.55
Ours	**0.94**	**0.96**	**0.79**	0.53	0.19	**0.88**	**0.72**	0.2









10 million points / minute

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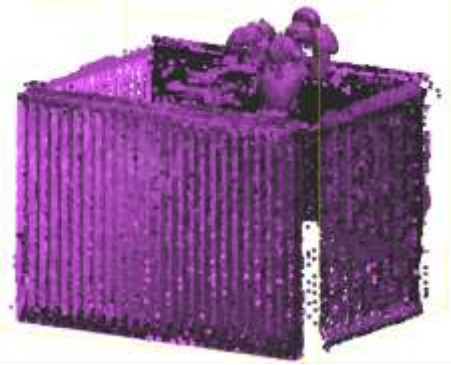
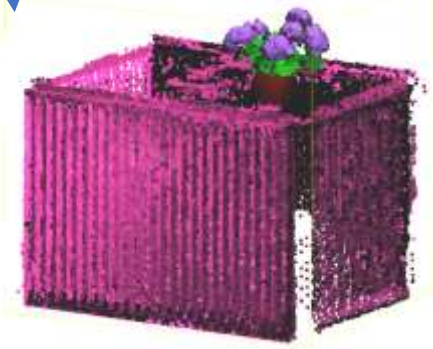
Isolation



Context / Proximity

Relation « host/guest »

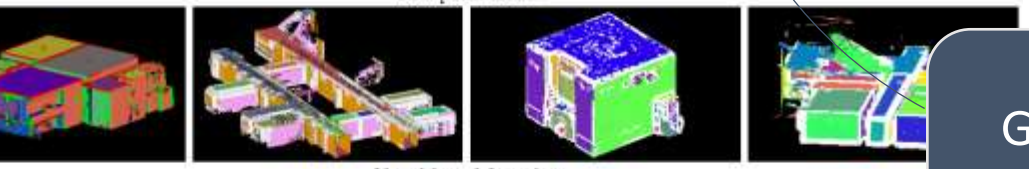


Relationships / Topology

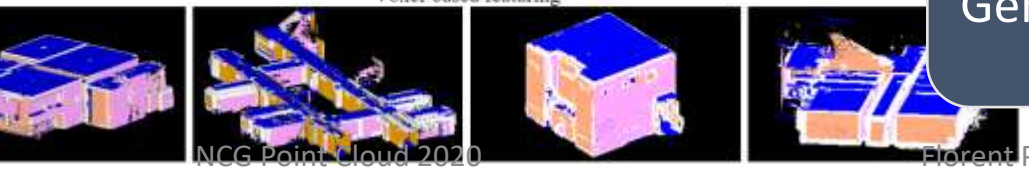
Extract

Local Features

Raw point cloud

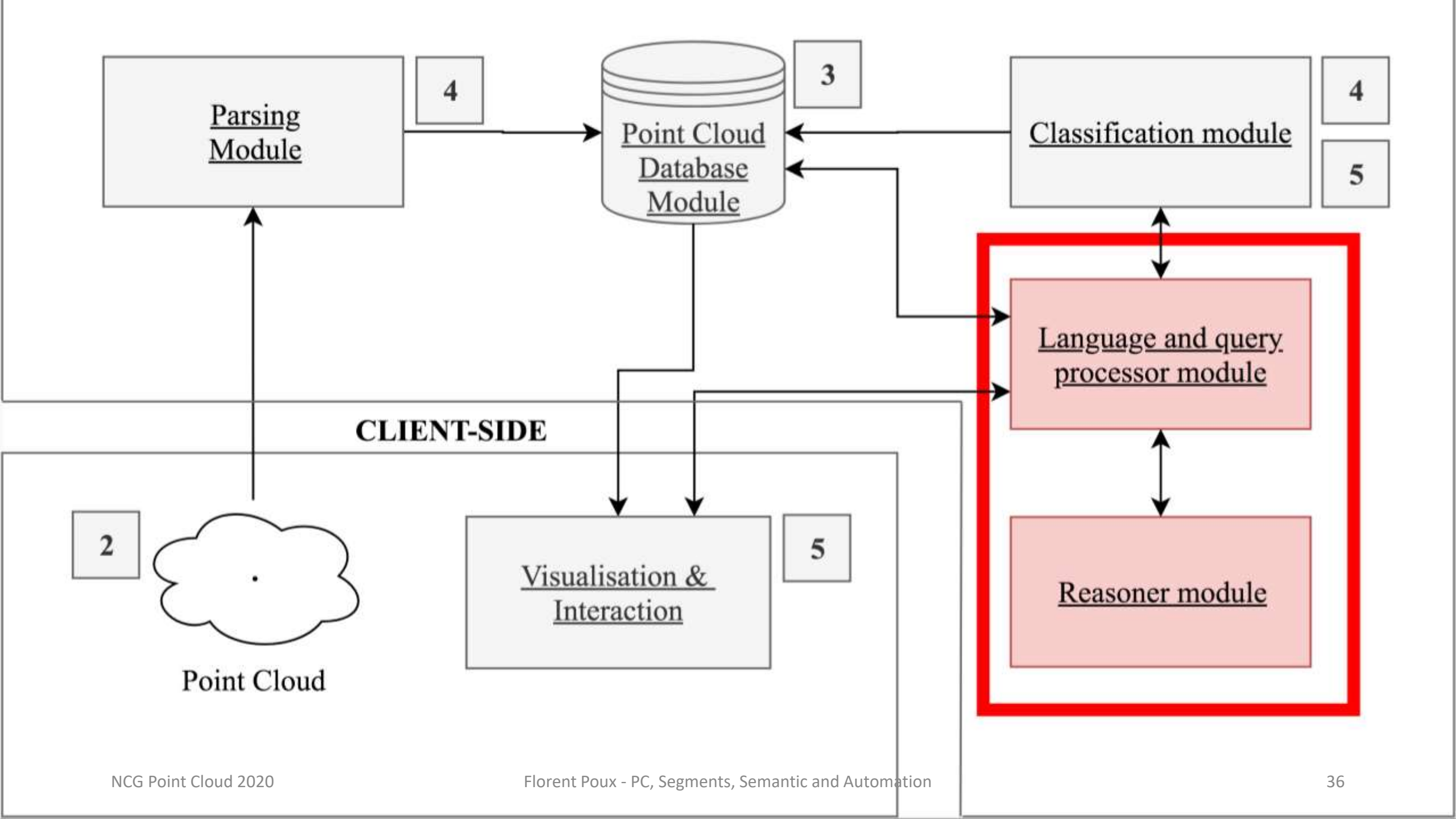


Voxel-based featuring



Geometries Generalizations

Knowledge-driven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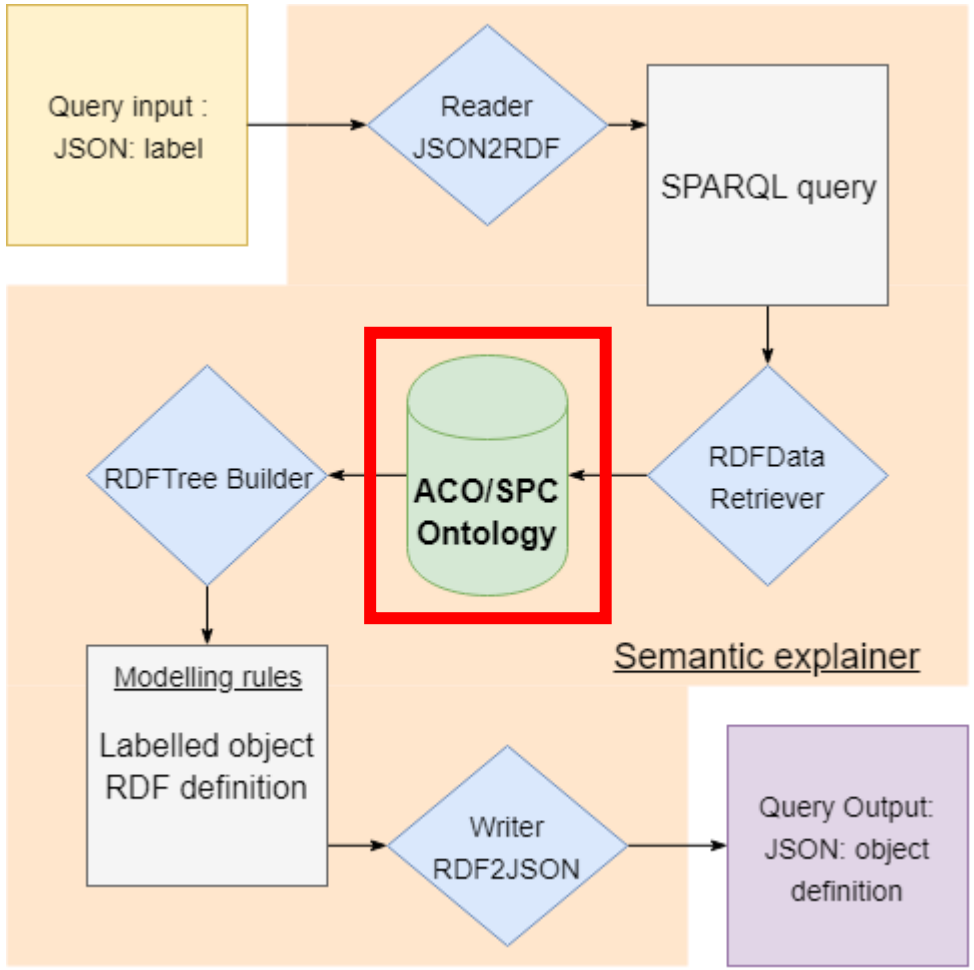
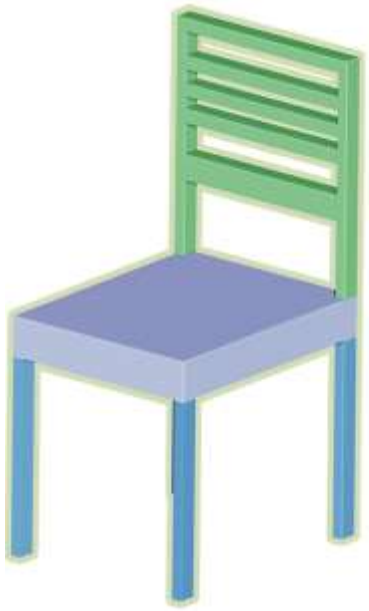
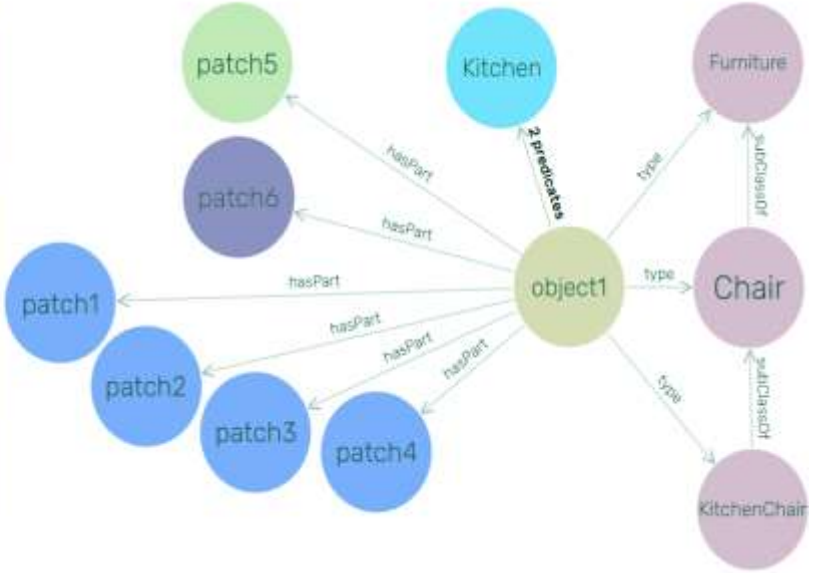
A classified entity

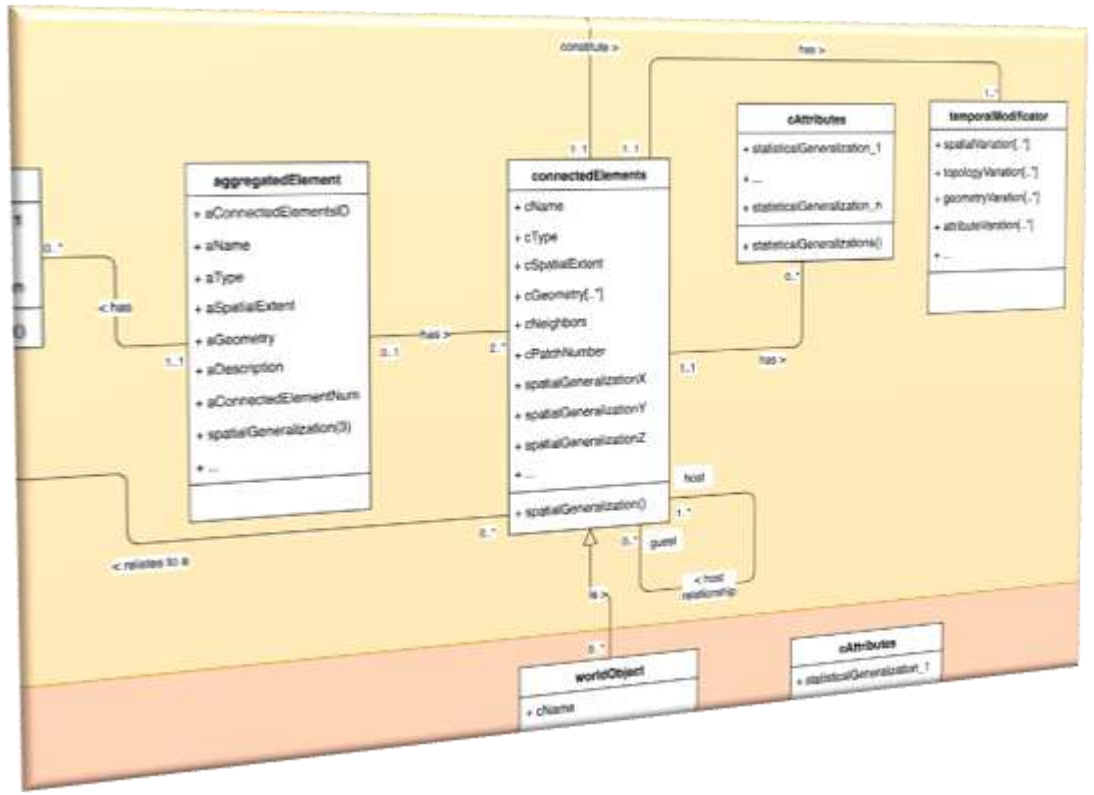
chair


DBpedia
About: Chaise
Une chaise est un type de siège, c'est-à-dire de meuble muni d'un dossier et destiné à ce qu'une personne s'assoie dessus. Un siège pour une personne sans dossier ni repose-bras est un tabouret ; pour plus d'une personne c'est un sofa ou un banc. Un repose-pieds séparé pour une chaise s'appelle un ottoman. La chaise comporte : * un piètement, généralement composé de quatre pieds, parfois renforcé par une entretoise ; * une assise, la profondeur d'assise d'une chaise est comprise entre 45 et 55 cm, et sa hauteur est normalement de 45 cm ; * un dossier.
Property
Value


Query input :
JSON: label
Reader
JSON2RDF
SPARQL query
RDFTree Builder
ACO/SPC
Ontology
RDFData
Retriever
Semantic explainer
Modelling rules
Labelled object
RDF definition
Writer
RDF2JSON
Query Output:
JSON: object
definition




patch5
Kitchen
Furniture
patch6
2 predicates
type
subClassOf
hasPart
patch1
object1
Chair
patch2
patch3
patch4
KitchenChair

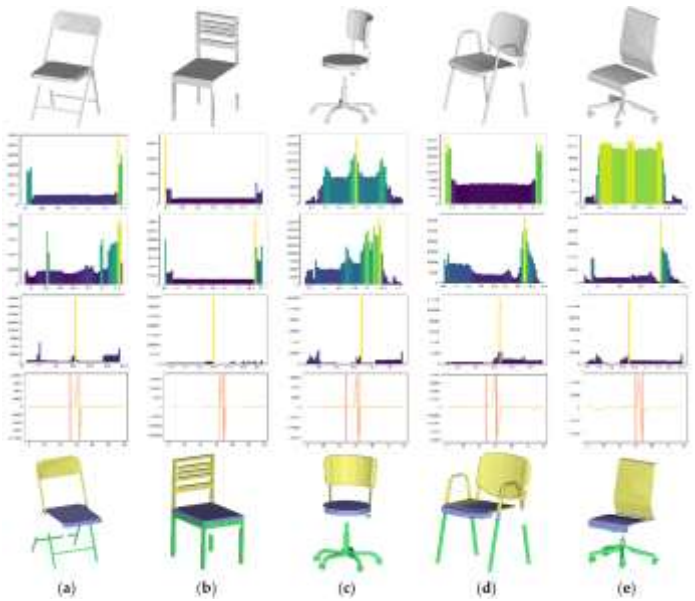


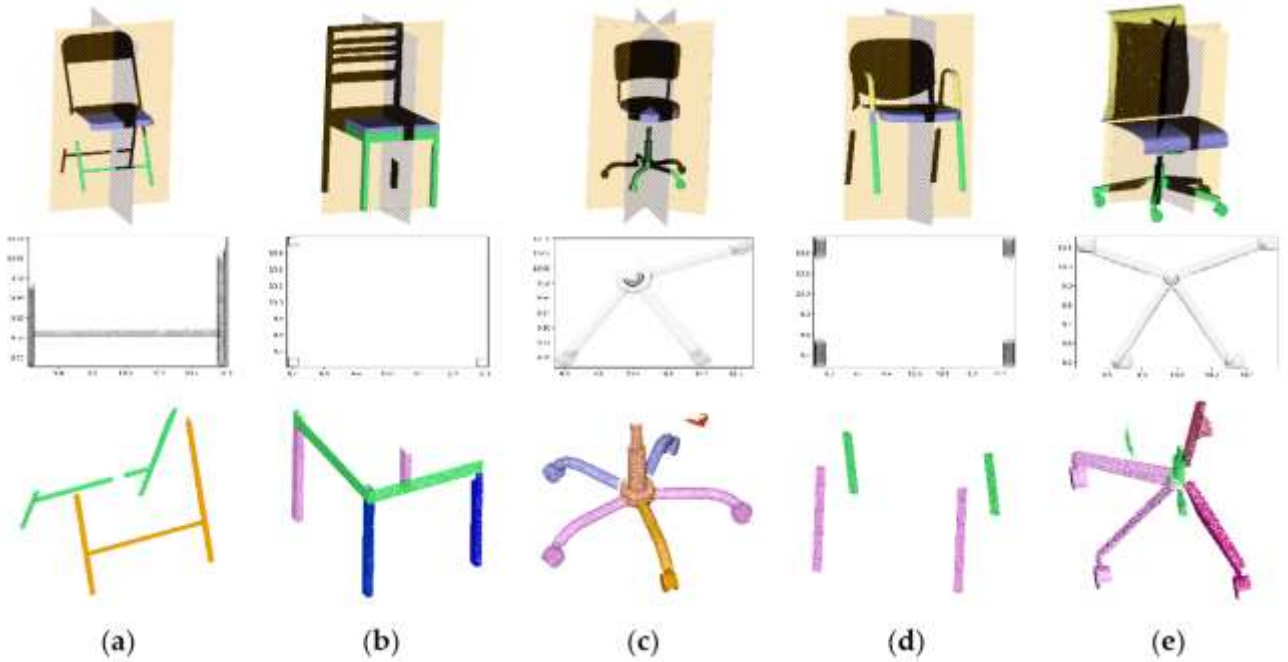
Connected Elements

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

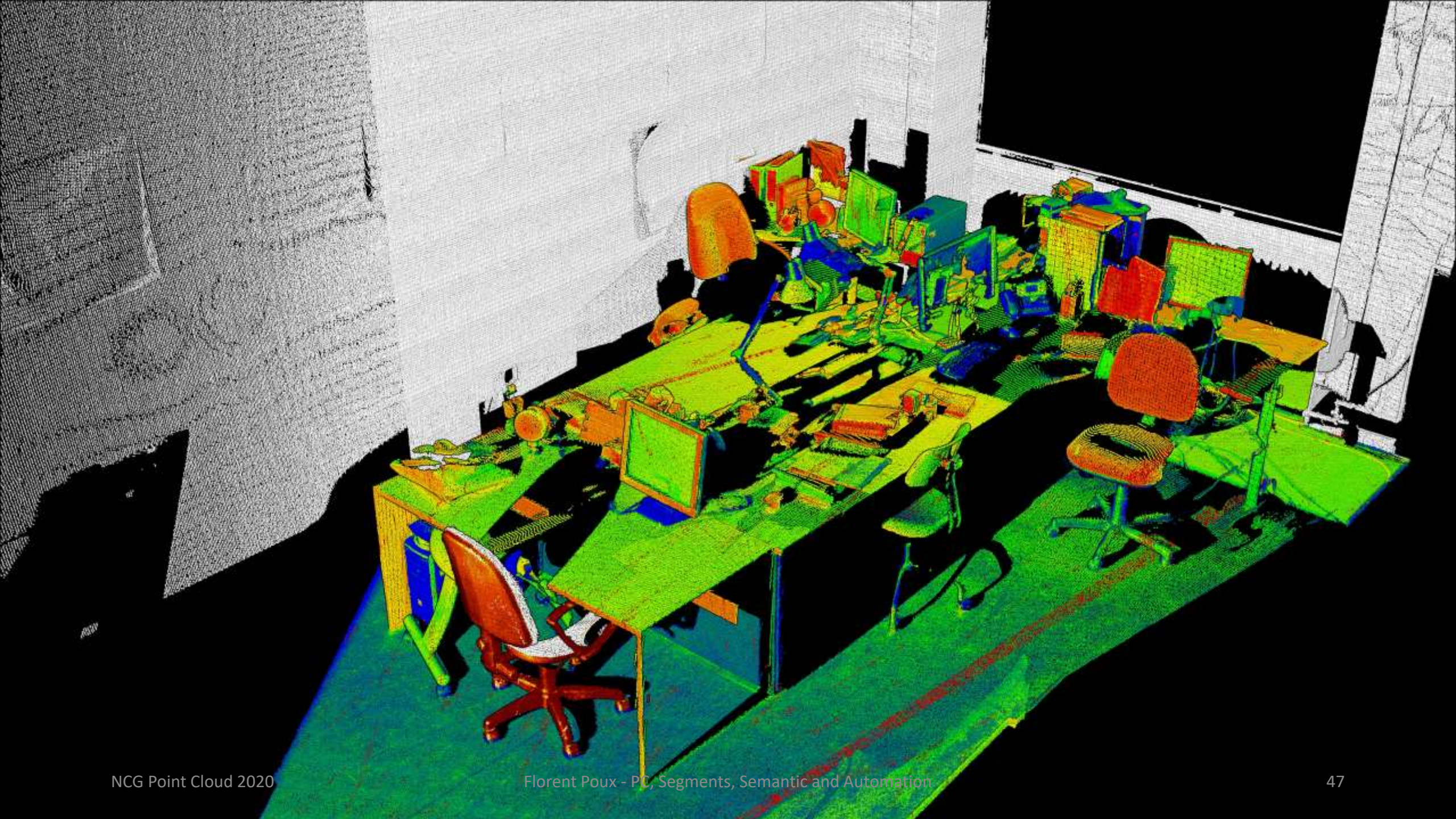
Chair = AE

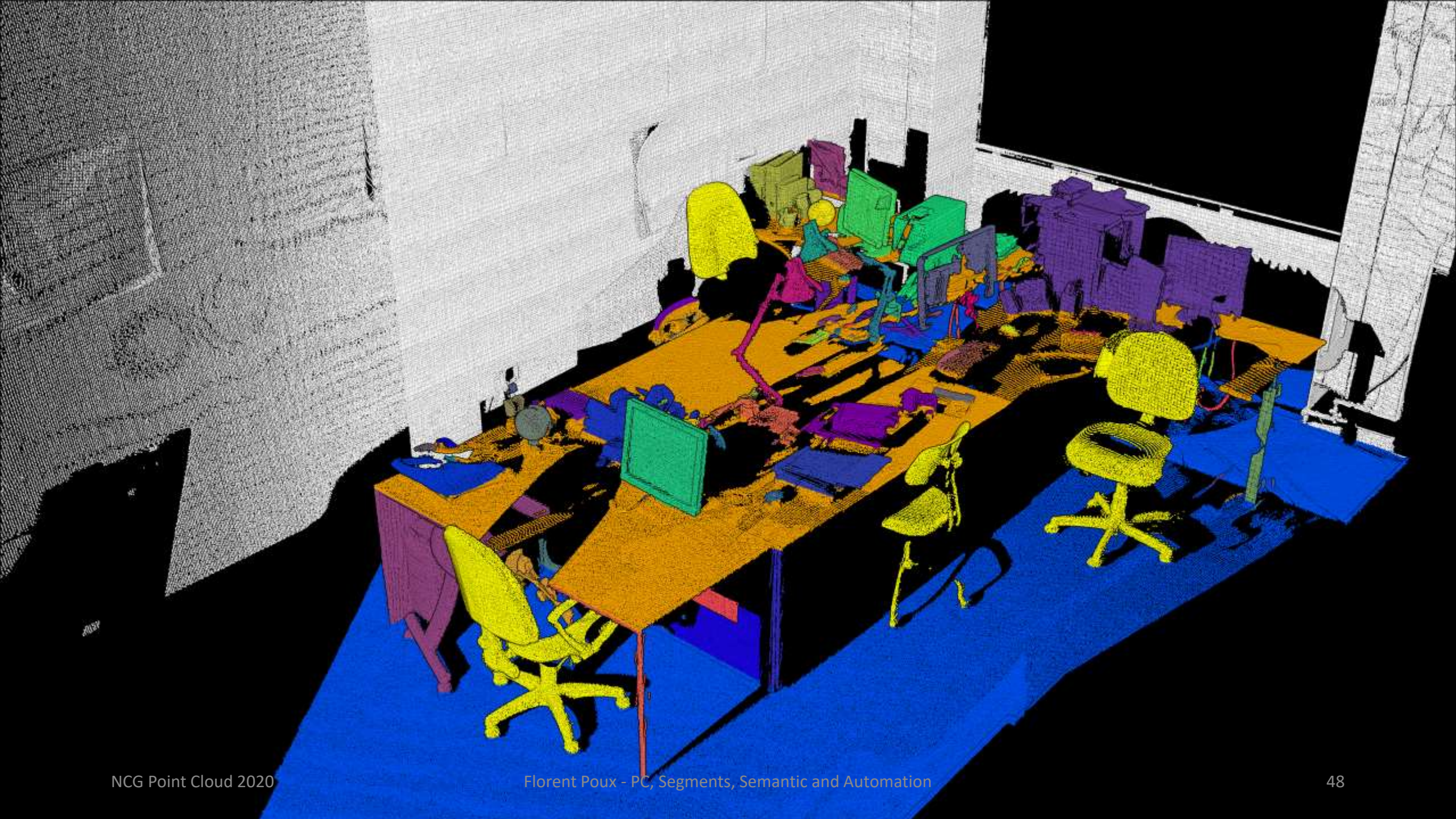
Part segmentation

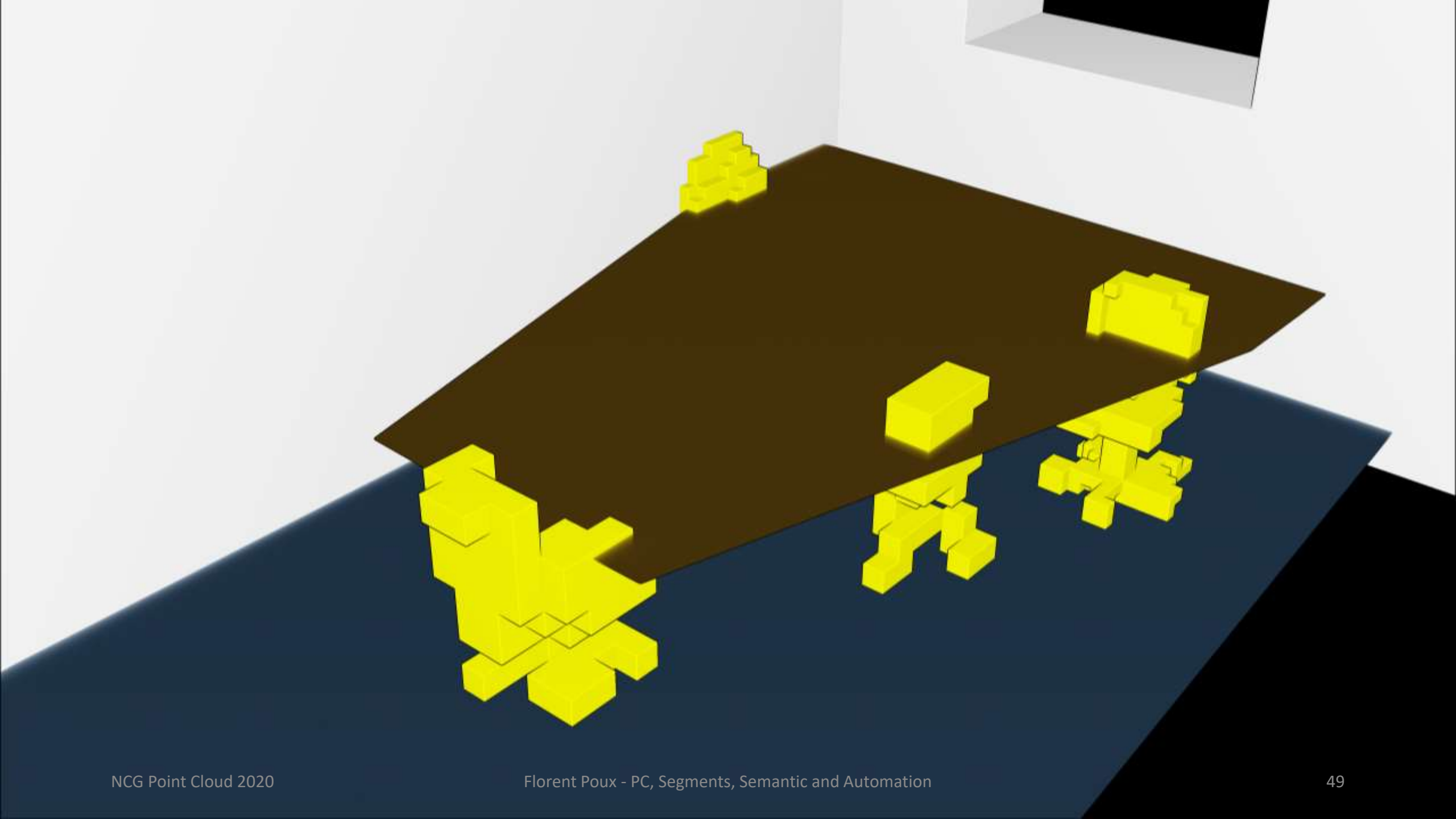

(a)
(b)
(c)
(d)
(e)

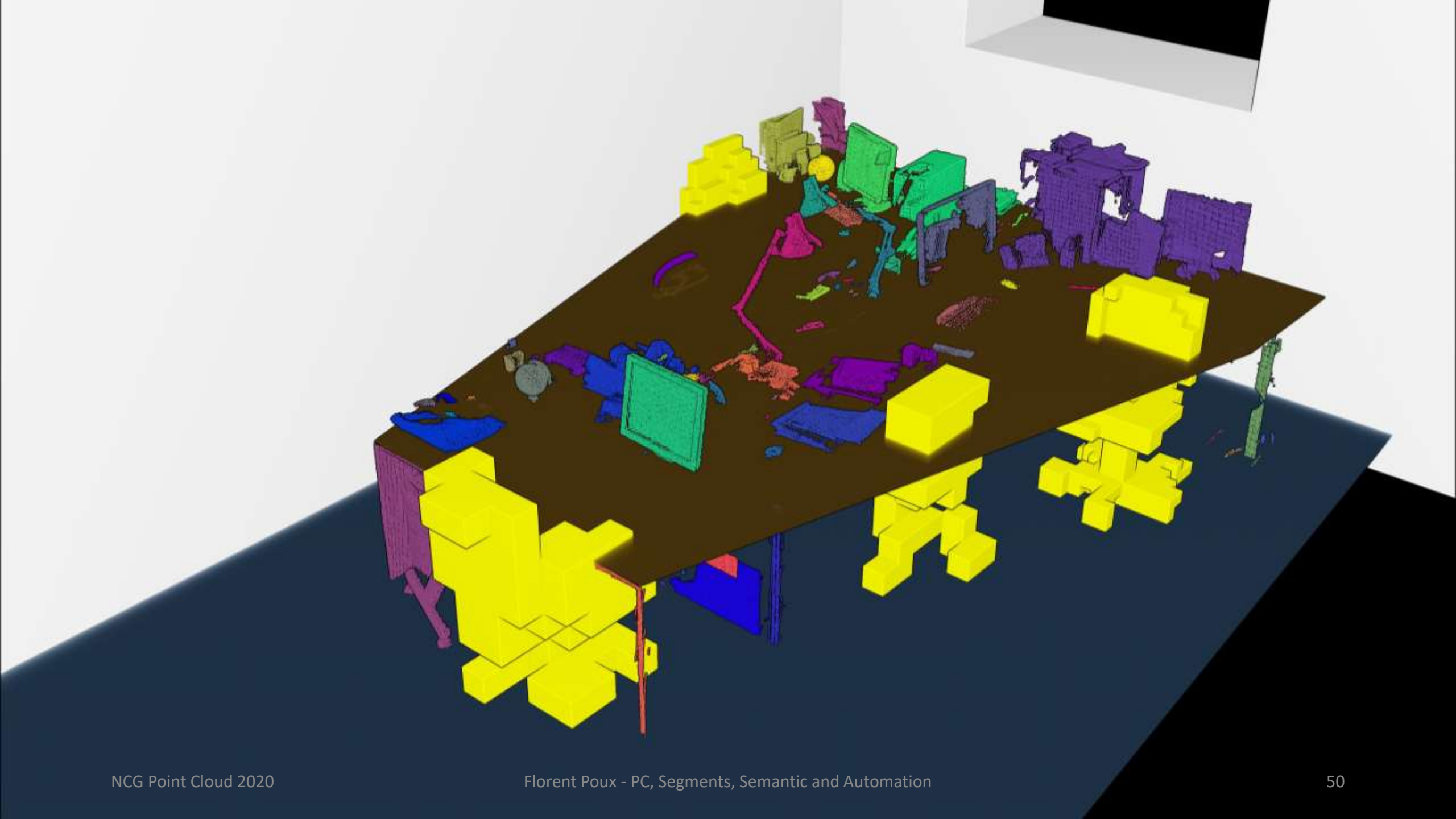

(a)
(b)
(c)
(d)
(e)

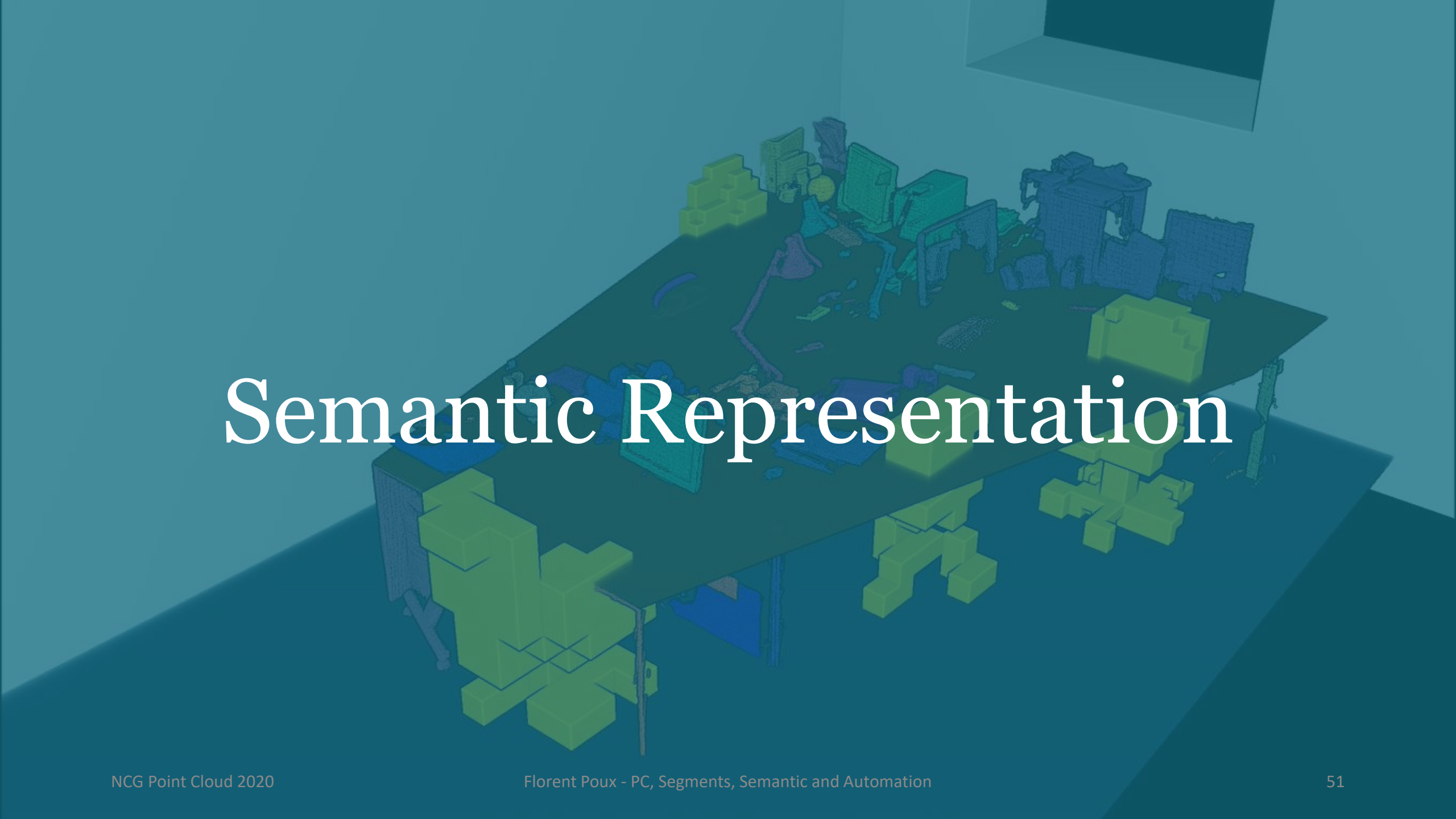
Characterization refinement









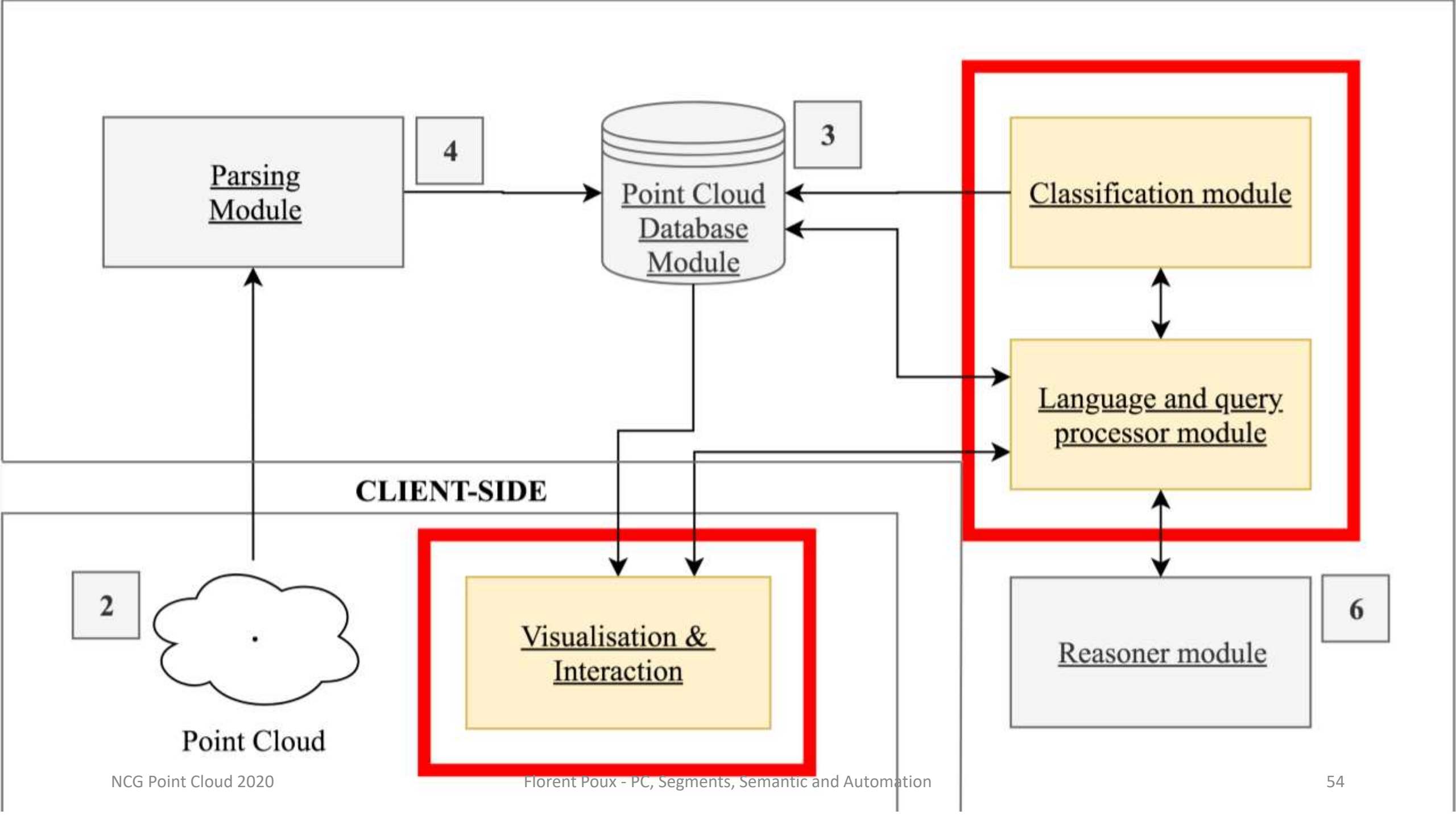


Semantic Representation

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 …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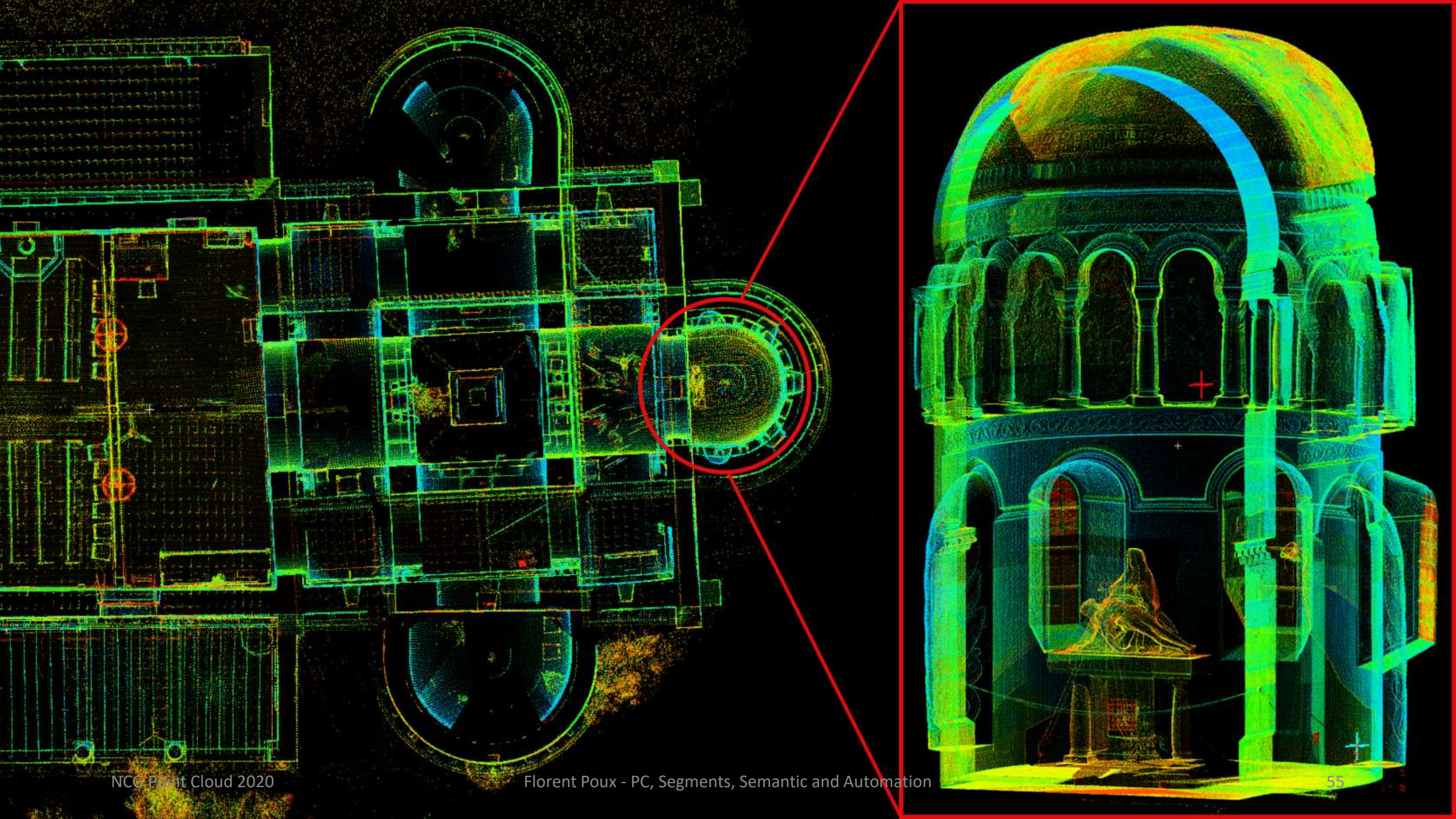
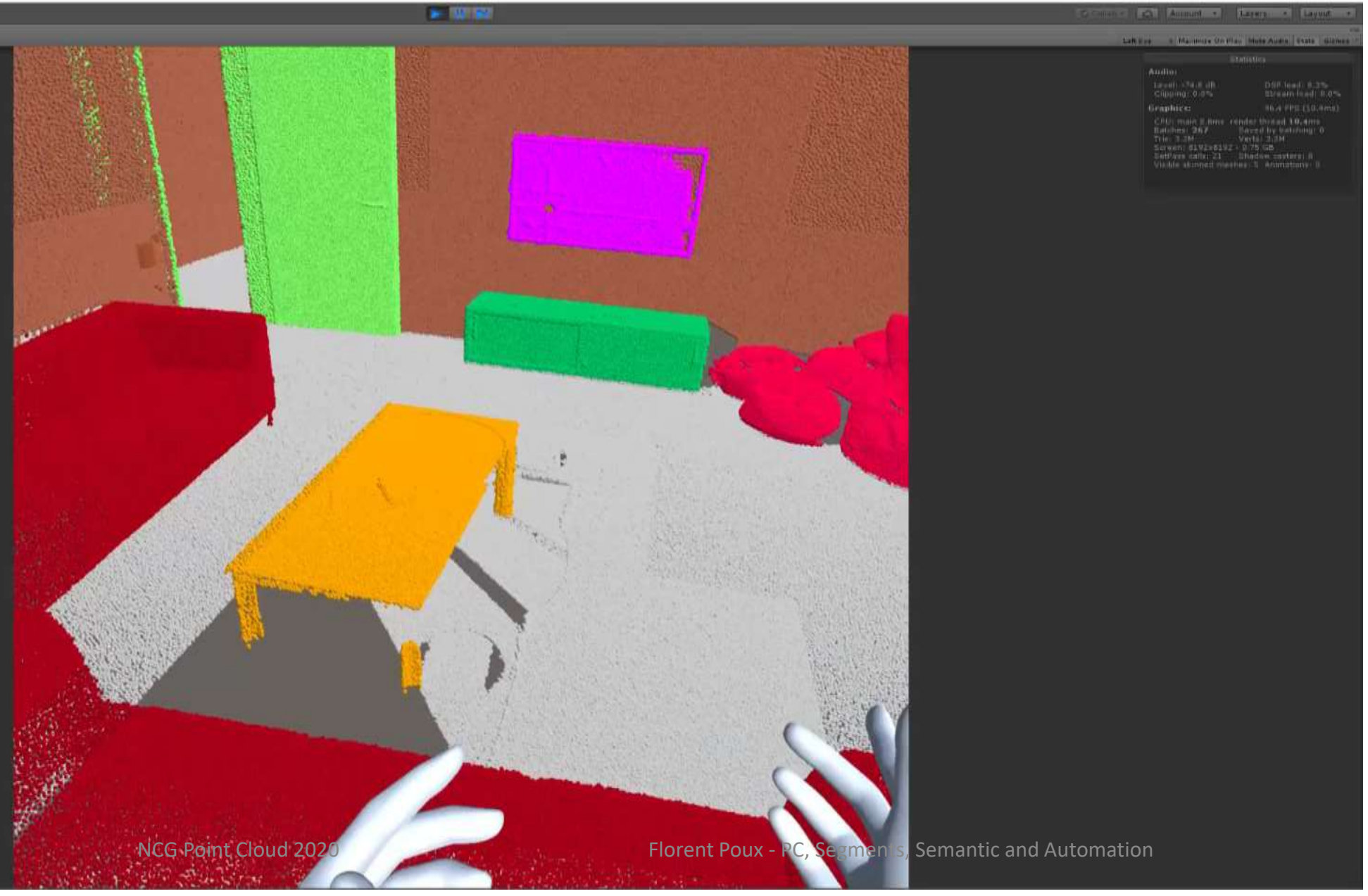


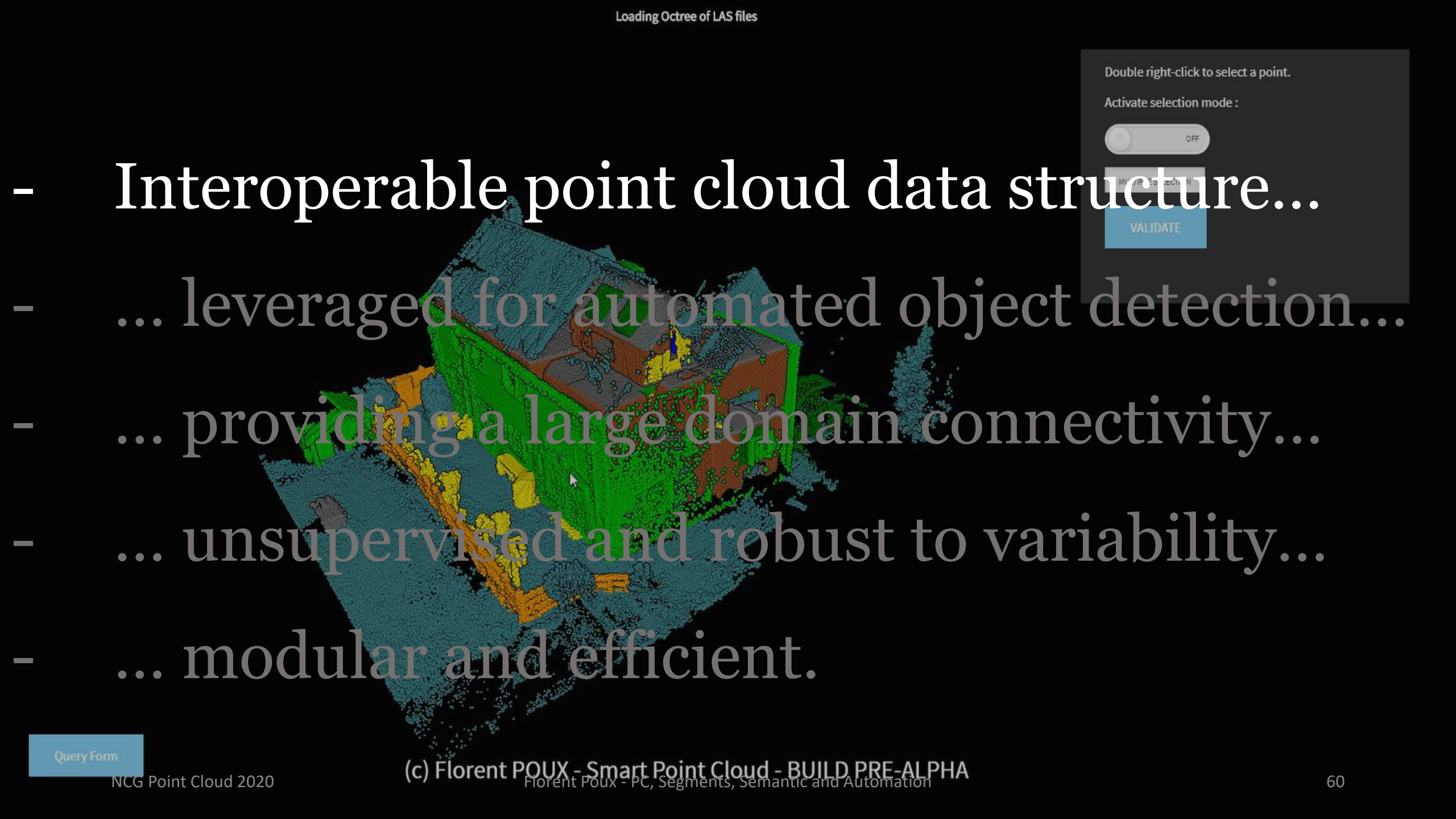
INITIAL GOLD FAIENCE SILVER

VR APPLICATION

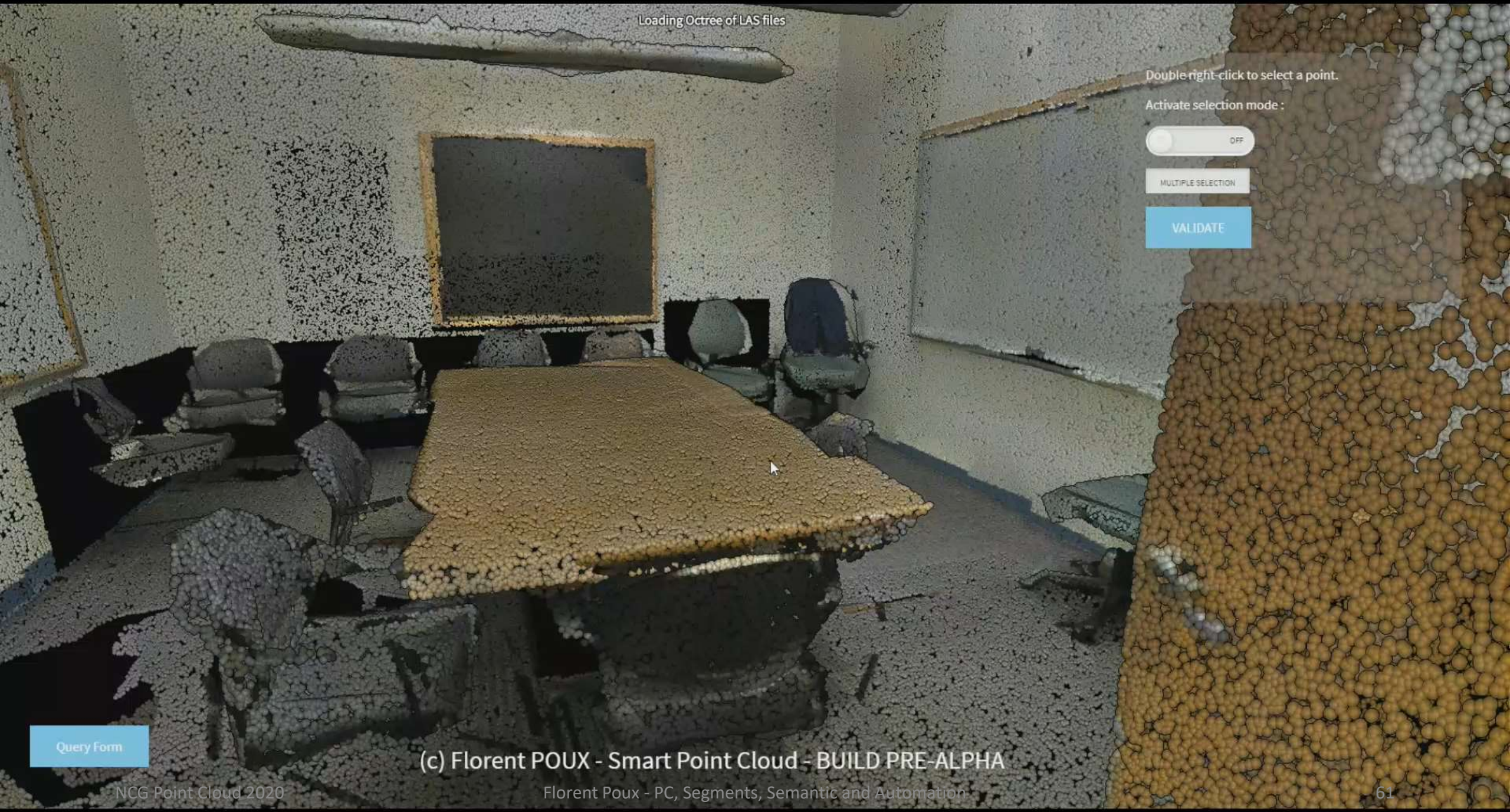


AR APPLICATION

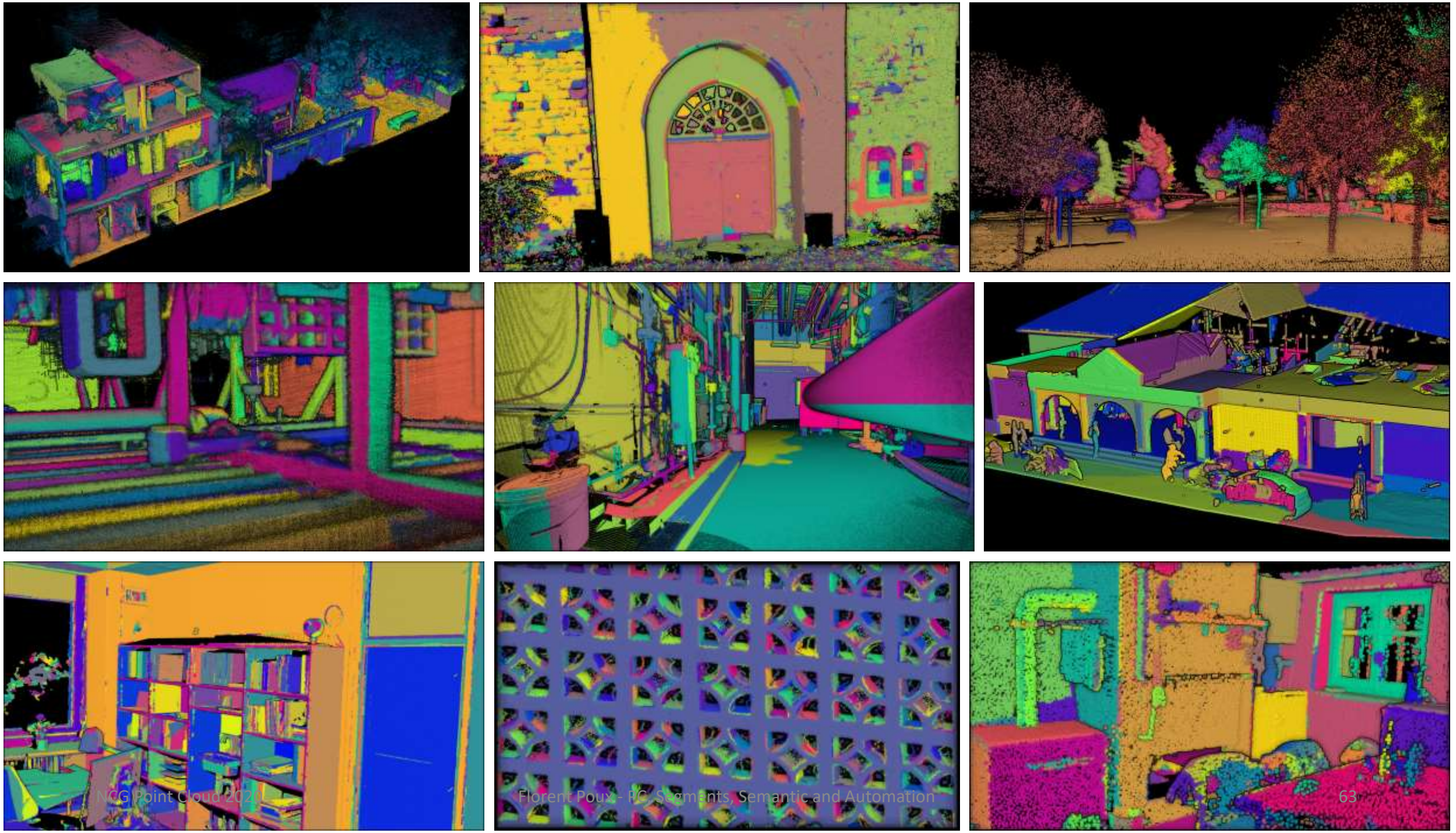
The SPC in 5 points

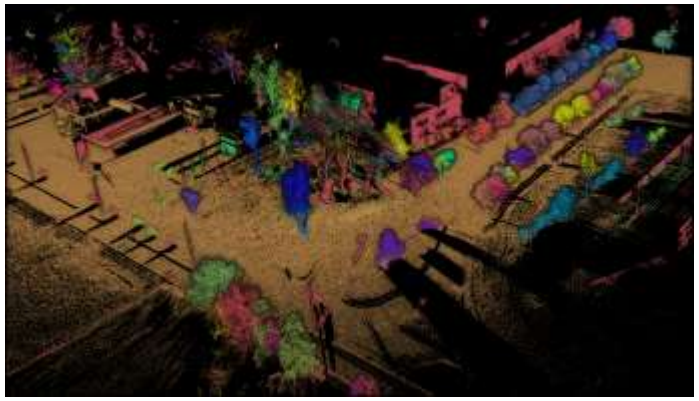


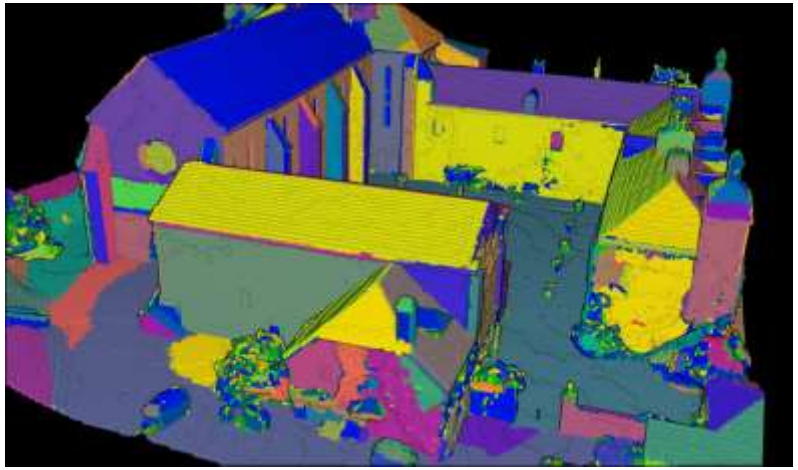
- Interoperable point cloud data structure…
- … leveraged for automated object detection…
- … providing a large domain connectivity…
- … unsupervised and robust to variability…
- … modular and efficient.

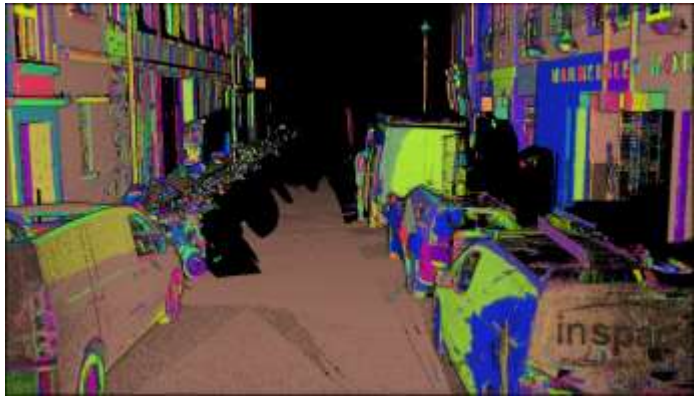

Loading Octree of LAS files
Double right-click to select a point.
Activate selection mode :
OFF
MULTIPLE SELECTION
VALIDATE
Query Form
(c) Florent POUX - Smart Point Cloud - BUILD PRE-ALPHA

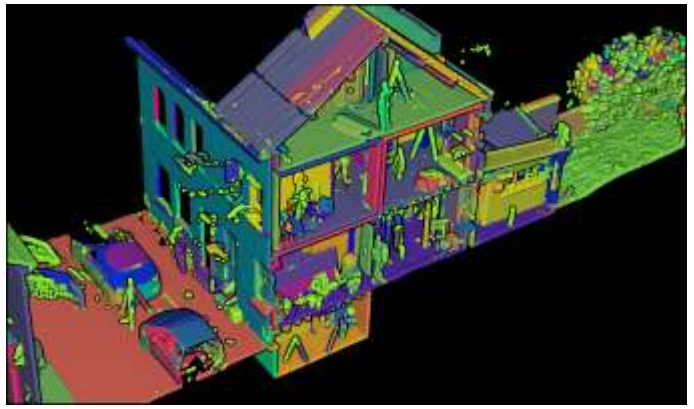
- Define powerful SPC-based AI Agents
- Increase generalization / specialization
- Dynamic data and LoD management
- Enhance unsupervised segmentation
- Enhance classification
- Integrate natural processes

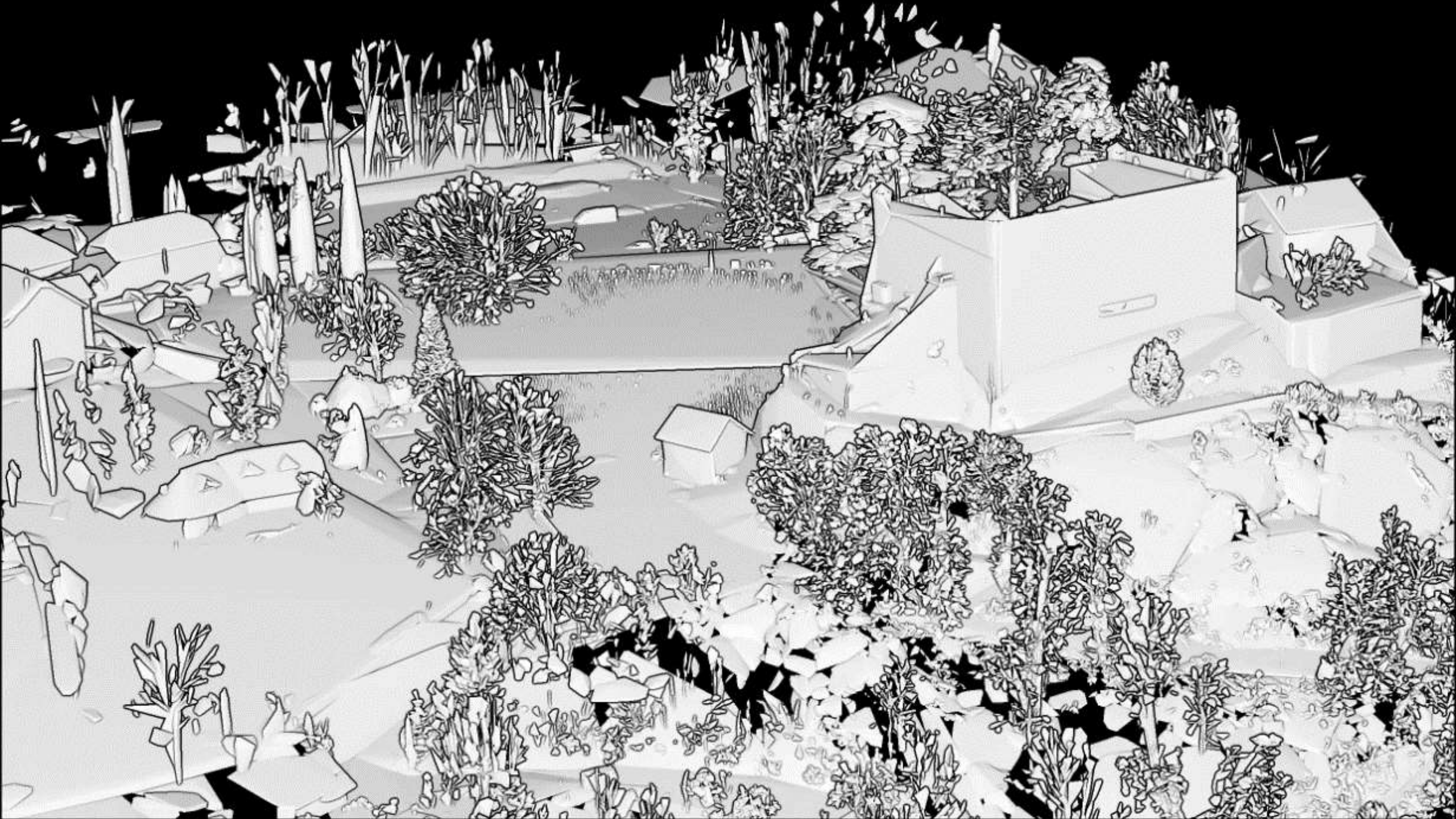












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Special Issue

Automatic Feature Recognition from Point Clouds

Special Issue Editors:

Florent Poux : University of Liège, Belgium

Roland Billen: University of Liège, Belgium

(Submission Deadline: Extended to 30 September 2020)

This *Special Issue aims to* submissions involves advancement of data mining and the infatuation of reality capture will continue to push the research communities forward. Particularly, ways to obtain high-quality application-oriented labelled datasets will permit a wider dissemination of robust learning approaches. Henceforth, we encourage authors to submit original research articles, review papers and case studies from both theoretical and application-oriented perspectives on this significant and exciting subject. In more details, topics suitable for this Special Issue *including but not limited to:*

- **Georeferenced point clouds from laser scanners (mobile, hand-held, backpack-mounted, terrestrial, aerial)**
- **Point clouds from panoramas, phone/cameras images, oblique and satellite imagery**
- **Point Cloud segmentation, classification, semantic enrichment for application-driven scenario**
- **Point Cloud structuration and knowledge integration**
- **Point Cloud Knowledge extraction and high-performance feature extraction for large-scale datasets**
- **2D floorplan generation of indoor point clouds**
- **Industrial applications with large-scale point clouds**
- **Feature-based rendering and visualization of large-scale point clouds**
- **Deep learning for point cloud processing**

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