Point Cloud Library

Release 0.0

Aug 22, 2020

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The following links describe a set of basic PCL tutorials. Please note that their source codes may already be provided as part of the PCL regular releases, so check there before you start copy & pasting the code. The list of tutorials below is automatically generated from reST files located in our git repository.

Note: Before you start reading, please make sure that you go through the higher-level overview documentation at http://www.pointclouds.org/documentation/, under **Getting Started**. Thank you.

As always, we would be happy to hear your comments and receive your contributions on any tutorial.

CHAPTER 1

Basic Usage

- walkthrough

Title: **PCL Functionality Walkthrough**
Author: *Razvan G. Mihalyi*
Compatibility: > PCL 1.6
Takes the reader through all of the PCL modules and offers basic explanations on their functionalities.

- basic_structures

Title: **Getting Started / Basic Structures**
Author: *Radu B. Rusu*
Compatibility: > PCL 1.0
Presents the basic data structures in PCL and discusses their usage with a simple code example.

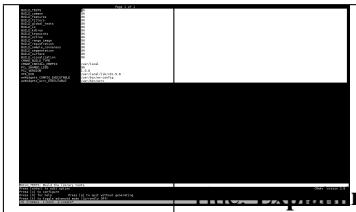
- using_pcl_pcl_config

Title: **Using PCL in your own project**
Author: *Nizar Sallem*
Compatibility: > PCL 1.0
In this tutorial, we will learn how to link your own project to PCL using cmake.

- compiling_pcl_posix

Title: **Compiling PCL from source on POSIX compliant systems**
Author: *Victor Lamoine*
Compatibility: > PCL 1.0
In this tutorial, we will explain how to compile PCL from sources on POSIX/Unix systems.

- building_pcl



ng PCL's cmake options
Author: *Nizar Sallem*
Compatibility: > PCL 1.0
In this tutorial, we will explain the basic PCL cmake options, and ways to tweak them to fit your project.

- compiling_pcl_dependencies_windows

Title: **Compiling PCL's dependencies from source on Windows**
Authors: *Alessio Placitelli* and *Mourad Boufarguine*
Compatibility: > PCL 1.0
In this tutorial, we will explain how to compile PCL's 3rd party dependencies from source on Microsoft Windows.

- compiling_pcl_windows

Title: **Compiling PCL on Windows**
Author: *Mourad Boufarguine*
Compatibility: > PCL 1.0
In this tutorial, we will explain how to compile PCL on Microsoft Windows.

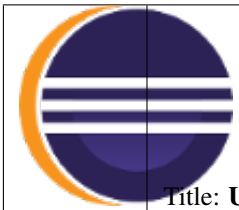
- compiling_pcl_macosx

Title: **Compiling PCL and its dependencies from MacPorts and source on Mac OS X**
Author: *Justin Rosen*
Compatibility: > PCL 1.0
This tutorial explains how to build the Point Cloud Library **from MacPorts and source** on Mac OS X platforms.

- installing_homebrew

Title: **Installing on Mac OS X using Homebrew**
Author: *Geoffrey Biggs*
Compatibility: > PCL 1.2
This tutorial explains how to install the Point Cloud Library on Mac OS X using Homebrew. Both direct installation and compiling PCL from source are explained.

- using_pcl_with_eclipse

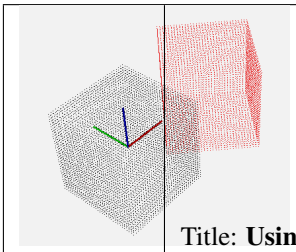


Title: **Using Eclipse as your PCL editor**
Author: *Koen Buys*
Compatibility: PCL git master
This tutorial shows you how to get your PCL as a project in Eclipse.

- generate_local_doc

Title: **Generate a local documentation for PCL**
Author: *Victor Lamoine*
Compatibility: PCL > 1.0
This tutorial shows you how to generate and use a local documentation for PCL.

- matrix_transform

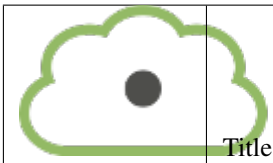


Title: **Using matrixes to transform a point cloud**
Author: *Victor Lamoine*
Compatibility: > PCL 1.5
This tutorial shows you how to transform a point cloud using a matrix.

CHAPTER 2

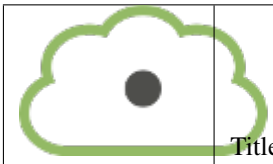
Advanced Usage

- adding_custom_ptype



Title: **Adding your own custom PointT point type**
Author: *Radu B. Rusu*
Compatibility: > PCL 0.9, < PCL 2.0
This document explains what templated point types are in PCL, why do they exist, and how to create and use your own *PointT* point type.

- writing_new_classes

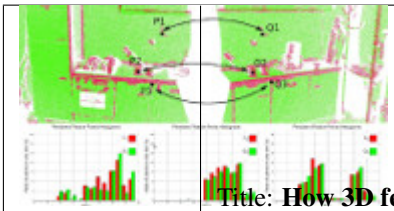


Title: **Writing a new PCL class**
Author: *Radu B. Rusu, Luca Penasa*
Compatibility: > PCL 0.9, < PCL 2.0
This short guide is to serve as both a HowTo and a FAQ for writing new PCL classes, either from scratch, or by adapting old code.

CHAPTER 3

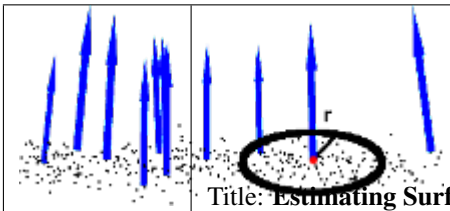
Features

- how_3d_features_work



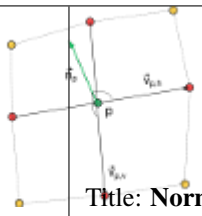
Title: **How 3D features work**
Author: *Radu B. Rusu*
Compatibility: > PCL 1.0
This document presents a basic introduction to the 3D feature estimation methodologies in PCL.

- normal_estimation



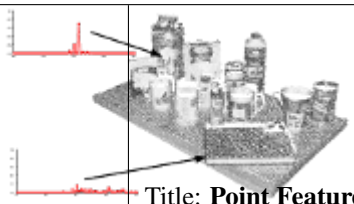
Title: **Estimating Surface Normals in a PointCloud**
Author: *Radu B. Rusu*
Compatibility: > PCL 1.0
This tutorial discusses the theoretical and implementation details of the surface normal estimation module in PCL.

- normal_estimation_using_integral_images



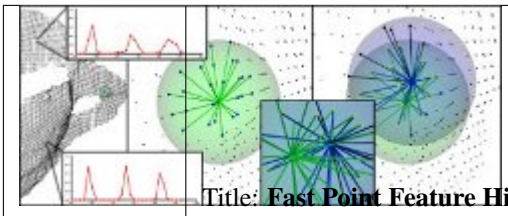
Title: **Normal Estimation Using Integral Images**
Author: *Stefan Holzer*
Compatibility: > PCL 1.0
In this tutorial we will learn how to compute normals for an organized point cloud using integral images.

- pfh_estimation



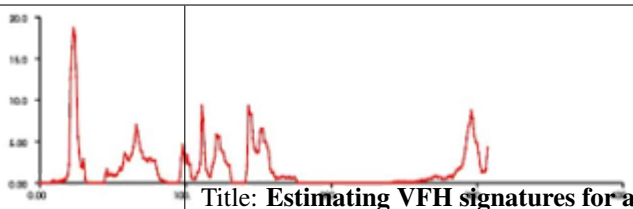
Title: **Point Feature Histograms (PFH) descriptors**
Author: *Radu B. Rusu*
Compatibility: > PCL 1.0
This tutorial introduces a family of 3D feature descriptors called PFH (Point Feature Histograms) and discusses their implementation details from PCL's perspective.

- fpfh_estimation



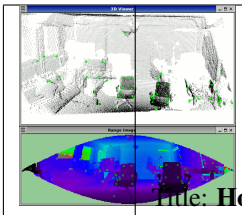
Title: **Fast Point Feature Histograms (FPFH) descriptors**
Author: *Radu B. Rusu*
Compatibility: > PCL 1.3
This tutorial introduces the FPFH (Fast Point Feature Histograms) 3D descriptor and discusses their implementation details from PCL's perspective.

- vfh_estimation



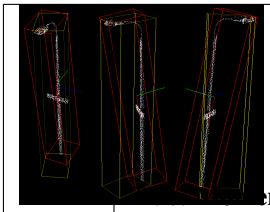
Title: **Estimating VFH signatures for a set of points**
Author: *Radu B. Rusu*
Compatibility: > PCL 0.8
This document describes the Viewpoint Feature Histogram (VFH) descriptor, a novel representation for point clusters for the problem of Cluster (e.g., Object) Recognition and 6DOF Pose Estimation.

- narf_feature_extraction



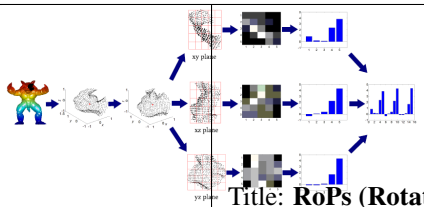
Title: **How to extract NARF features from a range image**
Author: *Bastian Steder*
Compatibility: > 1.3
In this tutorial, we will learn how to extract NARF features from a range image.

- moment_of_inertia



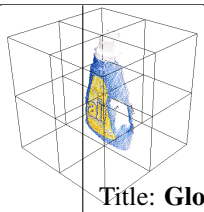
nt of inertia and eccentricity based descriptors
Author: *Sergey Ushakov*
Compatibility: > PCL 1.7
In this tutorial we will learn how to compute moment of inertia and eccentricity of the cloud. In addition to this we will learn how to extract AABB and OBB.

- rops_feature



Title: **RoPs (Rotational Projection Statistics) feature**
Author: *Sergey Ushakov*
Compatibility: > PCL 1.7
In this tutorial we will learn how to compute RoPS feature.

- gasd_estimation

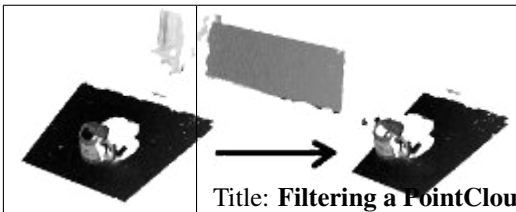


Title: **Globally Aligned Spatial Distribution (GASD) descriptors**
Author: *Joao Paulo Lima*
Compatibility: >= PCL 1.9
This document describes the Globally Aligned Spatial Distribution (GASD) global descriptor to be used for efficient object recognition and pose estimation.

CHAPTER 4

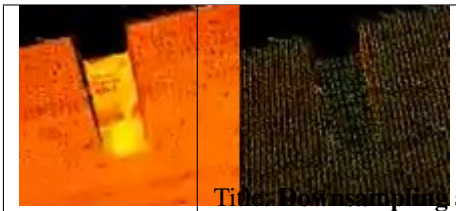
Filtering

- passthrough



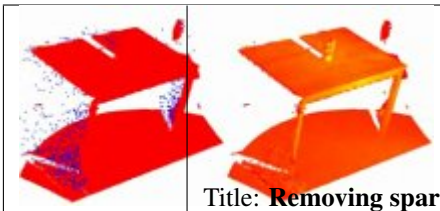
Title: **Filtering a PointCloud using a PassThrough filter**
Author: *Radu B. Rusu*
Compatibility: > PCL 1.0
In this tutorial, we will learn how to remove points whose values fall inside/outside a user given interval along a specified dimension.

- voxelgrid



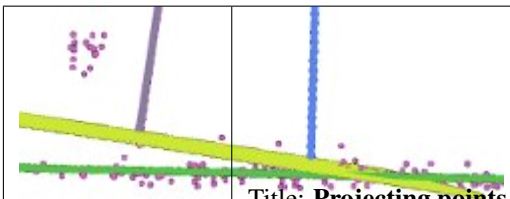
Title: **Downsampling a PointCloud using a VoxelGrid filter**
Author: *Radu B. Rusu*
Compatibility: > PCL 1.0
In this tutorial, we will learn how to downsample (i.e., reduce the number of points) a Point Cloud.

- statistical_outlier_removal



Title: **Removing sparse outliers using StatisticalOutlierRemoval**
Author: *Radu B. Rusu*
Compatibility: > PCL 1.0
In this tutorial, we will learn how to remove sparse outliers from noisy data, using StatisticalRemoval.

- project_inliers

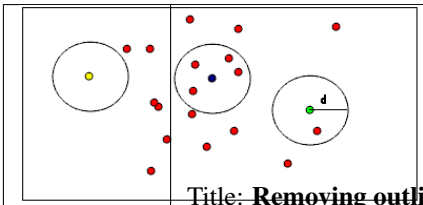


Title: **Projecting points using a parametric model**
Author: *Radu B. Rusu*
Compatibility: > PCL 1.0
In this tutorial, we will learn how to project points to a parametric model (i.e., plane).

- extract_indices

Title: **Extracting indices from a PointCloud**
Author: *Radu B. Rusu*
Compatibility: > PCL 1.0
In this tutorial, we will learn how to extract a set of indices given by a segmentation algorithm.

- remove_outliers



Title: **Removing outliers using a Conditional or RadiusOutlier removal**
Author: *Gabe O'Leary*
Compatibility: > PCL 1.0
In this tutorial, we will learn how to remove outliers from noisy data, using ConditionalRemoval, RadiusOutlierRemoval.

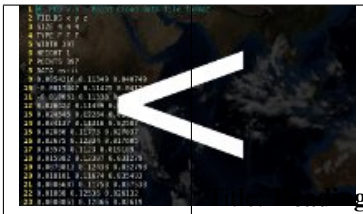
CHAPTER 5

I/O

- pcd_file_format

Title: **The PCD (Point Cloud Data) file format**
Author: *Radu B. Rusu*
Compatibility: > PCL 0.9
This document describes the PCD file format, and the way it is used inside PCL.

- reading_pcd

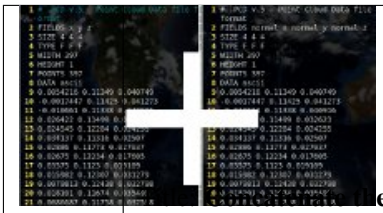


g Point Cloud data from PCD files
Author: *Radu B. Rusu*
Compatibility: > PCL 1.0
In this tutorial, we will learn how to read a Point Cloud from a PCD file.

- writing_pcd

g Point Cloud data to PCD files
Author: *Radu B. Rusu*
Compatibility: > PCL 1.0
In this tutorial, we will learn how to write a Point Cloud to a PCD file.

- concatenate_clouds



e fields or points of two Point Clouds
Author: *Gabe O'Leary / Radu B. Rusu*
Compatibility: > PCL 1.0
In this tutorial, we will learn how to concatenate both the fields and the point data of two Point Clouds. When concatenating fields, one PointClouds contains only *XYZ* data, and the other contains *Surface Normal* information.

- openni_grabber

Title: **Grabbing Point Clouds from an OpenNI camera**
Author: *Nico Blodow*
Compatibility: > PCL 1.0
In this tutorial, we will learn how to acquire point cloud data from an OpenNI camera.

- hdl_grabber

Title: **Grabbing Point Clouds from a Velodyne High Definition LiDAR (HDL)**
Author: *Keven Ring*
Compatibility: >= PCL 1.7
In this tutorial, we will learn how to acquire point cloud data from a Velodyne HDL.

- dinast_grabber

Title: **Grabbing Point Clouds from Dinast Cameras**
Author: *Marco A. Gutierrez*
Compatibility: >= PCL 1.7
In this tutorial, we will learn how to acquire point cloud data from a Dinast camera.

- ensenso_cameras

Title: **Grabbing point clouds from Ensenso cameras**
Author: *Victor Lamoine*
Compatibility: >= PCL 1.8.0
In this tutorial, we will learn how to acquire point cloud data from an IDS-Imaging Ensenso camera.

- david_sdk

Title: **Grabbing point clouds / meshes from davidSDK scanners**
Author: *Victor Lamoine*
Compatibility: >= PCL 1.8.0
In this tutorial, we will learn how to acquire point cloud or mesh data from a davidSDK scanner.

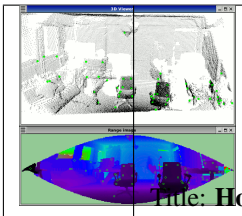
- depth_sense_grabber

Grabbing point clouds from DepthSense cameras
Author: *Sergey Alexandrov*
Compatibility: >= PCL 1.8.0
In this tutorial we will learn how to setup and use DepthSense cameras within PCL on both Linux and Windows platforms.

CHAPTER 6

Keypoints

- narf_keypoint_extraction

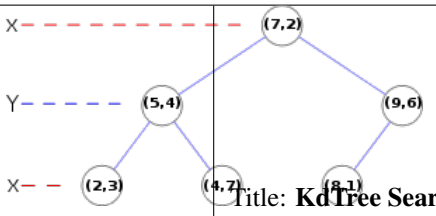


Title: **How to extract NARF keypoints from a range image**
Author: *Bastian Steder*
Compatibility: > 1.3
In this tutorial, we will learn how to extract NARF keypoints from a range image.

CHAPTER 7

KdTree

- kdtree_search



Title: **KdTree Search**
Author: *Gabe O'Leary*
Compatibility: > PCL 1.0
In this tutorial, we will learn how to search using the nearest neighbor method for k-d trees

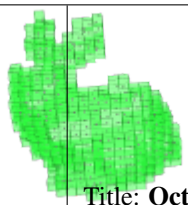
CHAPTER 8

Octree

- octree_compression

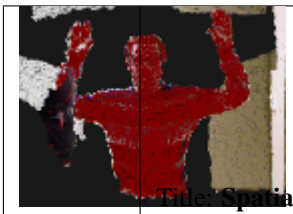
Title: **Point cloud compression**
Author: *Julius Kammerl*
Compatibility: > PCL 1.0
In this tutorial, we will learn how to compress a single point cloud and streams of point clouds.

- octree_search



Title: **Octrees for spatial partitioning and neighbor search**
Author: *Julius Kammerl*
Compatibility: > PCL 1.0
In this tutorial, we will learn how to use octrees for spatial partitioning and nearest neighbor search.

- octree_change_detection

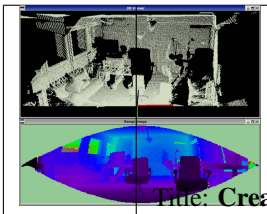


Title: **Spatial change detection on unorganized point cloud data**
Author: *Julius Kammerl*
Compatibility: > PCL 1.0
In this tutorial, we will learn how to use octrees for detecting spatial changes within point clouds.

CHAPTER 9

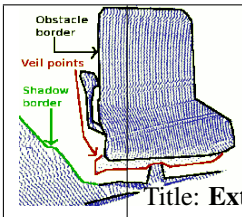
Range Images

- range_image_creation



Title: **Creating Range Images from Point Clouds**
Author: *Bastian Steder*
Compatibility: > PCL 1.0
This tutorial demonstrates how to create a range image from a point cloud and a given sensor position.

- range_image_border_extraction



Title: **Extracting borders from Range Images**
Author: *Bastian Steder*
Compatibility: > PCL 1.3
This tutorial demonstrates how to extract borders (traversals from foreground to background) from a range image.

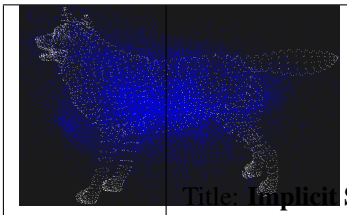
CHAPTER 10

Recognition

- correspondence_grouping

Title: **The PCL Recognition API**
Author: *Tommaso Cavallari, Federico Tombari*
Compatibility: > PCL 1.6
This tutorial aims at explaining how to perform 3D Object Recognition based on the pcl_recognition module.

- implicit_shape_model



Title: **Implicit Shape Model**
Author: *Sergey Ushakov*
Compatibility: > PCL 1.7
In this tutorial we will learn how the Implicit Shape Model algorithm works and how to use it for finding objects centers.

- global_hypothesis_verification

Verification for 3D Object Recognition

Author: *Daniele De Gregorio, Federico Tombari*

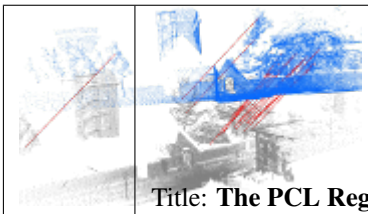
Compatibility: > PCL 1.7

This tutorial aims at explaining how to do 3D object recognition in clutter by verifying model hypotheses in cluttered and heavily occluded 3D scenes.

CHAPTER 11

Registration

- registration_api



Title: **The PCL Registration API**
Author: *Dirk Holz, Radu B. Rusu, Jochen Sprickerhof*
Compatibility: > PCL 1.5
In this document, we describe the point cloud registration API and its modules: the estimation and rejection of point correspondences, and the estimation of rigid transformations.

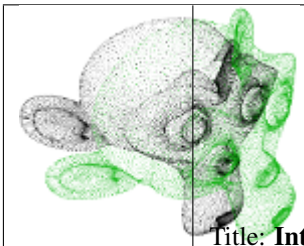
- iterative_closest_point

Title: **How to use iterative closest point algorithm**
Author: *Gabe O'Leary*
Compatibility: > PCL 1.0
This tutorial gives an example of how to use the iterative closest point algorithm to see if one PointCloud is just a rigid transformation of another PointCloud.

- pairwise_incremental_registration

Title: **How to incrementally register pairs of clouds**
Author: *Raphael Favier*
Compatibility: > PCL 1.4
This document demonstrates using the Iterative Closest Point algorithm in order to incrementally register a series of point clouds two by two.

- interactive_icp

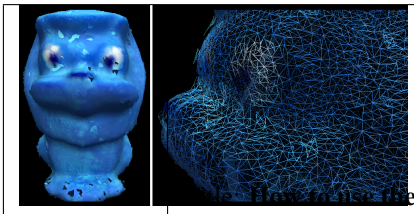


Title: **Interactive ICP**
Author: *Victor Lamoine*
Compatibility: > PCL 1.5
This tutorial will teach you how to build an interactive ICP program

- normal_distributions_transform

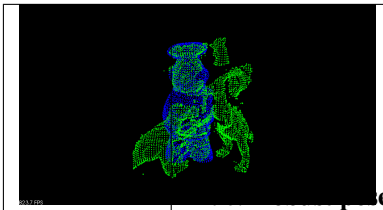
Title: **How to use the Normal Distributions Transform algorithm**
Author: *Brian Okorn*
Compatibility: > PCL 1.6
This document demonstrates using the Normal Distributions Transform algorithm to register two large point clouds.

- in_hand_scanner



In-hand scanner for small objects
Author: *Martin Saelzle*
Compatibility: >= PCL 1.7
This document shows how to use the In-hand scanner applications to obtain colored models of small objects with RGB-D cameras.

- alignment_prerejective

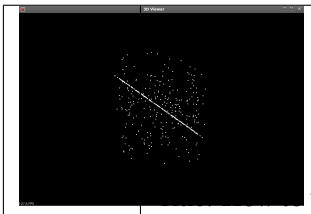


estimation of rigid objects
Author: *Anders Glent Buch*
Compatibility: >= PCL 1.7
In this tutorial, we show how to find the alignment pose of a rigid object in a scene with clutter and occlusions.

CHAPTER 12

Sample Consensus

- random_sample_consensus



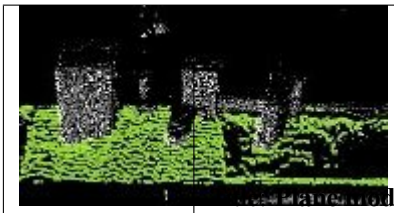
use Random Sample Consensus model

Author: *Gabe O'Leary*
Compatibility: > PCL 1.0
In this tutorial we learn how to use a RandomSampleConsensus with a plane model to obtain the cloud fitting to this model.

CHAPTER 13

Segmentation

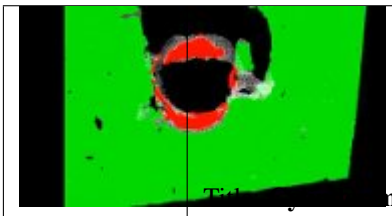
- planar_segmentation



del segmentation

Author: *Radu B. Rusu*
Compatibility: > PCL 1.3
In this tutorial, we will learn how to segment arbitrary plane models from a given point cloud dataset.

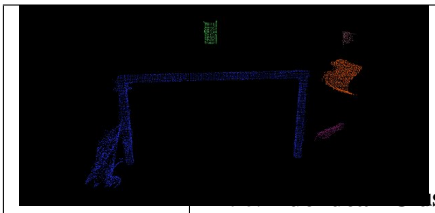
- cylinder_segmentation



nodel segmentation

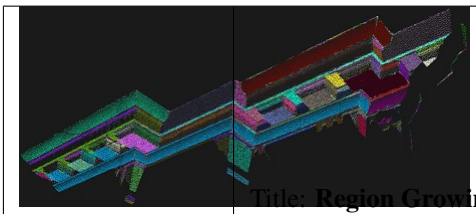
Author: *Radu B. Rusu*
Compatibility: > PCL 1.3
In this tutorial, we will learn how to segment arbitrary cylindrical models from a given point cloud dataset.

- cluster_extraction



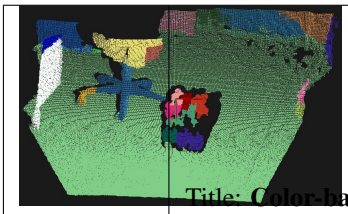
ster Extraction
Author: *Serkan Tuerker*
Compatibility: > PCL 1.3
In this tutorial we will learn how to extract Euclidean clusters with the `pcl::EuclideanClusterExtraction` class.

- region_growing_segmentation



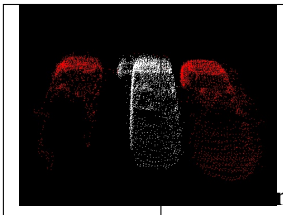
Title: **Region Growing Segmentation**
Author: *Sergey Ushakov*
Compatibility: >= PCL 1.7
In this tutorial we will learn how to use region growing segmentation algorithm.

- region_growing_rgb_segmentation



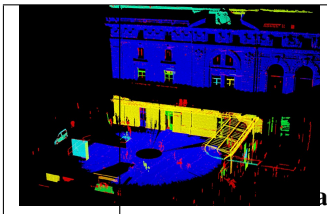
Title: **Color-based Region Growing Segmentation**
Author: *Sergey Ushakov*
Compatibility: >= PCL 1.7
In this tutorial we will learn how to use color-based region growing segmentation algorithm.

- min_cut_segmentation



n-Cut Based Segmentation
Author: *Sergey Ushakov*
Compatibility: >= PCL 1.7
In this tutorial we will learn how to use min-cut based segmentation algorithm.

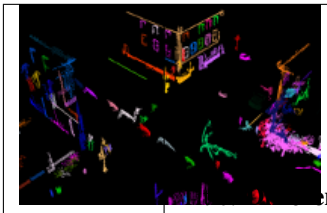
- conditional_euclidean_clustering



al Euclidean Clustering

Author: *Frits Florentinus*
Compatibility: >= PCL 1.7
This tutorial describes how to use the Conditional Euclidean Clustering class in PCL: A segmentation algorithm that clusters points based on Euclidean distance and a user-customizable condition that needs to hold.

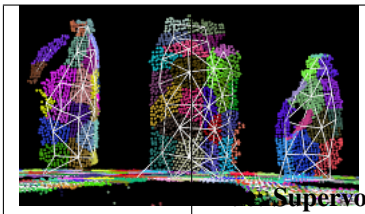
- don_segmentation



nce of Normals Based Segmentation

Author: *Yani Ioannou*
Compatibility: >= PCL 1.7
In this tutorial we will learn how to use the difference of normals feature for segmentation.

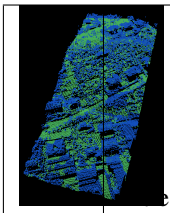
- supervoxel_clustering



Supervoxel Clustering

Author: *Jeremie Papon*
Compatibility: >= PCL 1.8
In this tutorial, we show to break a pointcloud into the mid-level supervoxel representation.

- progressive_morphological_filtering



Title: **Progressive Morphological Filtering**
Author: *Brad Chambers*
Compatibility: >= PCL 1.8
In this tutorial, we show how to segment a point cloud into ground and non-ground returns.

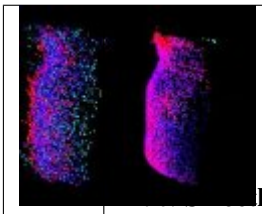
- model_outlier_removal

Title: **Model outlier removal**
Author: *Timo Häckel*
Compatibility: >= PCL 1.7.2
This tutorial describes how to extract points from a point cloud using SAC models

CHAPTER 14

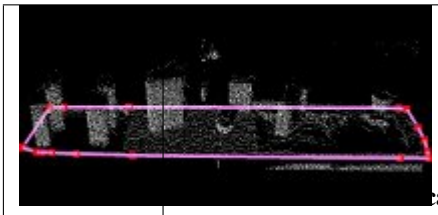
Surface

- moving_least_squares



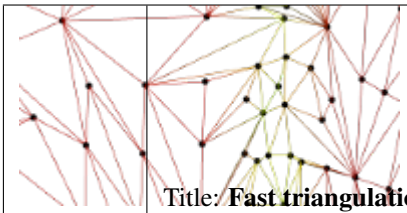
hing and normal estimation based on polynomial reconstruction
Author: *Zoltan-Csaba Marton, Alexandru E. Ichim*
Compatibility: > PCL 1.6
In this tutorial, we will learn how to construct and run a Moving Least Squares (MLS) algorithm to obtain smoothed XYZ coordinates and normals.

- hull_2d



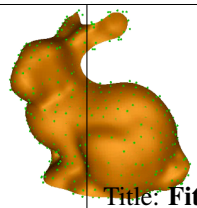
ave or convex hull polygon for a plane model
Author: *Gabe O'Leary, Radu B. Rusu*
Compatibility: > PCL 1.0
In this tutorial we will learn how to calculate a simple 2D concave or convex hull polygon for a set of points supported by a plane.

- greedy_triangulation



Title: **Fast triangulation of unordered point clouds**
Author: *Zoltan-Csaba Marton*
Compatibility: > PCL 1.0
In this tutorial we will learn how to run a greedy triangulation algorithm on a PointCloud with normals to obtain a triangle mesh based on projections of the local neighborhood.

- bspline_fitting

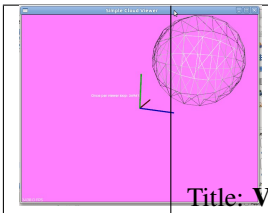


Title: **Fitting trimmed B-splines to unordered point clouds**
Author: *Thomas Mörwald*
Compatibility: > PCL 1.7
In this tutorial we will learn how to reconstruct a smooth surface from an unordered point-cloud by fitting trimmed B-splines.

CHAPTER 15

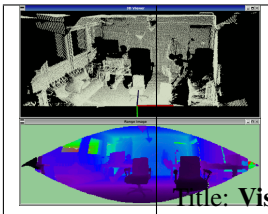
Visualization

- cloud_viewer



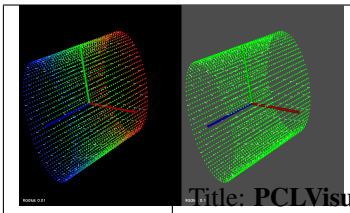
Title: **Visualizing Point Clouds**
Author: *Ethan Rublee*
Compatibility: > PCL 1.0
This tutorial demonstrates how to use the pcl visualization tools.

- range_image_visualization



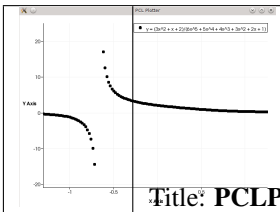
Title: **Visualizing Range Images**
Author: *Bastian Steder*
Compatibility: > PCL 1.3
This tutorial demonstrates how to use the pcl visualization tools for range images.

- pcl_visualizer



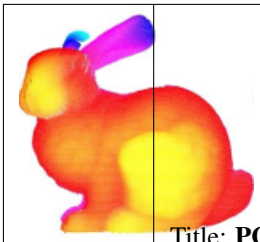
Title: **PCLVisualizer**
Author: *Geoffrey Biggs*
Compatibility: > PCL 1.3
This tutorial demonstrates how to use the PCLVisualizer class for powerful visualisation of point clouds and related data.

- pcl_plotter



Title: **PCLPlotter**
Author: *Kripasindhu Sarkar*
Compatibility: > PCL 1.7
This tutorial demonstrates how to use the PCLPlotter class for powerful visualisation of plots, charts and histograms of raw data and explicit functions.

- visualization



Title: **PCL Visualization overview**
Author: *Radu B. Rusu*
Compatibility: >= PCL 1.0
This tutorial will give an overview on the usage of the PCL visualization tools.

- qt_visualizer

Title: **Create a PCL visualizer in Qt with cmake**
Author: *Victor Lamoine*
Compatibility: > PCL 1.5
This tutorial shows you how to create a PCL visualizer within a Qt application.

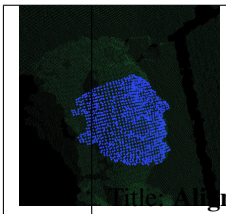
- qt_colorize_cloud

Title: **Create a PCL visualizer in Qt to colorize clouds**
Author: *Victor Lamoine*
Compatibility: > PCL 1.5
This tutorial shows you how to color point clouds within a Qt application.

CHAPTER 16

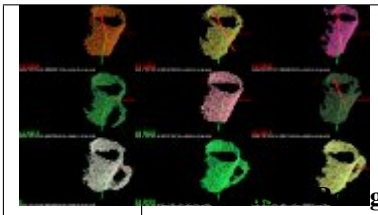
Applications

- template_alignment



Title: Aligning object templates to a point cloud
Author: *Michael Dixon*
Compatibility: > PCL 1.3
This tutorial gives an example of how some of the tools covered in the previous tutorials can be combined to solve a higher level problem — aligning a previously captured model of an object to some newly captured data.

- vfh_recognition

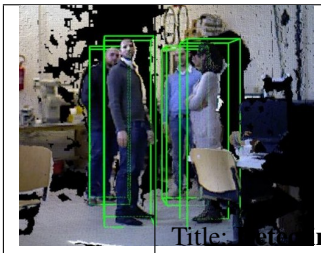


gnition and 6DOF Pose Estimation using VFH descriptors
Author: *Radu B. Rusu*
Compatibility: > PCL 0.8
In this tutorial we show how the Viewpoint Feature Histogram (VFH) descriptor can be used to recognize similar clusters in terms of their geometry.

- mobile_streaming

Title: **Point Cloud Streaming to Mobile Devices with Real-time Visualization**
Author: *Pat Marion*
Compatibility: > PCL 1.3
This tutorial describes how to send point cloud data over the network from a desktop server to a client running on a mobile device.

- ground_based_rgbd_people_detection



Title: **ng people on a ground plane with RGB-D data**
Author: *Matteo Munaro*
Compatibility: >= PCL 1.7
This tutorial presents a method for detecting people on a ground plane with RGB-D data.

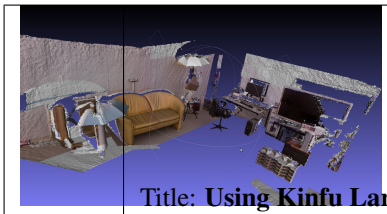
CHAPTER 17

GPU

- gpu_install

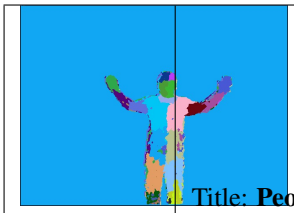
Title: **GPU Installation**
Author: *Koen Buys*
Compatibility: PCL git master
This tutorial explains how to configure PCL to use with a Nvidia GPU

- using_kinfu_large_scale



Title: **Using Kinfu Large Scale to generate a textured mesh**
Author: *Francisco Heredia and Raphael Favier*
Compatibility: PCL git master
This tutorial demonstrates how to use KinFu Large Scale to produce a mesh from a room, and apply texture information in post-processing for a more appealing visual result.

- gpu_people



Title: **People Detection**
Author: *Koen Buys*
Compatibility: PCL git master
This tutorial presents a method for people and pose detection.