What is machine learning about

• Building machines that learn from examples rather than explicit programming a specific task

• Solve problems that have been difficult to solve otherwise (object recognition, text translation, speech recognition, ...)

Machine learning is also a general theory to study

• How to build adaptive systems

• How do brains work (real intelligence)
What this course is about

• Applying machine learning is easy with existing software and programming libraries

• Many courses teach you how to apply these tools and maybe outline roughly some ideas behind these algorithms (“neural networks are like the brain”). This course includes such tools.

• However, this course also delves into the theory behind these algorithms. It is a theory course and we will implement rudimentary version of the algorithms from scratch.

• Requires concepts from calculus, linear algebra, and probability theory.

• Discussion of application examples and communicate experience
The deep learning frenzy
The ImageNet story

Released in 2009

1.2 Million Images
More than 1000 classes
2015: A MILESTONE YEAR IN COMPUTER SCIENCE

IMAGENET
Accuracy Rate

Images from EVIDIA
Alex Net

Alex Krizhevsky, Ilya Sutskever, and Geoffrey Hinton 2012
LeCunn: “Facebook uses networks with 50-100 layers”
Some ore examples

Images from EVIDIA DLI
Semantic segmentation

http://blog.qure.ai/notes/semantic-segmentation-deep-learning-review
A little History: Pioneers
Neural Networks

A: Node (neuron)

B: Network
Evolution of machine learning systems

from Goodfellow, Bengio, Courville 2015
Beyond deep learning: Probabilistic reasoning

- While deep learning is an exciting part of ML, there is a deeper level of modeling and explaining data.
- This course includes a basic introduction to the idea of probabilistic programming and Bayes nets.
Symbolic vs subsymbolic AI

Symbolic programming
Explicit Rules
Ontologies

Neural Networks
Deep Learning
SVM, Decision Trees, LDA, ...

Bayes
How this course works

• This is not an easy course and requires efforts on your part.
• 4th year/graduate course
• The lectures are used to provide an overview of new material and to discuss questions
• Details of the material are provided in a manuscript and I expect that this is read and studied in detail.
• Assignments must be started after posting so that questions can be discussed well before the due date. Extensions will not be granted as we will discuss the results in class right after due date.
• Grad students will have extra questions and must present a research paper from ICLR
• Ask, ask, ask, ask, ask, ask, ask ... . Unless you ask I assume that you understand what I am saying.
Types of machine learning

Supervised Learning

Unsupervised Learning

Reinforcement Learning
Mathematical representation

True underlying world:

Functional form: \( y = f(x) \)

Probabilistic form: \( p(Y = y|x) \)

Model:

Functional form: \( \hat{y} = \hat{f}(x; w) \)

Probabilistic form: \( p(\hat{Y} = \hat{y}|x; \theta) \)

Learning:

Functional form: \( w_i \leftarrow w_i - \alpha \nabla \mathcal{L} \)

Probabilistic form: \( w^* = \text{argmax}_w p(w|y, x) \)
A linear regression example

Training data: \( \{x^{(i)}, y^{(i)}\} \)

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.80</td>
</tr>
<tr>
<td>1</td>
<td>6.72</td>
</tr>
<tr>
<td>2</td>
<td>7.56</td>
</tr>
<tr>
<td>3</td>
<td>10.15</td>
</tr>
</tbody>
</table>

Example:

Derived from the world model: \( y = 2x + 3 + \eta \)

Model assumption:
Training, validation and testing

**Training set**: Used to calculate primary model parameters

**Validation set**: Used to tune the hyper-parameters

**Testing set**: Used to predict performance on unseen data

A common mistake in ML: **Information contamination**

* Can be made small and even zero. Only for development purpose
Supervised ML: high-dimensional and non-linear regression
Todo:

• Make sure you have Python installed with the required packages.

• Read through Chapter 1 and come with questions next class about the things which are unclear.