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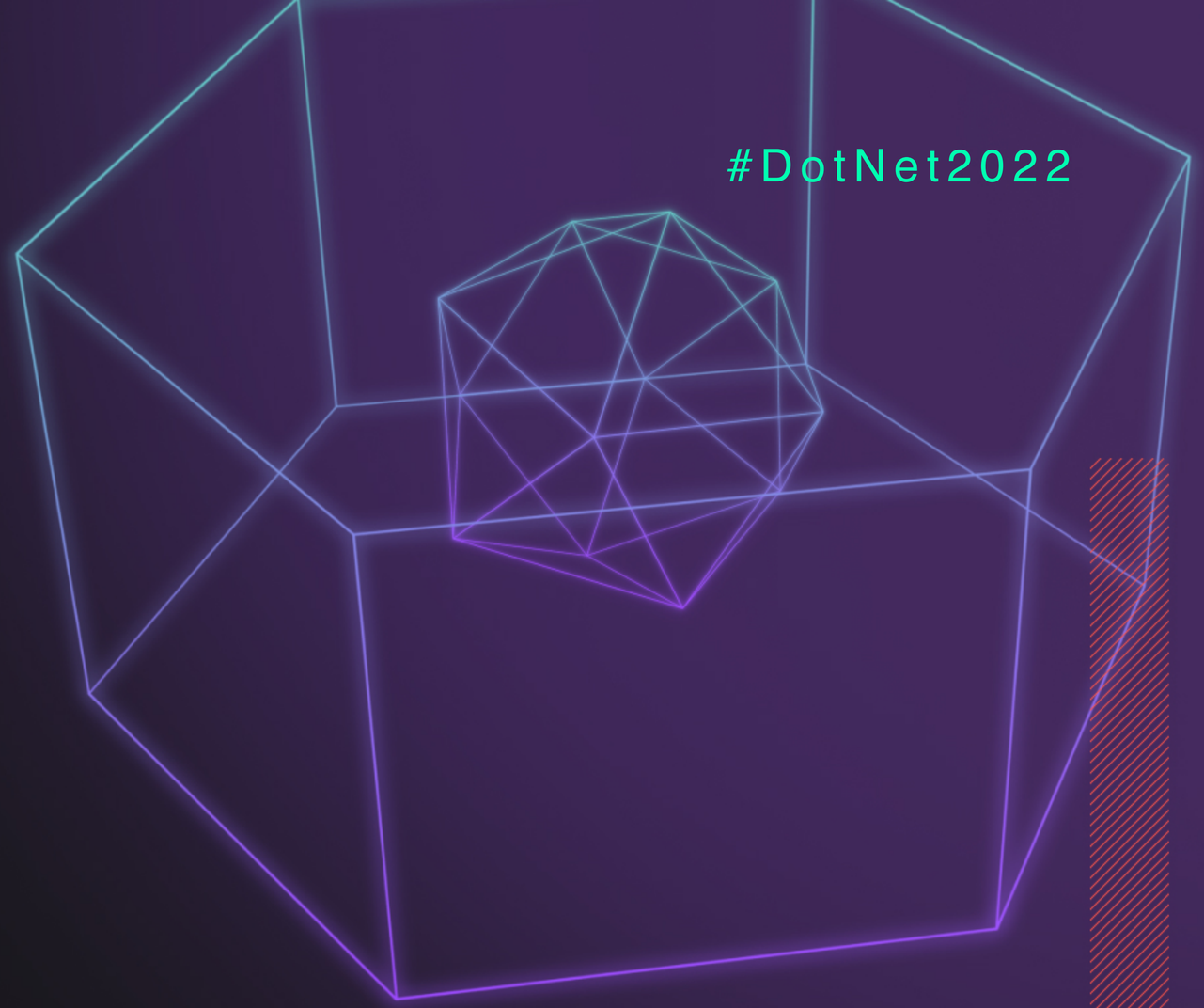
28th June



Enriching 3D point cloud data with Artificial Intelligence

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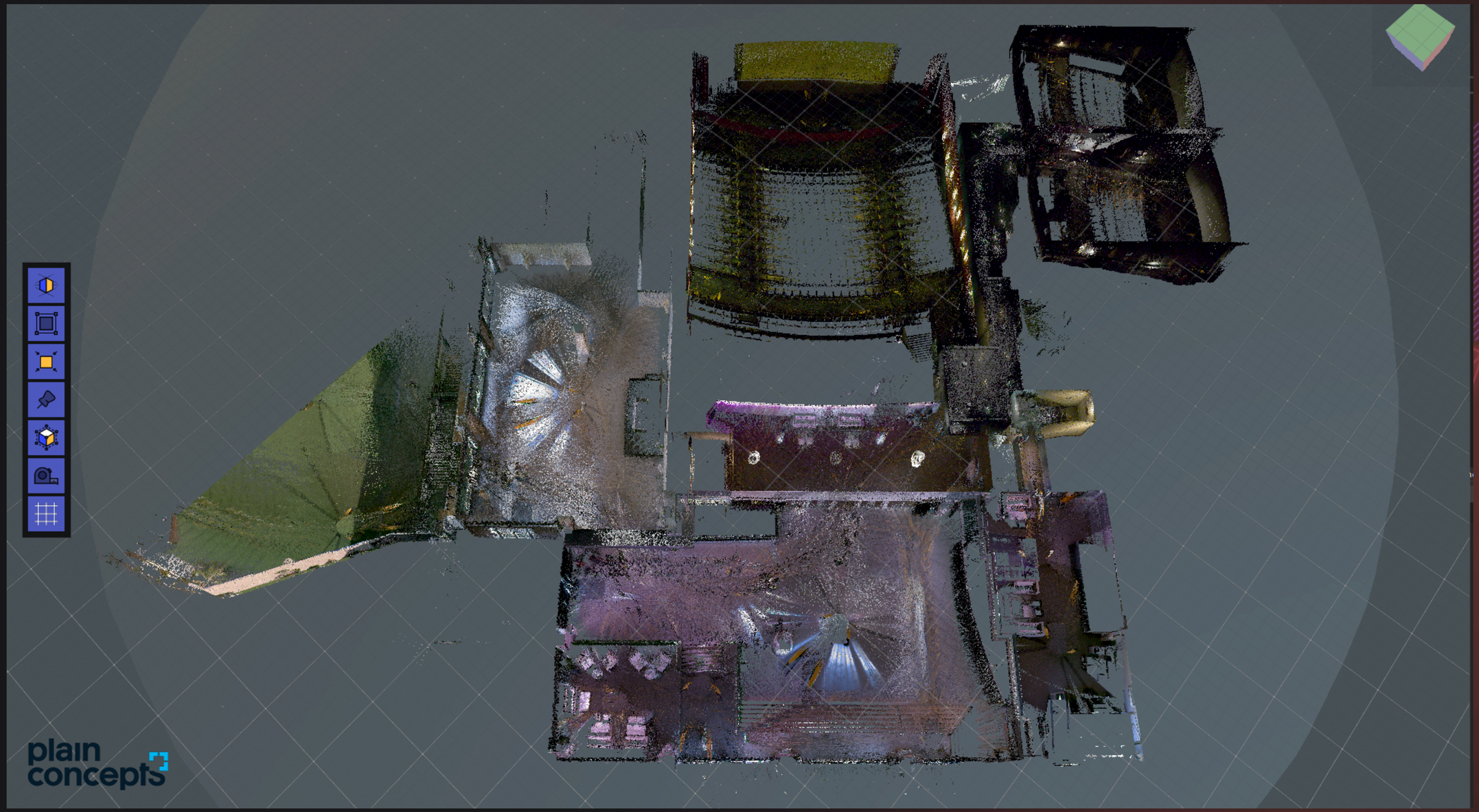
Rodrigo Cabello

Research Engineer

Microsoft Most Valuable Professional

@mrcabellom

mrcabellom@plainconcepts.com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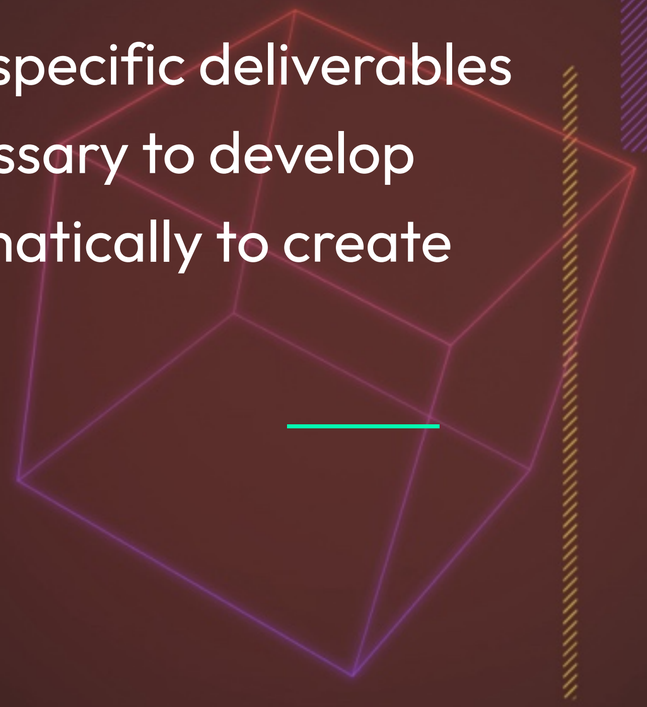
The procedures to convert point clouds into application-specific deliverables are very costly in time/manual intervention. It is necessary to develop processes that extract the essential information automatically to create valuable data for decision-making.



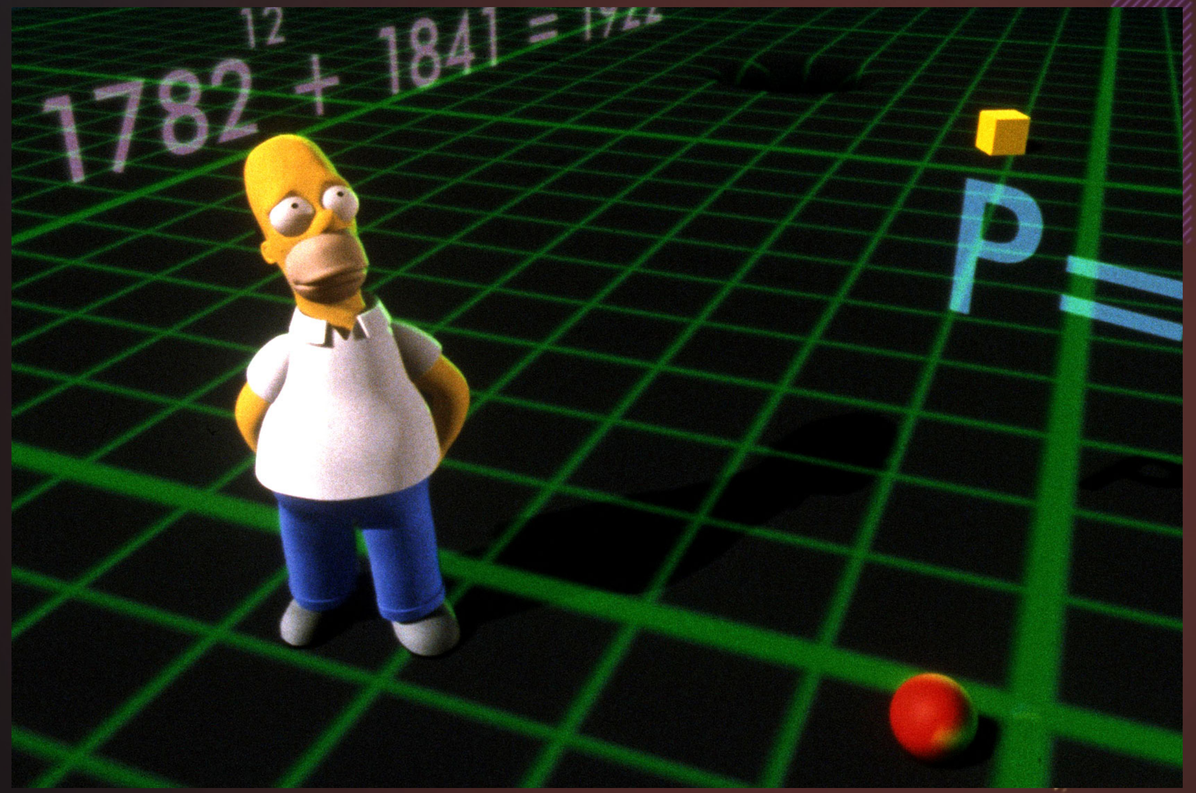
3D representation

- Better understanding of our environment. 3D data can provide more dimensional information.

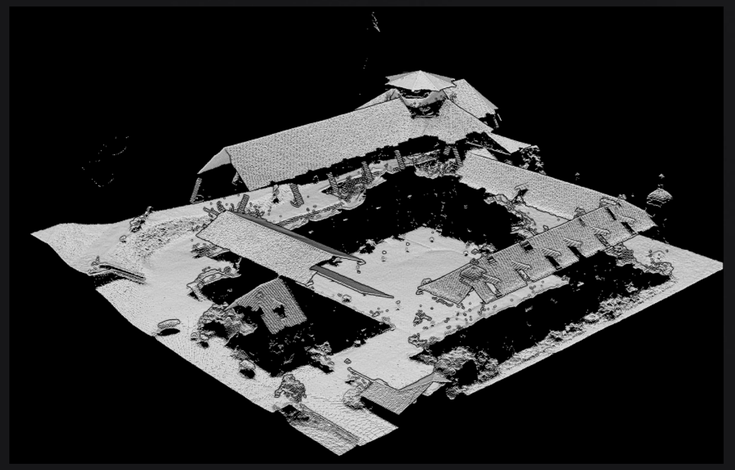
- 3D models can:
  - Represent the features of virtually any object.
  - Represent complex objects with a finite number of elements. (Point Cloud)

- Improve the decision-making process.

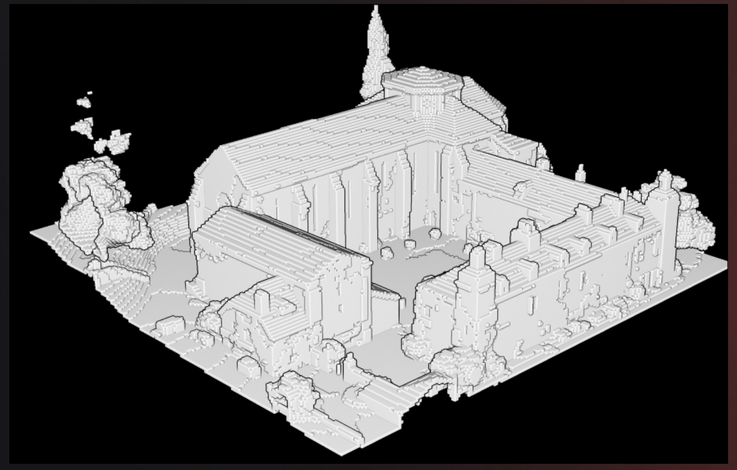
- Design error reduction:
  - industry and building sector.



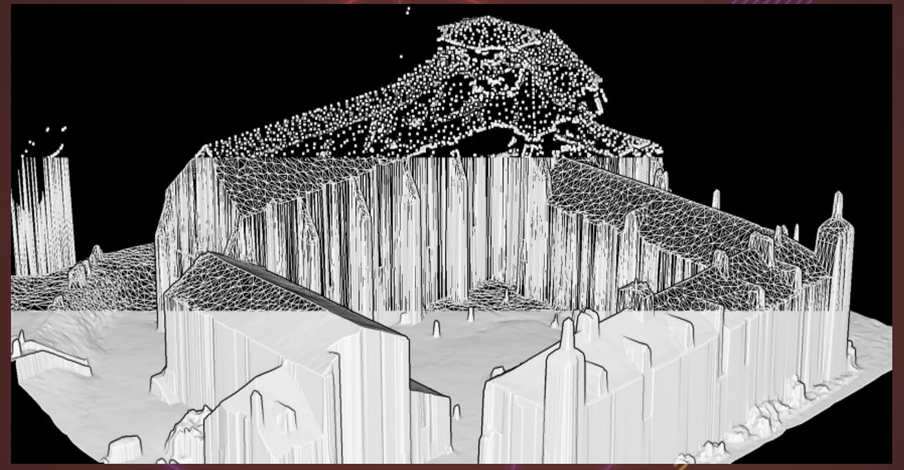
3D data representation



Point Cloud



Voxels



Meshes

3D data representation

RGB-D provides a 2,5D information

3D data representation

Multi-view

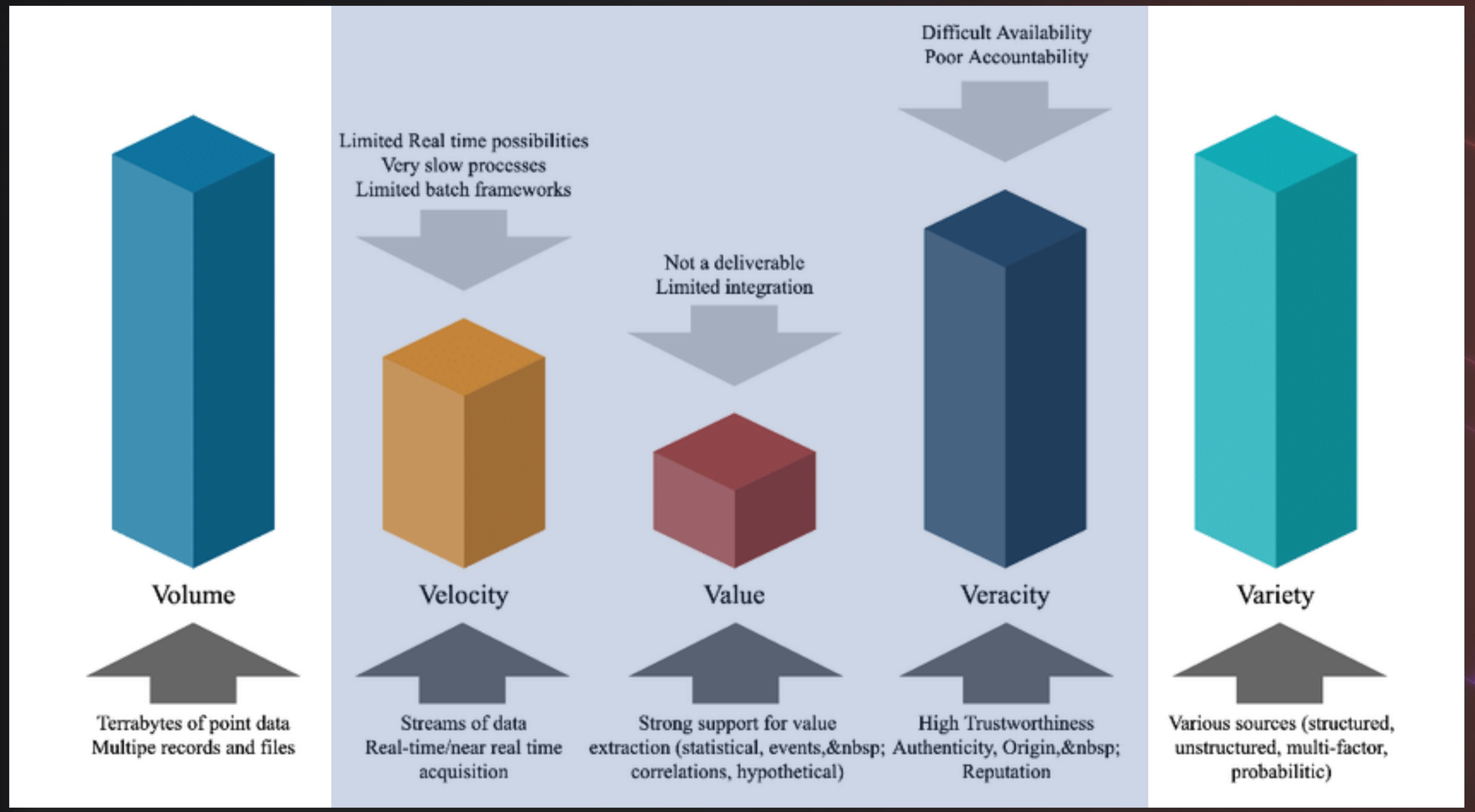
Point cloud

What is a point cloud?

- A point cloud is a set of data points in space.
- Points may represent a 3D shape or object.
- Each point position has its set of Cartesian coordinates (X, Y, Z).
- Points can include attributes like RGB, intensity, and classification.

An example of a 1.2 billion data point cloud render of Beit Ghazaleh,

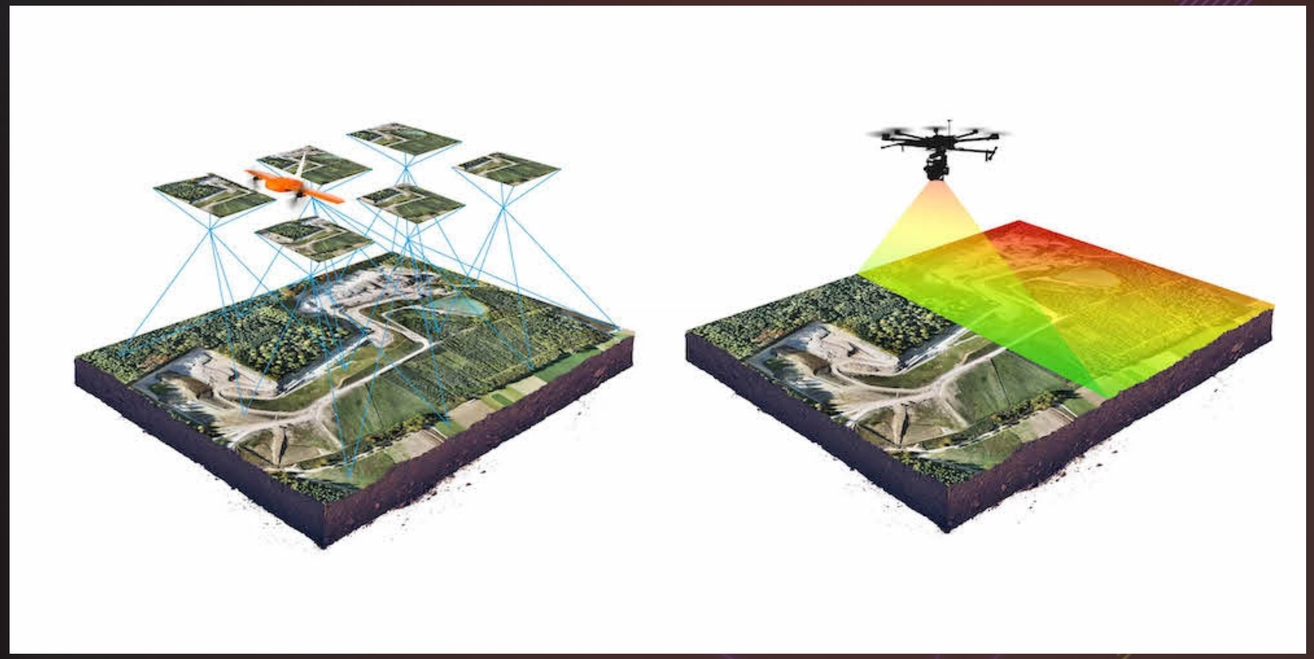
Point cloud Big data



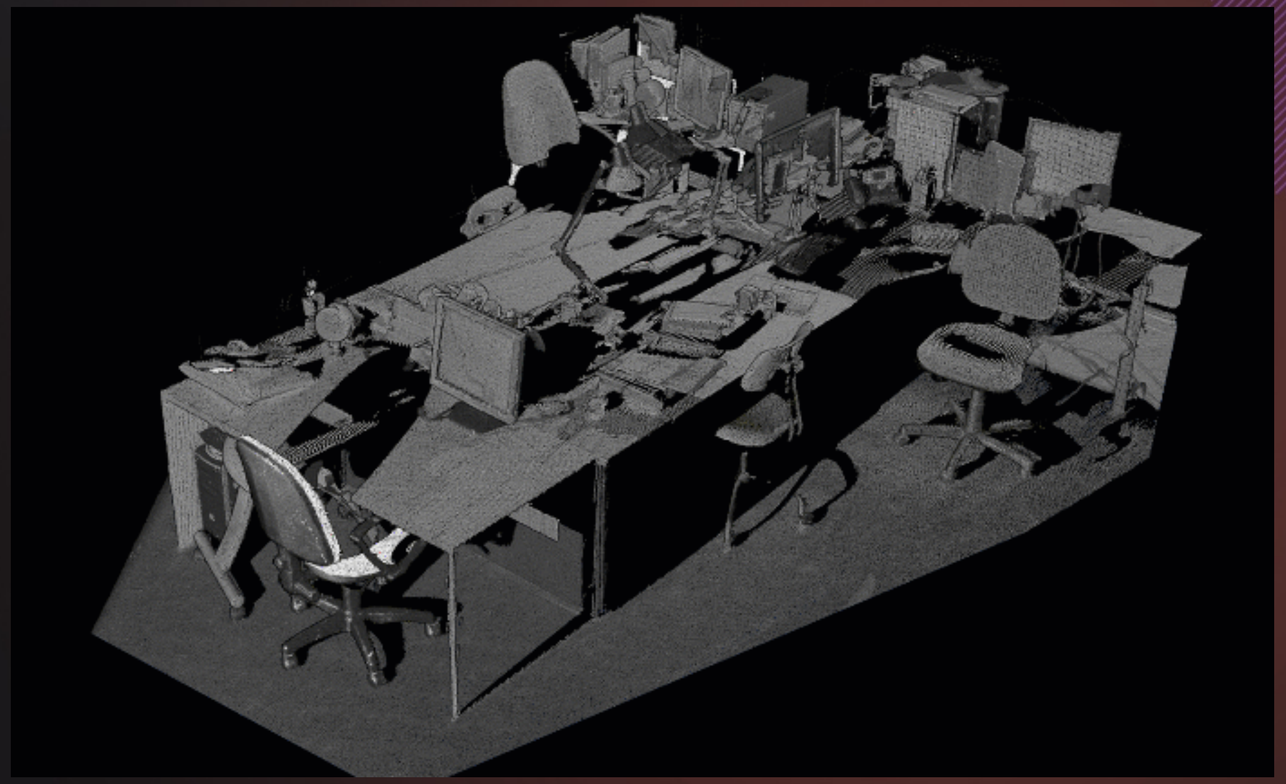
Poux, Florent. (2019). The Smart Point Cloud: Structuring 3D intelligent point data.

Point cloud creation

- Point clouds are generally produced by 3D scanners (LIDAR) or by photogrammetry software.
- LiDar:
  - Uses lasers in order to measure distances from the sensor on the LiDAR device to objects in the environment.
- Photogrammetry:
  - Three-dimensional scale model from a set of photographs taken from different angles.

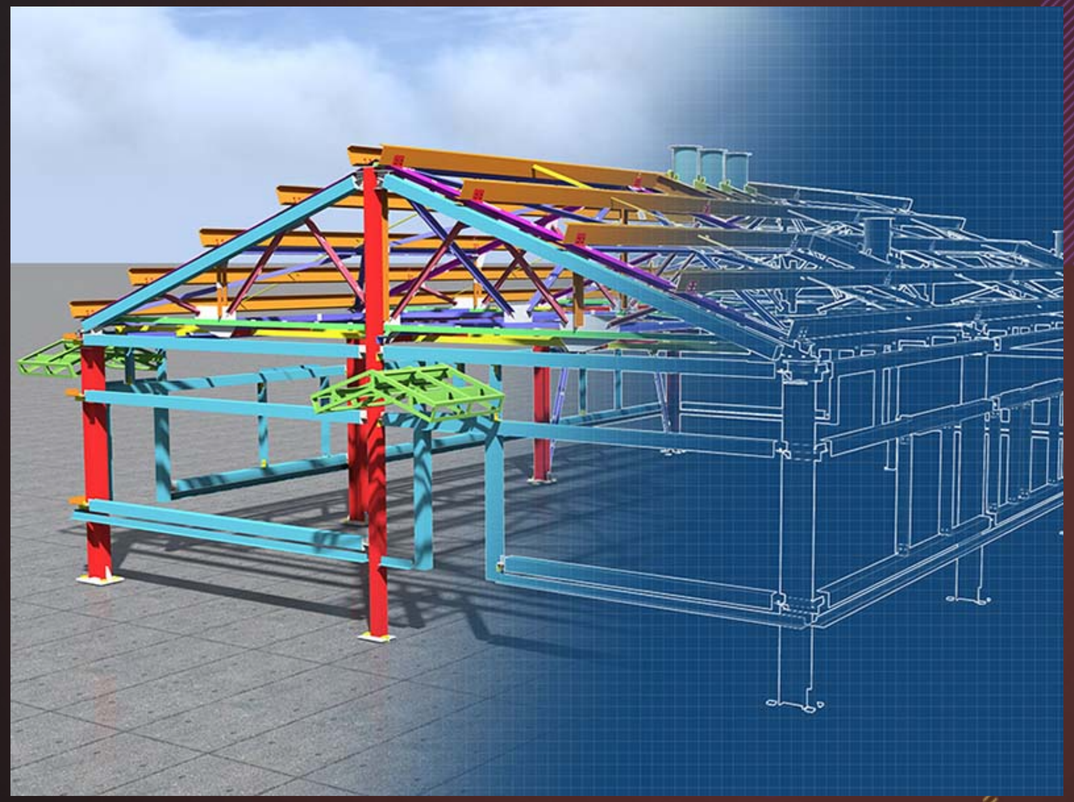


Artificial intelligence in point cloud

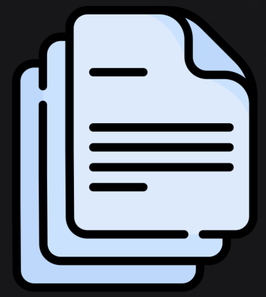


Point cloud + AI

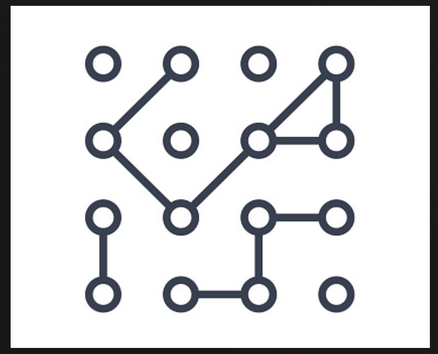
- Automated insights extraction in large point clouds.
- ML-assisted capacity can help reduce human errors by automatically pre-labeling.
- Basic object recognition: Walls, floor, cylinder, pipes.
- Deep learning: Custom object detection and segmentation.



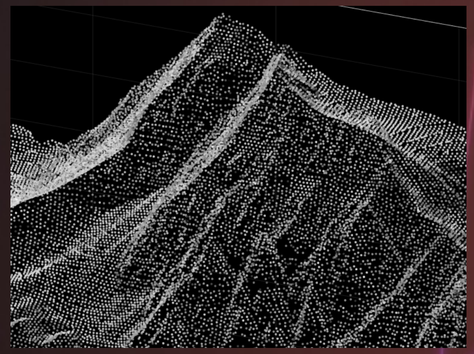
Challenges



Multiple file formats



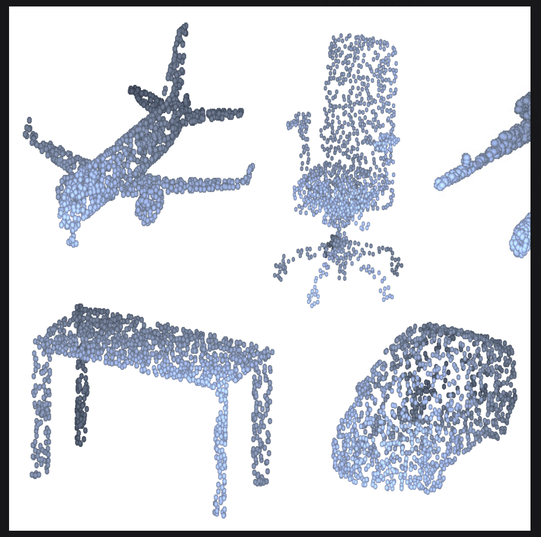
Unstructured data



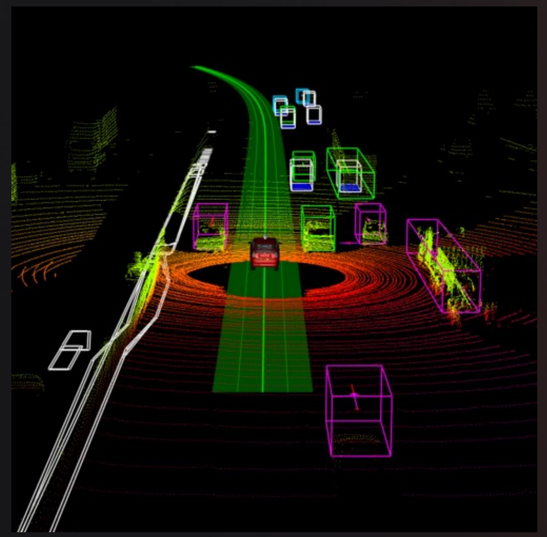
Millions of points

Noisy data
Sensors

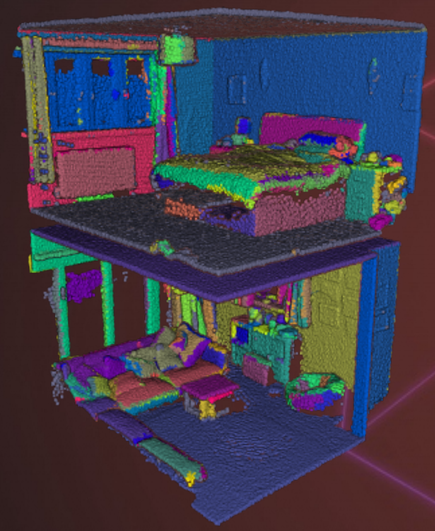
Computer vision tasks



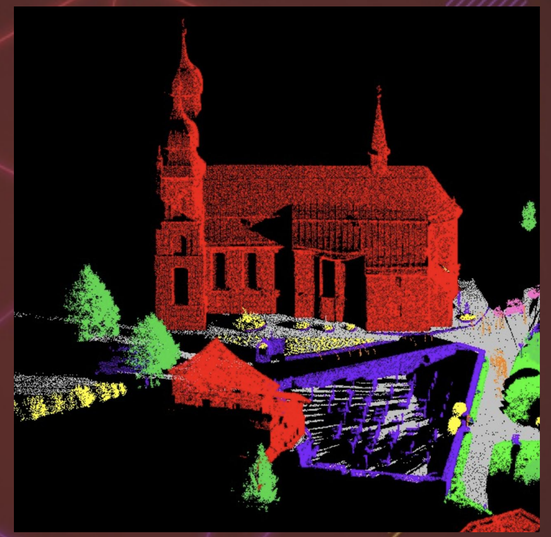
Classification



Object detection and localization

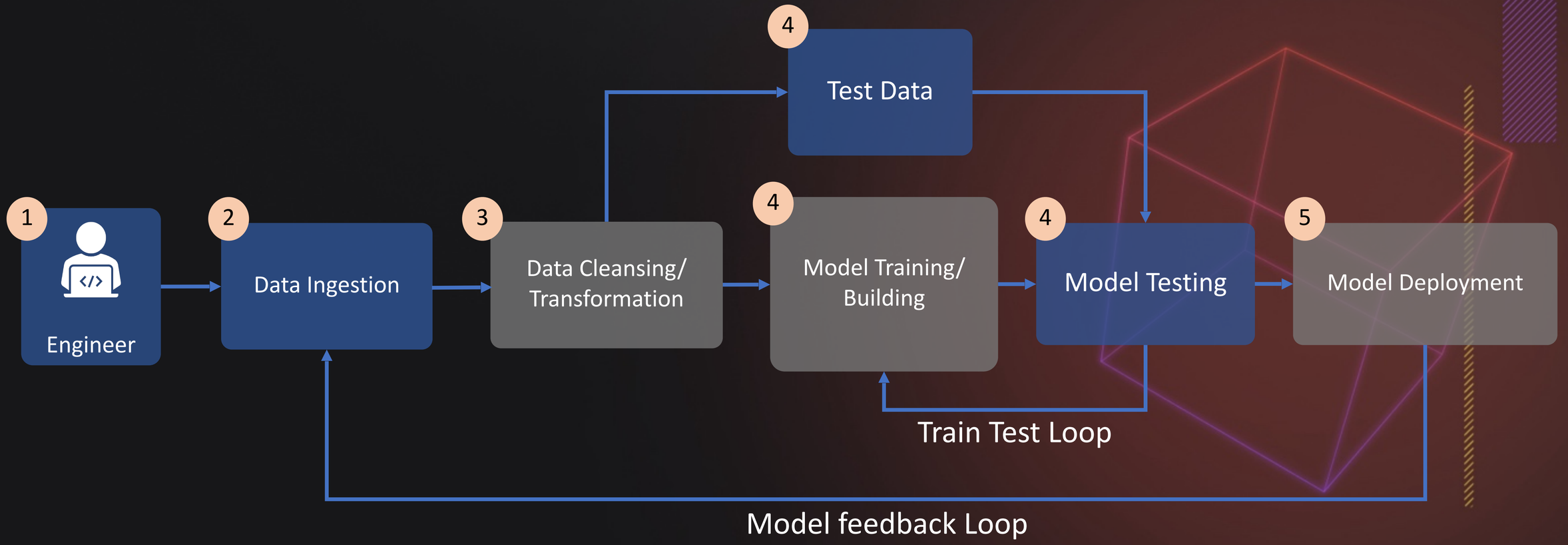


Clustering segmentation

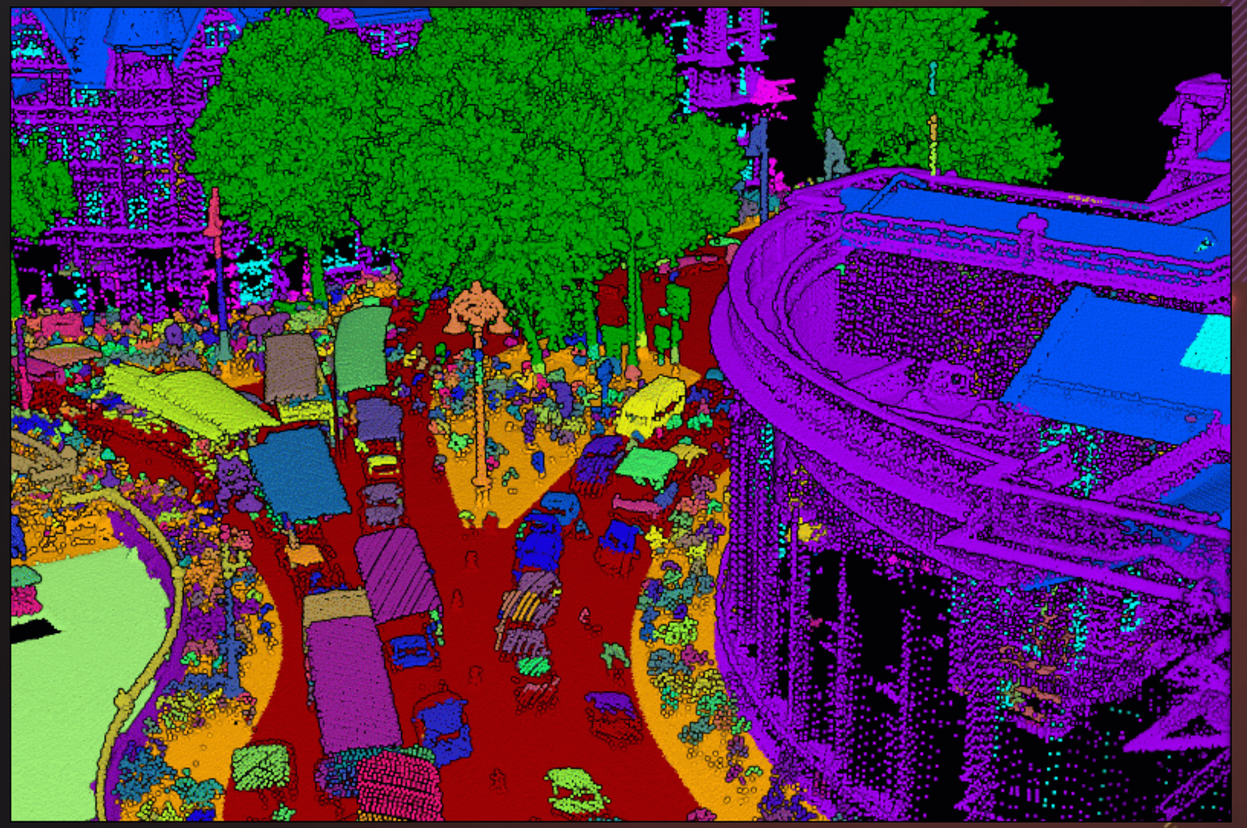


Semantic segmentation

Point cloud AI project



Clustering

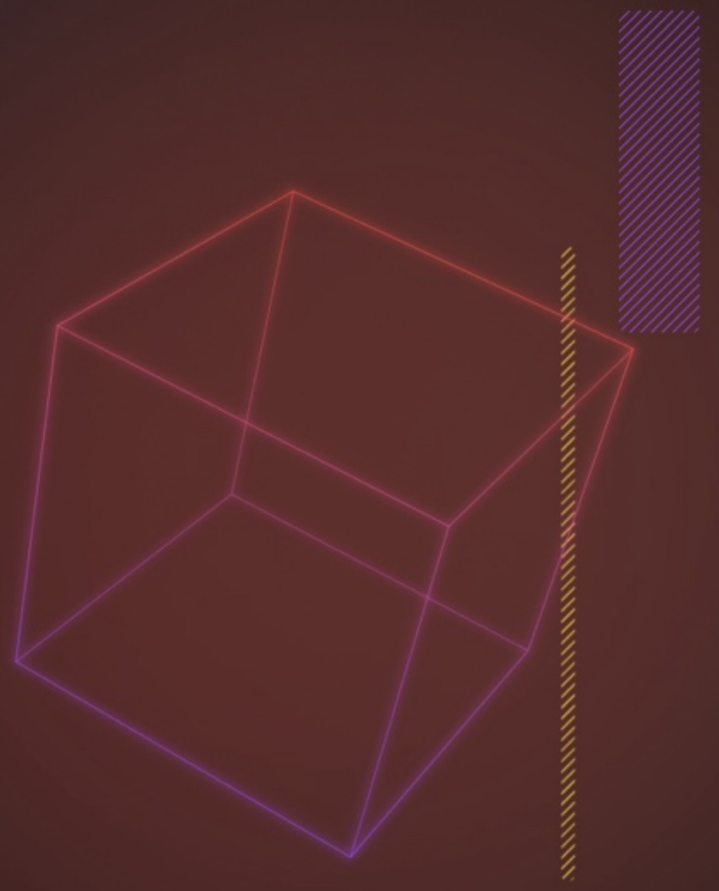


Point cloud. Clustering

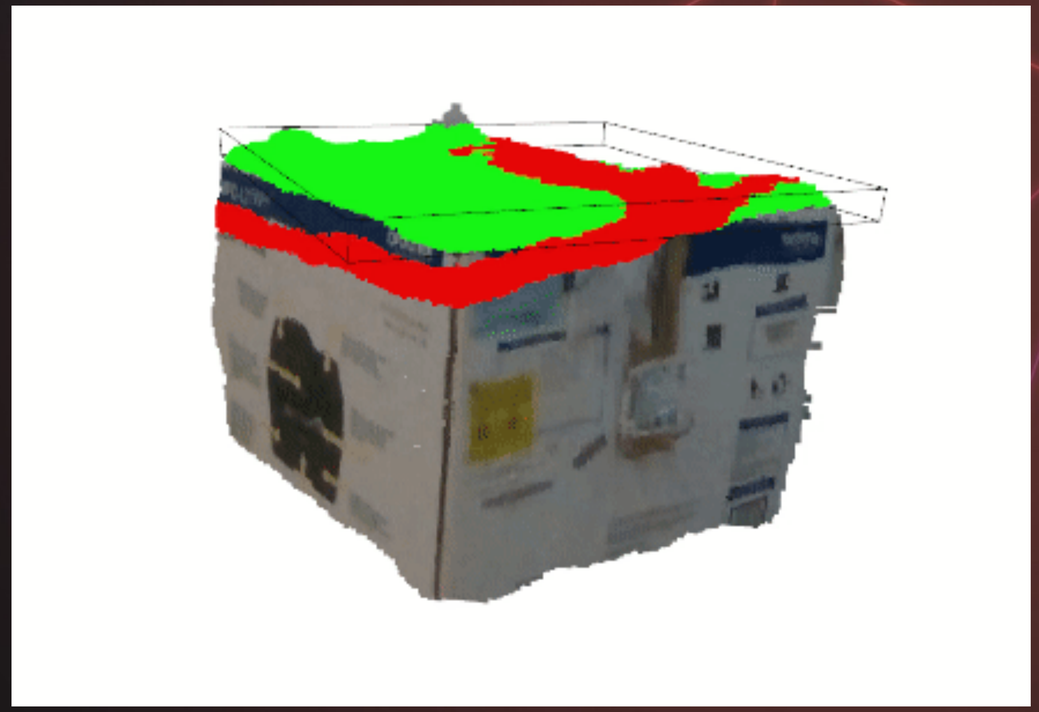
- Unsupervised and self-learning methods are very important for solving automation challenges.
- Helping to annotate a large point cloud.
    - Better data understanding
    - Data visualization.
    - Infer data properties.
- Several clustering algorithms (K-means, DBSCAN…)
    - The number of clusters
    - The stability of the algorithm
    - The compatibility of the results with domain-specific knowledge.

Poux, Florent.

Demo: K-means

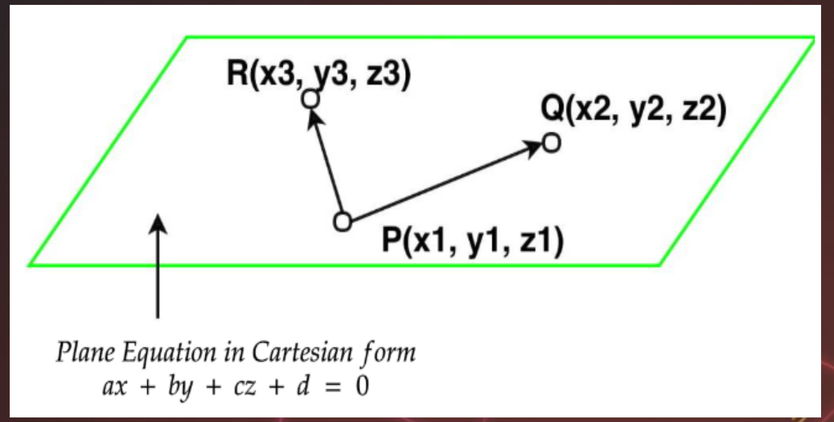


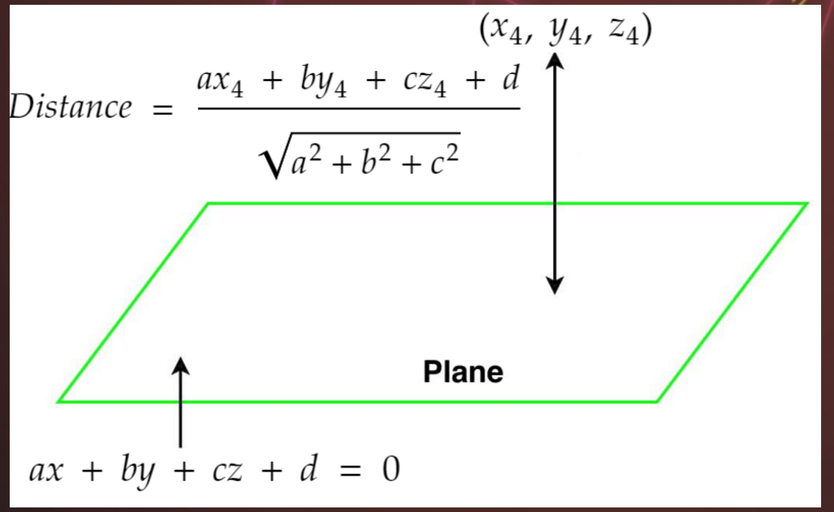
Segmentation



Segmentation - RANSAC

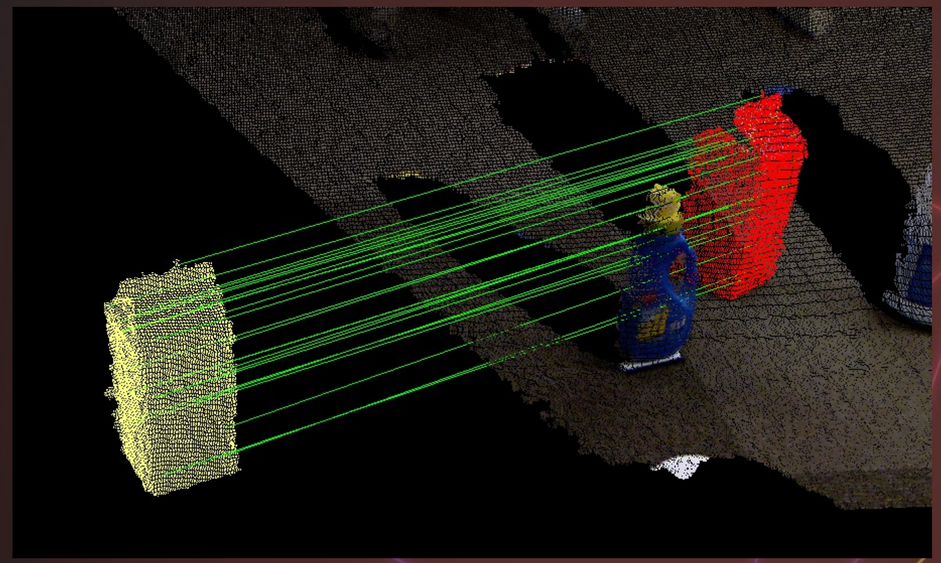
- Goal: The process of dividing an image into different regions based on the characteristics of points.
- RANSAC stands for RANdom Sampling and Consensus.
- It's a robust model-fitting algorithm.
- It can be used for detecting basic primitives such as planes or cylinders.
- RANSAC has a good performance detecting outliers.



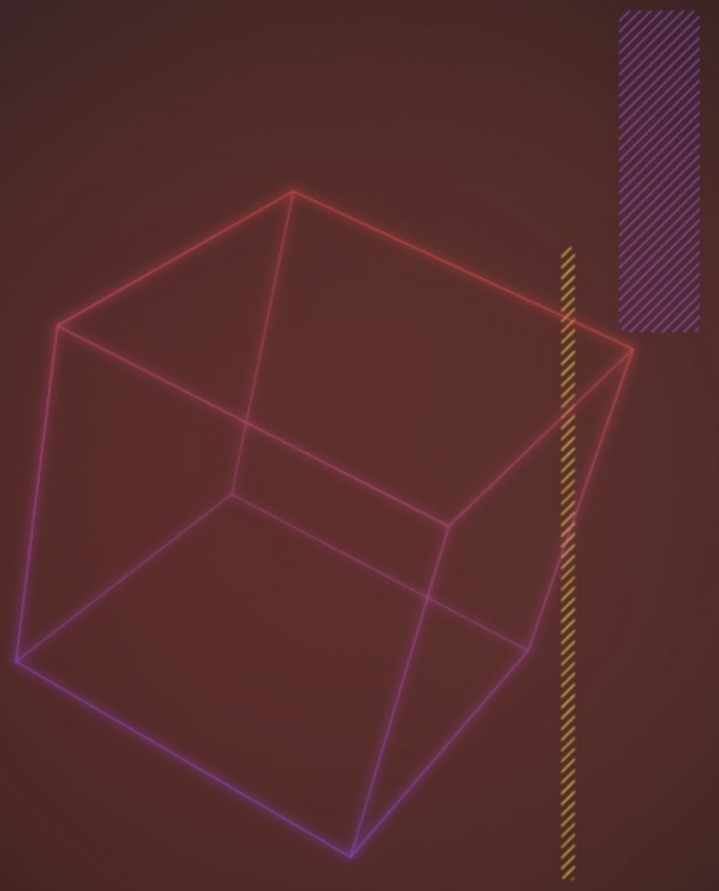


Segmentation – Correspondence Grouping

- Goal: search similar objects in the point cloud.
- Cluster a set of point-to-point correspondences obtained after the 3D descriptor.
- Detect model instances that are represented in the point cloud.
- For each cluster, the algorithm gets the transformation matrix (rotation + translation) of that model in the point cloud.



Demo: Segmentation



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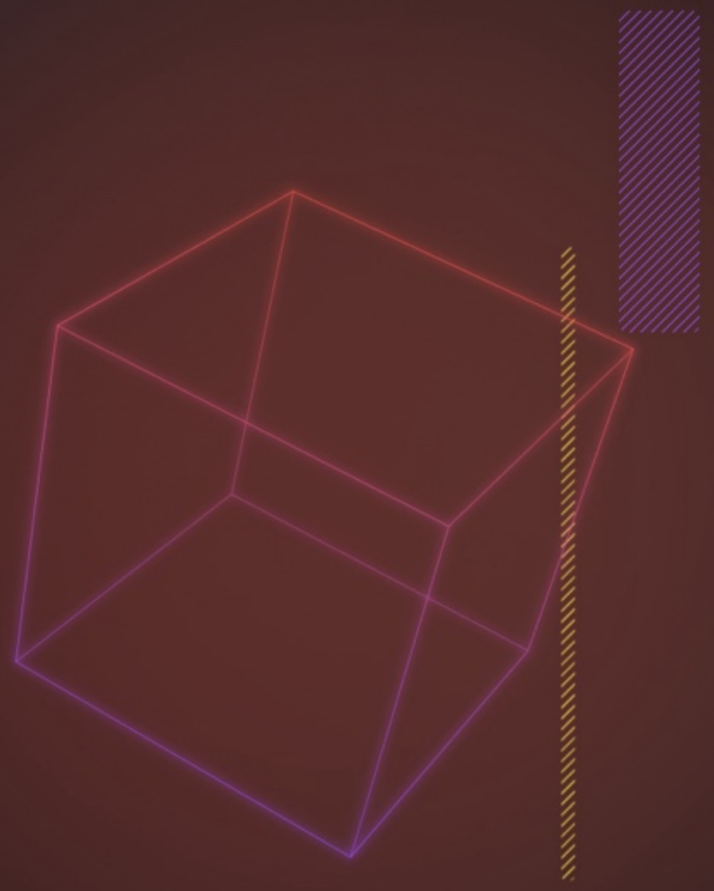
Object classification
Deep Learning

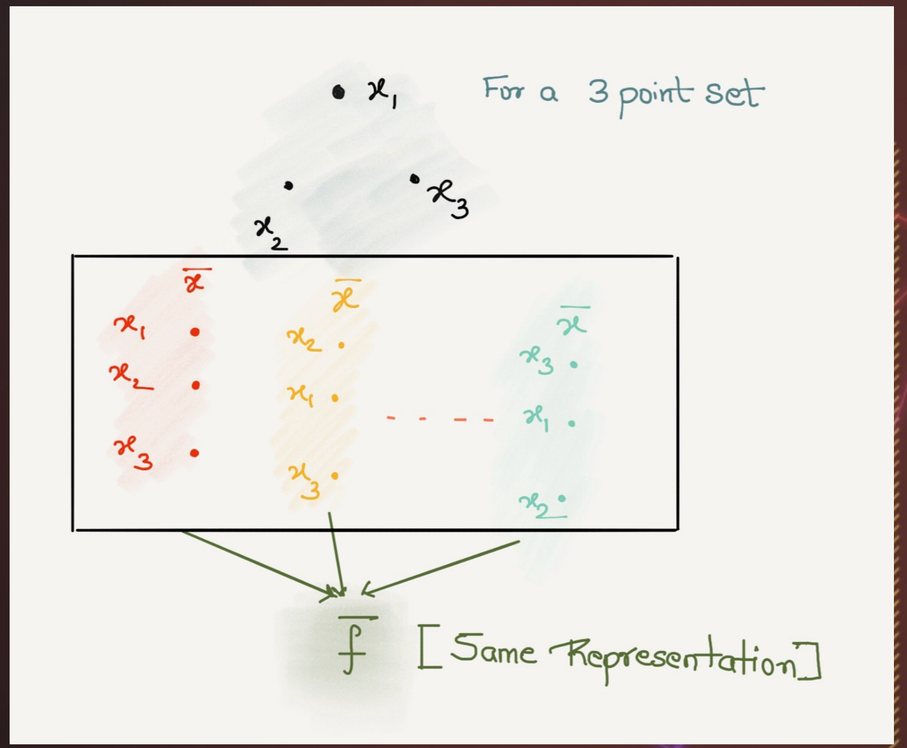


Object classification - Deep Learning

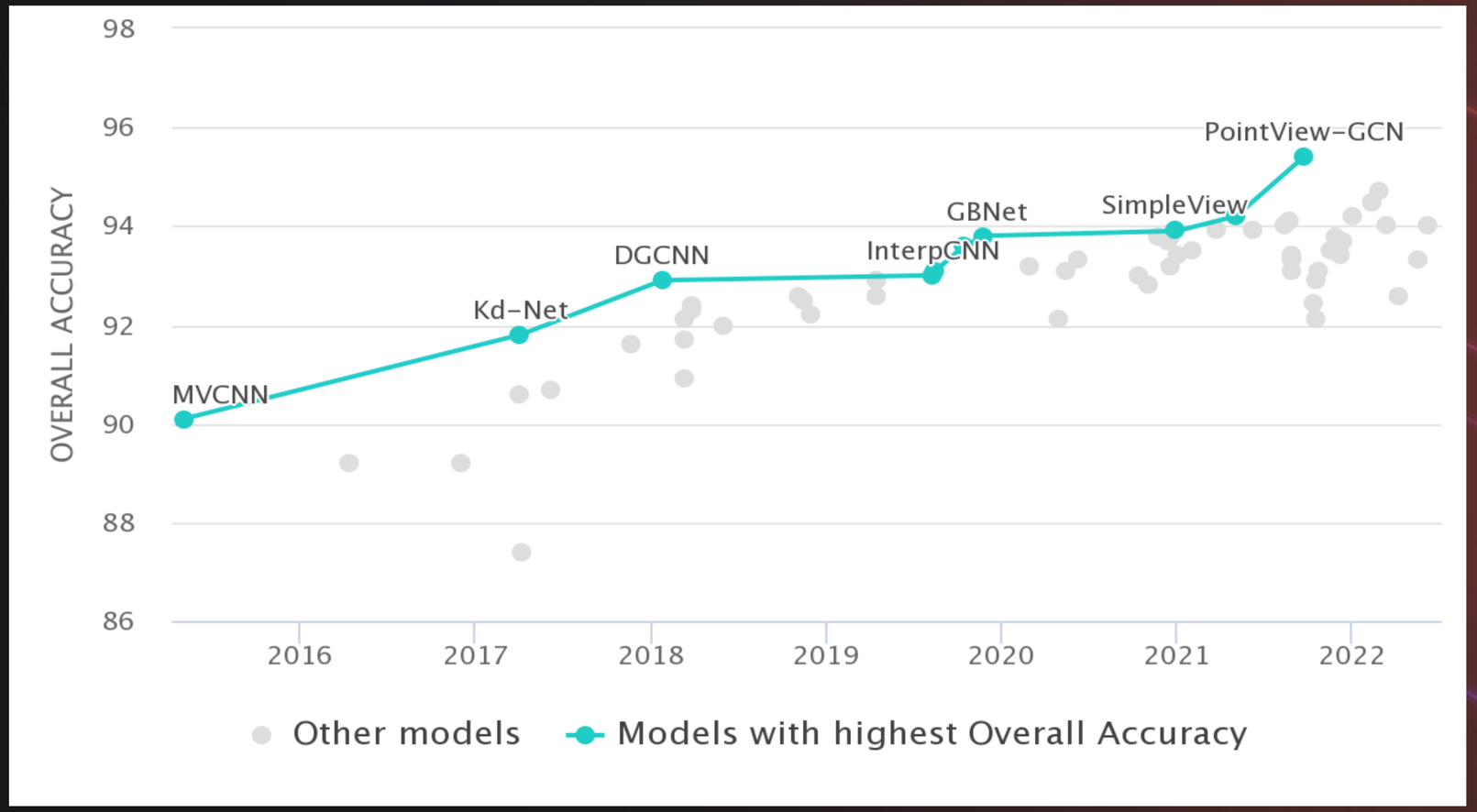
- Deep learning architectures are capable of reasoning and can learn features about 3D geometric data.

- Unordered point cloud
  - Data transformation to 3D voxel grid projections.
  - Translation, rotation, and permutation invariance.
  - Sort input into canonical order.

- Large point clouds. Memory consumption.
  - Slices, segmentation

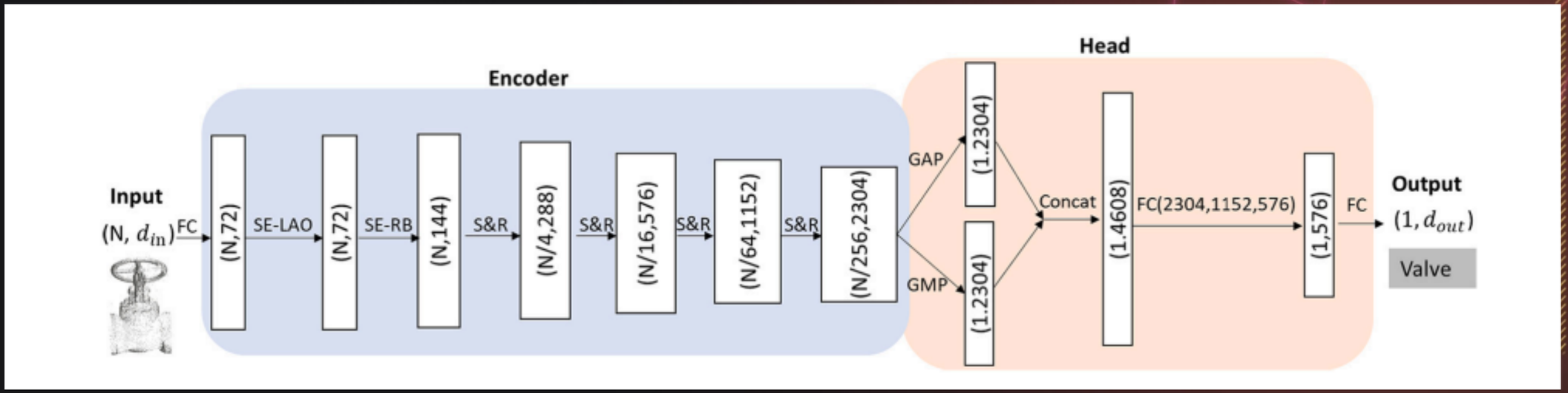


Object classification - Deep Learning



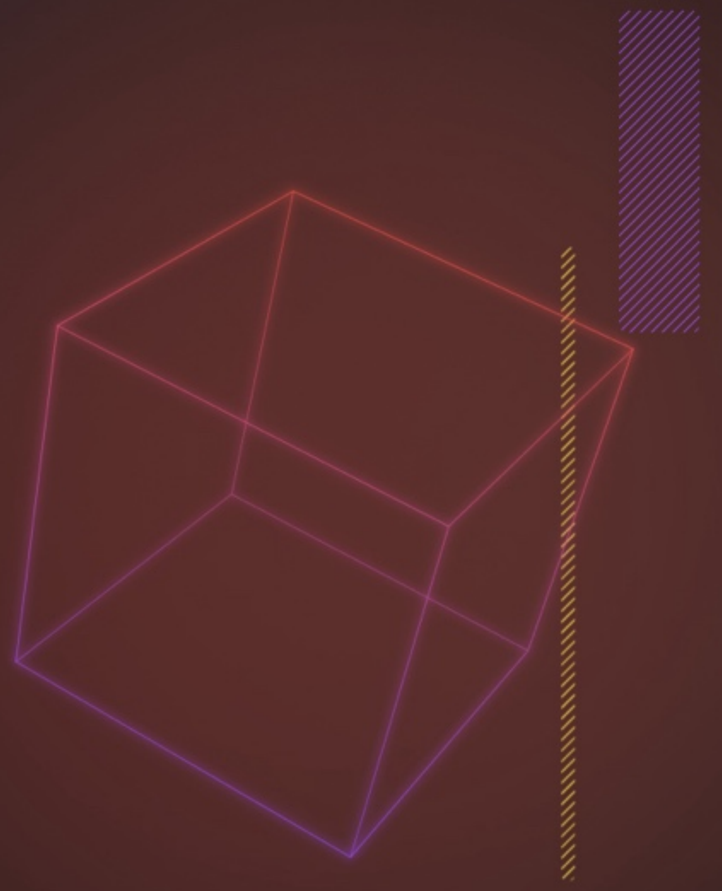
Object classification - Deep Learning

- SE-PseudoGrid object classification for Piping systems.
- Main features:
  - Inputs: 3D point cloud.
  - Squeeze-and-Excitation blocks.



Yin, Chao & Cheng, Jack & Wang, Boyu & Gan, Vincent. (2022). Automated classification of piping components from 3D LiDAR point clouds using SE-PseudoGrid. Automation in Construction

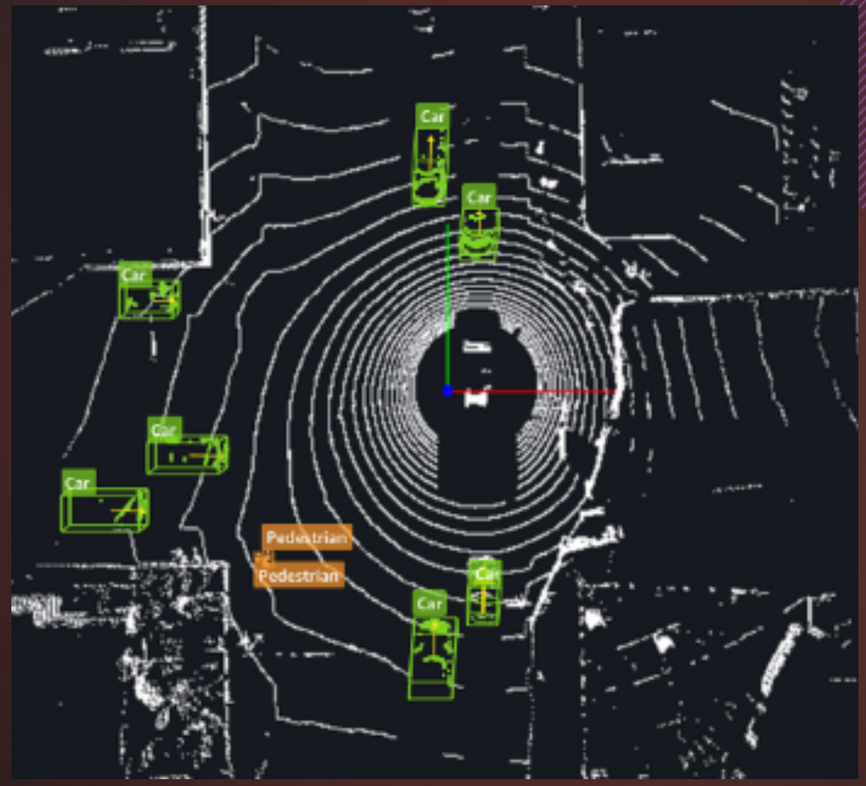
Demo: Pipe classification



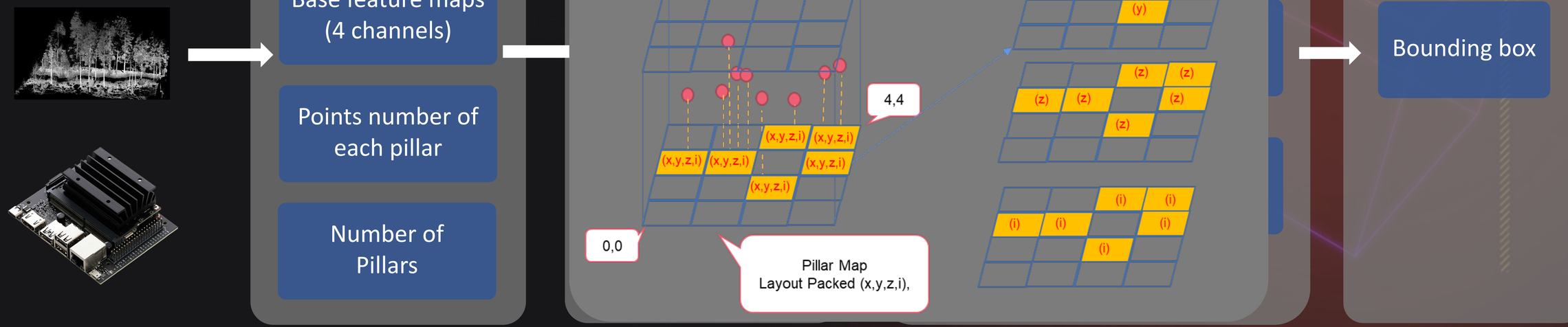
Object localization – Real time

- 3-D real-time Object detection is a key capability for autonomous driving.
- Point clouds mostly come from lidars used in some IoT modules.
- Applications:
  - Autonomous machines.
  - Perception modules.
  - 3D modeling.

- Leverage long-range and high-precision data sets to achieve 3D object detection for perception, mapping, and localization algorithms.



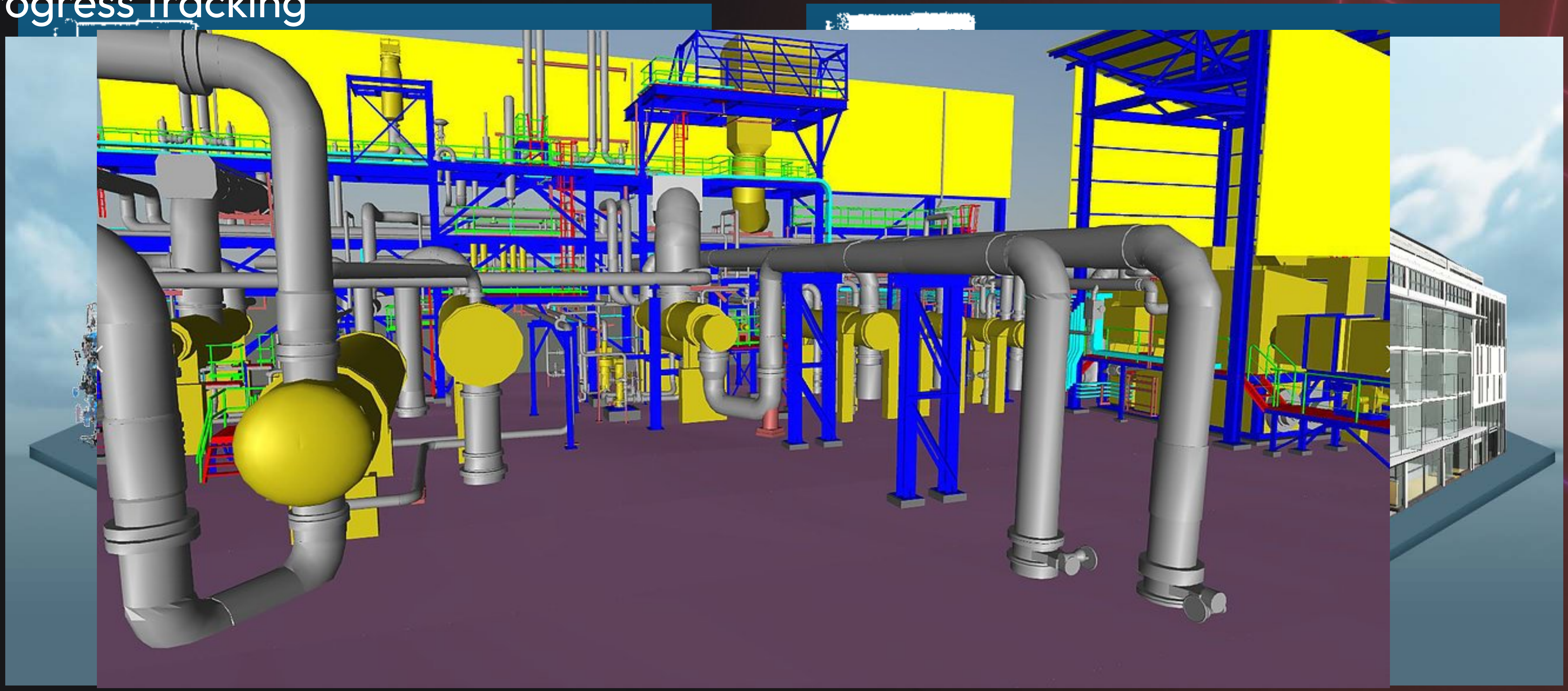
Cuda-Point Pillars



Demo: Point-Pillars Nvidia Jetson nano

What is next?

- Building information modeling
  - Compare the design models of the building against the 'as-designed' to check for errors, conflicts, and clashes.
- Construction progress tracking



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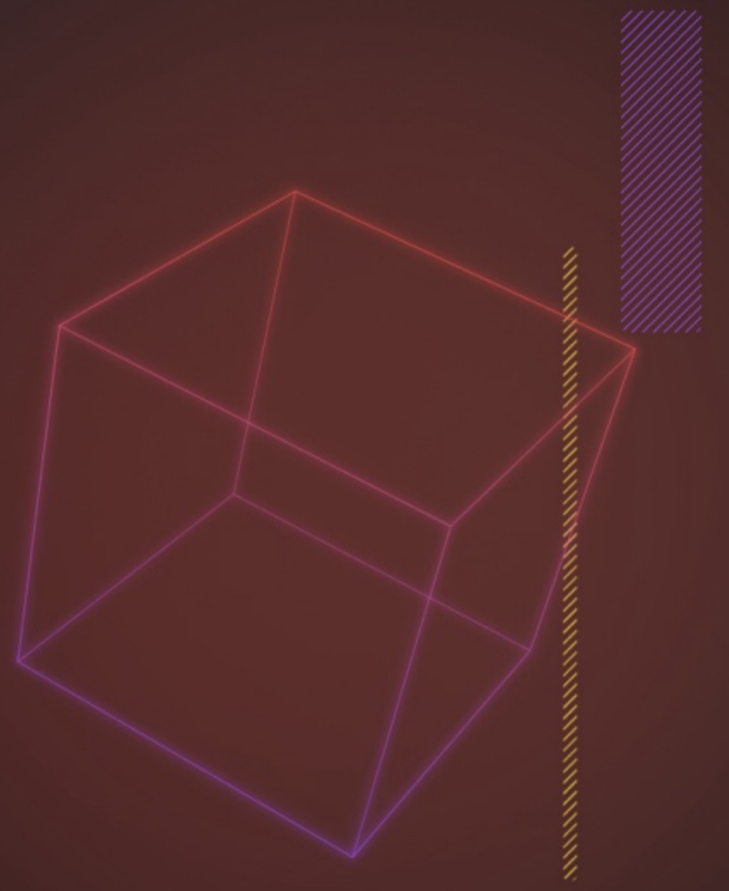
Questions & Answers



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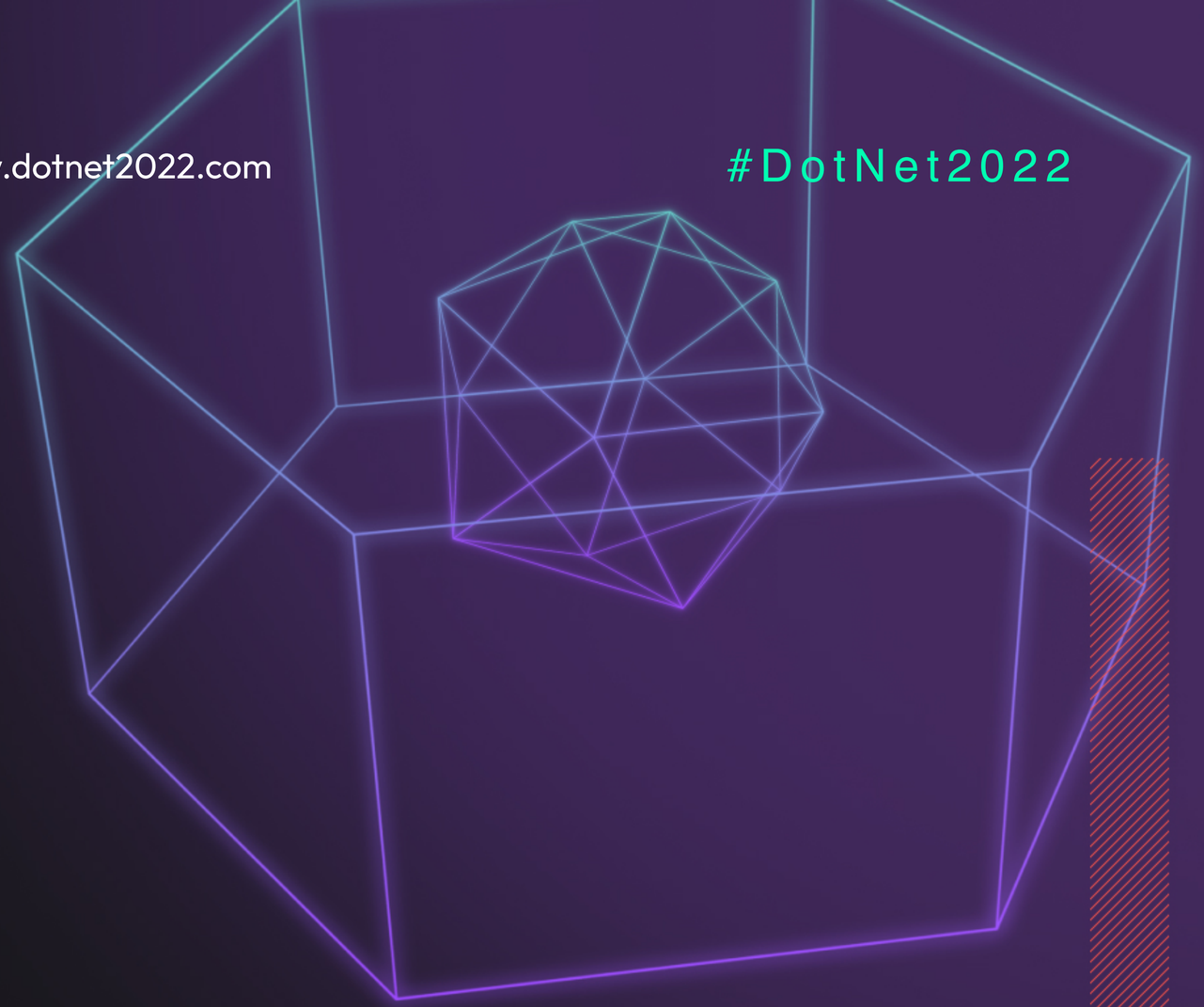

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