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Automatic use of Spot on construction sites

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Agenda

1. SPOT
2. Simultaneous Localisation and Mapping (SLAM)
3. From a 3D model to an as-built model
4. Path Planning using a recorded map
5. Conclusion and future work

SPOT

Four-legged robot

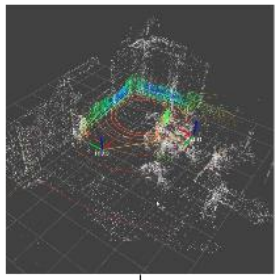
Carries up to 14 kg

Controlled manually or via a code

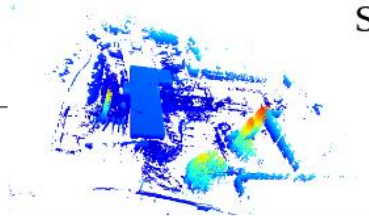
Progammable to repeat missions autonomously and gather consistent data

Cost ~ 100K

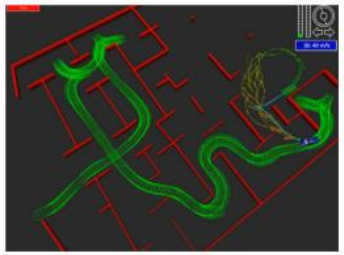
Data Acquisition



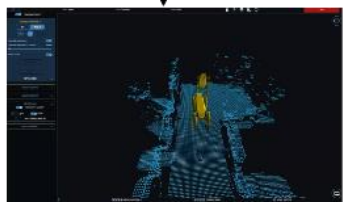
SLAM



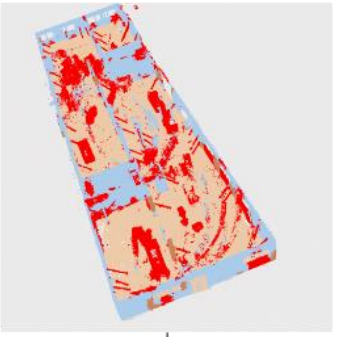
Path Planning



Machine Instruction



Point cloud Segmentation



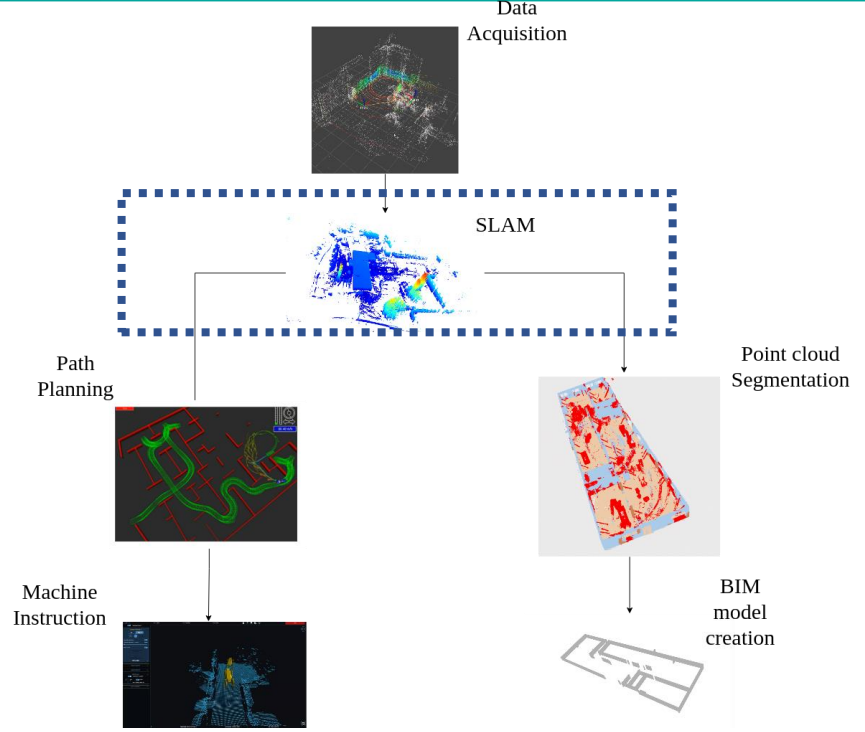
BIM model creation

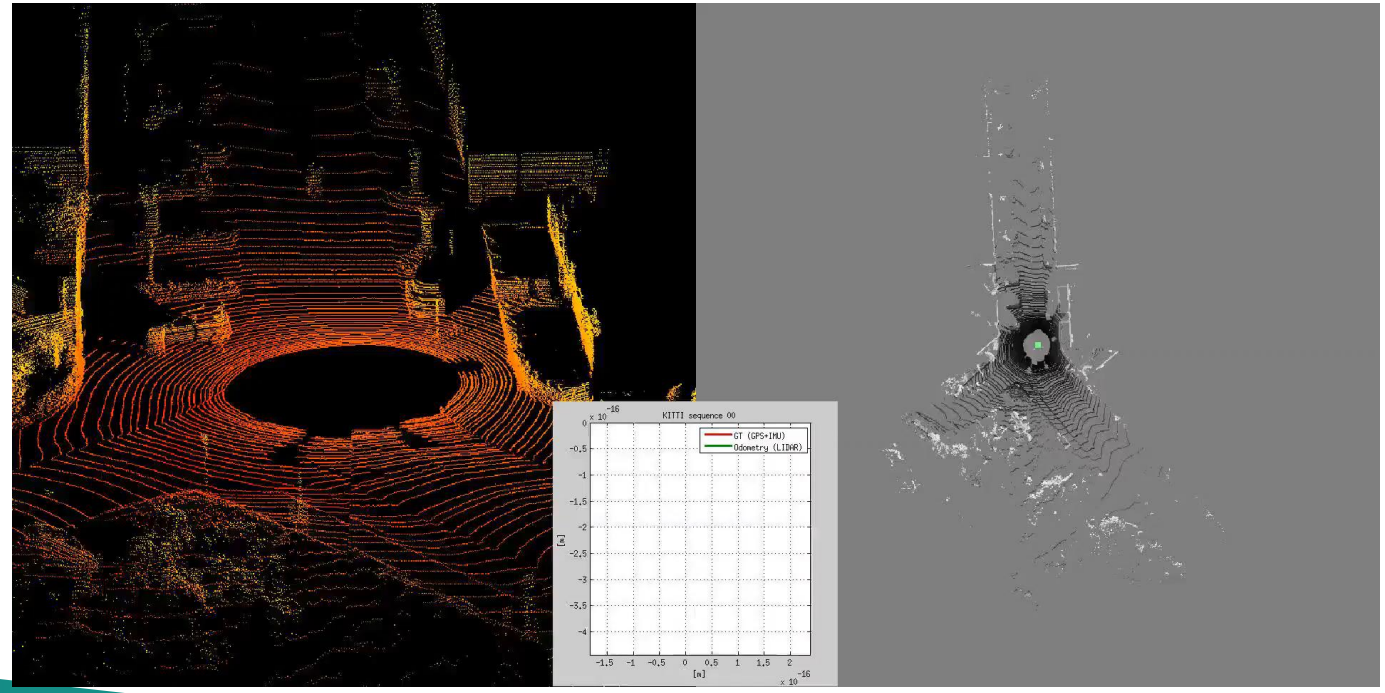
SLAM

SLAM attempts to address the problem of **building a map** of an unknown environment, while keeping track of an **agent location** within this map using sensor data.

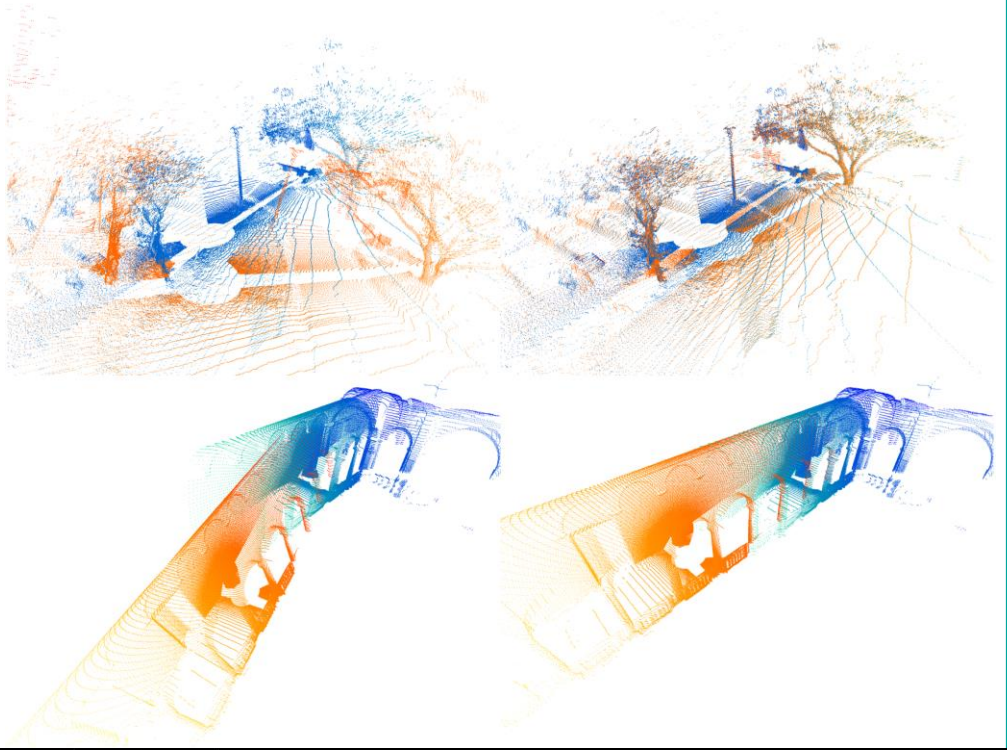
Many different use cases:

- Automated car piloting
- Medicine – e.g. minimally invasive surgery
- Construction site monitoring and maintenance





Lidar Odometry and Mapping



Input :

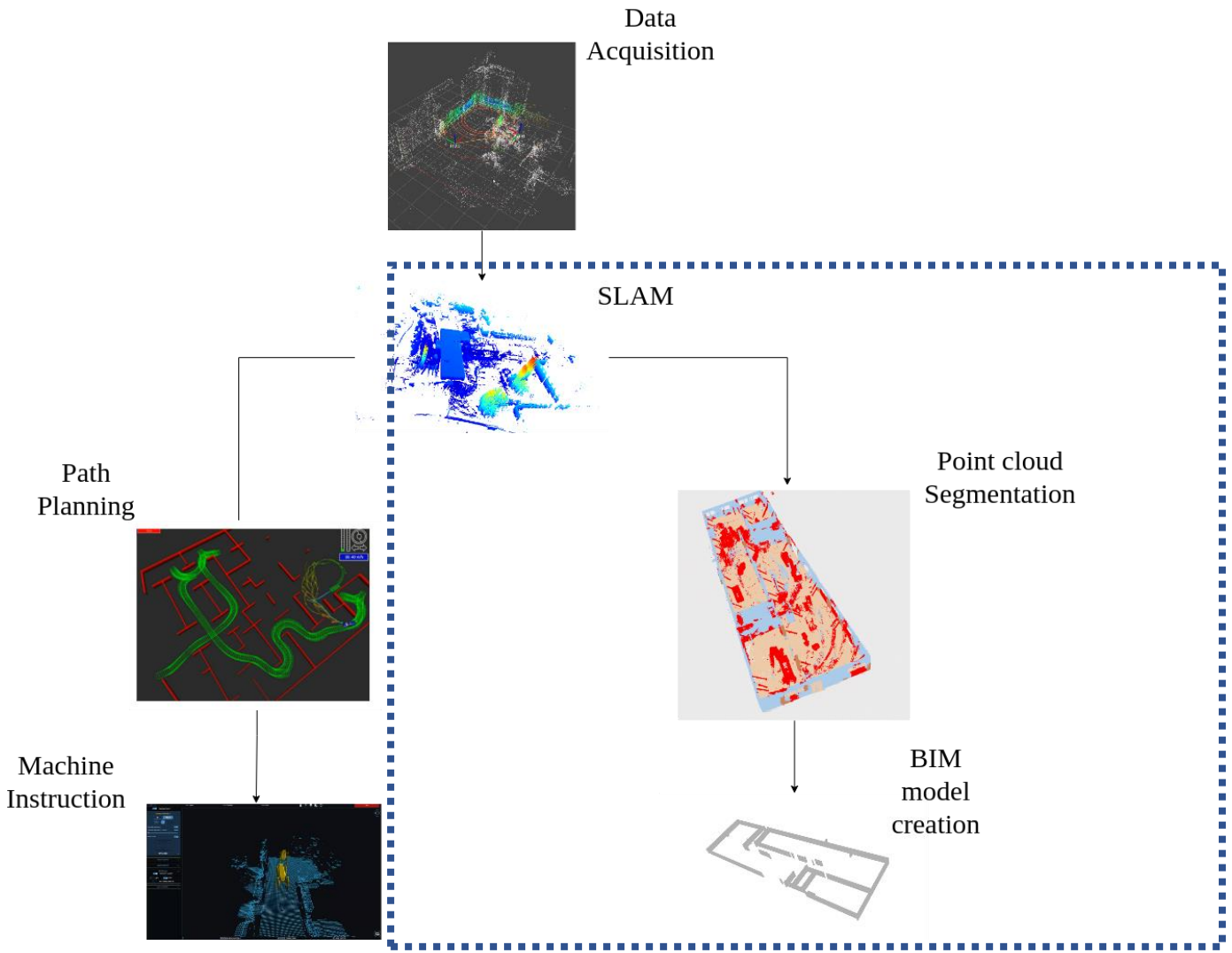
- Almost continously position retrieval given Spot's motor information (**noisy**)
- Point cloud acquiring rate ~ 5 Hz

Problem : Finding spatial transformation that aligns consecutive point clouds

How ?

- Point cloud features computation
- Matching point cloud features (optimization problem)

Automatic Scan to BIM



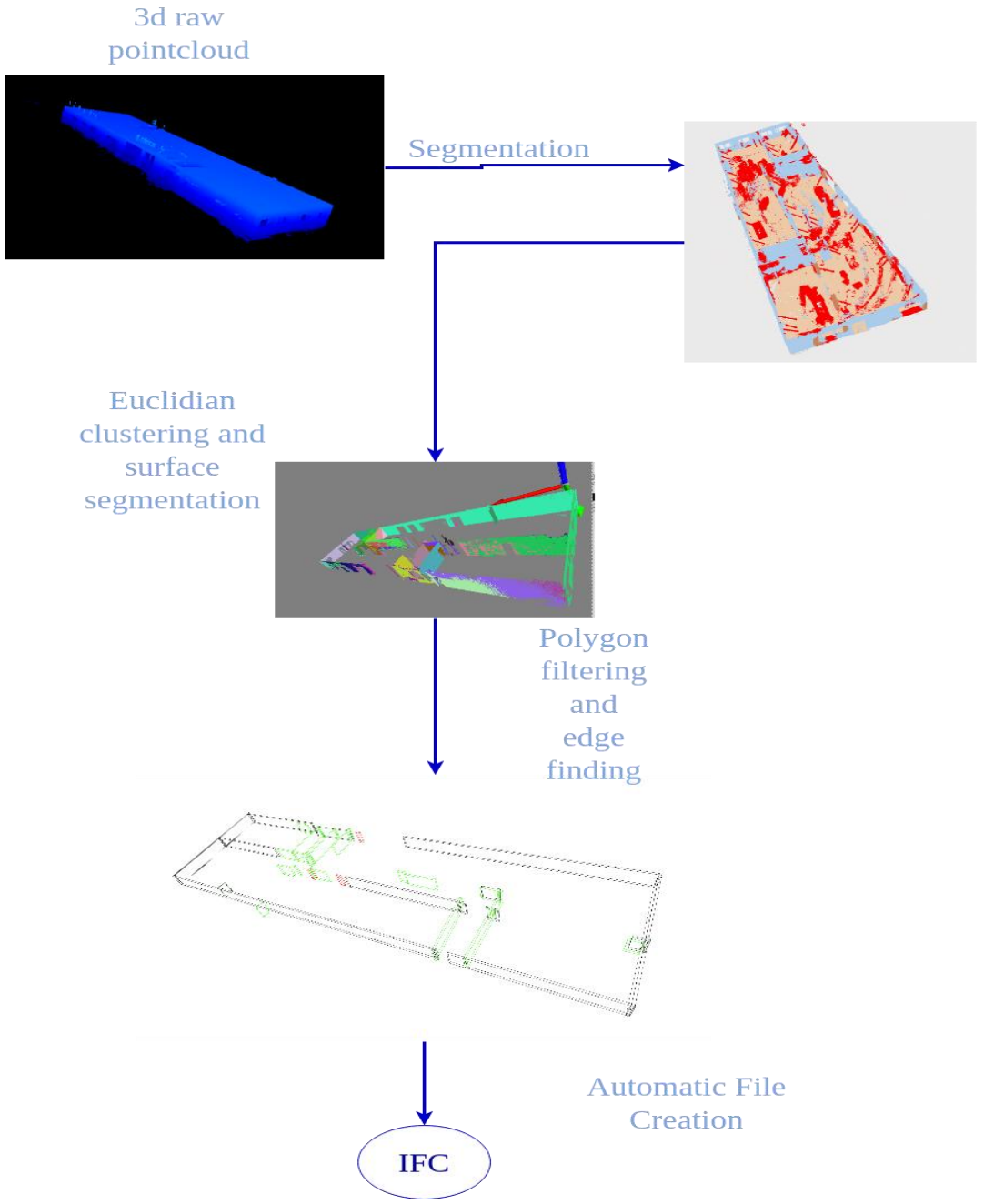
Automatic scan To BIM

Point cloud segmentation

Euclidian clustering and surface segmentation

Polygon filtering and edge finding

Automatic IFC file creation



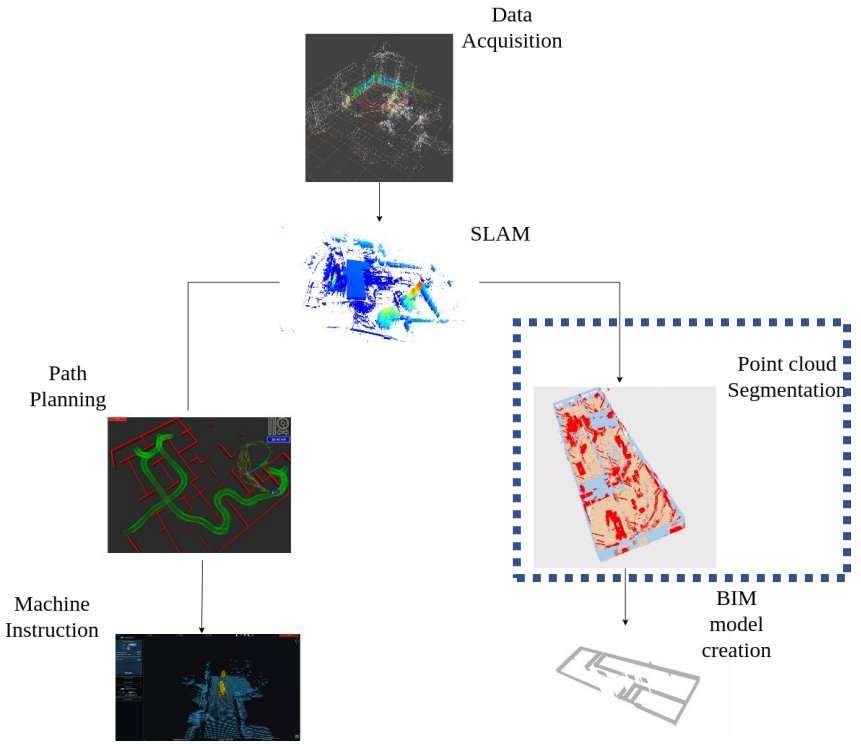
Deep learning segmentation

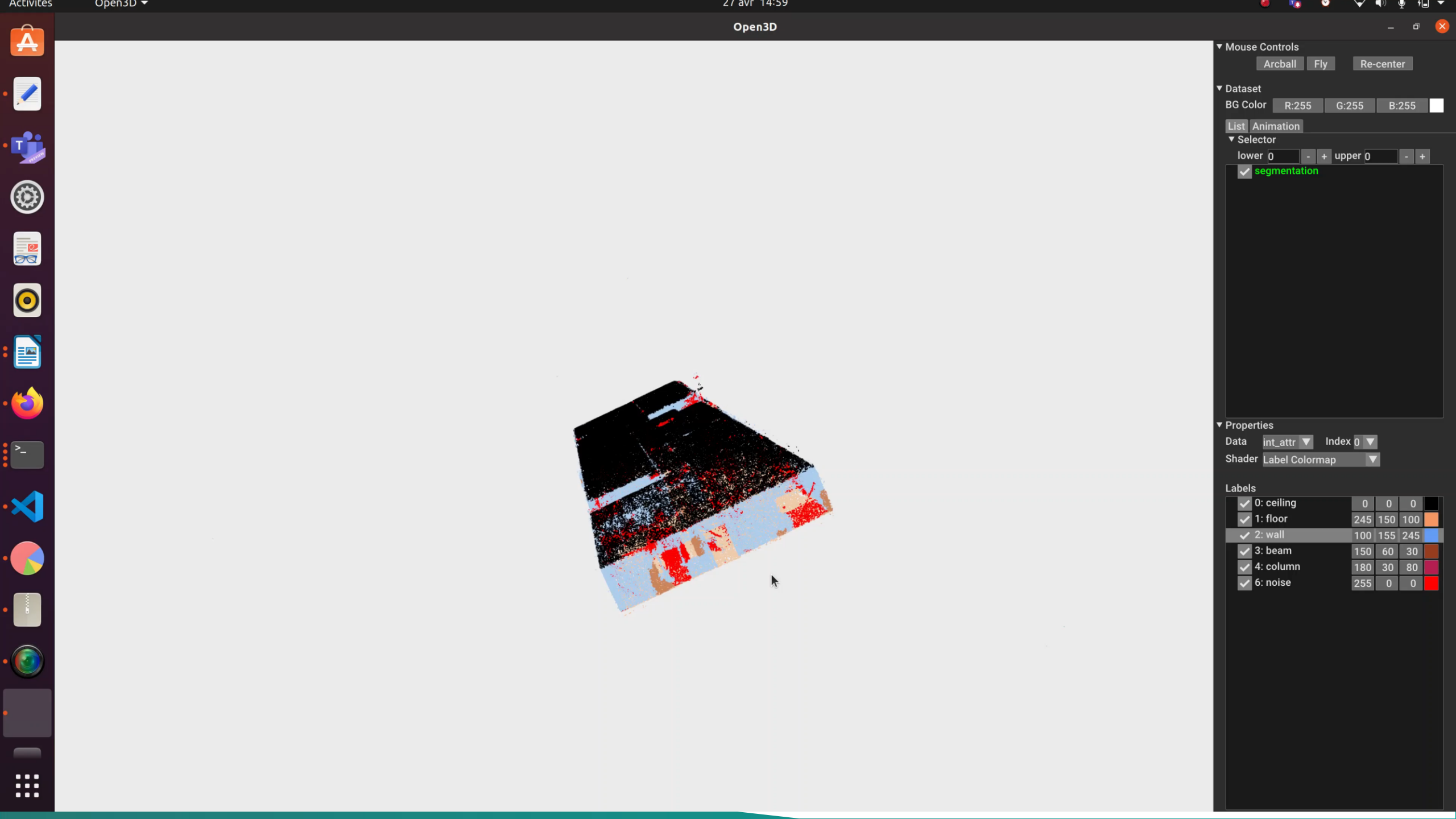
No 3D annotated construction site data availabe -> Impossible to use pre-existing trained model

Retrain the model on the S3DIS dataset (indoor dataset) with a model similar to RandLanet

Dataset modifications:

1. Axes rescaling
2. Noise
3. Deletion of windows (due to reflection)




Activités
Open3D
27 avr 14:59
Open3D
Mouse Controls
Arcball
Fly
Re-center
Dataset
BG Color
R:255
G:255
B:255
List
Animation
Selector
lower 0
upper 0
segmentation
Properties
Data
int_attr
Index 0
Shader
Label Colormap
Labels
0: ceiling 0 0 0
1: floor 245 150 100
2: wall 100 155 245
3: beam 150 60 30
4: column 180 30 80
6: noise 255 0 0

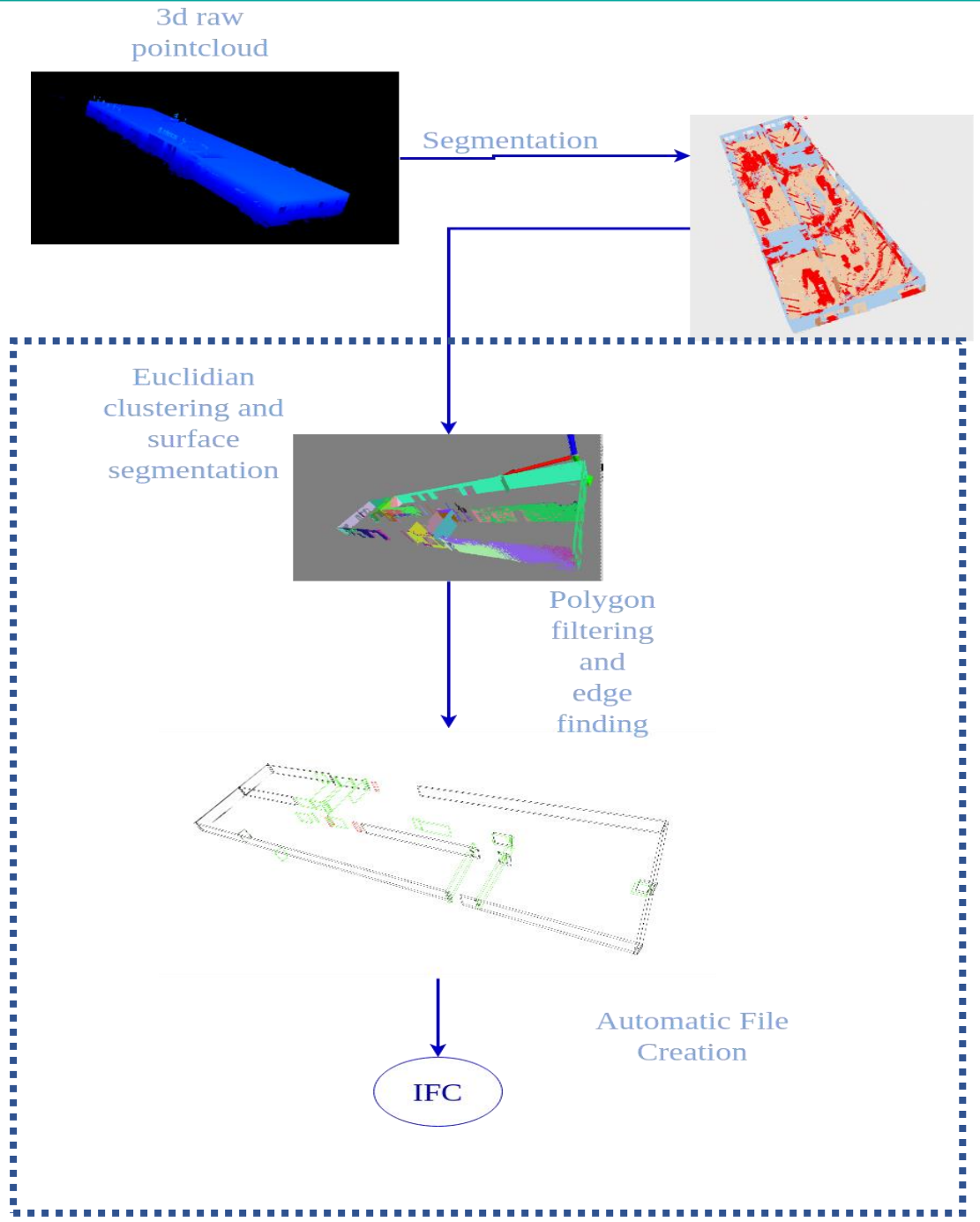
Point cloud to BIM model

Point cloud Separation (wall, floor ceiling, ..)

Detection of planes/surfaces

Box detection

Conversion to IFC file format



Detection of objects

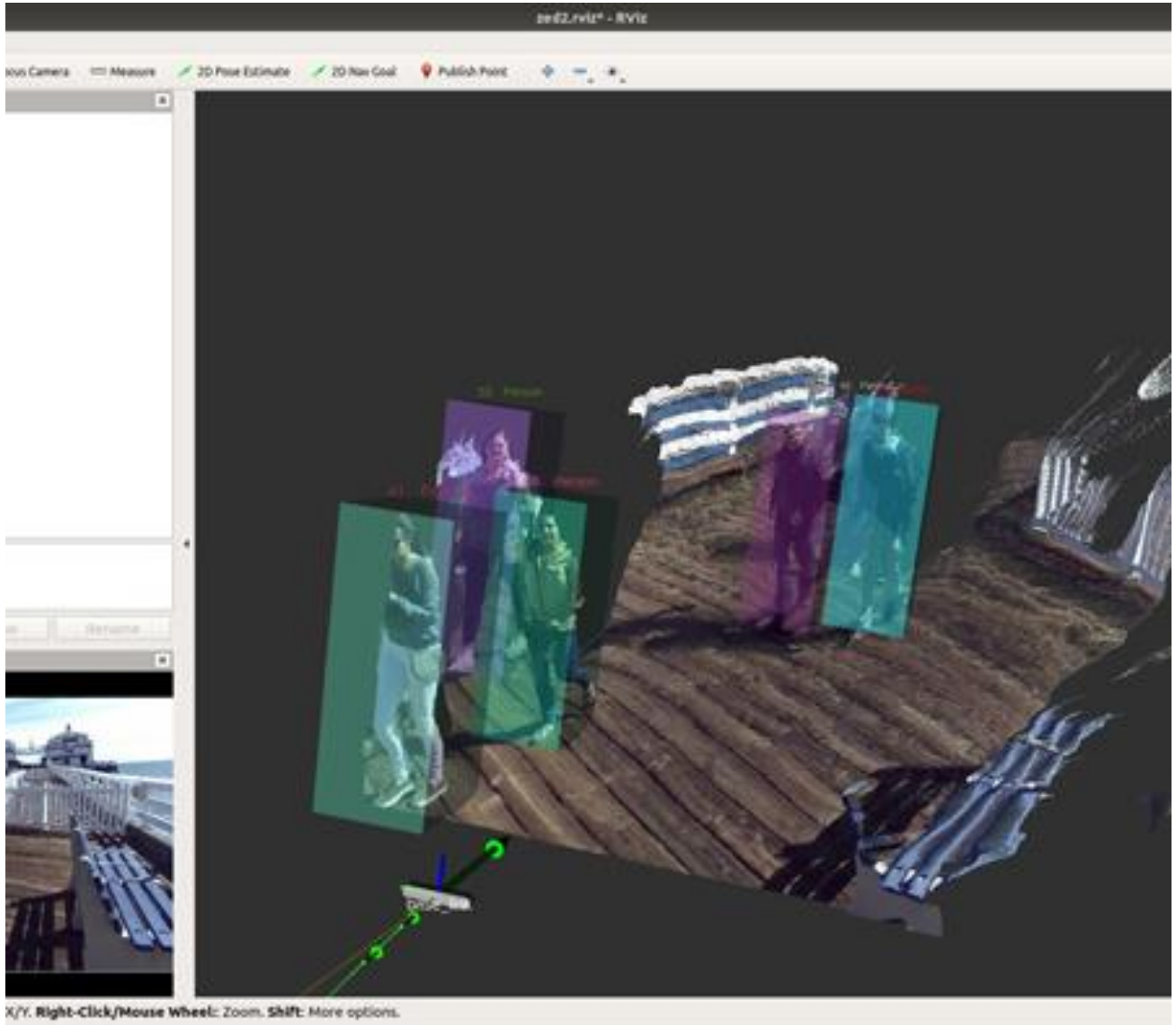
Point clouds are sufficient for structure segmentaion, not for object detections, as:

- 3D deep learning models are **not well suited enough**
- Datasets are **not available**

Alternatives:

- Pictures from point clouds

- Working directly with images, but there is **no notion of distance**
  -> **photogrammetry**



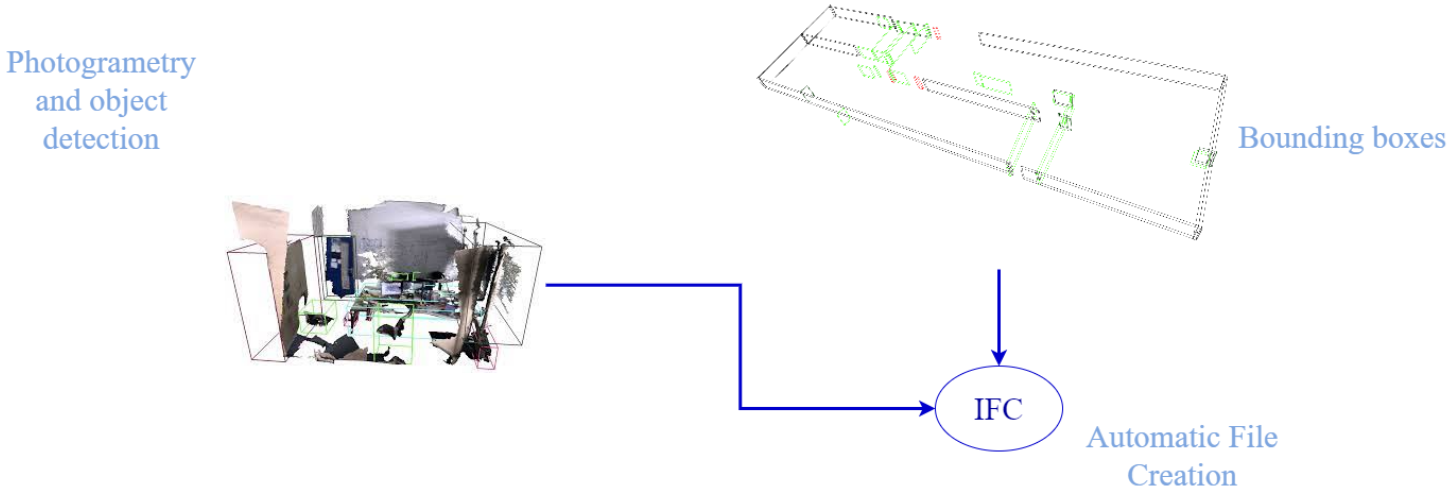
Linking photogrammetry and SPOT

We equipped the robot with a stereoscopic camera

It perceives surroundings in 3D up to 20 m distance with an accuracy of a few cm

Run of CV object detections algorithms on the camera

Link of those detected objects with structure (wall, floor, ceiling,..)



Path Planning

- The tools shown are interesting, but not meaningful if it is required that a person is present at all times
- Given a 3D map, a current position and target, which path to take?
- Can we program repeatable autonomous missions to gather consistent data?
- This could be used to ask the robot to go to same places and take pictures, detect objetcs, etc ..

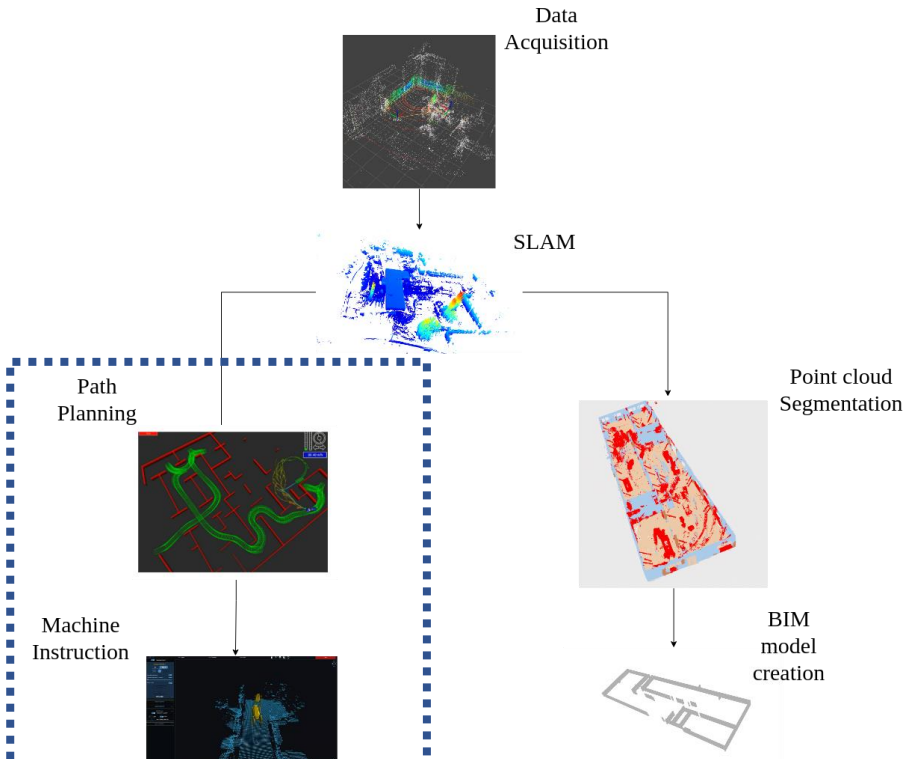
Path Planning

Creation of a binary 2D grid from a point cloud

Each cell is full or empty if enough points (hyperparameter) are present in this position within a height of 0 to 80 cm (robot's height)

Path is found in this grid and transferred in **SPOT language** machine instruction

Only working in **non-changing environments** currently



Future work

- Detection of cylinders in point clouds and thus creation of beams and columns in the BIM model
- Detection of smaller objects and insertion into the BIM model
- Path planning in changing environments by adapting the map
- Adding color to the point cloud using cameras