INTRODUCTION

Machine Learning for Autonomous Robots

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Motivation

Machine Learning

How can computers learn to solve problems without being explicitly programmed?
Arthur Samuel (1959)

Lecture Overview

Lecture Outline

- Preprocessing
- Evaluation and Metrics
- Clustering
- Classification
- Regression
- Neural networks
- Deep Learning
- Applied Machine Learning

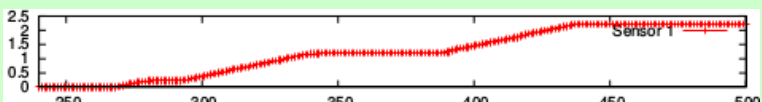
Features

Feature Generation and Preprocessing

1. The sensor data, autonomous robots have to decide on can be **simple and "ready to use"**.
2. However, often the available sensor signals have to be **preprocessed** to be usable.
3. Or there is even **no sensor existing** to deliver the needed information.

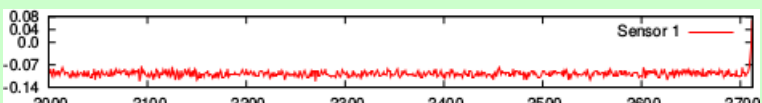
Examples

- Wheel speed measurement for a speed controller:



Examples

- Noisy signal of an Inertial Measurement Unit (IMU):

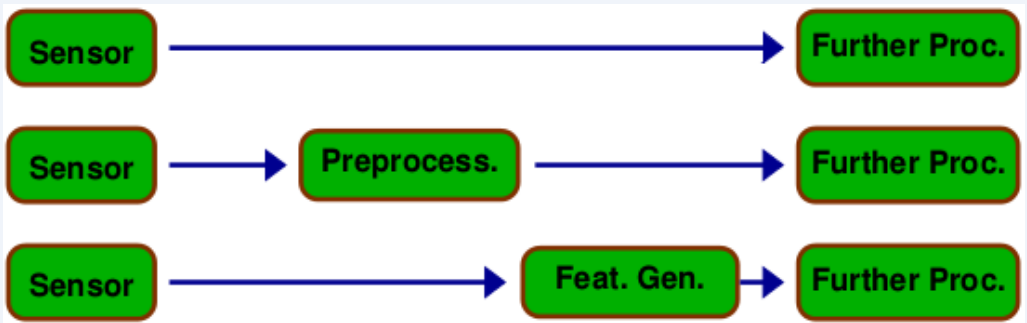


Examples

- Sensor for
  “large rock in camera image”:

Data Processing Chain

In general we can find these setups (partly or in parallel):



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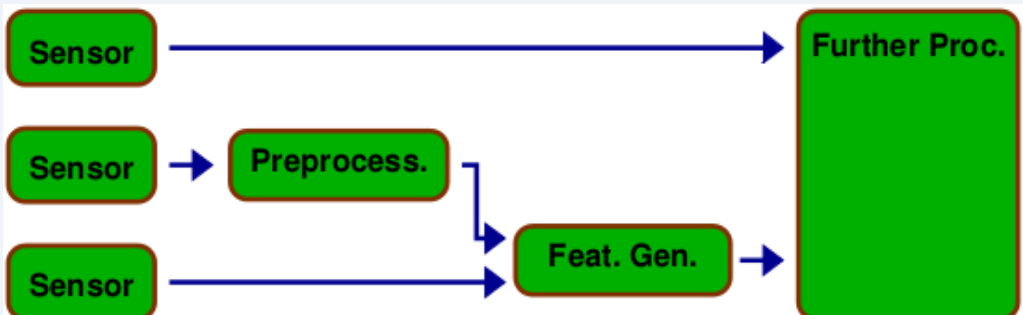
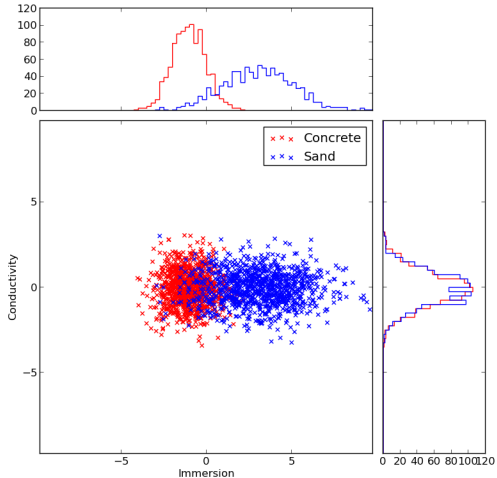


Preprocessing

Find/construct features that contain useful information for distinguishing different situations



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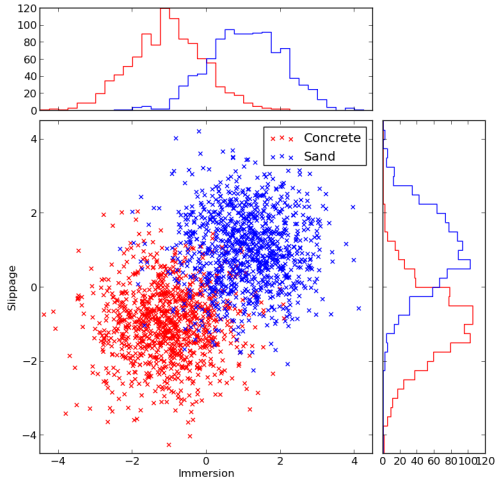

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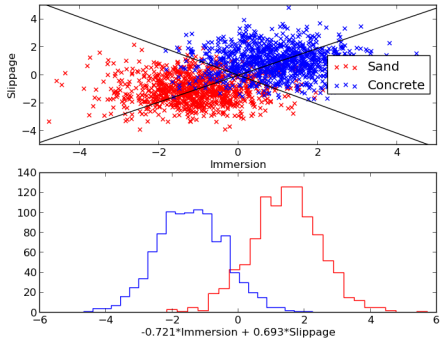


Preprocessing

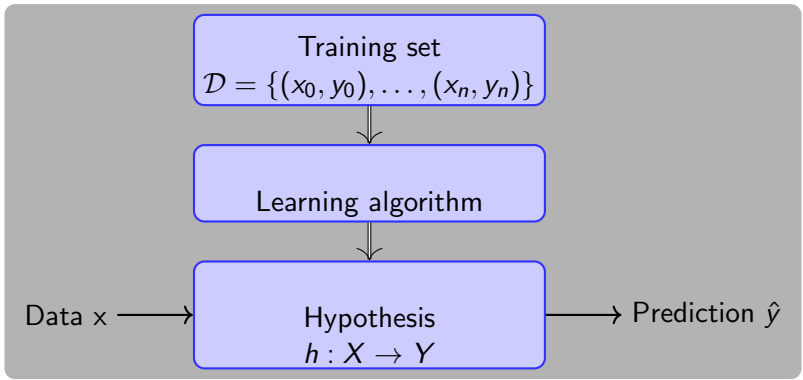
Applications in robotics:

- Determine relevant sensors (reduce sensors and save money)
- Reduce dimensionality of data (e.g. for memory efficient storing or for speed up of further processing)
- Improve data processing

Further applications:

- Data mining
- Computer Vision

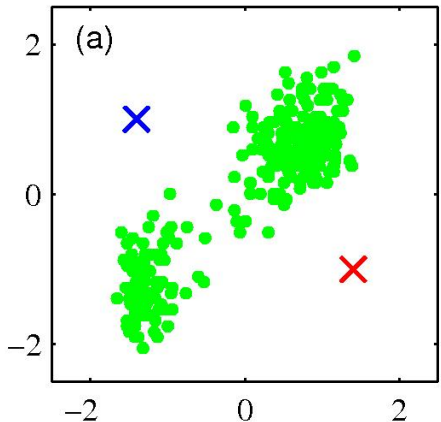
Supervised vs. Unsupervised Learning



- If Y is a discrete domain: classification
- If Y is a continuous domain: regression
- If we don't have the y_i in training: unsupervised learning

Clustering

Find clusters such that the within-cluster similarity is larger than the across-cluster similarity



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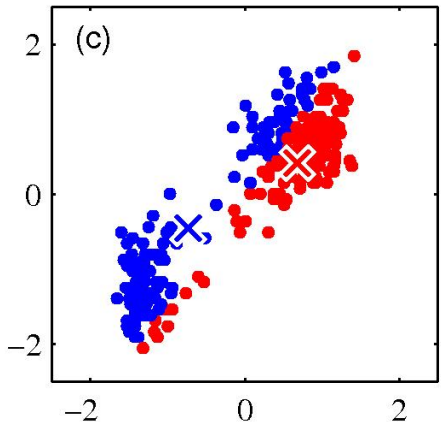

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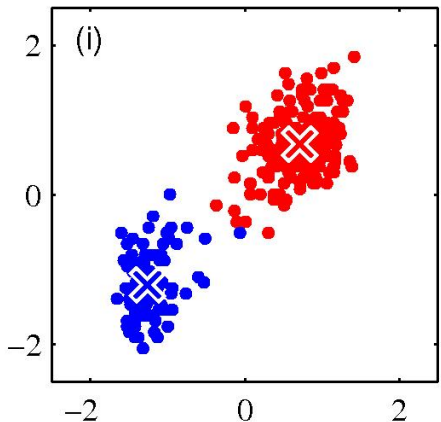


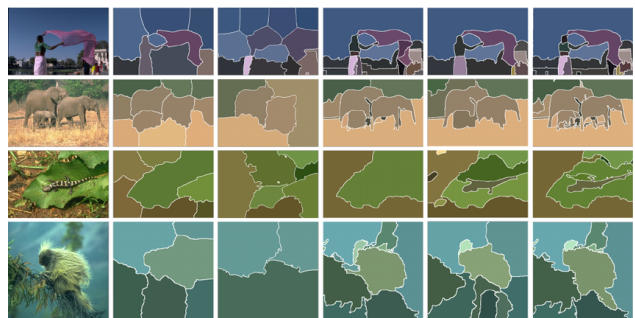
Clustering

Applications in robotics:

- Cluster different substrates a robot has walked over
- Cluster different objects a robot can interact with into different categories

Further applications:

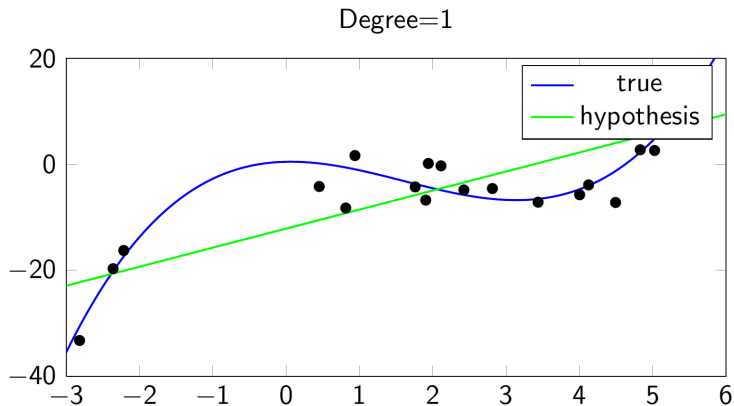
- Computer vision (segmentation)
- ...



https://www.researchgate.net/figure/285926394_fig3_Figure-6-Comparison-of-segmentation-results-Spectral-clustering-uses-the-mPb-affinity

Regression

- Uncover functional relationships
- Curve fitting



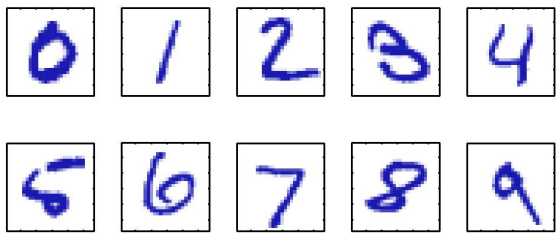
Regression

Applications in robotics:

- Learning a model of the dynamics of a robot
- Modeling of sensors and actuators: detect failures and wear-off

Classification

Searching for known classes, how can we label our data best:



Classification

Applications in robotics:

- recognize objects that need to be manipulated correctly
- know the type of terrain from sensor data
- allow a robot to understand speech
- recognize the owner/user and his intentions
- anomaly and novelty detection

Further applications (not exhaustive):

- spam detection
- handwriting recognition
- speech recognition
- fraud detection (e.g., credit card fraud)

(Artificial) neural networks

- ... are loosely based on the animal brain
- ... can be used for regression, *feature learning*, classification
- State of the art in image classification, speech recognition, ...

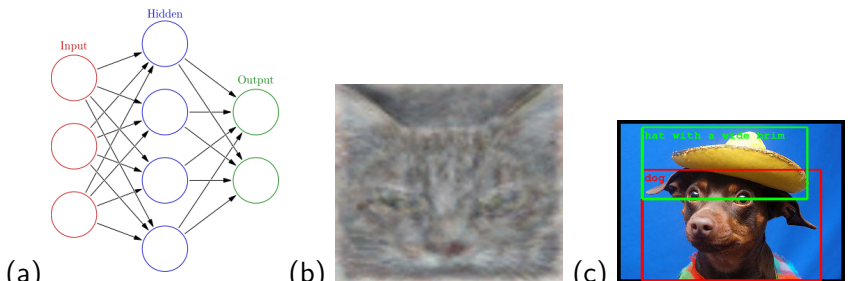


Figure: (a) Neural net (Wikipedia, CC BY SA 3.0) (b) Cat neuron (c) Object classification

Thank You! Any Questions?