

Sharp Reconstruction of Building Geometry

Eric Turner

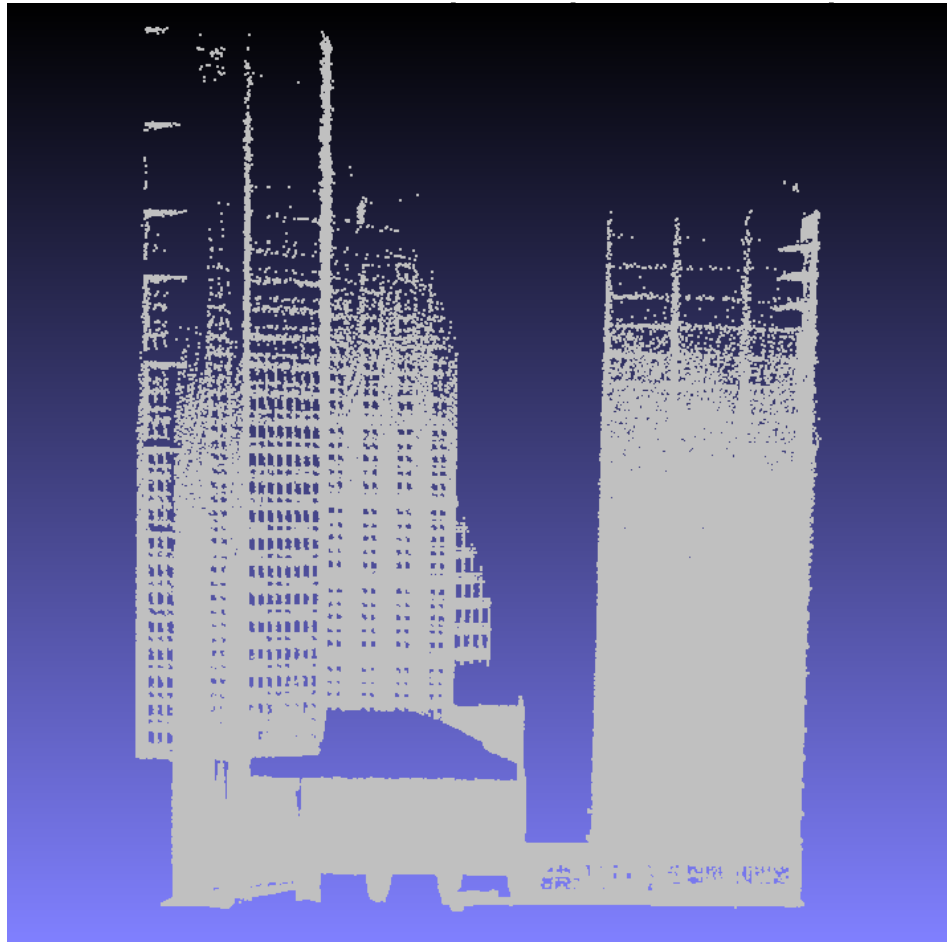
Avideh Zakhor

Video and Image Processing
Lab

University of California
Berkeley

Problem Statement

- Given scans of urban environments
 - Laser Range Data



Problem Statement

- Want to create 3D computer models
 - Centimeter-level accuracy
 - High Resolution Texture



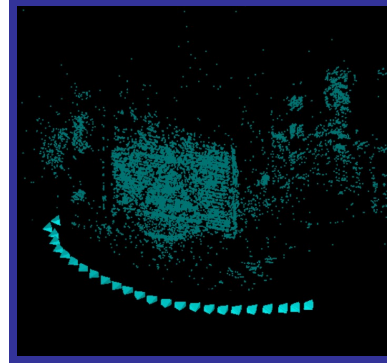
Overview

- Existing Approaches
- Input Scans
- Geometry Reconstruction
- Results

EXISTING Geometry

Reconstruction

- Geometry reconstruction is **not a new problem**



fountain-R25

, Strecha et al, CVPR

- Stationary** scanning can yield **excellent** results



Alexa et al. 2003



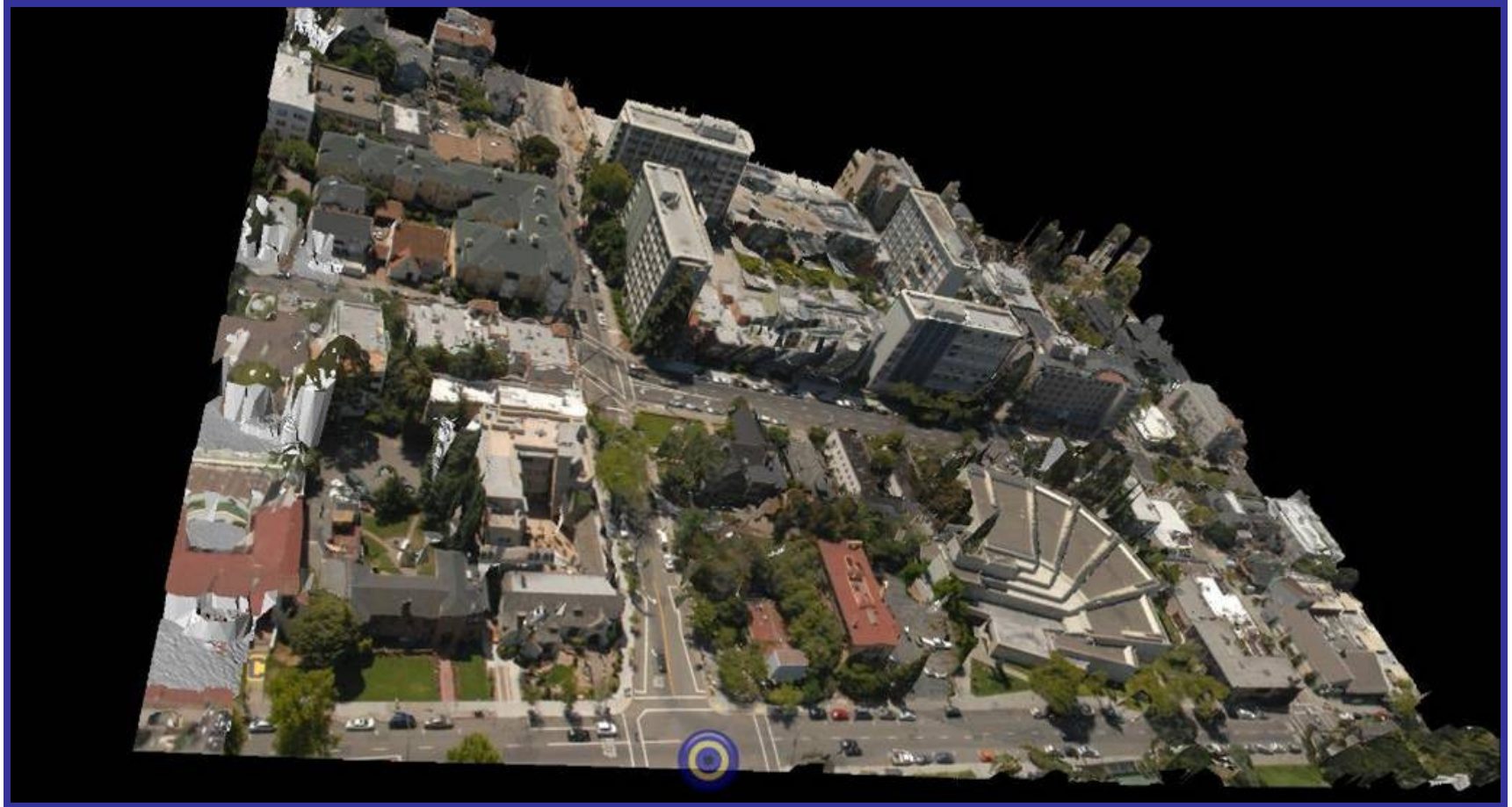
Digital Michelangelo Project



Turk and Levoy, 1994

Existing Urban Modeling VIP Lab

- Aerial Range Data



Scan Input

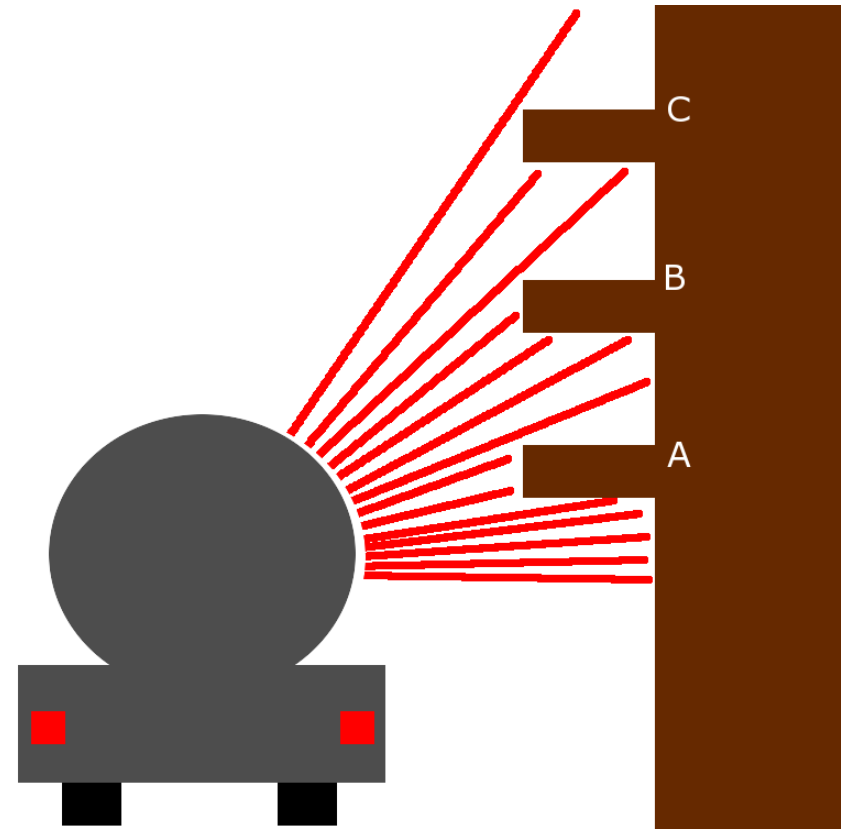
- **Street-Level LiDAR**
 - High density point-cloud
 - High resolution photography
 - **Limited viewing of environment**



Photos courtesy of gizmodo.com

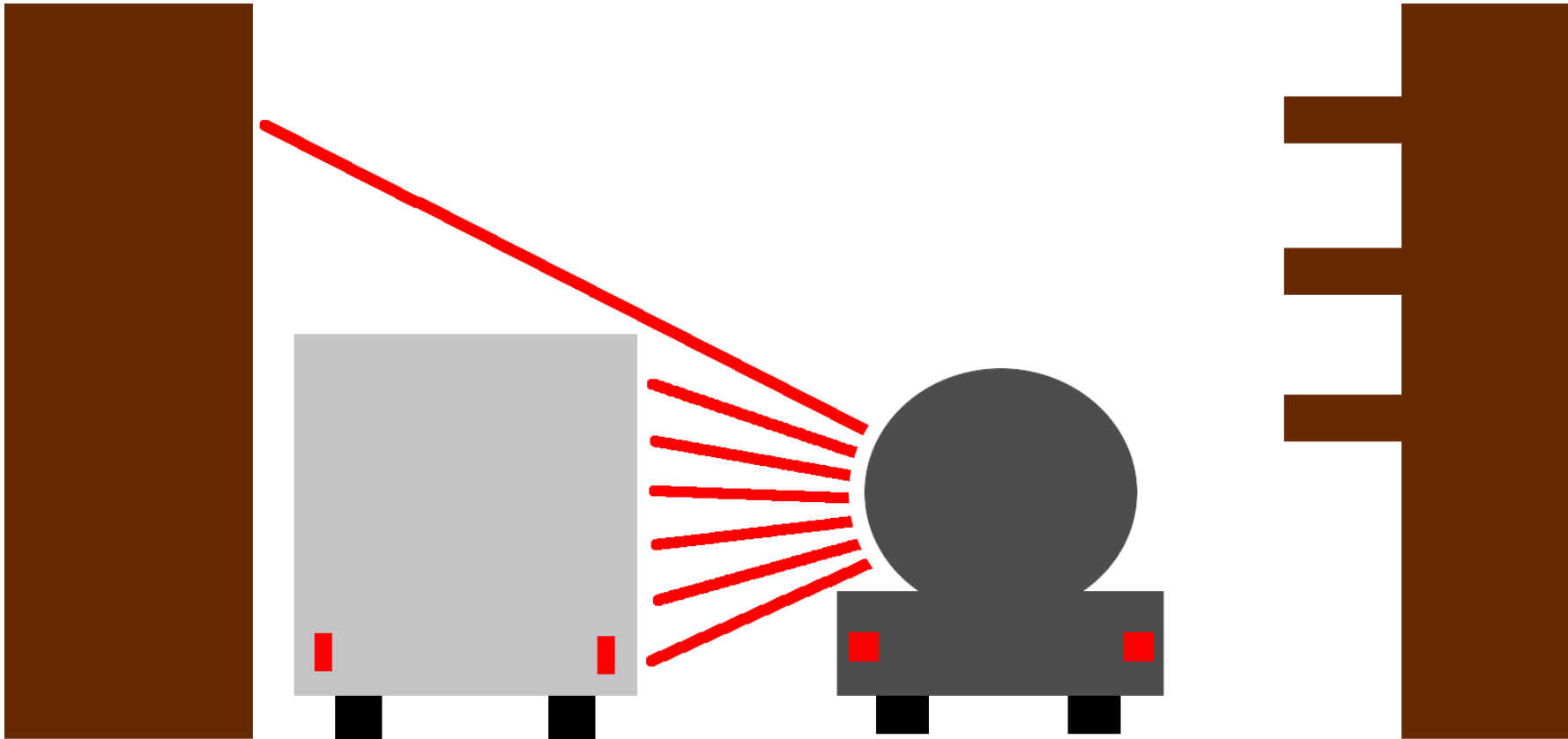
Street-Level Scanning

- Occlusion concerns



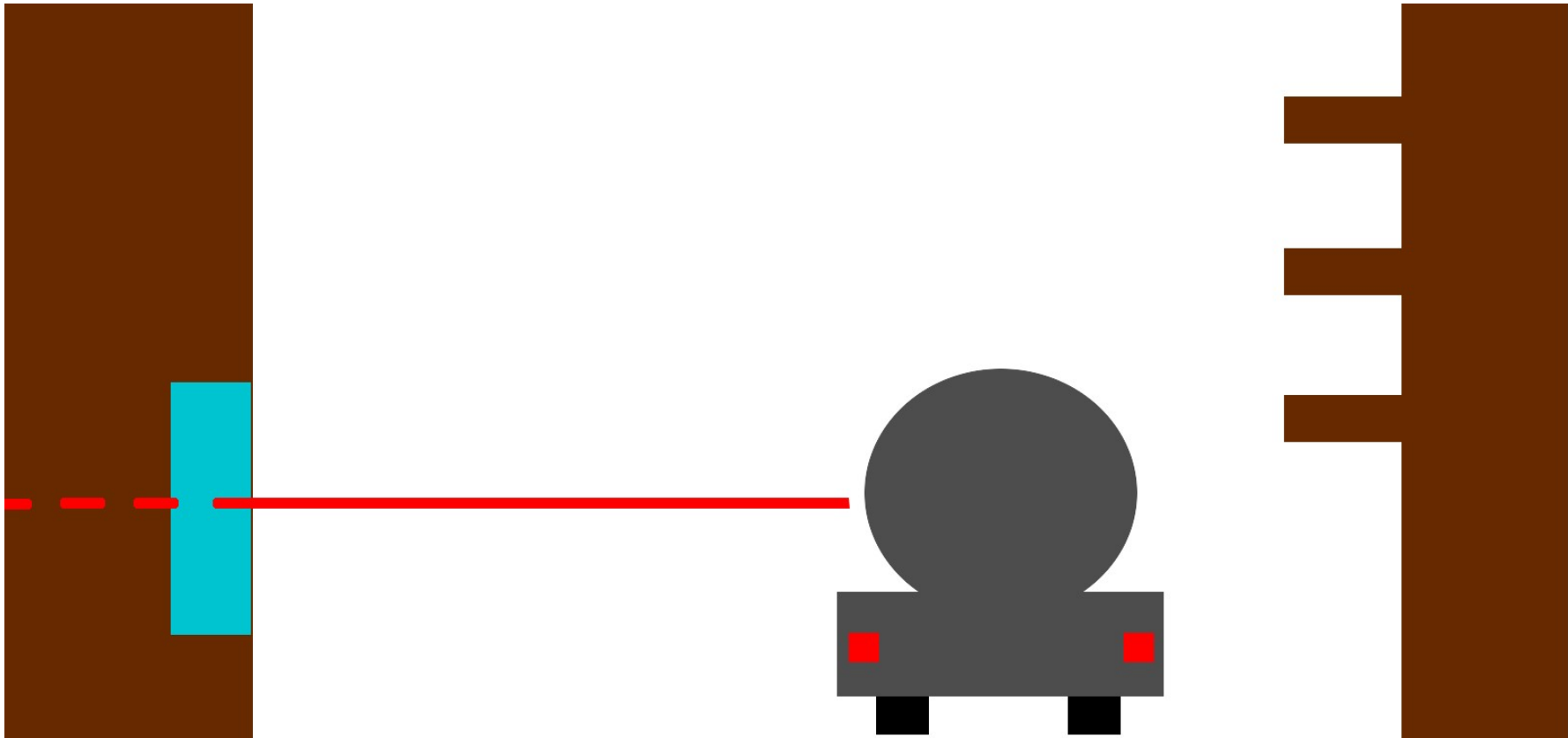
Street-Level Scanning

- Occlusion concerns



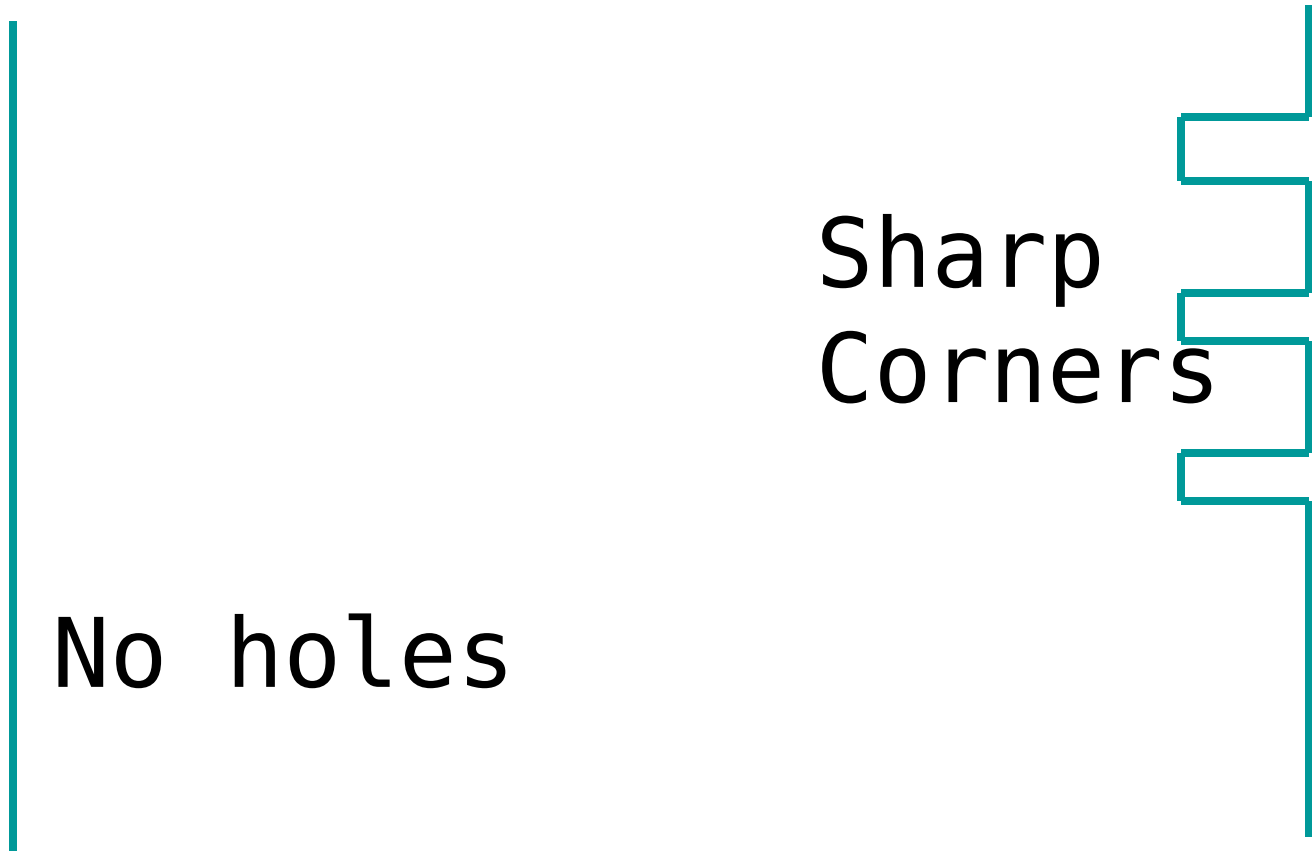
Street-Level Scanning

- Window concerns



Street-Level Scanning

- Desired Model



Input Photograph



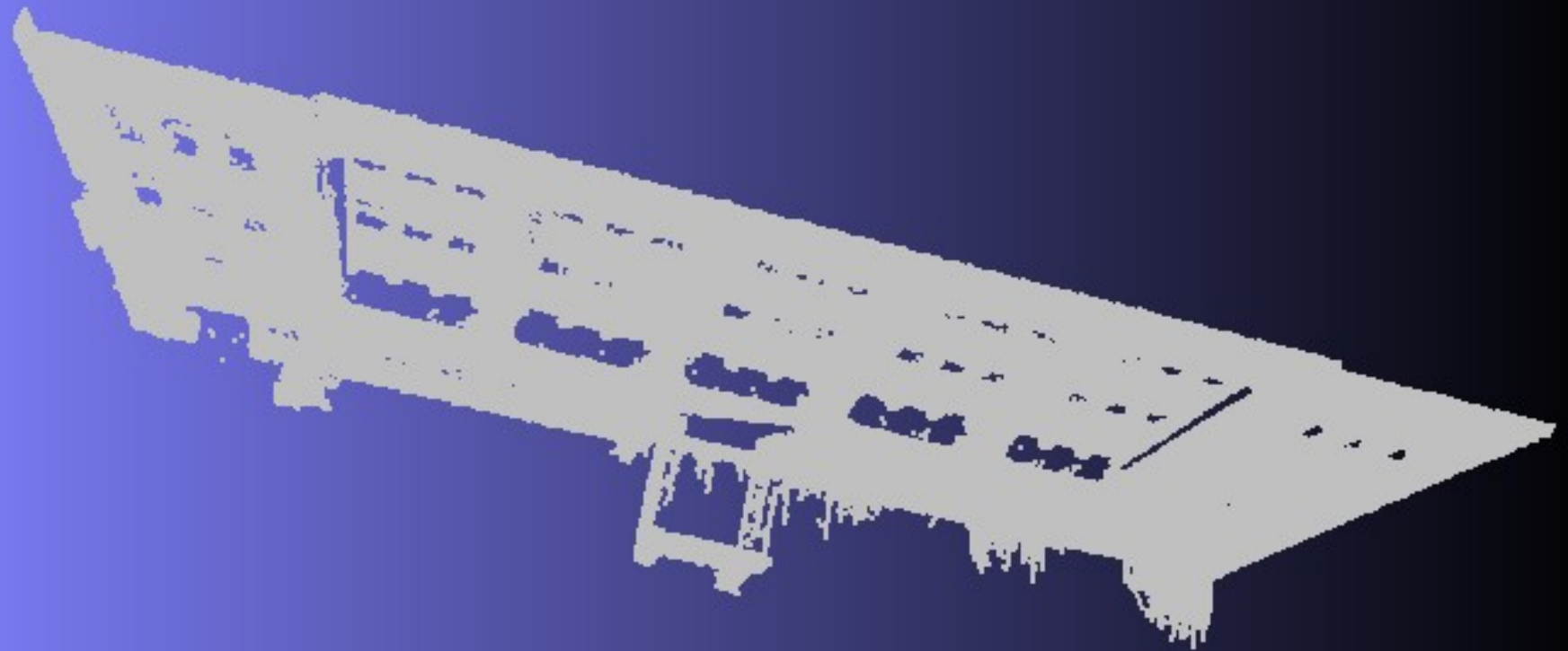
Input Point-Cloud



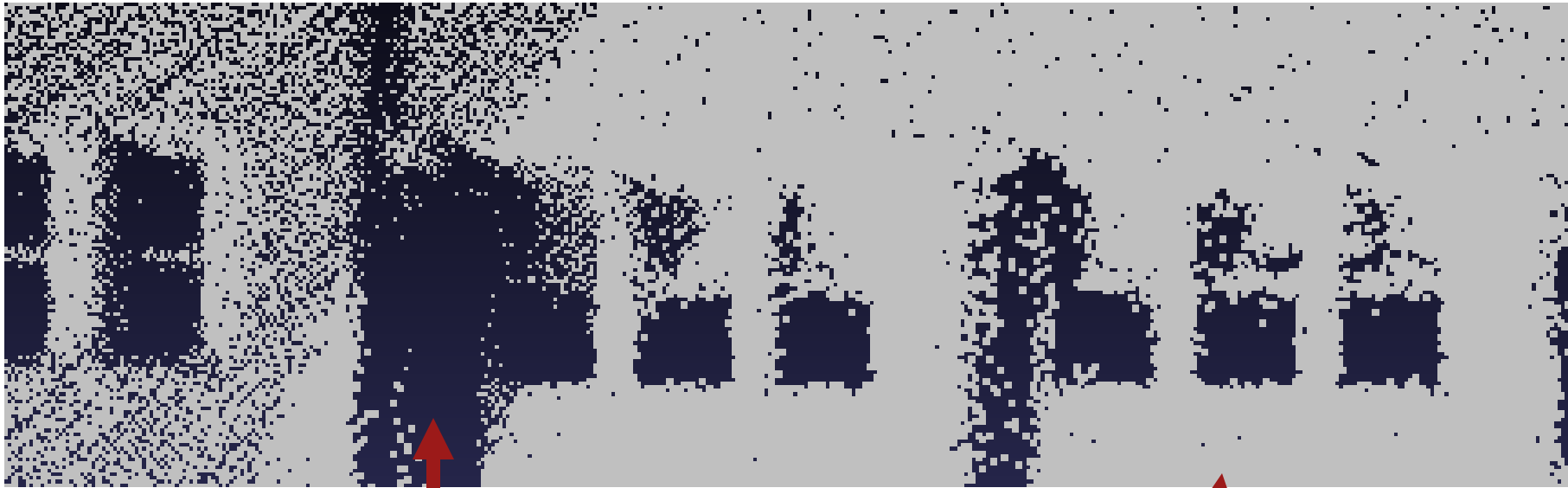
Input Building Façade



Input Building Façade (Top)



Point-cloud Resampling



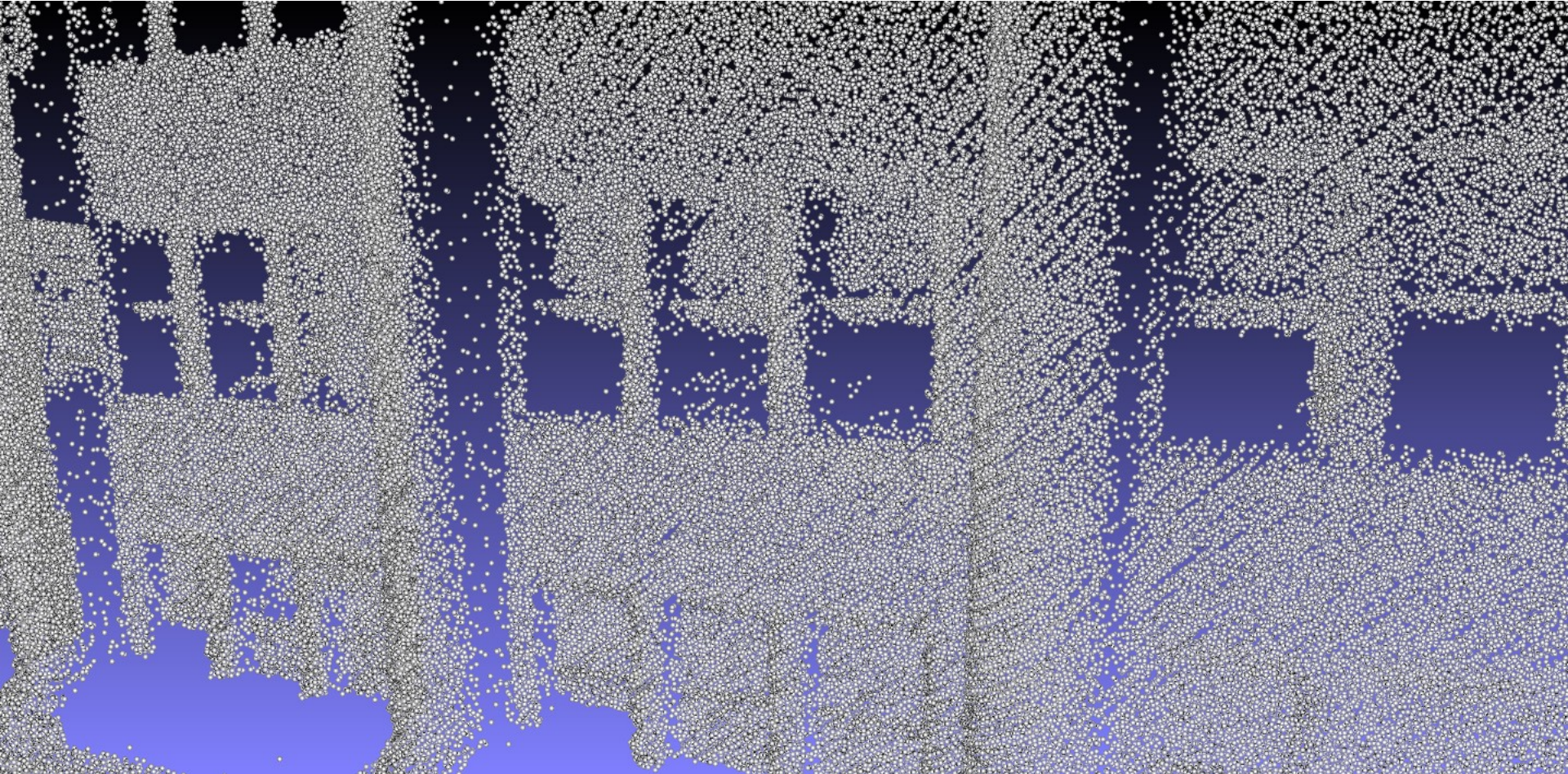
Areas of *undersampling*
~~Noisy~~ *oversampling*



Uniformly resample

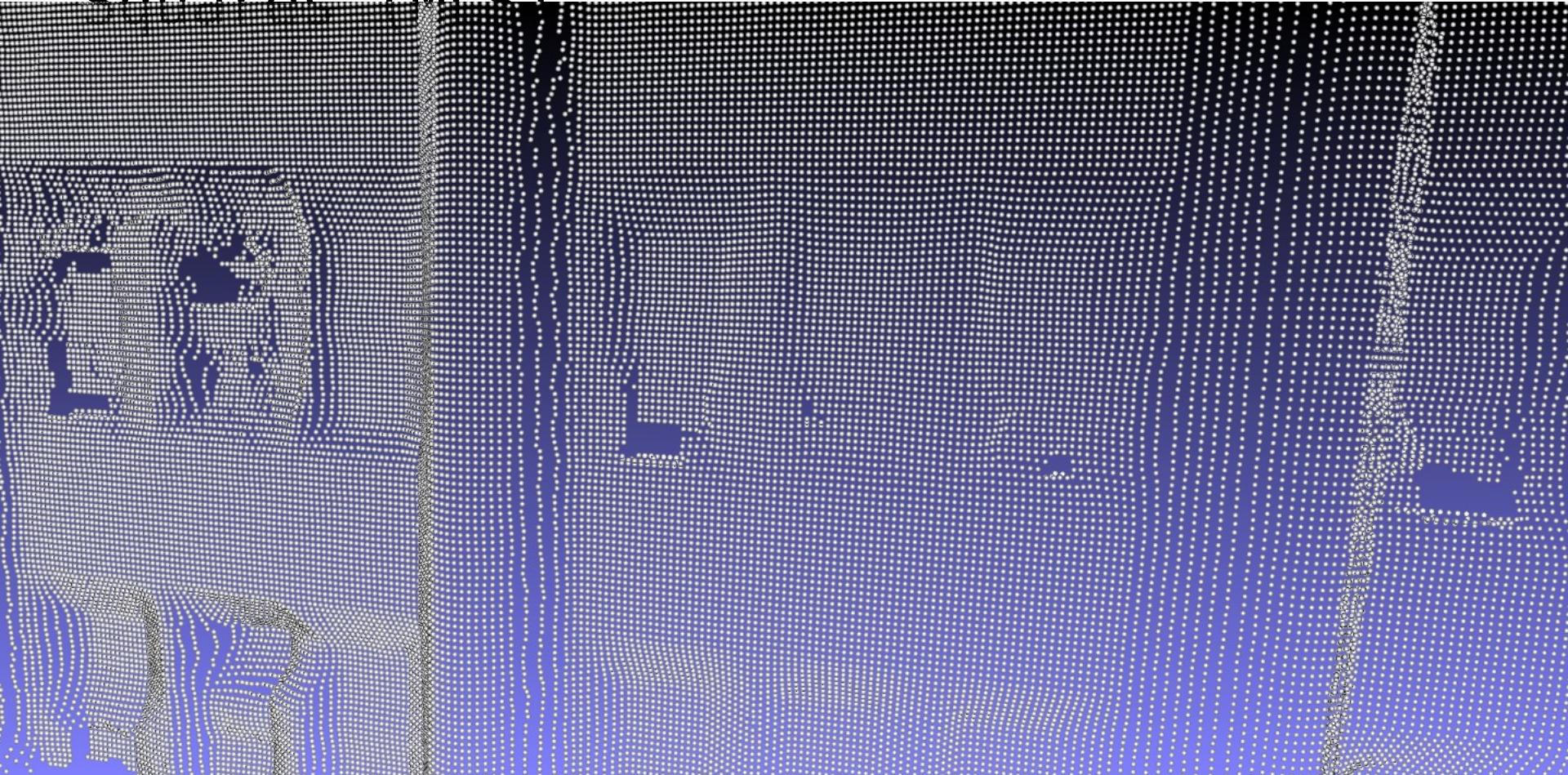
Point-cloud Resampling

- Original Points



Point-cloud Resampling

- Grid Resampled using Moving Least-Squares (MLS)

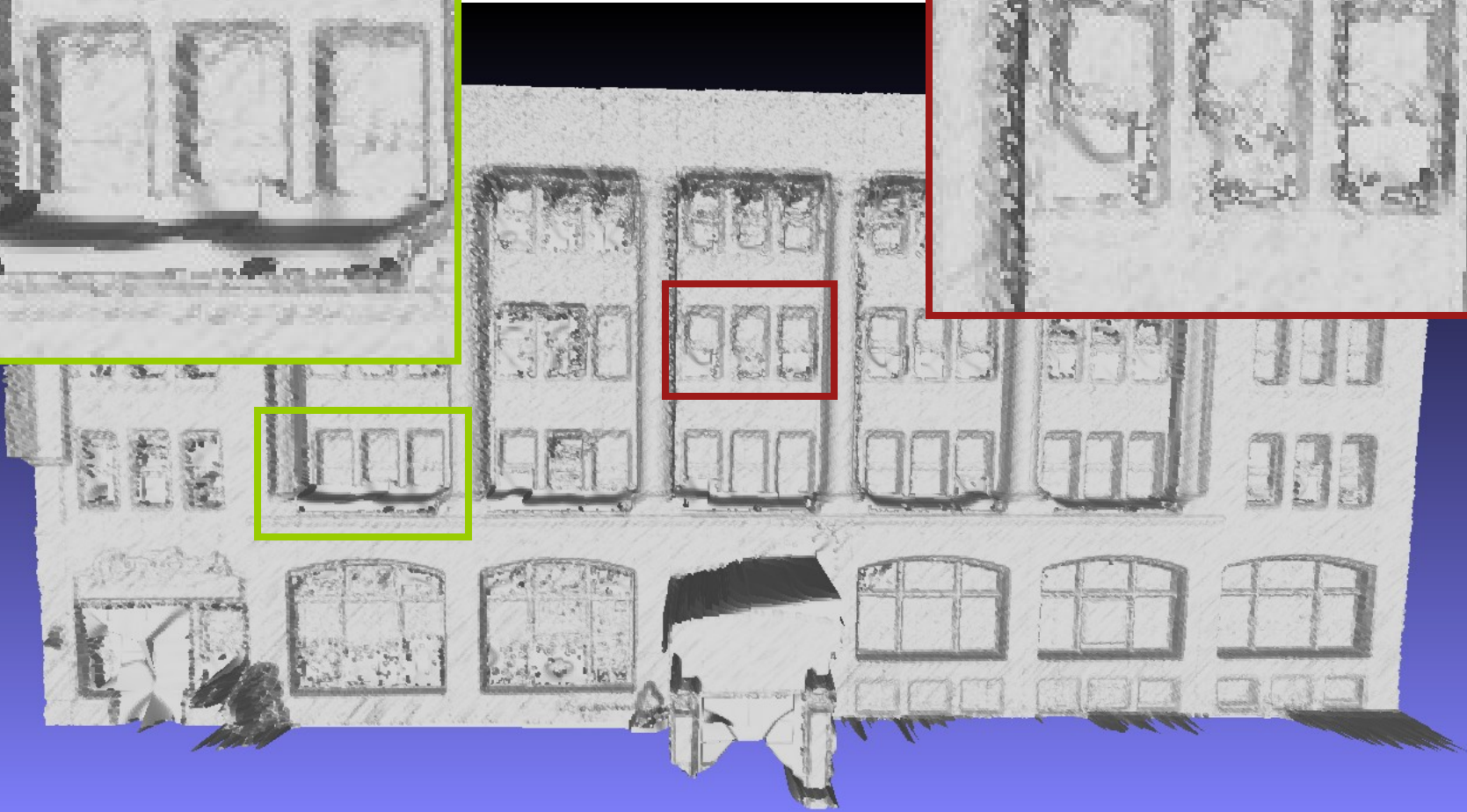
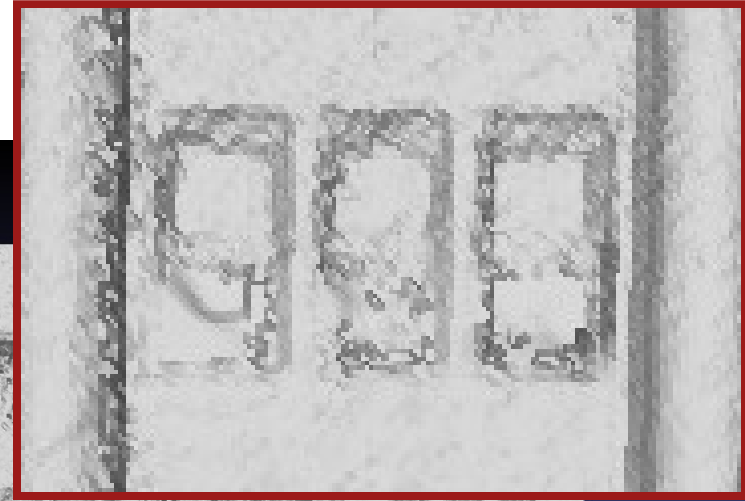
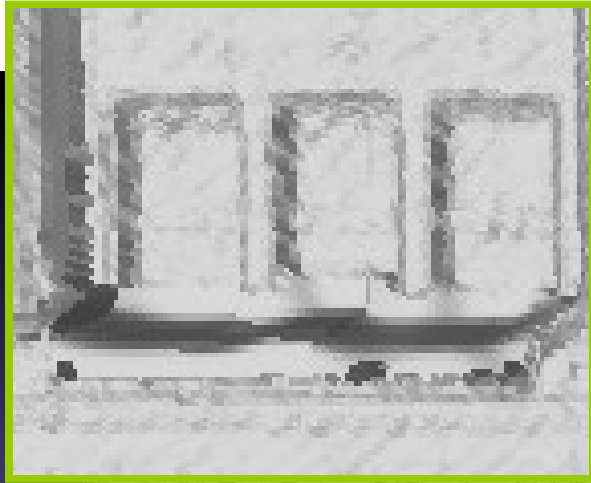


Geometry Reconstruction



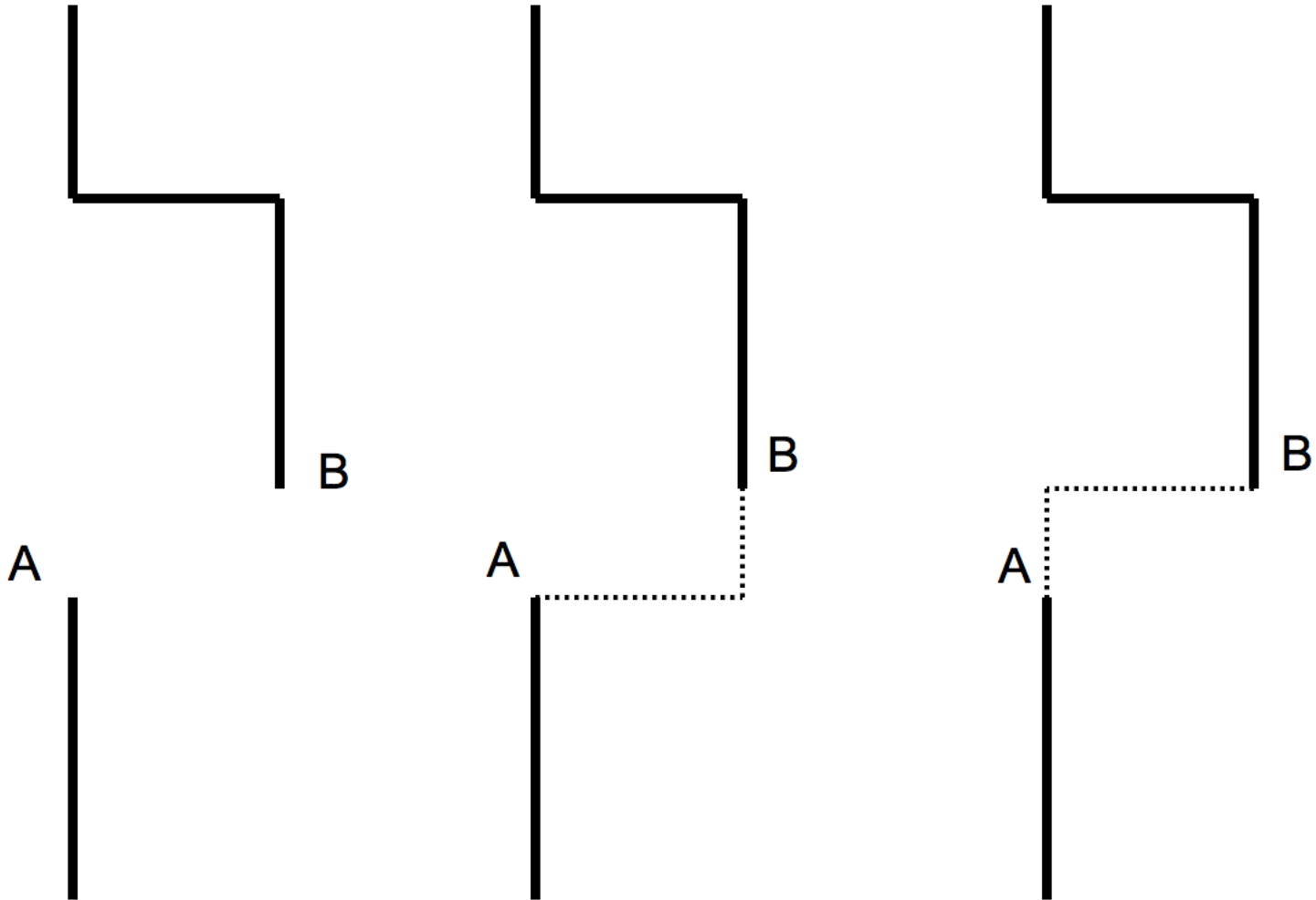
Geometry Reconstruction

- What about the holes?



Geometry Reconstruction

- Sharp Hole Filling



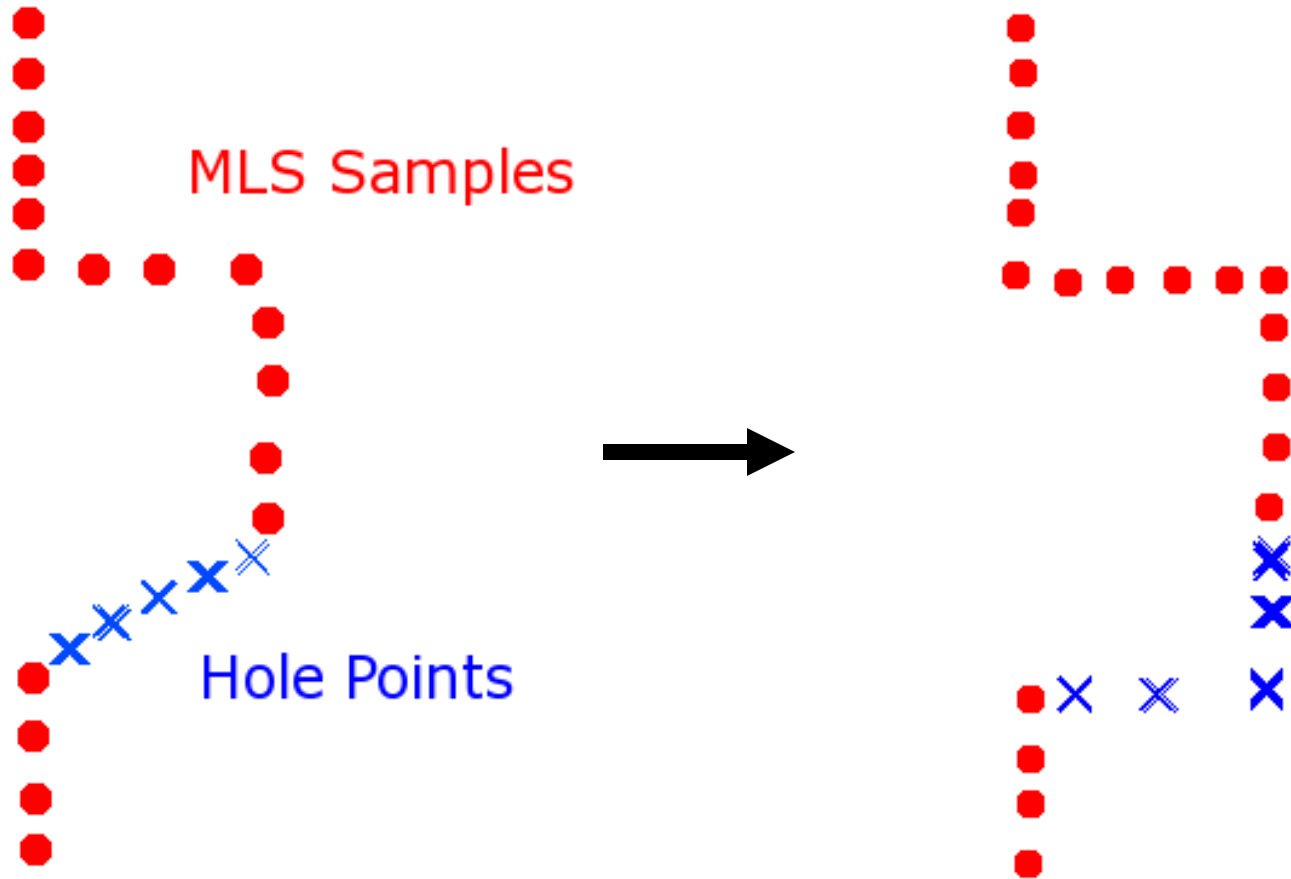
Geometry with hole

Possible Solution #1

Possible Solution #2

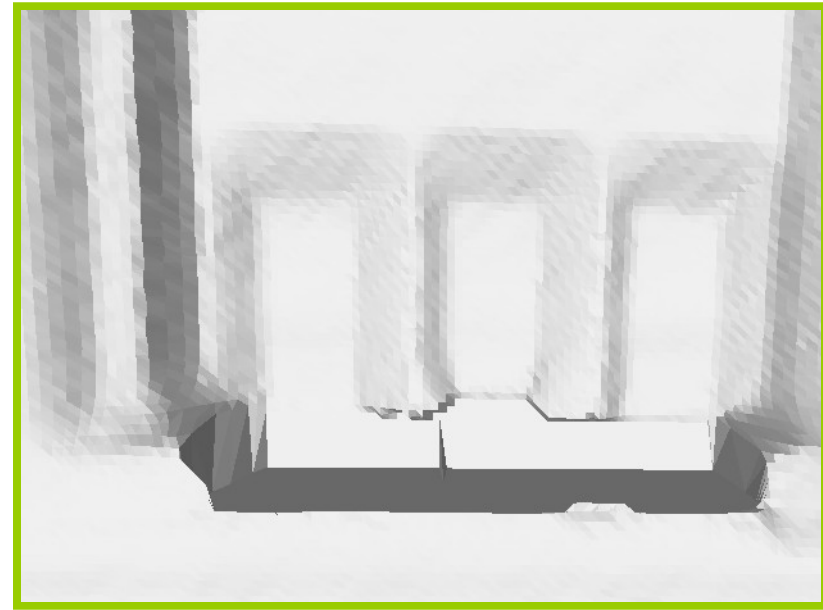
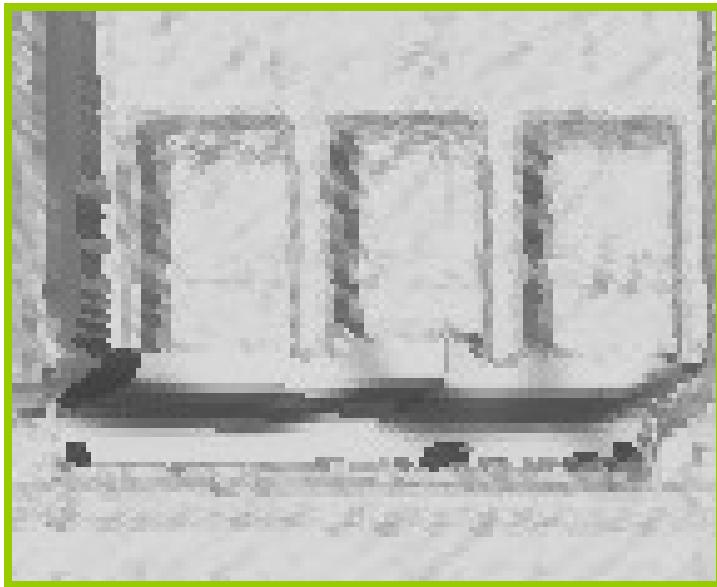
Geometry Reconstruction

- Fitting Deepest Planes



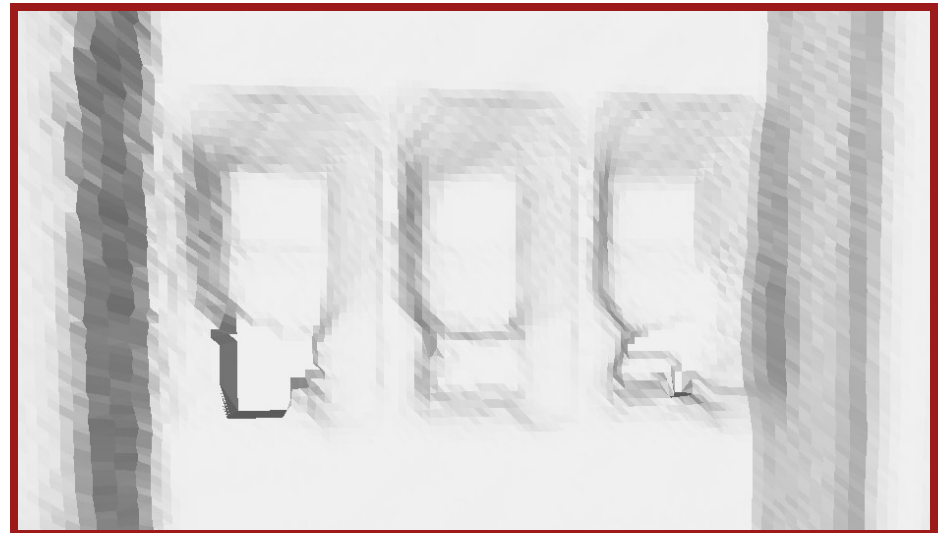
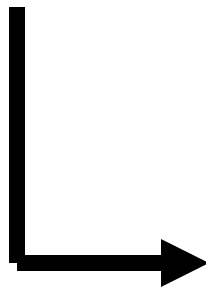
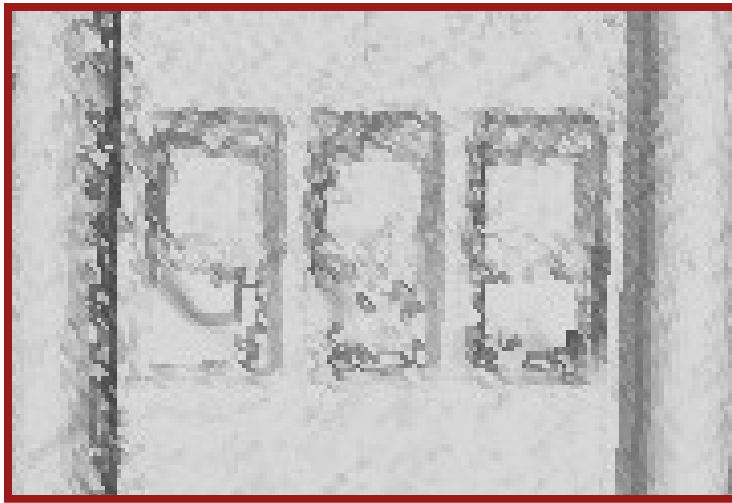
Geometry Reconstruction

- Model Results - Ledge



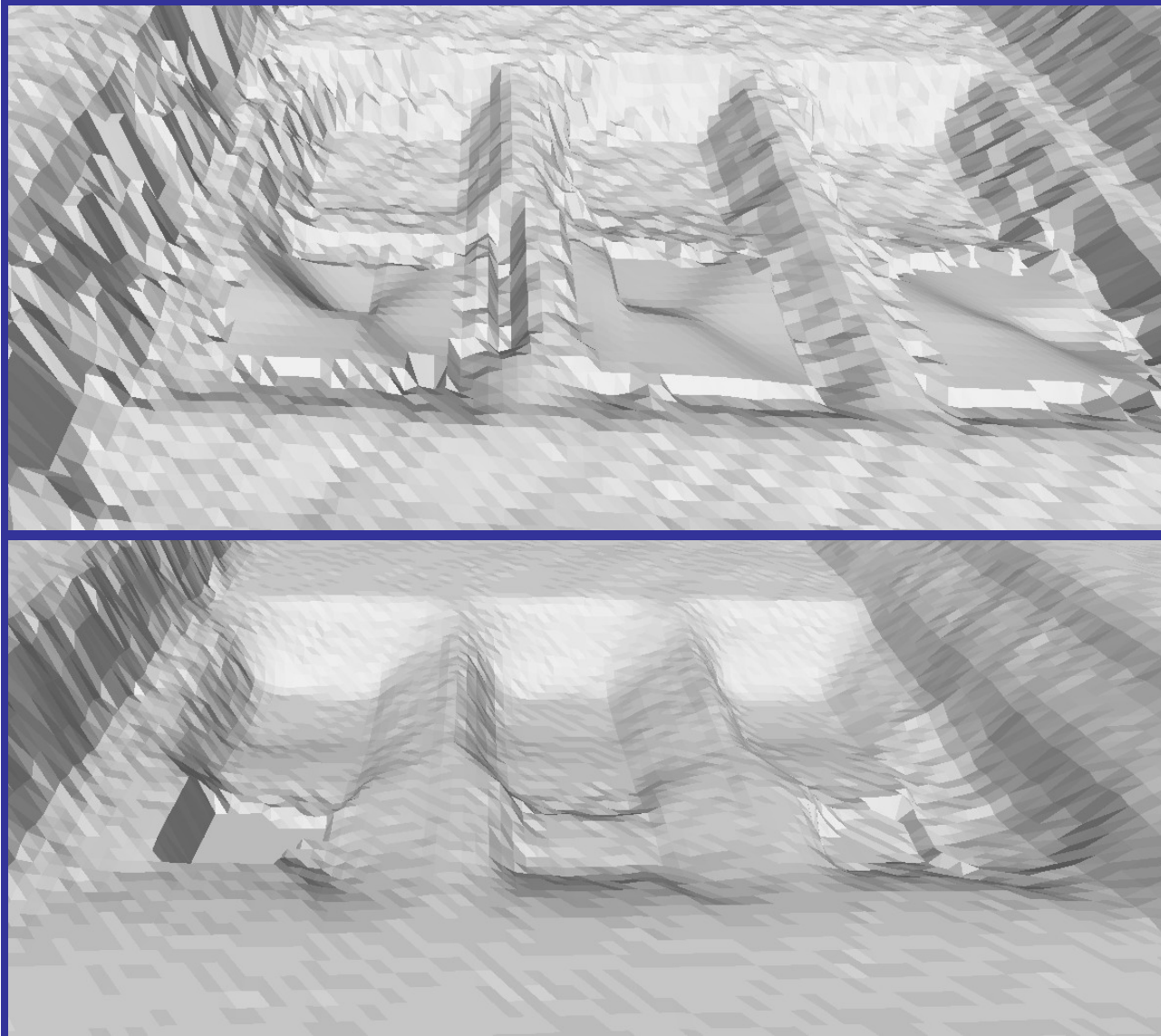
Geometry Reconstruction

- Model Results - Windows



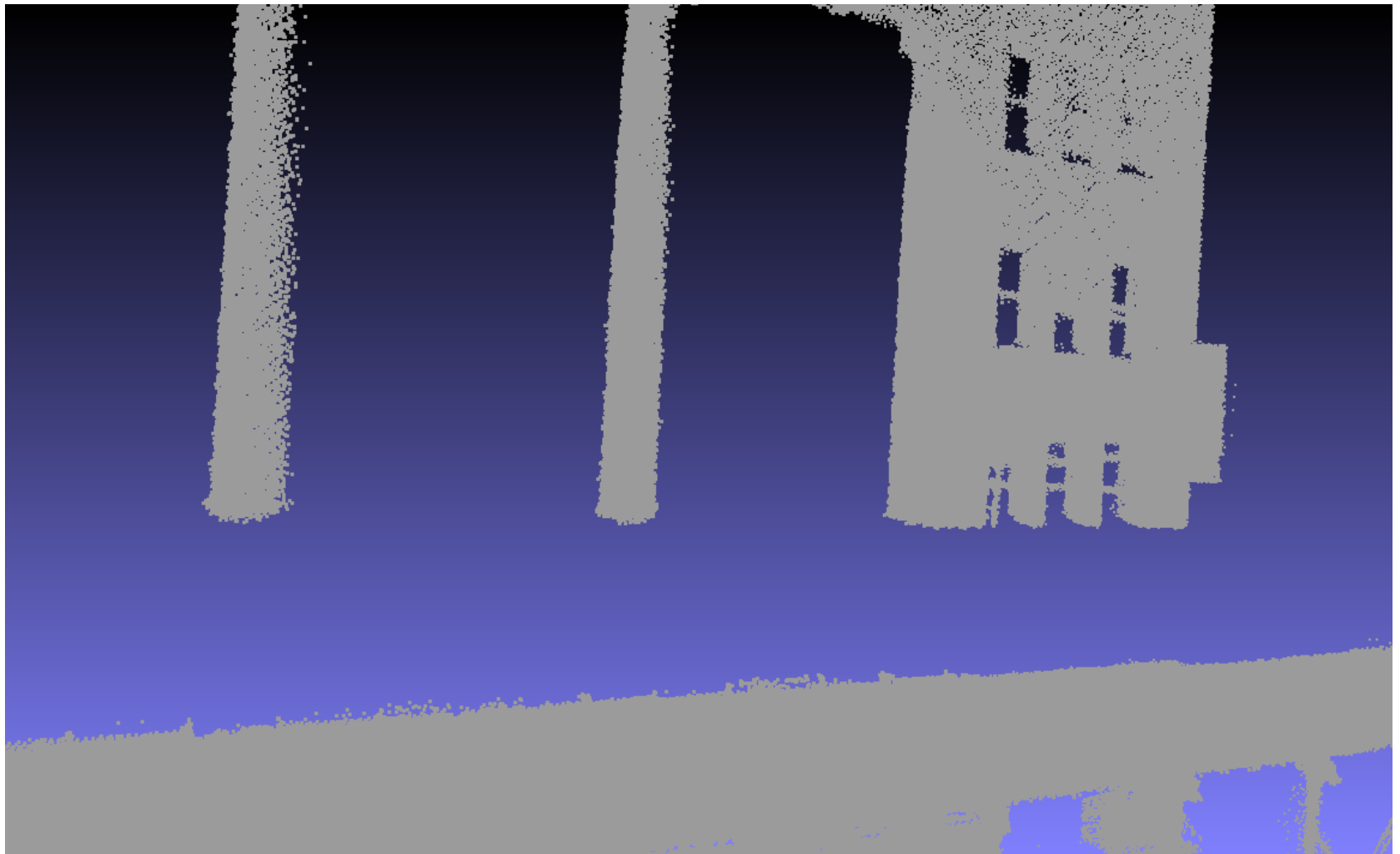
Geometry Reconstruction

- Model Results - Windows



Geometry Reconstruction

- Example Pointcloud



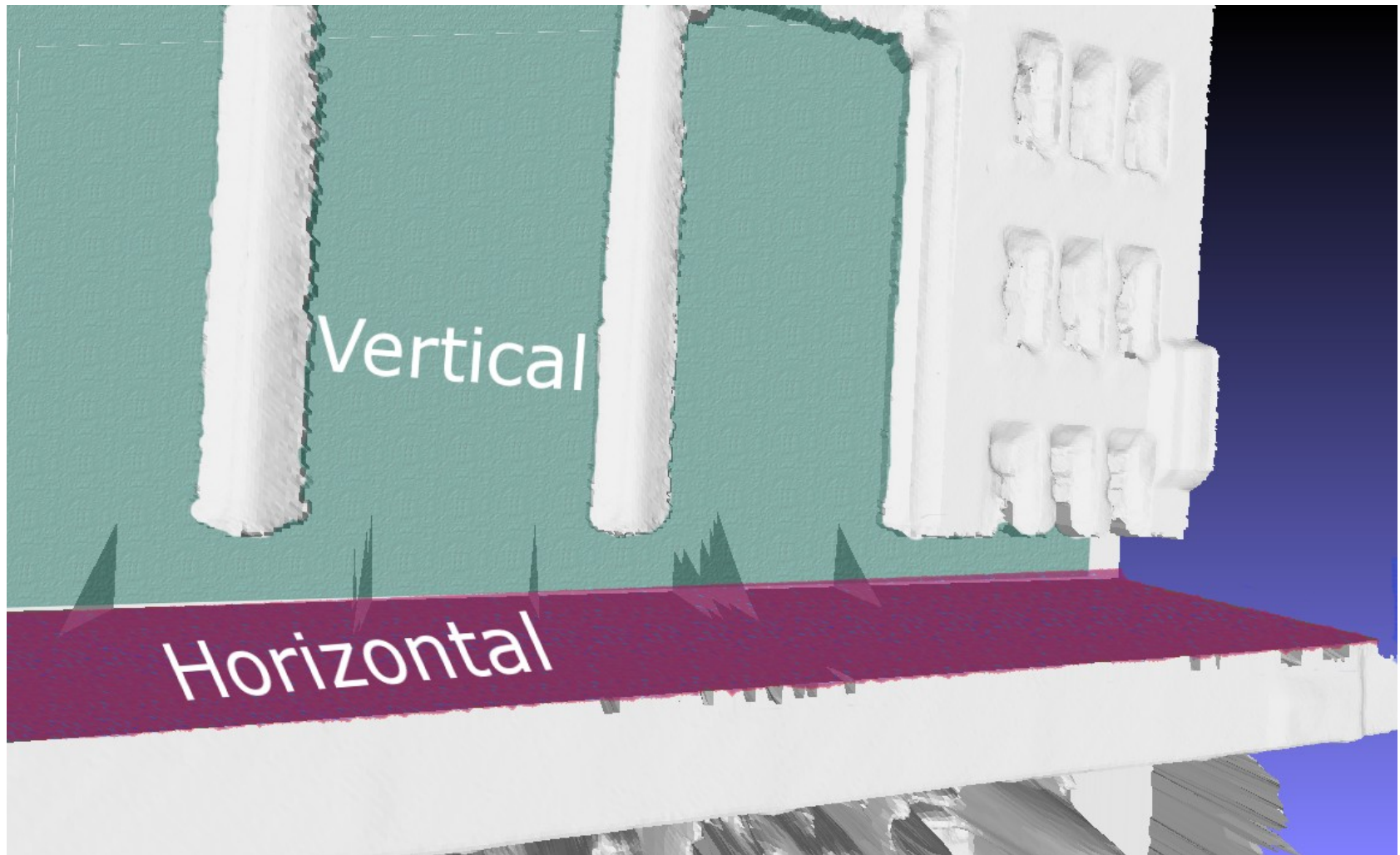
Geometry Reconstruction

- Just MLS Resampling



Geometry Reconstruction

- Fit Axis-aligned planes



Results



(c) 2011
NAVTEQ

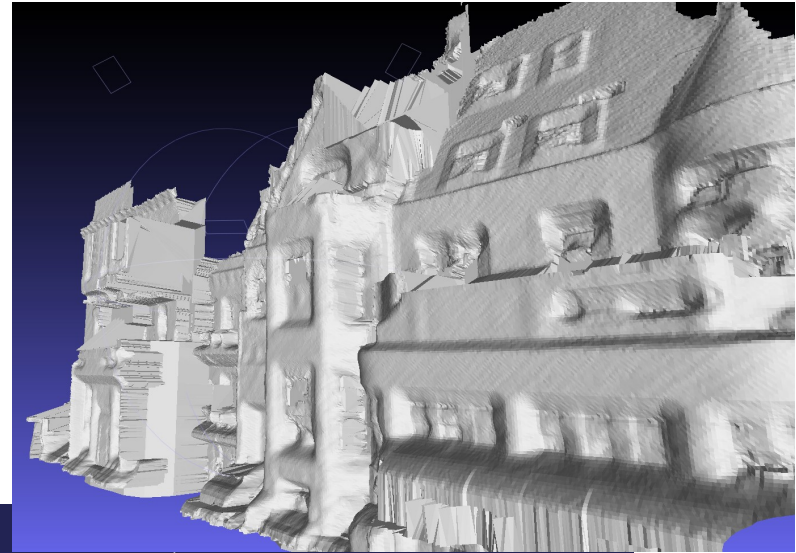
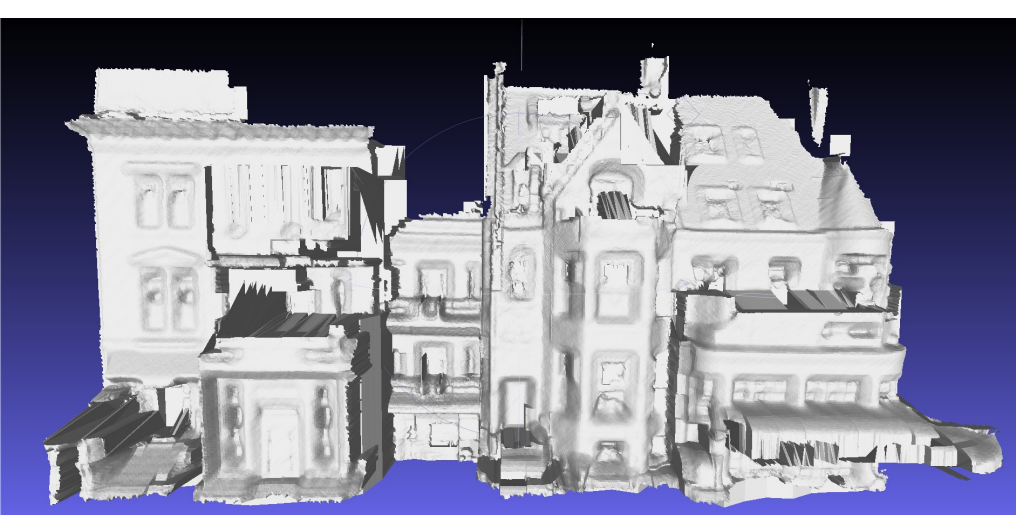
Results (Textured)



Results (Textured)



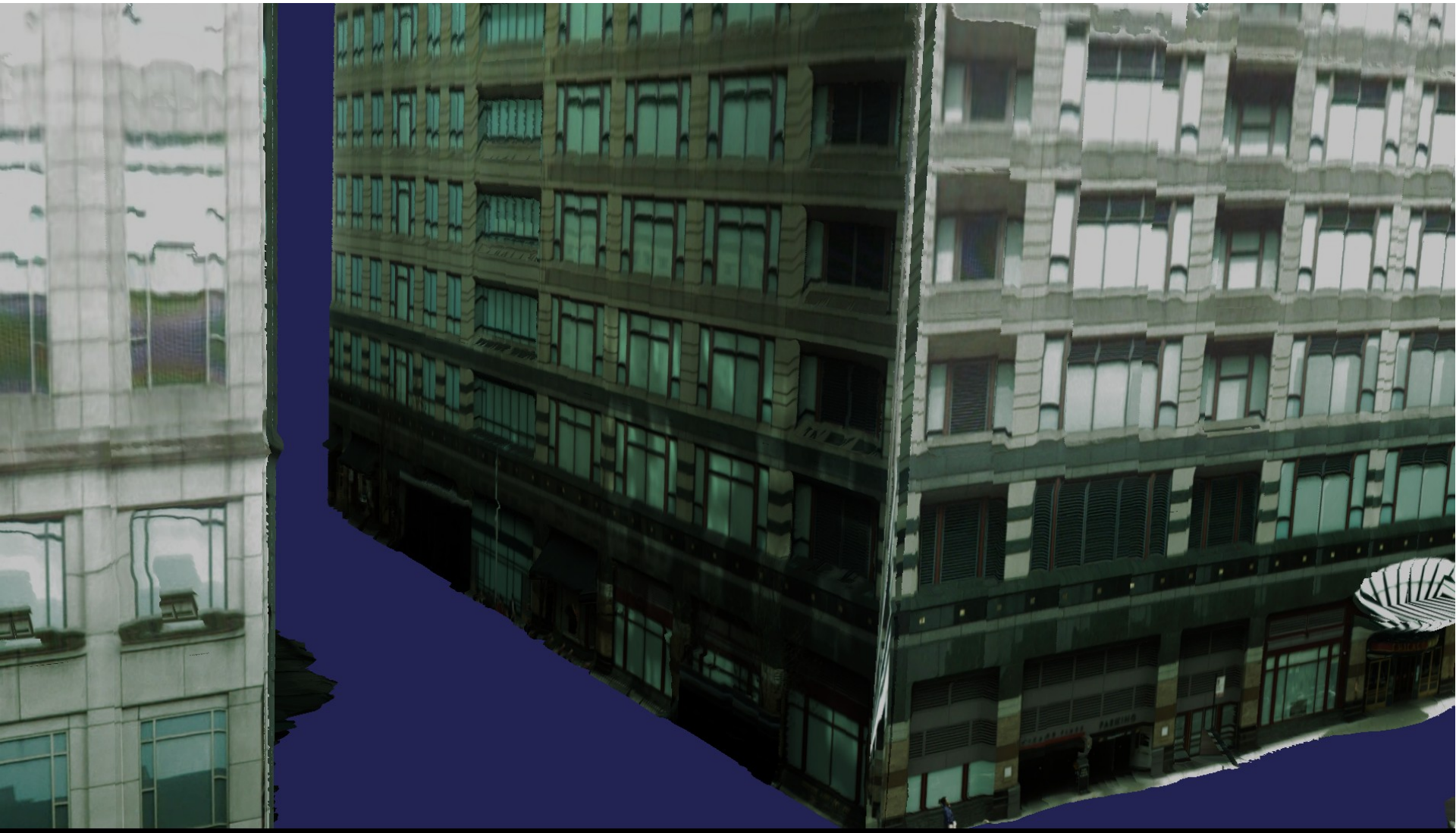
Results (Textured)



Results (Textured)



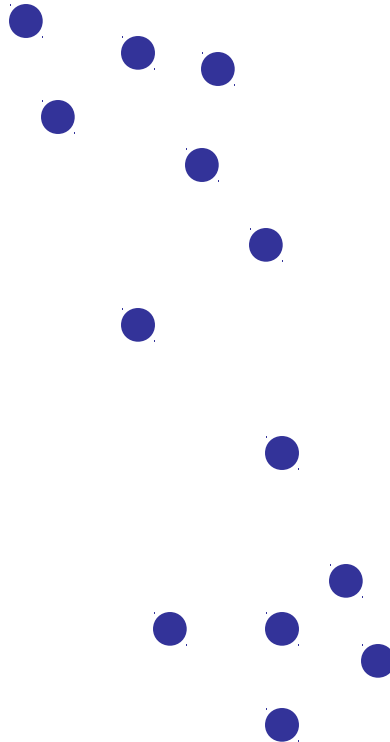
Results (Textured)



Extra: Moving Least-Squares

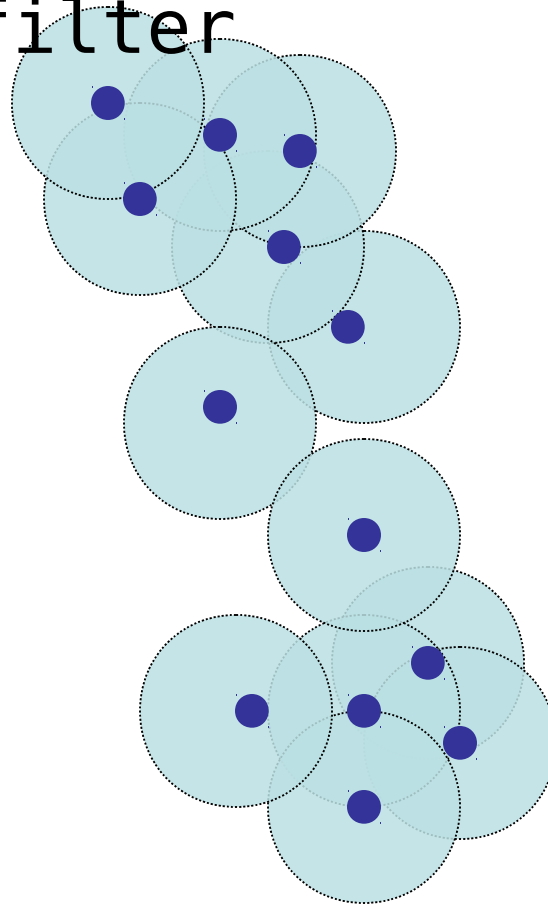
Moving Least-Squares

- Treat each point as a delta-function



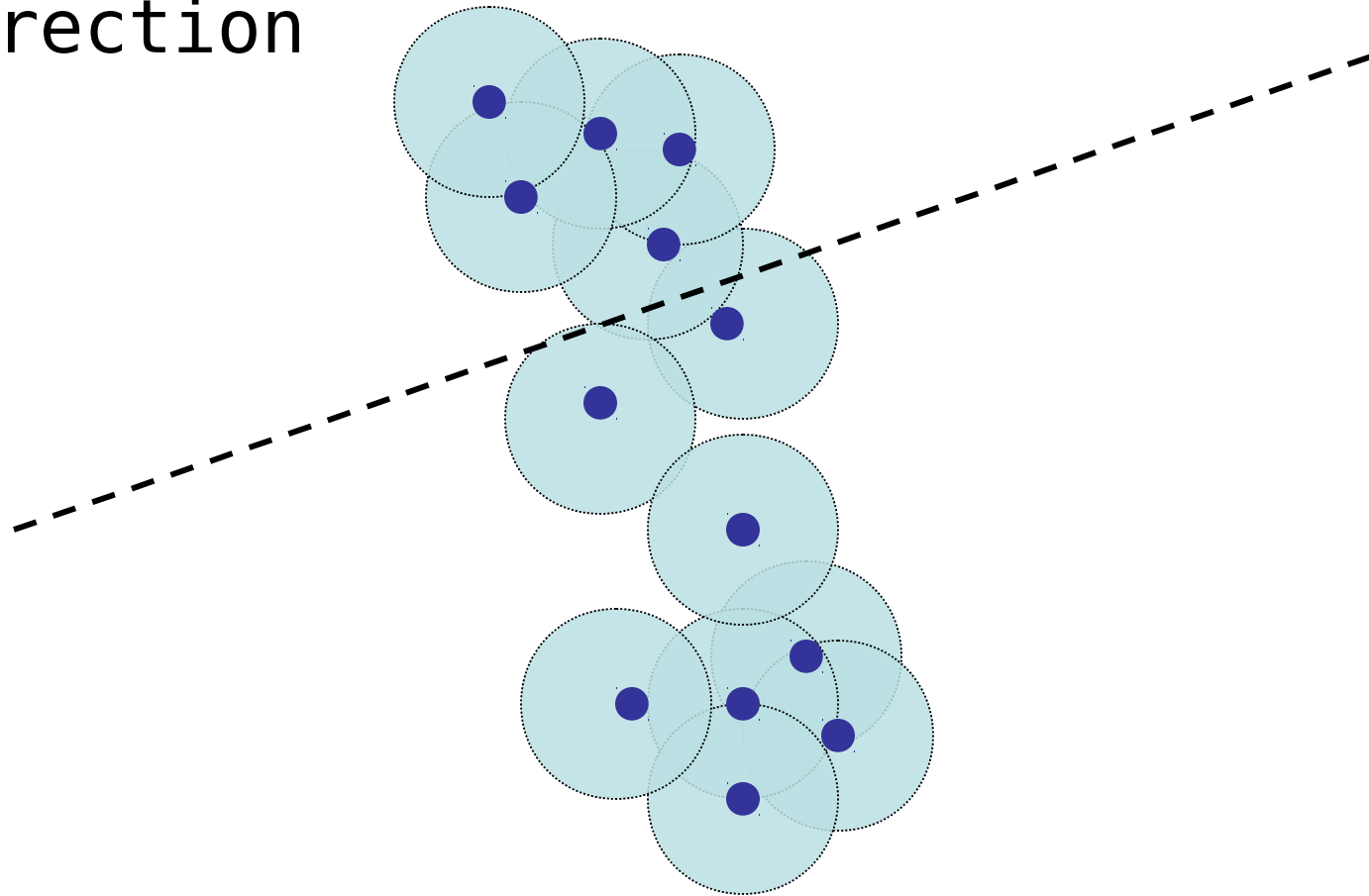
Moving Least-Squares

- Convolve with Gaussian smoothing filter



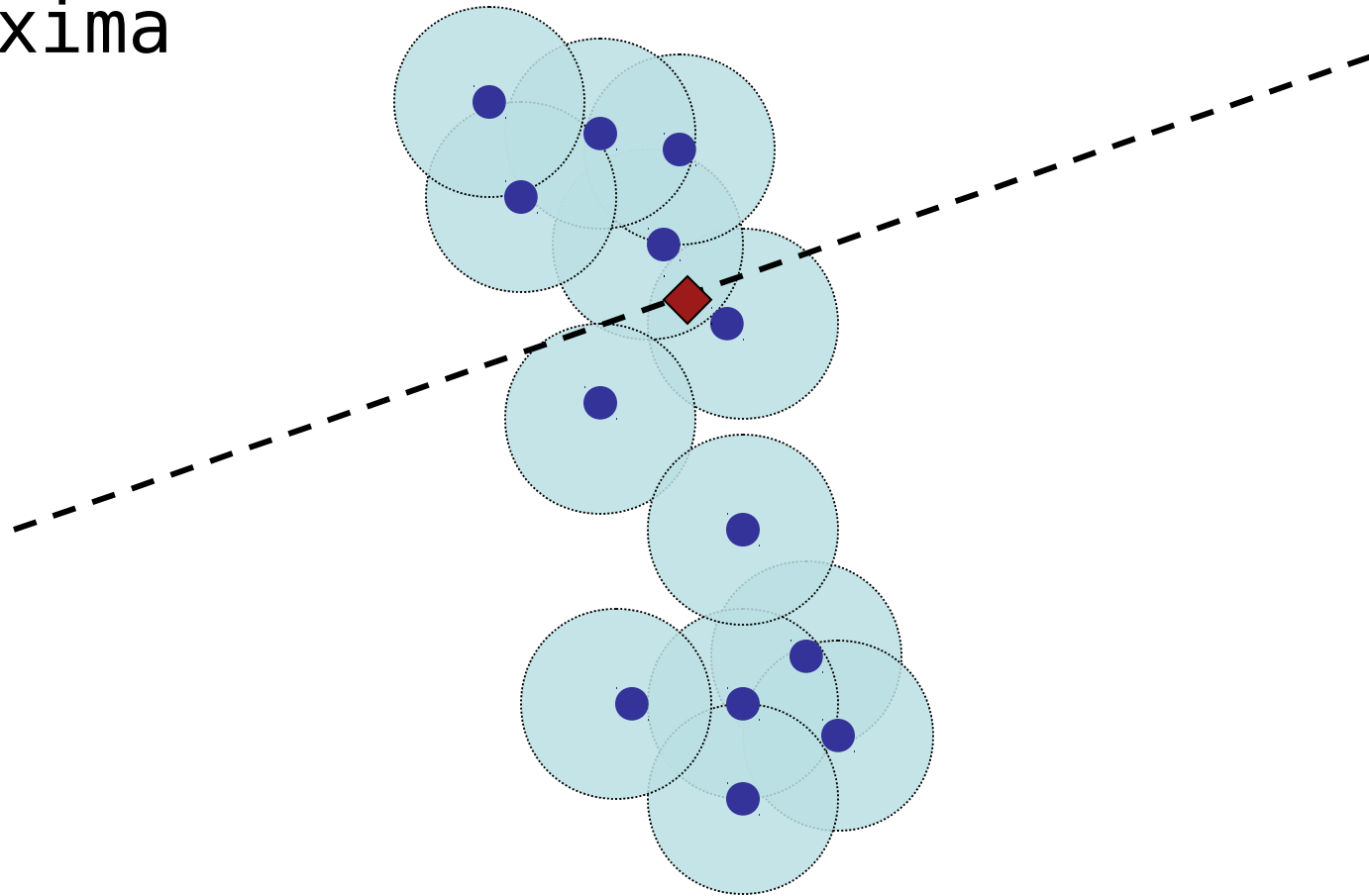
Moving Least-Squares

- Analyze signal along chosen direction



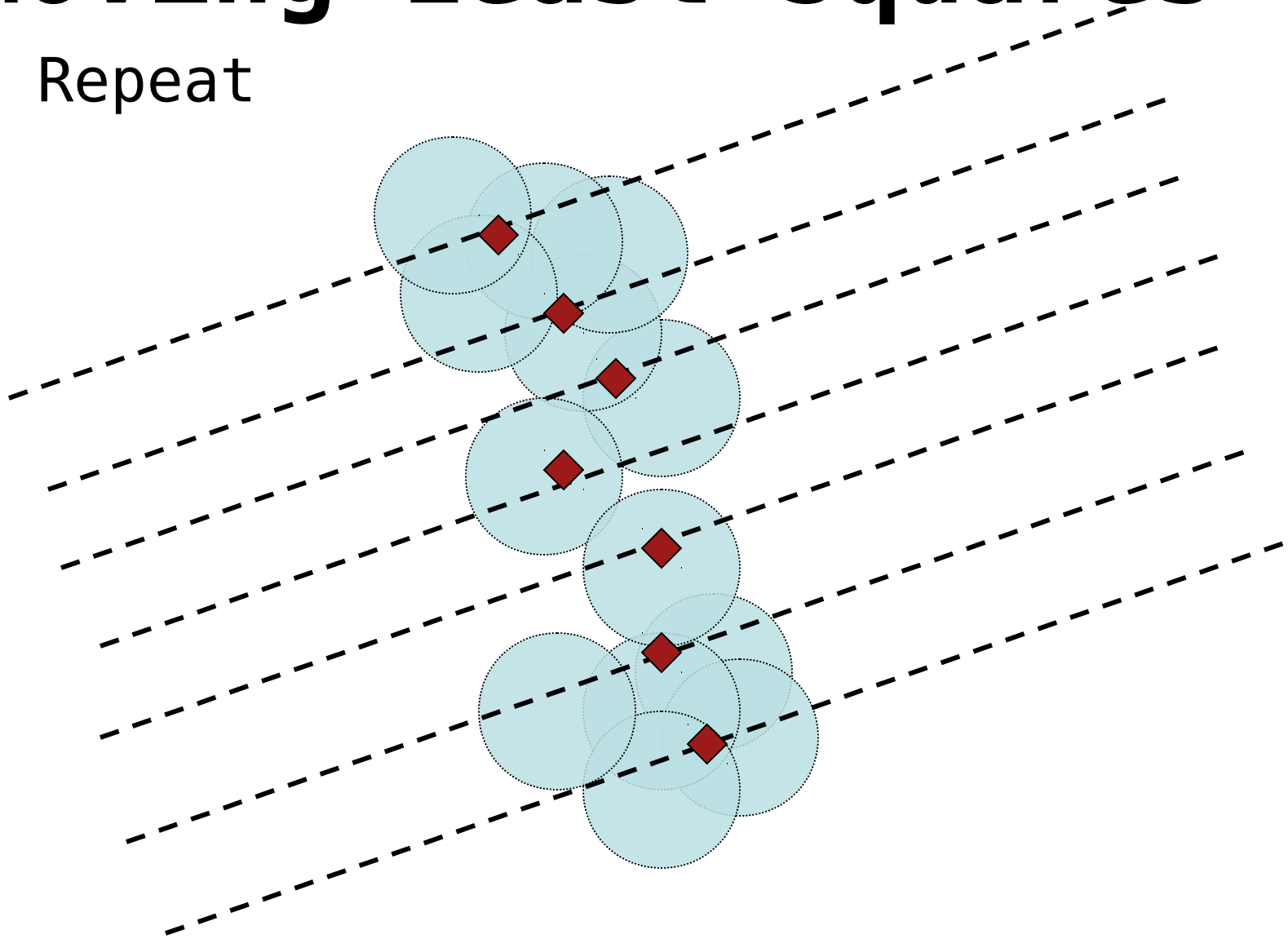
Moving Least-Squares

- Choose sample at local maxima



Moving Least-Squares

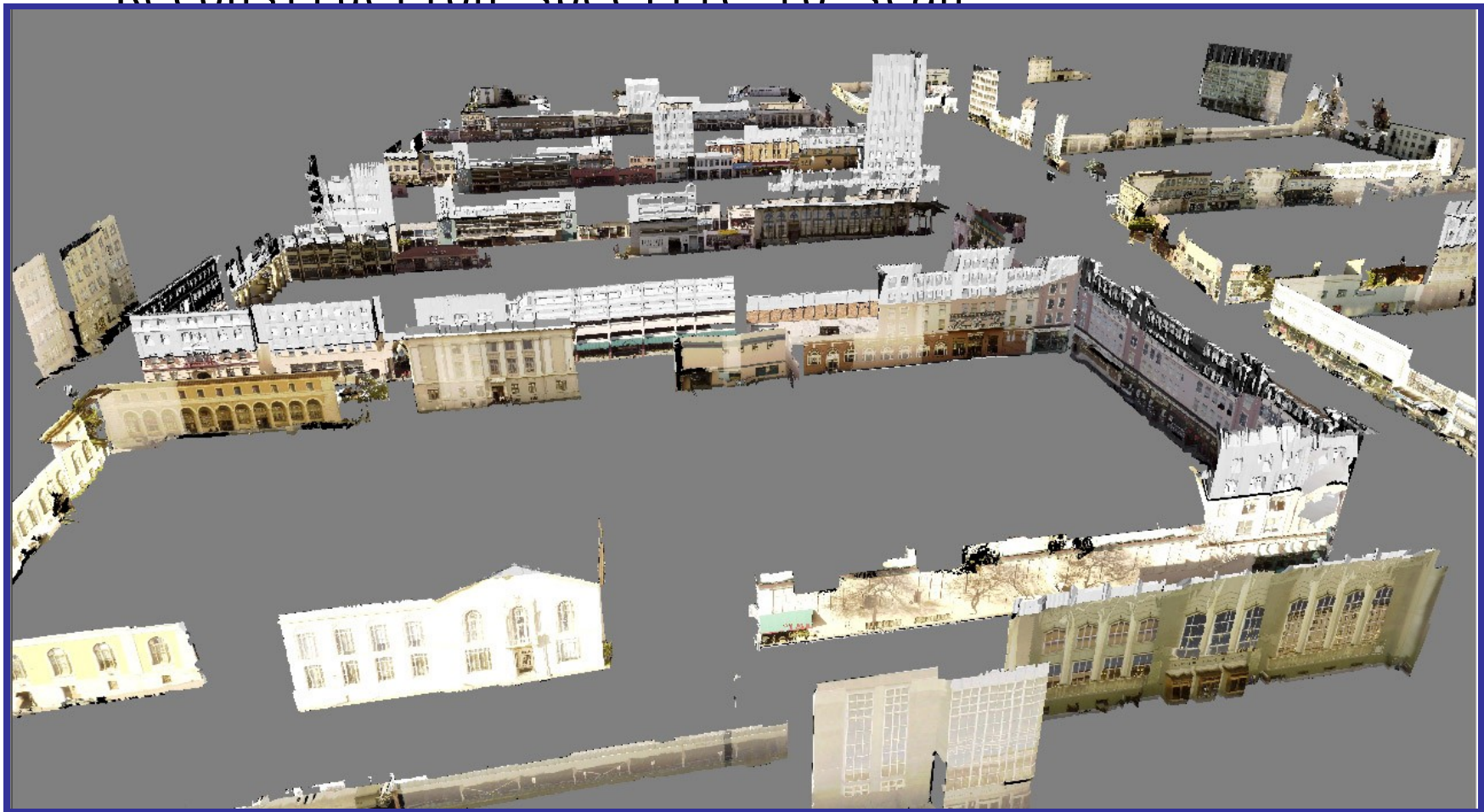
- Repeat



Extra: Existing Techniques

Existing Urban Modeling

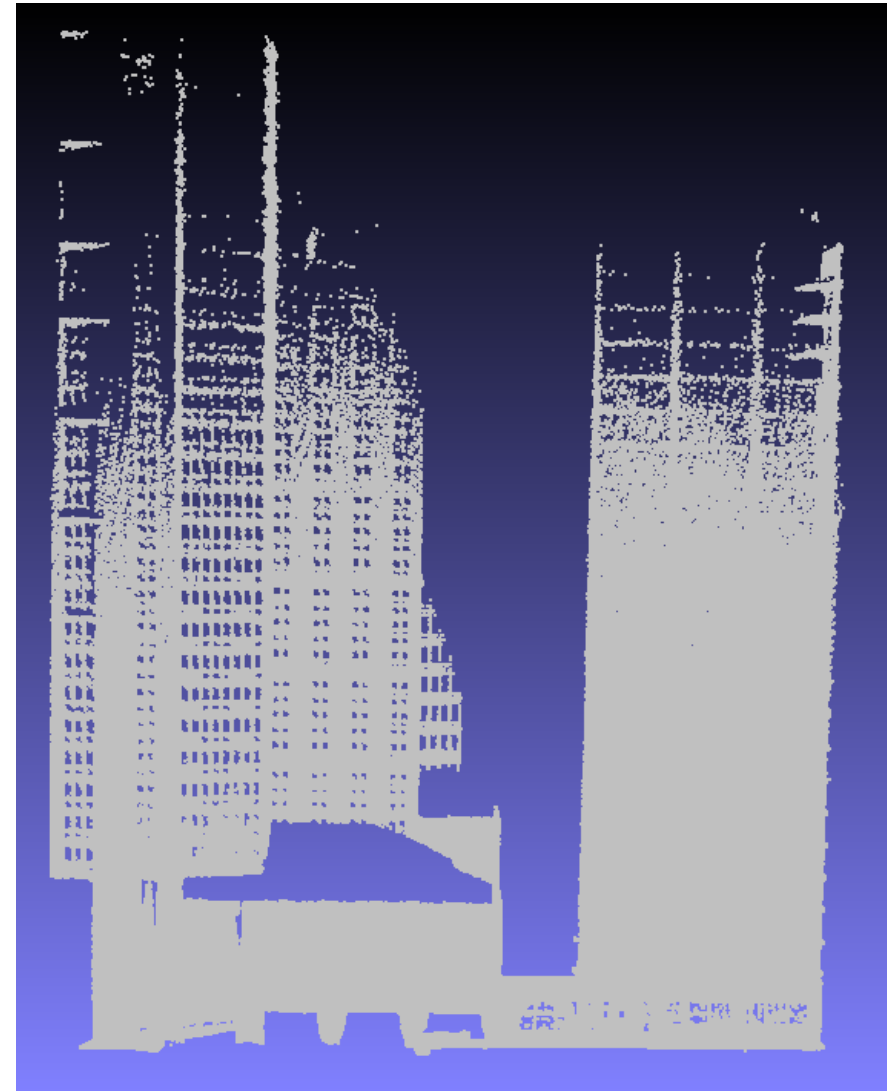
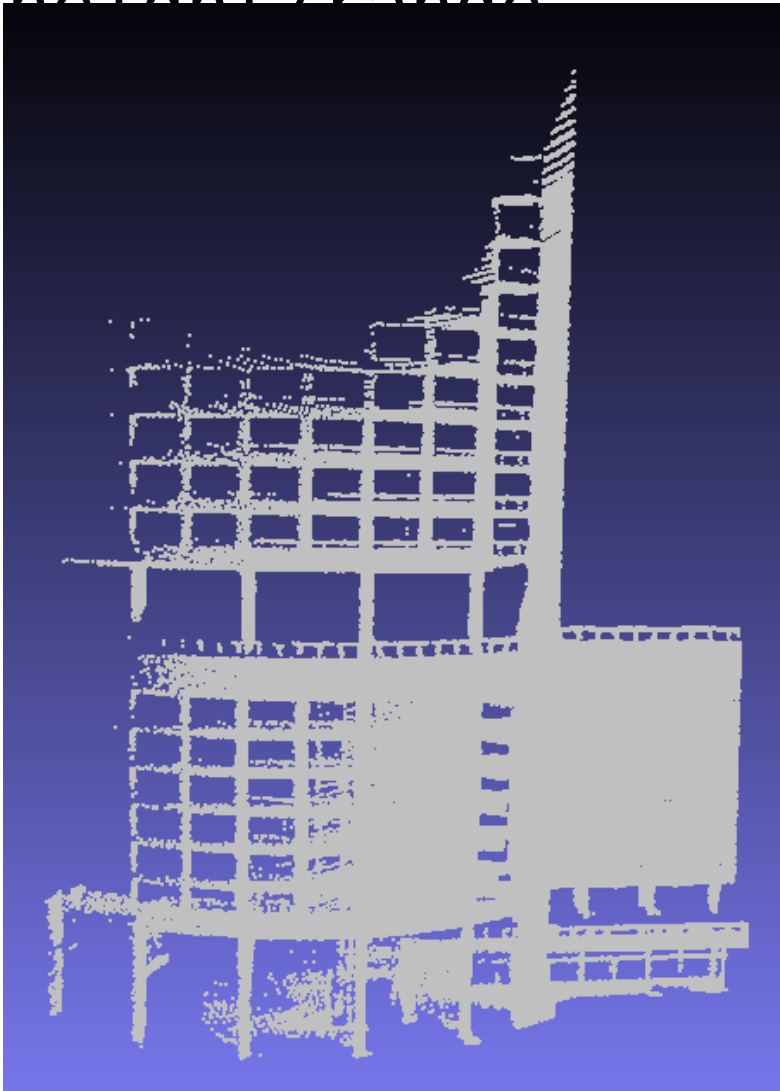
- Previous Ground-Based Range Data
 - Reconstruction specific to scan



Extra: Extrapolating Façades

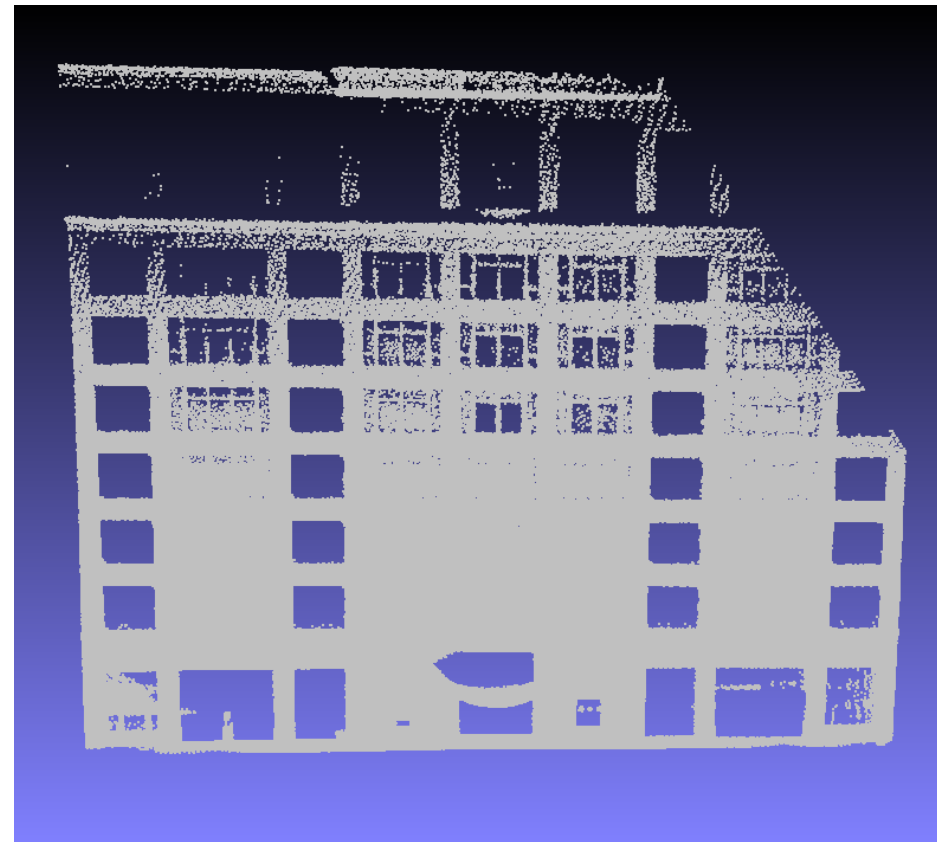
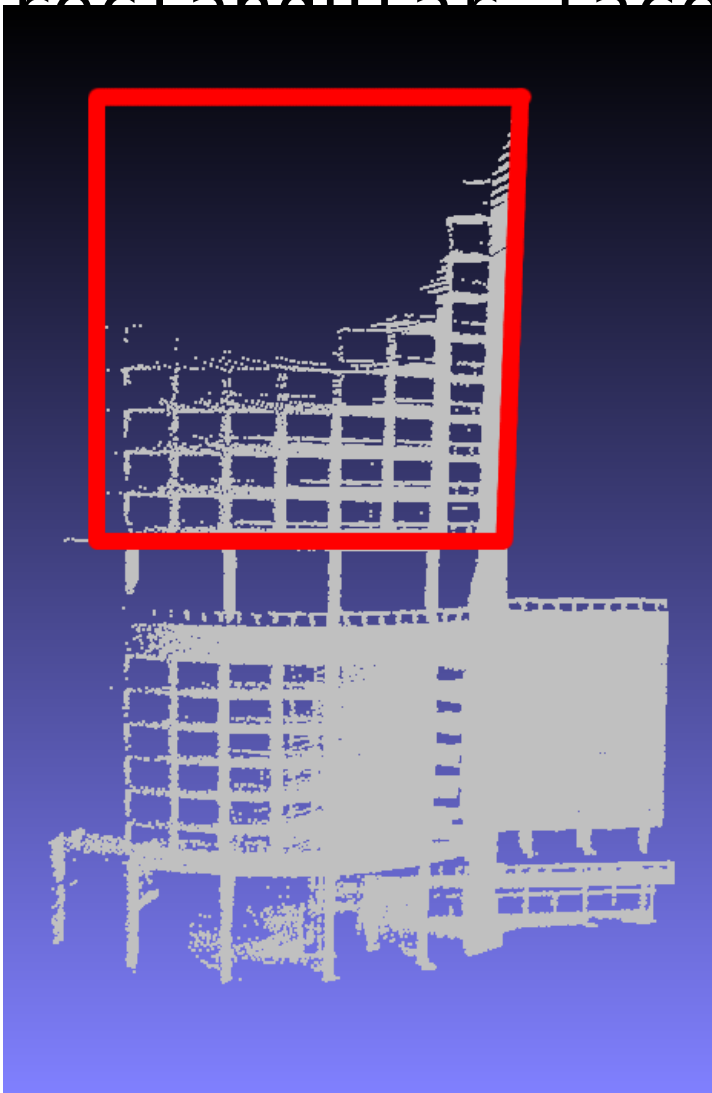
Extrapolating Façades

- Laser scanner has finite height/range



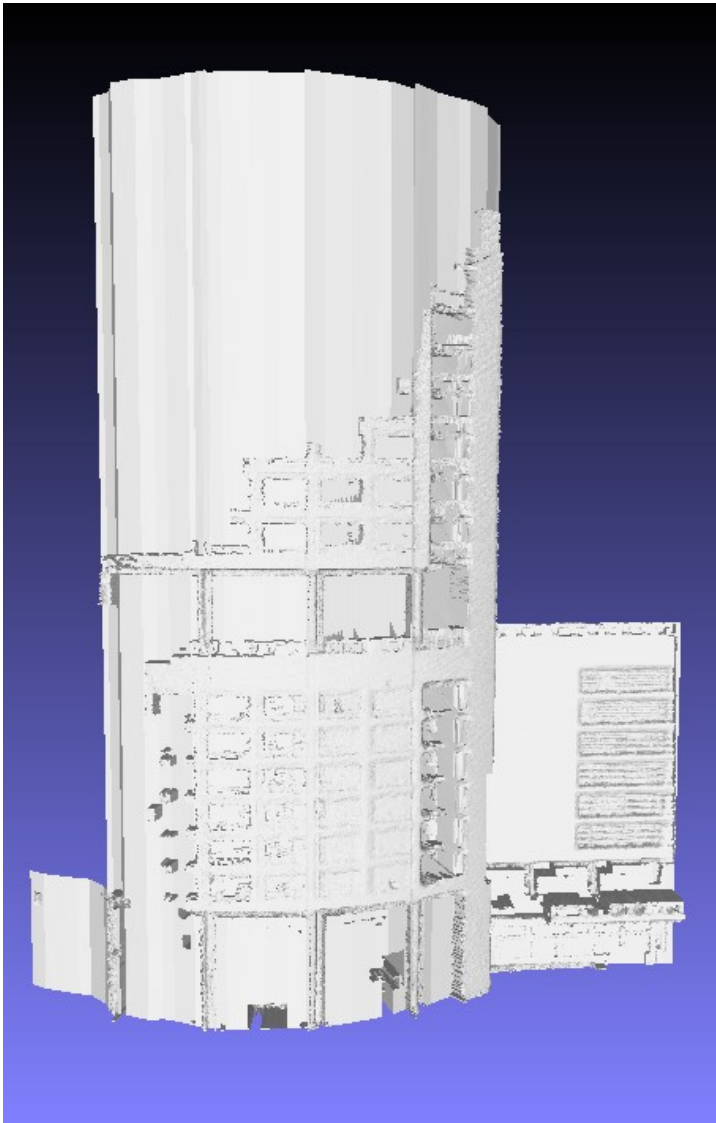
Extrapolating Façades

- Can extrapolate by assuming rectangular faces



Extrapolating Façades

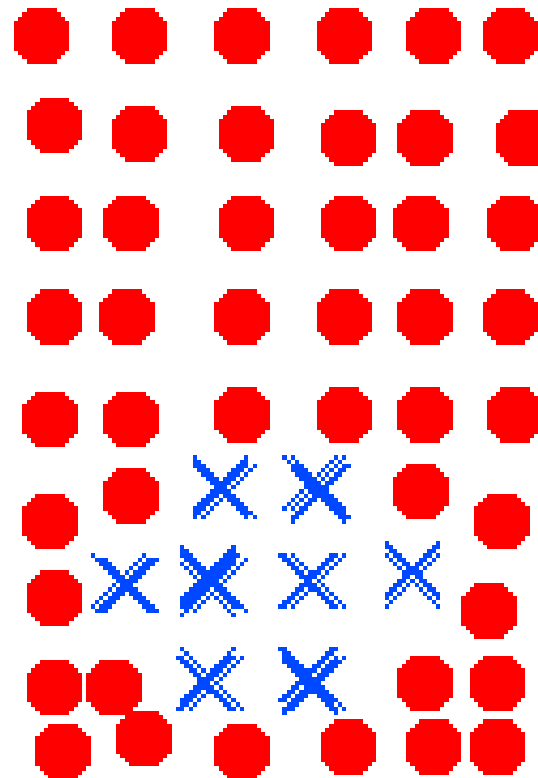
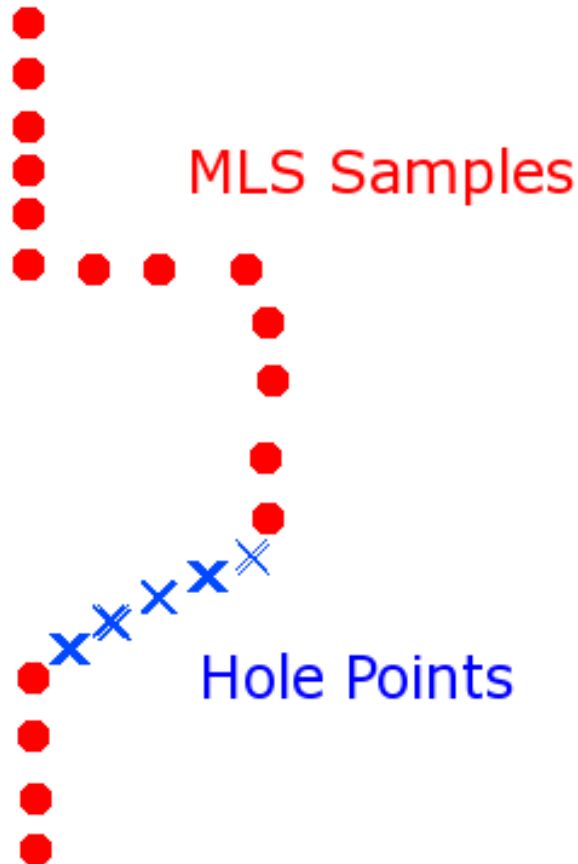
- Extrude shape from below



Extra: Geometry Reconstruction Details

Geometry Reconstruction

- Fitting Deepest Planes

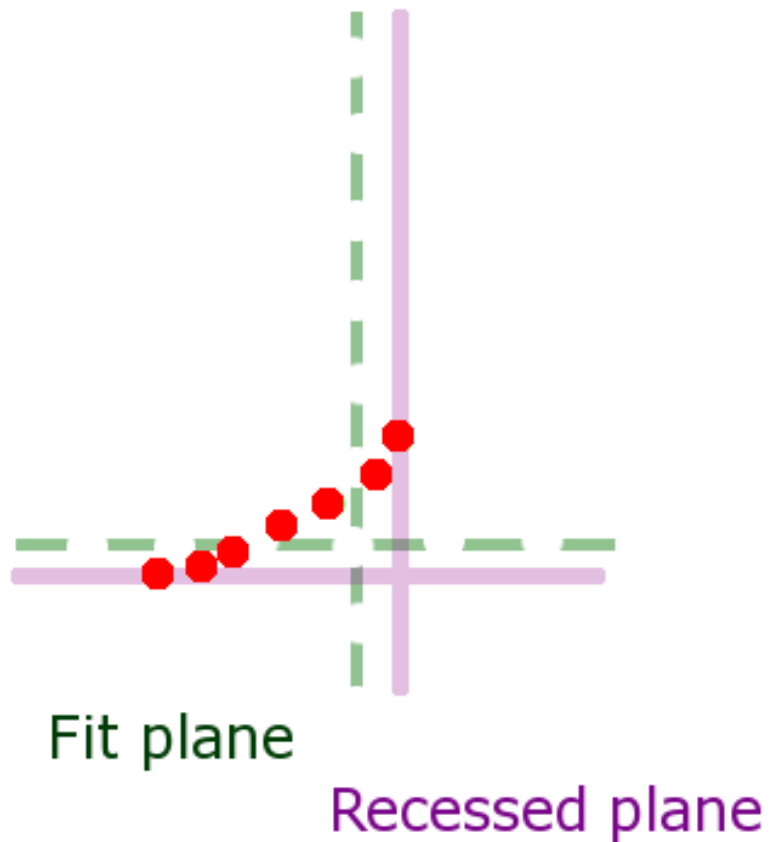


Side View

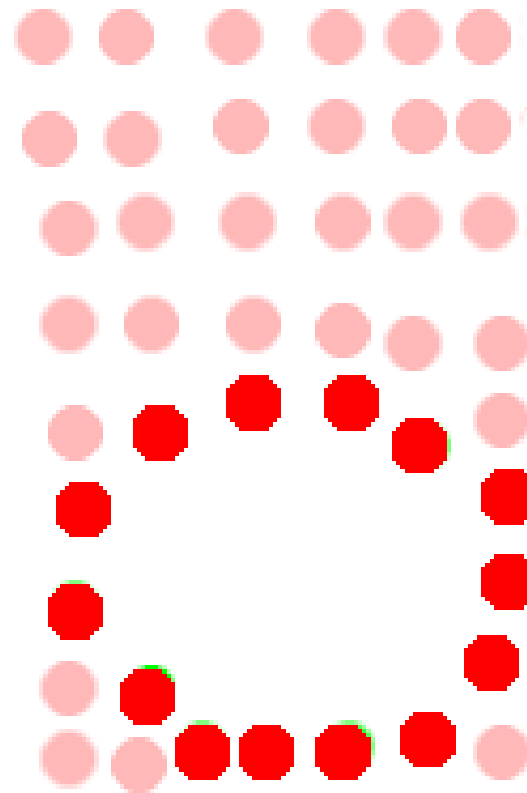
Front View

Geometry Reconstruction

- Fitting Deepest Planes



Side View



Front View