ROS-Industrial Advanced Developer's Training Class

October 2022

Southwest Research Institute

Advanced Topic:

Building a Perception Pipeline

Southwest Research Institute

Perception Processing Pipeline

- Goal: Gain knowledge from sensor data
- Process data in order to
  - Improve data quality
    - -> filter noise
  - Enhance succeeding processing steps
    - -> reduce amount of data
  - Create a consistent environment model
    - -> Combine data from different view points
  - Simplify detection problem
    - -> segment interesting regions
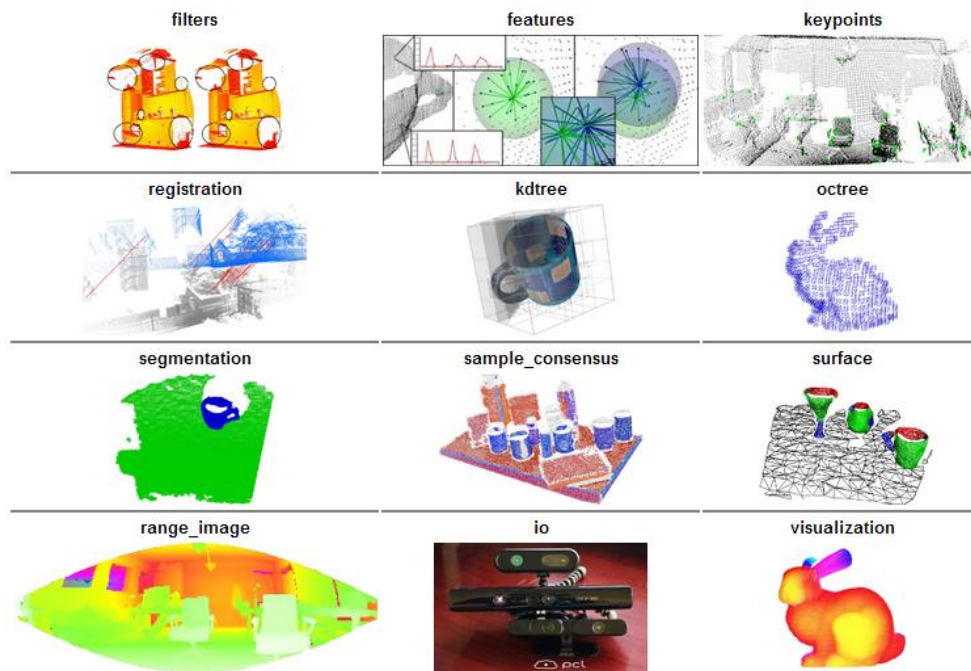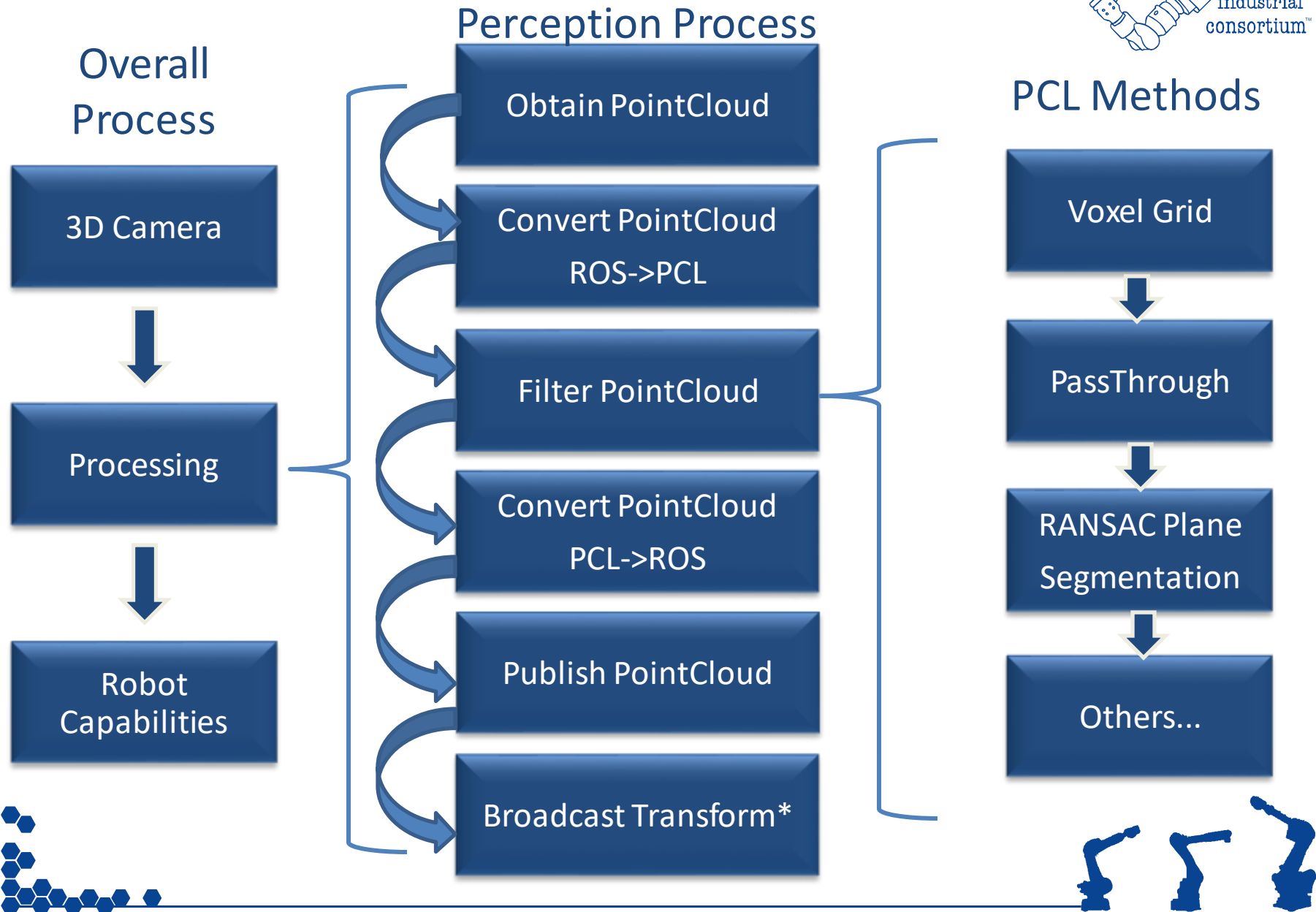 - Gain knowledge about environment
    - -> classify surfaces

Camera

↓

Processing

↓

Robot Capabilities
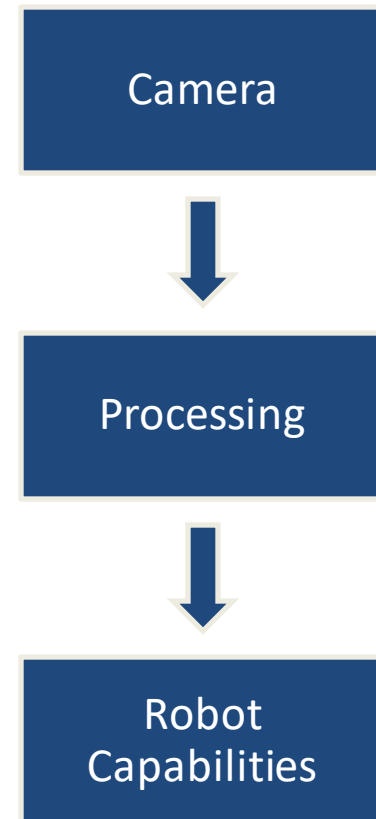
Perception Libraries (PCL)

- Point Cloud Library (PCL) - https://pcl.readthedocs.io/projects/tutorials/en/latest/

- Documentation - http://pointclouds.org/documentation/
  - Focused on 3D Range(Colorized) data

Perception Pipeline

Overall Process

```
3D Camera
    ↓
Processing
    ↓
Robot Capabilities
```

Perception Process

```
Obtain PointCloud
    ↓
Convert PointCloud ROS->PCL
    ↓
Filter PointCloud
    ↓
Convert PointCloud PCL->ROS
    ↓
Publish PointCloud
    ↓
Broadcast Transform*
```

PCL Methods

```
Voxel Grid
    ↓
PassThrough
    ↓
RANSAC Plane Segmentation
    ↓
Others...
```

Voxel Grid

- Creates a 3D voxel grid over the input point cloud data

- In each voxel (i.e., 3D box), all the points present will be approximated (i.e., downsampled) with their centroid

  - https://pcl.readthedocs.io/projects/tutorials/en/latest/voxel_grid.html
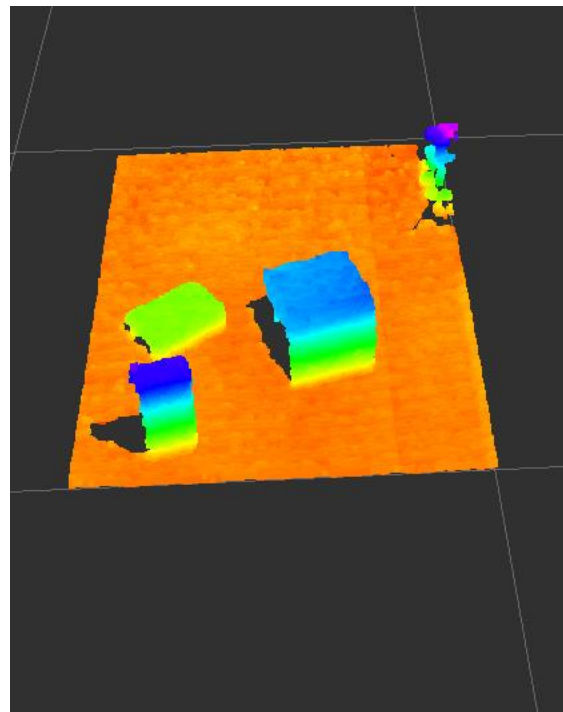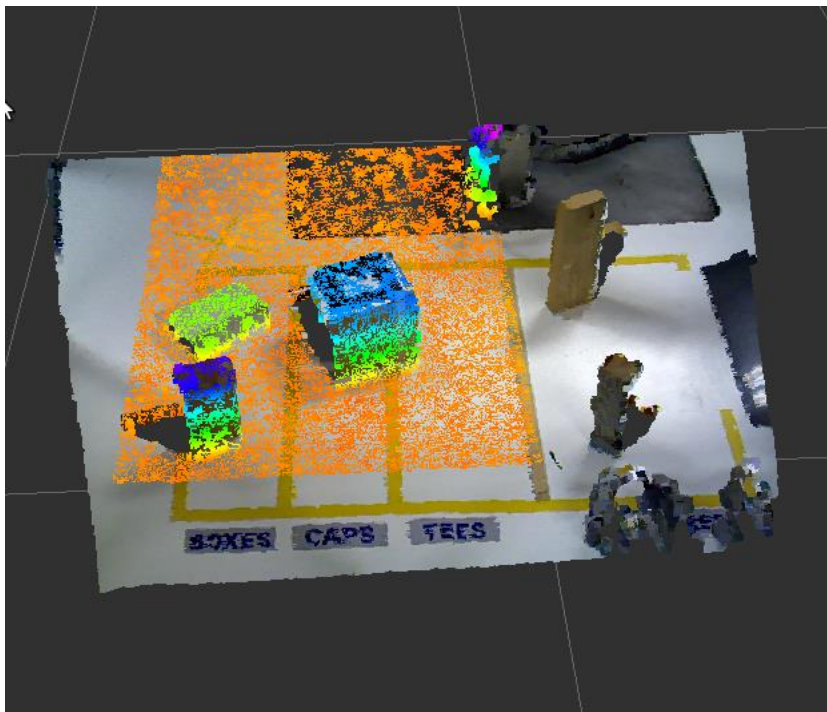
PassThrough

- Cut off values that are either inside or outside a given user range
  - https://pcl.readthedocs.io/projects/tutorials/en/latest/passthrough.html

Plane Segmentation - RANSAC

- "RANdom SAmple Consensus" (RANSAC), and it is an iterative method that is used to estimate parameters of a mathematical model from a set of data containing outliers

- https://pcl.readthedocs.io/projects/tutorials/en/latest/random_sample_consensus.html

Plane model:
$ax+by+cz+d=0$

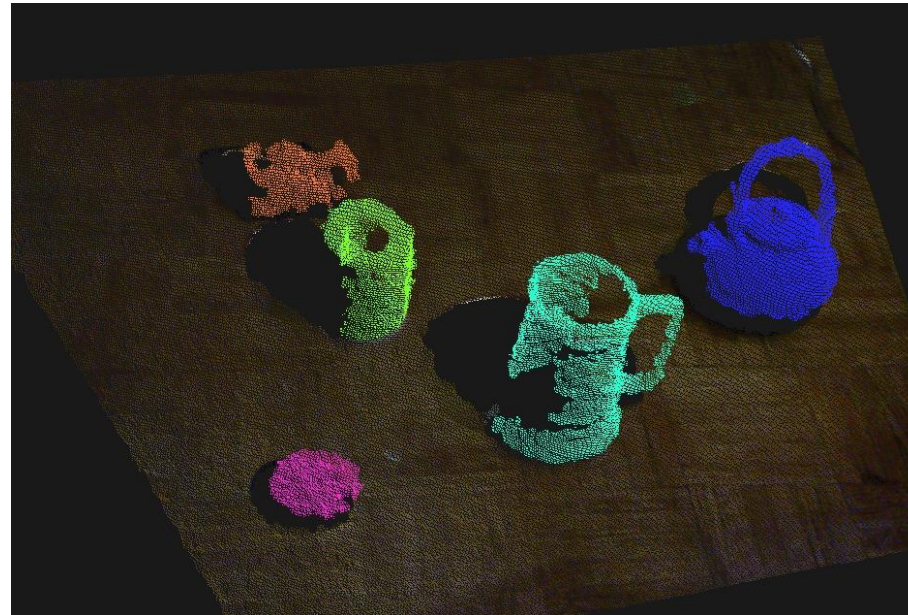- Find all the points within a point cloud that support a plane model

  https://pcl.readthedocs.io/projects/tutorials/en/latest/planar_segmentation.html

Other – Clusters

- Euclidean Cluster Extraction - A clustering method needs to divide an unorganized point cloud model into smaller parts

 - https://pcl.readthedocs.io/en/latest/cluster_extraction.html

http://plasmodic.github.io/ecto_pcl/examples/colorize_clusters.html

Other – SOR

- Statistical Outlier Removal - Remove noisy measurements, e.g. outliers, from a point cloud dataset using statistical analysis techniques

  - https://pcl.readthedocs.io/projects/tutorials/en/latest/statistical_outlier.html
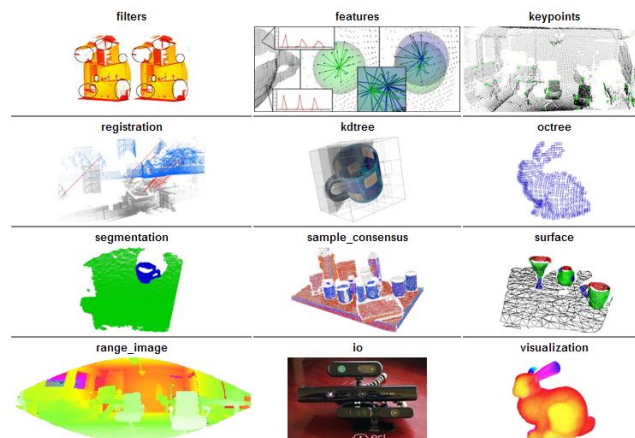
Other
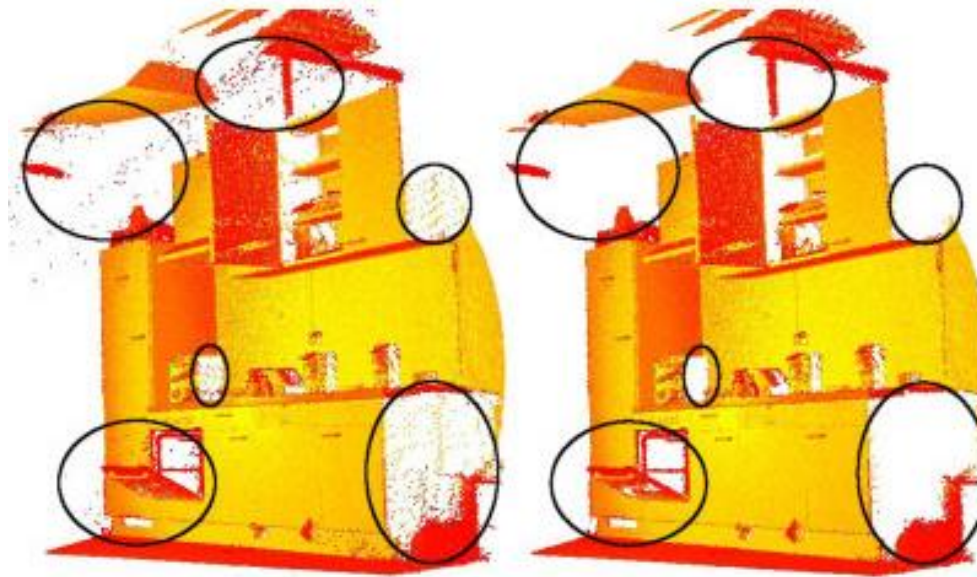
- CropBox

- Segmentation - Region Growing, Min-Cut Based, Cylinder Model

- Clustering - Conditional Euclidean

Even more:

- Features

- Recognition

- Registration...

- https://pcl.readthedocs.io/projects/tutorials/en/latest/

Exercise 5.1

- Exercise 5.1 - https://industrial-training-master.readthedocs.io/en/foxy/_source/session5/Building-a-Perception-Pipeline.html
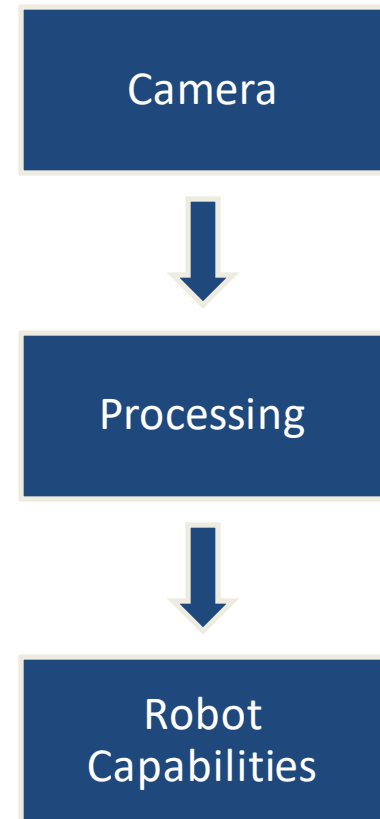
SIMPLE PCL INTERFACE FOR PYTHON

Simple PCL interface for python

- Goal: Create a ROS python node that uses PCL to process point cloud data
- Objectives
  - Create a python package
  - Call a service from python to filter a point cloud
  - Apply multiple filtering operations to a point cloud

```
Camera
   ↓
Processing
   ↓
Robot Capabilities
```

Exercise 5.3

- Exercise 5.3 - https://industrial-training-master.readthedocs.io/en/foxy/_source/session5/Simple-PCL-Interface-for-Python.html