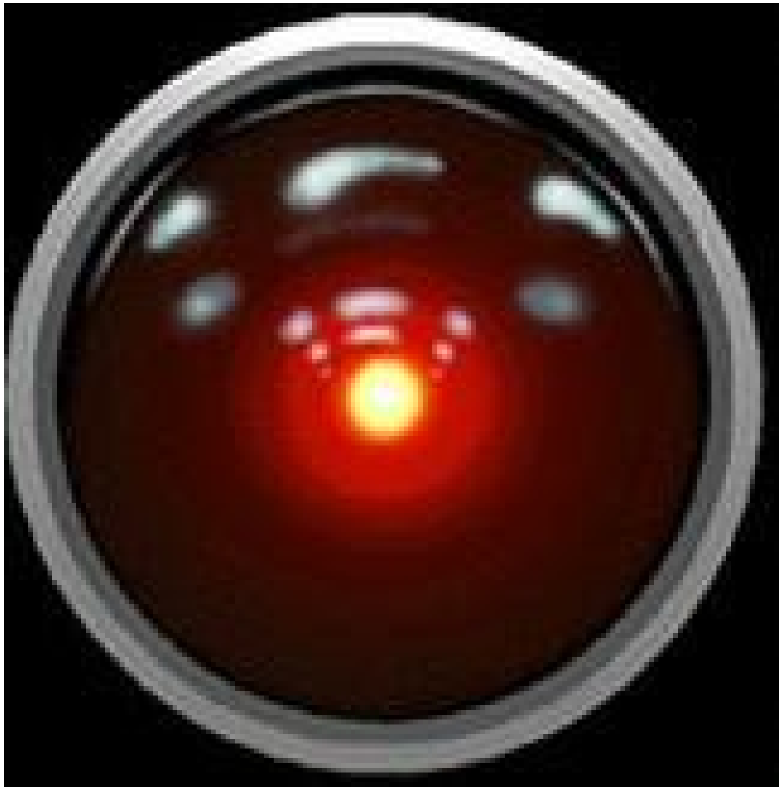


CS 309: Autonomous Intelligent Robotics

Instructor: Jivko Sinapov

http://www.cs.utexas.edu/~jsinapov/teaching/cs309_spring2017/

Announcements

- Homework 5 was due yesterday

Readings For This Week
(responses due Apr 13)

Bobick, Aaron F. "Movement, activity and action: the role of knowledge in the perception of motion." Philosophical Transactions of the Royal Society of London B: Biological Sciences 352.1358 (1997): 1257-1265.

Poppe, Ronald. "A survey on vision-based human action recognition." Image and vision computing 28.6 (2010): 976-990.

Frintrop, Simone, *et al.* "Computational visual attention systems and their cognitive foundations: A survey." ACM Transactions on Applied Perception (2010): 6.

Introduction to
Point Cloud Library (PCL)

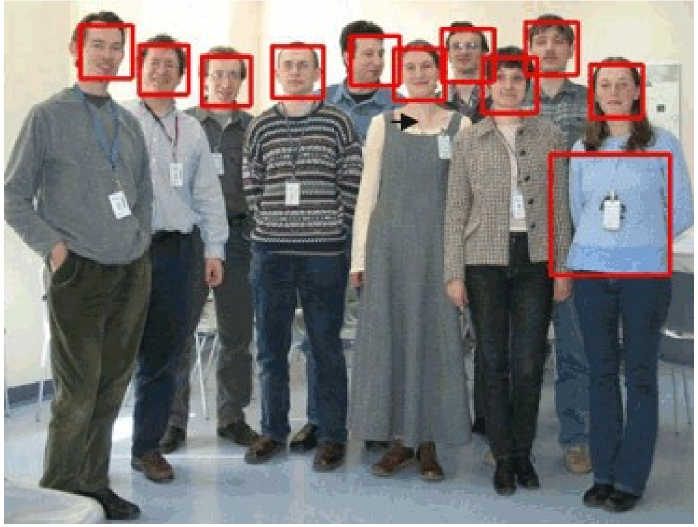
Main References

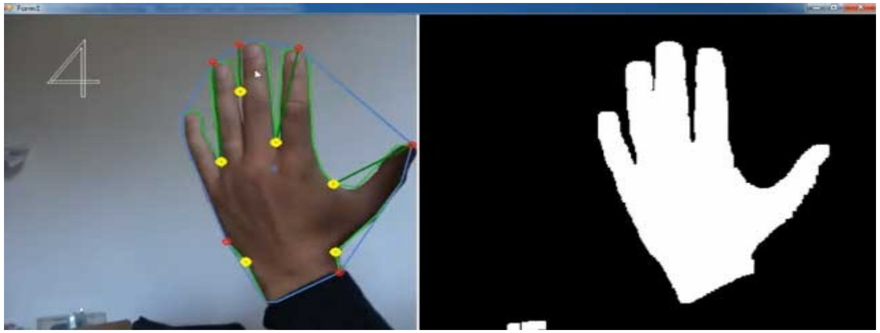
- “Rusu, Radu Bogdan, and Steve Cousins. "3d is here: Point cloud library (pcl)." Robotics and Automation (ICRA), 2011 IEEE International Conference on. IEEE, 2011.”

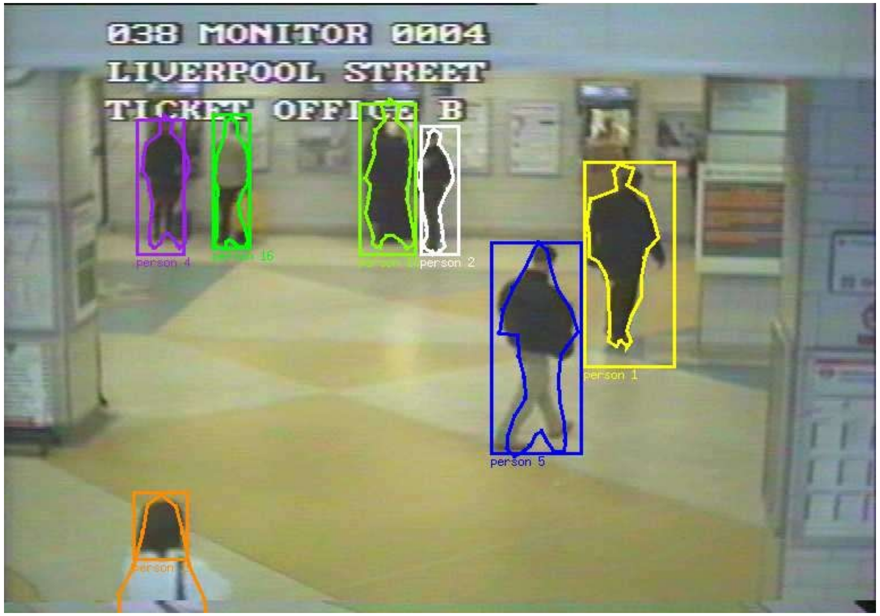
- “Tutorial: Point Cloud Library – USC Robotics Research Lab”

Why PCL?

The Impact of OpenCV







Traditional 3D sensors

Latest Technology

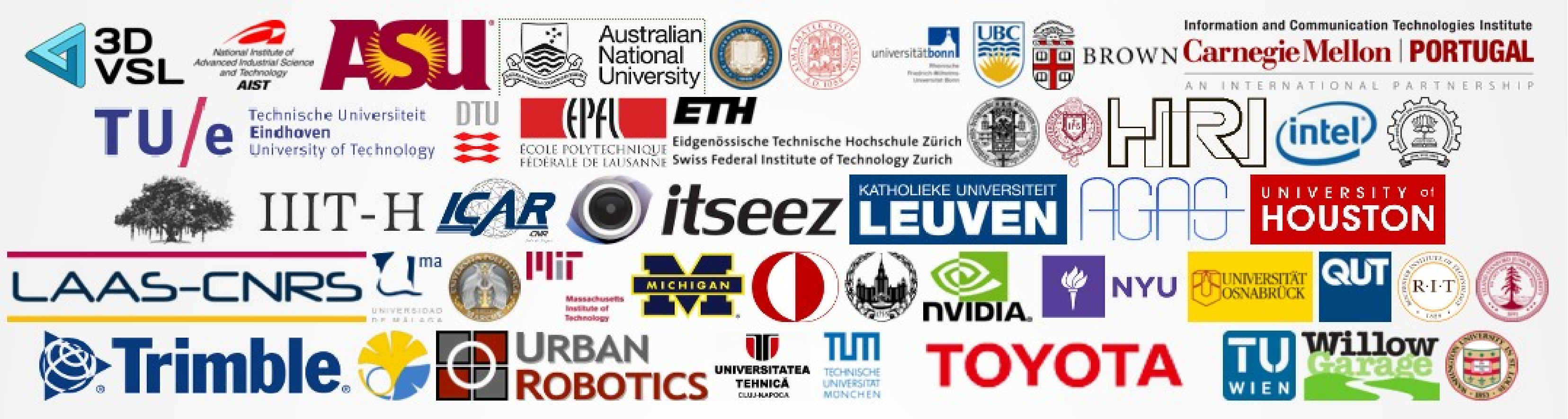
KINECT™
for XBOX 360.

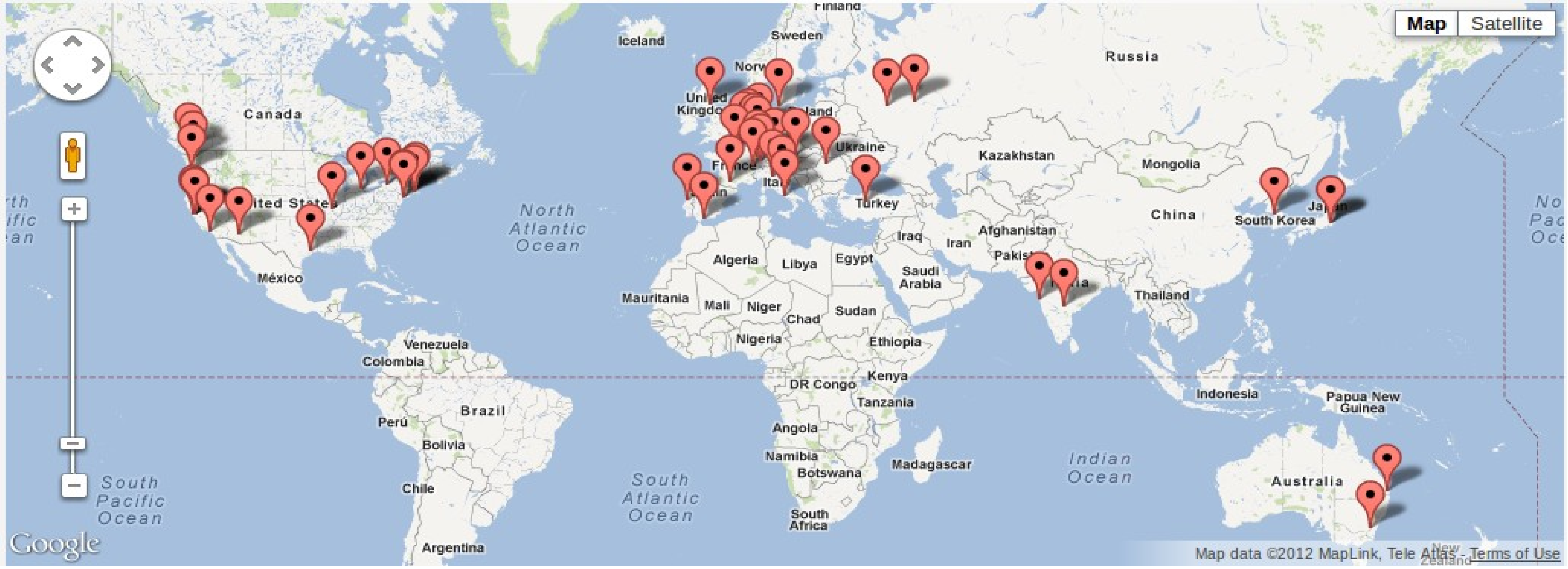
3D is now cheap!

What is PCL?

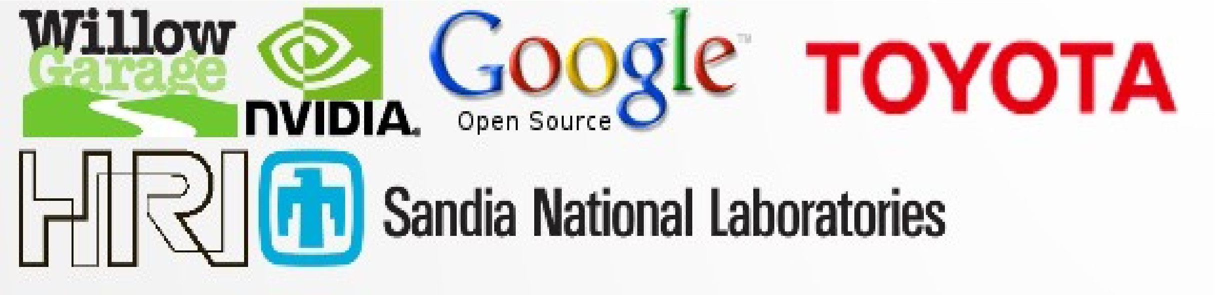
- Open Source C++ Library:
  - http://pointclouds.org/
- Cross-platform*
  - (Ubuntu 12.04+, Windows 7+, Mac)
- Strives to be the equivalent of OpenCV for 3D

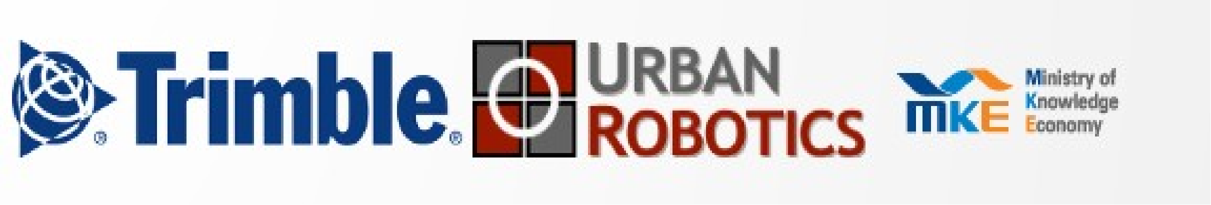
Who is developing it?


3D VSL
National Institute of Advanced Industrial Science and Technology AIST
ASU
Australian National University
universität bonn
UBC
BROWN
Information and Communication Technologies Institute
Carnegie Mellon | PORTUGAL
AN INTERNATIONAL PARTNERSHIP
TU/e Technische Universiteit Eindhoven University of Technology
DTU
EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich
HRI
intel
IIIT-H
ICAR
itseez
KATHOLIEKE UNIVERSITEIT LEUVEN
AGAS
UNIVERSITY of HOUSTON
LAAS-CNRS
Uma UNIVERSIDAD DE MÁLAGA
MIT Massachusetts Institute of Technology
MICHIGAN
NVIDIA
NYU
UNIVERSITÄT OSNABRÜCK
QUT
R·I·T
Trimble
URBAN ROBOTICS
UNIVERSITATEA TEHNICĂ CLUJ-NAPOCA
TUM TECHNISCHE UNIVERSITÄT MÜNCHEN
TOYOTA
TU WIEN
Willow Garage



Who is paying for it?



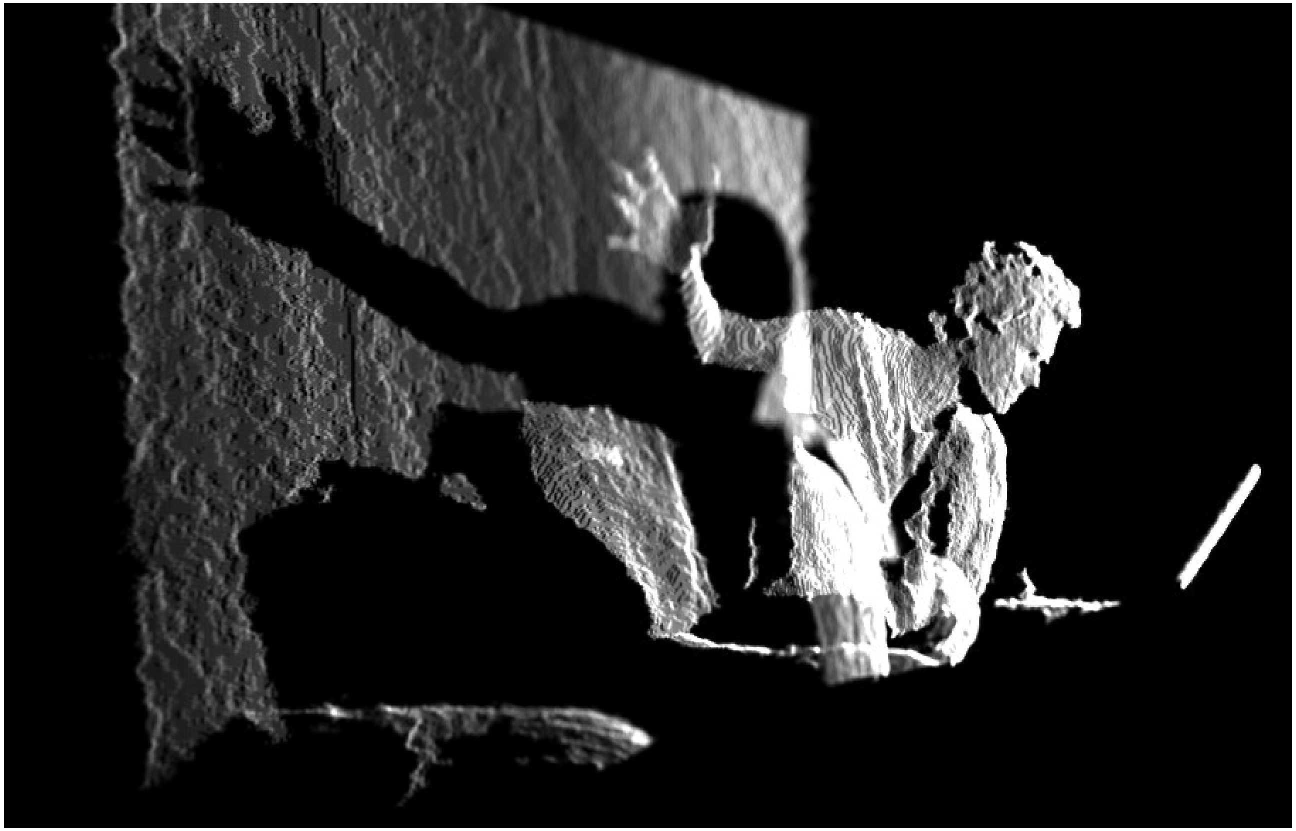


What is a PCL point cloud?

```
# .PCD v0.7 - Point Cloud Data file format
VERSION 0.7
FIELDS x y z
SIZE 4 4 4
TYPE F F F
COUNT 1 1 1
WIDTH 2500
HEIGHT 1
VIEWPOINT 0 0 0 1 0 0 0
POINTS 2500
DATA ascii
-0.0017353802 0.063134596 -0.047117598
-0.00391143 0.064091198 -0.047013
0.00073380599 0.064106099 -0.047437999
0.0021609101 0.063522704 -0.047437999
0.0072039799 0.063331202 -0.0471754
-0.0013178901 0.065206803 -0.0471658
0.00238145 0.0648202 -0.047421999
0.00742169 0.064781599 -0.0471754
-0.00240529 0.065845296 -0.046584301
0.0021517898 0.0657662 -0.047015704
.
.
```

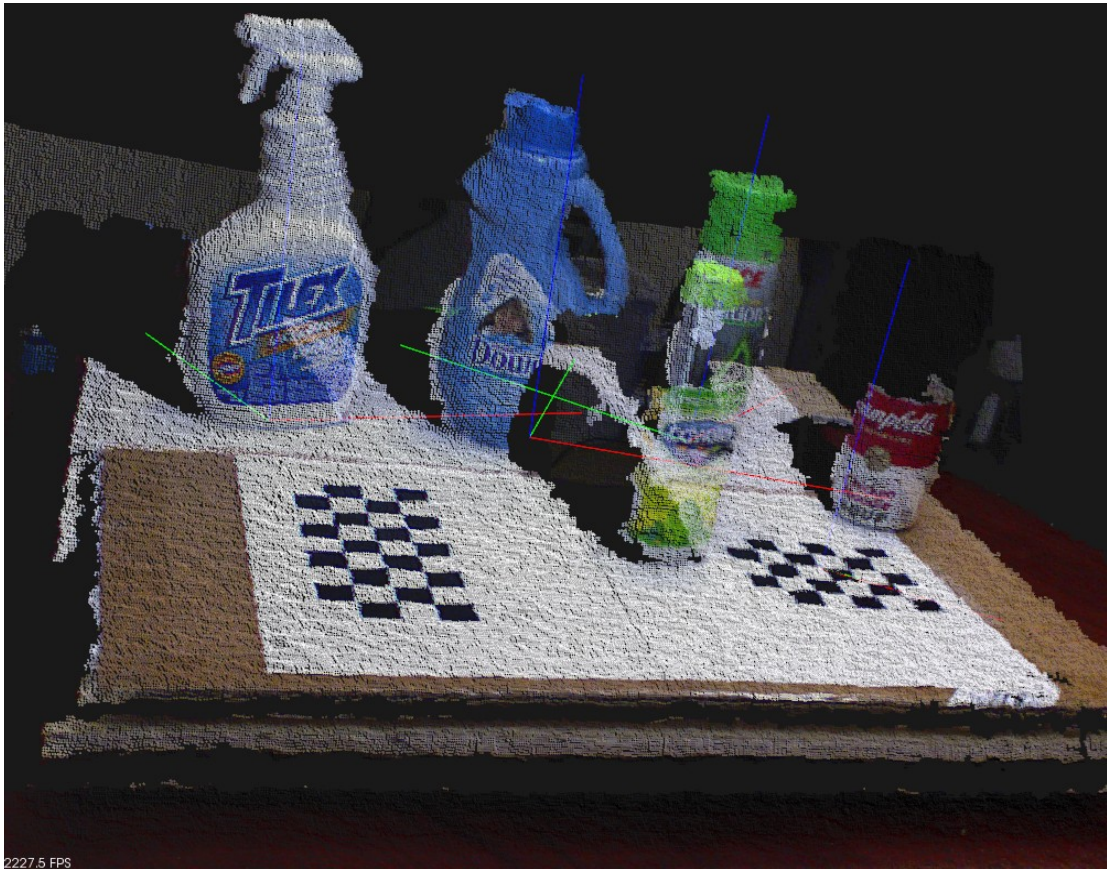
Types of Point Clouds

- XYZ:



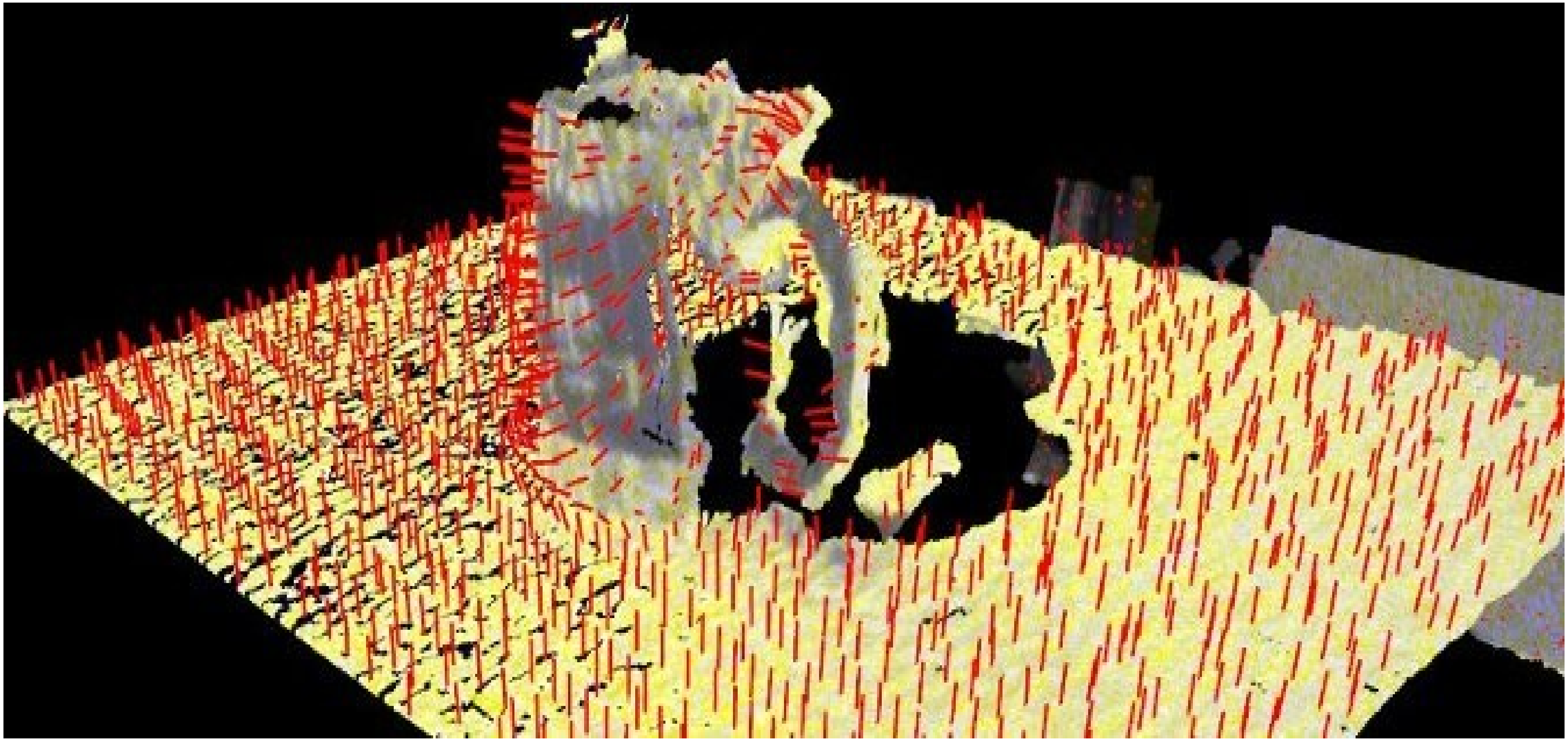
Types of Point Clouds

- XYZRGB:

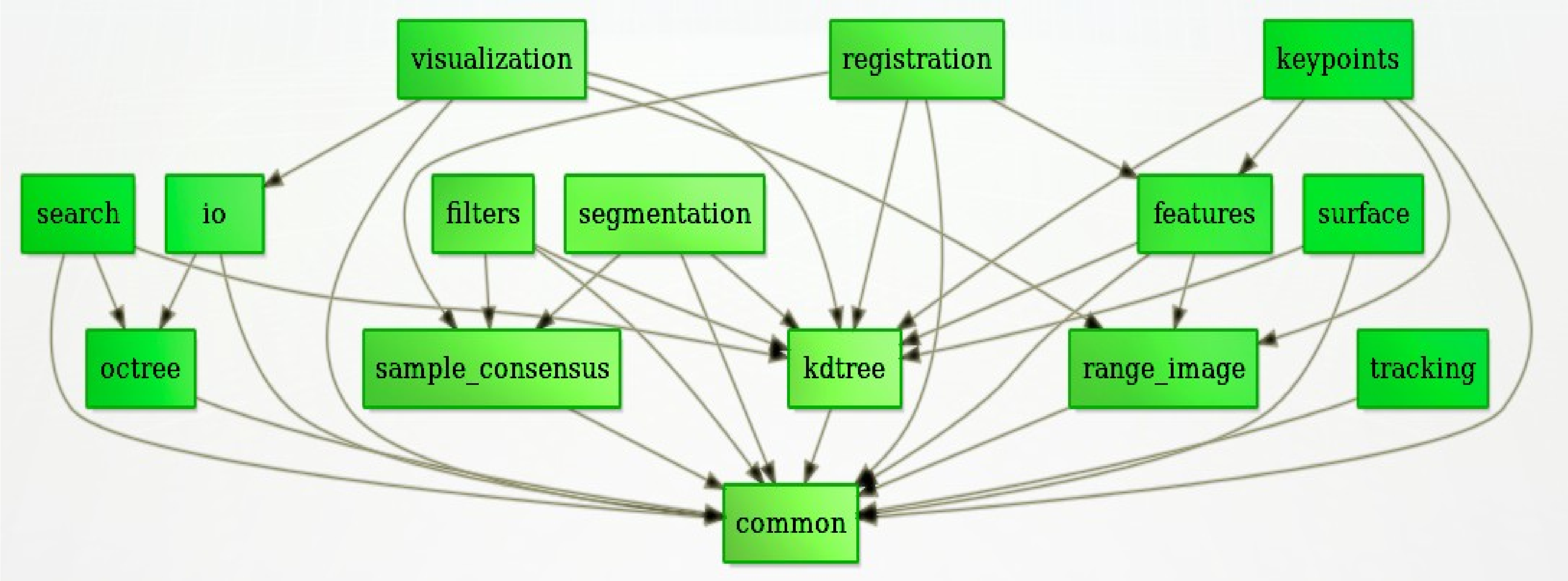


Types of Point Clouds

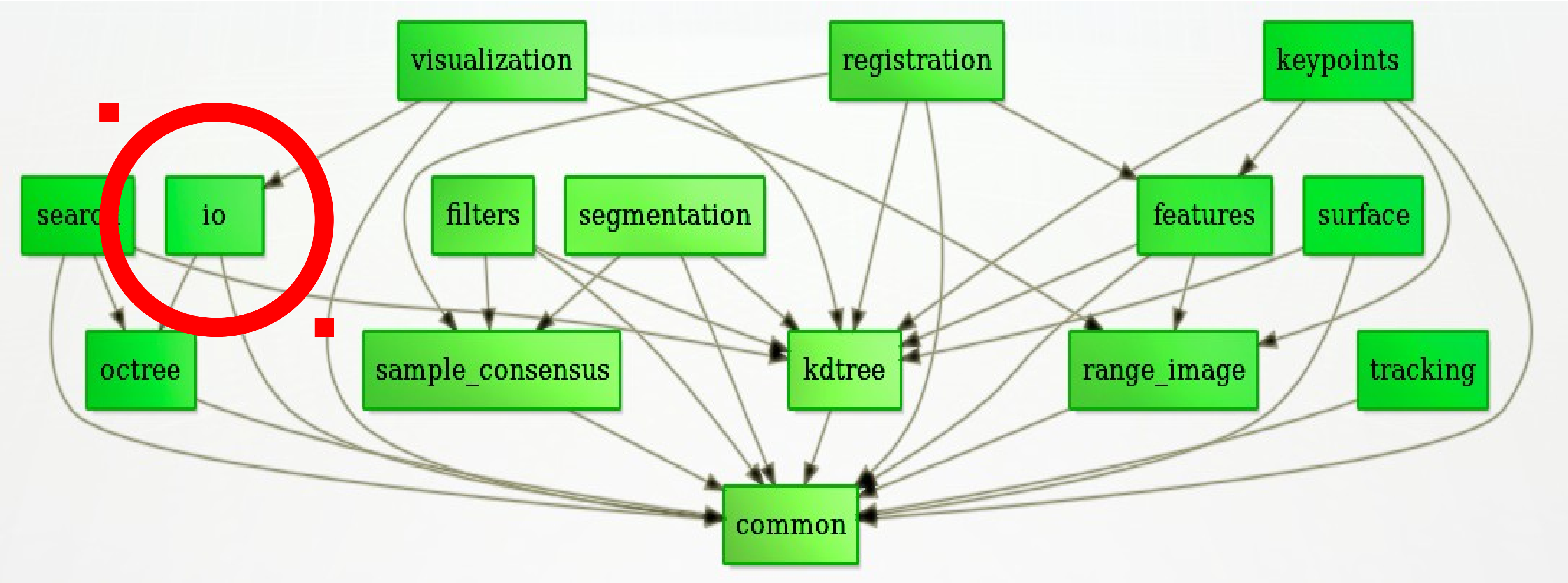
- XYZ+Normals:



PCL Breakdown



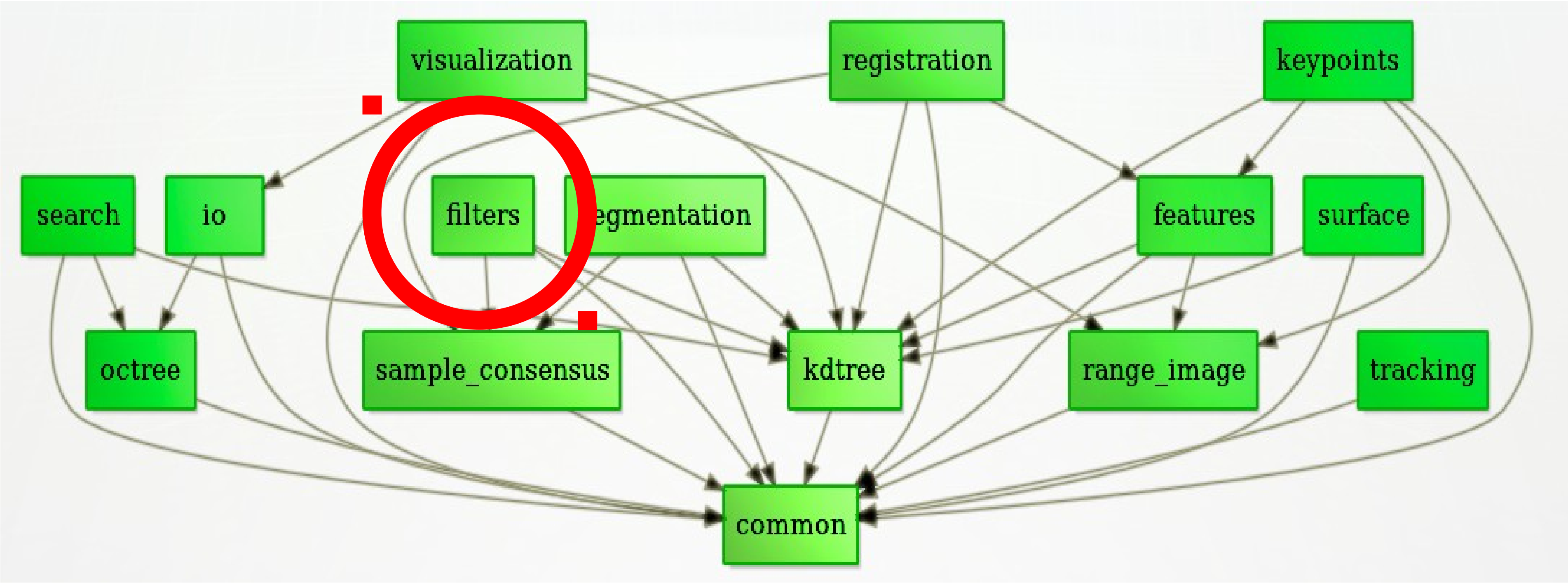
PCL Breakdown



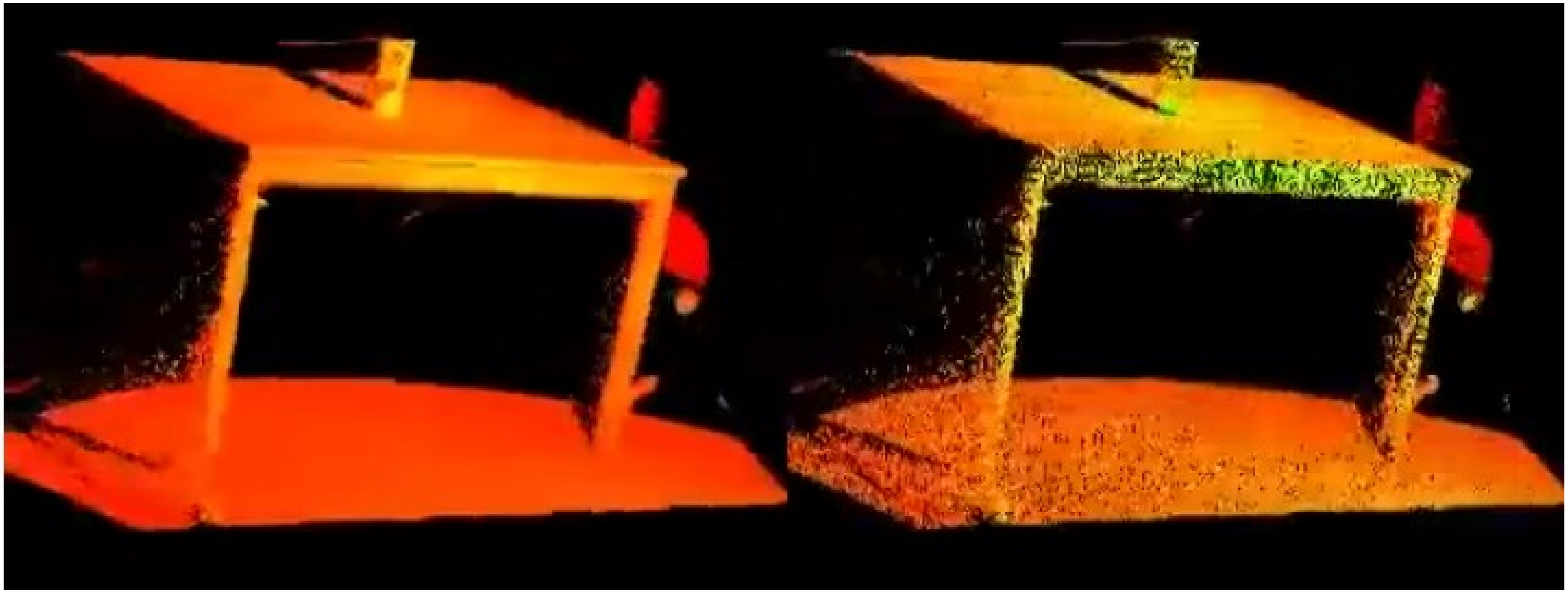
Getting a Point Cloud from an OpenNI Sensor

- Code sample and Demo

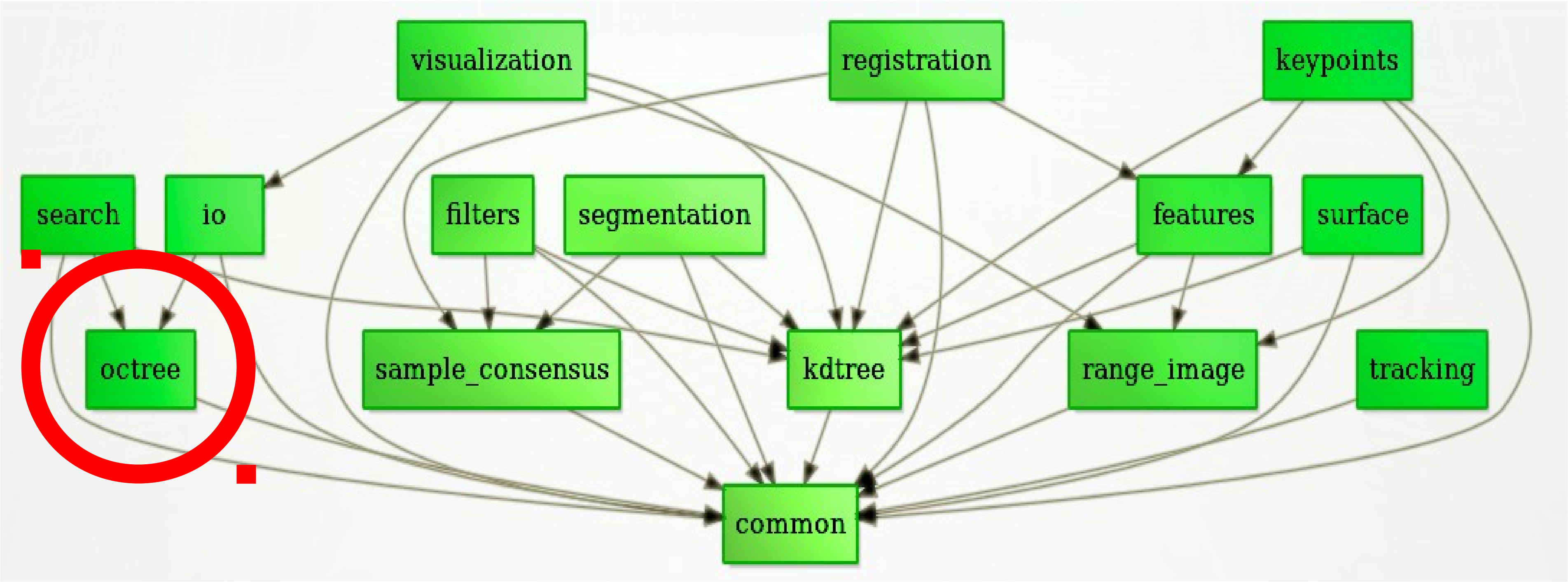
PCL Breakdown



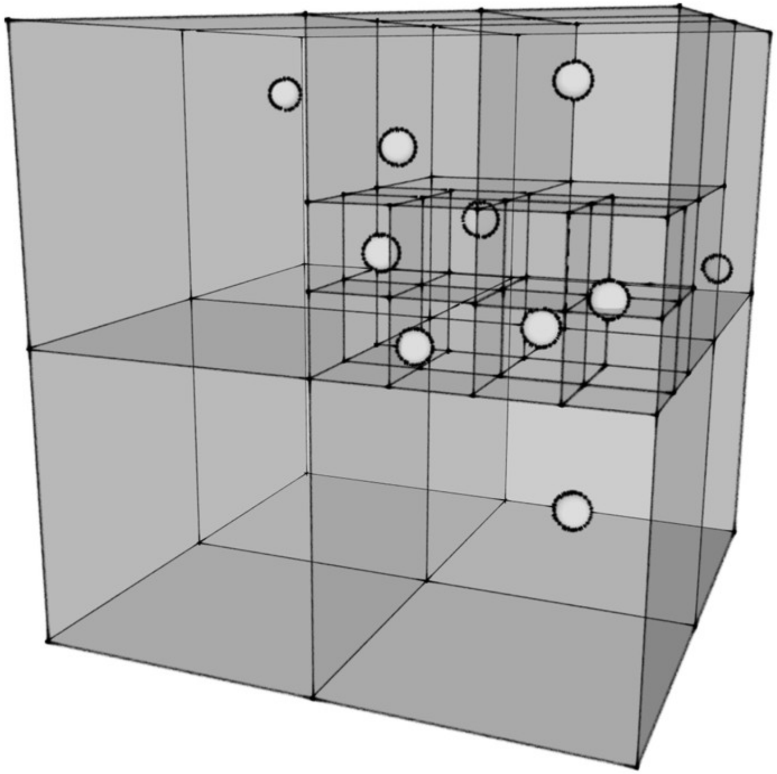
Downsampling a Point Cloud

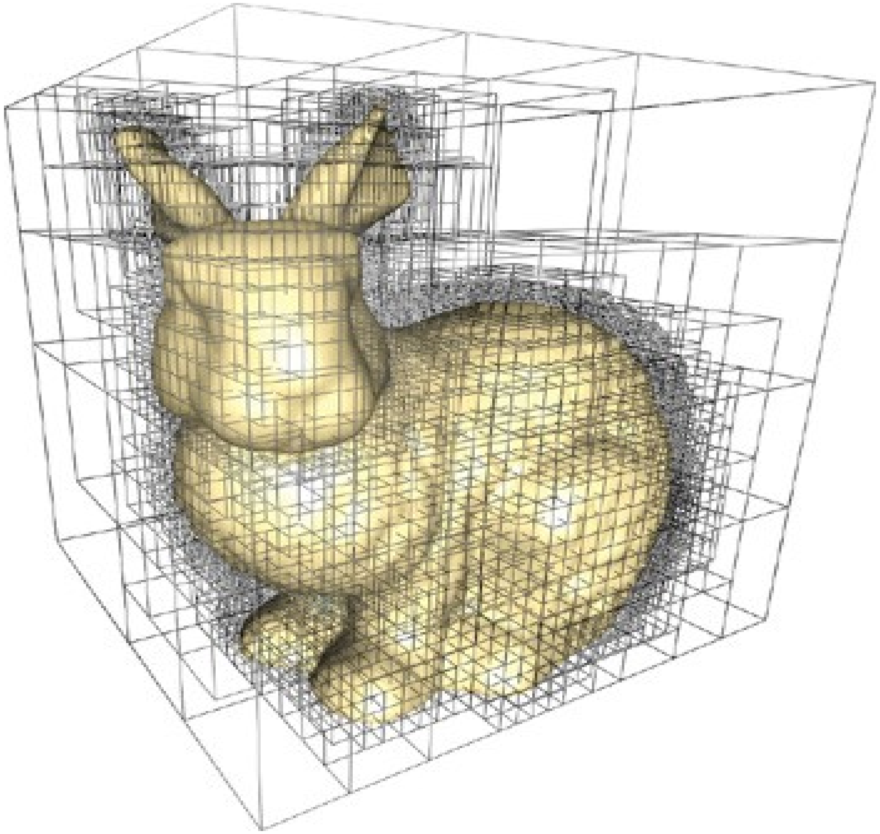


Change Detection using Octree



Octrees



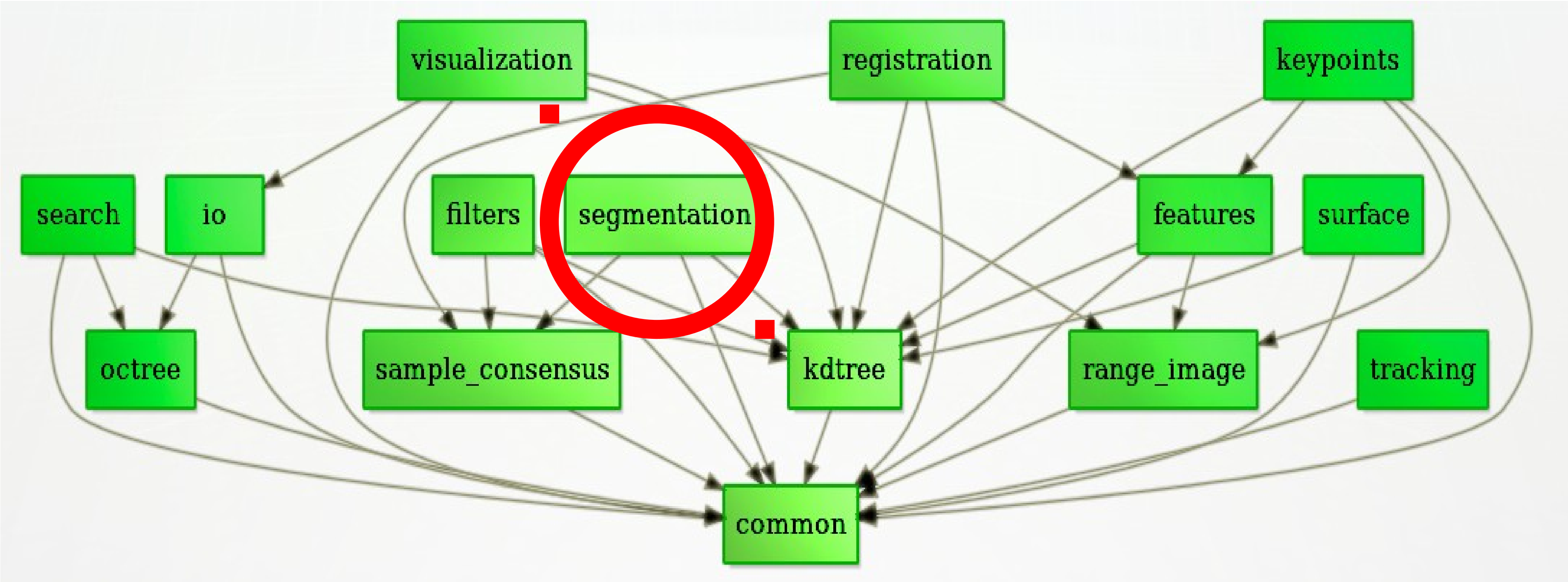


An octree is a *tree data structure* in which each internal node has exactly eight children. Octrees are most often used to partition a three dimensional space by recursively subdividing it into eight octants. Octrees are the three-dimensional analog of quadtrees.

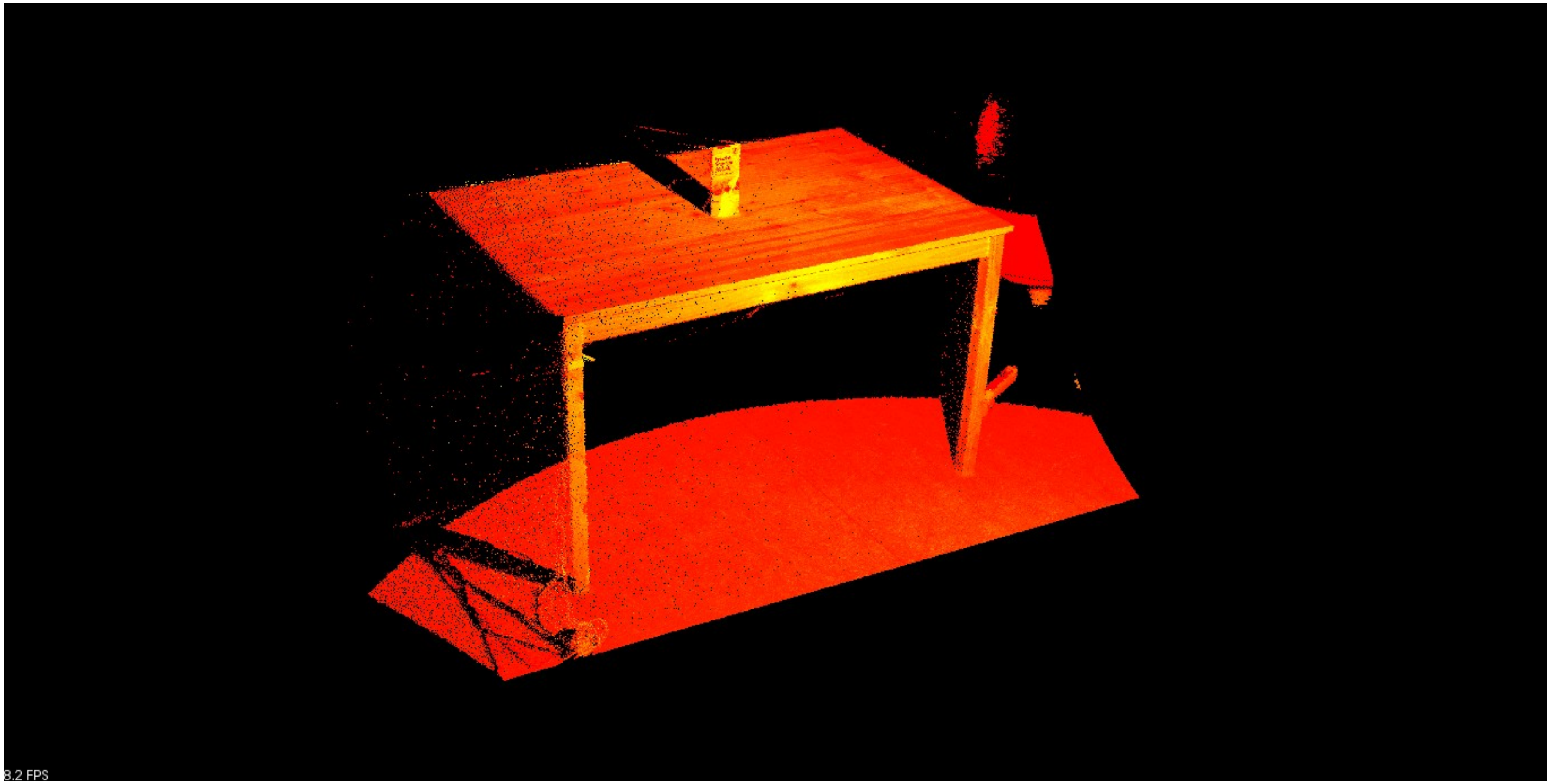
Octrees

Application: change detection

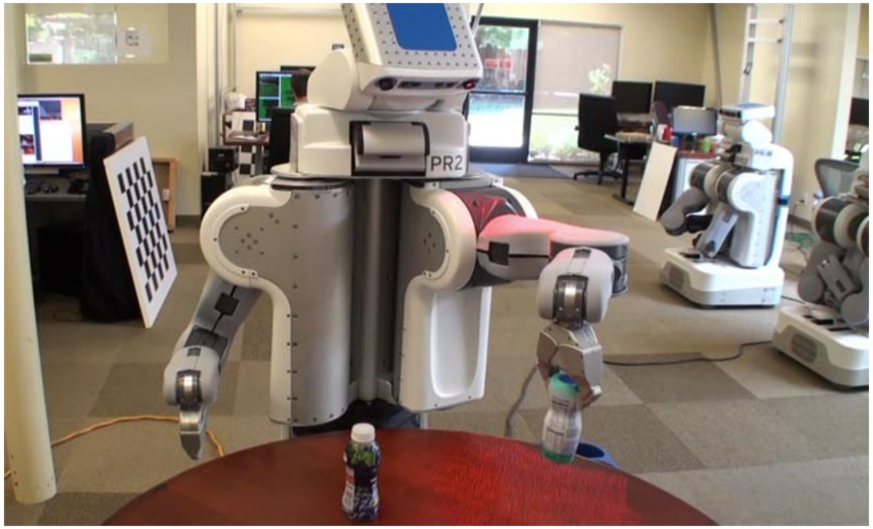
Segmentation

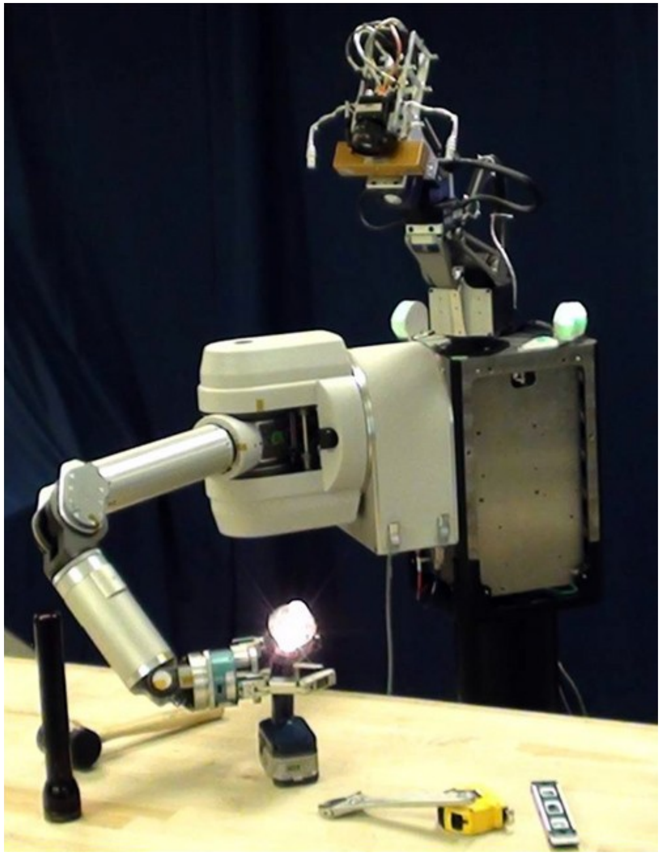


Example:
finding the floor and the table

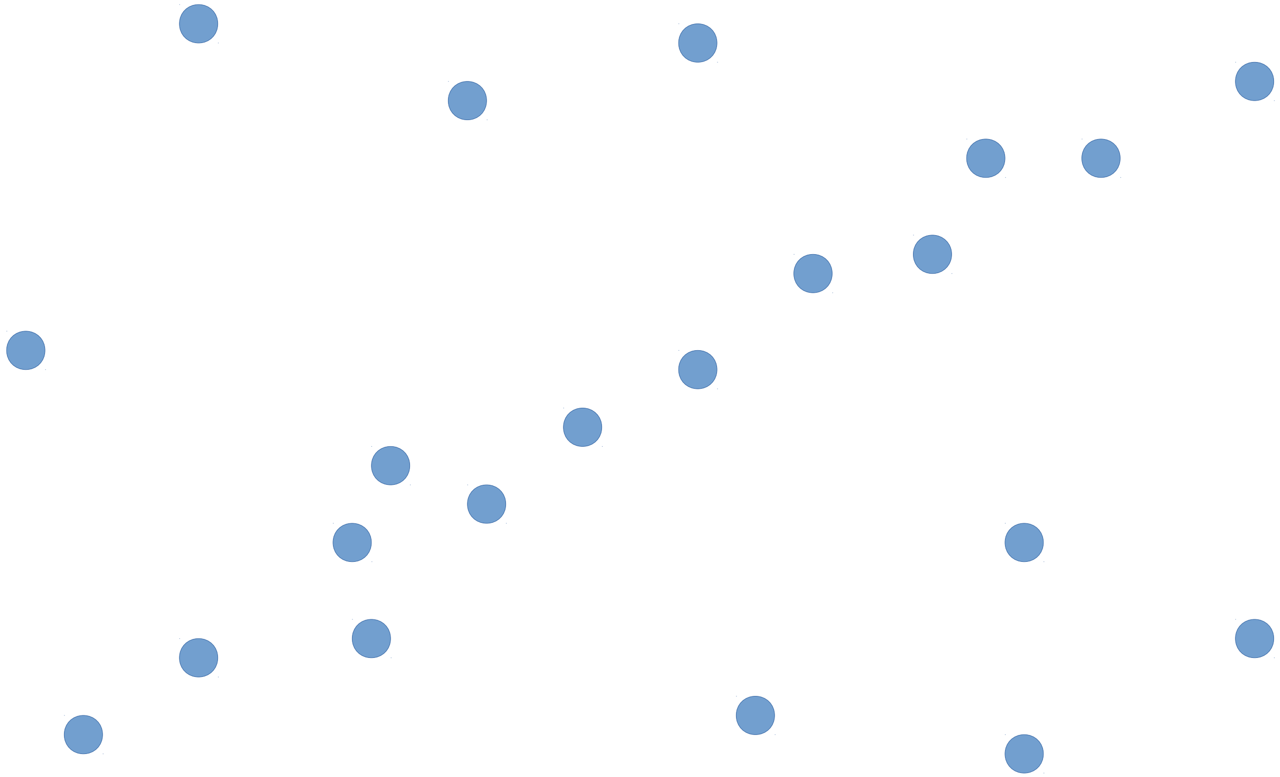


Robots and Tables

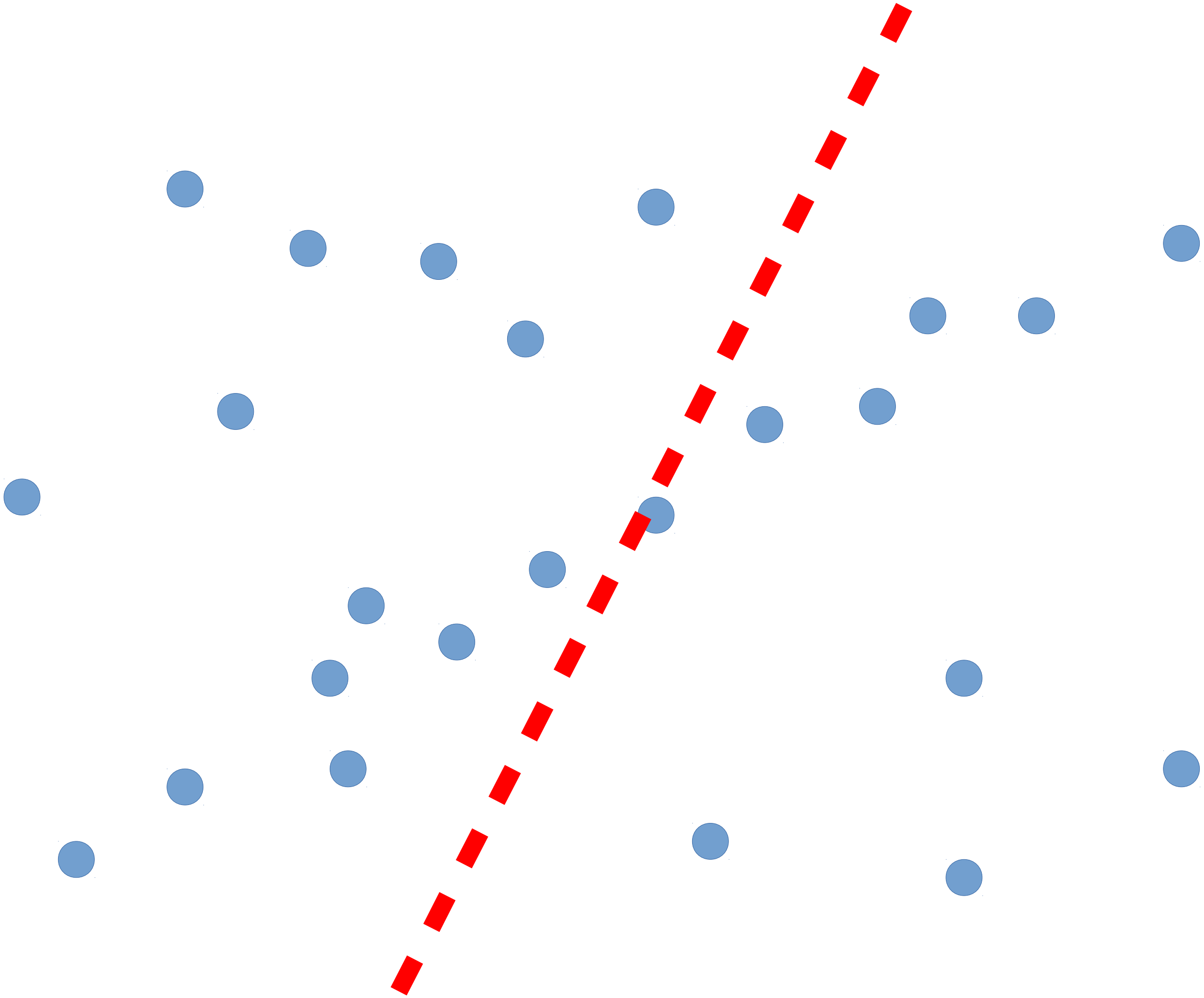




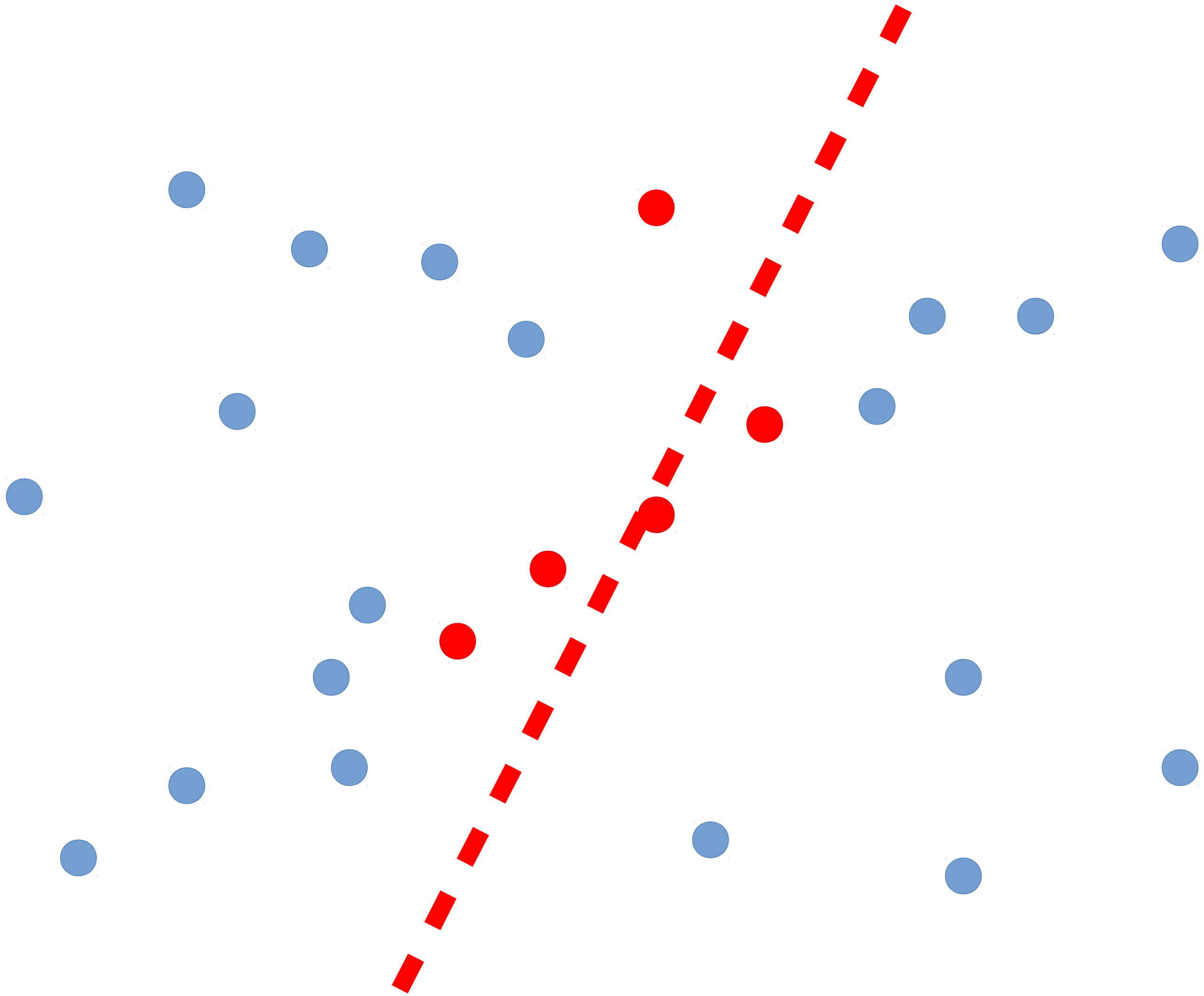
An Example in 2D



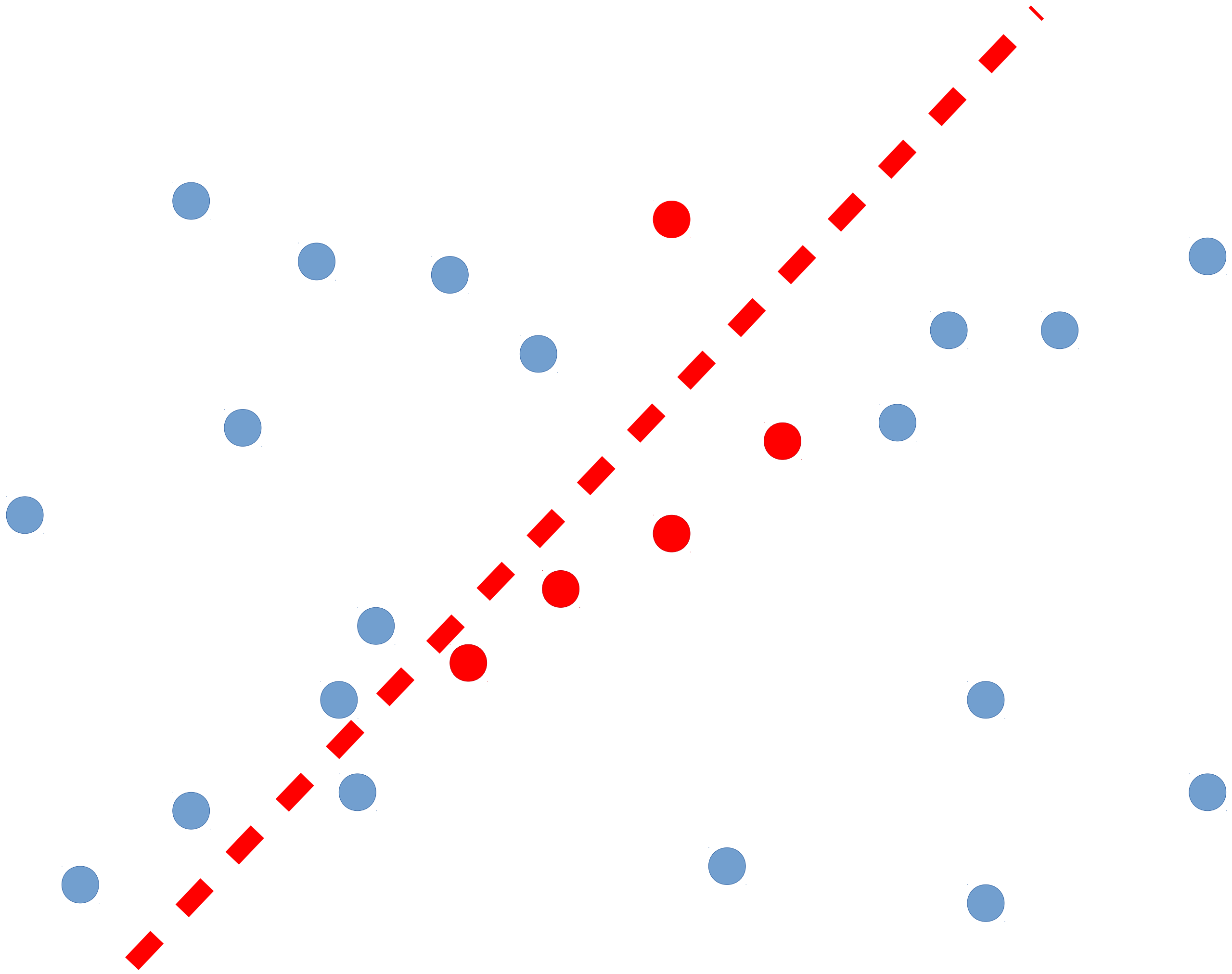
An Example in 2D



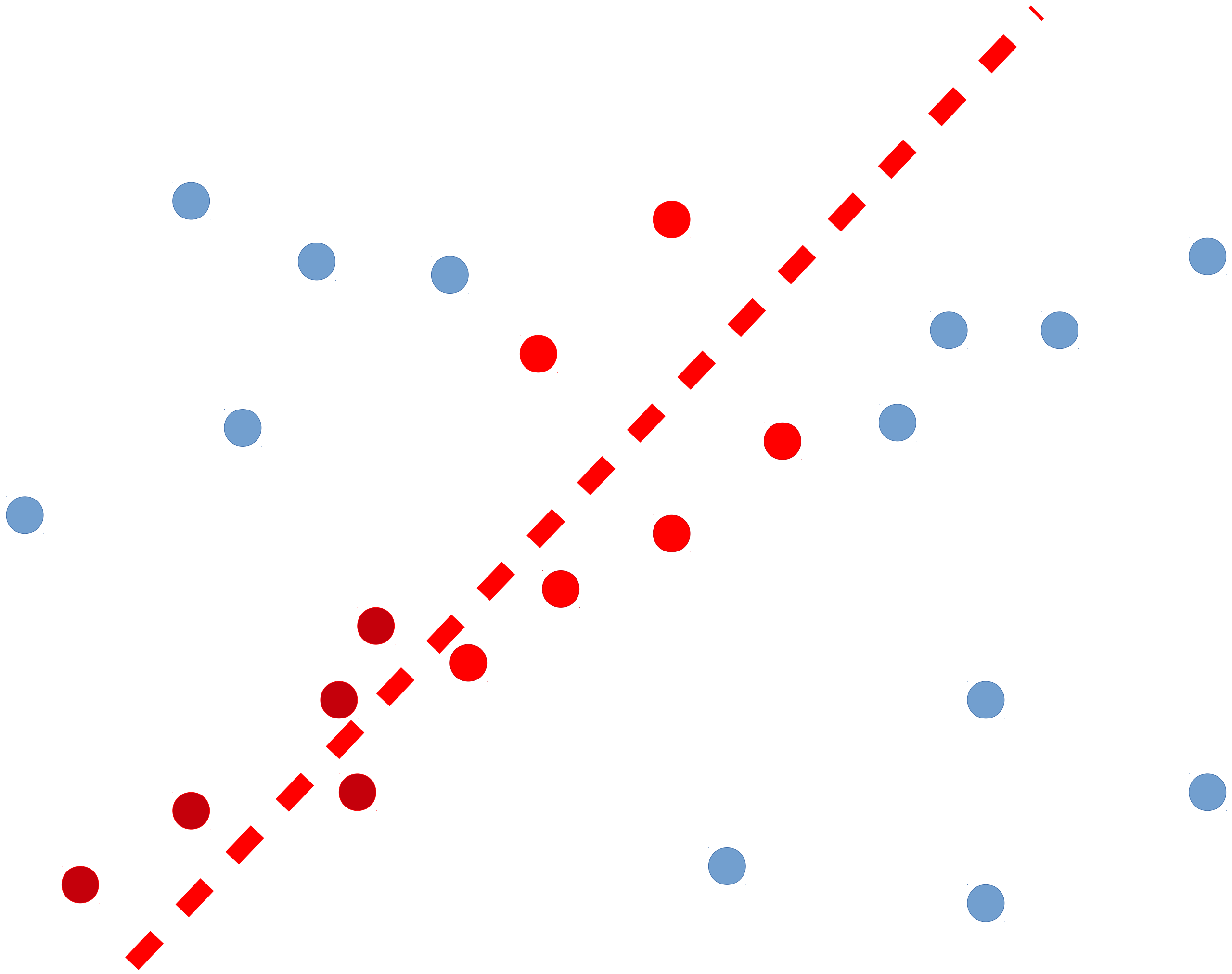
An Example in 2D



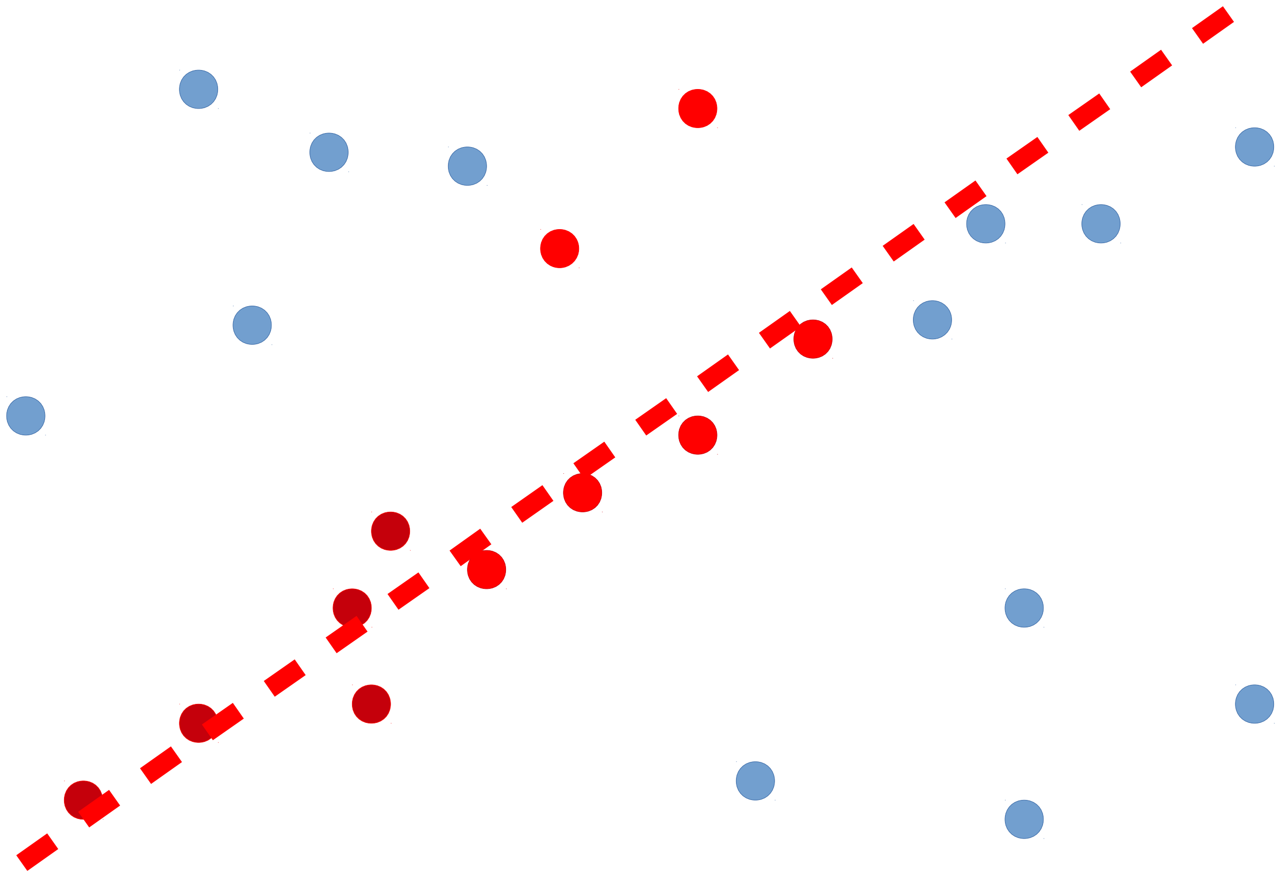
An Example in 2D



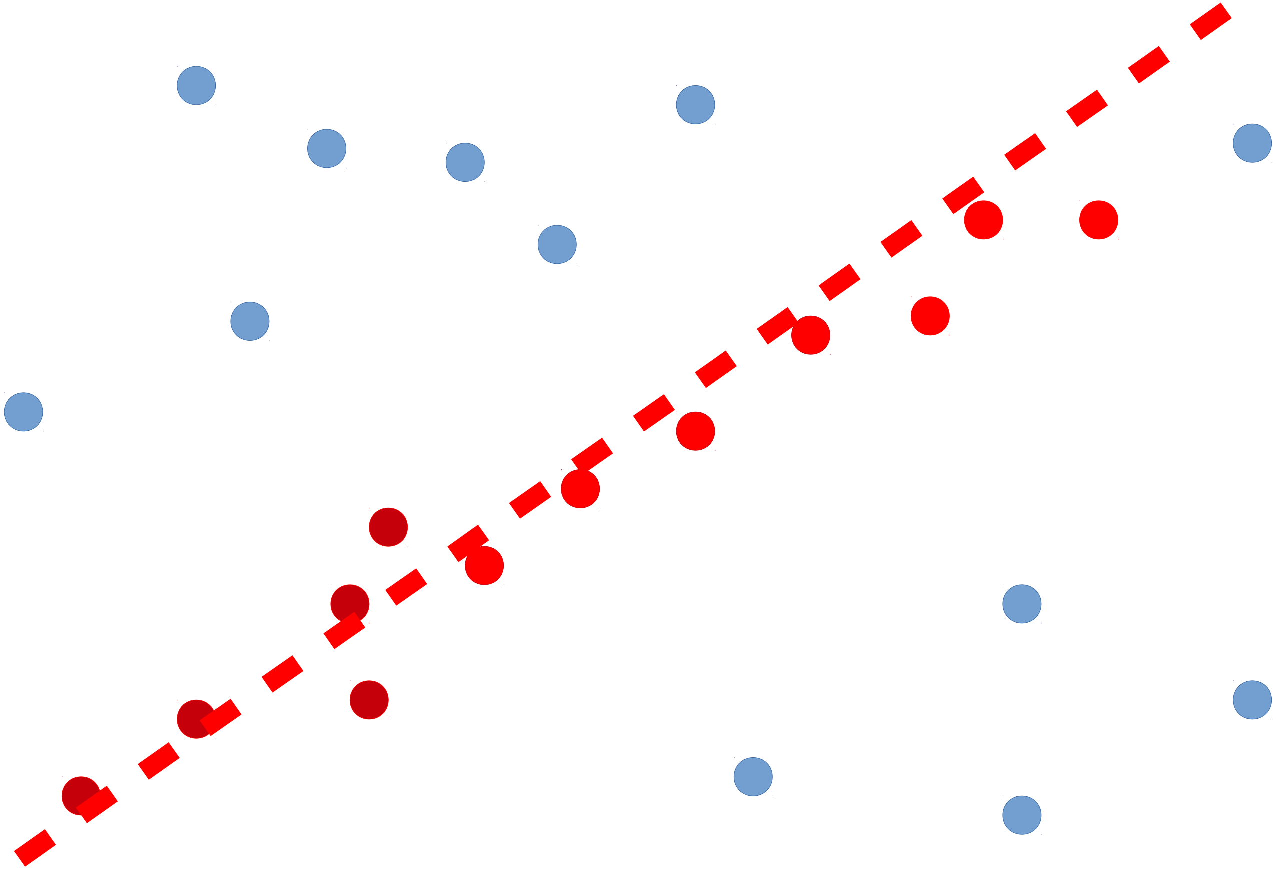
An Example in 2D



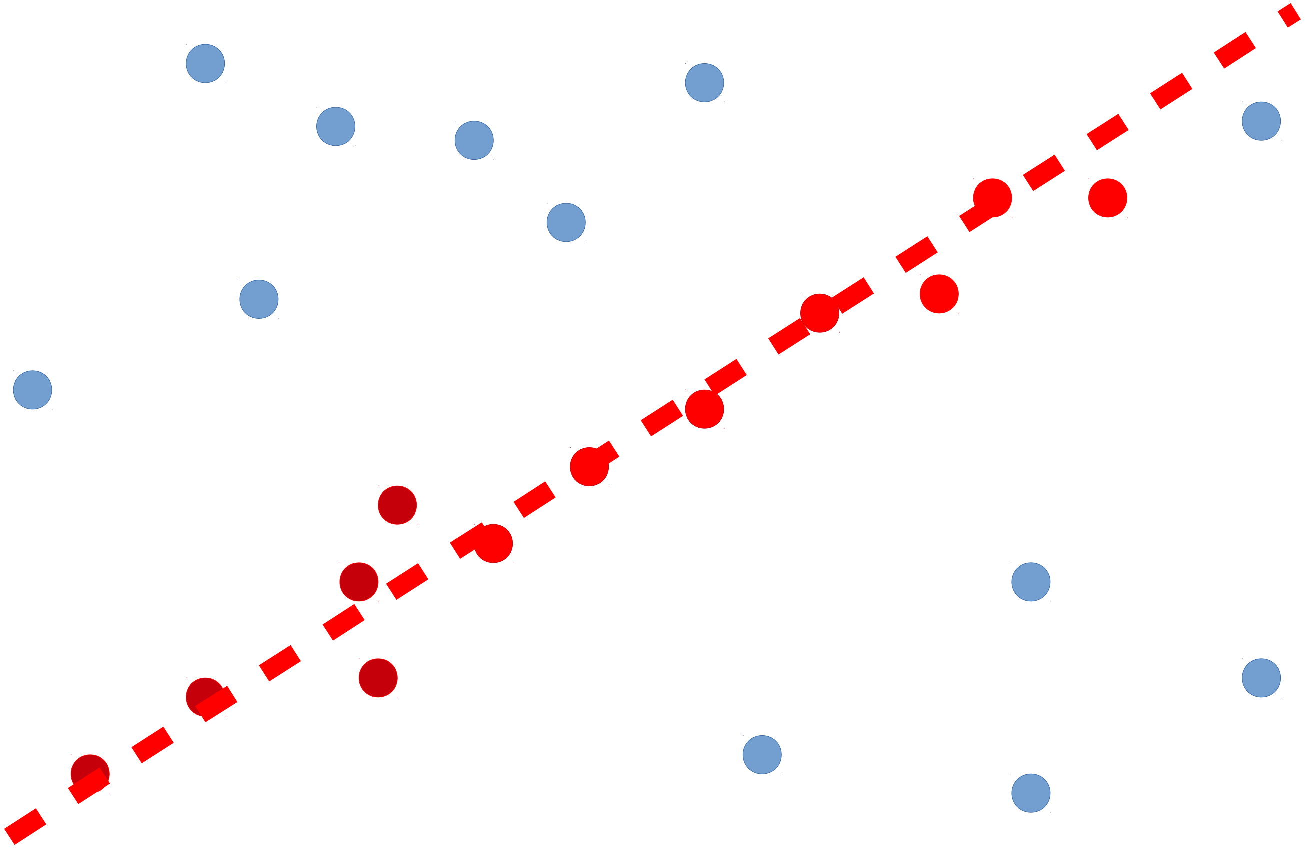
An Example in 2D



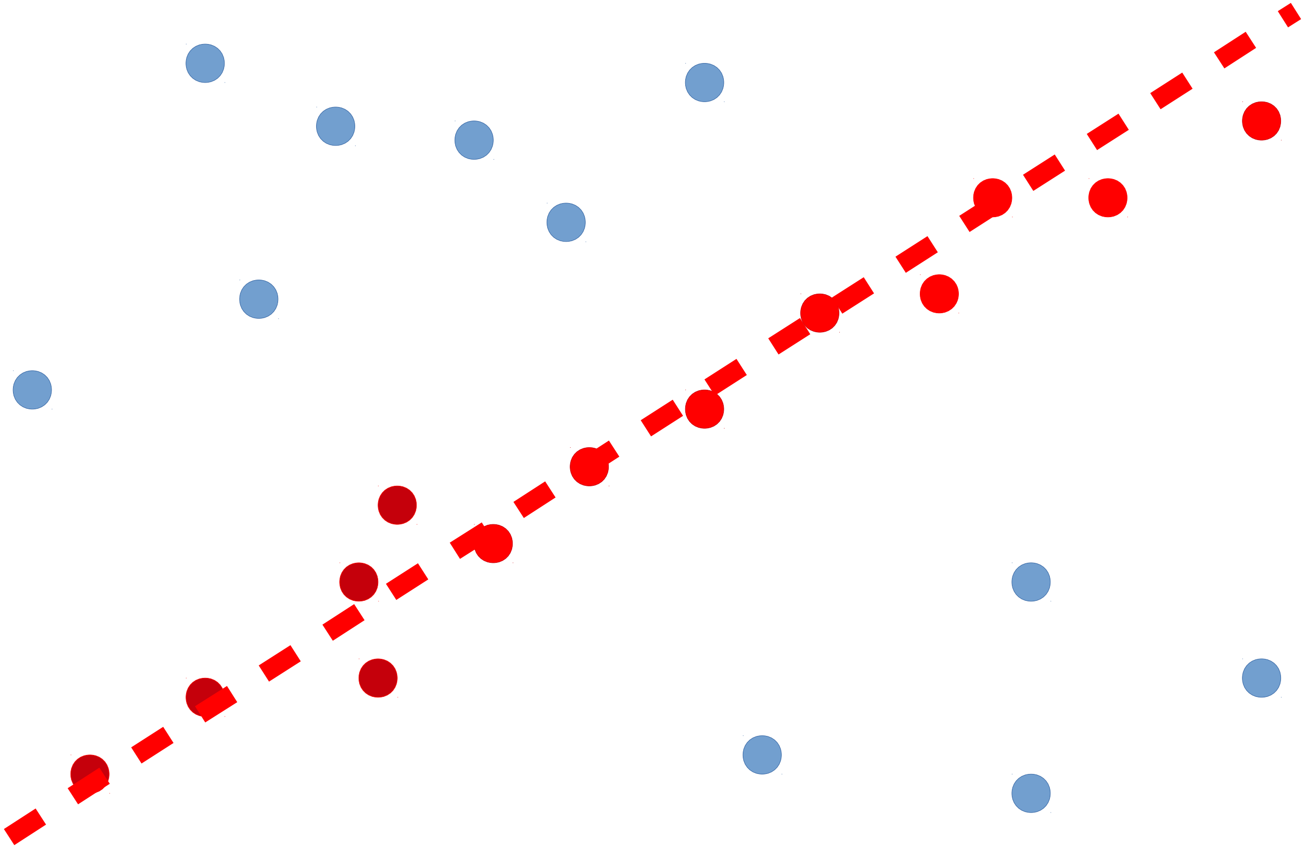
An Example in 2D



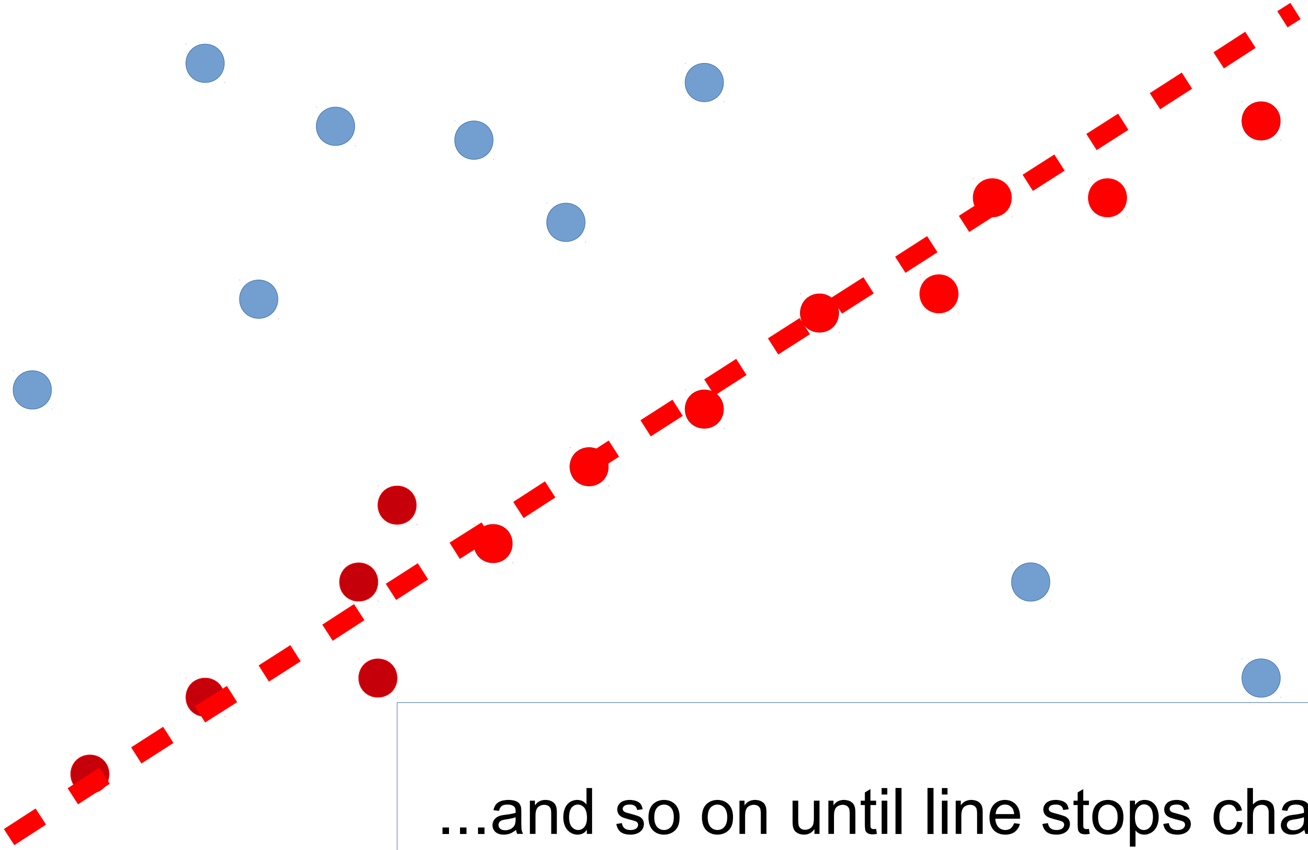
An Example in 2D



An Example in 2D



An Example in 2D

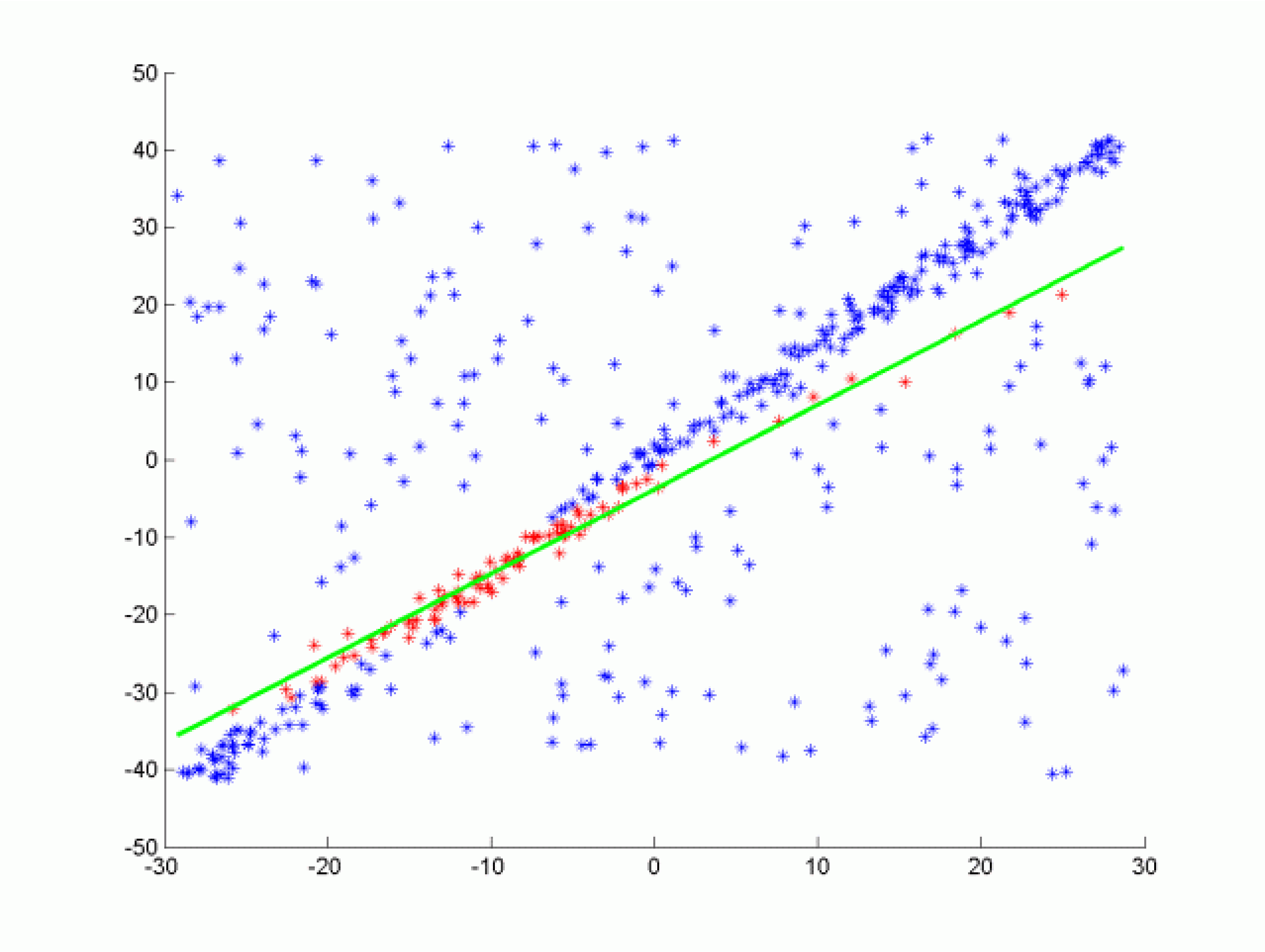


...and so on until line stops changing

RANSAC

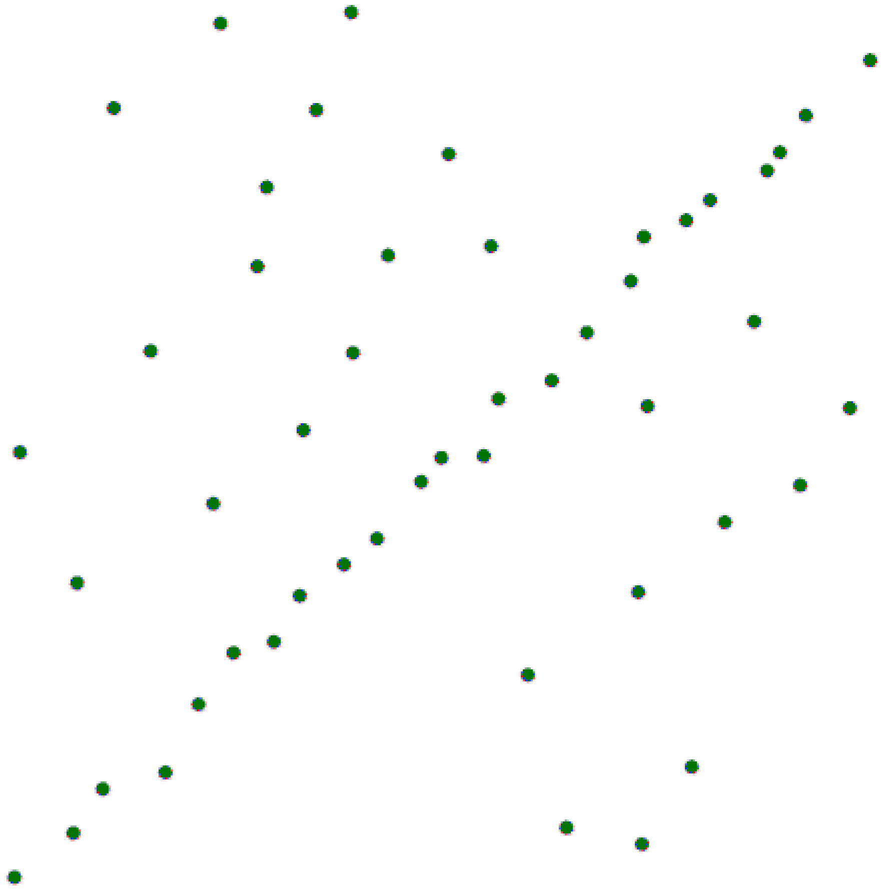
“Random sample consensus (RANSAC) is an iterative method to estimate parameters of a mathematical model from a set of observed data which contains outliers. “ - Wikipedia

RANSAC



[https://upload.wikimedia.org/wikipedia/commons/c/c0/RANSAC_LINIE_Animiert.gif]

RANSAC



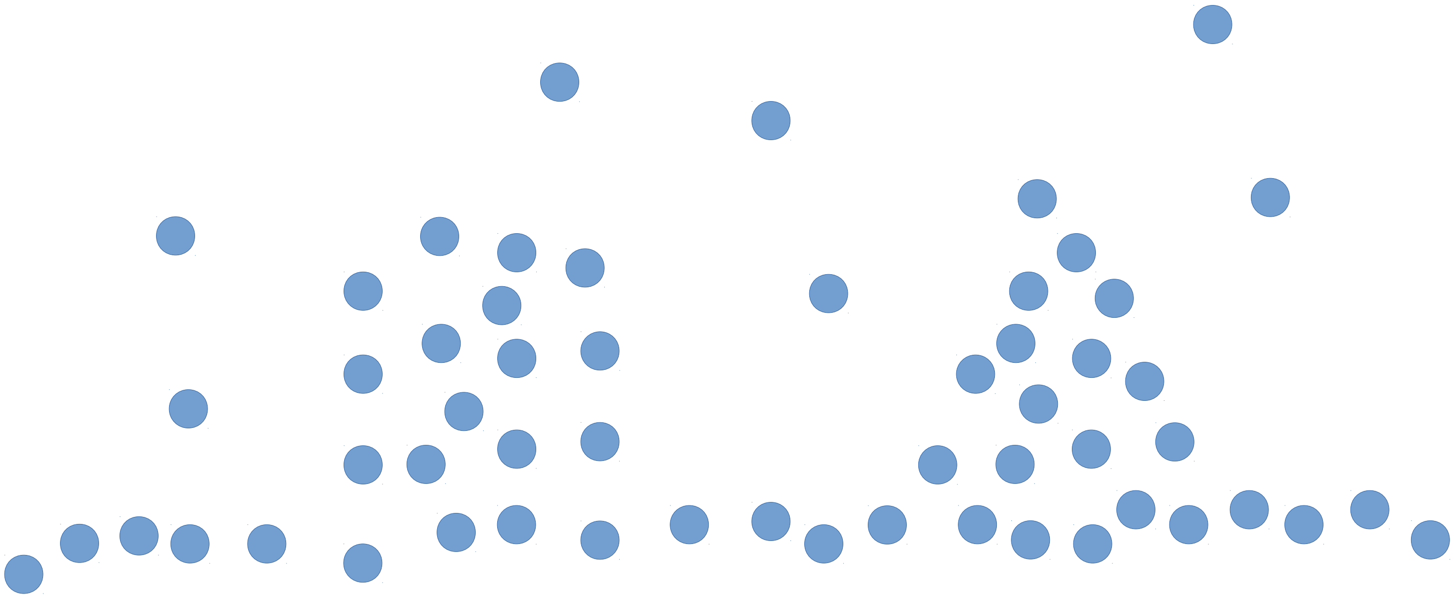
[http://www.visual-experiments.com/blog/wp-content/uploads/2012/04/ransac_line_fitting1.gif]

Finding a plane using RANSAC

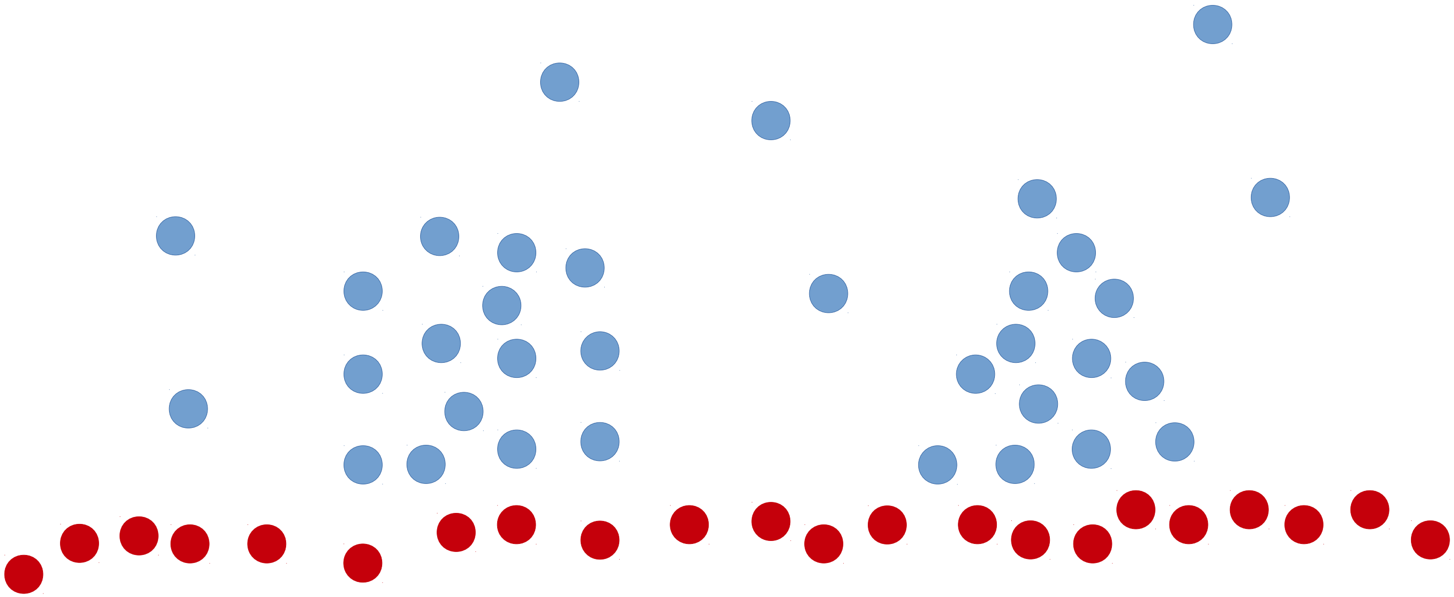
Cylinder Detection with RANSAC

https://www.youtube.com/watch?v=tasdvsnGCH0

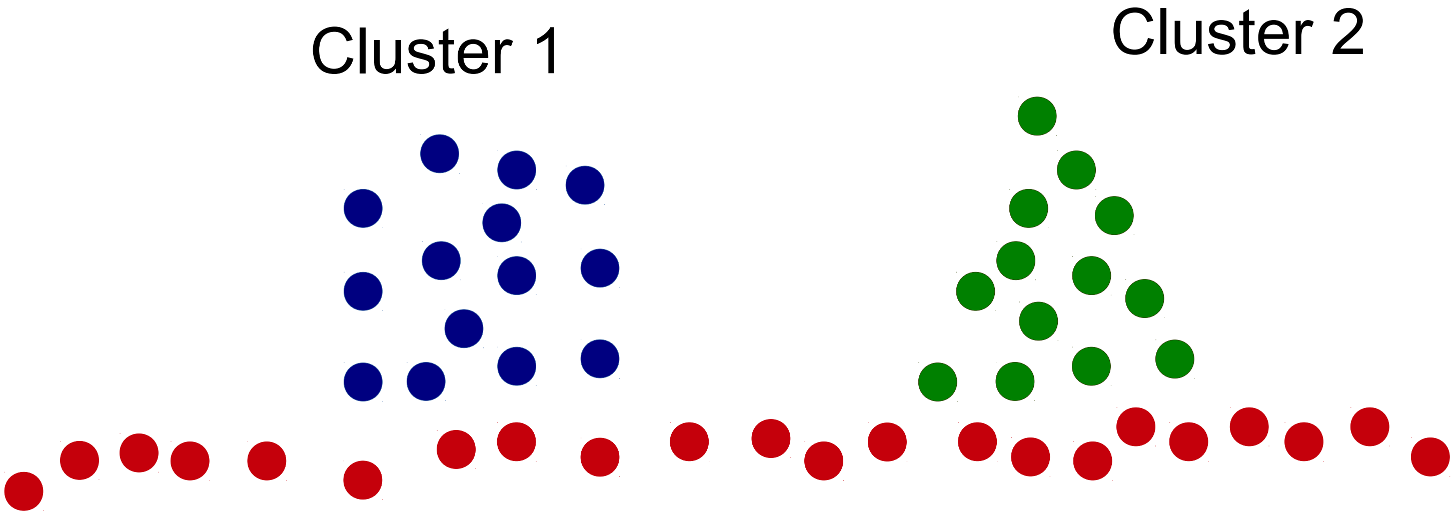
Cluster Extraction



Cluster Extraction



Cluster Extraction



Cluster Extraction in PCL

- Code example

Further Applications

Obstacle Detection

https://www.youtube.com/watch?v=jHKzBMKk4hY

Object Tracking in 3D

https://www.youtube.com/watch?v=NzRME9ZEOnY

Resources

- Main website: https://ointclouds.org
- Tutorials: http://pointclouds.org/documentation/tutorials/
- API: http://docs.pointclouds.org/1.7.2/
- Blog: http://pointclouds.org/blog/

THE END