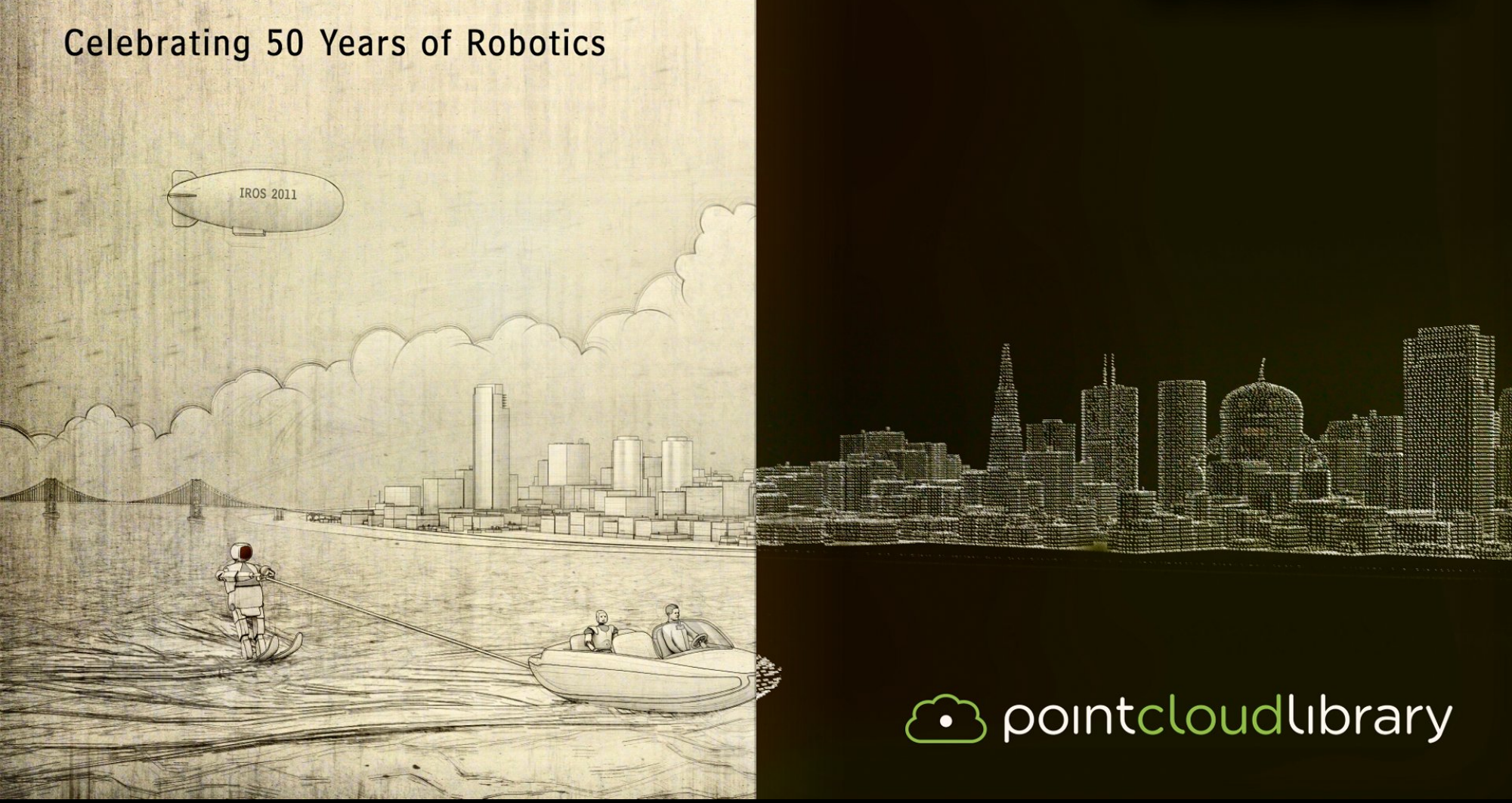

PCL :: Segmentation

September 25, 2011

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Outline

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Introduction

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RANSAC

If we know what to expect, we can (usually) efficiently segment our data:

RANSAC (Random Sample Consensus) is a randomized algorithm for robust model fitting.

Its basic operation:

1. select sample set
2. compute model
3. compute and count inliers
4. repeat until sufficiently confident

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RANSAC

If we know what to expect, we can (usually) efficiently segment our data:

RANSAC (Random Sample Consensus) is a randomized algorithm for robust model fitting.

Its basic operation: line example

1. select sample set — 2 points
2. compute model — line equation
3. compute and count inliers — e.g. ϵ-band
4. repeat until sufficiently confident — e.g. 95%

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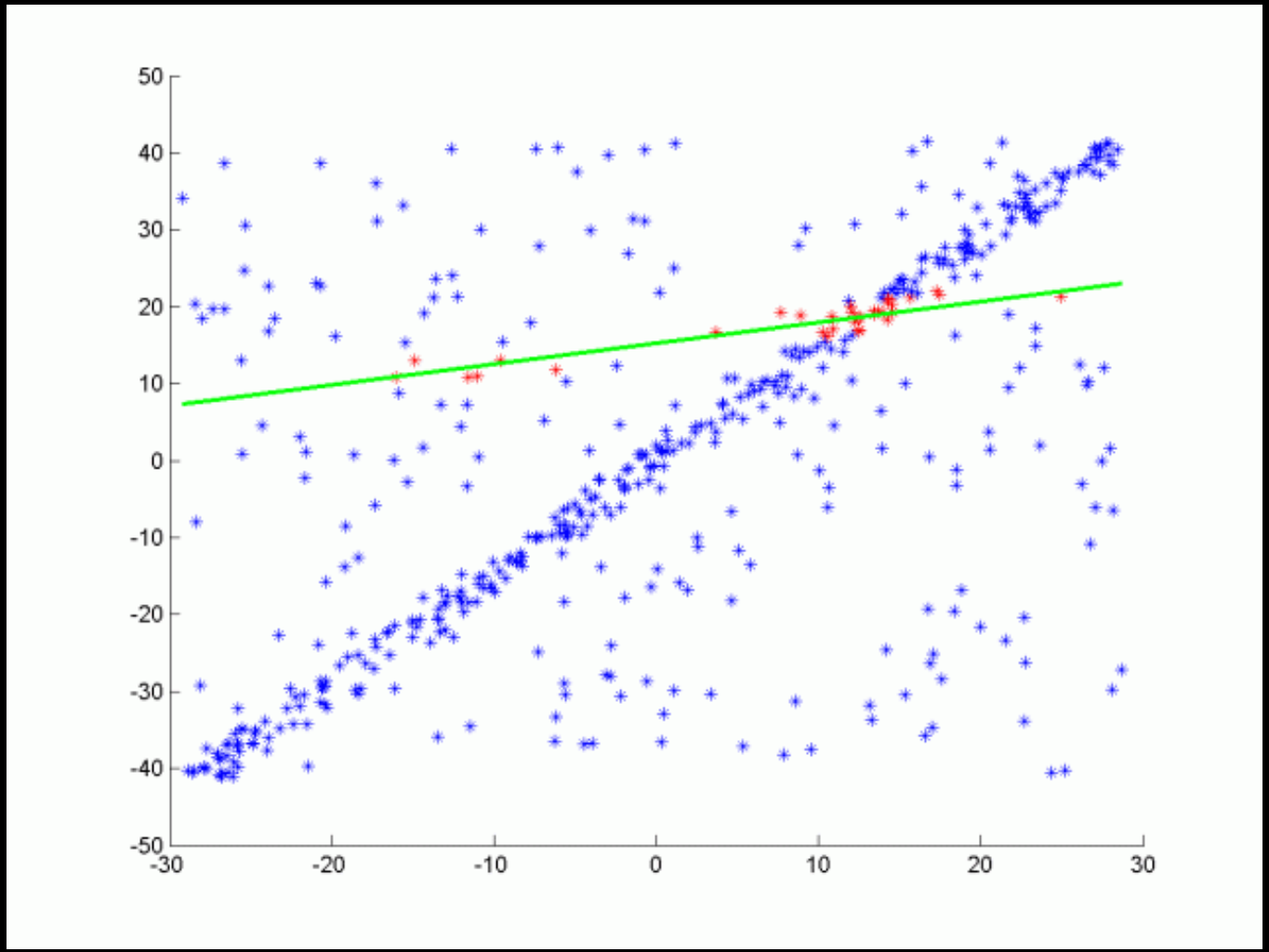
RANSAC



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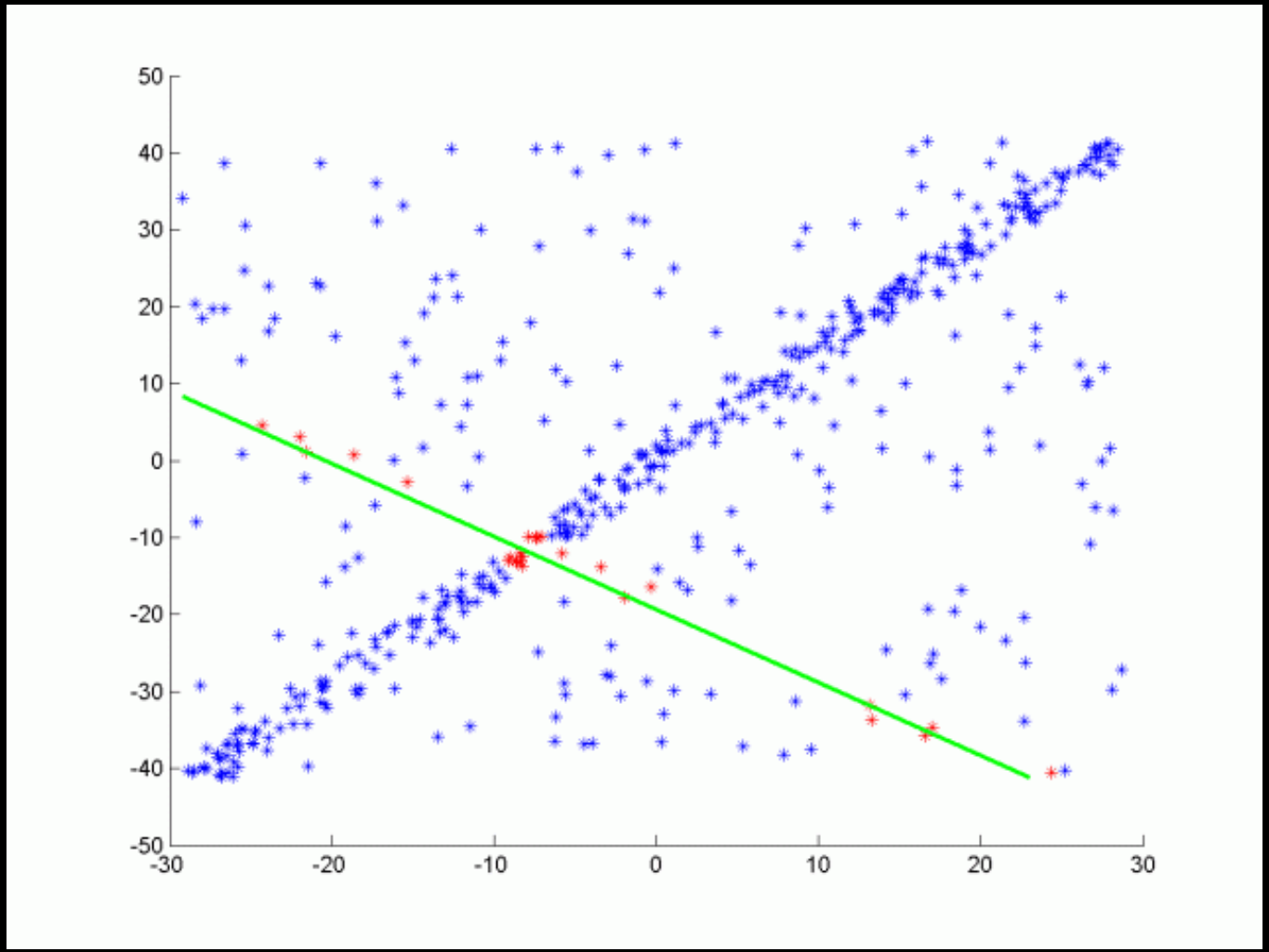
RANSAC



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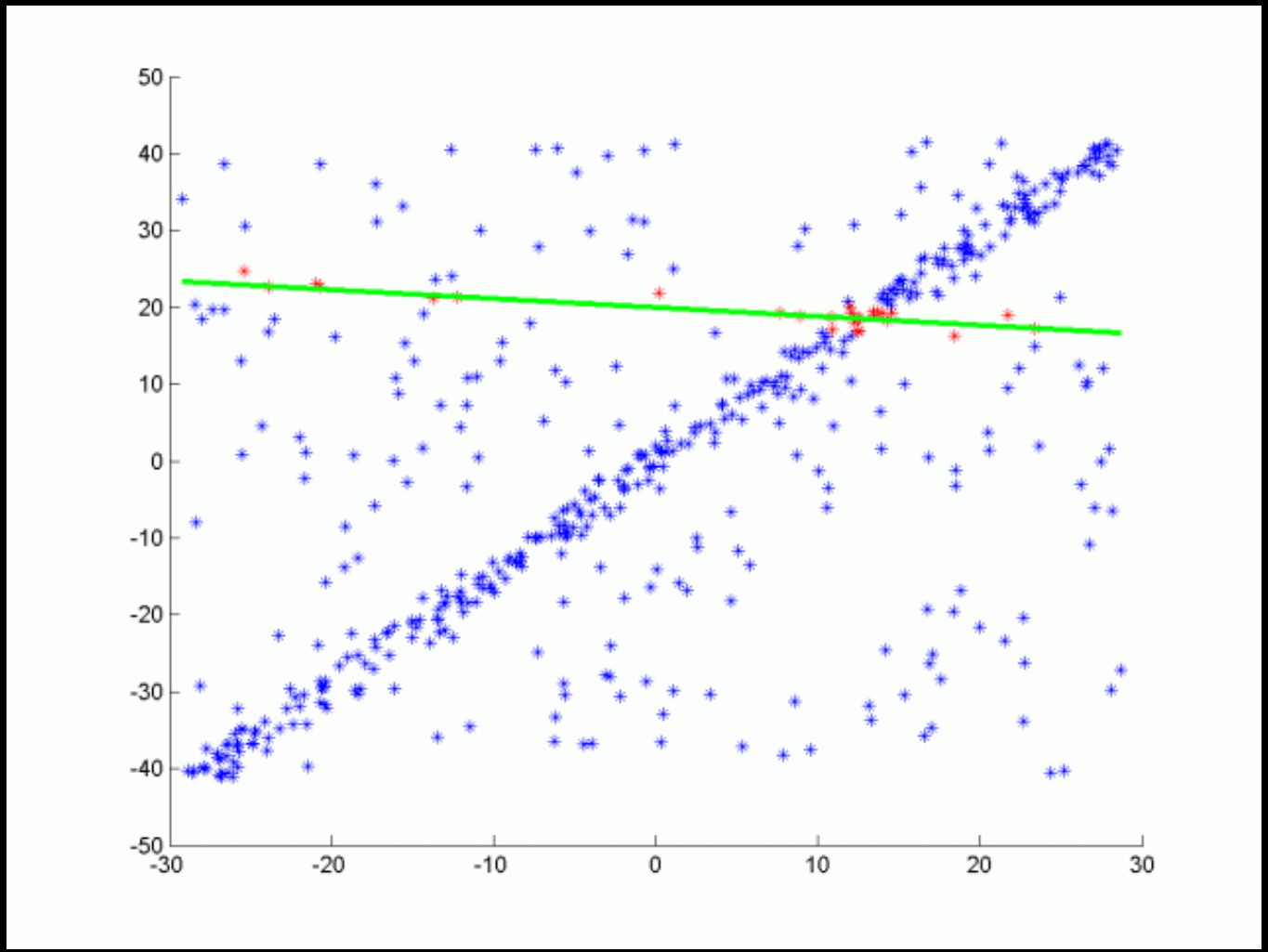
RANSAC



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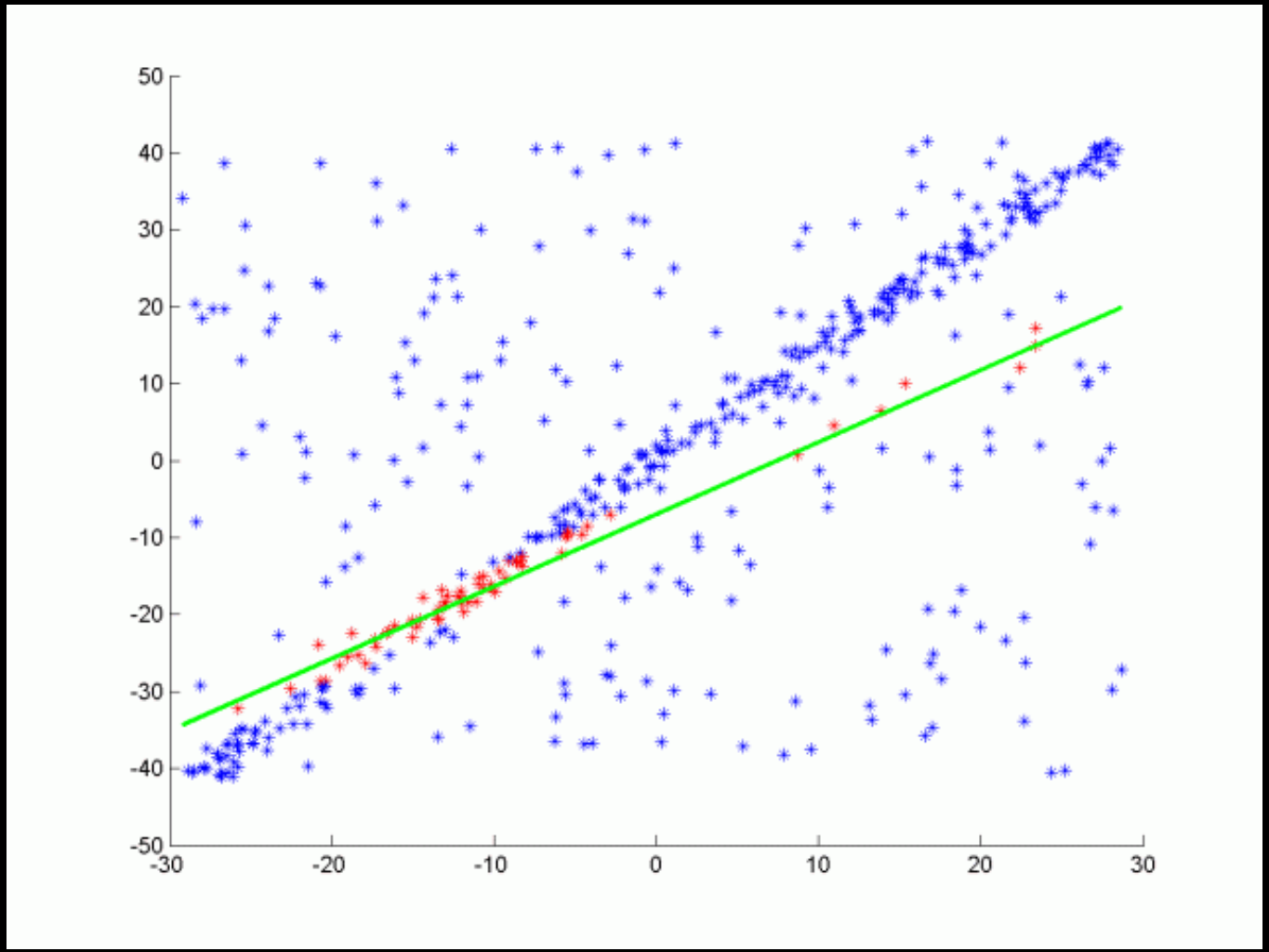
RANSAC



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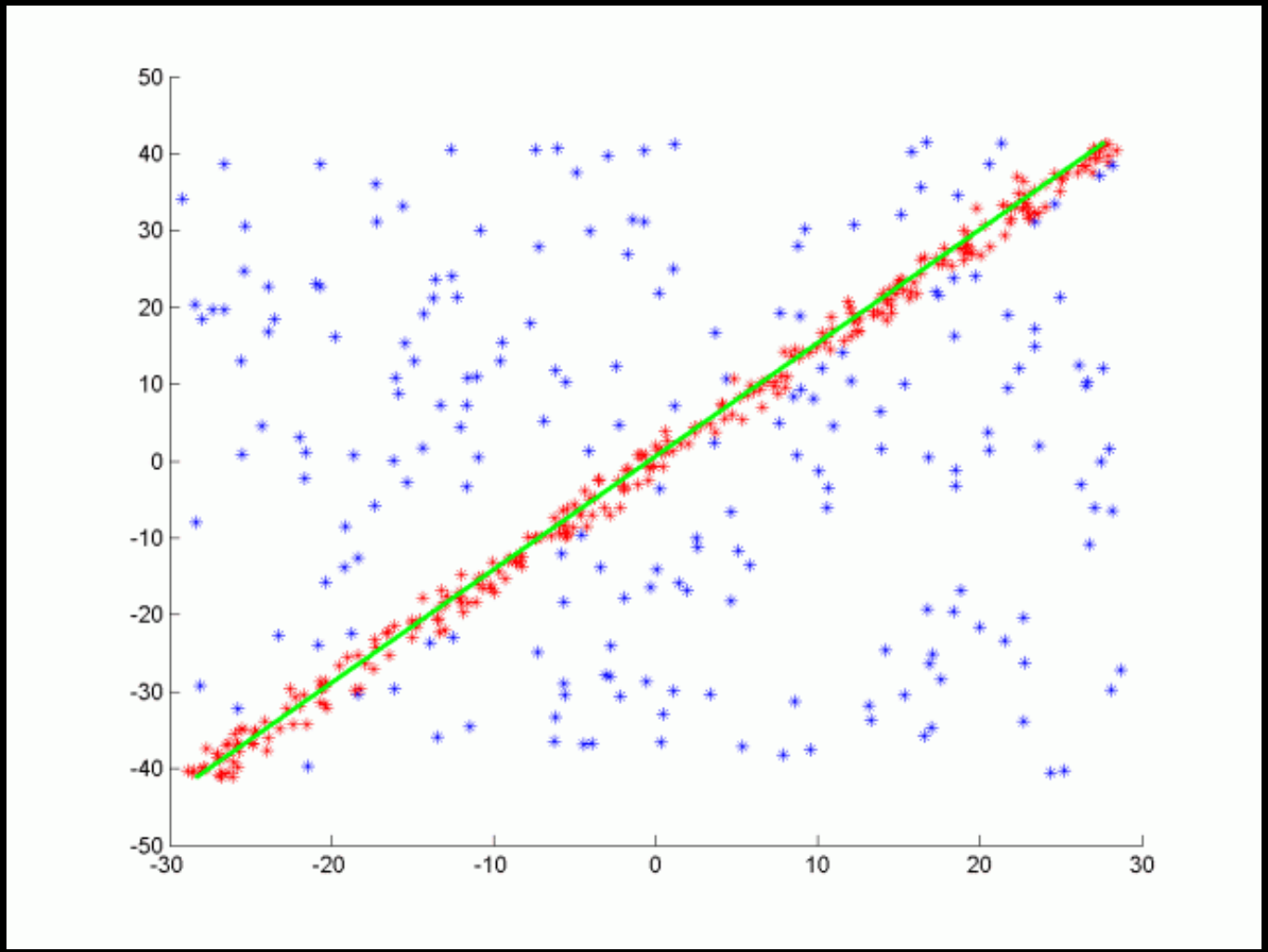
RANSAC



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*SAC

several extensions exist in PCL:

- MSAC (weighted distances instead of hard thresholds)
- MLESAC (Maximum Likelihood Estimator)
- PROSAC (Progressive Sample Consensus)

also, several model types are provided in PCL:

- Plane models (with constraints such as orientation)
- Cone
- Cylinder
- Sphere
- Line
- Circle
- ...

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Example 1

So let's look at some code:

```
// necessary includes
#include <pcl/sample_consensus/ransac.h>
#include <pcl/sample_consensus/sac_model_plane.h>

// ...

// Create a shared plane model pointer directly
SampleConsensusModelPlane<PointXYZ>::Ptr model
  (new SampleConsensusModelPlane<PointXYZ> (input));

// Create the RANSAC object
RandomSampleConsensus<PointXYZ> sac (model, 0.03);

// perform the segmenation step
bool result = sac.computeModel ();
```

Here, we

- create a SAC model for detecting planes,
- create a RANSAC algorithm, parameterized on $\epsilon = 3cm$,
- and compute the best model (one complete RANSAC run, not just a single iteration!)

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Example 1

```
// get inlier indices
boost::shared_ptr<vector<int> > inliers (new vector<int>);
sac.getInliers (*inliers);
cout << "Found model with " << inliers->size () << " inliers";

// get model coefficients
Eigen::VectorXf coeff;
sac.getModelCoefficients (coeff);
cout << ", plane normal is: " << coeff[0] << ", " << coeff[1] << ", "
```

We then

- retrieve the best set of inliers
- and the corr. plane model coefficients

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Example 1

Optional:

```
// perform a refitting step
Eigen::VectorXf coeff_refined;
model->optimizeModelCoefficients
  (*inliers, coeff, coeff_refined);
model->selectWithinDistance
  (coeff_refined, 0.03, *inliers);
cout << "After refitting, model contains "
                              << inliers->size () << " inliers";
cout << ", plane normal is: " << coeff_refined[0] << ", "
                              << coeff_refined[1] << ", "
                              << coeff_refined[2] << "." << endl;

// Projection
PointCloud<PointXYZ> proj_points;
model->projectPoints (*inliers, coeff_refined, proj_points);
```

If desired, models can be refined by:

- refitting a model to the inliers (in a least squares sense)
- or projecting the inliers onto the found model

PCL also provides a more convenient wrapper in SACSegmentation:

```
pcl::SACSegmentation<PointT> seg;

seg.setModelType (pcl::SACMODEL_PLANE);
seg.setMethodType (pcl::RANSAC);
seg.setDistanceThreshold (threshold);
seg.setInputCloud (input);

seg.segment (*inliers, *coefficients);
```

We will use this class in this session.

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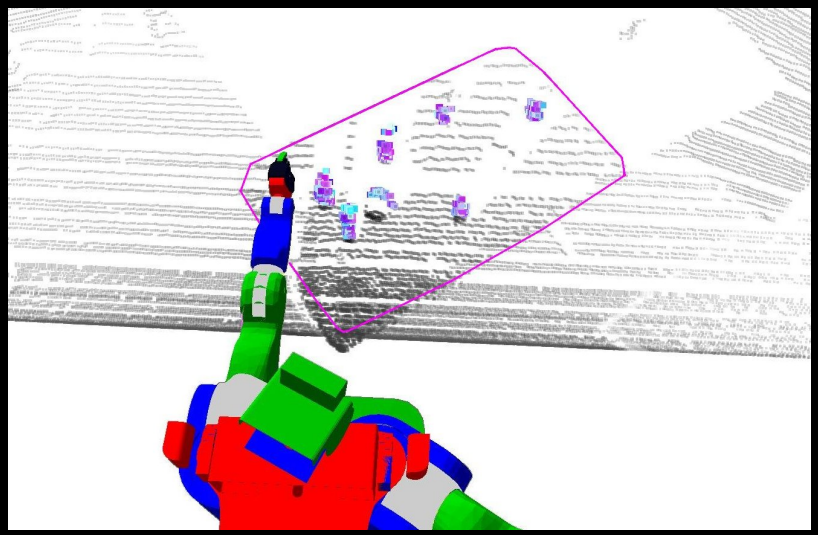
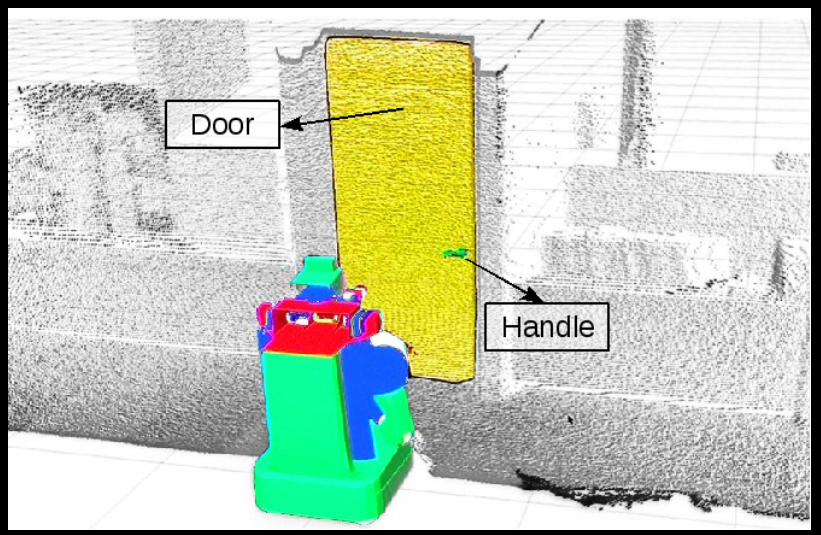
Polygonal Prism





Once we have a plane model, we can find

- objects standing on tables or shelves
- protruding objects such as door handles

by

- computing the convex hull of the planar points
- and extruding this outline along the plane normal

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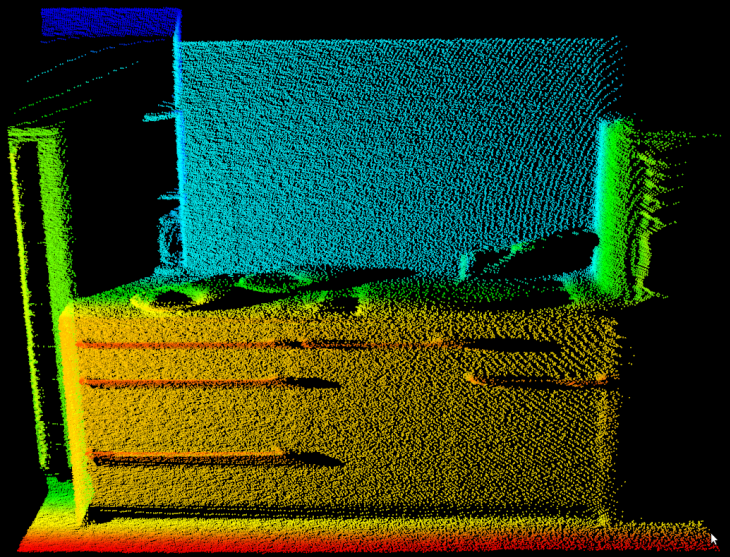
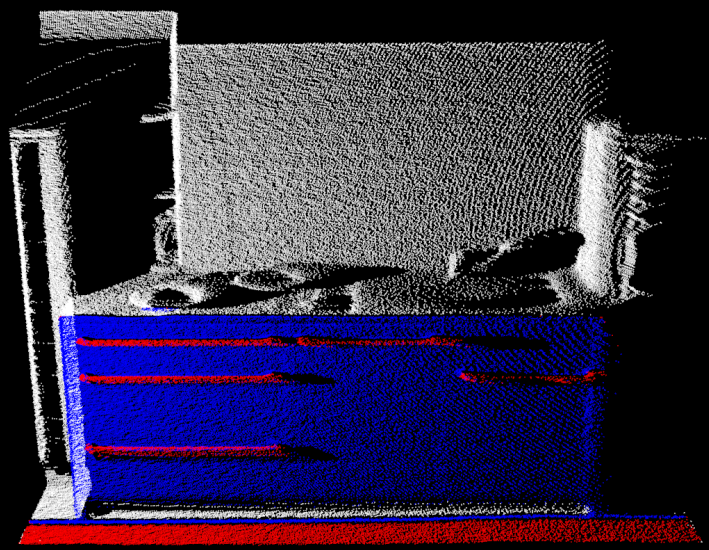
ExtractPolygonalPrismData

ExtractPolygonalPrismData is a class in PCL intended fur just this purpose.
Let's look at the front drawer handles of a kitchen:





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ExtractPolygonalPrismData

```
// Create a Convex Hull representation of the projected inliers
pcl::PointCloud<pcl::PointXYZ>::Ptr cloud_hull
  (new pcl::PointCloud<pcl::PointXYZ>);
pcl::ConvexHull<pcl::PointXYZ> chull;
chull.setInputCloud (inliers_cloud);
chull.reconstruct (*cloud_hull);

// segment those points that are in the polygonal prism
ExtractPolygonalPrismData<PointXYZ> ex;
ex.setInputCloud (outliers);
ex.setInputPlanarHull (cloud_hull);

PointIndices::Ptr output (new PointIndices);
ex.segment (*output);
```

Starting from the segmented plane for the furniture fronts,

- we compute its convex hull,
- and pass it to a ExtractPolygonalPrismData object.

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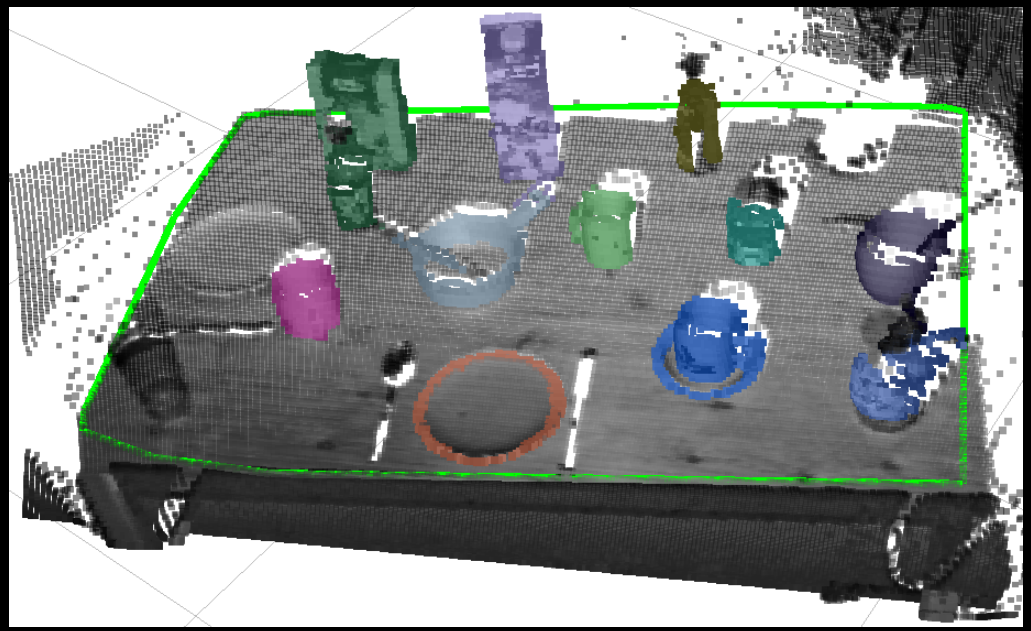
Table Object Detection



Finally, we want to segment the remaining point cloud into separate clusters. For a table plane, this gives us table top object segmentation.

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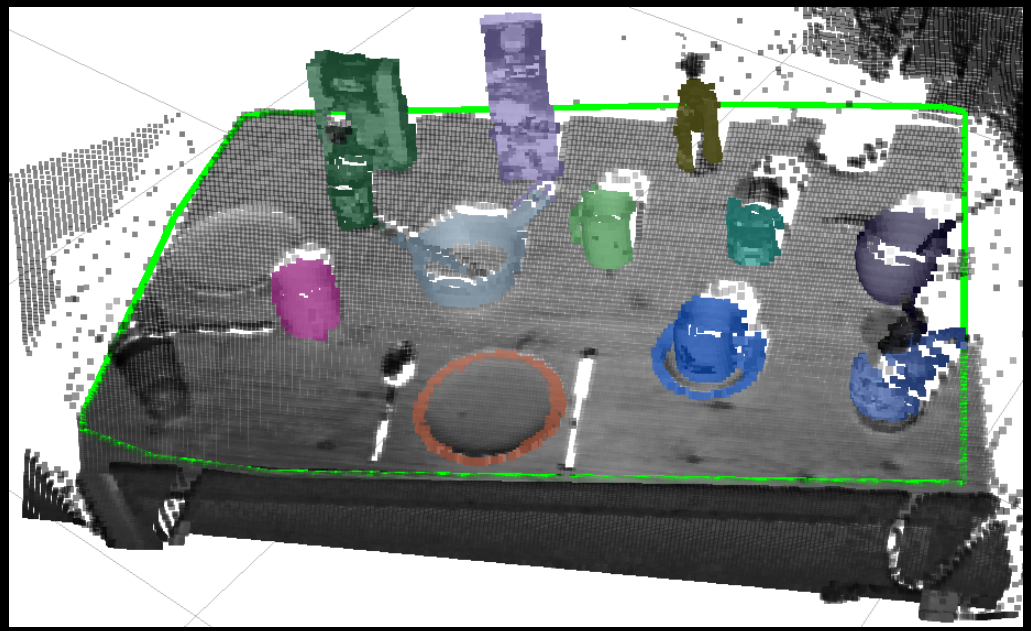
Table Object Detection



The basic idea is to use a region growing approach that cannot “grow” / connect two points with a high distance, therefore merging locally dense areas and splitting separate clusters.

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Sample 4

```
// Create EuclideanClusterExtraction and set parameters
pcl::EuclideanClusterExtraction<PointT> ec;
ec.setClusterTolerance (cluster_tolerance);
ec.setMinClusterSize (min_cluster_size);
ec.setMaxClusterSize (max_cluster_size);

// set input cloud and let it run
ec.setInputCloud (input);
ec.extract (cluster_indices_out);
```

Very straightforward.

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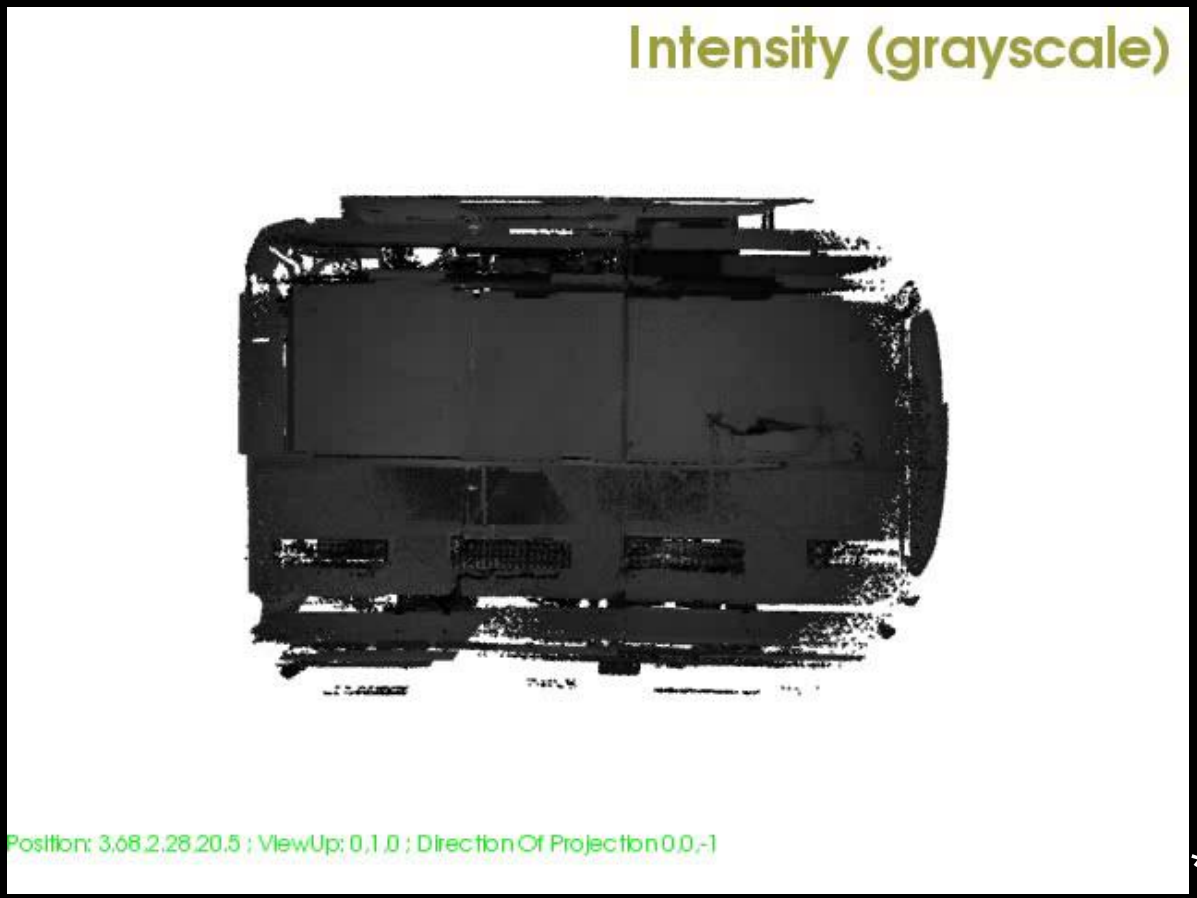
Outlook

When we combine these segmentation algorithms consequently, we can use them to effectively and efficiently process whole rooms:



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