Visibility analysis with the 3D skeleton of a point cloud

OGC point cloud DWG meeting
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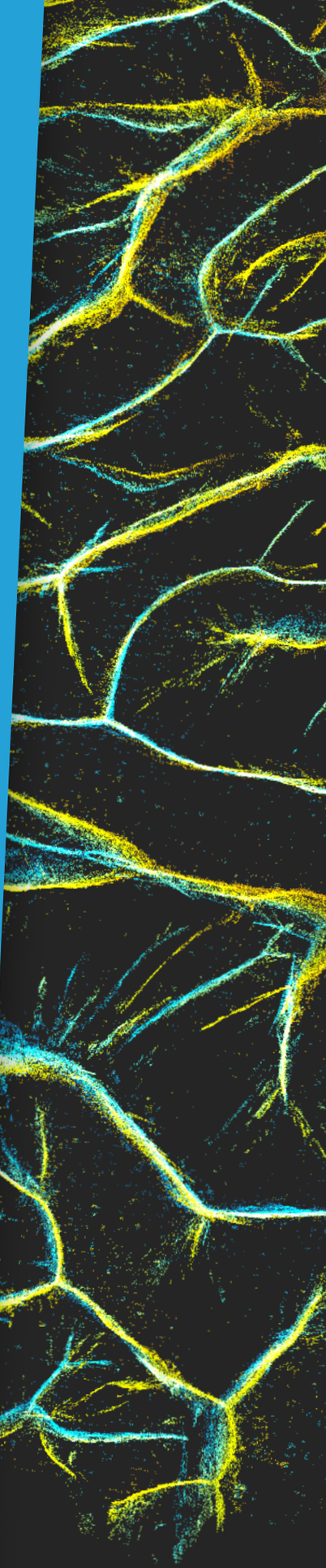
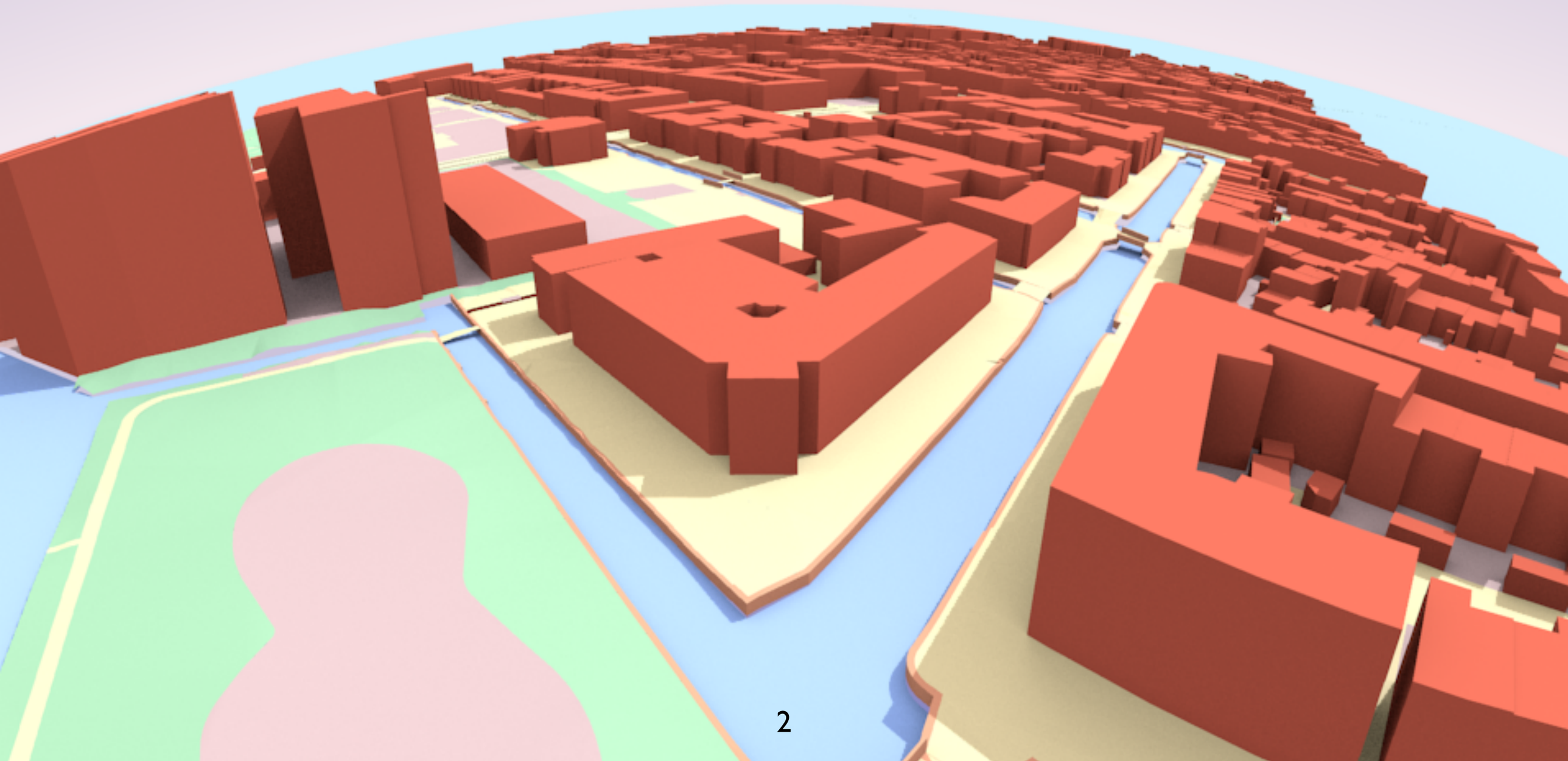


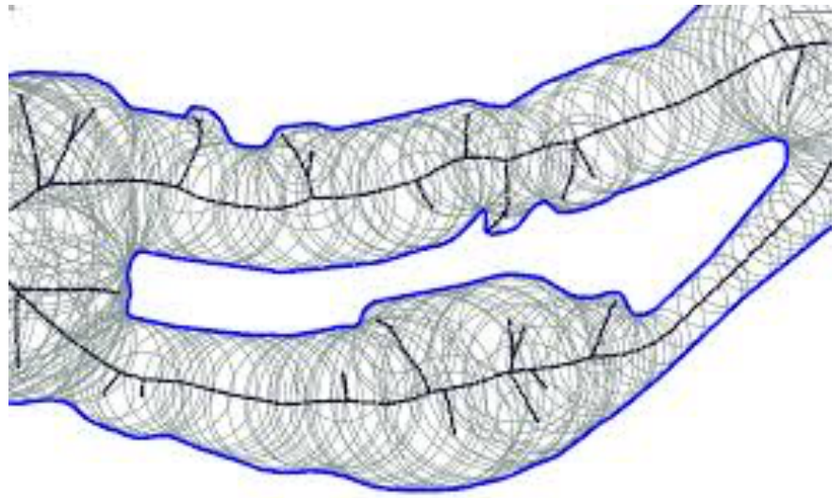
3D city model



Point cloud

Medial Axis Transform

MAT

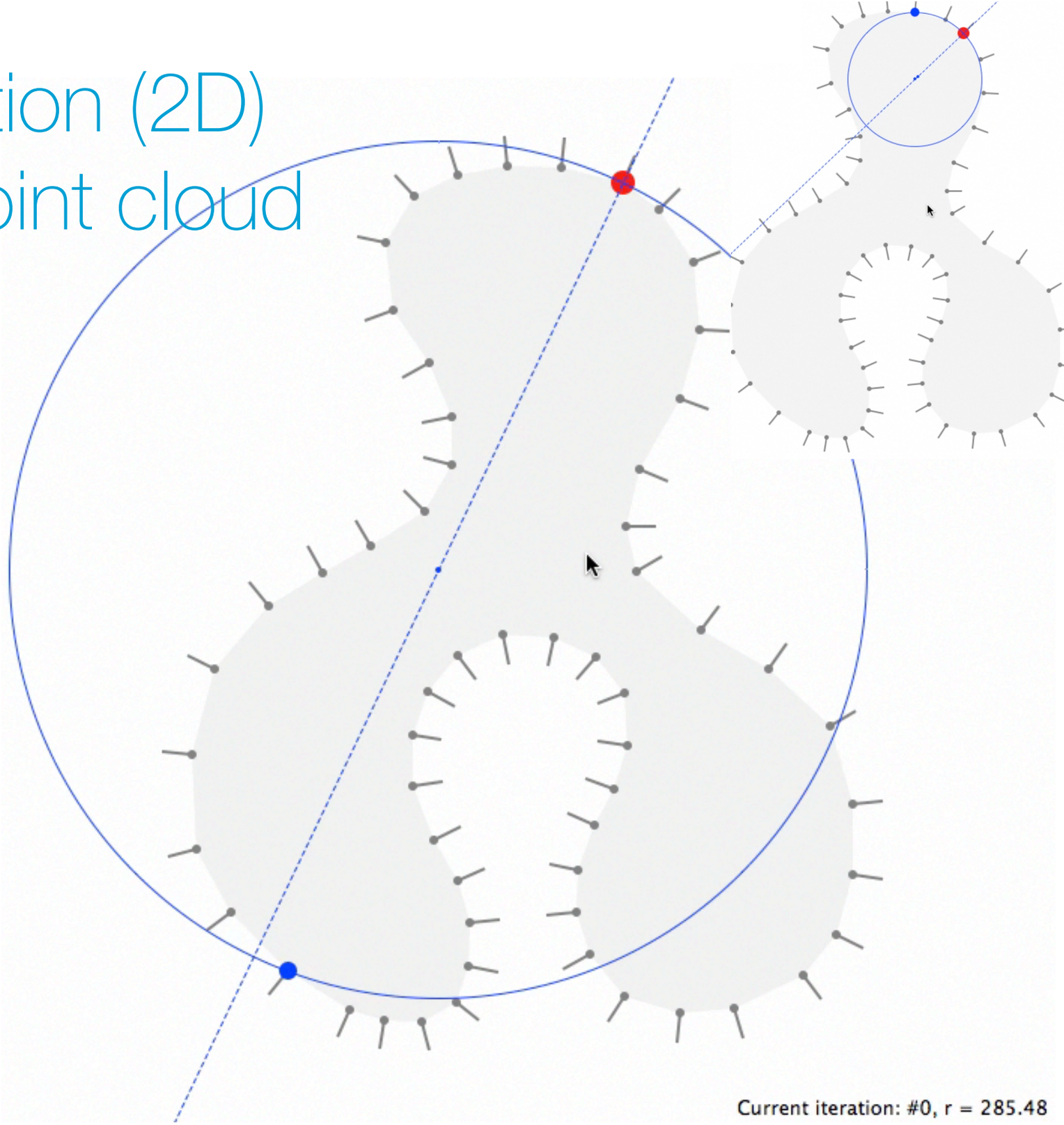


- skeleton-like shape-descriptor
- models object as union of balls:
  - maximal balls tangent to the surface of an object at 2 or more points
- centers of these balls form skeleton structure
- fully equivalent representation to original shape

MAT approximation (2D) from oriented point cloud

Shrinking ball algorithm

(Ma et al., 2012)



For each point, medial ball is found by iteratively shrinking very large ball centered along normal

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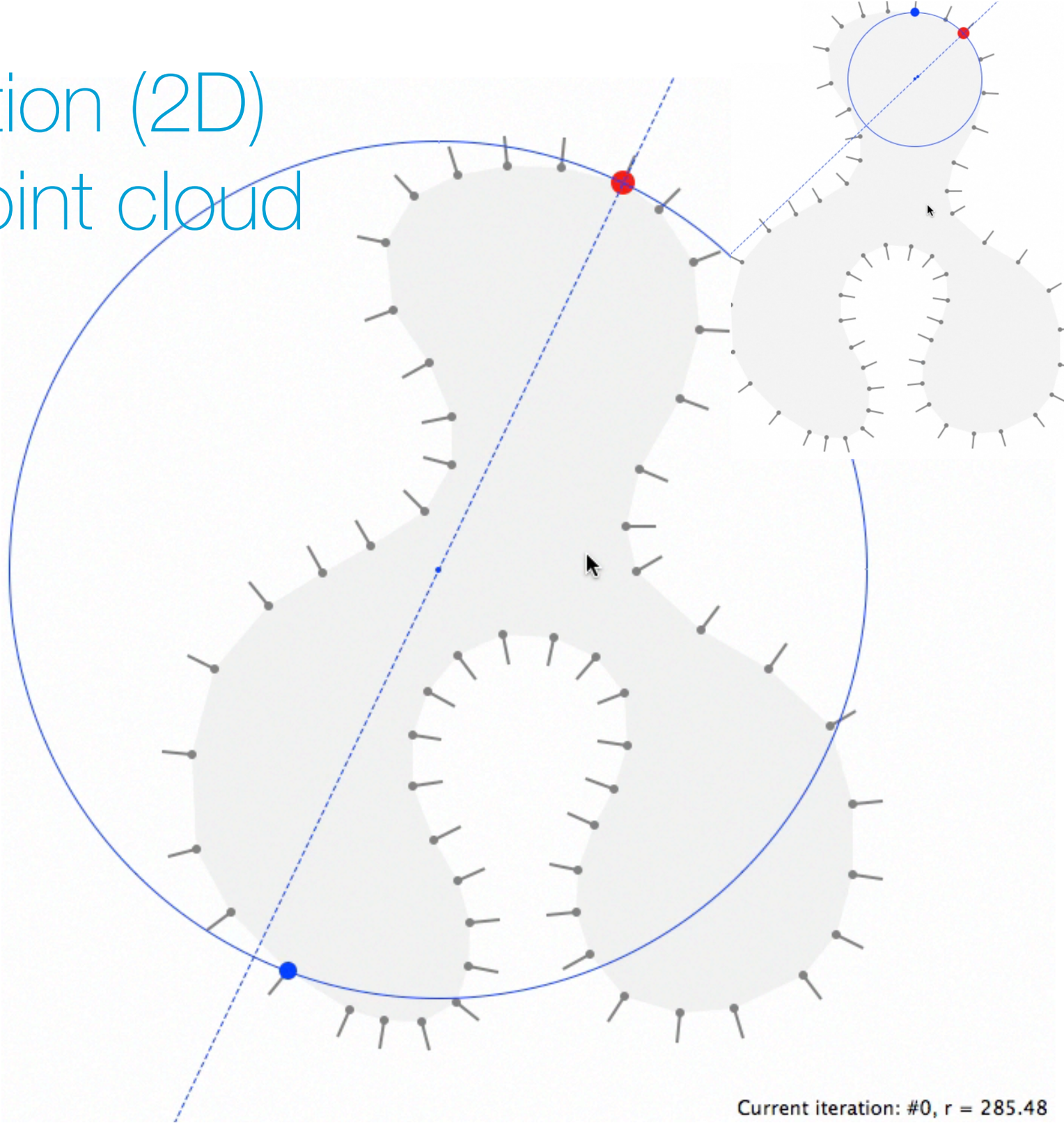

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Hypotheses

Medial Axis Transform (MAT) of LiDAR point cloud:

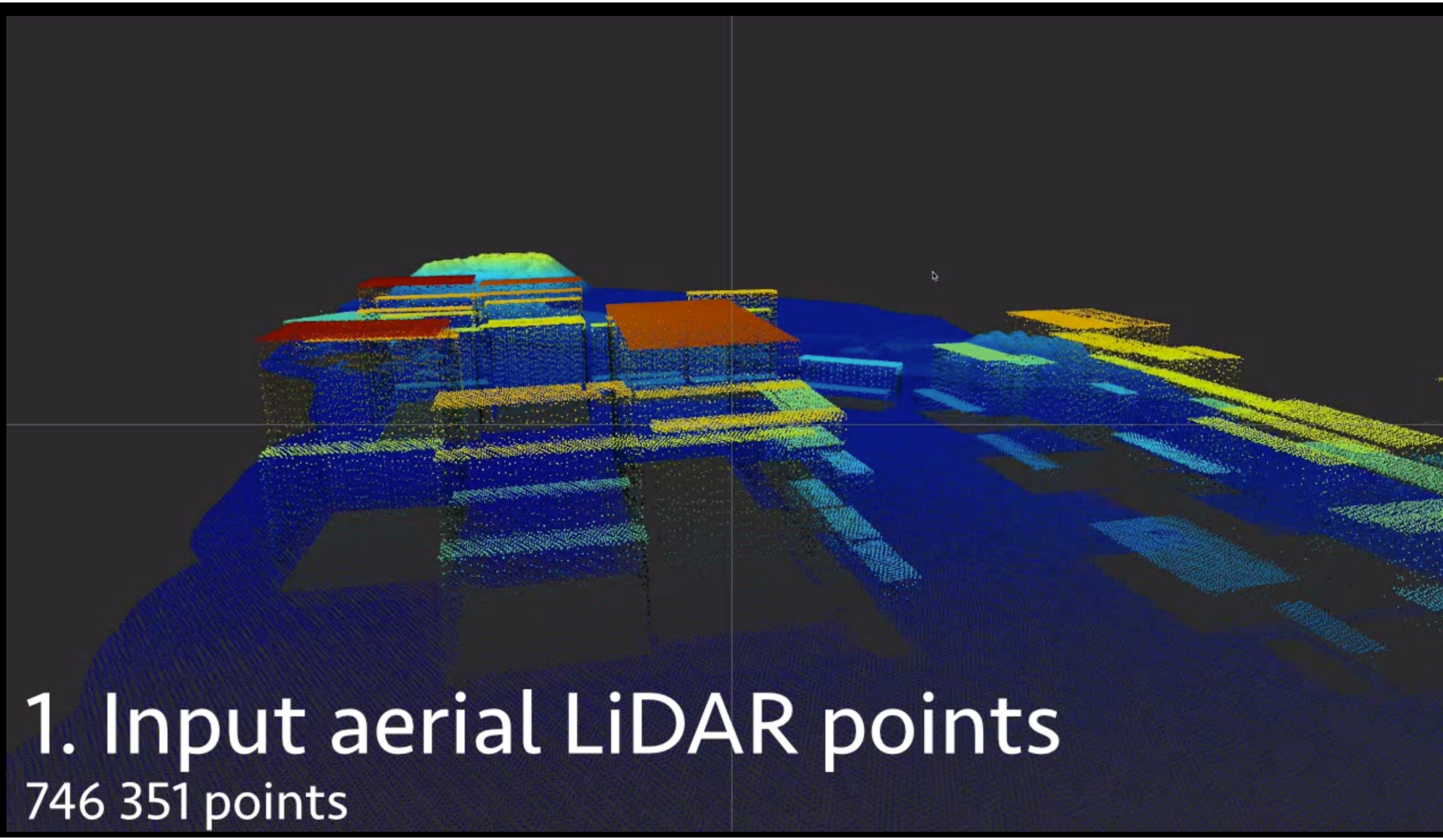
1. *enables truly **3D** analysis*
2. *can be used to effectively **define features** in point clouds using its **geometry** and **topology***

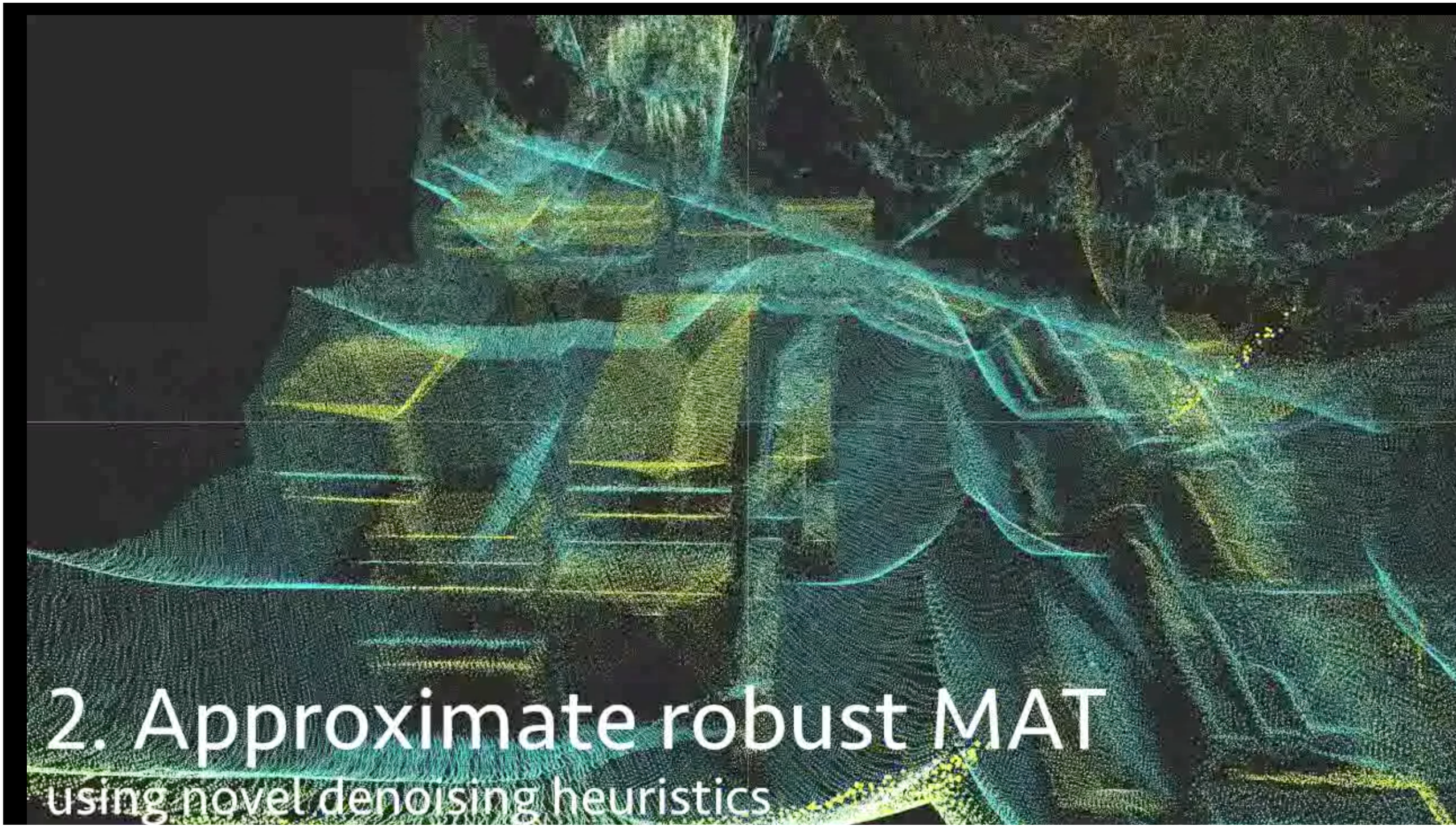
MAT approximation (3D)

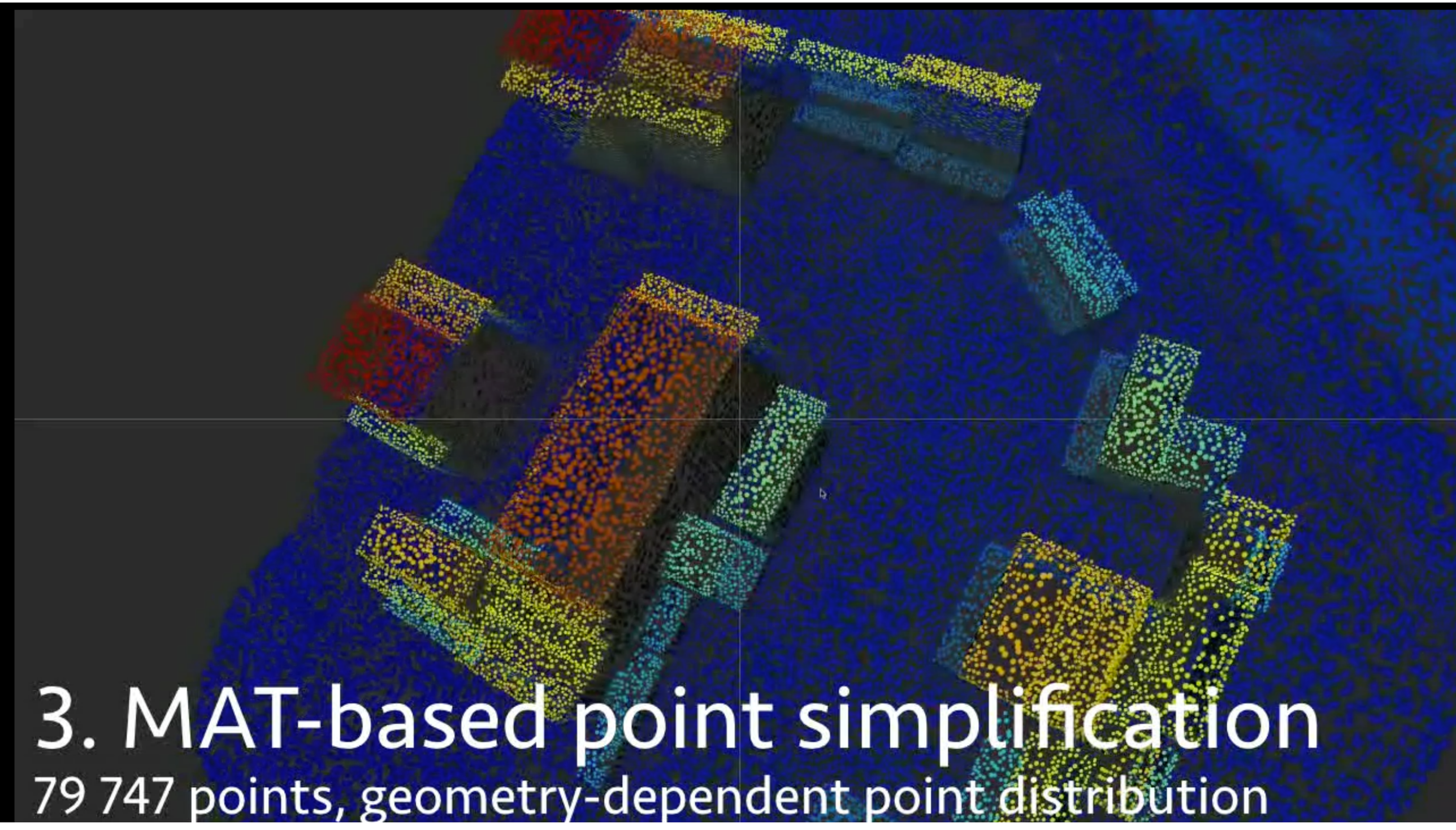
Robust MAT approximation

MAT approximation (3D)

Robust MAT approximation


1. Input aerial LiDAR points
746 351 points

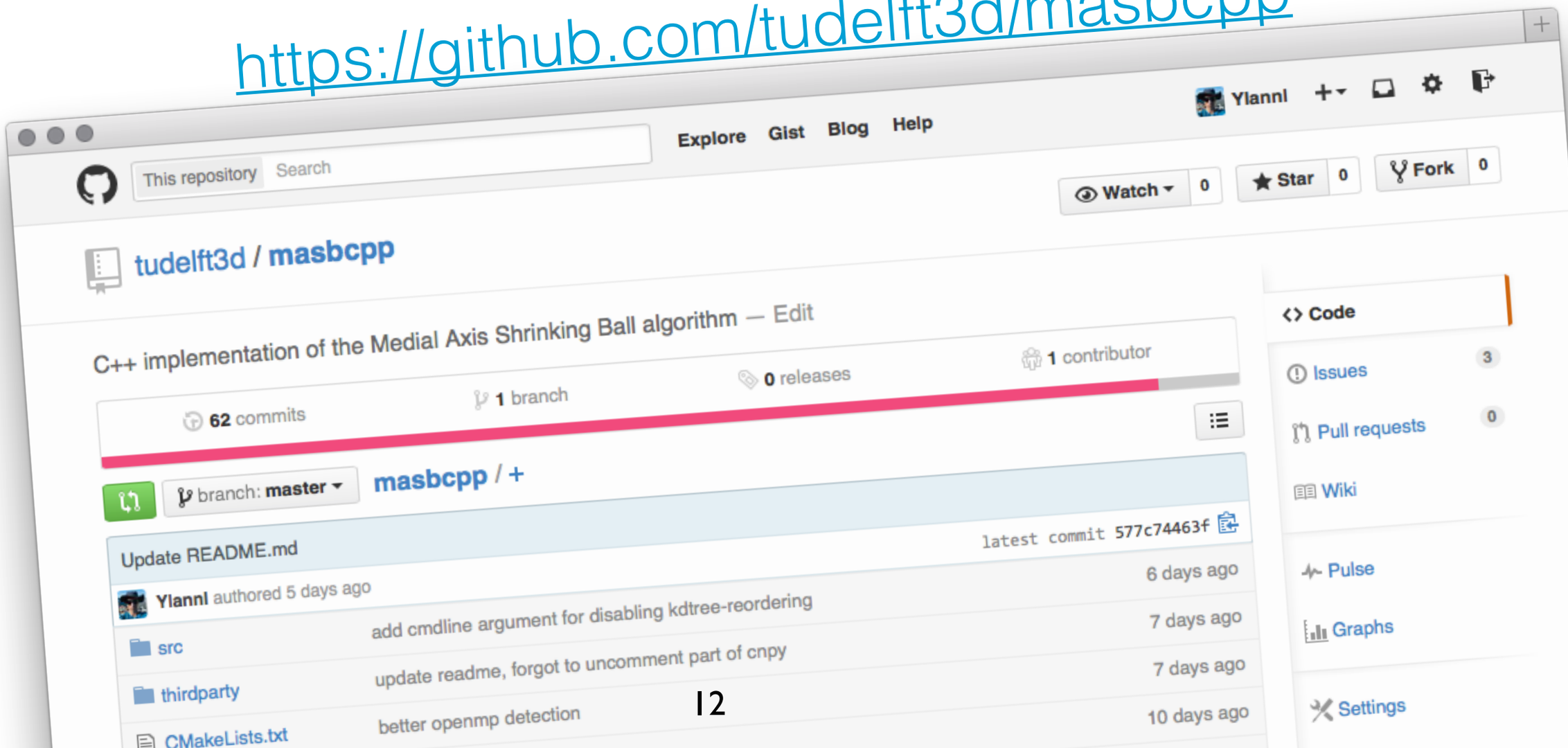

2. Approximate robust MAT
using novel denoising heuristics


3. MAT-based point simplification
79 747 points, geometry-dependent point distribution

MAT approximation for point clouds

Open source implementation main algorithm
(~250.000 points/s with 16-cores)

https://github.com/tudelft3d/masbcpp



Visibility analysis

Line-of-sight/shadow analysis

- typically requires meshed city model
  - needs to be computed first (non-trivial for higher LOD)
- why not use high resolution point cloud directly?
- points do not cast shadows, but MAT balls do

Workflow

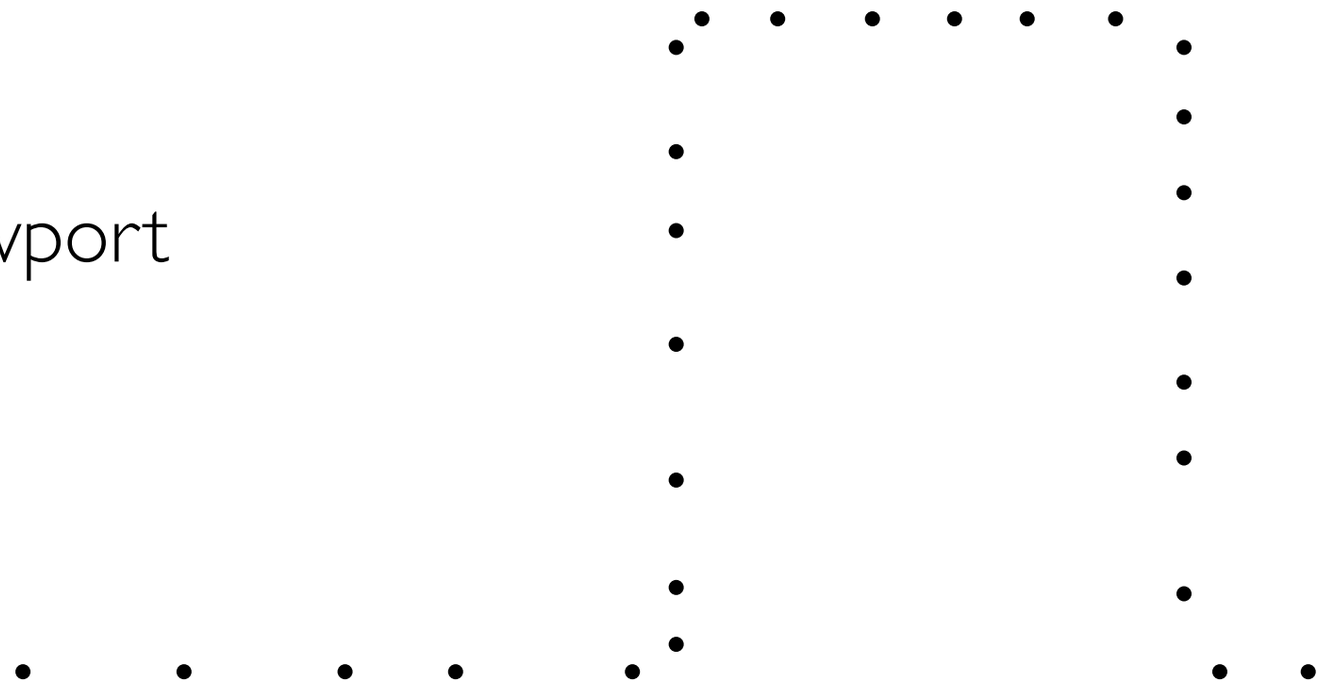
Depth map: distances from viewpoint to all visible balls

1. project each ball center
2. rasterise ball to viewport
3. perform depth test for each pixel

Point is invisible:

if it is further away from the viewport

than depth map to the object



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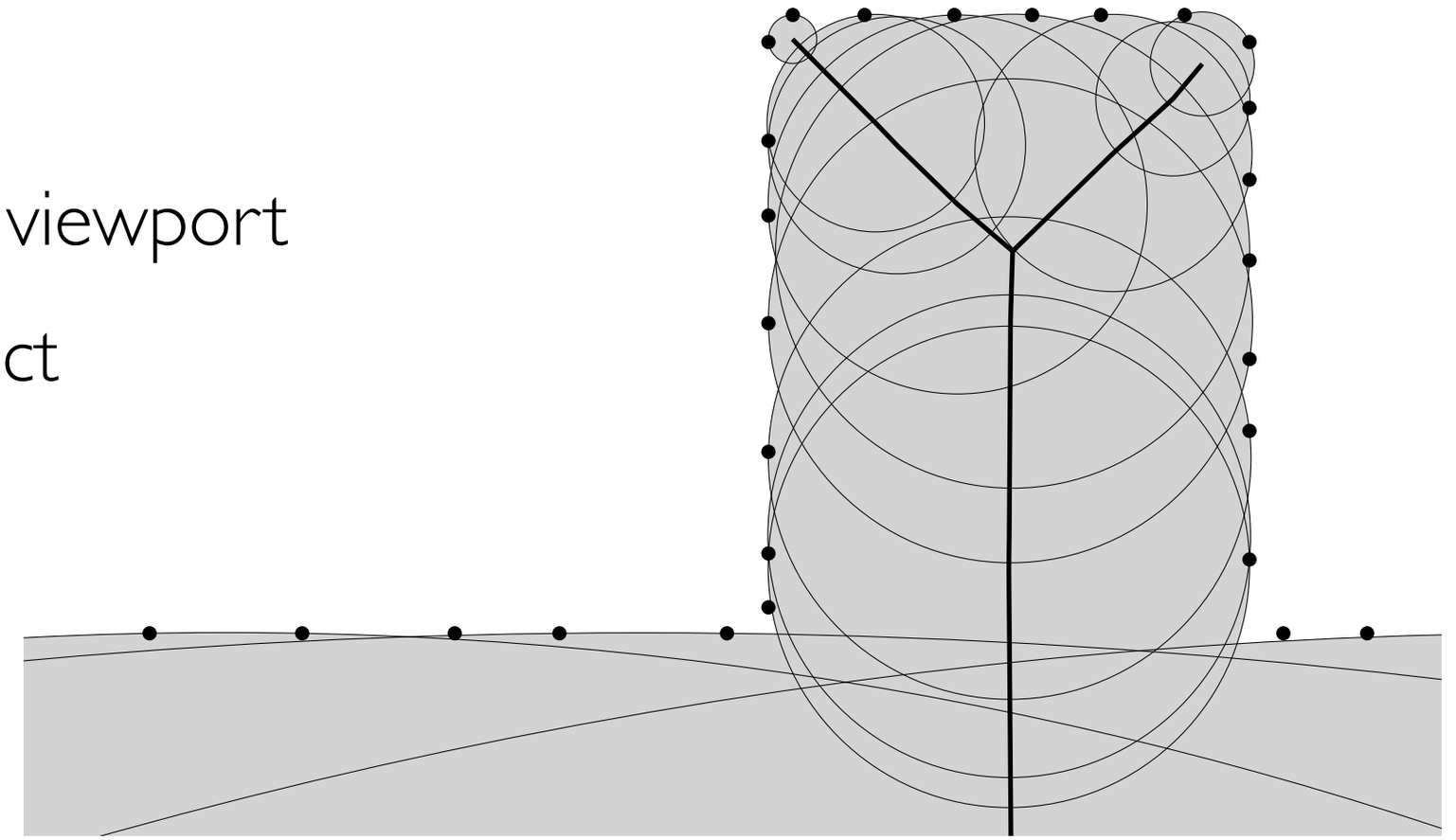

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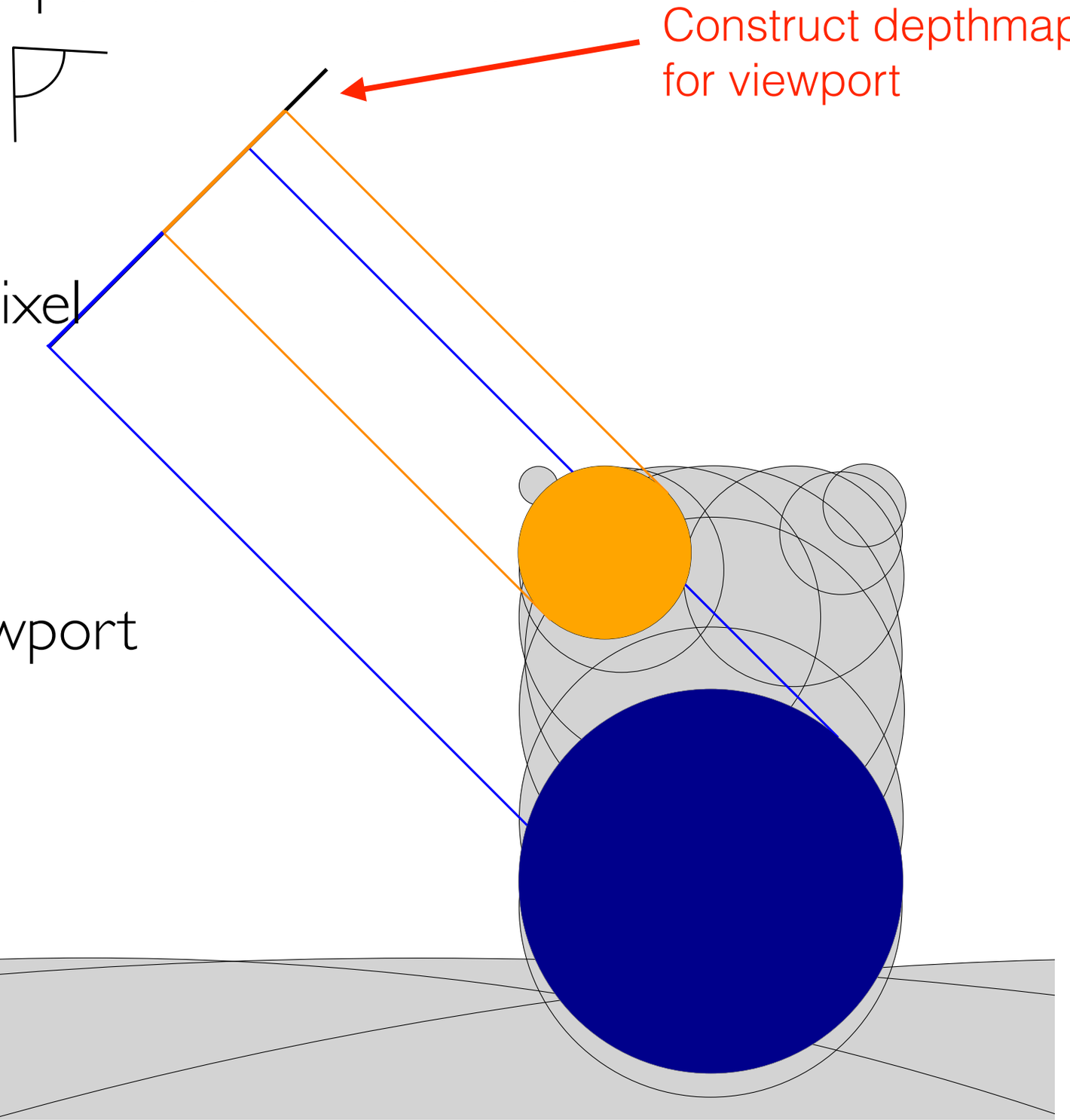

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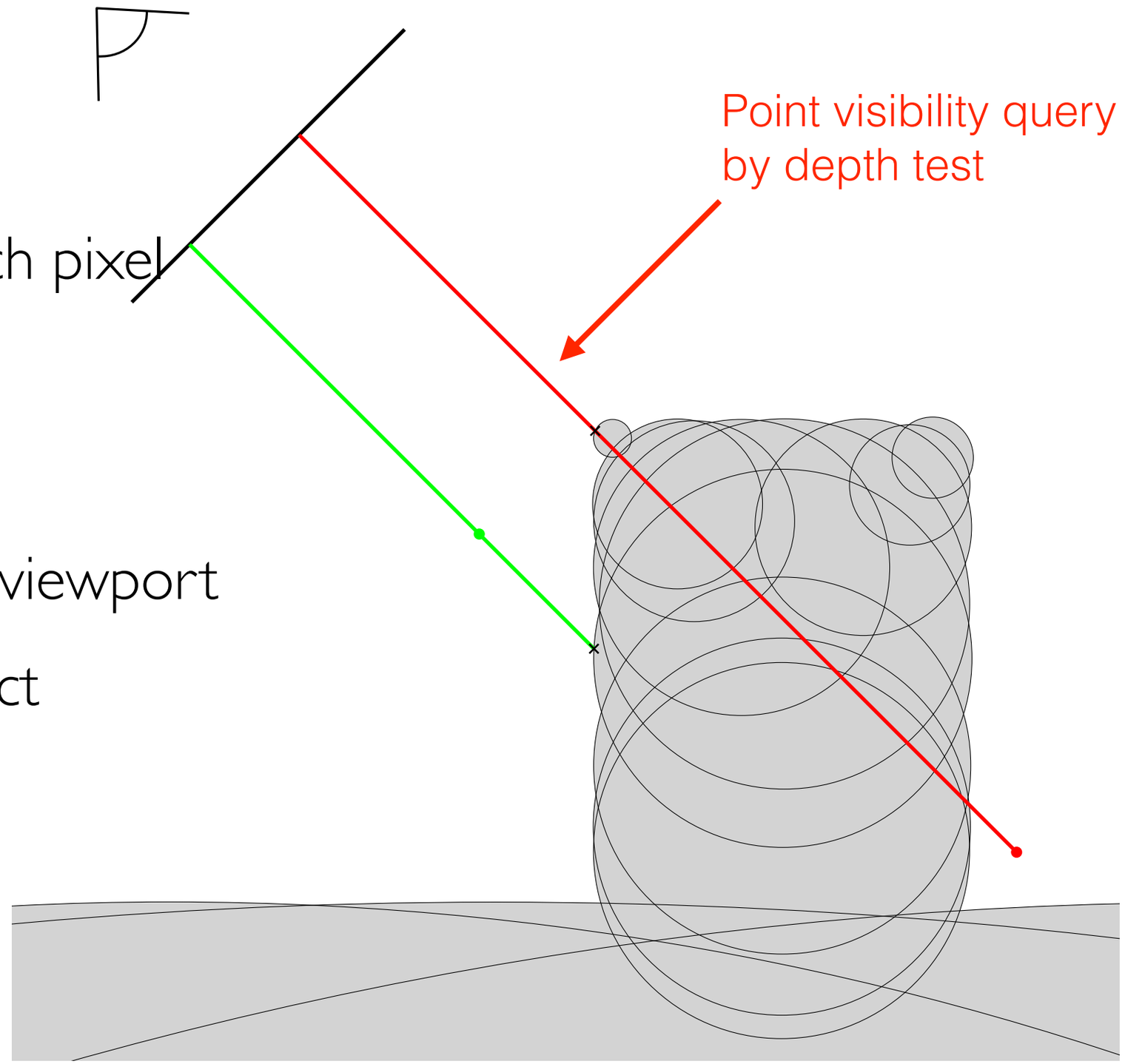

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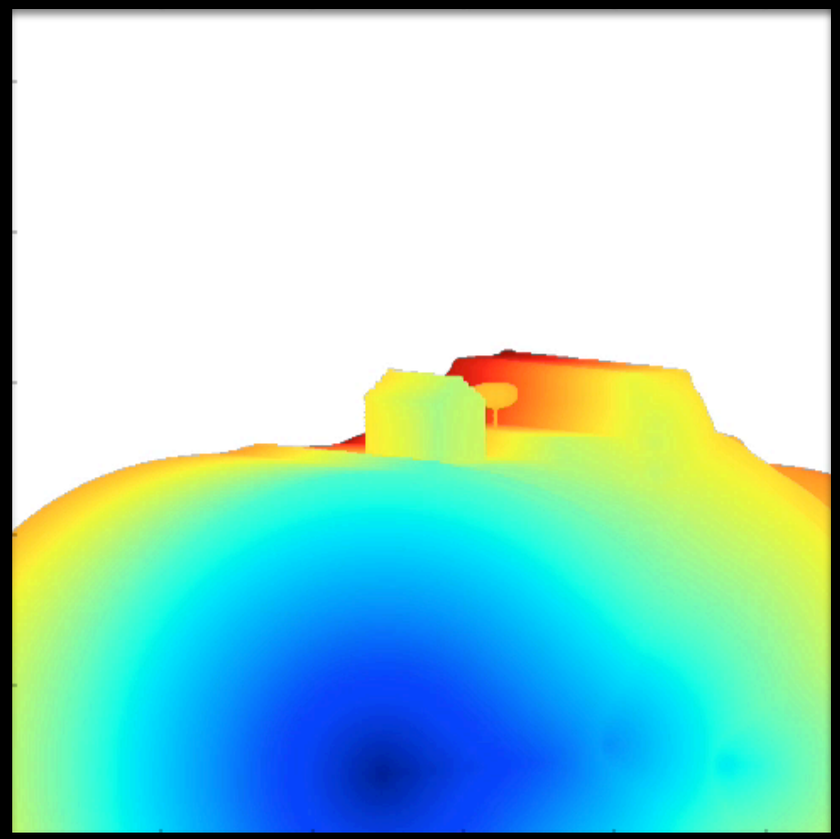
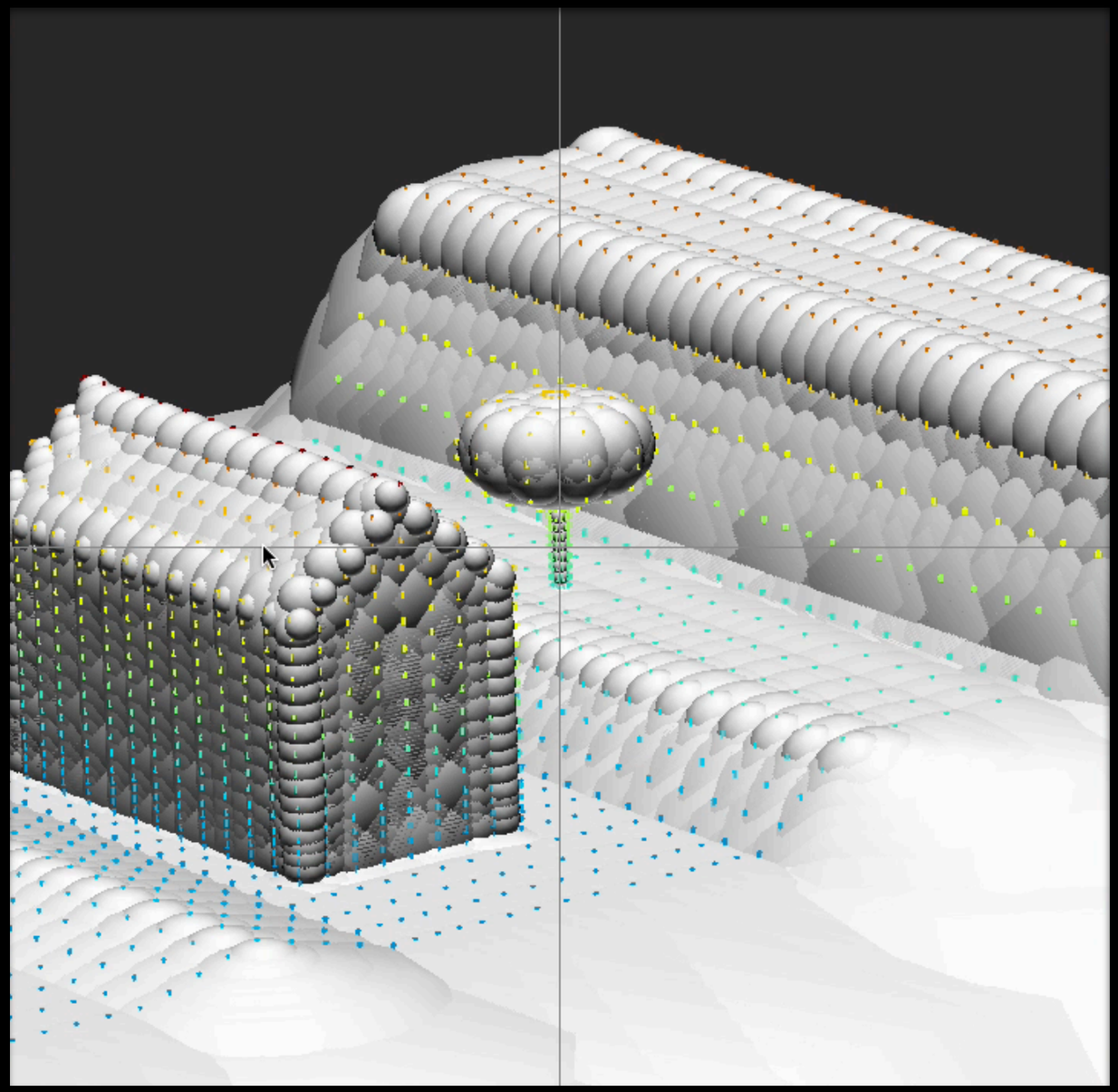
In practice

Depth map for selected viewpoint





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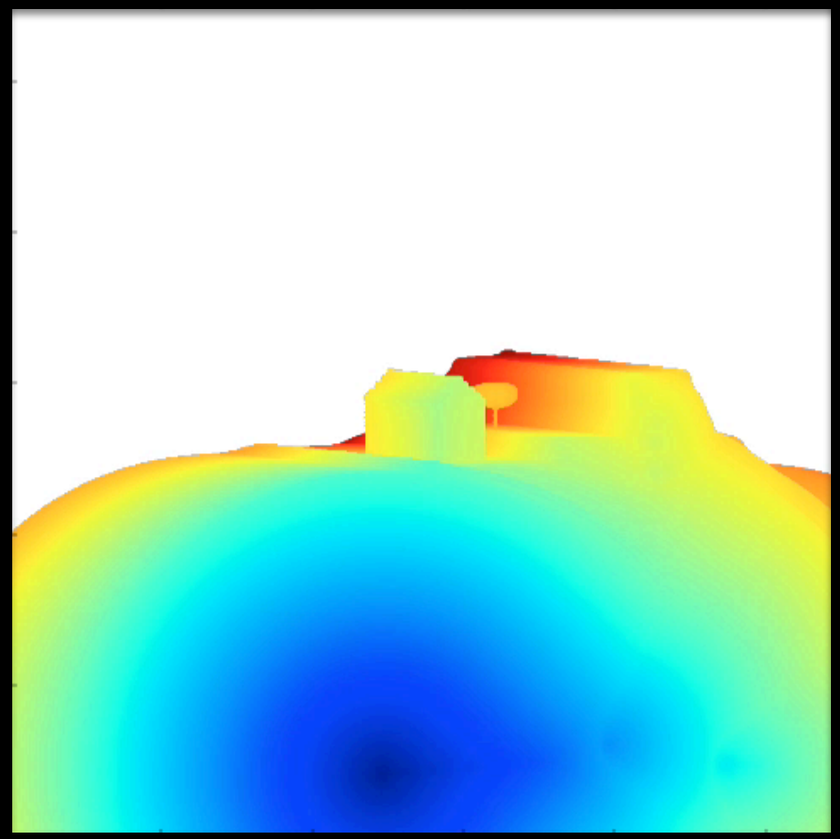
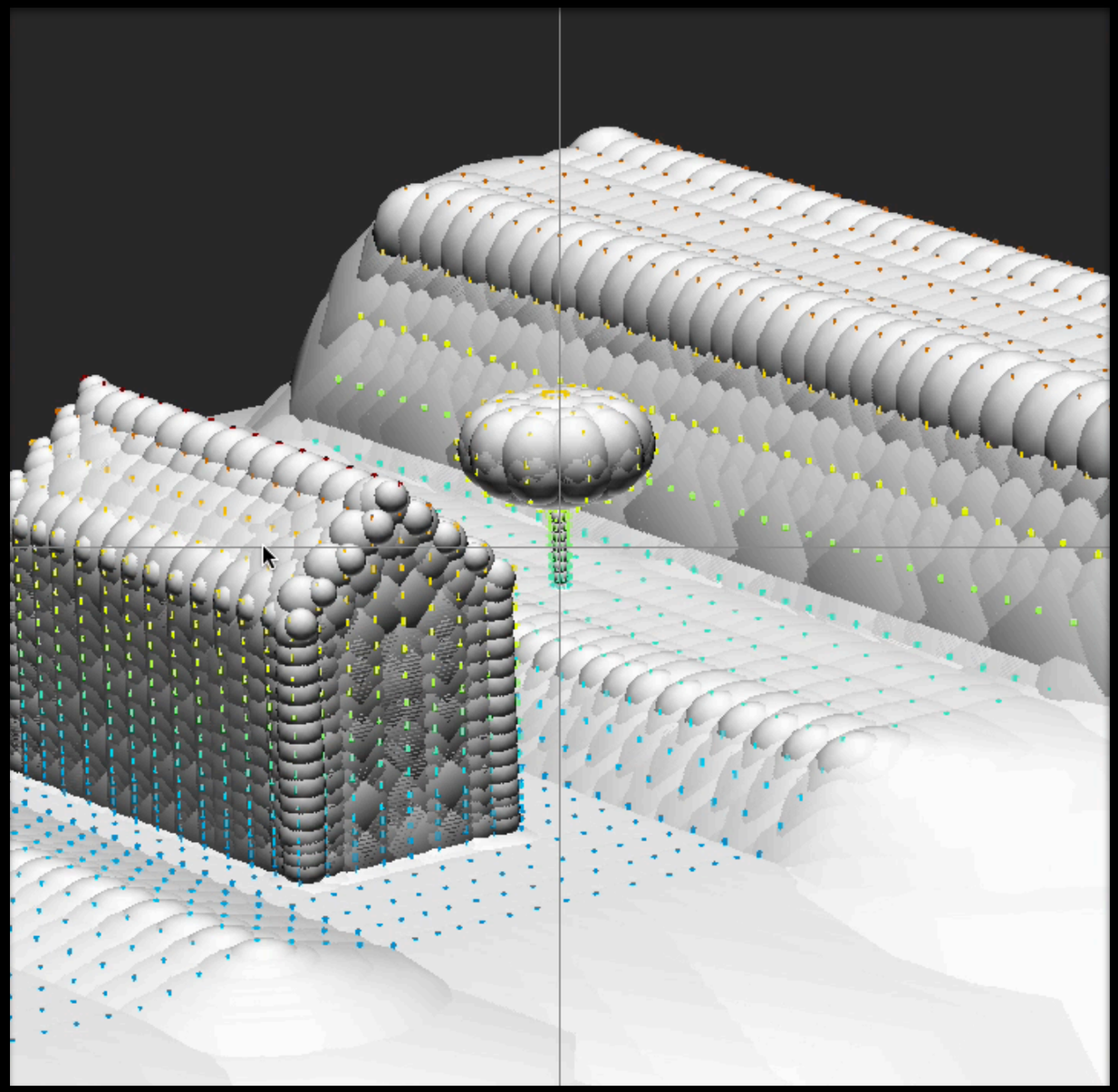
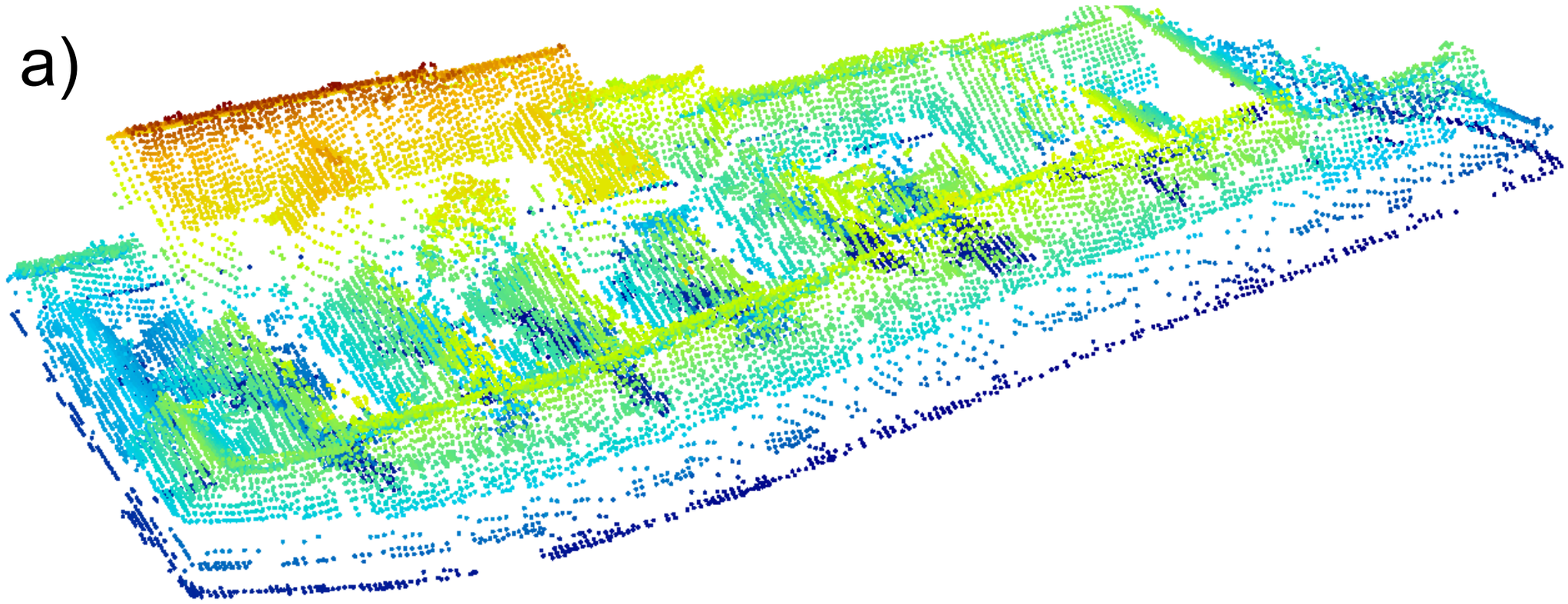


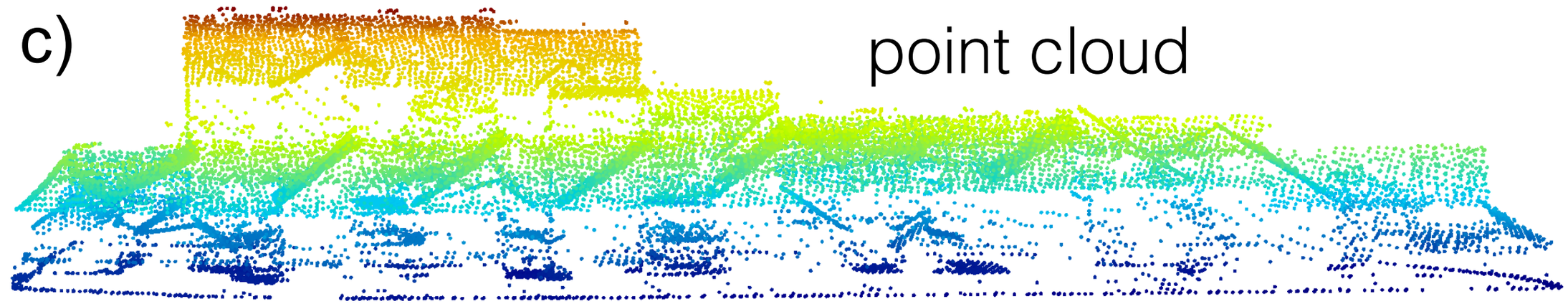


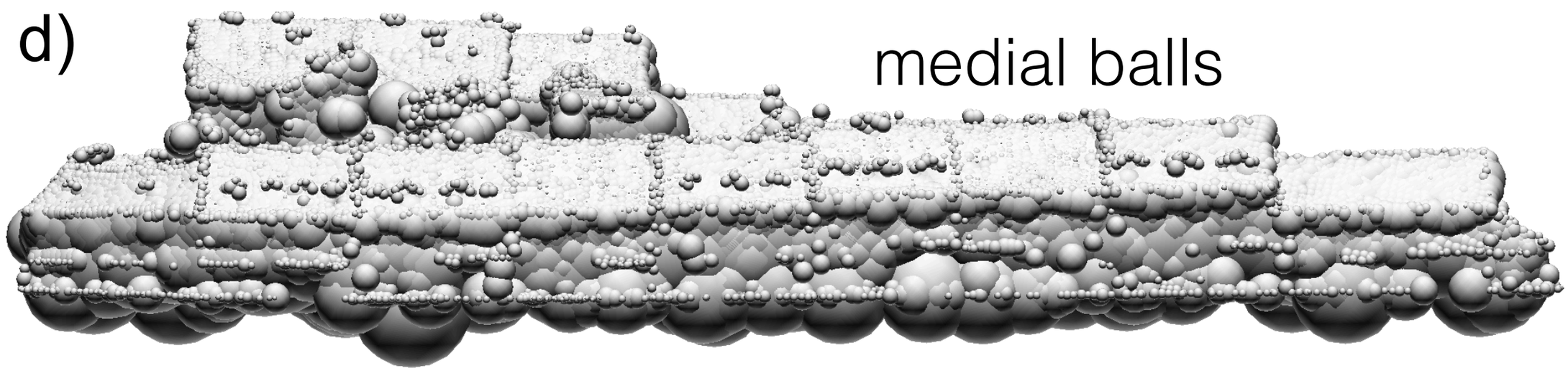
Real LiDAR point cloud

a)



Real LiDAR point cloud, viewport view





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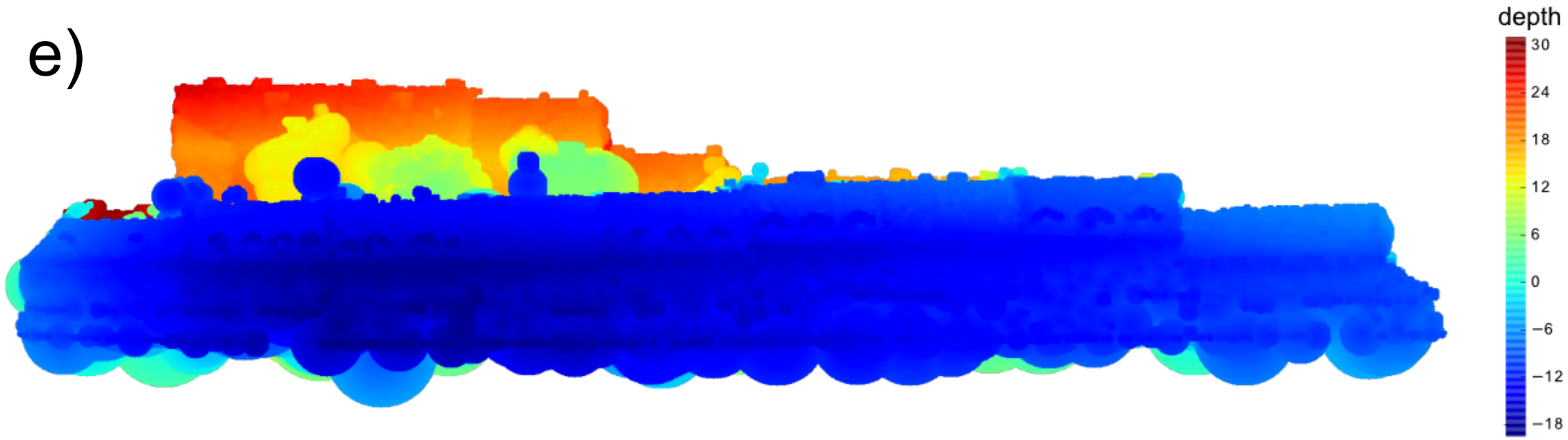

depth map for selected viewpoint

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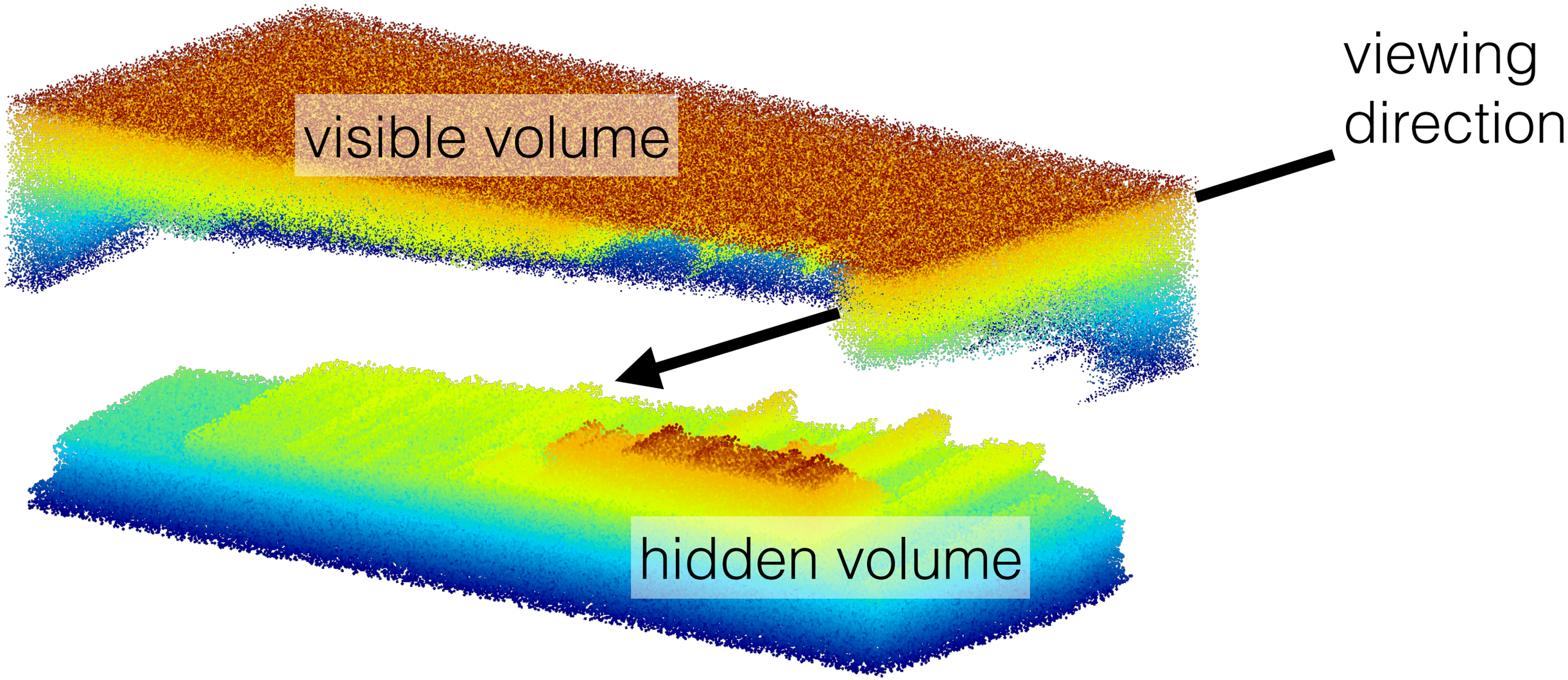

Further reading

Visibility Analysis in a Point Cloud Based on the Medial Axis Transform. Ravi Peters, Hugo Ledoux and Filip Biljecki. In *Eurographics Workshop on Urban Data Modelling and Visualisation 2015*, Delft, Netherlands, November 2015, pp. 7–12

Thank you!

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