Machine Learning in Robotics

Lecture 1: Course introduction

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Today's Lecture Outline

- Introduction of the course "Machine Learning in Robotics"
- Important stuffs
- Course Outlines

Contact

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Teaching Assistant	**Matteo Saveriano** Email : matteo.saveriano@tum.de **Affan Pervez** Email : affan.pervez@tum.de

Course Information

Time and Location	**Friday 9:00 - 11:15**, Room 1180
References	• R. O. Duda, P. E. Hart and D. G. Stork, 2001, Pattern Classification, 2nd ed., Wiley. • C. M. Bishop, Pattern Recognition and Machine Learning, 1st ed., Springer, 2006. • T. Mitchell, Machine Learning, 1997
Course Contents	Applications of Machine Learning for Robots, Density Estimation, Probabilistic Methods for Classification, Dimensionality Reduction, PCA, Feature Selection, Statistical Clustering, Unsupervised Learning, EM algorithm, Validation, Support Vector Machines, Hidden Markov Models, Reinforcement Learning, Gaussian Process
Grading	• Final Exam • Assignment
Online	www.moodle.tum.de
ECTS, SWS	5ECTS, 4SWS

Schedule (tentative)

	Fri 9:00 – 10:30, Room: 1180	Fri 10:30 – 11:15, Room: 1180
15.04	Lecture 1	
22.04	Lecture 2	Exercise
29.04	Lecture 3	Exercise
06.05	Lecture 4	Exercise, HW1
13.05	Lecture 5	Exercise
20.05	No lecture	
27.05	Lecture 6	Exercise
3.06	lecture 7	Exercise
10.06	lecture 8	Exercise
17.06	No lecture	
24.06	Lecture9	Exercise
1.07	Lecture10 (**Room 1100**)	Exercise (**Room 1100**)
08.07	Lecture11	Exercise, HW2
15.07	Lecture12	Exercise

Contents (tentative)

Lecture	Contents
1	Introduction
2	Linear Regression, Gradient Descent (M)
3	Bayesian Theory, Linear and Quadratic classifiers (M)
4	Logistic Regression, Unsupervised Clustering (k-means, LBG) (M)
5	Maximum Likelihood Estimation, Gaussian Mixture Model (A)
6	Gaussian Mixture Model, Expectation-Maximization (A)
7	Nonparametric Density Estimation (A)
8	Dimensionality Reduction (PCA, LDA, ICA) (A)
9	Markov Process, Hidden Markov Model (M)
10	Hidden Markov Model (M)
11	Reinforcement Learning (A)
12	Gaussian Process (A, M)

Exam & Programming Assignments

- Exam (70%)
  - Course: EI7419, Machine Learning in Robotics
  - Time: 26.07.2016 13:30
  - Duration: 90min
  - Location: TBA

- Programming Assignments (30%)
  - Assignment1
    - Release: 06.05 (Fri)
    - Deadline: 06.06 (Mon)
  - Assignment2
    - Release: 08.07 (Fri)
    - Deadline: 15.08 (Mon)
  - Don‘t copy. You won‘t learn anything if you do.

Student's background

- Background Knowledge
  - Linear algebra
  - Probability and Statistics
  - Matlab skills
- Motivation and Expectation
  - I like to learn about ....

Objectives of the course

- The lecture imparts understanding of methods from machine learning.
- After the course, students can apply state-of-the-art machine learning in practical problems.
- After the course, students are qualified in doing researching in machine learning.

Machine Learning Definition

- Arthur Samuel (1959). Machine Learning: Field of study that gives computers the ability to learn without being explicitly programmed.

- Tom Mitchell (1998)

  Study of algorithms that

  –improve their performance P

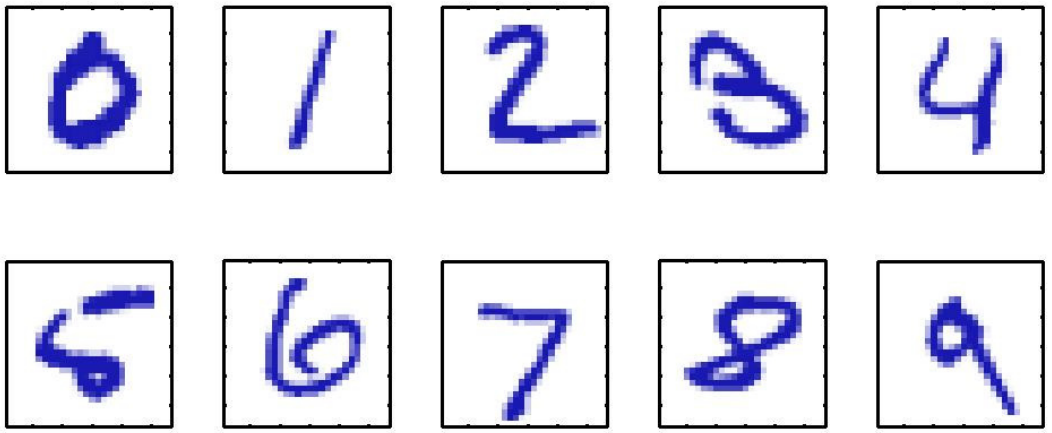
  –at some task T

  –with experience E

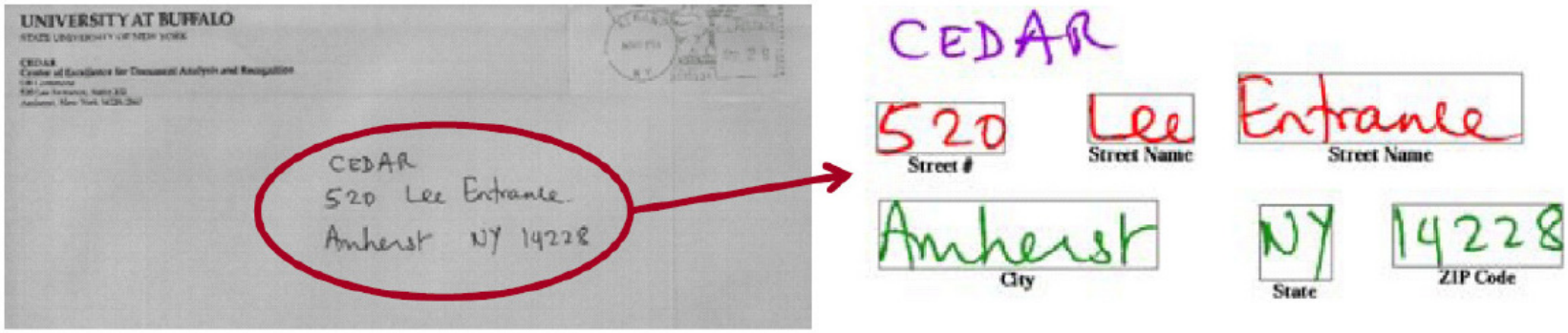
  Well-defined learning task: <P,T,E>

Applications

– Hand written character recognition



Handwritten Digit Recognition



Applications

- Hand written character recognition
- Fingerprint Identification

Applications

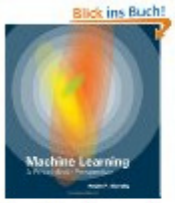
- Hand written character recognition
- Fingerprint Identification
- Iris identification

from [Minority Report]

Applications

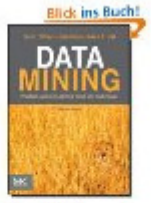
- Hand written character recognition
- Fingerprint Identification
- Iris identification
- Medical diagnosis
- Amazon books

Kunden, die diesen Artikel gekauft haben, kauften auch



Machine Learning: A Probabilistic Perspective (Adaptive computation ...
› Kevin P. Murphy
Gebundene Ausgabe
EUR 67,00

Probabilistic Graphical Models: Principles and ...
› Daphne Koller
★★★★★ (2)
Gebundene Ausgabe
EUR 76,80



Data Mining: Practical Machine Learning Tools ...
› Ian H. Witten
★★★★★ (2)
Taschenbuch
EUR 46,95

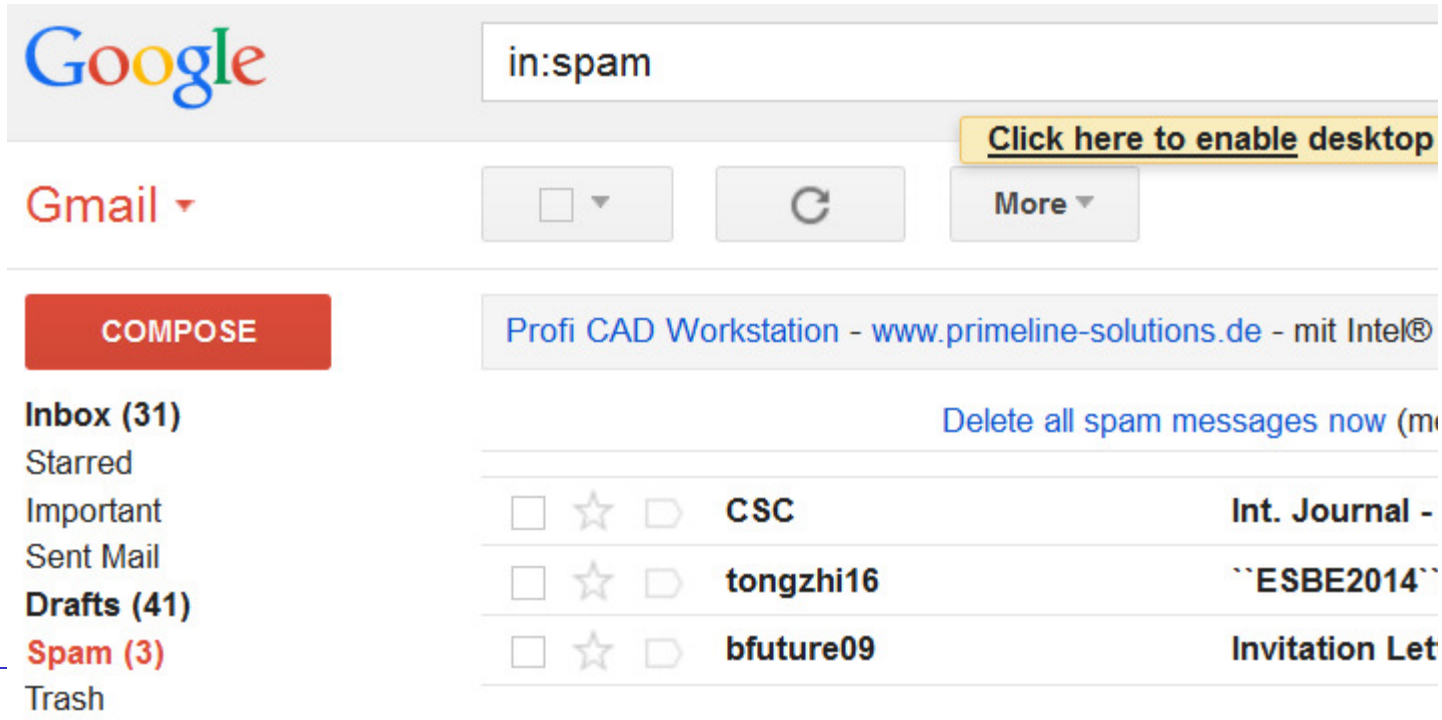
The Elements of Statistical Learning: ...
Trevor Hastie
★★★★☆ (2)
Gebundene Ausgabe
EUR 69,99

Applications

- Hand written character recognition
- Fingerprint Identification
- Iris identification
- Medical diagnosis
- Amazon
- Google
- Face recognition

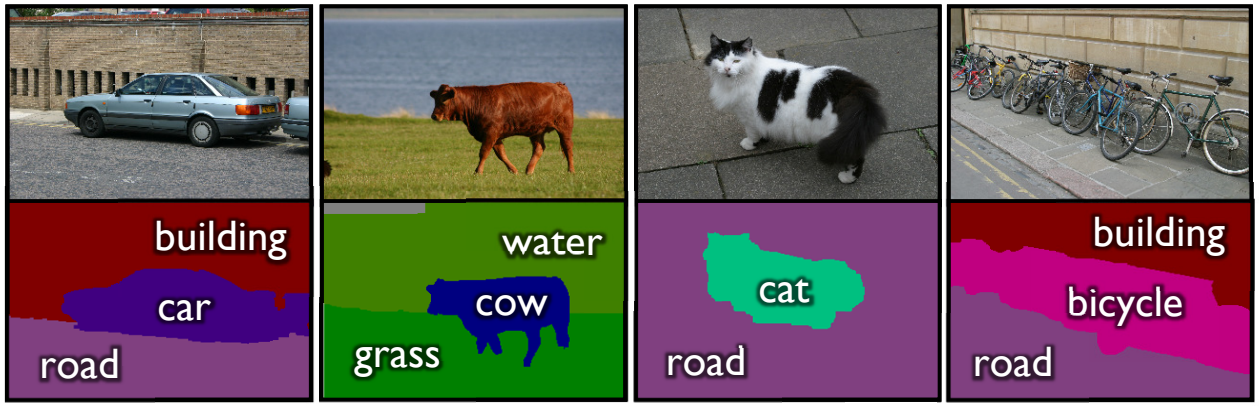
Applications

- Hand written character recognition
- Fingerprint Identification
- Iris identification
- Medical diagnosis
- Amazon
- Google
- Face recognition
- Spam filtering



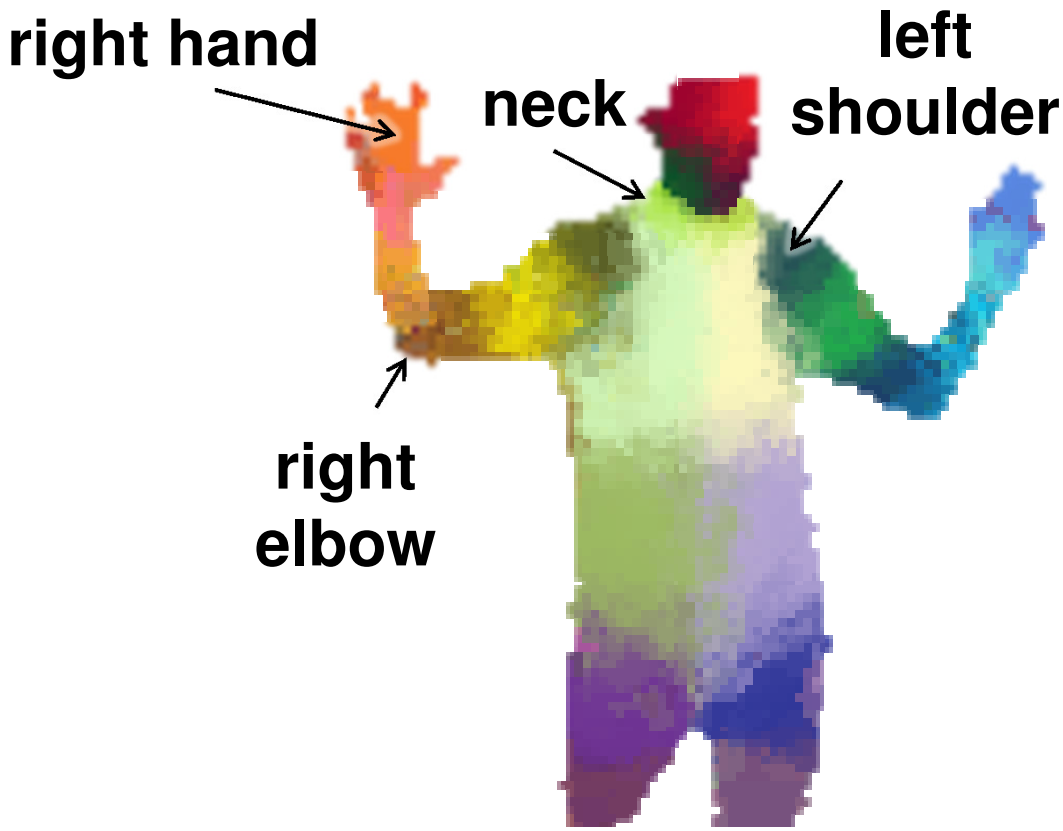
Applications

- Hand written character recognition
- Fingerprint Identification
- Iris identification
- Medical diagnosis
- Amazon
- Google
- Face recognition
- Spam filtering
- Object segmentation



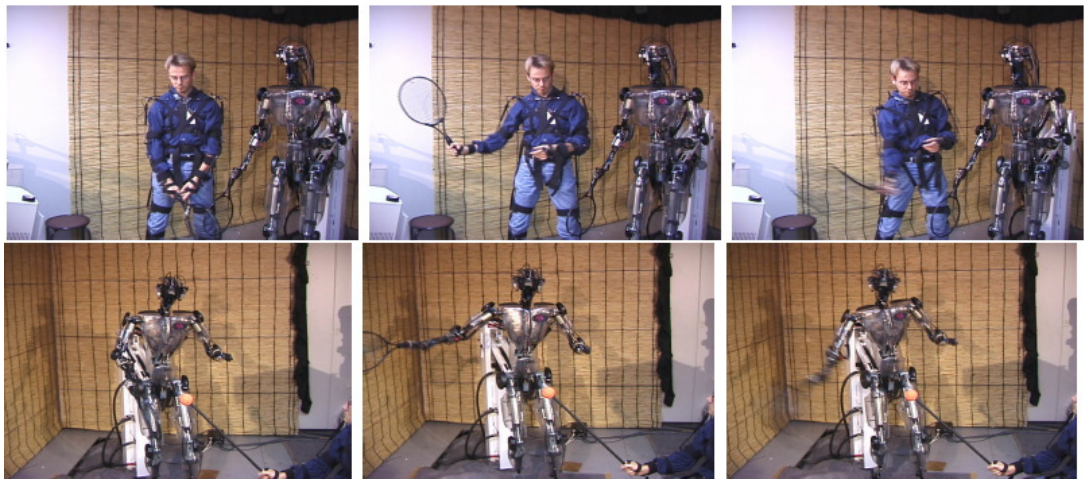
Applications

- Hand written character recognition
- Fingerprint Identification
- Iris identification
- Medical diagnosis
- Amazon
- Google
- Face recognition
- Spam filtering
- Object segmentation
- Human motion tracking



Applications

- Hand written character recognition
- Fingerprint Identification
- Iris identification
- Medical diagnosis
- Amazon
- Google
- Face recognition
- Spam filtering
- Object segmentation
- Human motion tracking
- Financial Forecast
- Human skill transfer to robots



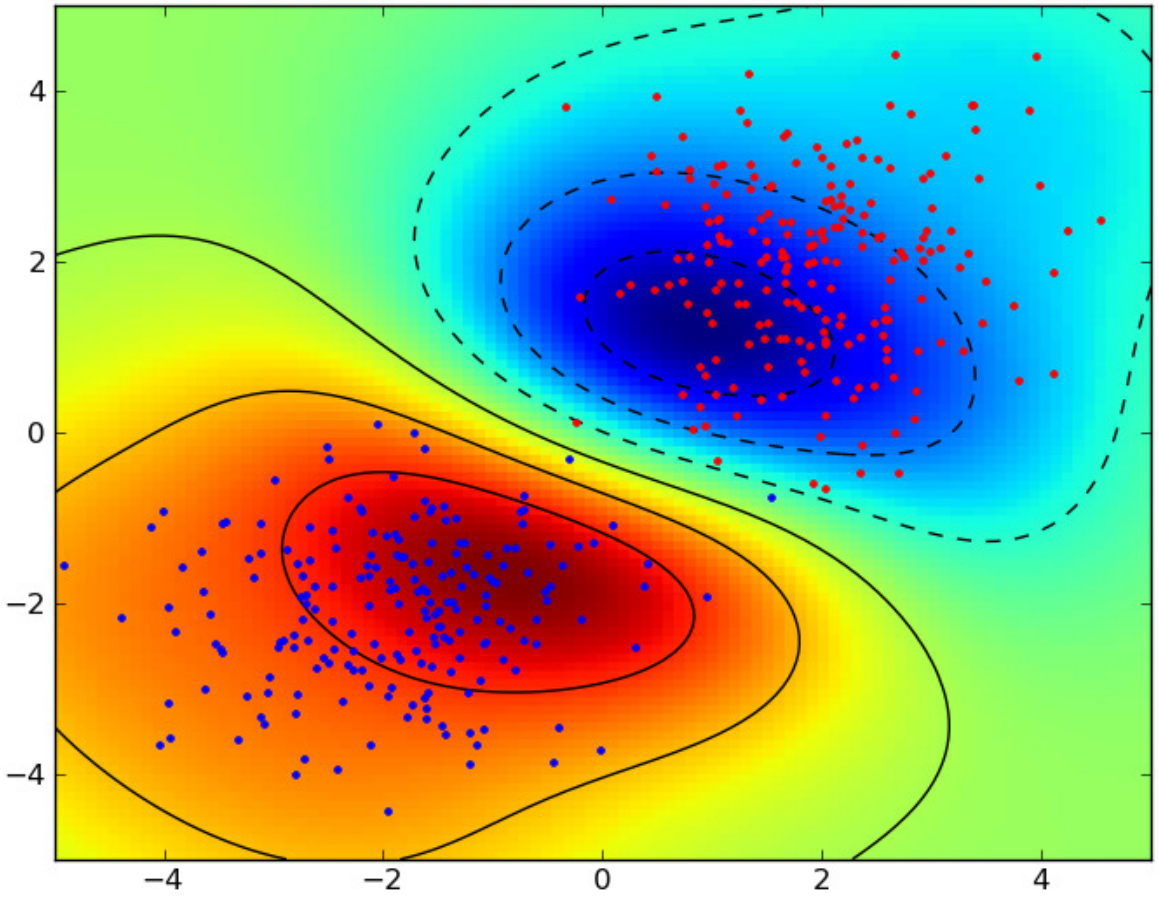
Supervised Learning

- Regression
- Classification

Regression

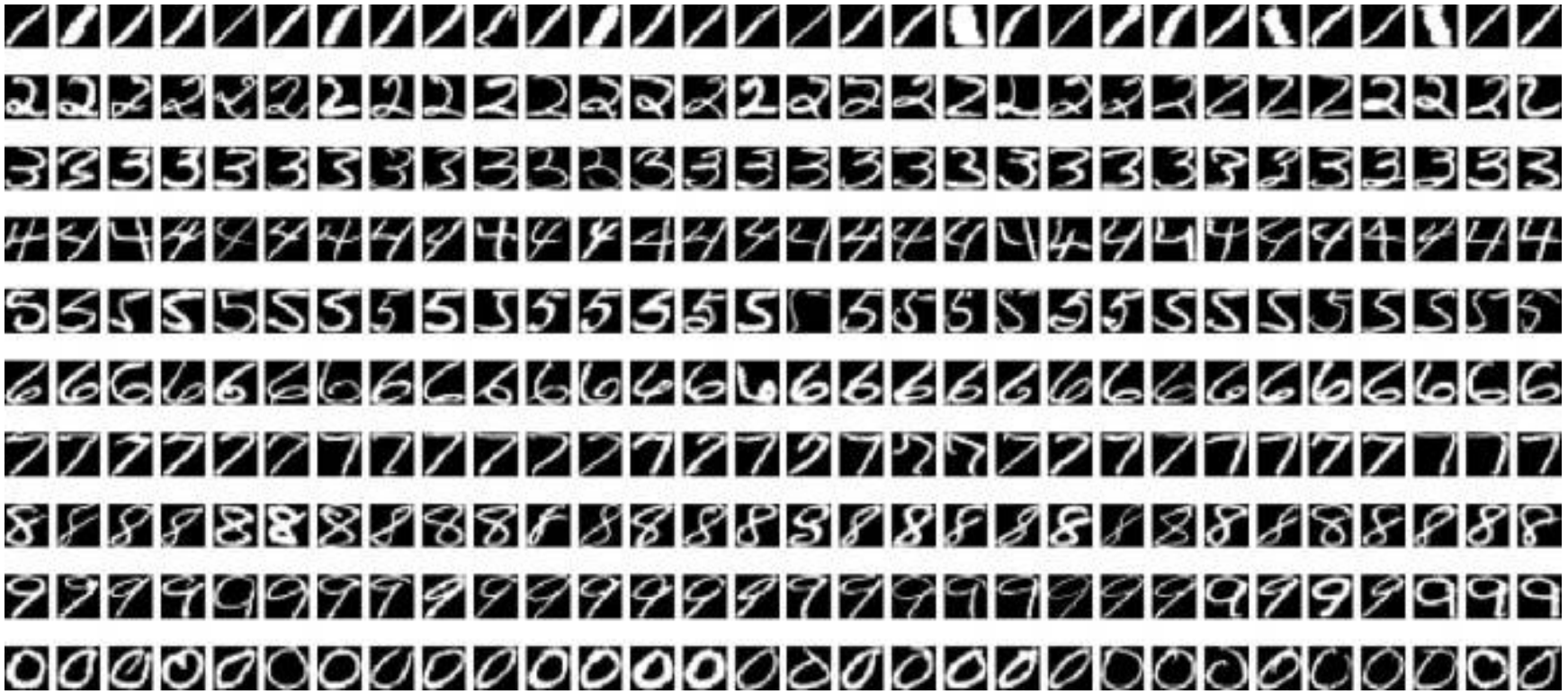
Supervised Learning

- Binary classification



Supervised Learning

- Multiclass classification

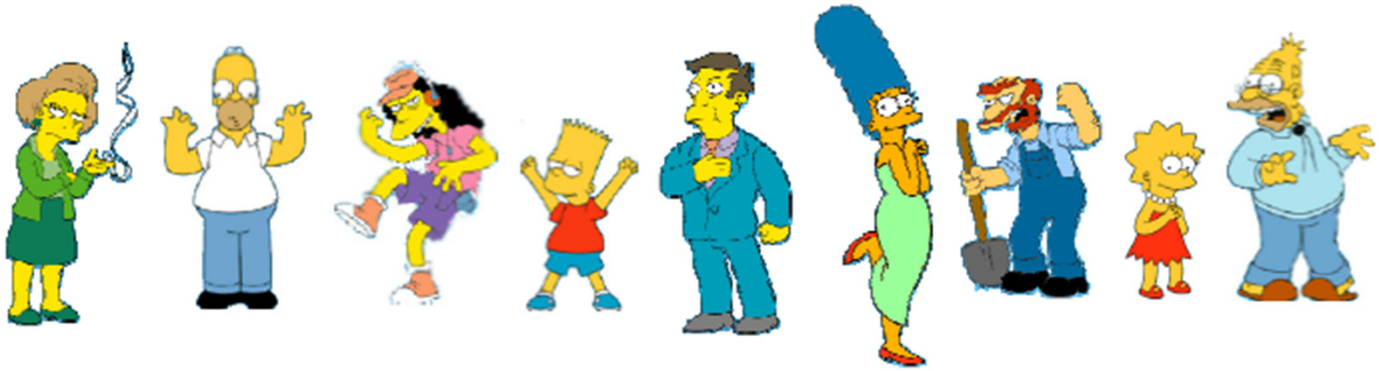


Map image x to digit y

Unsupervised Learning

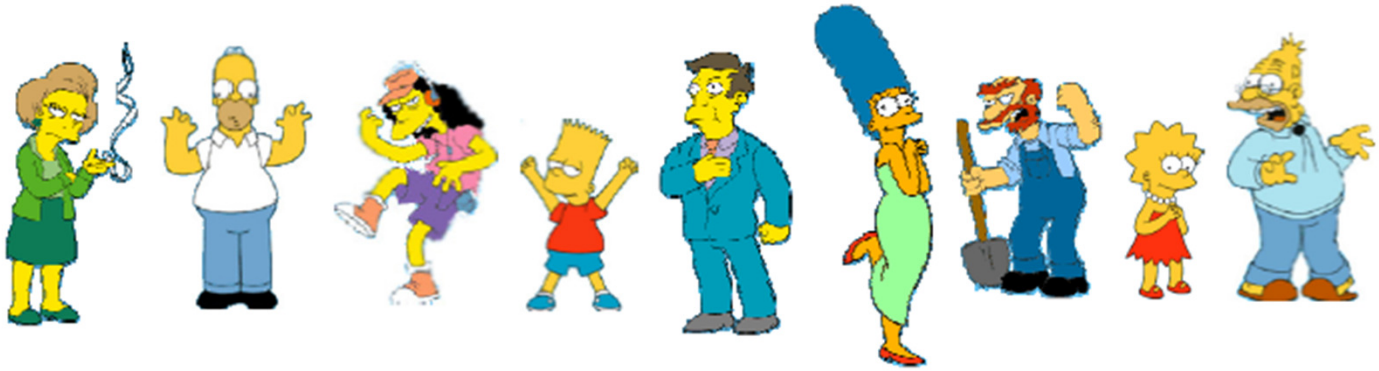
Test

- What is the natural grouping among those objects?



Test

- What is the natural grouping among those objects?



Many possibilities!!!

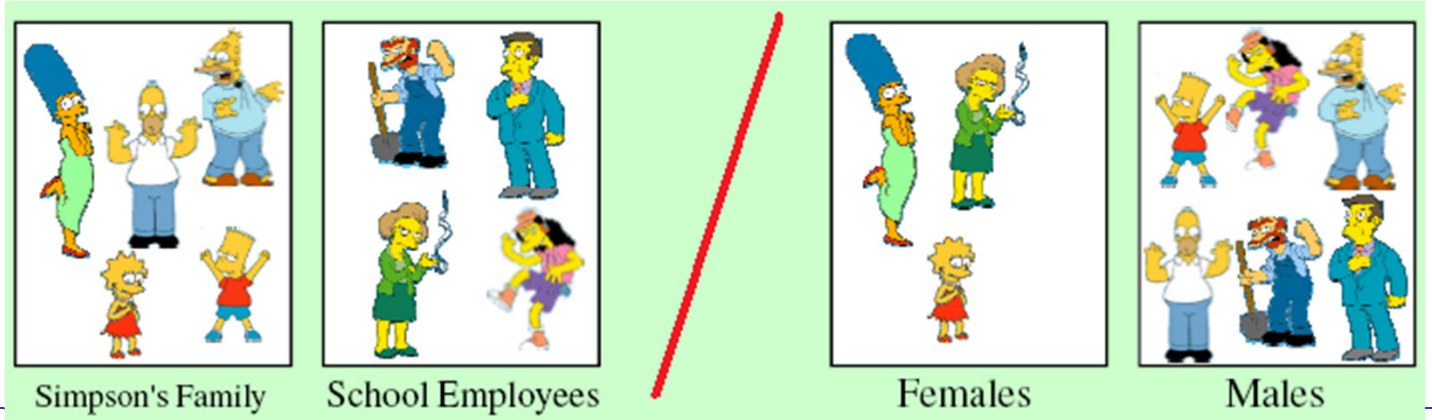
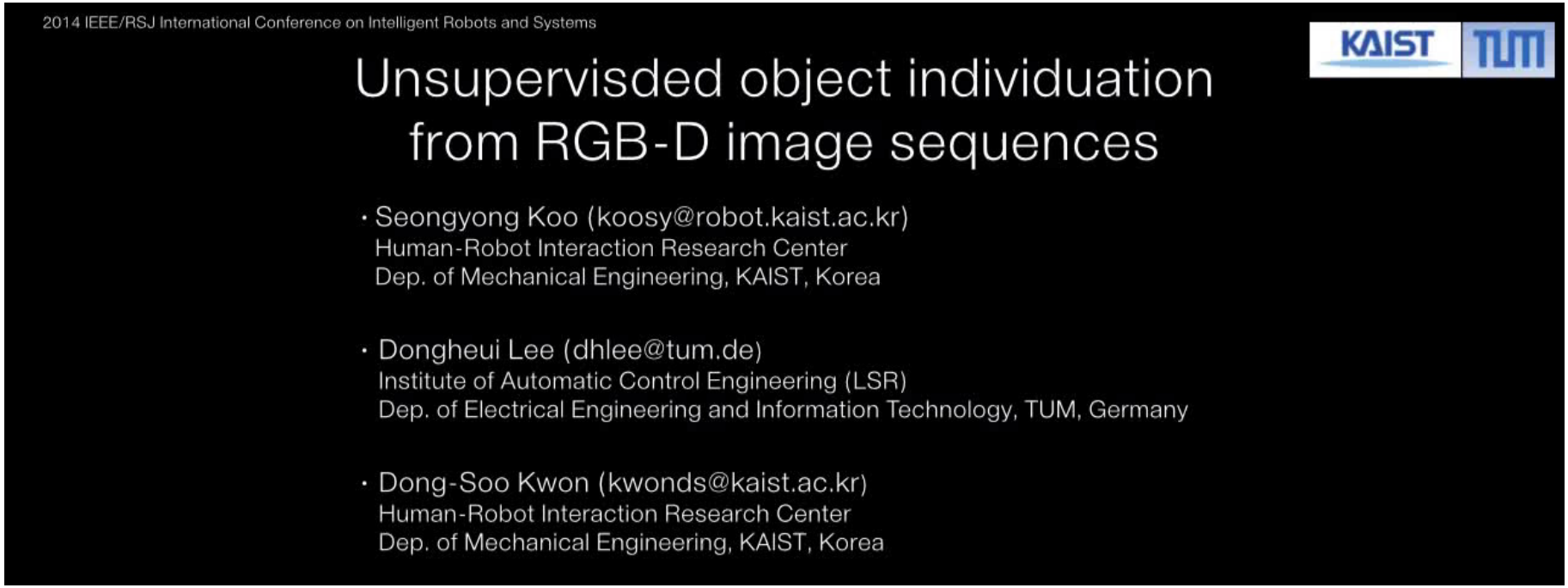


Image Segmentation

Examples of “k-means clustering” applications

Unsupervised multiple object tracking



Reinforcement Learning


Robot Learning From Human
Demonstration

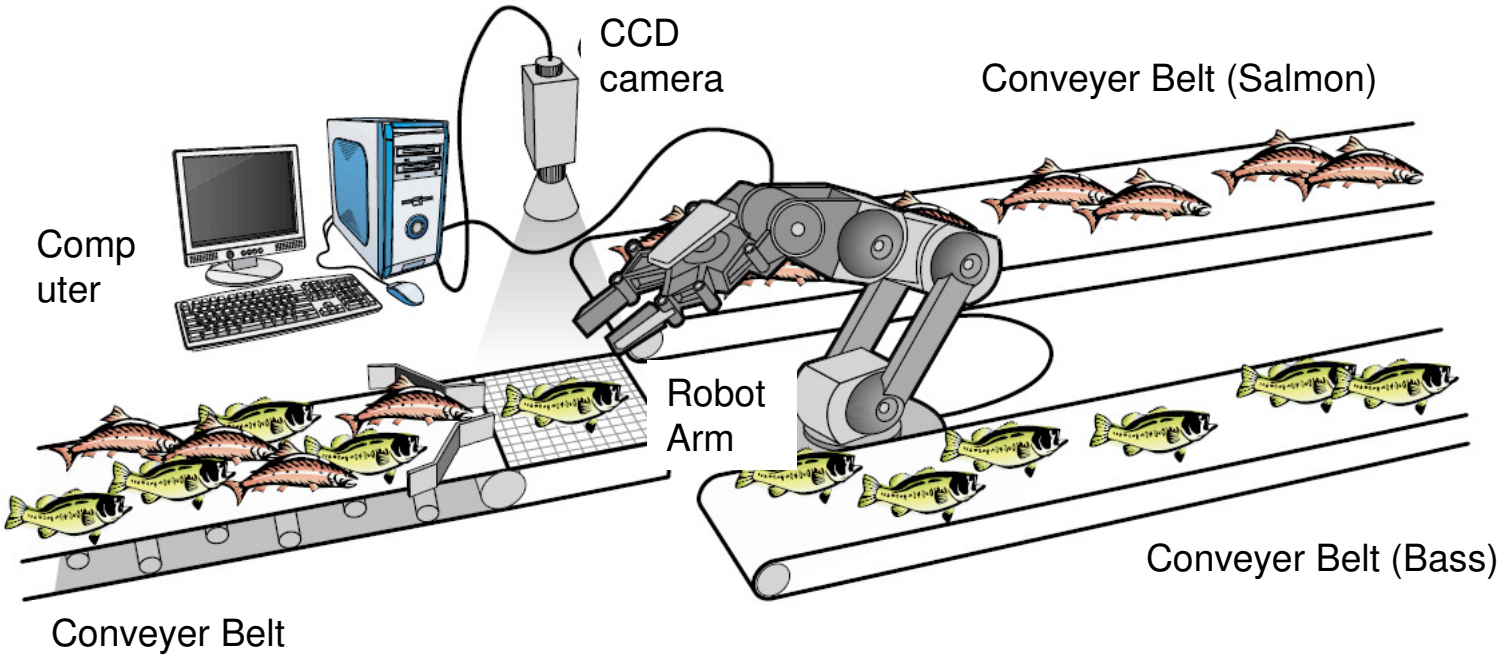

Learning Locomotion
with LittleDog
http://www-clmc.usc.edu
Mrinal Kalakrishnan, Jonas Buchli,
Peter Pastor, Michael Mistry, and
Stefan Schaal

Designing a Learning System

- Step 1 : Data Collection
  - Collect an adequately large and representative set of examples for training and tesing the system
- Step 2 : Feature Choice
  - Feature choice depends on the characteristics of the problem domain.
  - Prior knoweldge also plays a major role
  - Simple to extract, invariant to irrelevant transformations, insensitive to noise, useful for discriminatiing patterns in different categories
- Step 3 : Model Choice
  - Which approach to use,
  - Which models and algorithms to use
  - Prior knoweldge also plays a major role
- Step 4 : Training
  - The process of using data to determine the classifier
  - Supervised learning, Unsupervised learning, Reinforcement learning
- Step 5 : Evaluation
  - Evaluation is important both to measure the performance of the system and to identify the need for improvements in its components.

Example: Fish sorting system

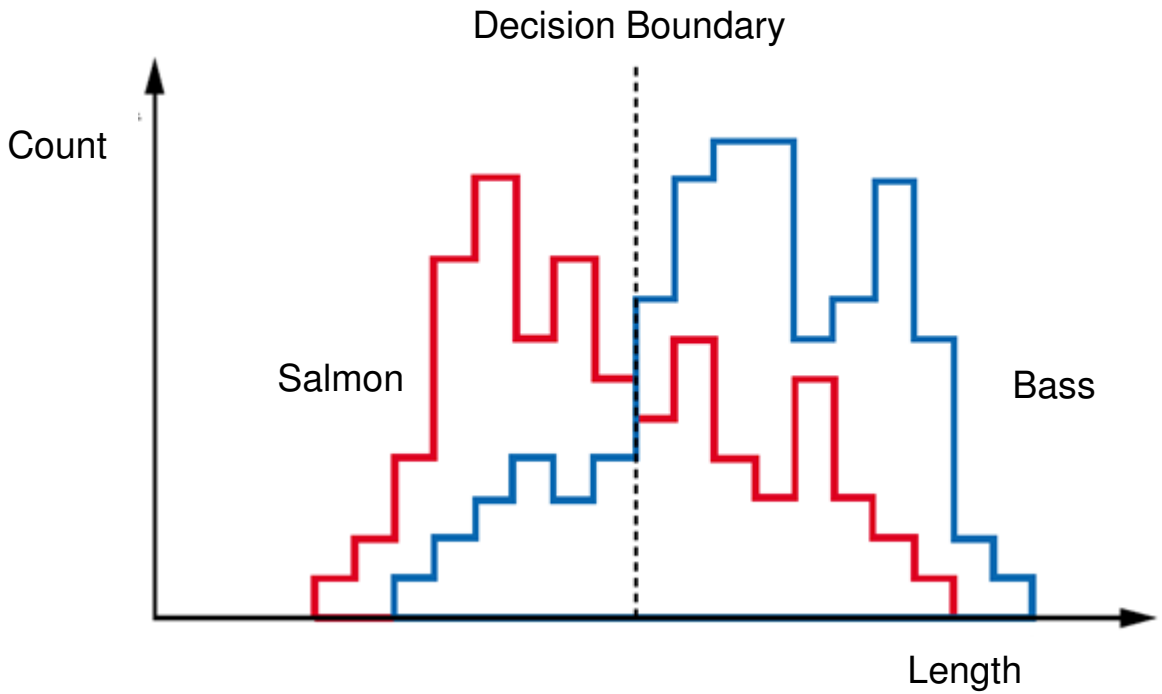
- Automation system of sorting incoming fish according to species (salmon or sea bass)



- The system consists of
  - Conveyer belts, robotic arm, a vision system, a computer

Example: Fish sorting system

Select the length of the fish as a possible feature for discrimination

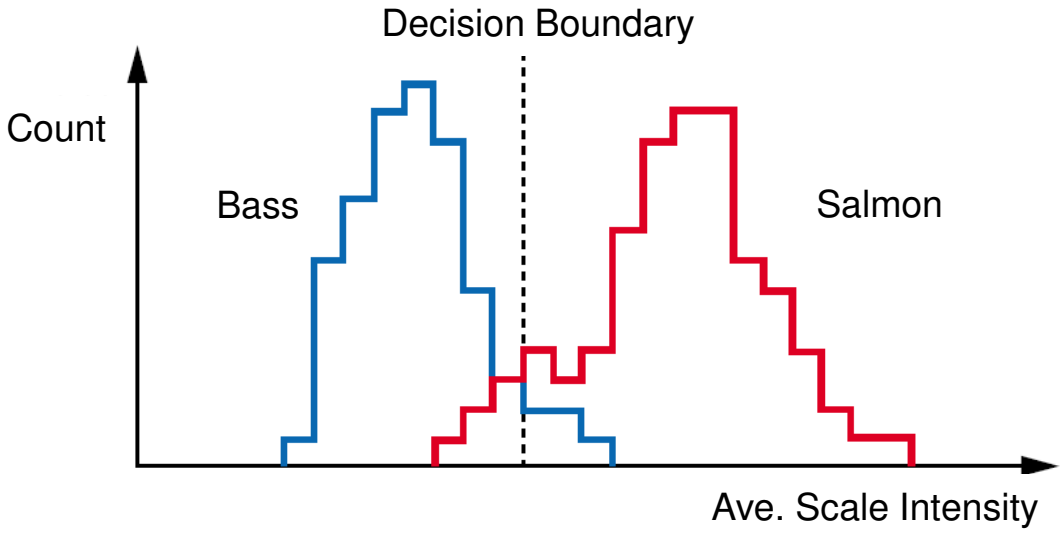


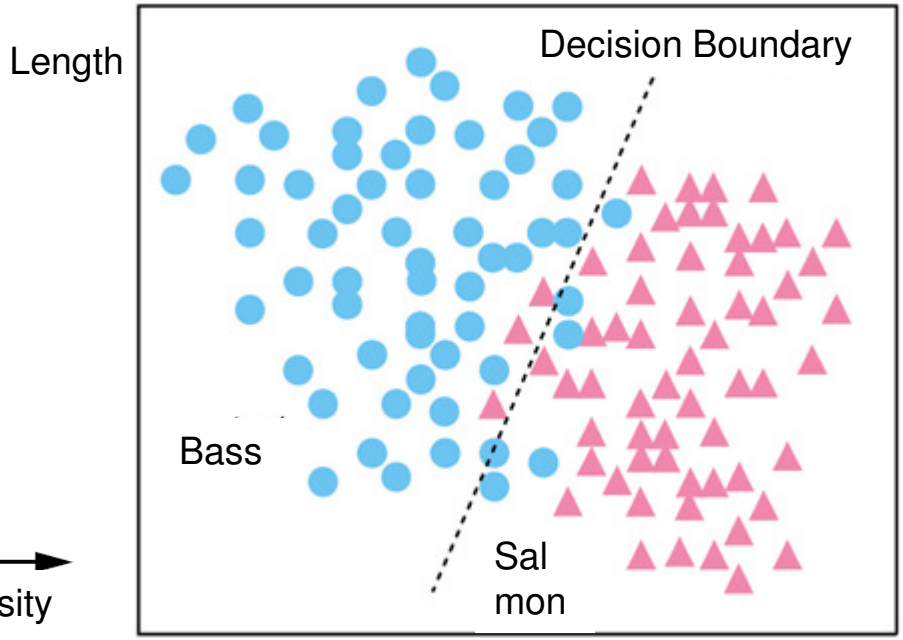
Recognition Success Rate: 60%

The length is a poor feature alone!
Select the lightness as a possible feature.

Example: Fish sorting system

Select/Add the lightness as a possible feature.





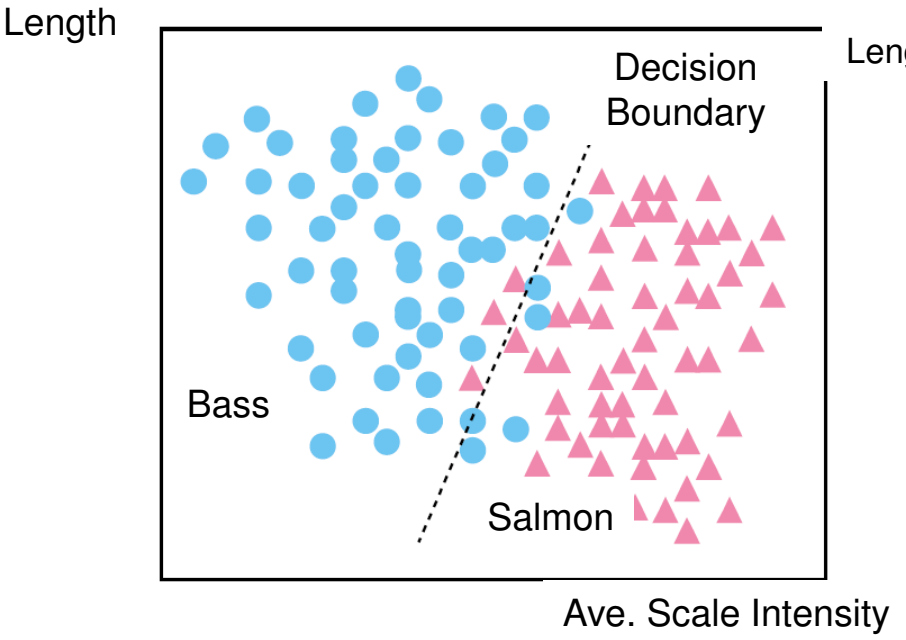
Recognition Success Rate: 95%

Recognition Success Rate: 95.7%

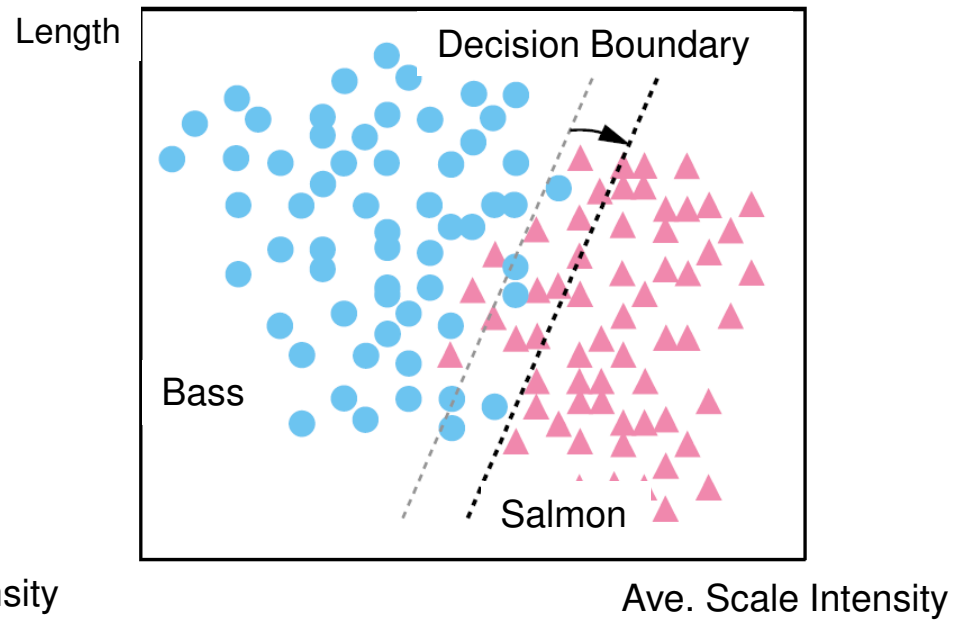
Example: Fish sorting system

Task of decision theory

– Cost vs. Classification Rate



To minimize the overall misclassification rate

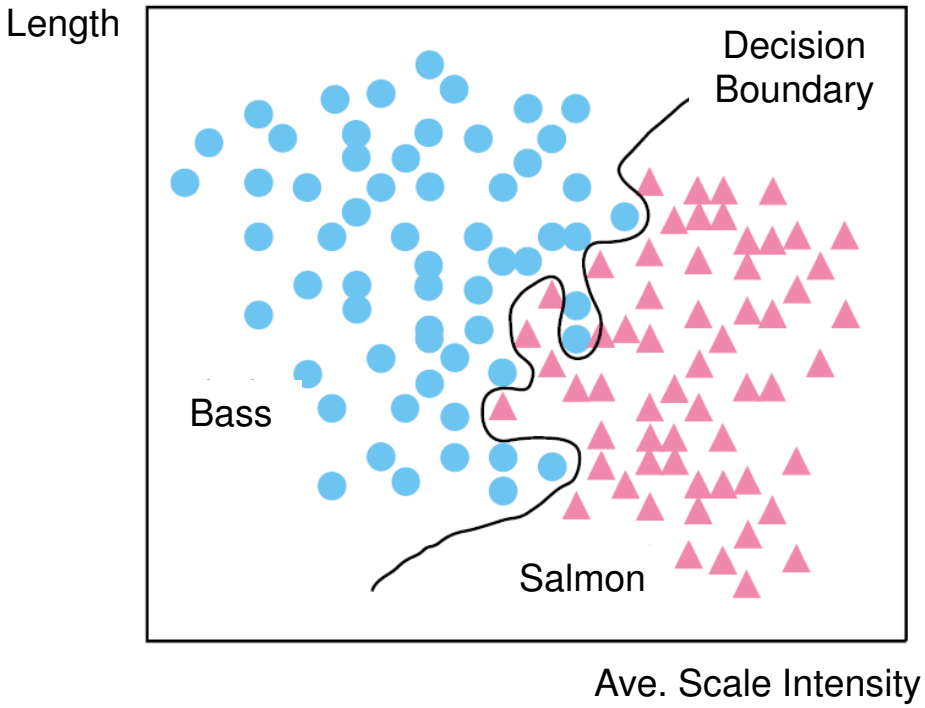


To minimize the overall cost

Example: Fish sorting system

- Improving Classification Performance by using Artificial Neural Networks ➔ 99.9975%
- Generalization Issue!

  designing a classifier is to correctly classify novel input



Summary and Next Lecture

- Summary of today's lecture
  - Introduction to Machine Learning
    - Definitions and related terms
    - Applications
    - System Design
- Topics of next lecture
  - Regression