Automatic valid LOD2 building models from aerial point clouds with the 3D Medial Axis Transform

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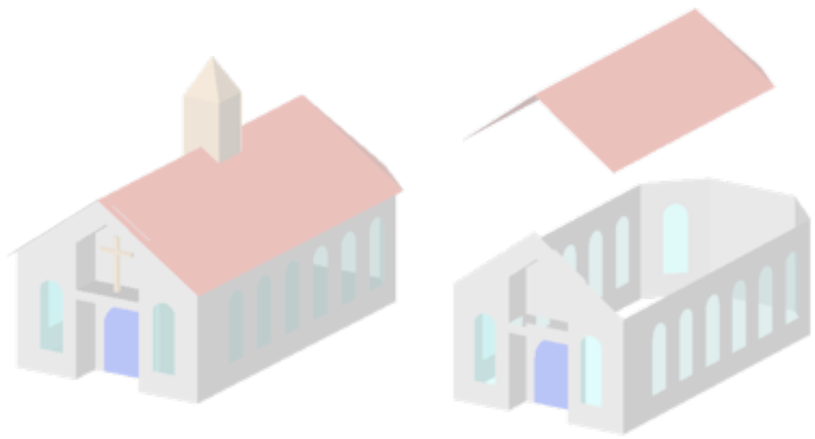
3Dgeoinfo

3D city

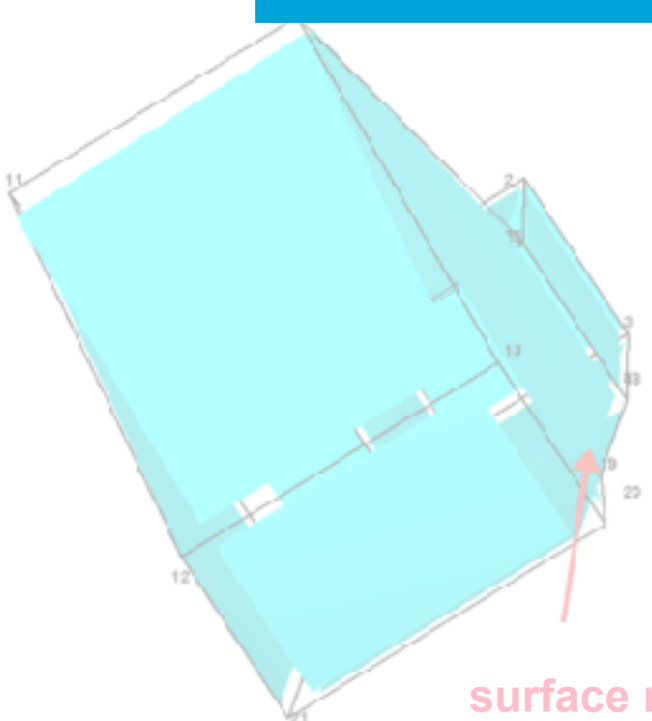
Table 1. Overview of the documented use cases of 3D city models, divided into two groups: non-visualisation and visualisation use cases.

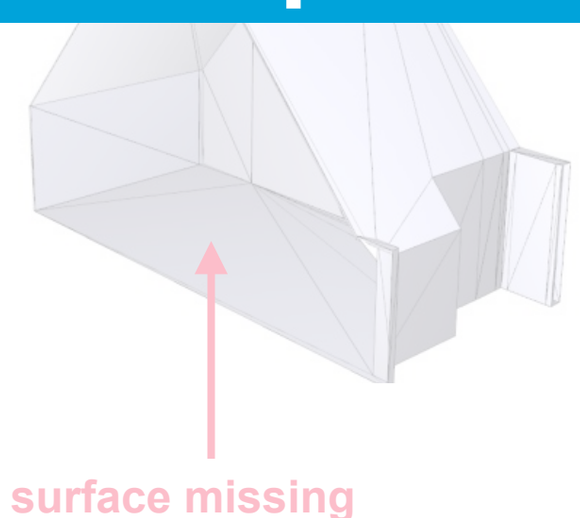
§	Use Case	Example of an Application
4.1.1	Estimation of the solar irradiation	Determining the suitability of a roof surface for installing photovoltaic panels
4.1.2	Energy demand estimation	Assessing the return of a building energy retrofit
4.1.3	Aiding positioning	Map matching
4.1.4	Determination of the floorspace	Valuation of buildings
4.1.5	Classifying building types	Semantic enrichment of data sets
4.2.1	Geo-visualisation and visualisation enhancement	Flight simulation
4.2.2	Visibility analysis	Finding the optimal location to place a surveillance camera
4.2.3	Estimation of shadows cast by urban features	Determination of solar envelopes
4.2.4	Estimation of the propagation of noise in an urban environment	Traffic planning
4.2.5	3D cadastre	Property registration
4.2.6	Visualisation for navigation	Navigation
4.2.7	Urban planning	Designing green areas
4.2.8	Visualisation for communication of urban information to citizenry	Virtual tours
4.2.9	Reconstruction of sunlight direction	Object recognition
4.2.10	Understanding SAR images	Interpretation of radar data
4.2.11	Facility management	Managing utilities
4.2.12	Automatic scaffold assembly	Civil engineering
4.2.13	Emergency response	Planning evacuation
4.2.14	Lighting simulations	Planning lighting of landmarks
4.2.15	Radio-wave propagation	Optimising radio infrastructure
4.2.16	Computational fluid dynamics	Predicting air quality
4.2.17	Estimating the population in an area	Crisis management
4.2.18	Routing	Understanding accessibility
4.2.19	Forecasting seismic damage	Insurance
4.2.20	Flooding	Mitigating damage to utility management
4.2.21	Change detection	Urban inventory
4.2.22	Volumetric density studies	Urban studies
4.2.23	Forest management	Predicting tree growth
4.2.24	Archaeology	Visualising ancient sites

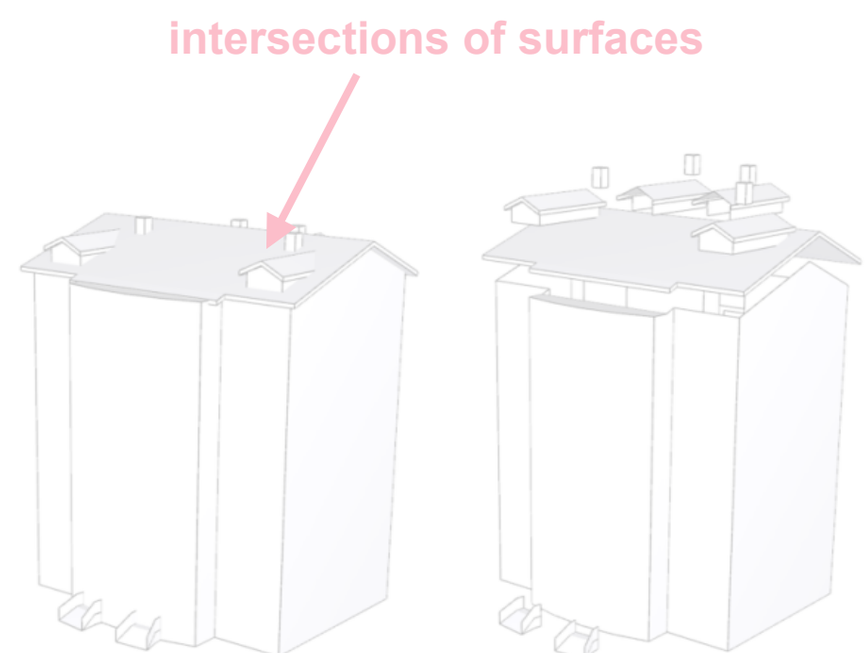
Geometrical errors



Difficult to repair afterwards







Errors are common

"While the problem may be considered to be solved for visualisation purposes, the production of ***geometrically and topologically correct LoD2 building models still poses challenges*** *in difficult urban environments."*

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Results of the ISPRS benchmark on urban object detection and 3D building reconstruction

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Method

Topology of a polyhedron

Represented explicitly using e.g. quad-edge data-structure

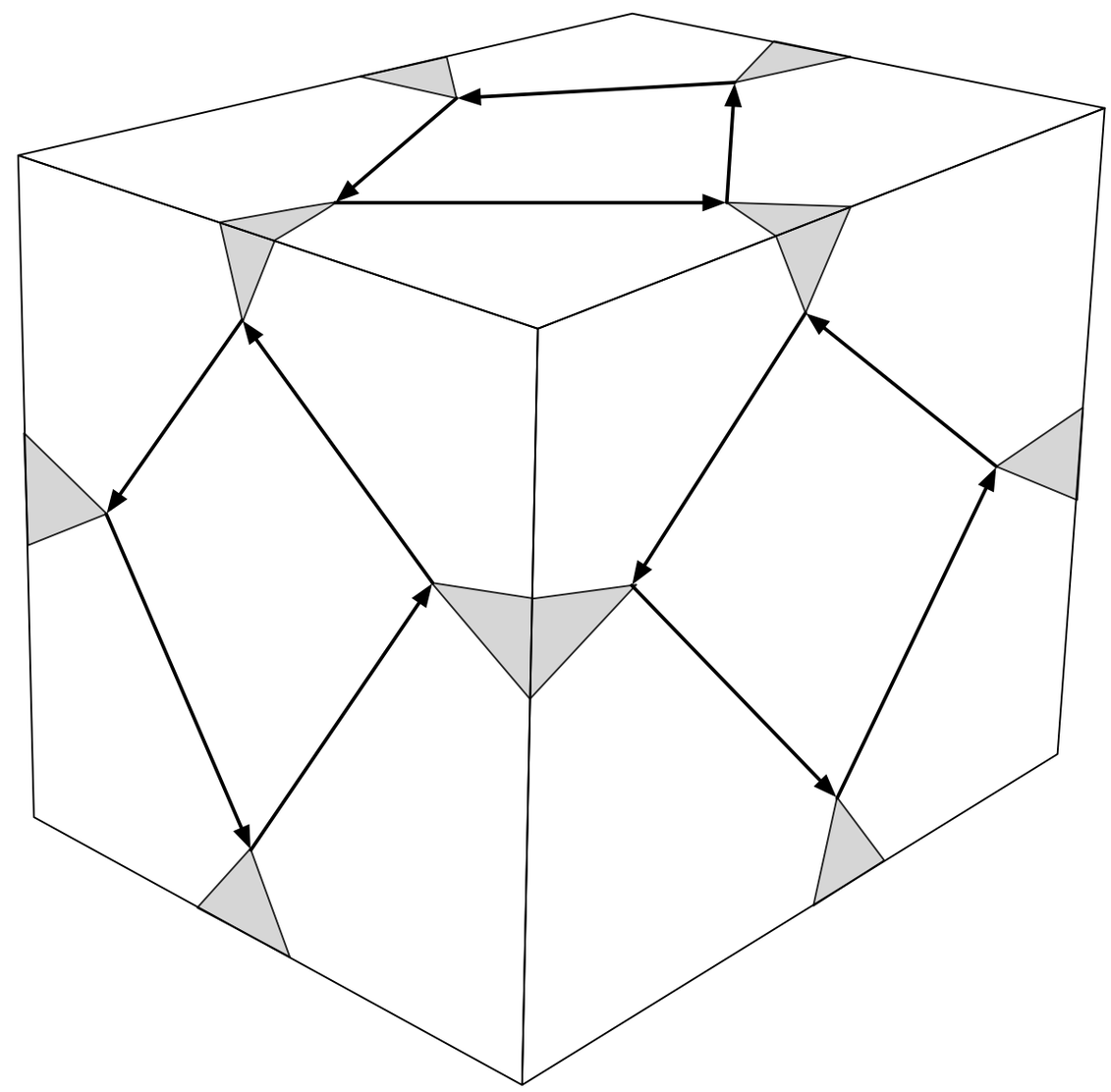
valid topology

+

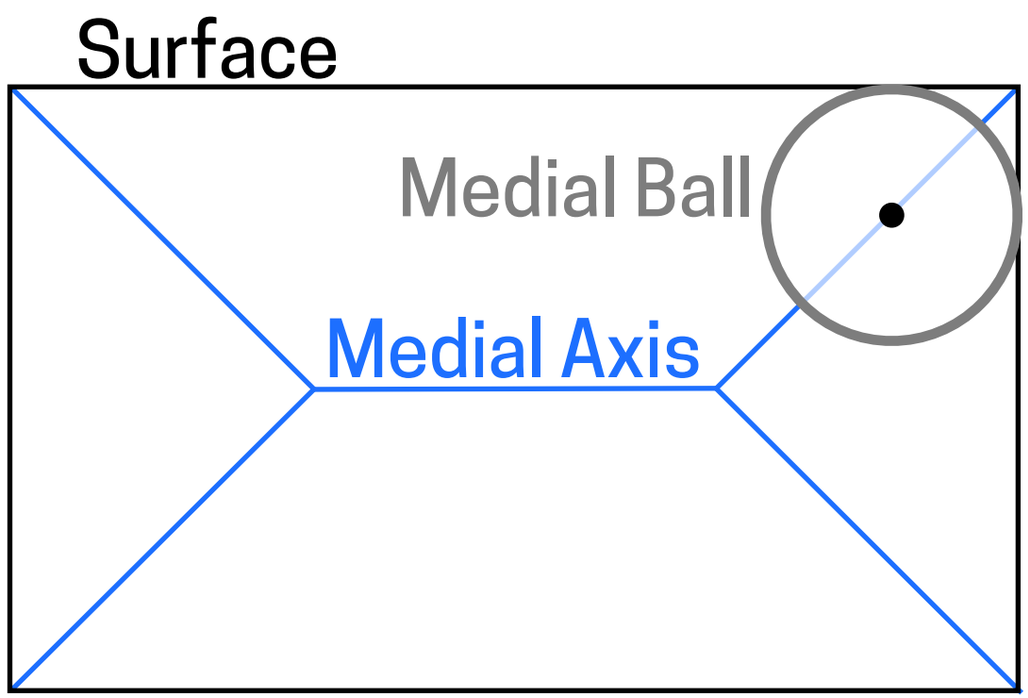
face plane equations

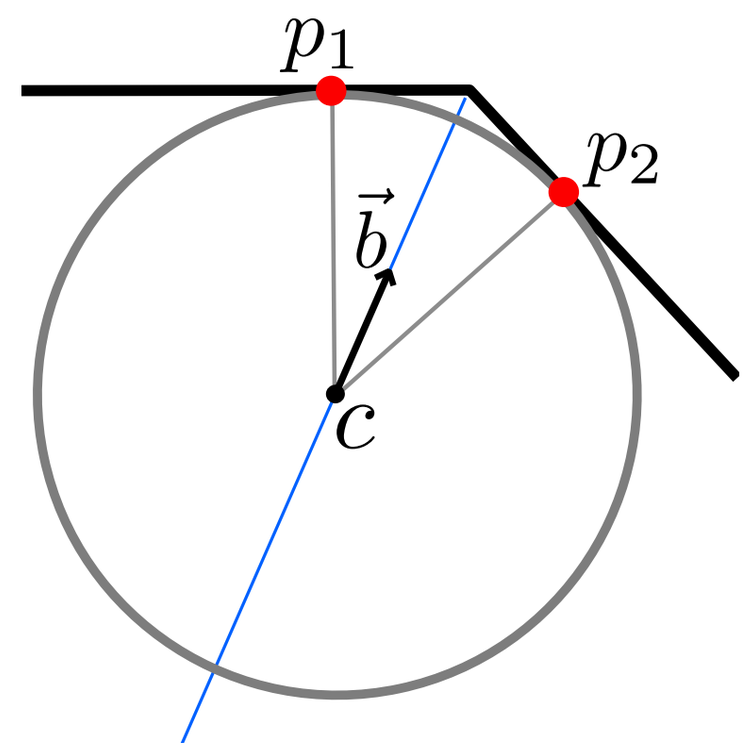
=

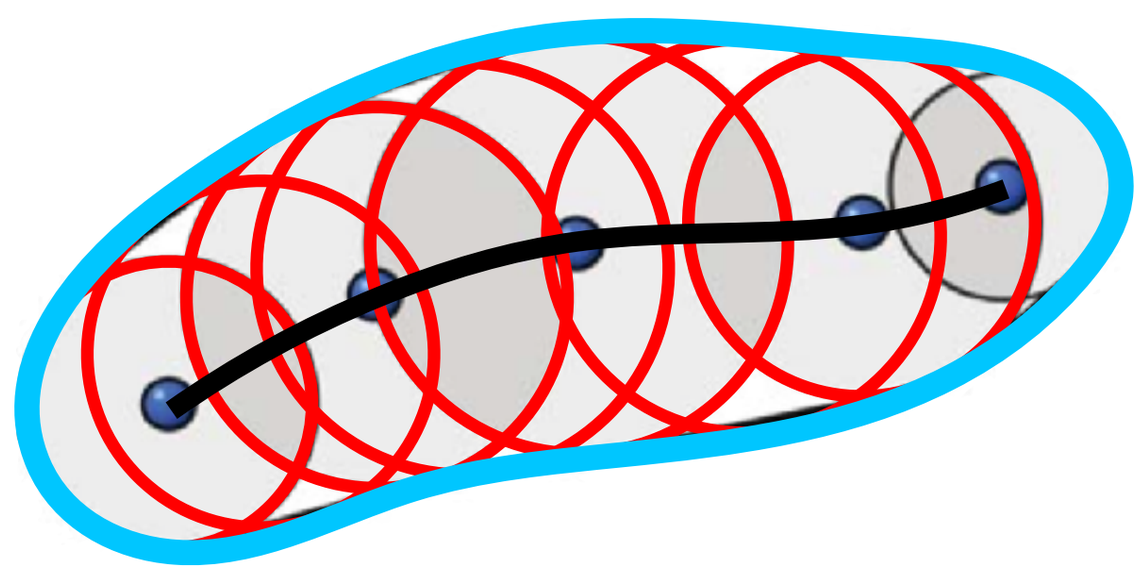
valid geometry



Medial Axis Transform (Skeleton)







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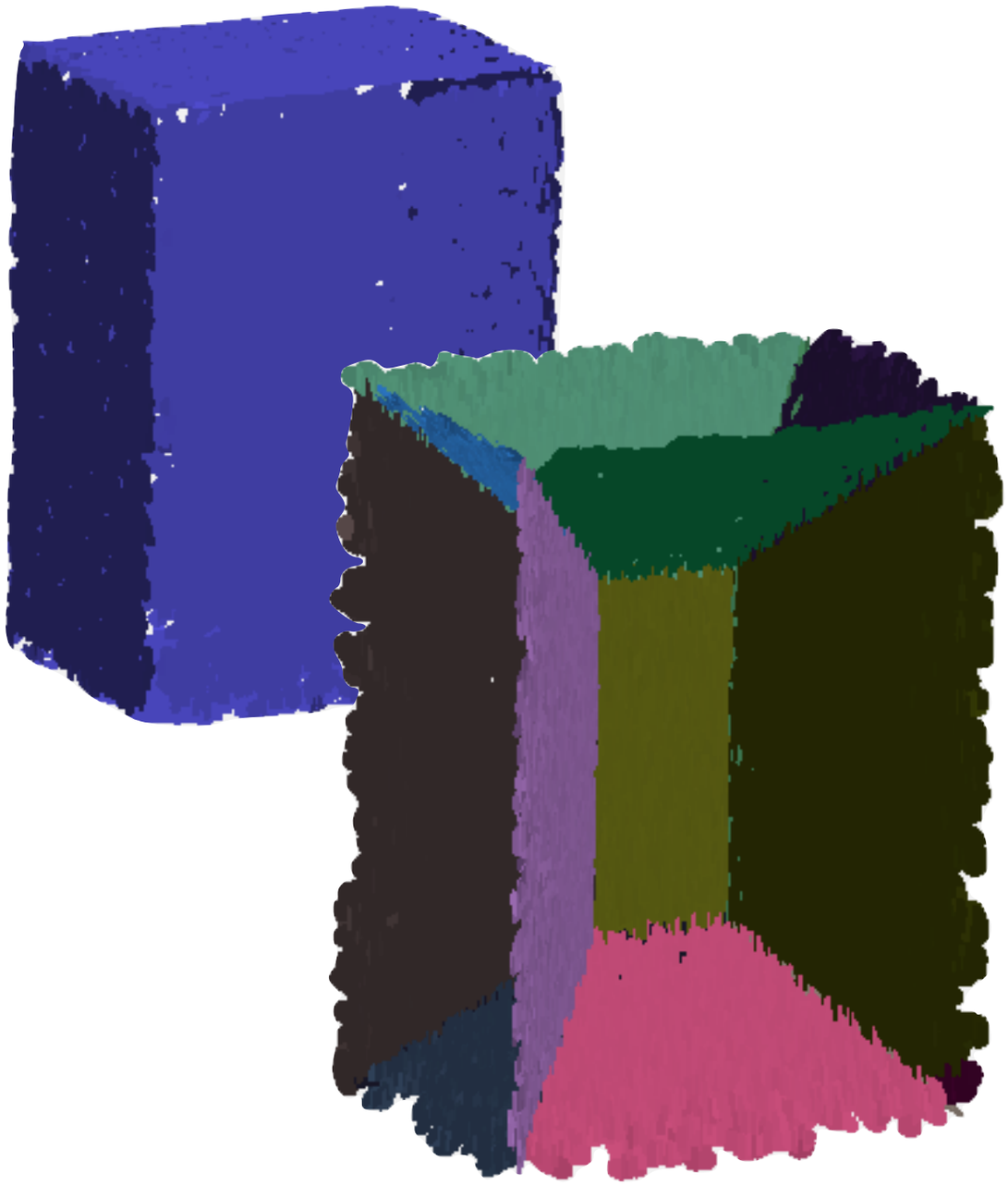
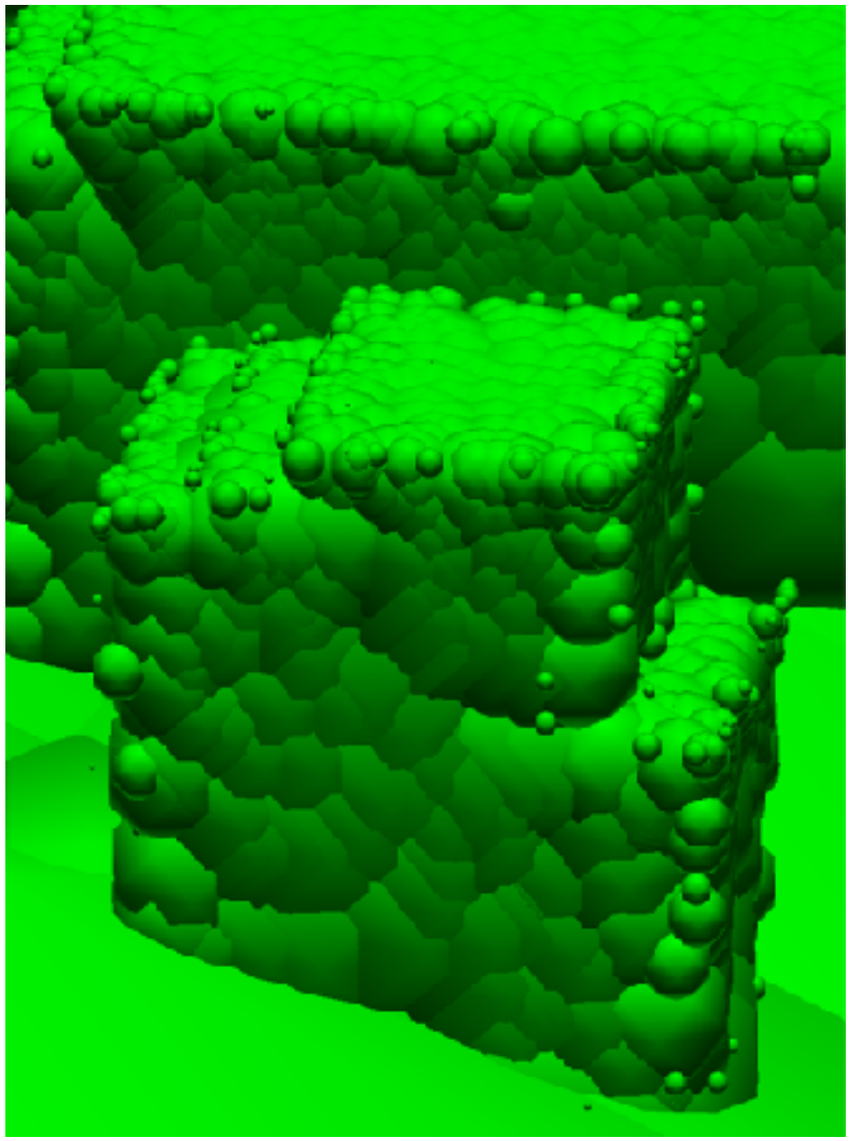
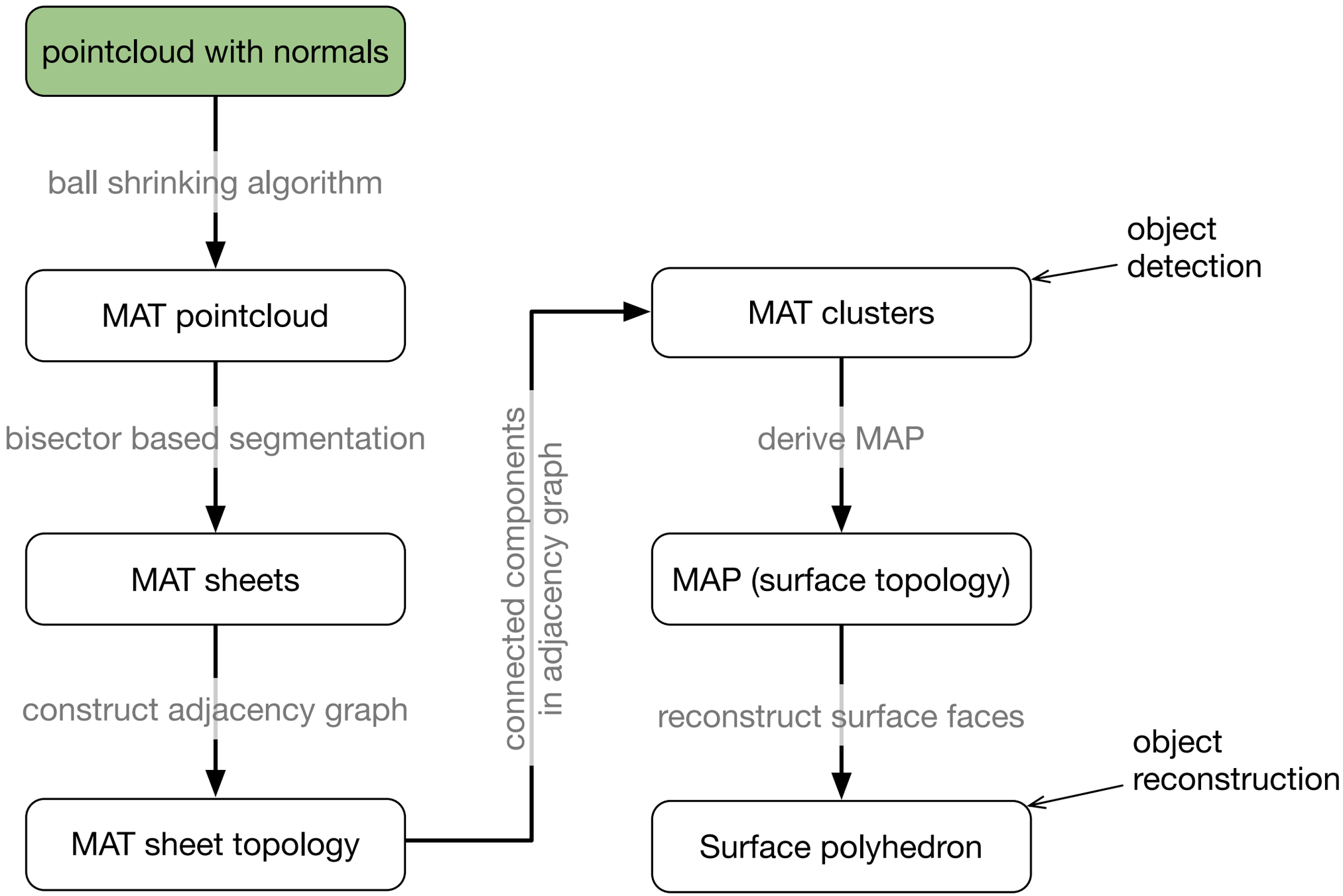
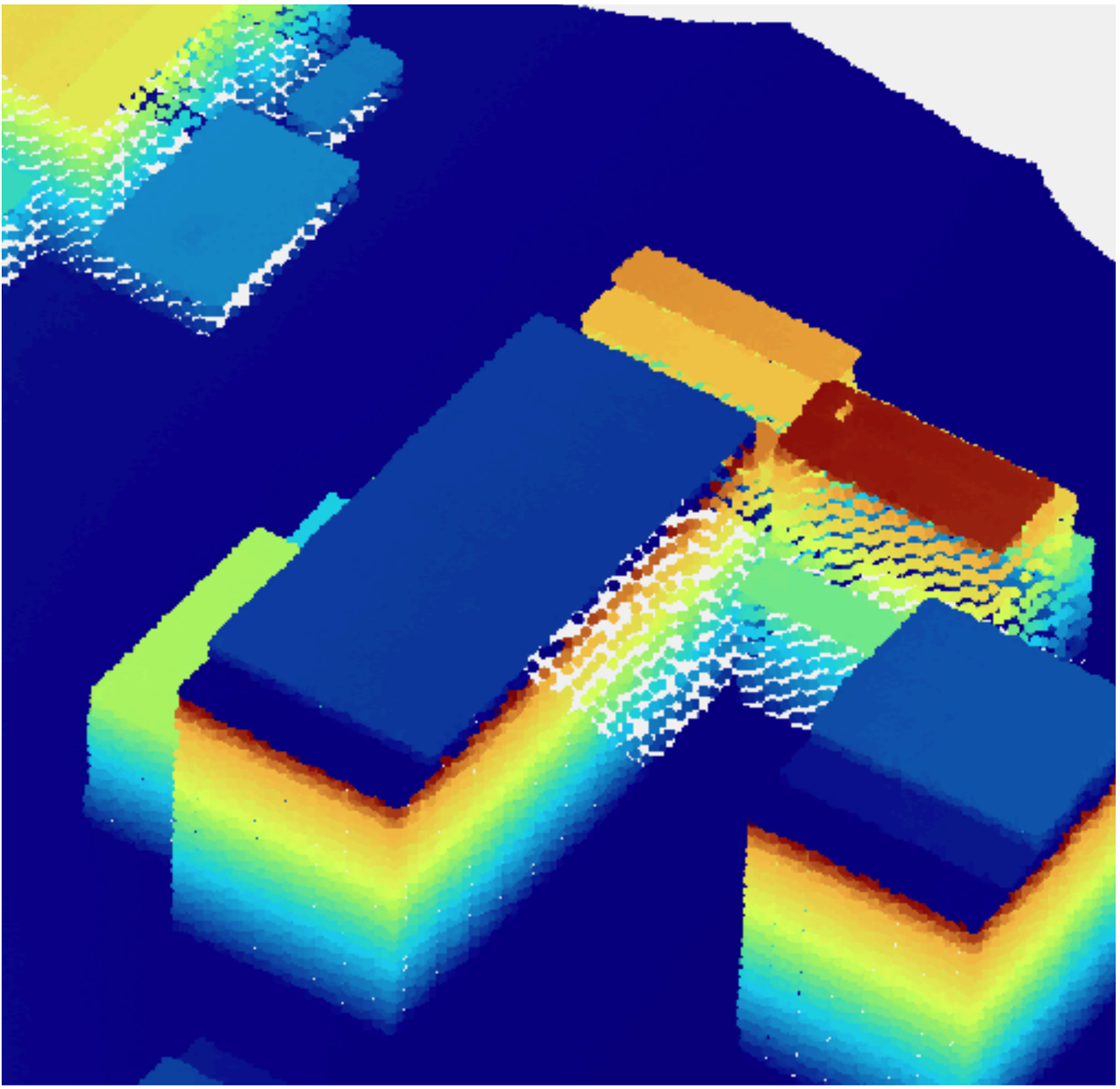


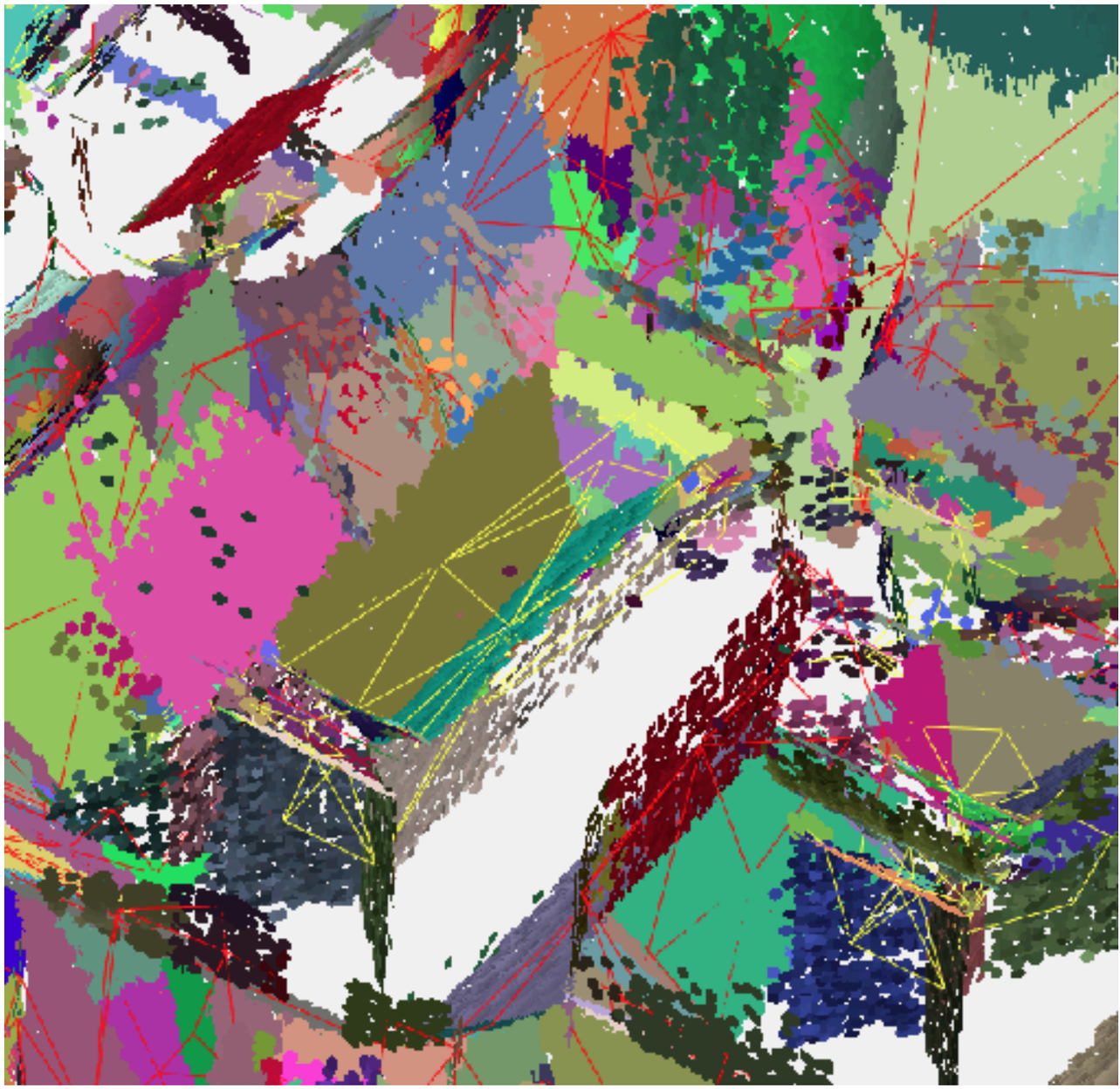


Processing scheme

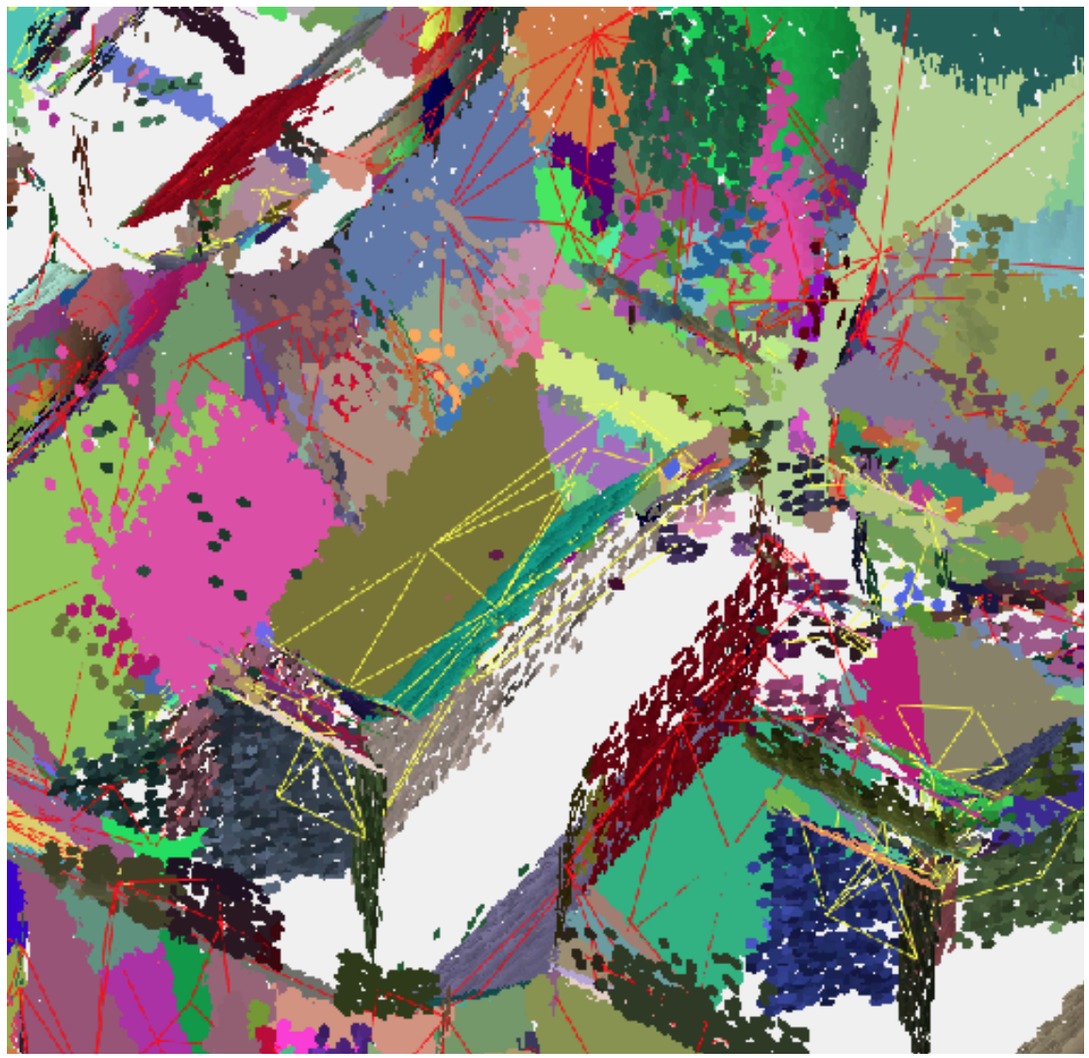


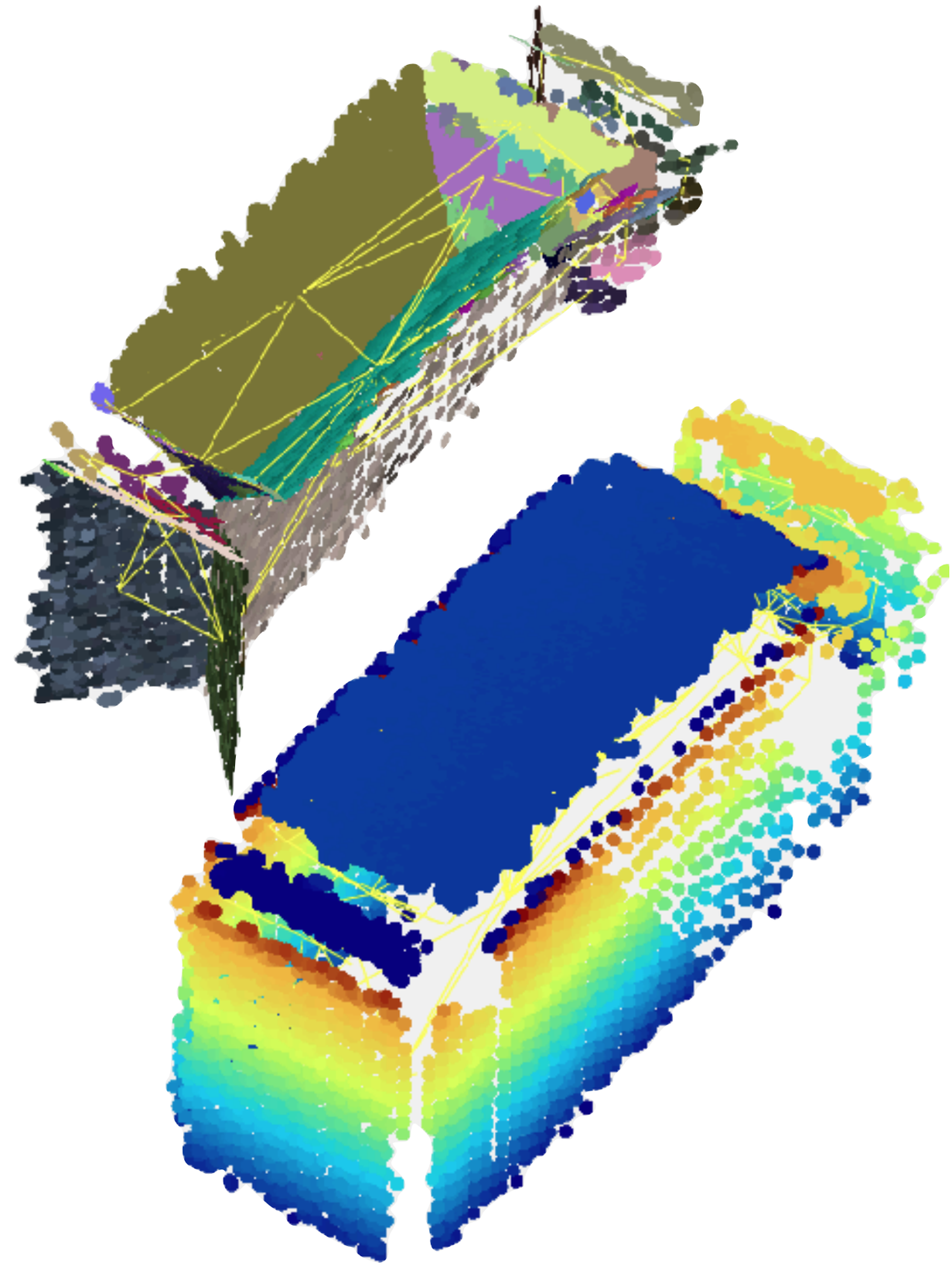
Object detection



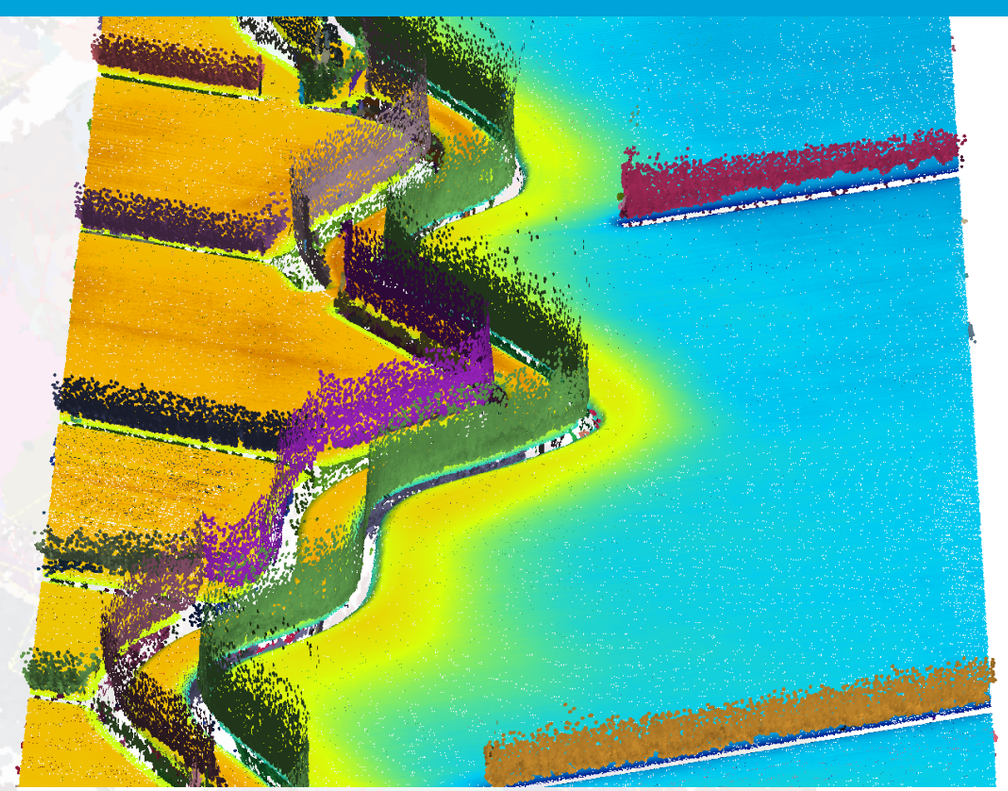


Object detection

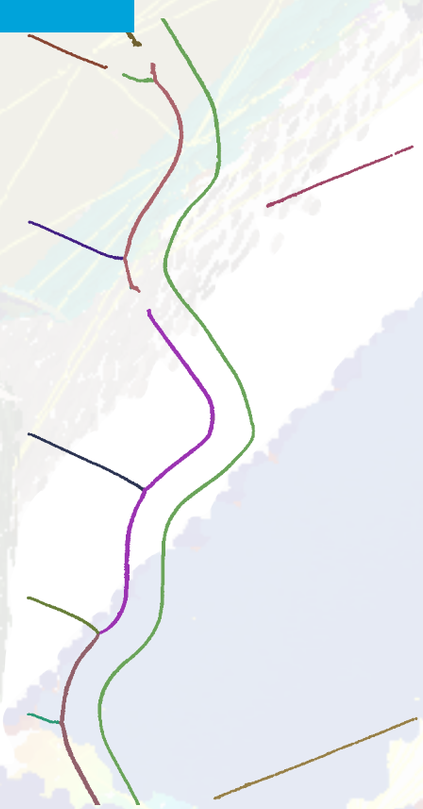




Watercourse detection

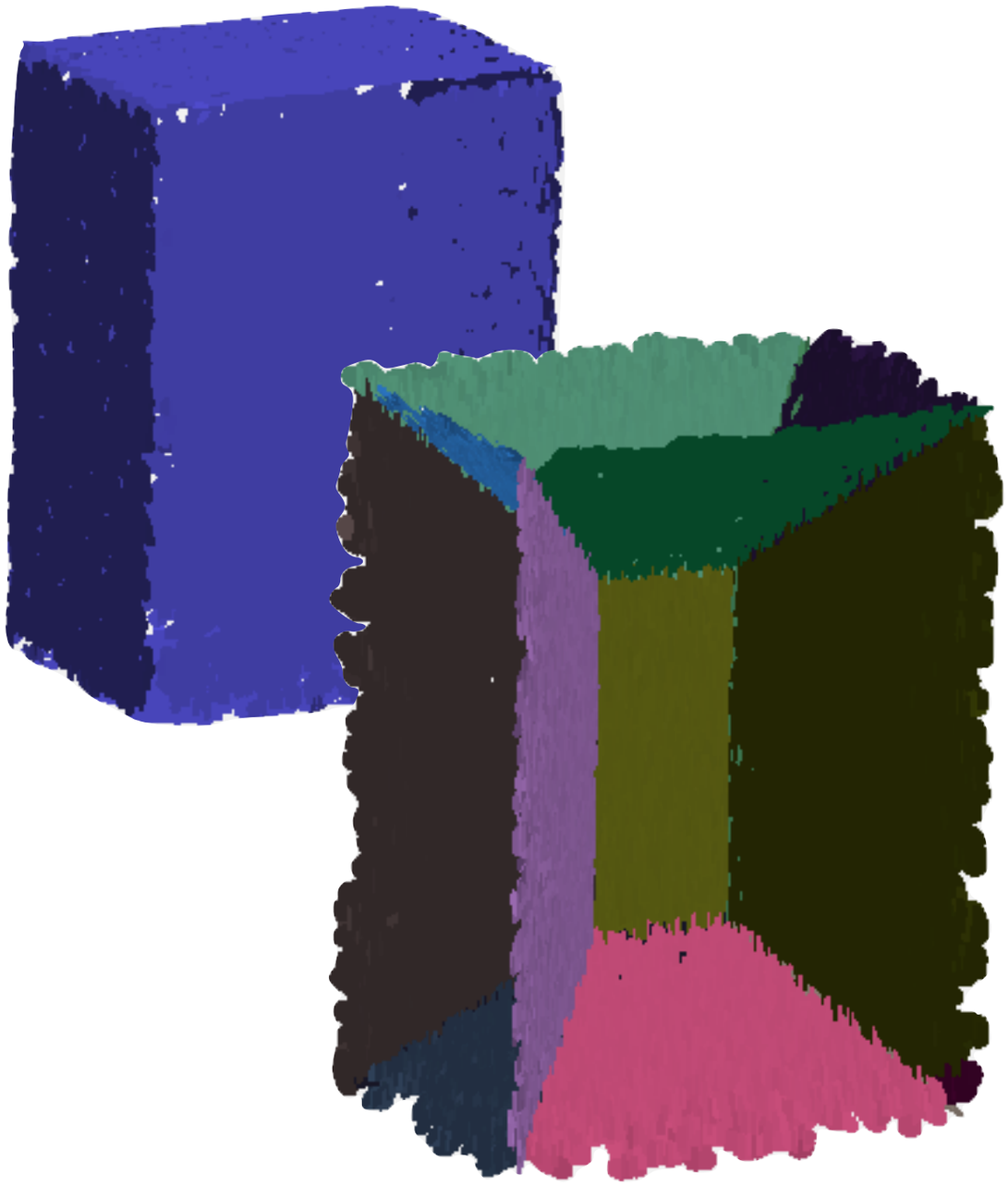


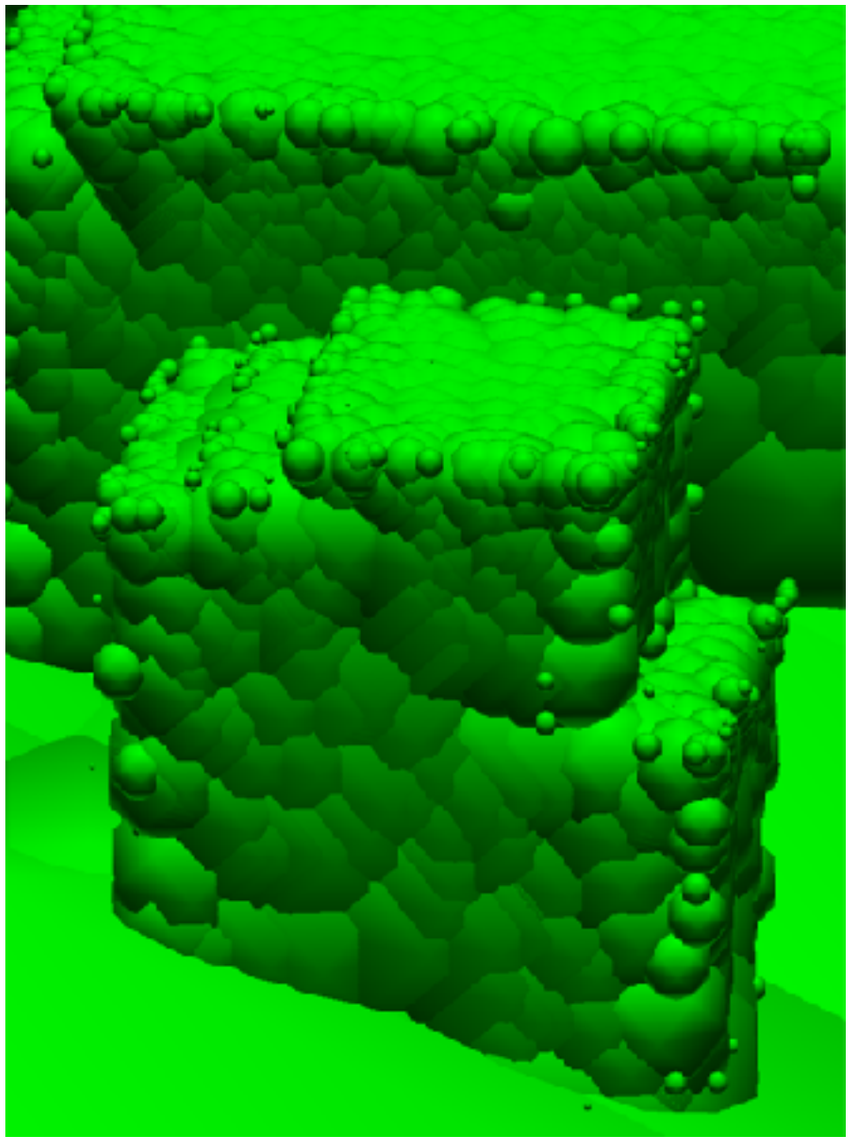
(a) Perspective view of skeleton and ground points.



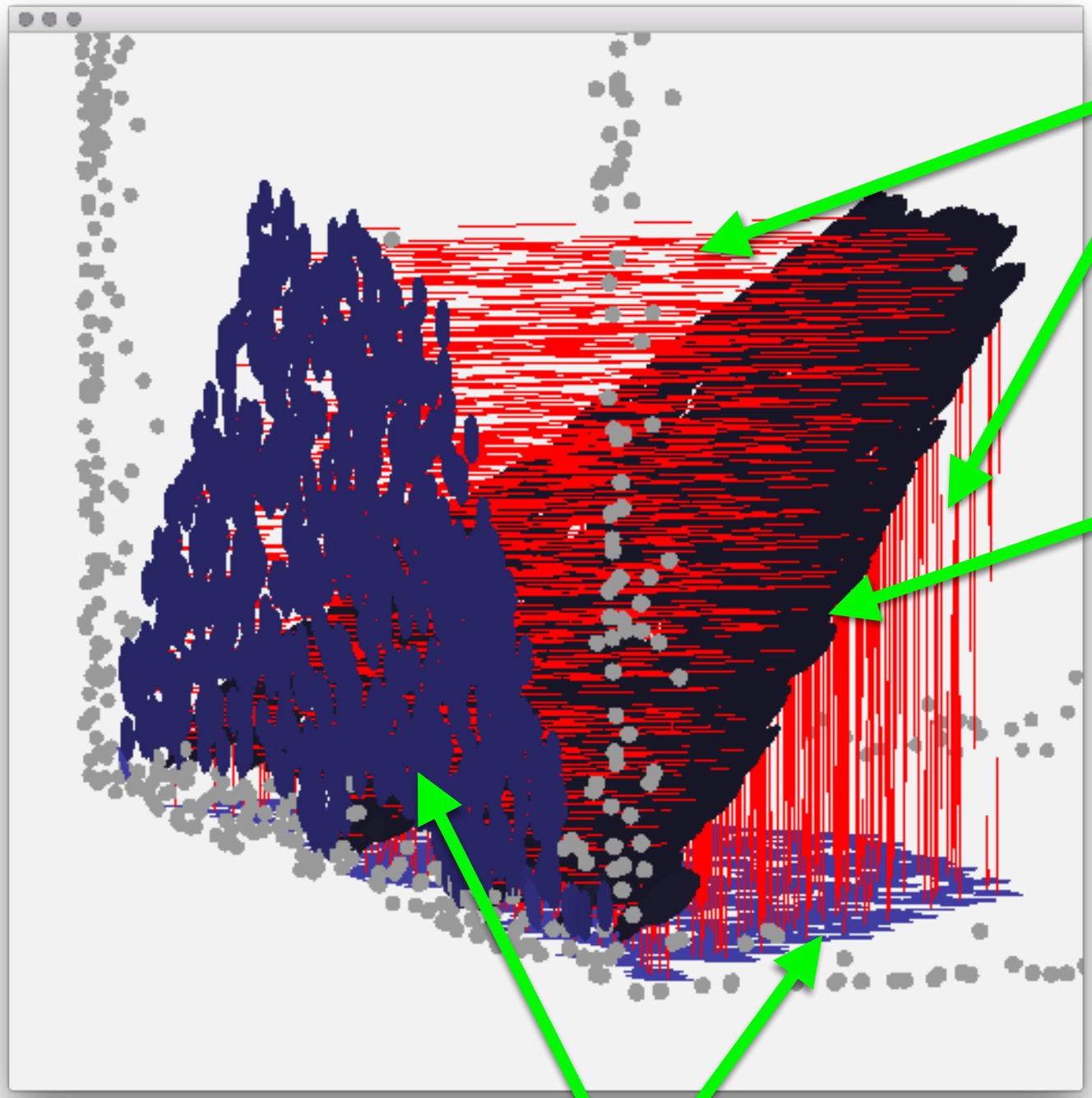
(b) Plan view of exterior skeleton sheets.

Object reconstruction





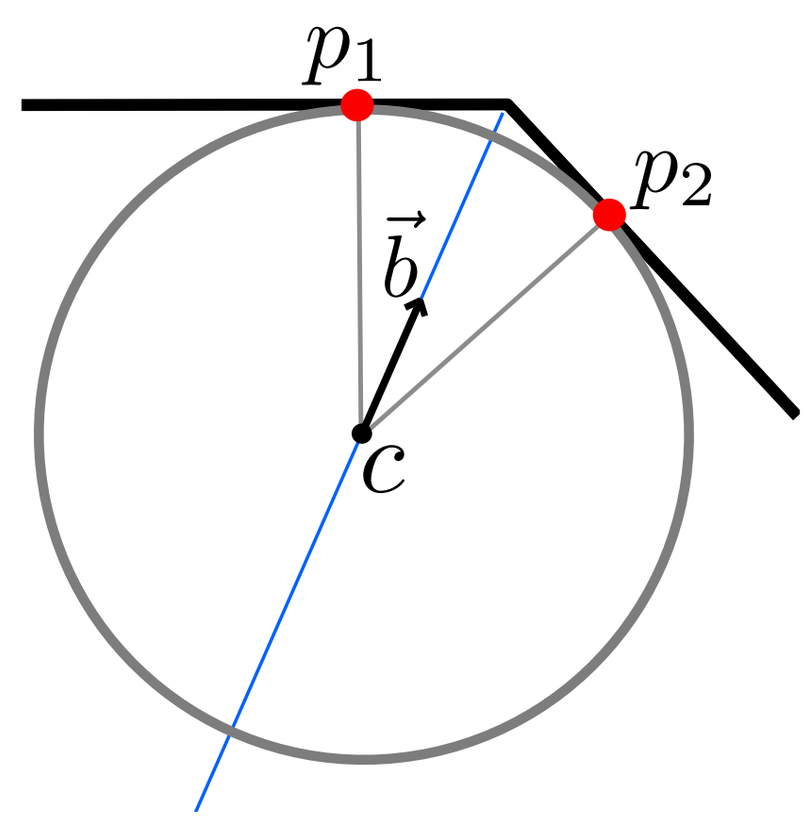
Object reconstruction

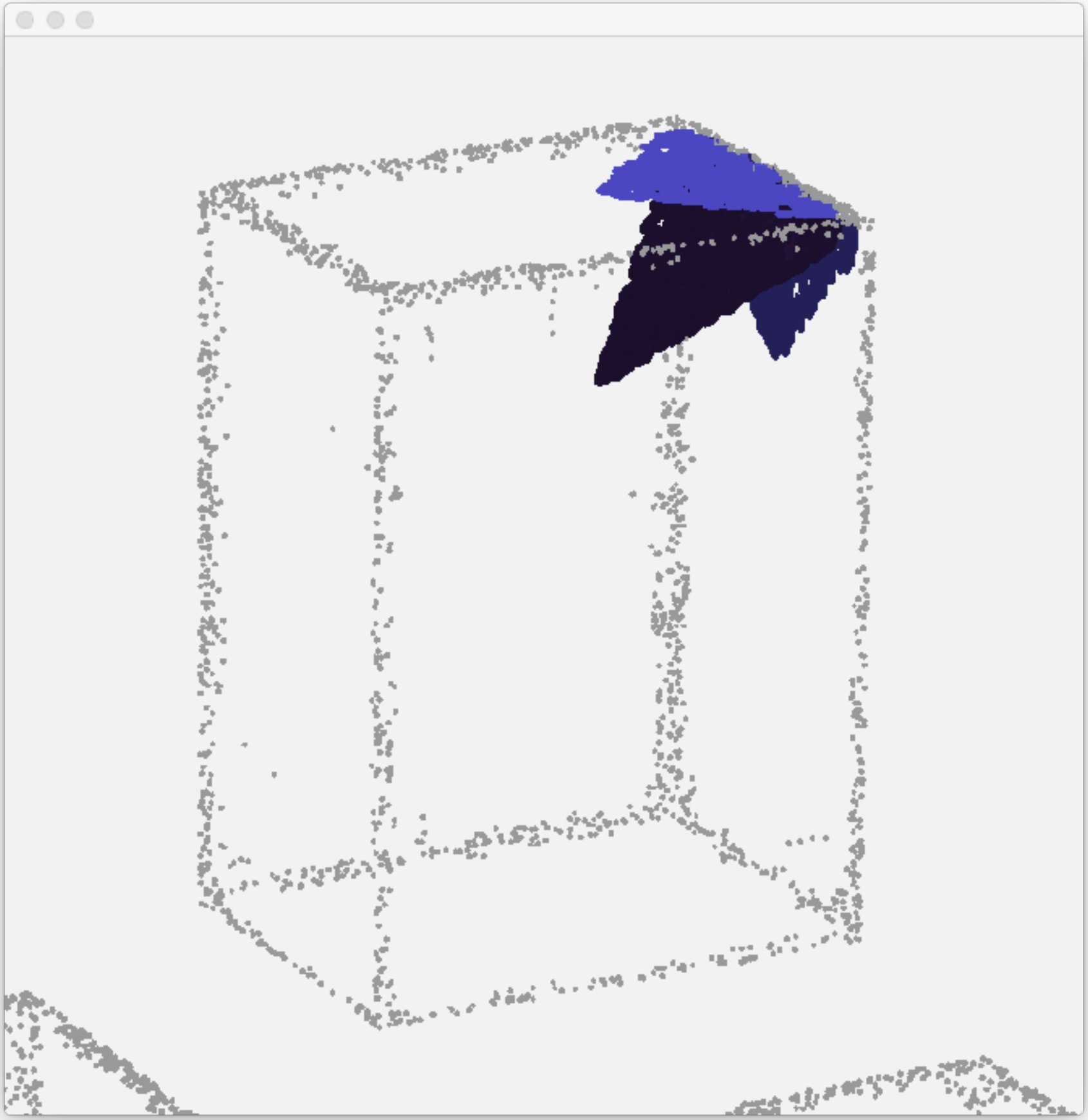


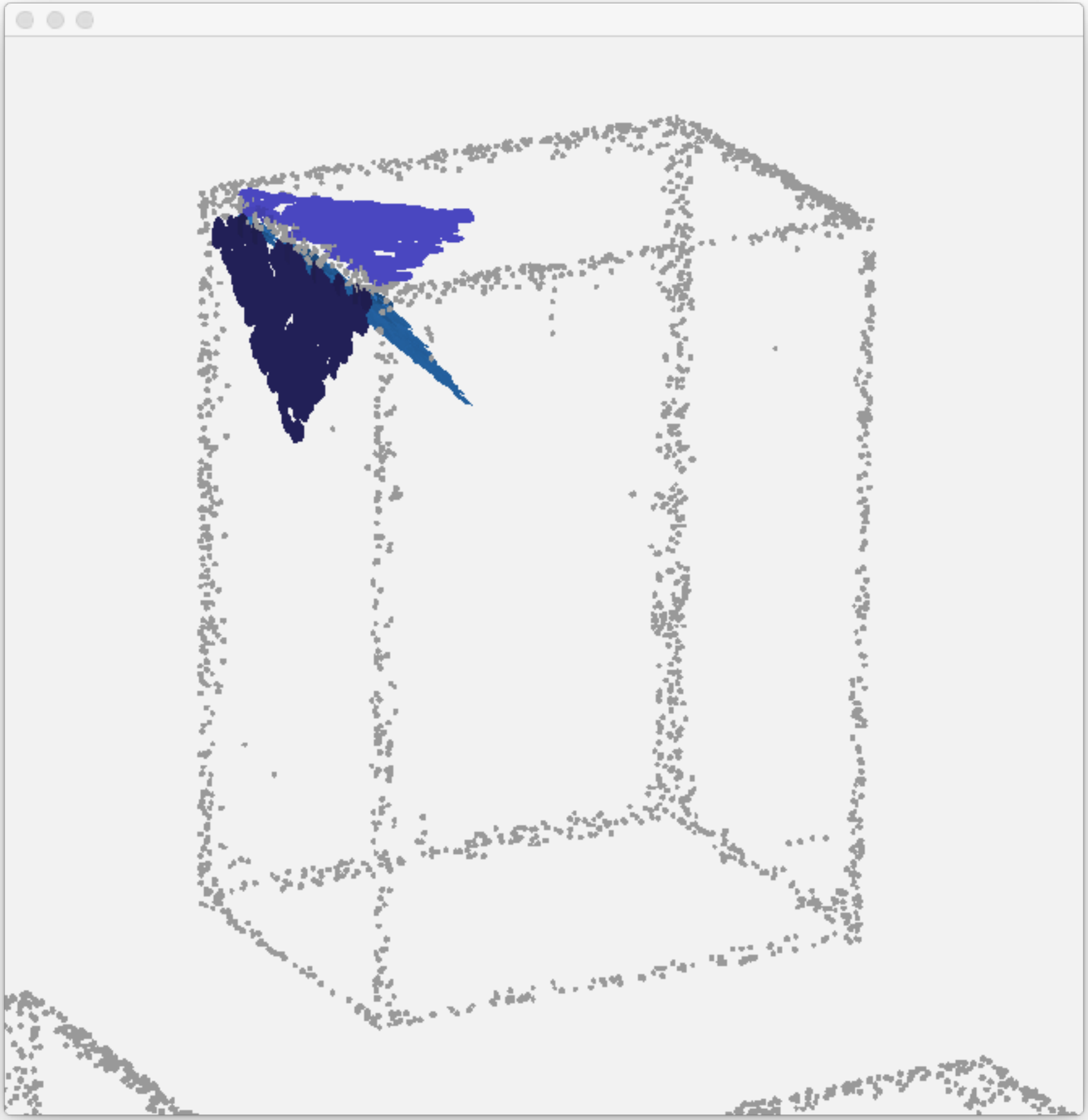
Spokes

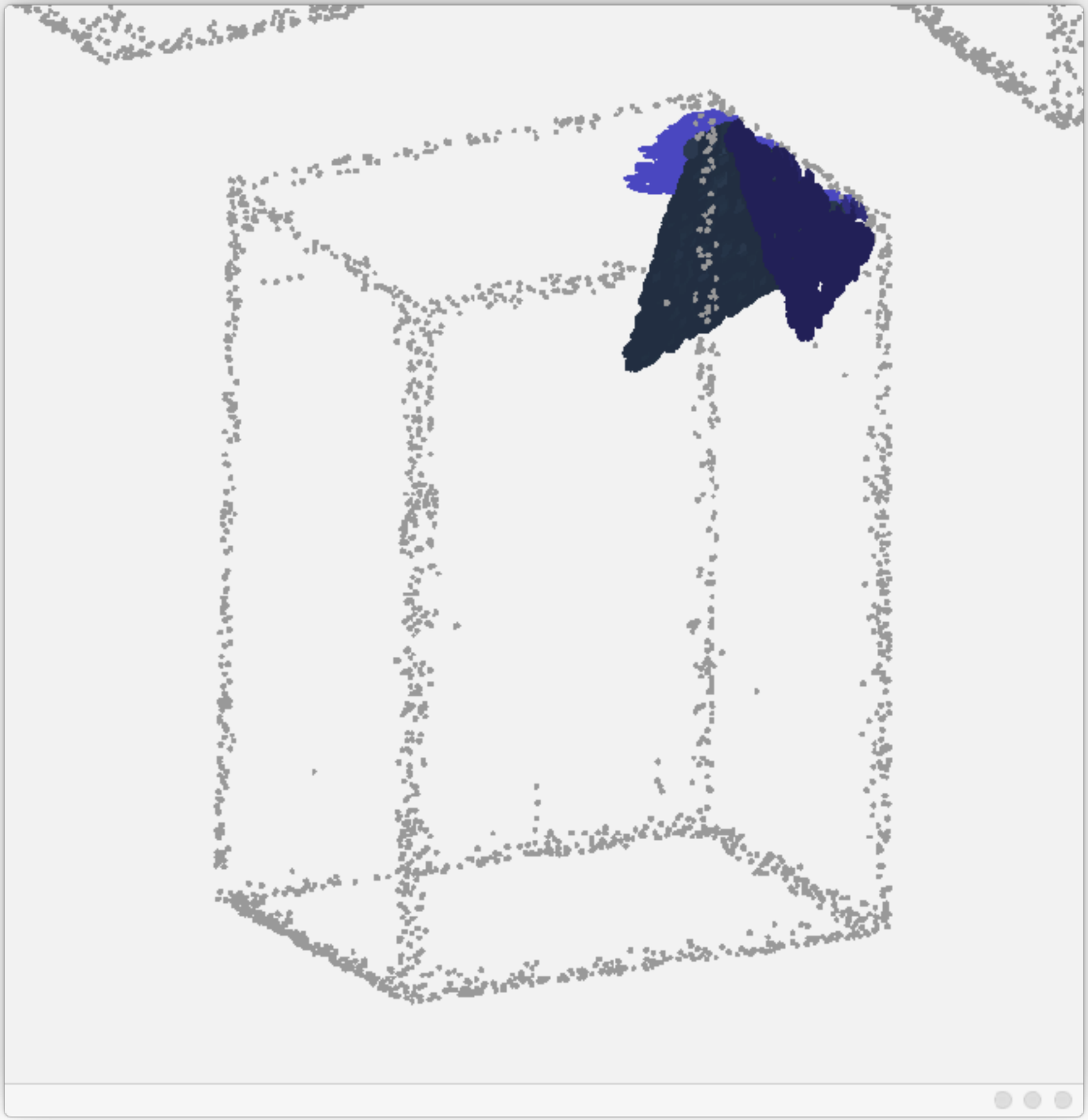
Medial sheet

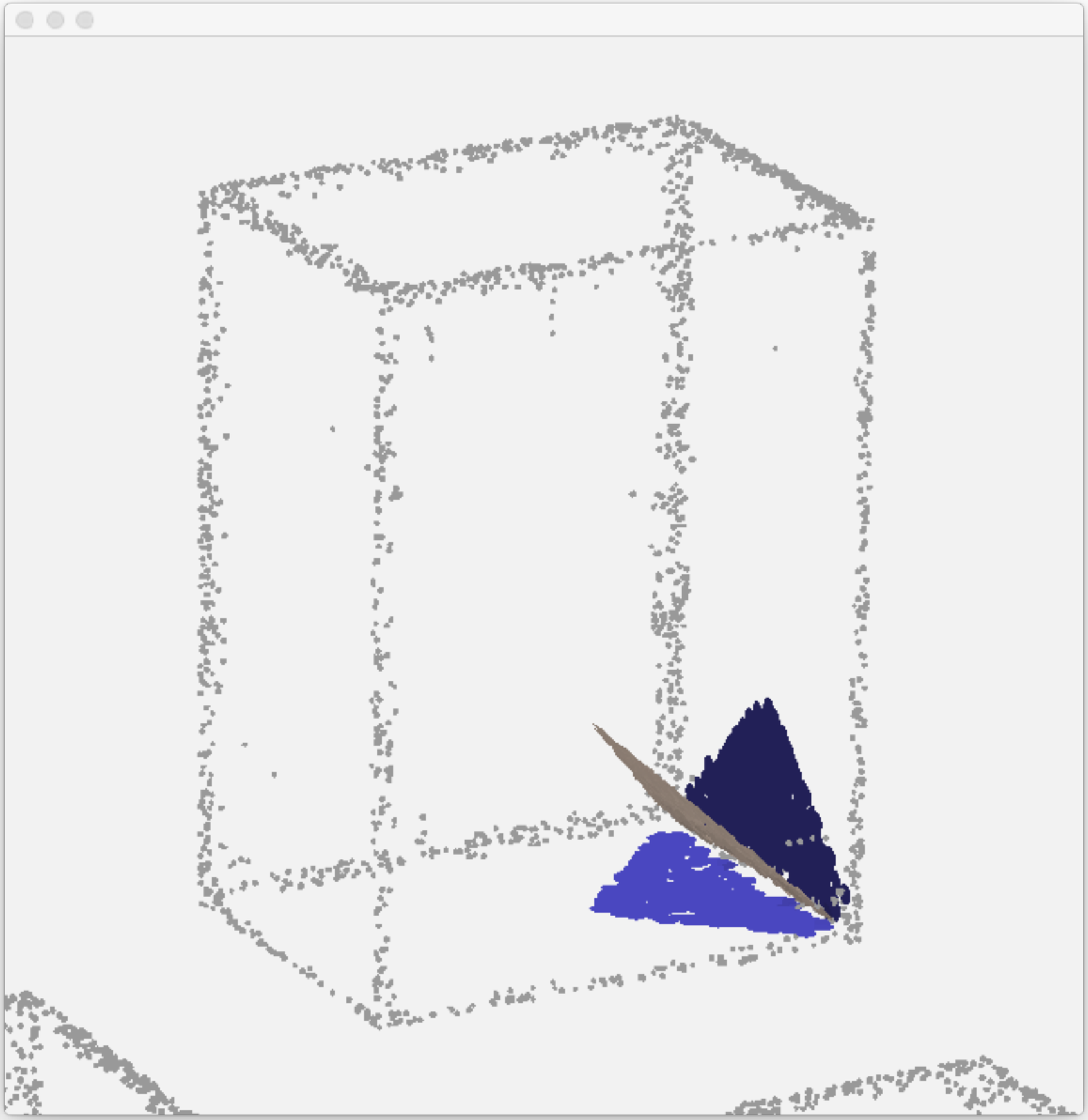
Surface points

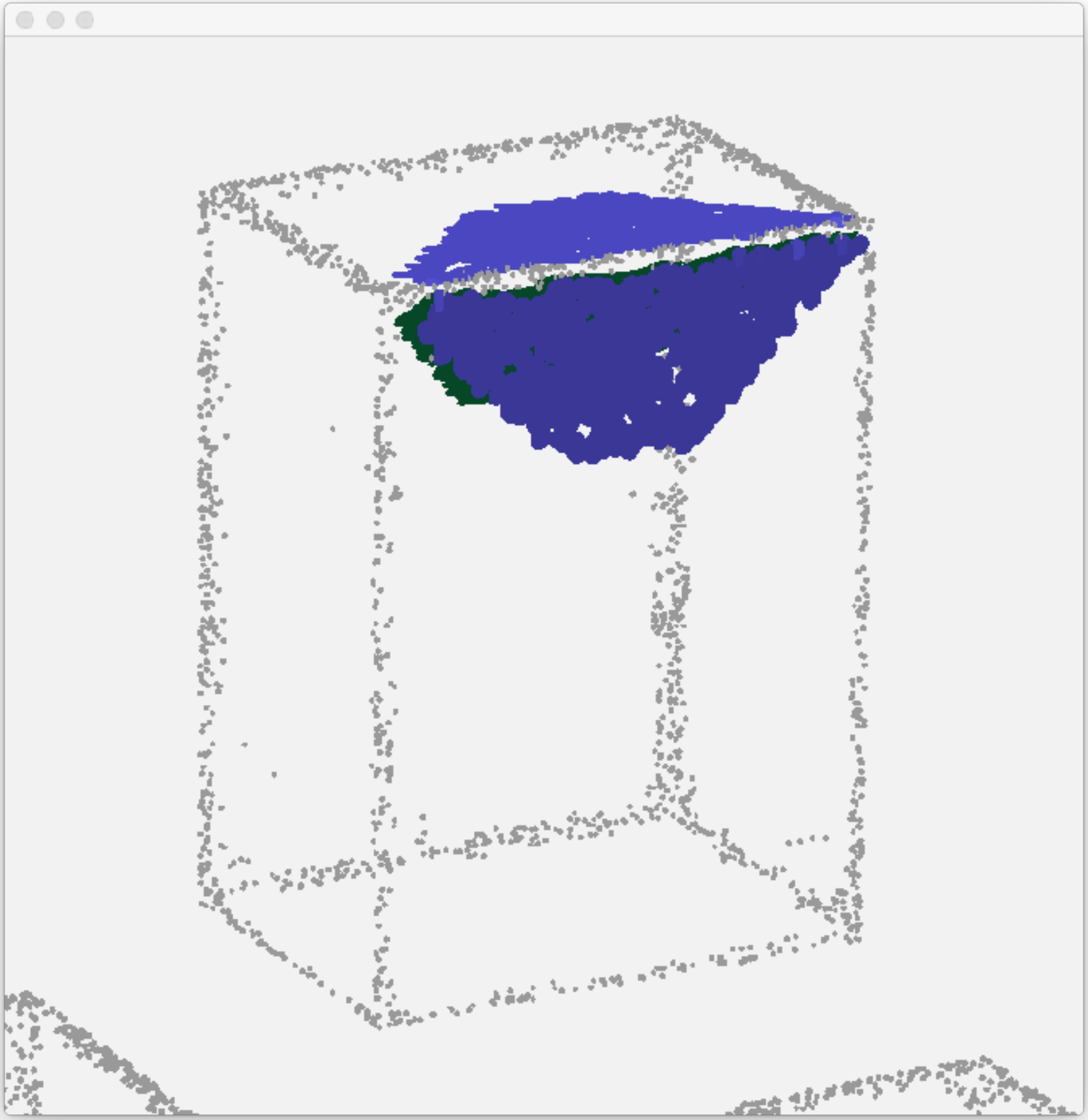


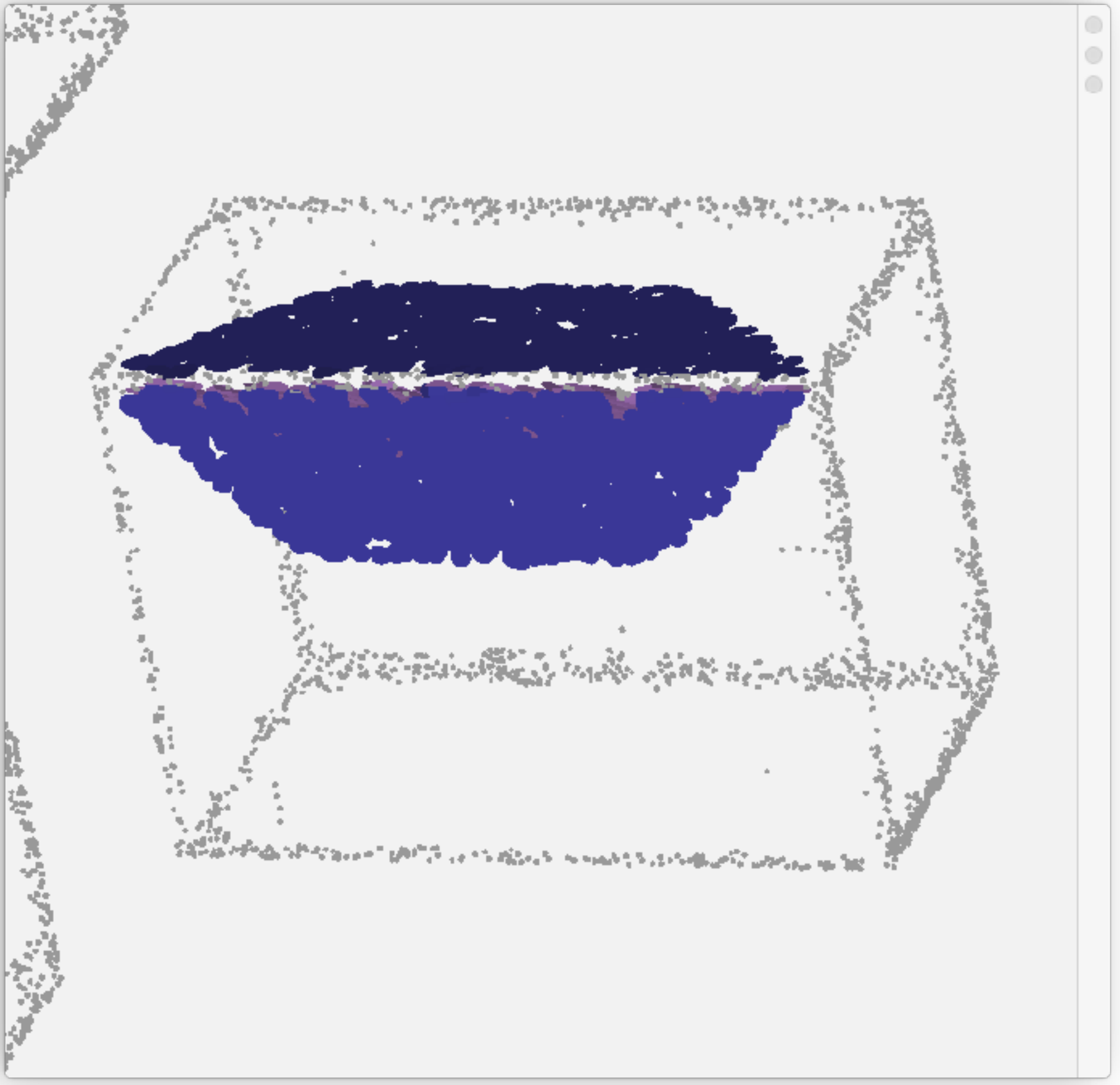


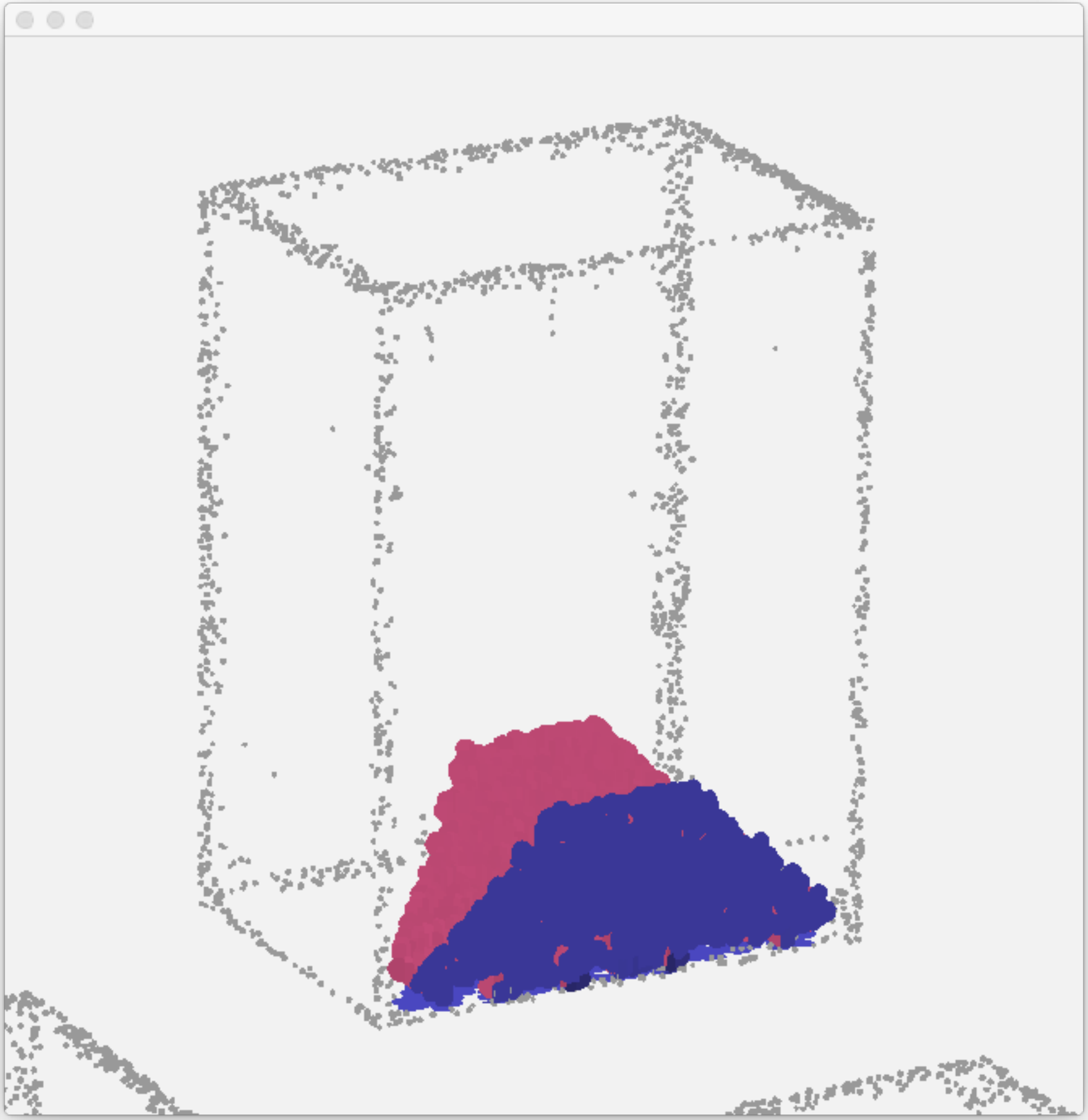


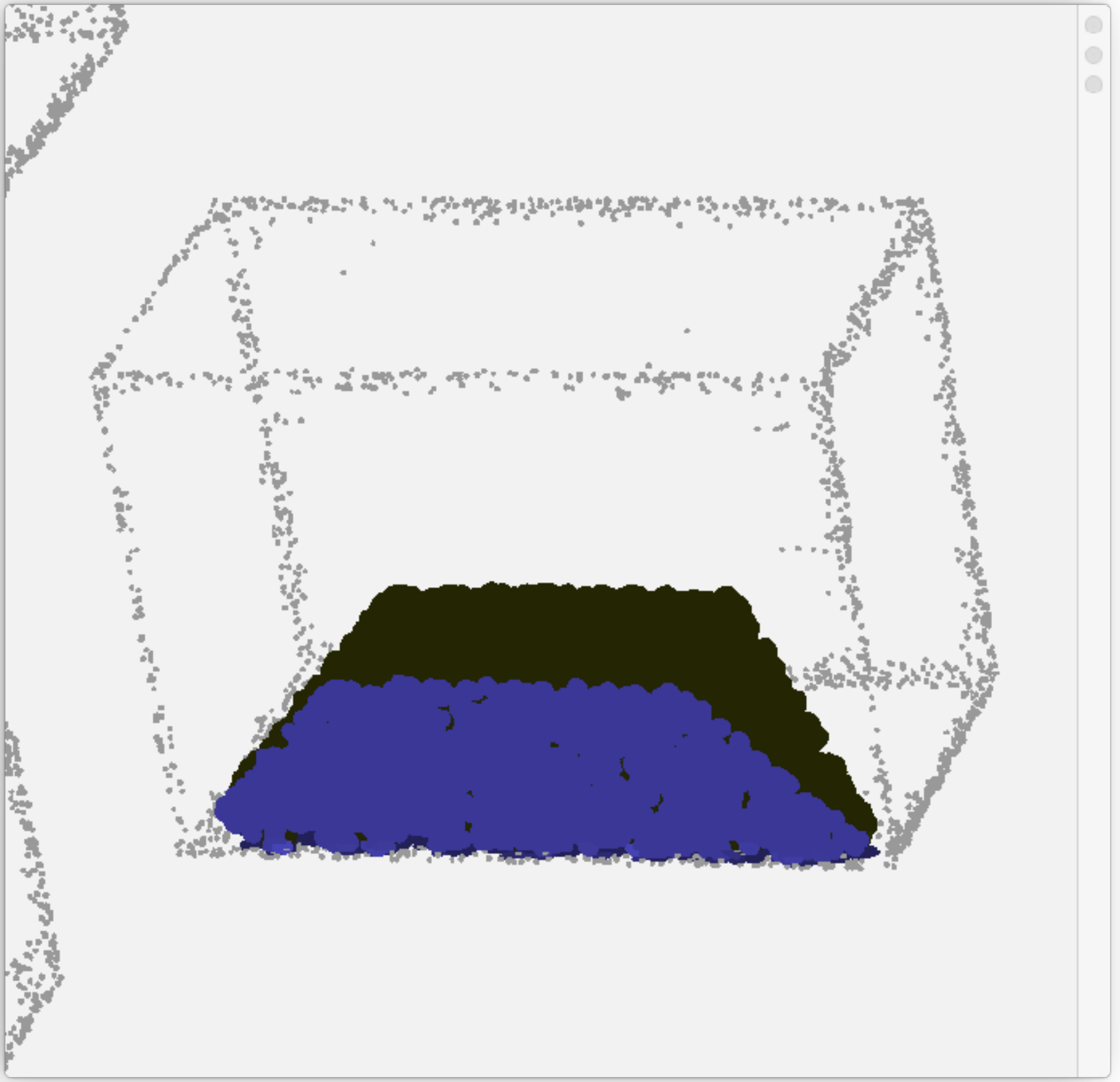


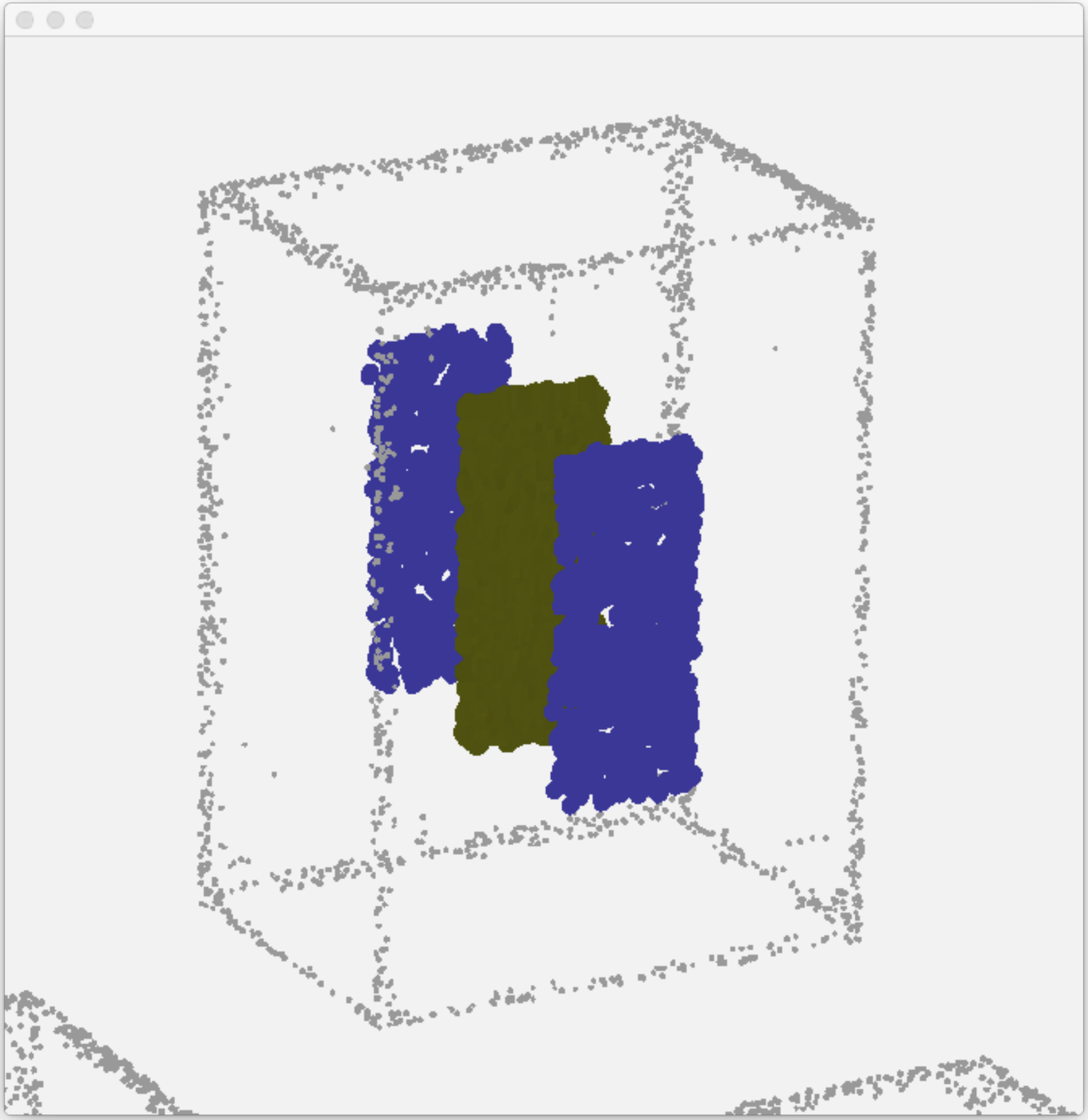










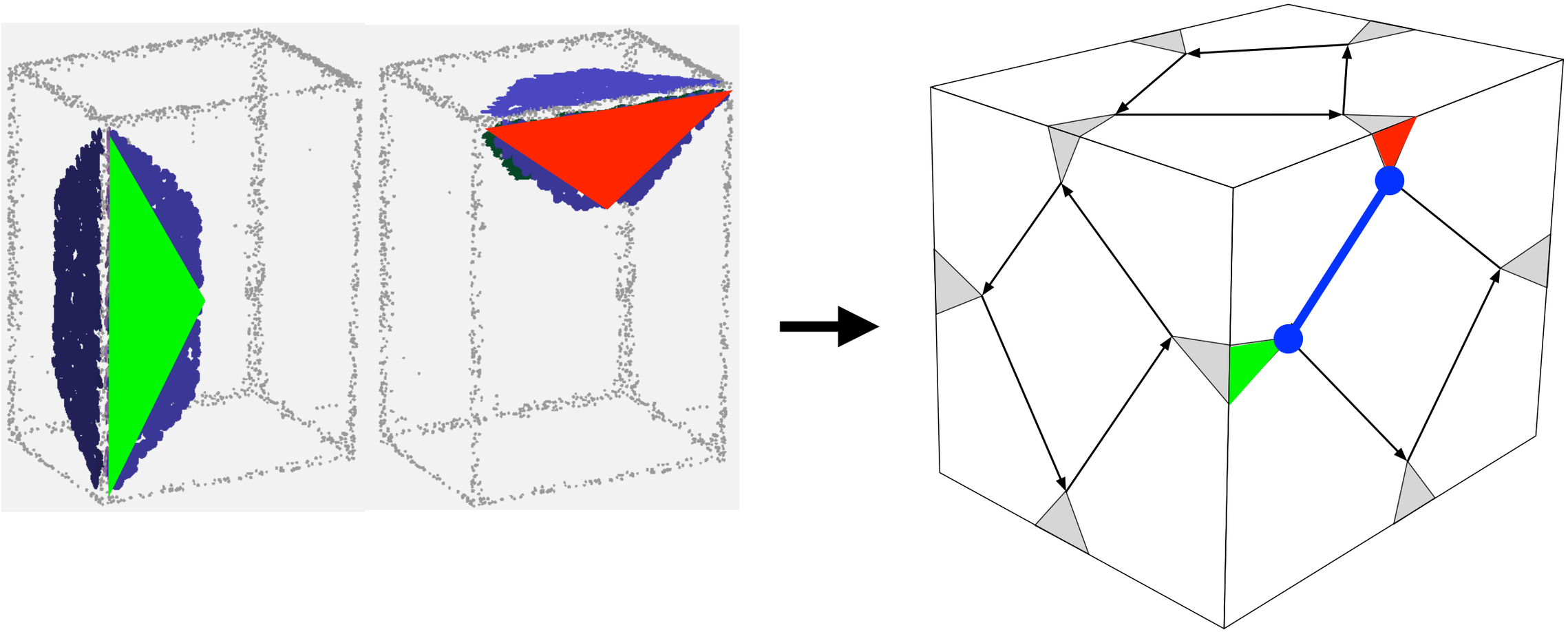


Medial Axis Polyhedral Map (MAP)

A datastructure that is '*dual*' to both
the **sheets of the MAT** and
the **faces of the polyhedron**.

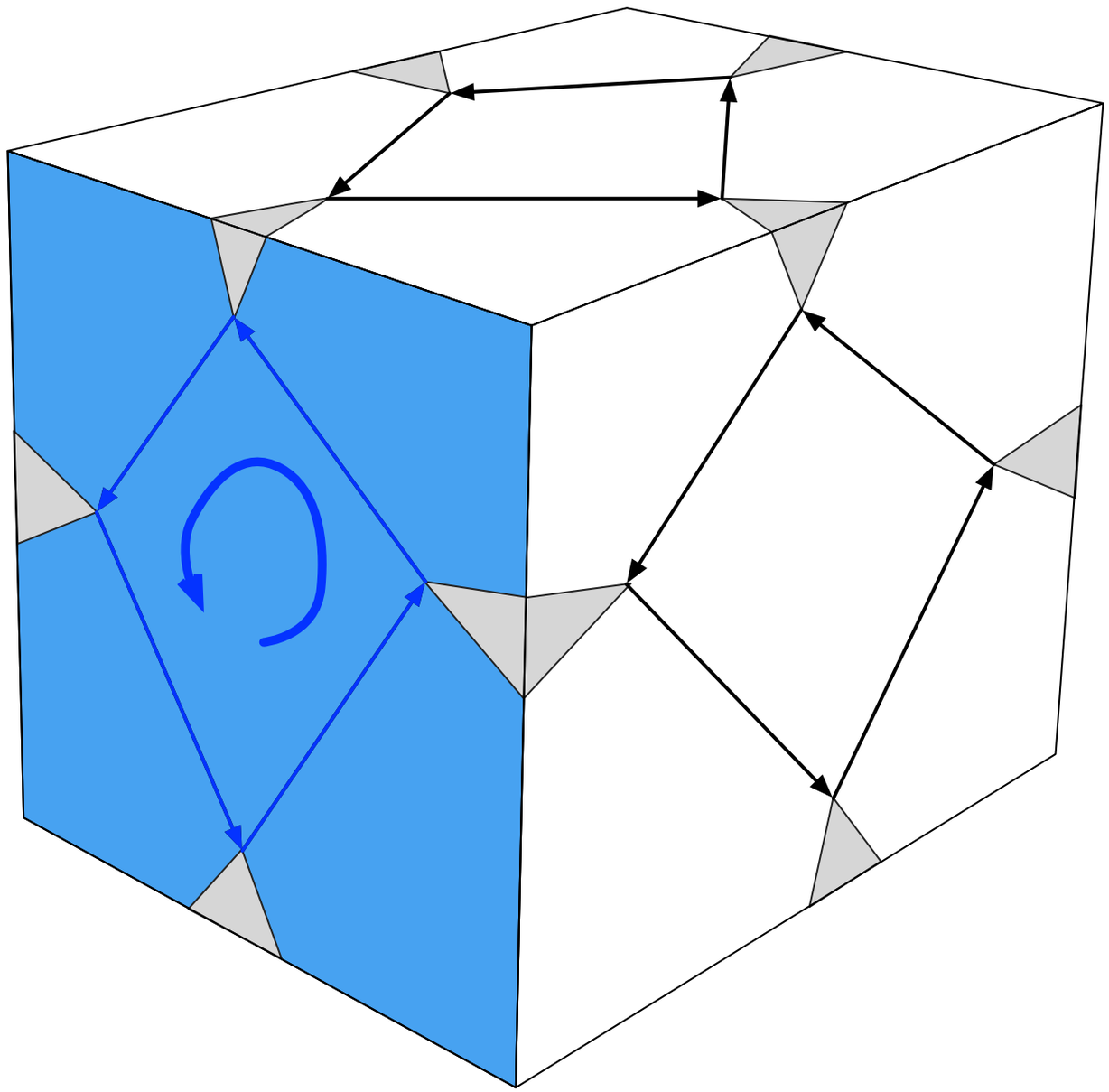
Thus mapping the MAT topology back to the surface

Constructing the MAP

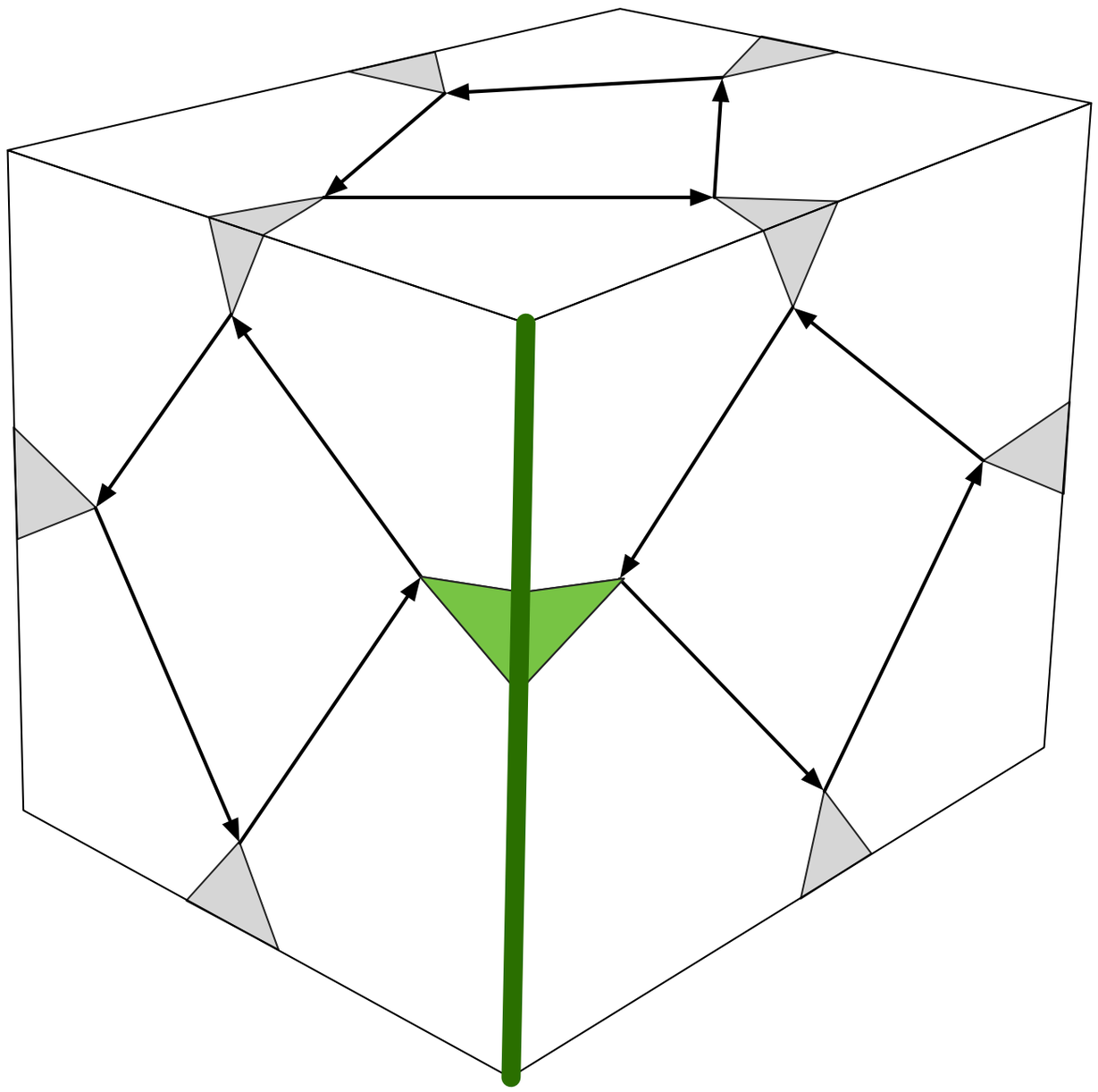


Connect half-nodes that support the same face

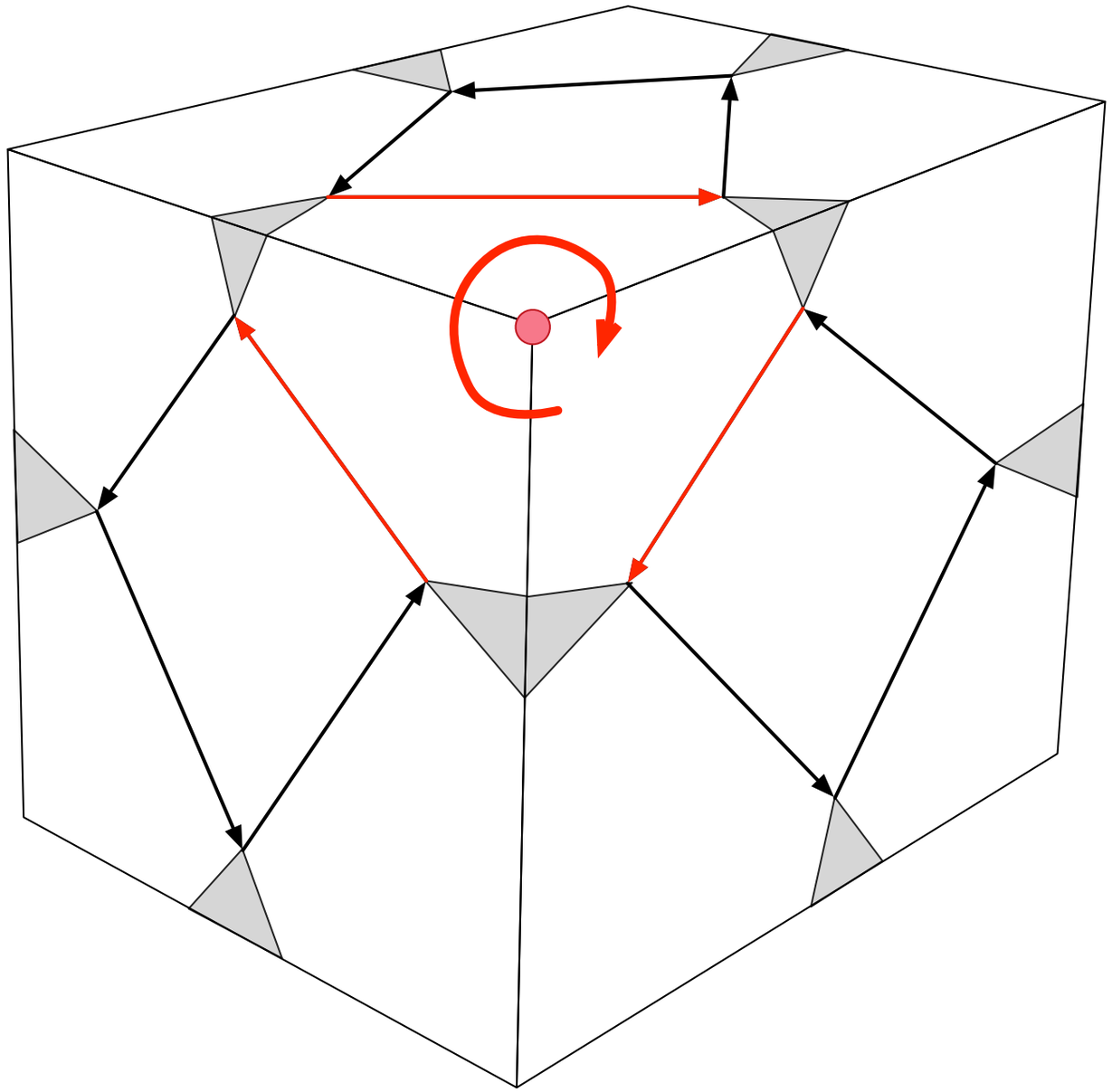
Object reconstruction: *planes*

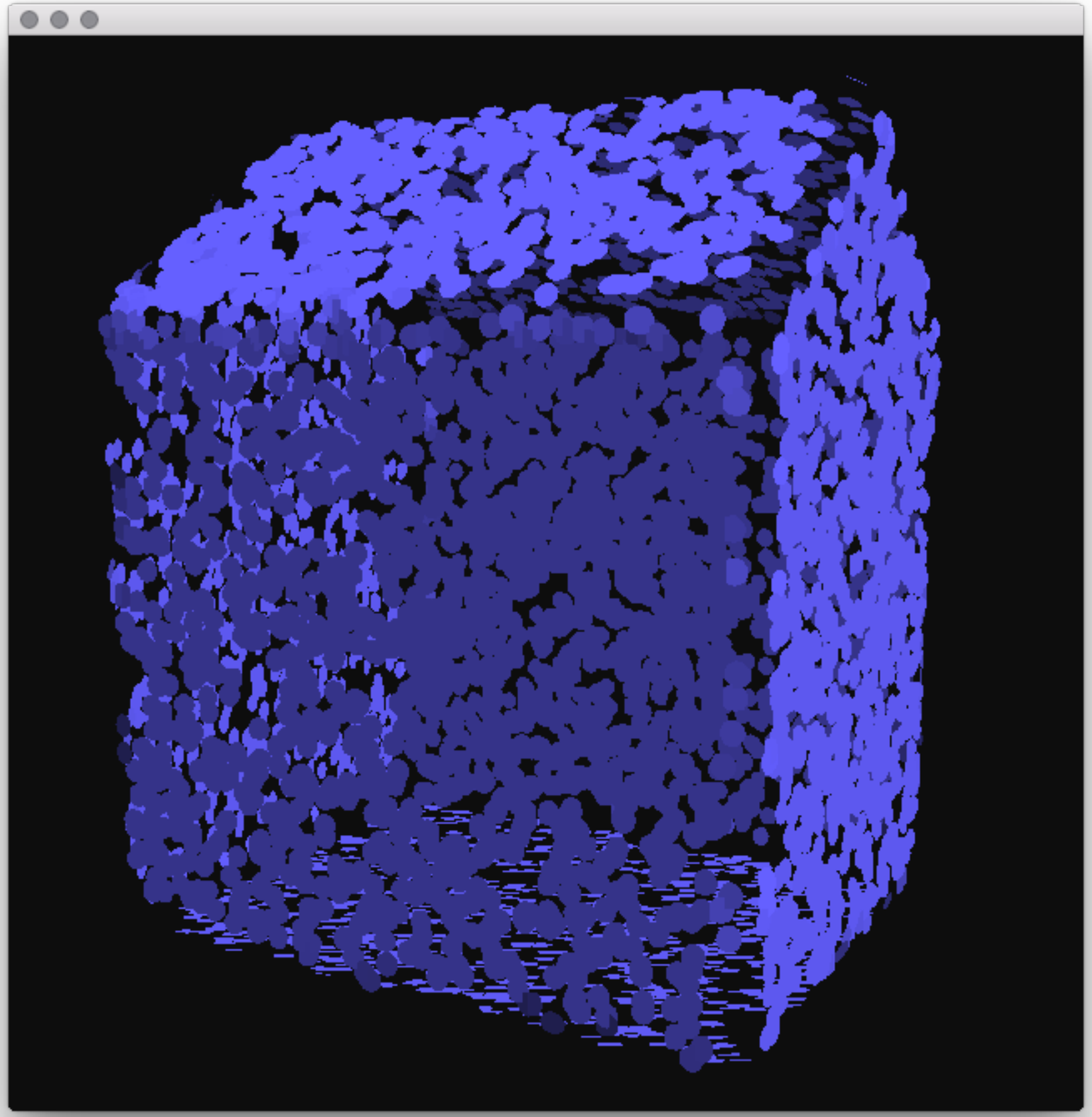


Object reconstruction: *edges*

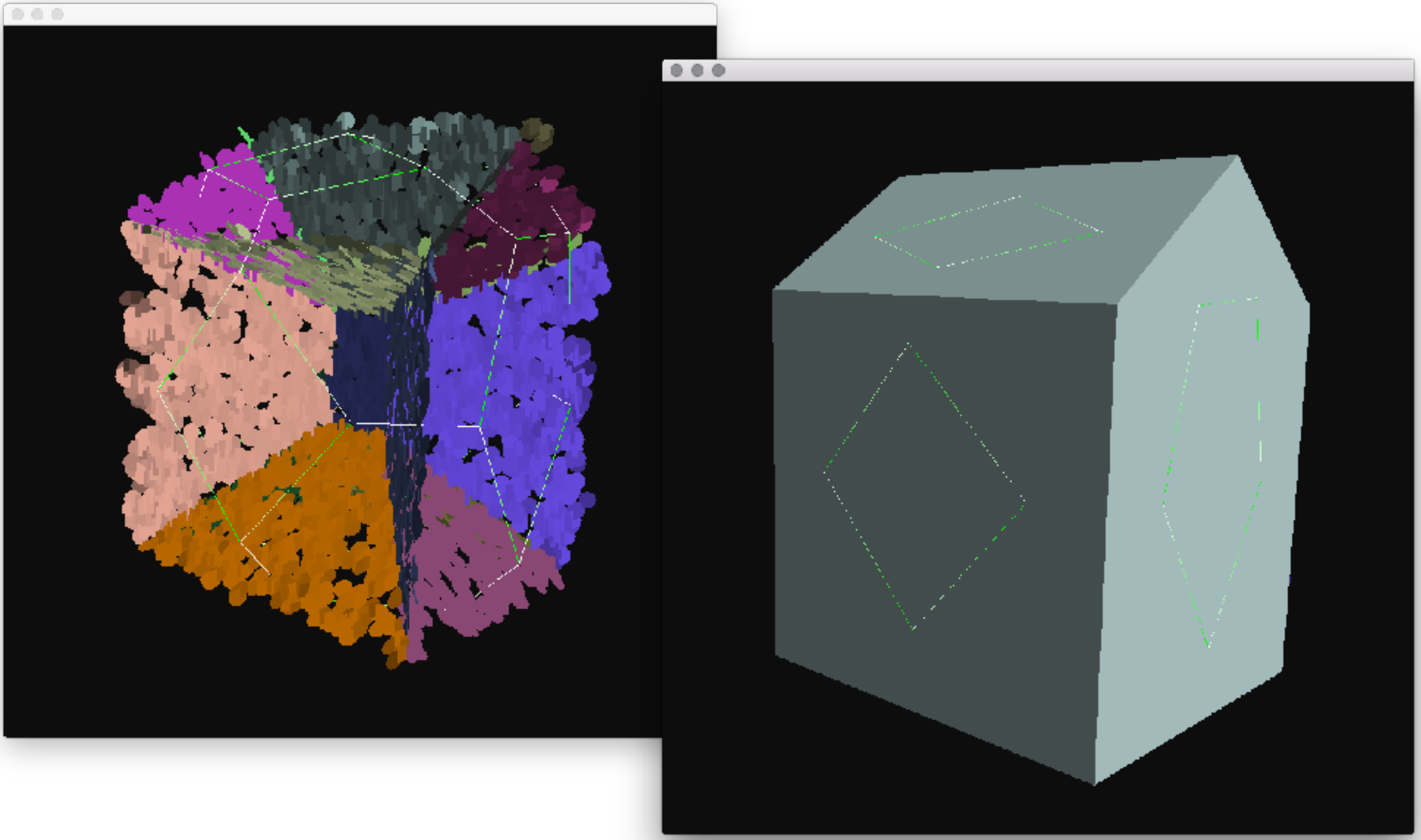


Object reconstruction: *vertices*





Example



Strengths

- works for every polyhedron
- no ‘footprints’ required
- plane fitting uses points that we know are on the plane (ie. high quality fit and no RANSAC needed)
- watertight surfaces
- correct face orientation (normals) for ‘free’

Limitations

- only works for polyhedra
- ideally *well-sampled* & fully *3D* surface point cloud needed
- current implementation only works for convex shapes

Conclusion & outlook

- theory is sound
- challenge lies in obtaining good MAP
- could be combined with graph matching approach

Thank you!