Machine Learning Introduction

20.09.2017

Course Information

2413, Lectures and exercises, 5.0 ECTS

Lectures
Location: ExWi, Hörsaal B006
Time: Wednesdays, 13:15 to 15:00

Exercises
Location: ExWi, Hörsaal B006
Time: Wednesdays, 15:15 to 16:00

Course webpage:
http://www.cvg.unibe.ch/machine%20learning.html

Acknowledgements: Prof. Andrew Ng
Stanford University

Course Information

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Neubrückstrasse 10

Review Assignments

- Topic: Basic Math and Probability
- 3 weekly review assignments
  - All 3 **mandatory** to be admitted to the exam
  - 2 on linear algebra and 1 on probability theory
  - starting today 20.09.2017; due date 11.10.2017 (in 3 weeks)
  - **pass/fail marking**
  - marks **not included** in the final course mark

Course Assignments

- 3 assignments (~3 weeks time)
- Maximum mark 100 points
- **Admission to exam with minimum 50 points in each assignment**
- Grades contribute to the final course grade
- Purpose
  - Each assignment allows you to test and understand machine learning methods

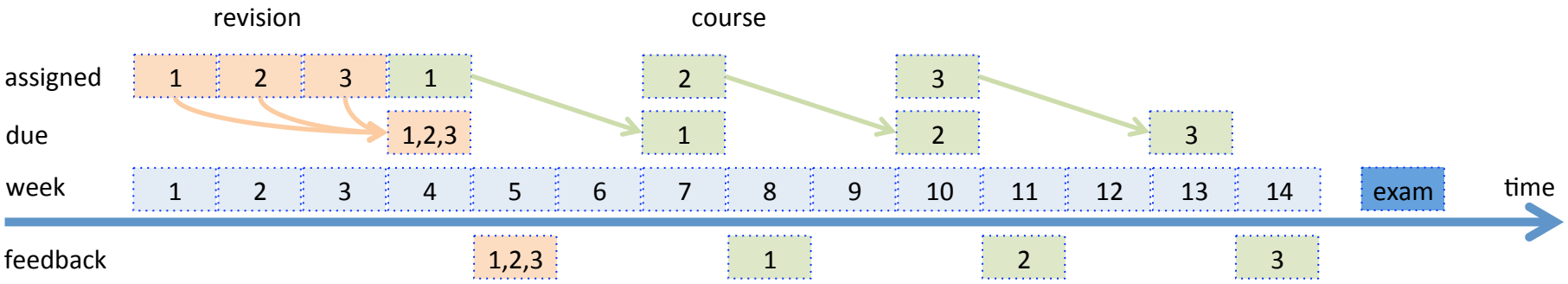
Course Assignments

- Requirements
  - Each assignment requires programming in Python+numpy-side kick+matplot (e.g., design a function) and answering questions
- Timing
  - Provided every three weeks and solutions must be submitted every three weeks
  - First assignment provided on 11.10.2017 and must be submitted on 01.11.2017

Exam

- Admission
  - **At least 50 points in each course assignment**
- Final grade
  - **75% based on the final exam and 25% based on the course assignment average mark**
- Date and place
  - **Final exam on 10 January 2018 at 16.00-18.00 in ExWi A006**
- **Notes, books and cheat sheets are not allowed**

Assignments Calendar



requirements

Revision assignments 1, 2, 3 (PASS/FAIL)

if mark(ALL) == PASS then

Course assignments 1, 2, 3 (GRADED)

if mark(ALL) > 50% then

Exam

used towards final mark
0.25 x Assign. (1,2,3) + 0.75 x Exam

Review Session

- On 20.12.2017
- Mock exam (1 hour instead of 2 hours)
- A chance for you to ask questions on the topics/problems/assignments taught during the whole course

Course Information

Resources

There is no required textbook for this course. The following books are recommended as additional reading:

• Richard Duda, Peter Hart and David Stork, *Pattern Classification*, 2nd ed. John Wiley & Sons, 2001.

• Christopher M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2007.

• Trevor Hastie, Robert Tibshirani and Jerome Friedman, *The Elements of Statistical Learning*. Springer, 2009.

Course handouts and other materials can be found on Ilias.

Related activities

Computer vision course

It is a MSc course to understand how to process images to detect, classify and segment objects and to obtain 3D geometry, 3D motion and illumination. Machine learning techniques are often used to design these algorithms.

Location: Engehaldenstrasse 8, room 002

Time: Tuesdays, 14:15 to 17:00

Check the website:

http://www.cvg.unibe.ch/computer vision.html

Related activities

Advanced topics in machine learning course

It is a MSc course to learn the latest techniques in machine learning. This year we will focus on **neural networks**. It is the natural continuation of the machine learning course.

What is machine learning?

- Not easy to define
- Here is a first attempt

- Arthur Samuel (1959)
  - **Machine learning**: „Field of study that gives computers the ability to learn without being explicitly programmed“
    - Samuels wrote a checkers playing program
      - He had the program play 10000 games against itself
      - and work out which board positions were good and bad depending on wins/losses

What is machine learning?

- Here is a more recent attempt

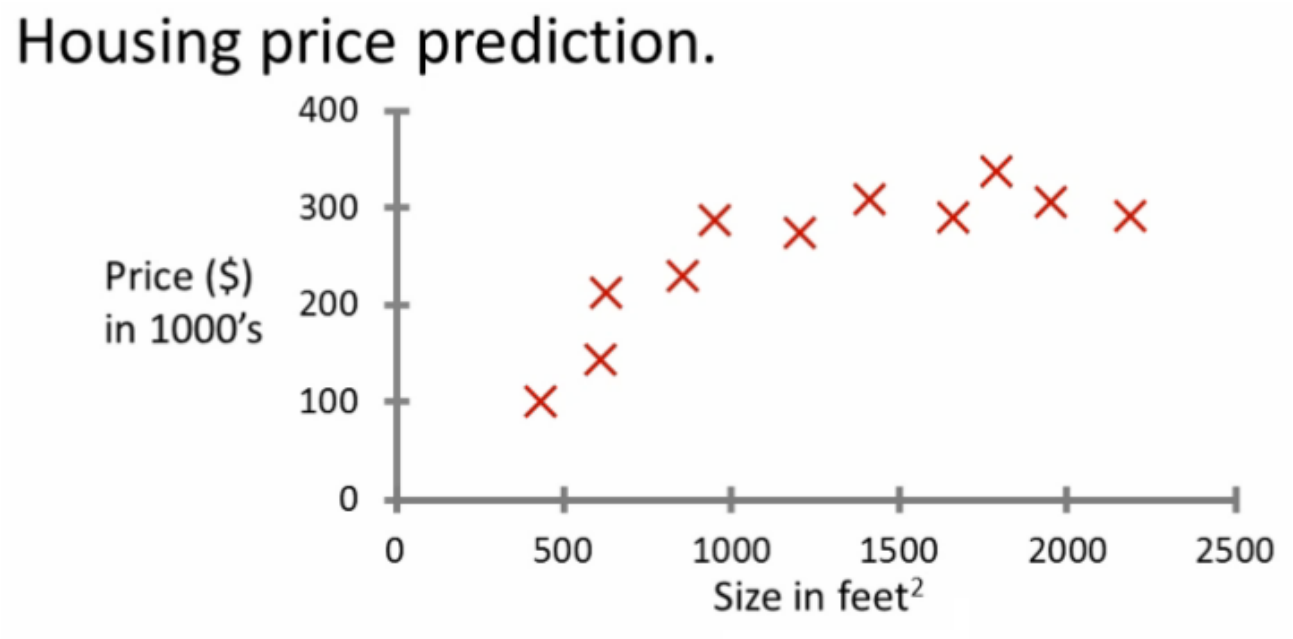
- Tom Michel (1999)
  - **Well-posed learning problem**: „A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E.“
    - The checkers example
      - E = 10000s games
      - T is playing checkers
      - P if you win or not

What is machine learning?

- There are several types of learning algorithms
  - Supervised learning
    - Teach the computer how to do something, then let it use its new found knowldege to do it
  - Unsupervised learning
    - Let the computer learn how to do something, and use this to determine structure and patterns in data
  - Reinforcement learning
    - Let the computer learn from its own decisions/actions
- This course
  - Look at practical advice for applying learning algorithms
  - Learning a set of tools and how to apply them

Supervised Learning - introduction

- Probably the most common problem type in machine learning



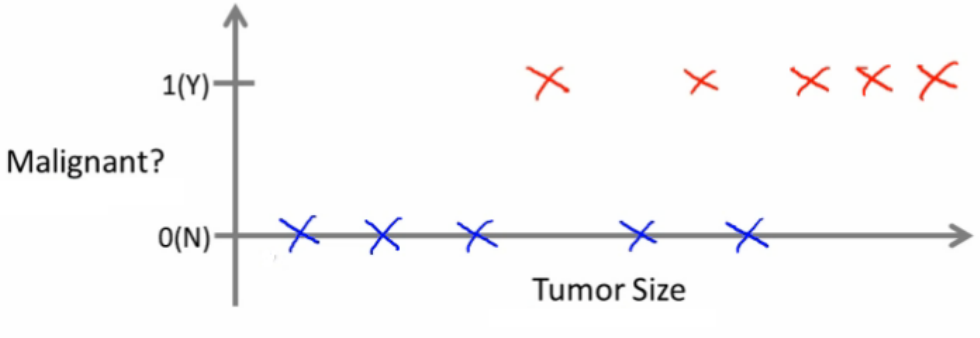
Example problem: „Given this data, a friend has a house 750 square feet – What is the value of the property?“

Supervised Learning - regression

- What approaches can we use to solve it?
  - Straight line through data
    - Maybe $ 150.000
  - Second order polynomial
    - Maybe $ 200.000
  - One thing we discuss later – how to choose straight or curved line?
  - Each of these approaches represents a way of doing supervised learning
- What does this mean?
  - We gave the algorithm a data set where a „right answer“ was provided
    - This is the **training data**
  - The algorithm should then produce more right answers based on new data where we do not already know the price, i.e., predict the price
    - We call this a **regression problem**

Supervised Learning - classification

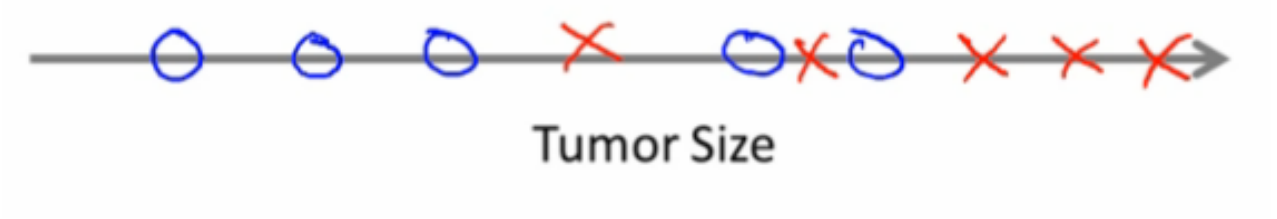
- Example
  - Can we define breast cancer as malignant or benign based on tumor size?



  - Looking at data
    - Can you estimate prognosis based on tumor size?
    - This is an example of a **classification problem**

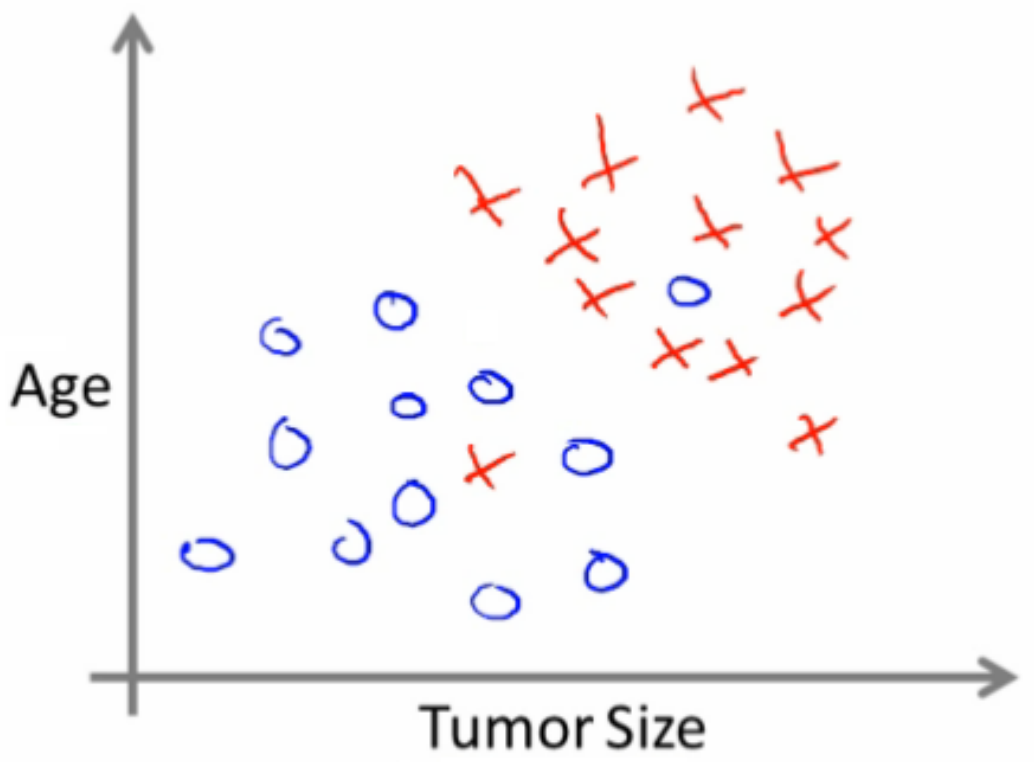
Supervised Learning - classification

- Classification Problem
  - Classify data into one of two discrete classes – no in between, but either malignant or not
  - In classification problems we can have a discrete number of possible values for the output
    - E.g. maybe four values
      - 0 – benign
      - 1 – type 1
      - 2 – type 2
      - 3 – type 3
  - In classification problems we can plot data in a different way



Supervised Learning - classification

- In the previous example we use only one attribute (size)
  - In other problems we may have multiple attributes
  - For example, we may know age and tumor size



Supervised Learning - classification

- Based on that data, you can try and define separate classes by
  - Drawing a straight line between the two groups
  - Using a more complex function to define the two groups (which we will discuss later)
  - Then, when you have an individual with a specific tumor size and who is a specific age, you can hopefully use that information to place them into one of your classes
- You might have many features to consider
  - Clump thickness
  - Uniformity of cell size
  - Uniformity of cell shape
- The most exciting algorithms can deal with an infinite number of features
  - How do you deal with an infinite number of features?
  - Neat mathematical trick in support vector machine (which we discuss later)
  - If you have an infinitely long list - we can develop an algorithm to deal with that

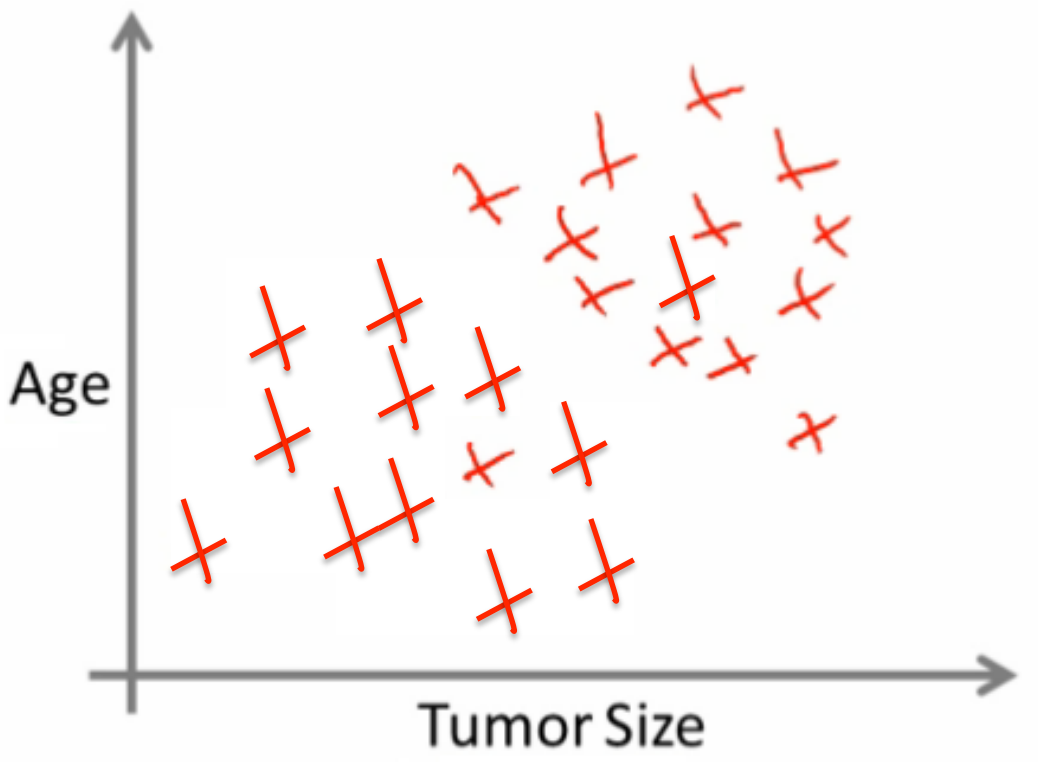
Learning Theory

- It answers the following questions:
  - Why and how do learning algorithms work?
  - How well can an algorithm perform at most?
  - How much training data do we need?

- It helps getting the most from learning algorithms and applying them in the most effective way

Unsupervised learning - introduction

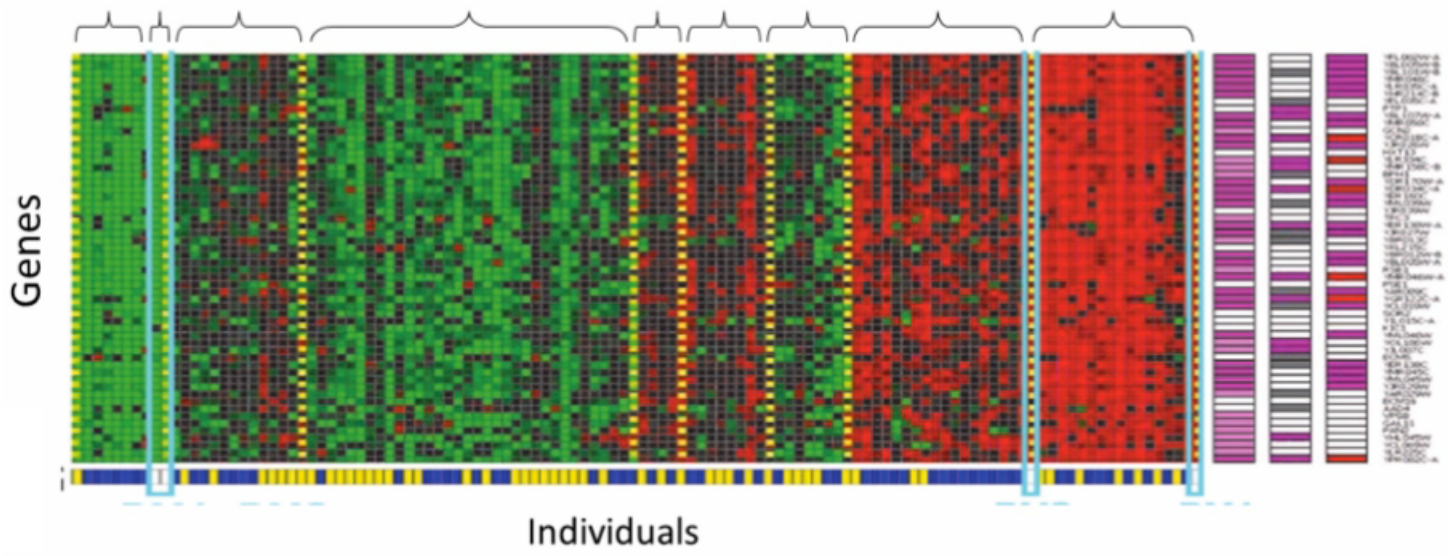
- Second major problem type
  - In unsupervised learning, we get unlabeled data
  - Given a data set, can you structure it?



One way of doing this is to cluster data into groups
This is a **clustering algorithm**

Unsupervised learning - clustering

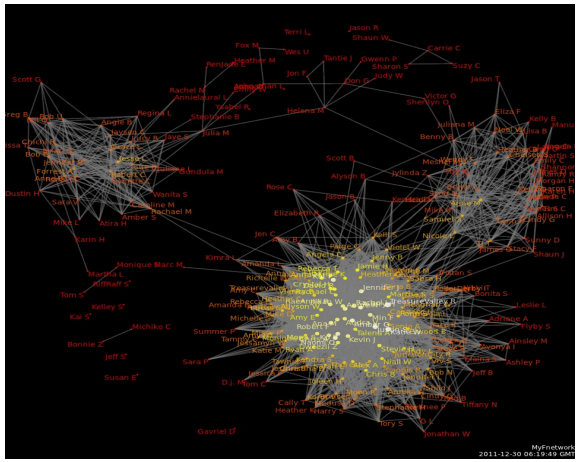
- Example of clustering algorithm
  - Google news
    - Groups news stories into cohesive groups
  - Used in any other problems as well
    - Genomics
    - Microarray data
      - Have a group of individuals
      - On each measure expression of a gene
      - Run algorithm to cluster individuals into types of people



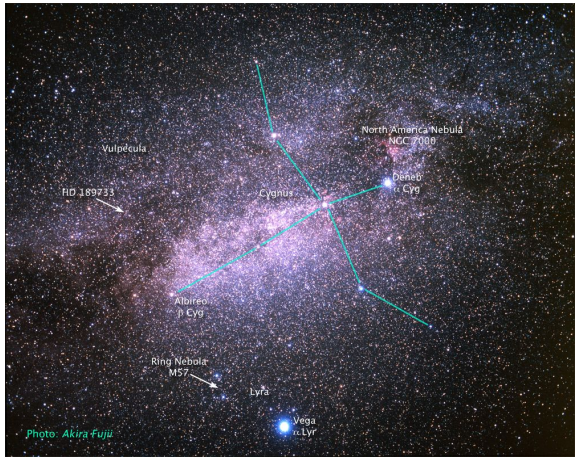
Unsupervised learning - clustering

Image segmentation

Unsupervised learning - Clustering



Social Network Analysis



Astronomical data analysis

Market segmentation

Semi-supervised learning

- Example: The Netflix Million Dollar Challenge

  - Given a partial movie ratings predict all movie ratings
  - Main assumption is that people's taste falls into a few groups
  - 480,189 users X 17,770 movies with only 100,480,507 ratings (~12% of all values)

	movies												
users						2							
		5			?								
				1									
								3	3				
							1						

Cocktail party problem

Speaker #1

Microphone #1

Speaker #2

Microphone #2

Cocktail party problem

- Record slightly different versions of the conversation depending on where your microphone is
  - But overlapping
- Have recordings of the conversation from each microphone
  - Give them to a cocktail party algorithm
  - Algorithm processes audio recordings
    - Determines that there are two audio sources
    - Separates out the two sources

Cocktail party problem

- Is this a very complicated problem?
  - Algorithm can be done with one line of code!

```
[W,s,v] = svd((repmat(sum(x.*x,1), size(x,1),1).*x)*x');
```

  - Not easy to identify
  - But, programs can be short!
  - Using octave (or MATLAB) for example
    - Often prototype algorithms in octave/MATLAB to test as it's very fast
    - Only when it works migrate it to C++
    - Gives a much faster agile development
- Understanding this algorithm
  - svd - linear algebra routine which is built into octave
    - In C++ this would be very complicated!
  - Shown that using MATLAB to prototype is a really good way to do this

Reinforcement Learning

- Problems where a sequence of decisions over time is required
  - A few wrong decisions could be acceptable
  - Basic idea: reward function