# RoboCup@Home Practical Course

Dr. Pablo Lanillos

Technical University of Munich

Department of Electrical and Computer Engineering

Chair for Cognitve Systems

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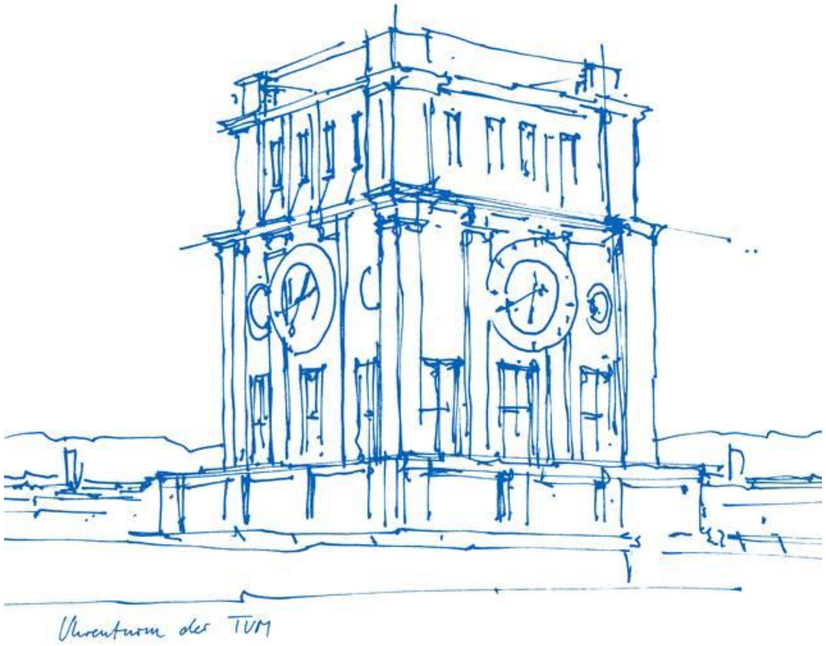

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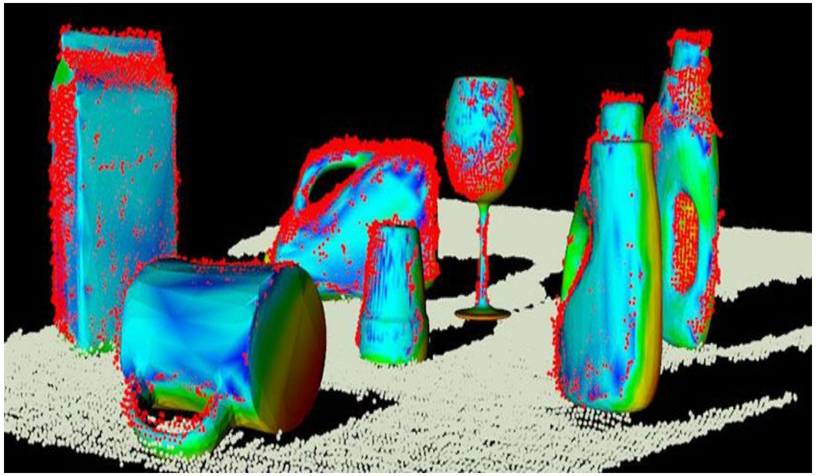
# RoboCup@Home Practical Course

## Tutorial: object recognition and 3D

Dr. Karinne Ramirez-Amaro
Dr. Emmanuel Dean
**Dr. Pablo Lanillos**
M.Sc. Roger Guadarrama
Dr. Gordon Cheng



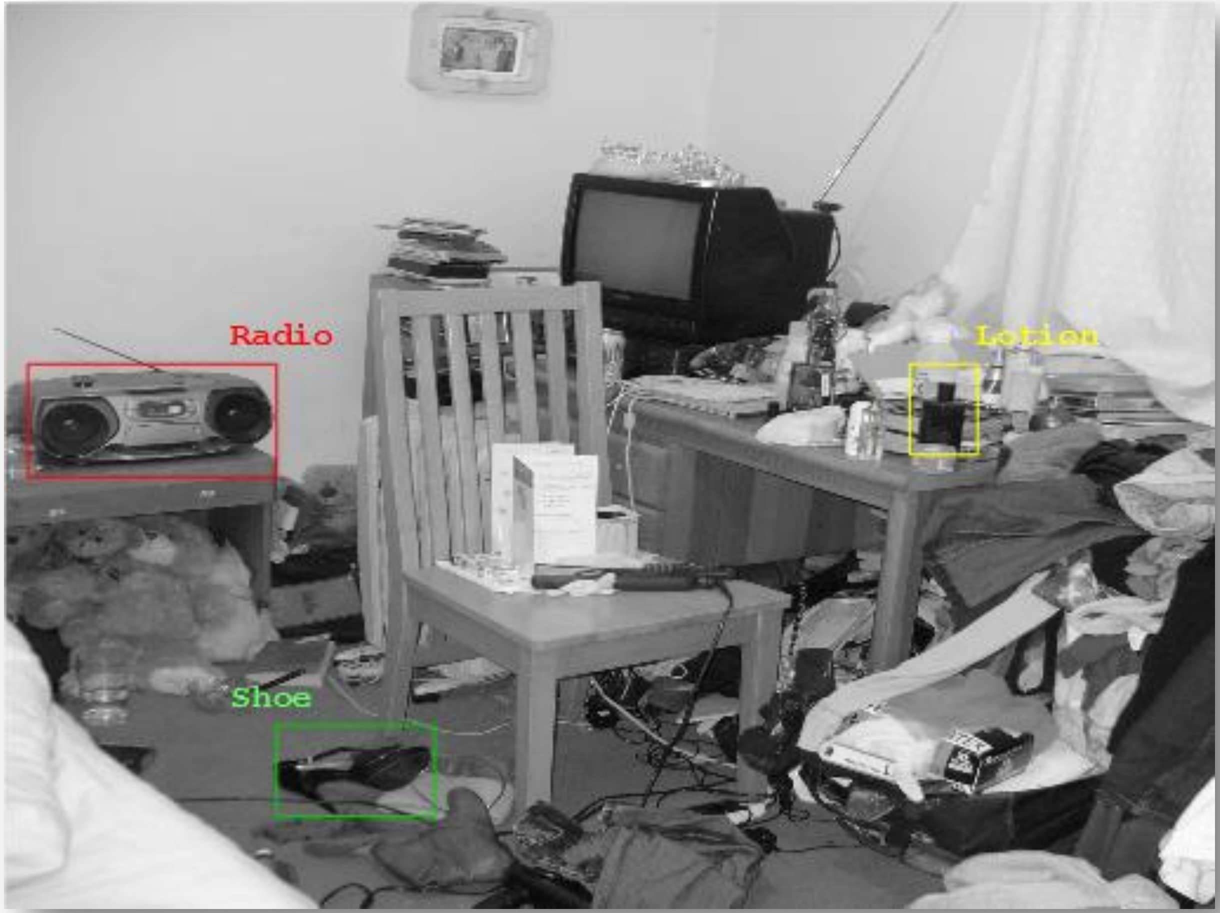
p.lanillos@tum.de
www.therobotdecision.com

# Exercises

**Email: robocup.atHome.ics@gmail.com**

- Compress all the folder containing the C++ nodes folders into one zip/rar/tar/gz file and name it as: Name_LastName_RCH_tutorial5.

# Motivation



# Goal: 3D object classification

3D point cloud algorithms and learn object recognition pipeline

Learn PCL in C++ under ROS

# RoboCup@Home qualification

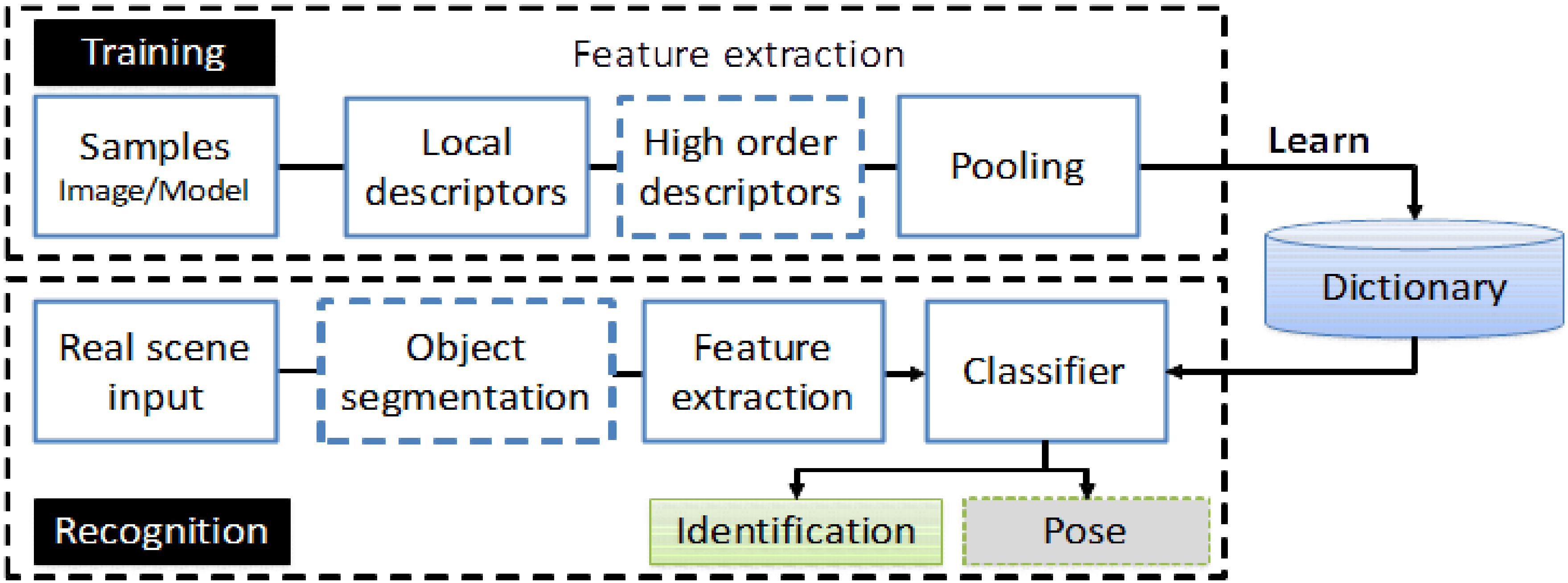
# Excercises

1. Implement a C++ ROS node that provides the 3D location of an object (optional: with respect to torso coordinate frame).

2. Implement a C++ ROS node that segments the table and the objects PointCloud in the scene.

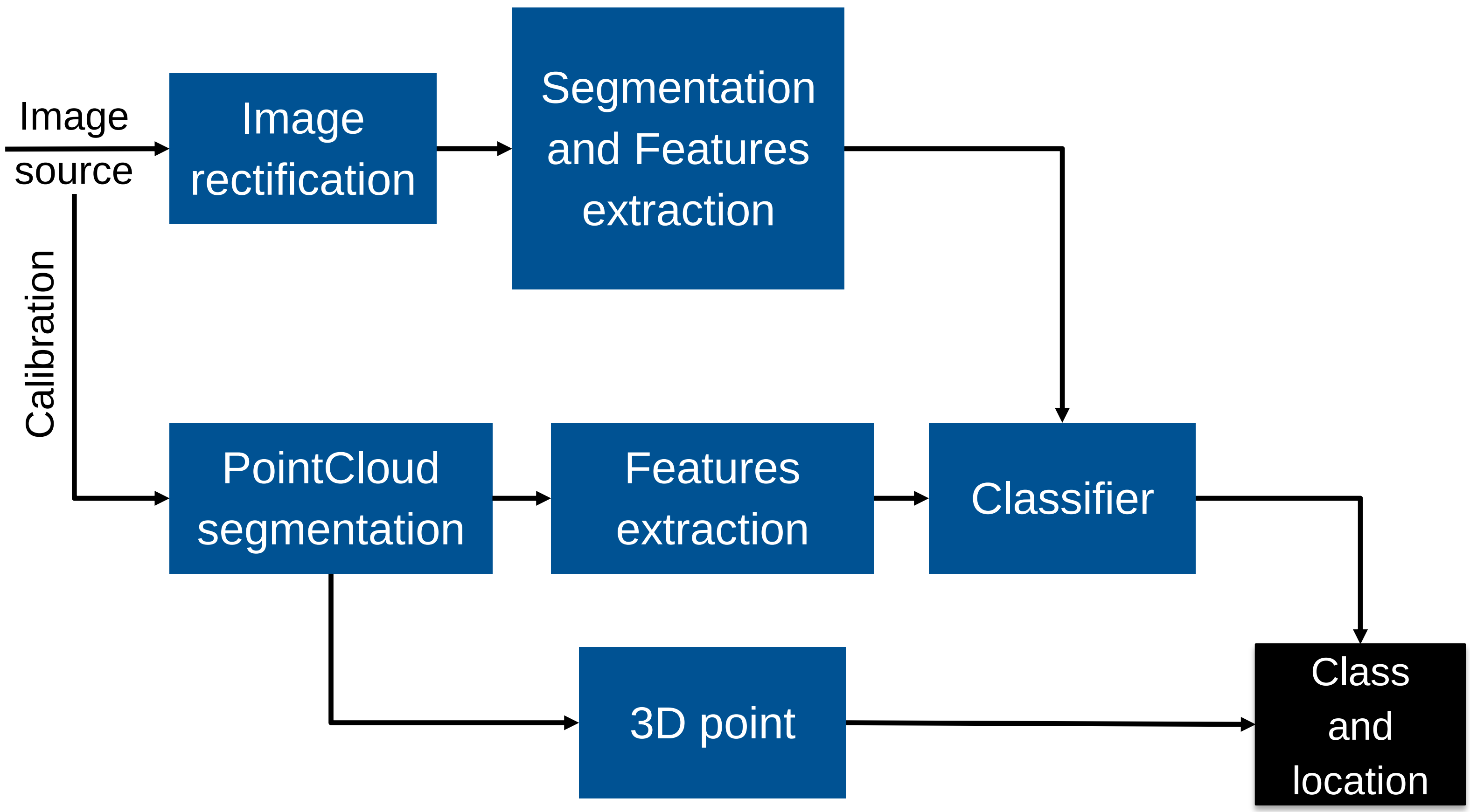
3. Implement a C++ ROS node that recognizes an object and provides its 3D location (template not provided).

# Classic pipeline



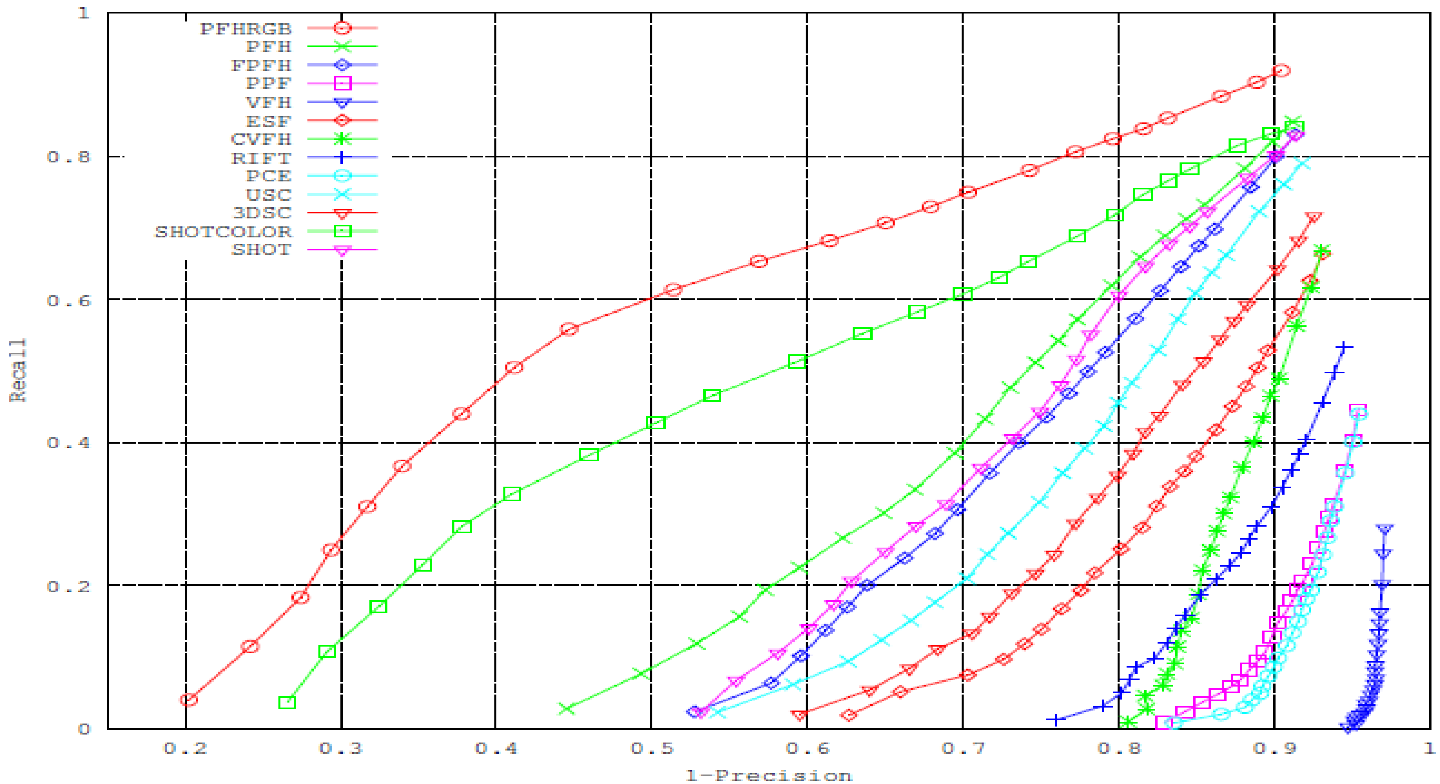

Adapted from: Wang, W., Chen, L., Liu, Z., Kühnlenz, K., & Burschka, D. (2015). Textured/textureless object recognition and pose estimation using RGB-D image. Journal of Real-Time Image Processing, 10(4), 667-682.

# ROS pipeline for the tutorial



# Descriptors

| | | | 2D | 3D |
|---|---|---|---|---|
| Gray scale | Geometric | Local | SIFT | RIFT |
| Color | Photometric | Global | HOG | SHOT |
| | | | SURF | FPFH |




Alexandre, L. A. (2012, October). 3D descriptors for object and category recognition: a comparative evaluation. In Workshop on Color-Depth Camera Fusion in Robotics at the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS).

# Exercise 1: Compute 3D point

1. Go to src/from2Dto3D

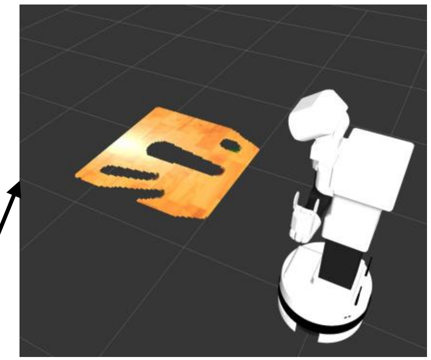
2. Implement a node that uses the kinect point cloud to transform the 2D point into a 3D coordinate

3. Publish to segmentation/point3D

**Input**: 2D point
**Output**: 3D point in torso coordinate frame

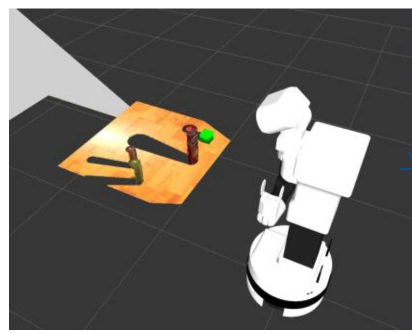
# Exercise 2: Point cloud segmentation - plane

1. Create a new package inside the catkin directory:
   /src/PlaneSegmentation/

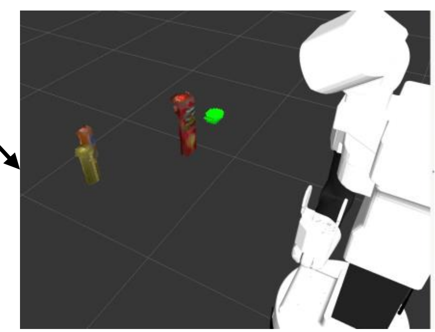


2. Copy the template from the wiki

3. Implement PlaneSegmentation.cpp using pcl library.



**Input**: Camera Point Cloud stream
**Output**:
1. Point cloud without the main plane
2. Point cloud of the main plane



http://wiki.ros.org/Robots/TIAGo/Tutorials/PointCloud

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# Exercise 3: Object recognition

Groups of 2 people

1. Create a new package inside the catkin directory:
/src/object_recognition/
2. Implement ObjectRecognition.cpp
   - Object to recognize:
     (a) two different classes of the same object semantic class (orange, coke)
     (b) two different semantic classes (ball – brick, person – noperson)
   - You can use 3D features or 2D features or combined
   - You can use opencv and pcl libraries

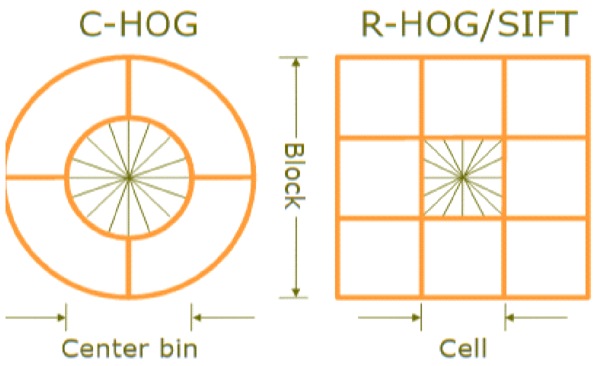
**Example 2: people detector**


**Example 1: ball and a brick**


# 2D Descriptors

## Histogram of Oriented Gradients (HOG)

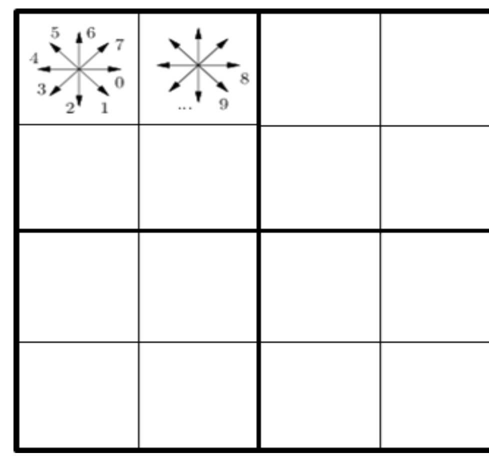
```
hx = [-1,0,1];
hy = hx';

% Compute the derivative in the x and y direction for
every pixel
dx = filter2(hx, double(img));
dy = filter2(hy, double(img));

% Convert the gradient vectors to polar coordinates
angles = atan2(dy, dx);
magnitude = ((dy.^2) + (dx.^2)).^.5;
```



# 2D Descriptors

**Scale-invariant feature transform (SIFT)**

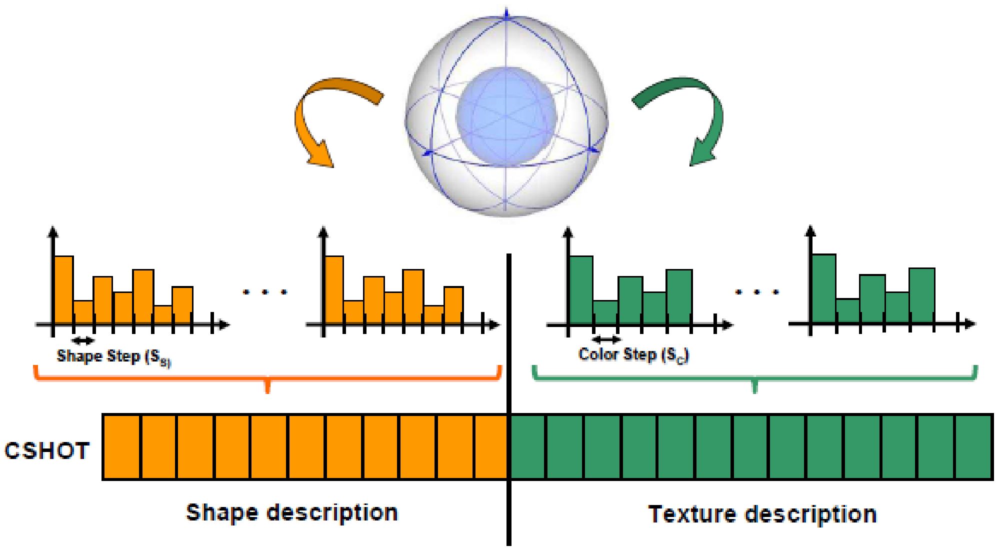
Descriptor= 4x4x8xN_Points = 128xN



# 3D Descriptors

**Signature of Histograms of OrienTations (SHOT)**

- Keypoints
- Normals




Salti, S., Tombari, F., & Di Stefano, L. (2014). SHOT: unique signatures of histograms for surface and texture description. Computer Vision and Image Understanding.

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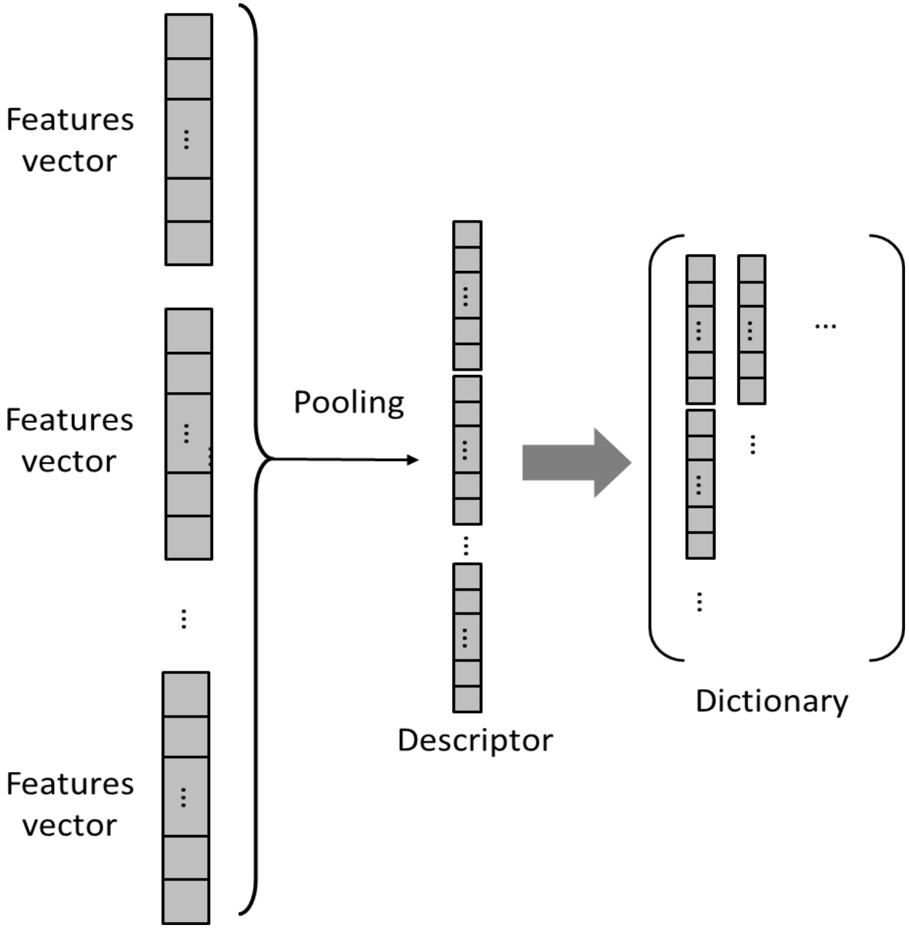
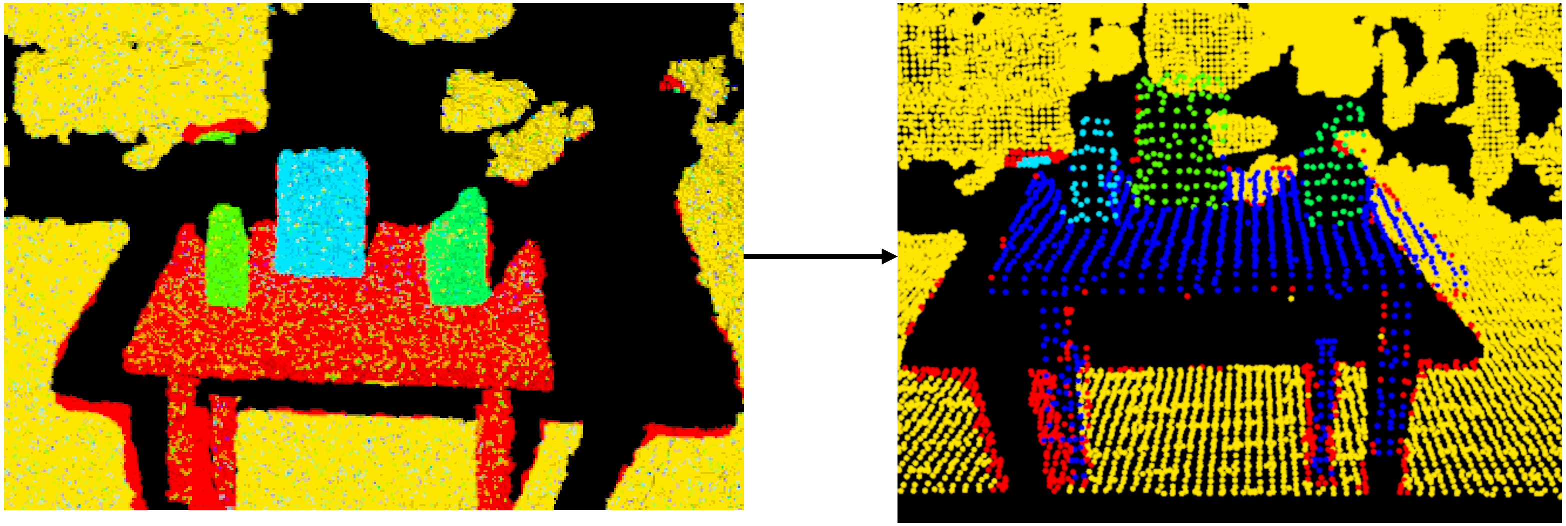
# Descriptors packing and storing



# PCL segmentation

Voxel grid down sampling: pcl::VoxelGrid<pcl::PointXYZ>



SetInputCloud( InputCloud )
SetLeafSize( x,y,z )
filter( Output PointCloud )

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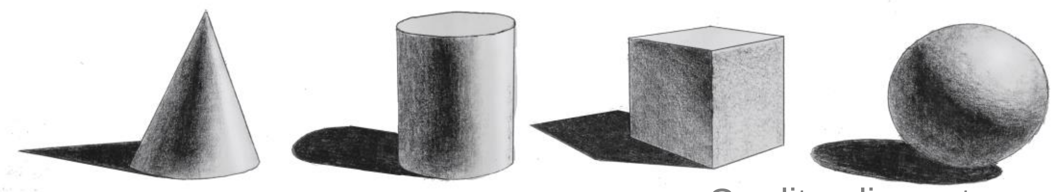
# PCL segmentation

## Consensus model segmentation: pcl::SACSegmentation

pcl::SACSegmentation<pcl::PointT>( pcl::PointIndices inliers, pcl::ModelCoefficients coefficients )



Credits: diaz-arts.com

SACMODEL_PLANE
SACMODEL_LINE
SACMODEL_CIRCLE2D
SACMODEL_CIRCLE3D
SACMODEL_SPHERE
SACMODEL_CYLINDER
SACMODEL_CONE
SACMODEL_TORUS
SACMODEL_PARALLEL_LINE
SACMODEL_PERPENDICULAR_PLANE
SACMODEL_PARALLEL_LINES
SACMODEL_NORMAL_PLANE
SACMODEL_NORMAL_SPHERE
SACMODEL_REGISTRATION
SACMODEL_REGISTRATION_2D
SACMODEL_PARALLEL_PLANE
SACMODEL_NORMAL_PARALLEL_PLANE
SACMODEL_STICK

RANSAC algorithm
pcl::SAC_RANSAC

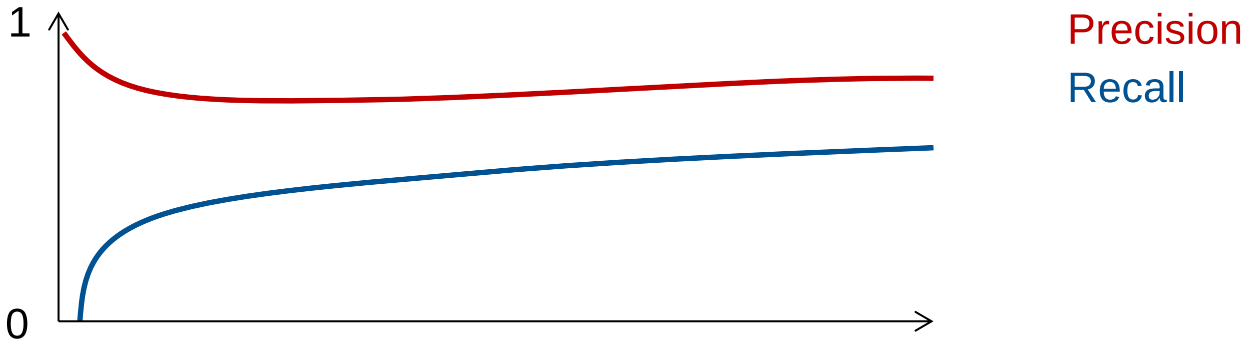
Extracting the output from segmentation
pcl::ExtractIndices<pcl::PointT>

setInputCloud( InputCloud )
setIndices( pcl::PointIndices )
setNegative( bool)
filter( Output PointCloud )

http://pointclouds.org/documentation/tutorials/walkthrough.php

# Tip: Generating labelled data

https://github.com/puzzledqs/BBox-Label-Tool



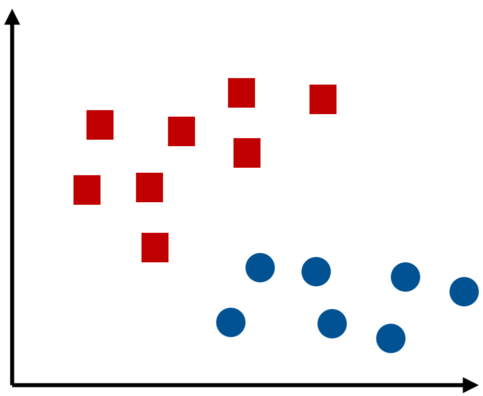

We know that the algorithm have this precision recall curve. Now we only have 30 images labelled.

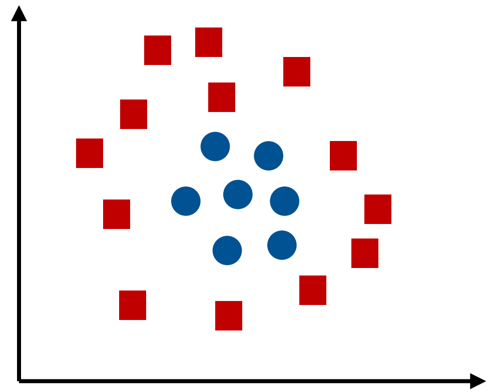
What we will do:

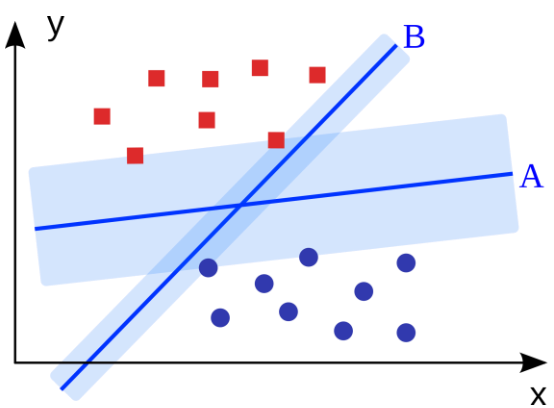
1) Improve the algorithm
2) Get more samples

3000 labeled samples → 1 min/sample → 3000 min → 50 h → 6,25 days

# Support Vector Machines (SVMs)








**Kernelized SVMs**

Boser, B. E., Guyon, I. M., & **Vapnik, V. N.** (1992, July). A training algorithm for optimal margin classifiers. In *Proceedings of the fifth annual workshop on Computational learning theory* (pp. 144-152). ACM.

# Tip: Recording data in a rosbag

> roslaunch kinect2_bridge kinect2_bridge.launch (for kinect)
> roslaunch openni2_launch openni2_launch.launch (for asus or orbbec)

> rosrun rviz rviz → add image → image_rectified

> rosbag record -a [-O session_name.bag]

To play

> rosbag play -l name_of_the_file
(-l makes the bag to play in a loop)

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# MIGHT THE PIXELS BE WITH YOU!