PCL - TOYOTA CODE SPRINT

SURFACE RECONSTRUCTION

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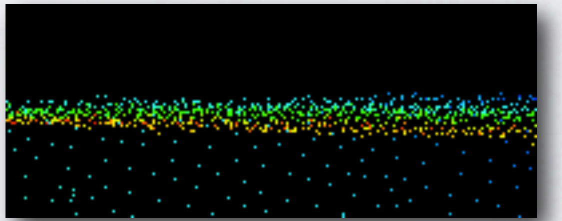
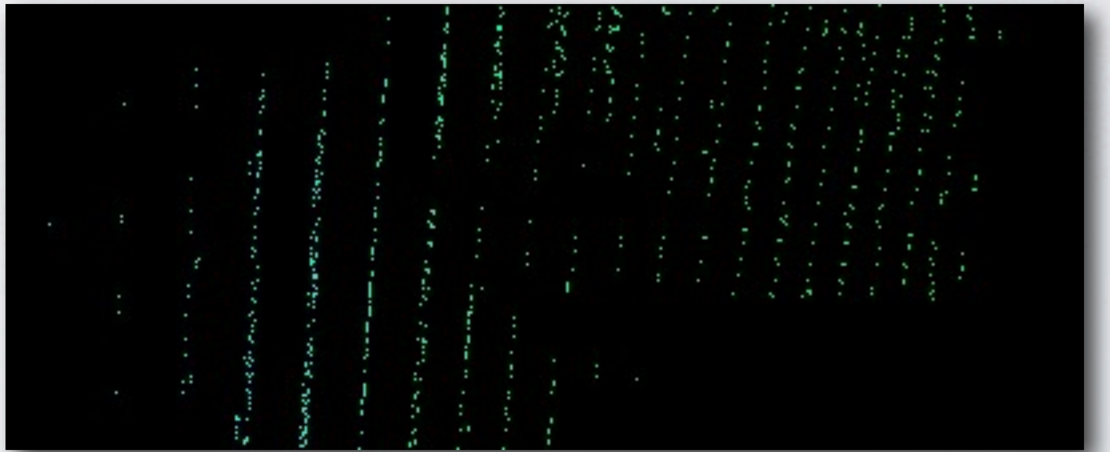
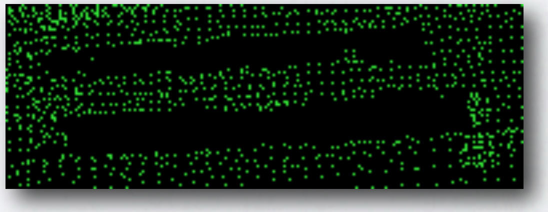
PROBLEM DESCRIPTION 1/2

- *3D revolution* due to cheap RGB-D cameras (Asus Xtion & Microsoft Kinect)
- Affordability comes with poor quality:
  - high level of noise in both the depth and the color images
  - quantization artifacts
  - missing pixels
  - various color image distortions, specific to webcam sensors and optics







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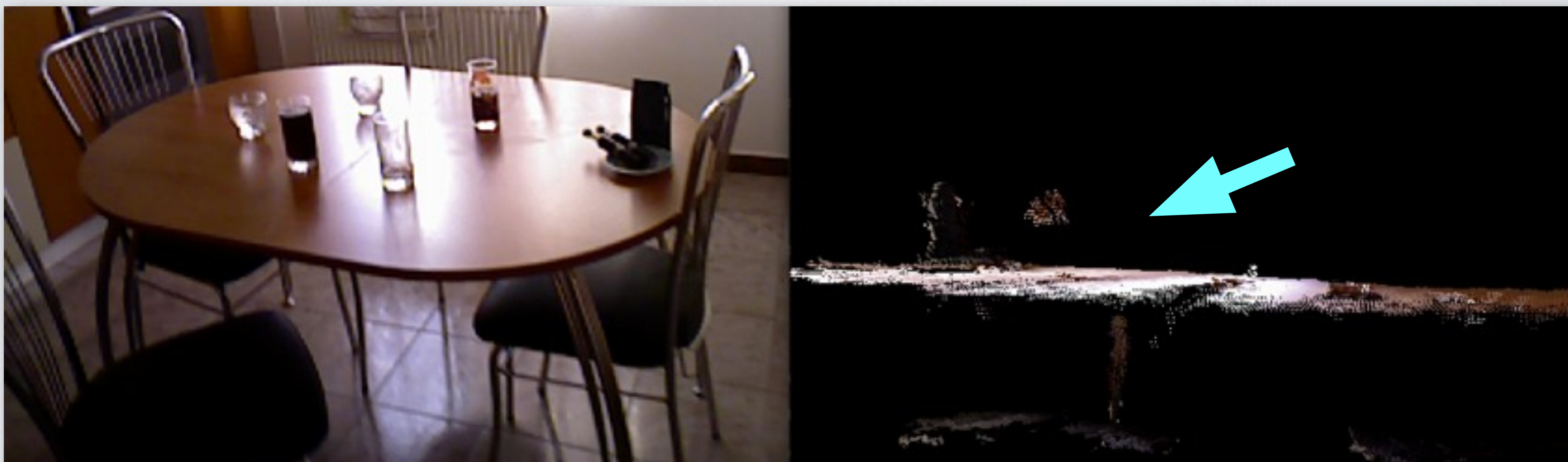
PROBLEM DESCRIPTION 2/2



Incapability of the Kinect to record transparent or shiny objects

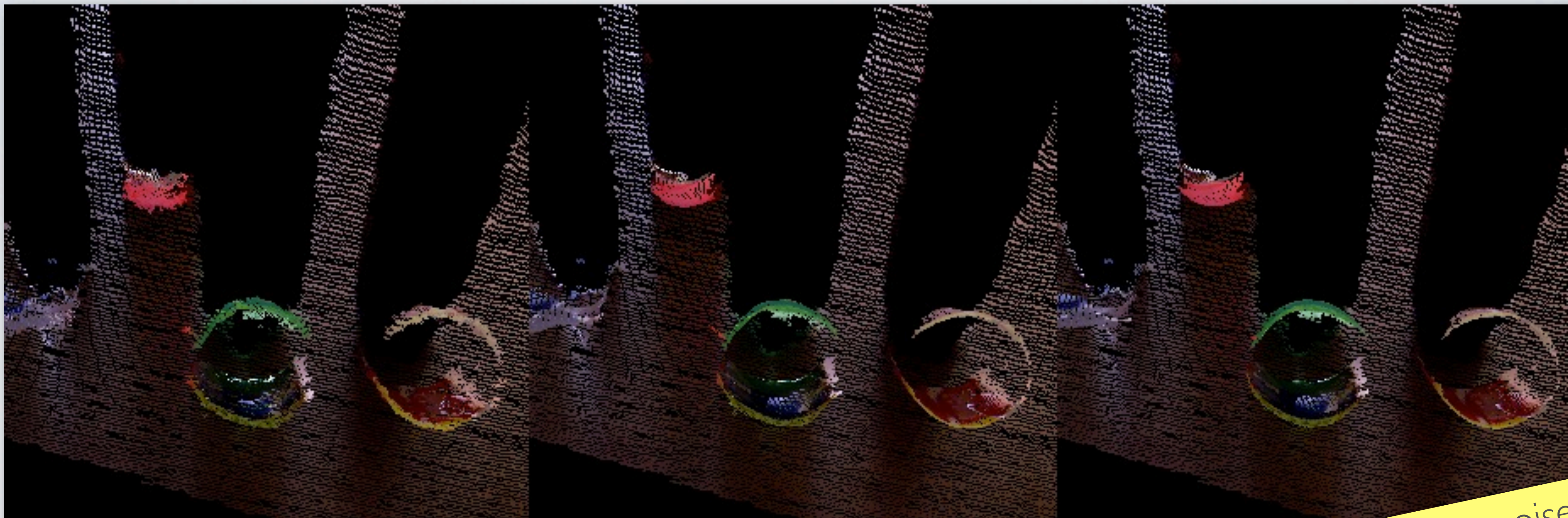
DATASET COLLECTION

- 30 realistic situations that a personal robot might face in an undirected human environment
- captured so that to simulate a robot movement and to record all the known sensor artifacts
- all available at http://svn.pointclouds.org/data/Toyota

`pcl::surface` REVAMP

- `CloudSurfaceProcessing`
  - PointCloud to PointCloud for better surface approximation
  - e.g., `MovingLeastSquares, BilateralUpsampling`
- `MeshConstruction`
  - PointCloud to PolygonMesh, convert cloud to mesh without modifying vertex positions
  - e.g., `ConcaveHull, ConvexHull, OrganizedFastMesh, GreedyProjectionTriangulation`
- `SurfaceReconstruction`
  - PointCloud to PolygonMesh, generate mesh with a possibly modified underlying vertex set
  - e.g., `GridProjection, MarchingCubes, SurfelSmoothing`
- `MeshProcessing`
  - PolygonMesh to PolygonMesh, improve input meshes by modifying connectivity and/or vertices
  - e.g., `EarClipping, MeshSmoothingLaplacianVTK, MeshSmoothingWindowedSincVTK, MeshSubdivisionVTK`

MOVING LEAST SQUARES 1.SMOOTHING 1/2



Eliminates noise.

MLS applied on the Bottles dataset

from left to right:

- original scan
- MLS smoothed with search radius = 3 cm and second order polynomial fitting
- MLS smoothed with search radius = 5 cm and second order polynomial fitting

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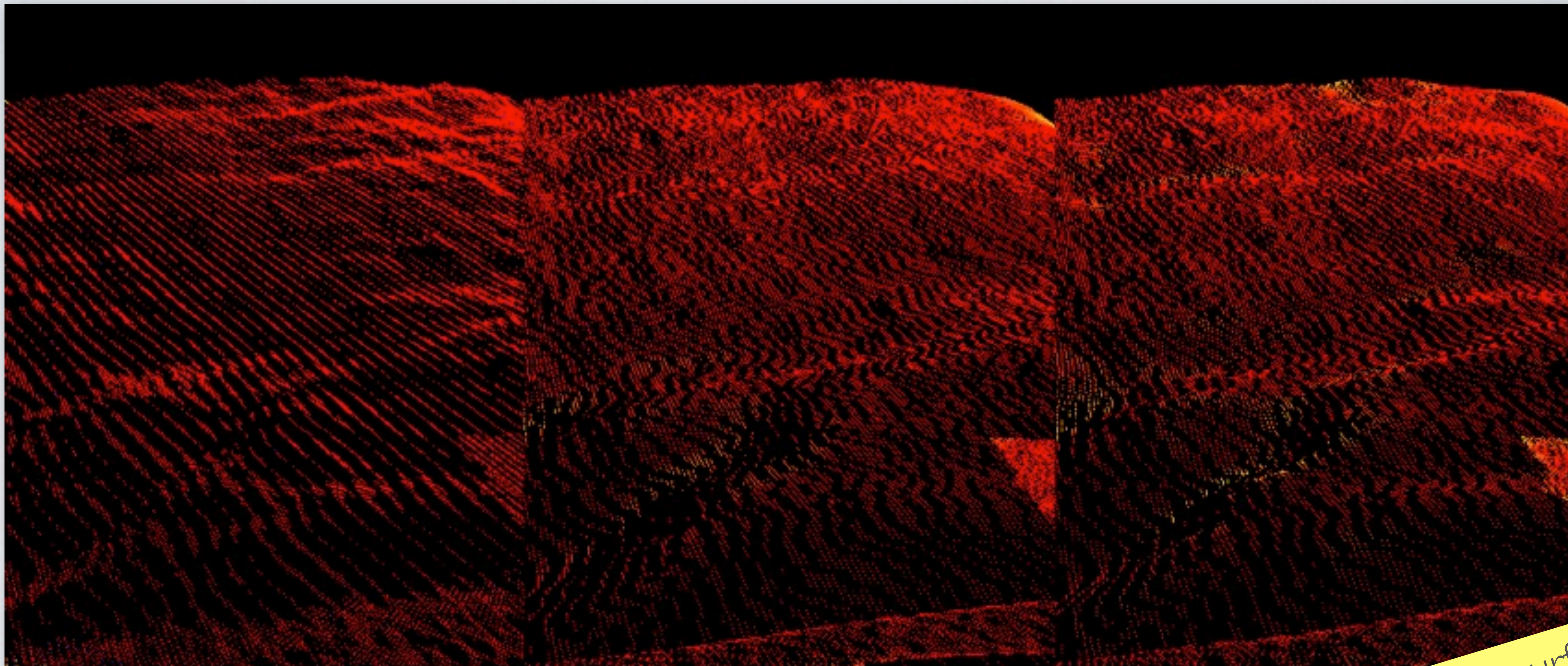
MOVING LEAST SQUARES 1.SMOOTHING 2/2



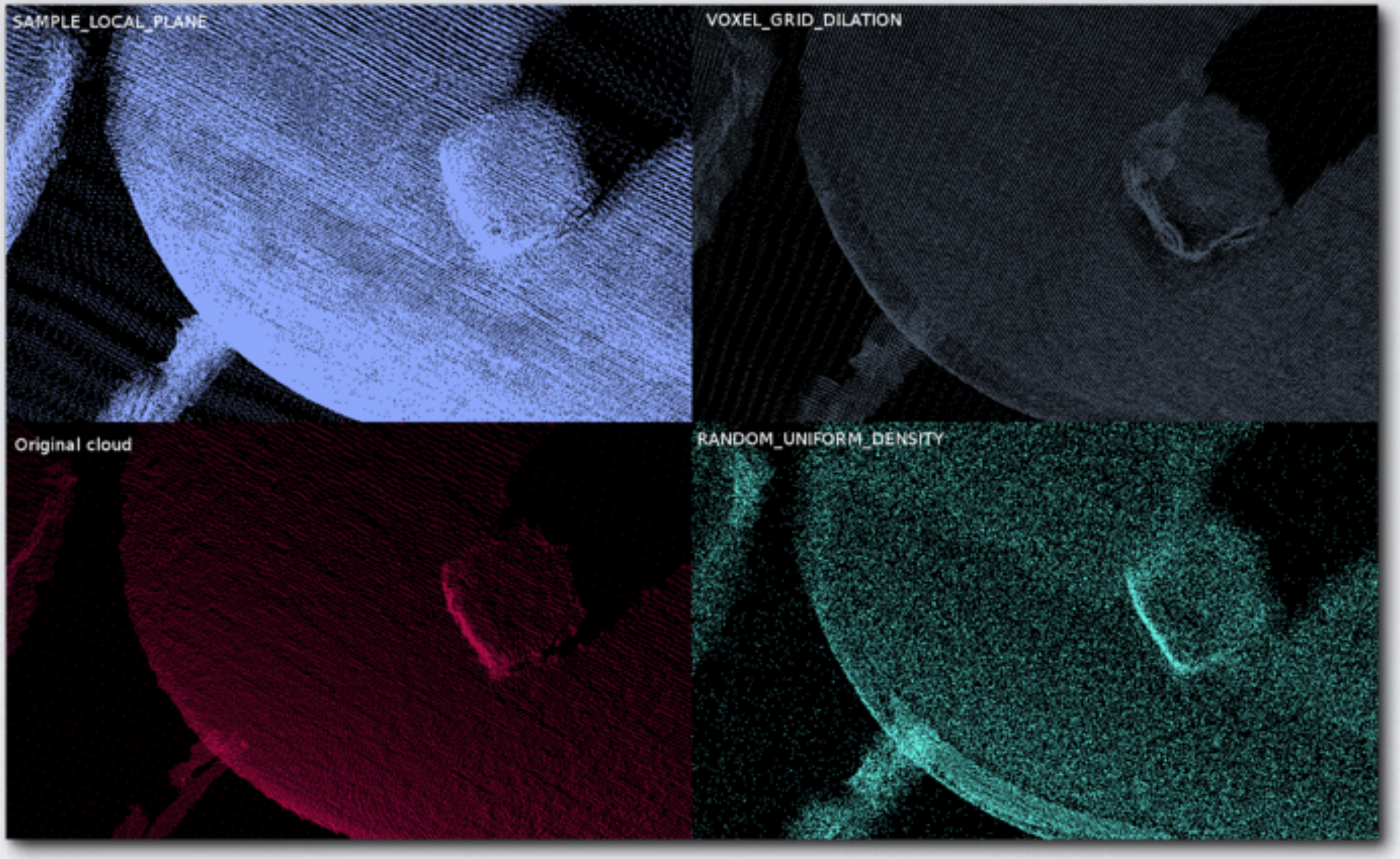
MLS applied on the Bed Sheets dataset

Smoother surfaces.

from left to right:

- original scan
- MLS smoothed with search radius = 5 cm and second order polynomial fitting
- MLS smoothed with search radius = 3 cm and second order polynomial fitting

MOVING LEAST SQUARES 2. UPSAMPLING 1/5

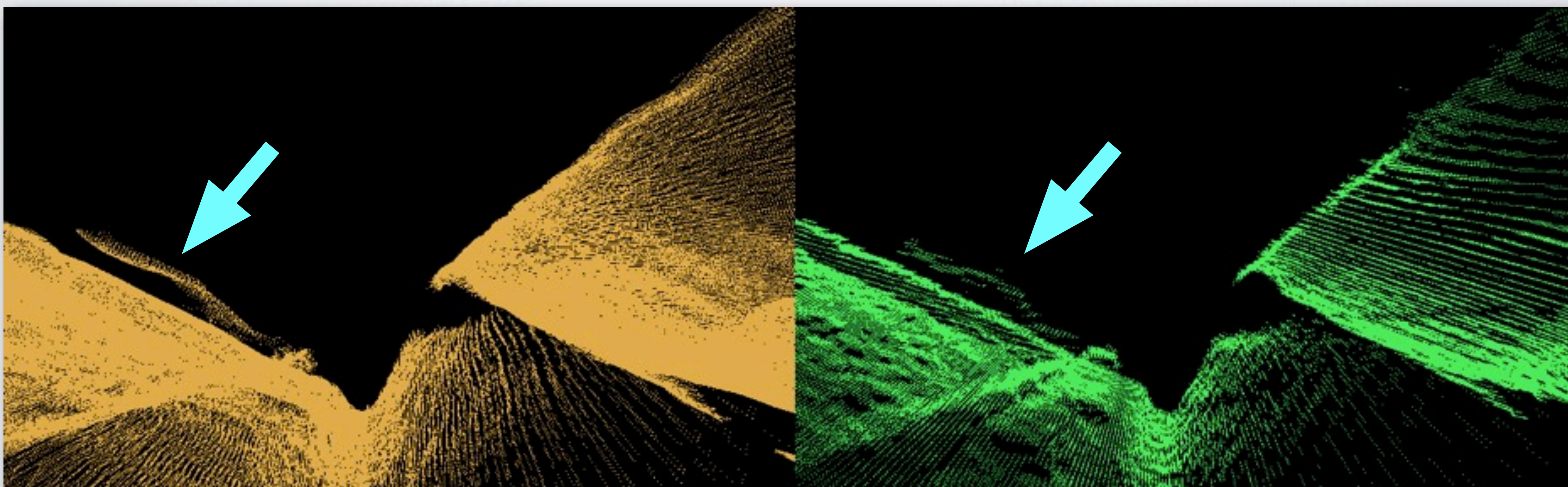


Sample locally fitted polynomial in different ways.

MOVING LEAST SQUARES 2. UPSAMPLING 2/5

SAMPLE_LOCAL_PLANE

Door Handle dataset



After Before

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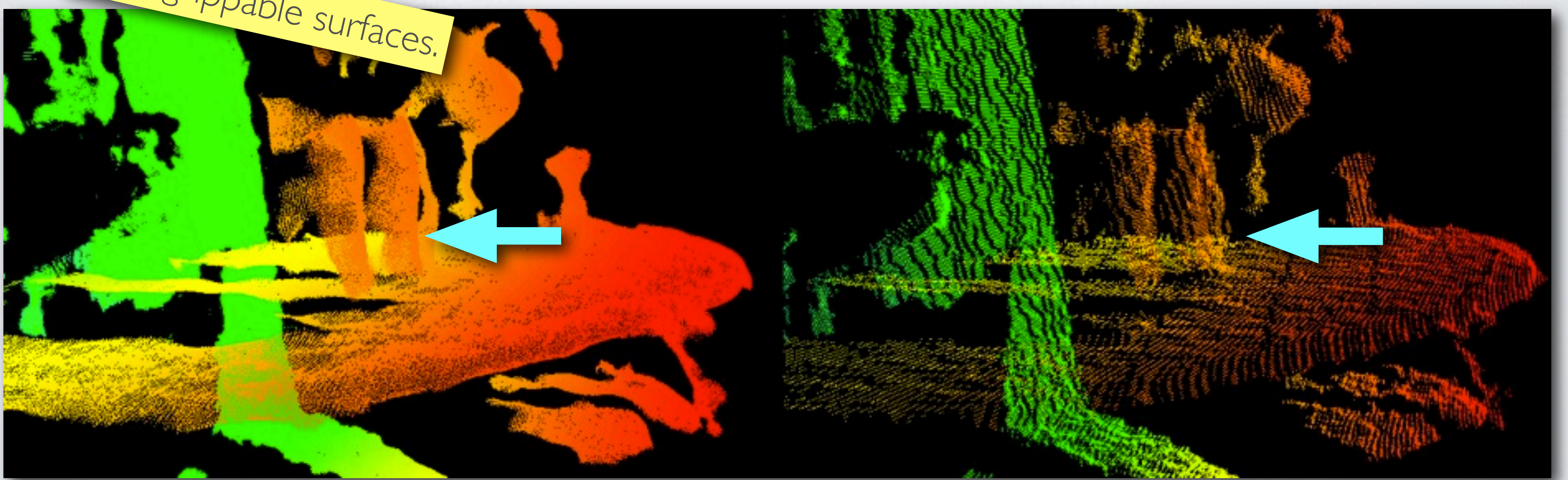
MOVING LEAST SQUARES 2. UPSAMPLING 3/5

SAMPLE_LOCAL_PLANE

Tupperware dataset

More grippable surfaces.



After

Before

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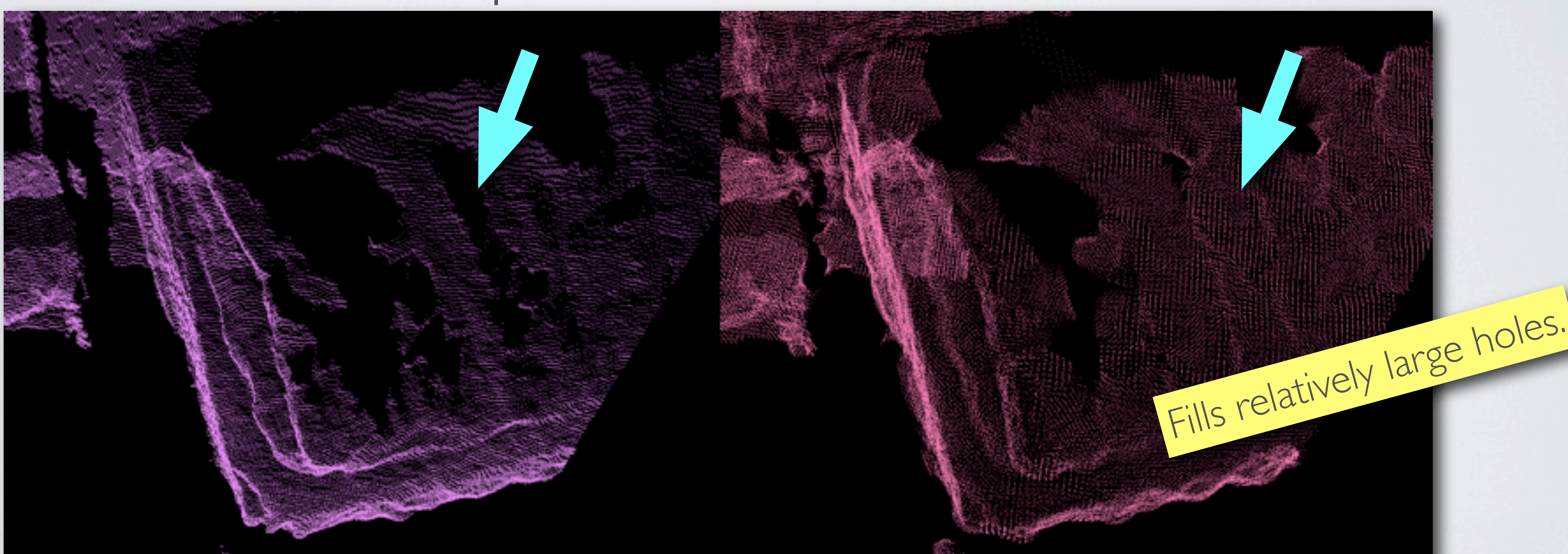
MOVING LEAST SQUARES 2. UPSAMPLING 4/5

VOXEL_GRID_DILATION

Computer Screen dataset



Before After

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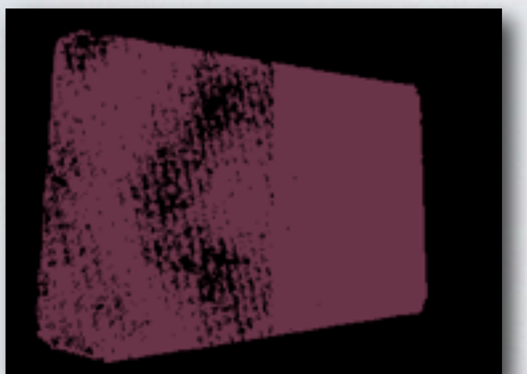
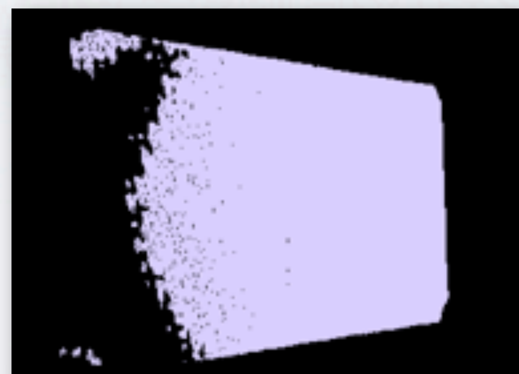
MOVING LEAST SQUARES 2. UPSAMPLING 5/5

Plane fitting quality (images show inliers)

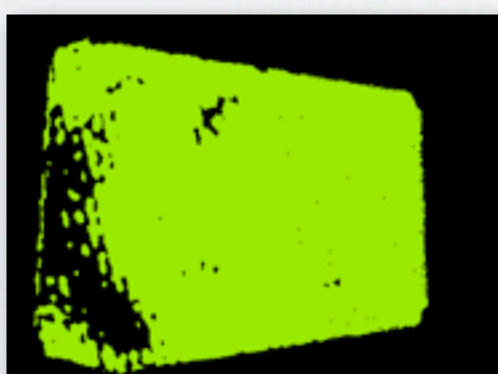


original

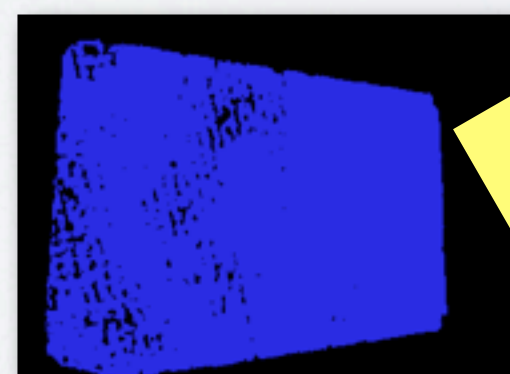


MLS, no upsampling

SAMPLE_LOCAL_PLANE



RANDOM_UNIFORM_DENSITY



Best performer!

VOXEL_GRID_DILATION

BILATERAL FILTERING UPSAMPLING 1/4

- Kinect modes:
  - 640x480 RGB image + 640x480 depth image at 30Hz
  - 1280x1024 RGB image + 640x480 depth image at 15 Hz

Why not use better quality RGB image to enhance depth map?

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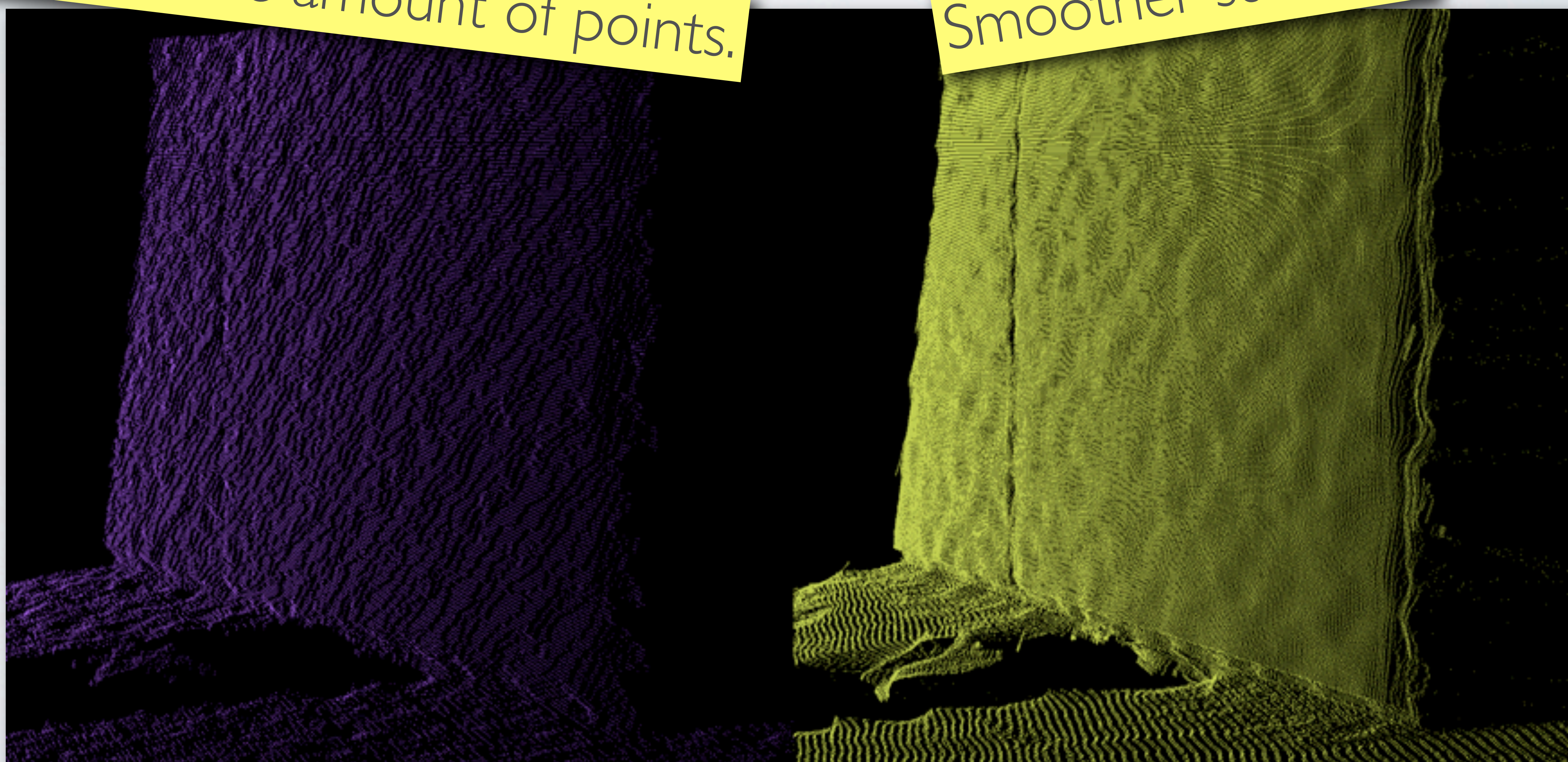
BILATERAL FILTERING UPSAMPLING 2/4

Double the amount of points.

Smoother surfaces.



original

upsampled

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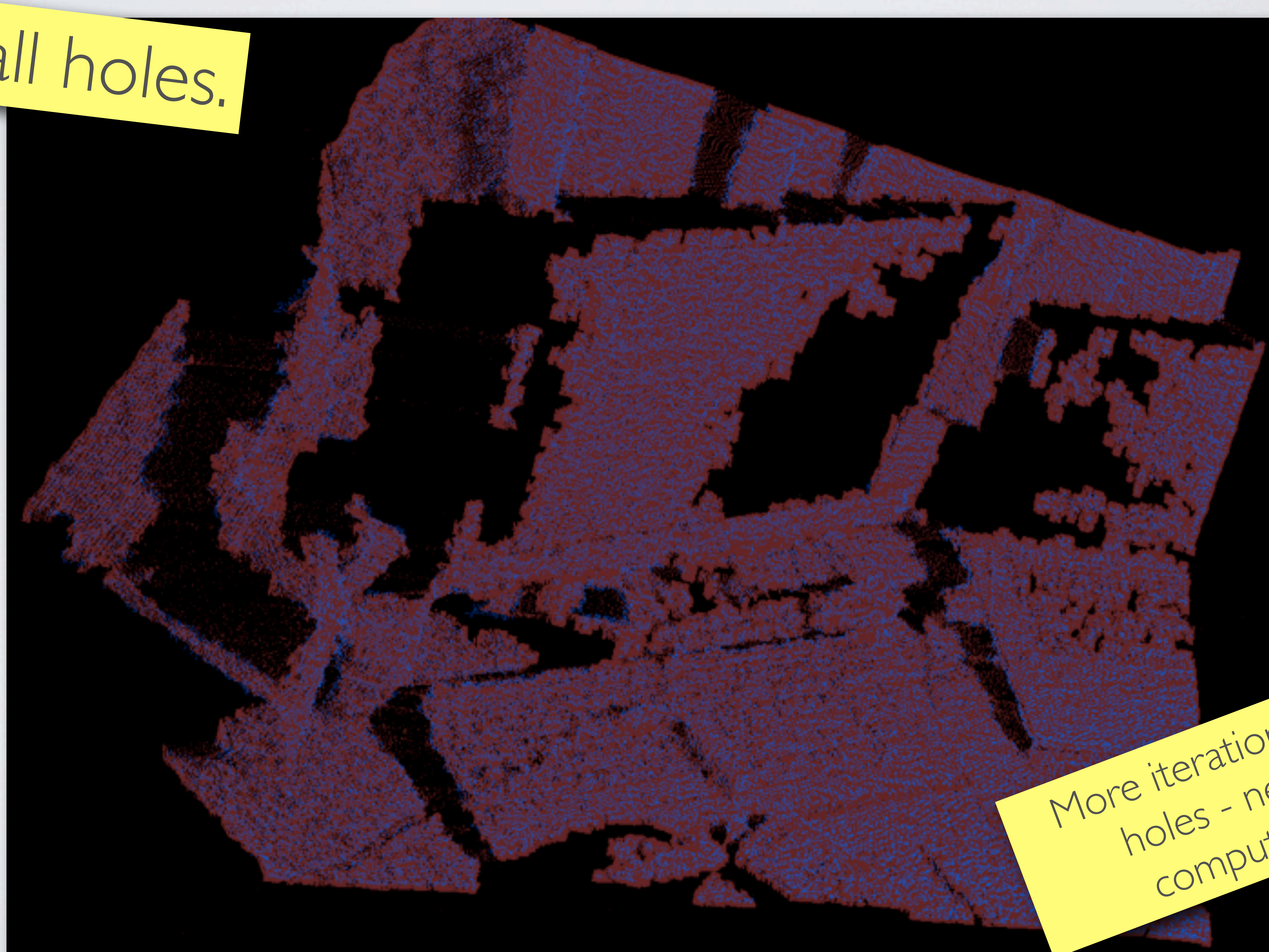
BILATERAL FILTERING UPSAMPLING 3/4

Fills small holes.



More iterations - fill larger holes - needs more computation time

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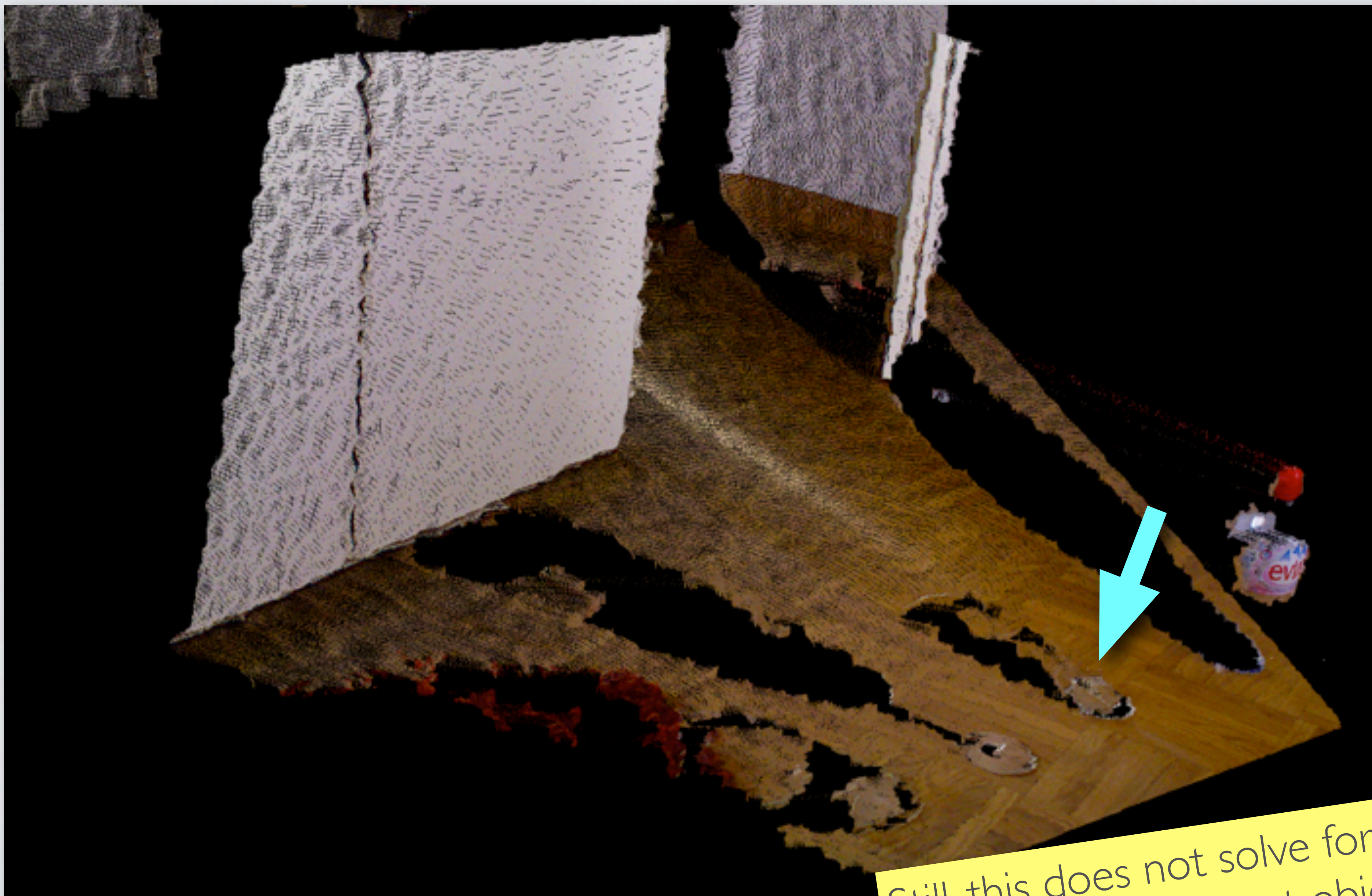
BILATERAL FILTERING UPSAMPLING 4/4



Still, this does not solve for the problem of transparent objects ...

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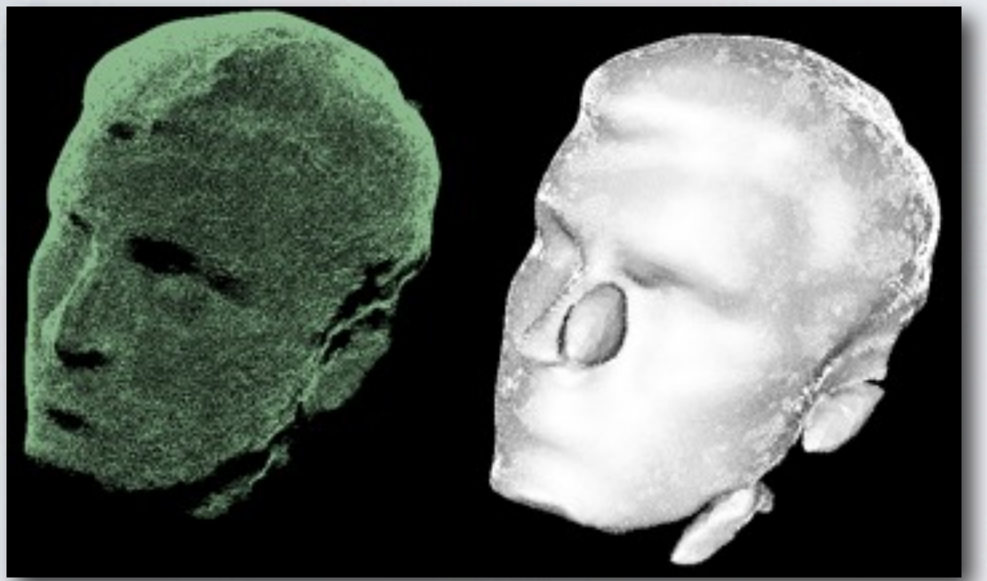
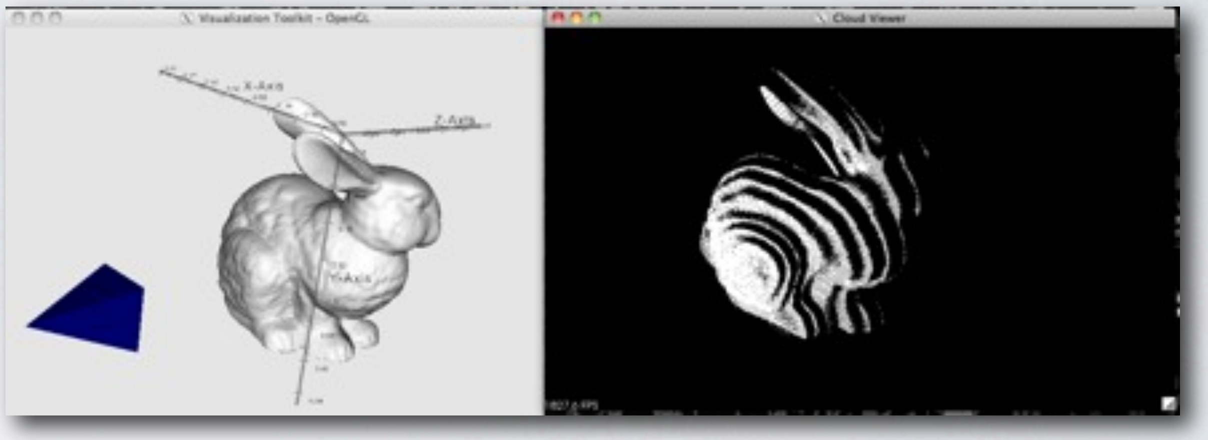
OTHER RESULTS



Poisson surface reconstruction



Virtual scanner

Mesh operations ported from VTK

Marching cubes meshing

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