Deep Learning

Lecture 1

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Learning goals

After completing this course, students should be able to

- explain basic principles behind neural networks and deep learning
- compare modeling aspects of various neural network architectures
- implement simple neural network algorithms
- apply and evaluate deep learning on real data sets
- provide successful examples how deep learning can be used in different contexts in the society
- read and critically assess papers on artificial neural networks and their applications

Flipped classroom

- What?
  - **Before** meetings: Self-study the learning material (traditionally provided at the lecture)
  - **During** meetings: Active learning
- Why?
  - Research shows that flipped classroom improves learning

Weekly organisation

- Read the assigned literature/Watch the assigned videos
- Answer to the weekly quiz by Tuesday at 12 (noon). (**Obligatory**)
  - Include any questions you have or topics that need clarification
- Meetings ("lectures" in the schedule) on Tuesdays at 12.15 and Wednesdays at 10.15
  - Going through "difficult" stuff
  - In-class exercises
  - Examples
  - Q & A
- Meetings are planned based on the assumption that students have done self-study before hand

Exercises and projects

- Weekly exercise sessions (Voluntary)
  - You can go to any session you want
- Mostly programming assignments
- Three **obligatory projects**
  - Deadlines: **23.2.**, **22.3.** and **3.5.**

Prerequisites

- Basics of machine learning (INF264 or equivalent)
- Calculus
  - Using derivative in optimization
  - Gradient
- Linear algebra
  - Basic matrix operations
- Math refresher tomorrow
- Basic skills in programming using Python

Grading

- Projects (3) 45%
- Exam 55%
  - Written exam on 4.6.
- **To pass the course, you have to get a passing grade both from the exam and the projects**

Course material

- **Course book**: Understanding Deep Learning (Simon J.D. Prince)
  - Available online `https://udlbook.github.io/udlbook/`
- Additional material:
  - Zhang et al.: Dive into Deep Learning (Available online `https://d2l.ai/index.html`)
  - Goodfellow et al.: Deep learning (Available online `deeplearningbook.org`)
  - Videos
  - Additional pointers to online material

Course staff

- Lecturer: Pekka Parviainen
- Teaching assistant: Maryam Yousefian
- Group leaders: Marius Binner, Runar Fosse, Viljar Gjerde, Caroline Haugen, Borghild Larsen

Communication

- MittUiB
- Discord server
  - Follow the link to join: `https://discord.gg/KdHT7ByY6x`

Background poll

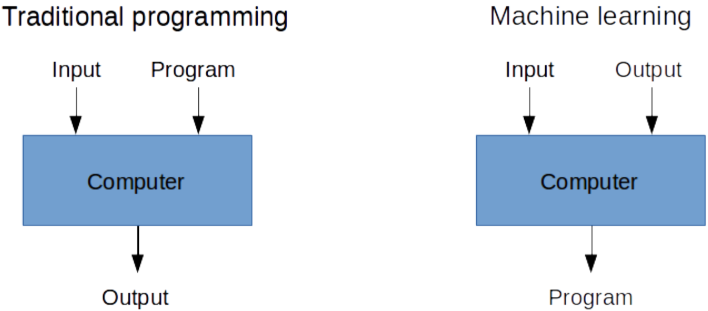
Machine and deep learning

That is, INF264 in 30 minutes

What is machine learning?

- "Field of study that gives computers the ability to learn without being explicitly programmed" (Arthur Samuel, 1959)
- A well-defined machine learning problem (Mitchell):
  - 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 in tasks in T, as measured by P, improves with experience E
- Three important concepts:
  - Task: What is the problem that the program is solving?
  - Performance measure: How is performance of the program (when solving the given task) measured?
  - Experience: What is the data (examples) that the program is using to improve its performance?

Machine learning paradigm



The ultimate goal of machine learning

???

The ultimate goal of machine learning

Generalization

Make predictions about examples that you have not seen

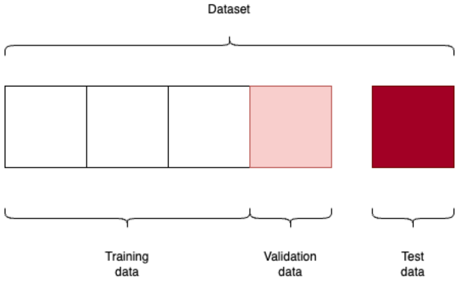
Machine learning pipeline

Terminology

- **Model selection**: estimating the performance of several models in order to choose the best one
  - Model selection is a part of training
- **Model evaluation** (or assesment): having chosen the final model, evaluating its prediction error on new data

Datasets

- Training data
- Validation data
  - Used for selecting the model and (hyper)parameters
- Test data
  - Used to estimate the performance of the selected model on unseen data
  - DO NOT touch this data until you have a fixed model and hyperparameters

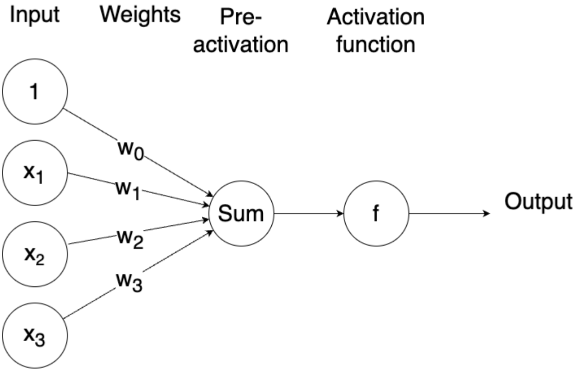


What is deep learning?

Source: xkcd

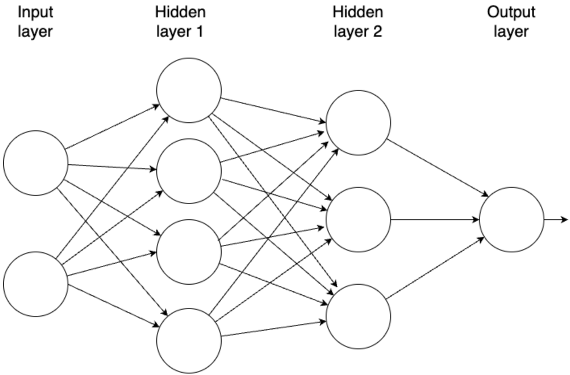
Artificial neuron

- Multiply each input with a corresponding weight
- Take a sum of these products and feed it into a (non-linear) activation function
- Output the result



Feedforward neural network

- Also known as multi-layer perceptron (MLP)
- Organize several neurons into layers
- Outputs from one layer are inputs for the next layer



- Note: each arc is associated with a weight

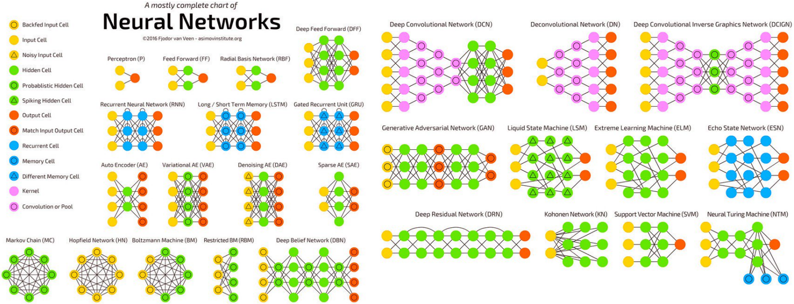
Learning

- Let f_θ be a neural network with parameter values θ
- Loss function $L(y, f_\theta(\mathbf{x}))$ measures "cost" of predicting $f_\theta(\mathbf{x})$ when the true label is y
- Learning corresponds to finding weights θ such that the loss on the training data $\sum_{(\mathbf{x},y)\in D} L(f_\theta(\mathbf{x}), y)$ is minimised
- Typically, one uses gradient descent
- Gradient is computed using back-propagation

What is deep learning?

- Traditionally, neural networks were “shallow”, that is, had only one (or few) hidden layer
- Modern neural networks have typically many (up to dozens) hidden layers $\approx$ They are *deep*
- Why does deepness help?
  - Universal approximator theorem: Even neural networks with a single hidden layer can approximate any (with some assumptions) function with arbitrary precision given enough neurons
  - Often having several narrow layers works better than one wide
  - First layers produce simple features, later ones more complex ones
  - But having too many layers can lead to overfitting

Deep learning



Source: Fjodor van Veen

Contents of the course

- Theoretical understanding of basic deep learning concepts
- Implementation of deep learning algorithms using the Pytorch framework
- Real-life deep learning projects
- Topics:
  - Basics
  - Image data
  - Sequence data

What's next?

- Pytorch crash course in this week's exercise sessions (except on Monday)
- First quiz due to next Tuesday