

# TTT4185 Machine Learning for Signal Processing

## Introduction

Giampiero Salvi and Tor Andre Myrvoll

Department of Electronic Systems  
NTNU

HT2021

# Who we are

## Lecturers

- Giampiero Salvi: course responsible and lecturer
- Tor Andre Myrvoll: lecturer

## Teaching assistants:

- Bettina D'Avila Barros
- Mohammad Adiban
- Ziaoyu Zhu
- Hossein Darvishi
- Zijian Fan

# Who I am

## Giampiero Salvi

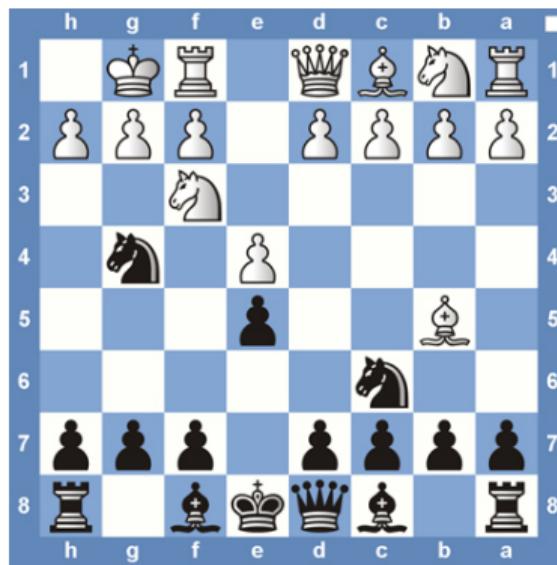
- MSc Electronic Engineering, Sapienza U. Rome, Italy
- PhD Computer Science, KTH, Stockholm, Sweden
  - Speech Technology
- PostDoc IST, Lisbon Portugal
  - Computer Vision and Robotics
- Associate Prof. at KTH since 2013
- Prof. at NTNU since 2019
- responsible 2-year MSc program in ML at KTH (2015-2019)
- teaching ML, Speech Recognition

# Who are you?



# Why Machine Learning?

AI in the 1970s



AI today



# Examples of applications

Google self driving



IBM congestion fees



autonomous ships



Voice assistants



DeepMind AlphaGo



smart buildings



# Moravec's Paradox

## High cognitive processes

- conscious processes (chess, problem solving, . . . )
- difficult for humans
- easy for computers

## Low cognitive processes

- perception, action, (social) interactions
- easy for humans
- difficult for computers

# Explanation

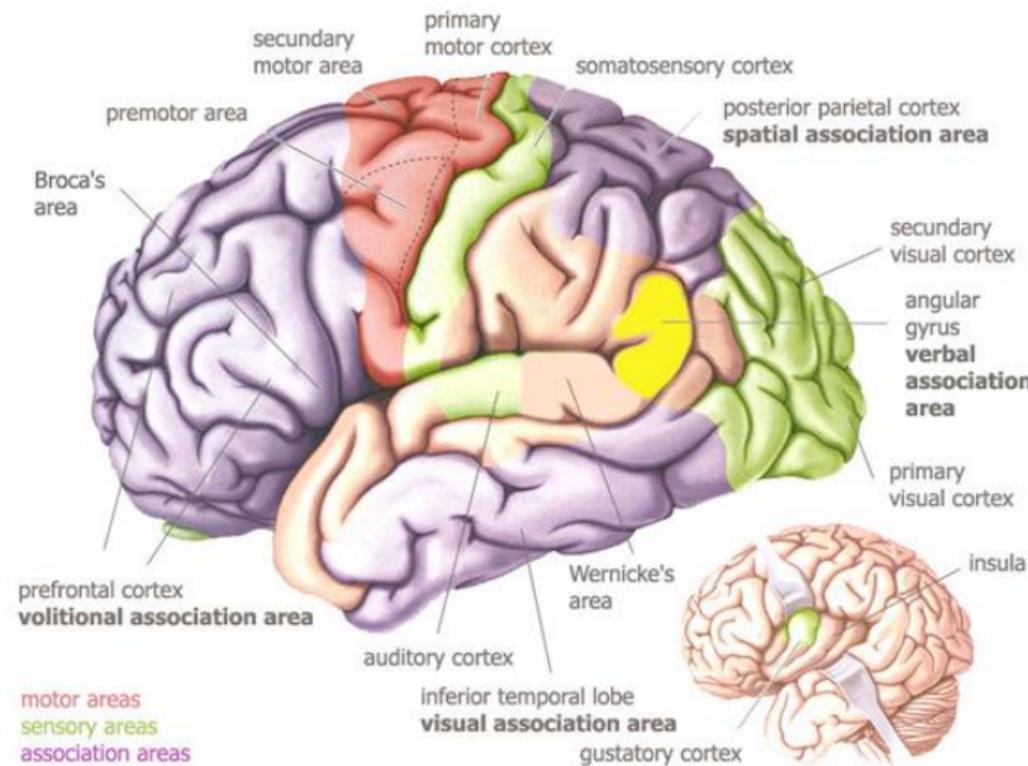
Interactions with the world have evolved over billions of years

- essential for survival and reproduction
- mainly **unconscious processes**
- we are **not aware** of the difficulty

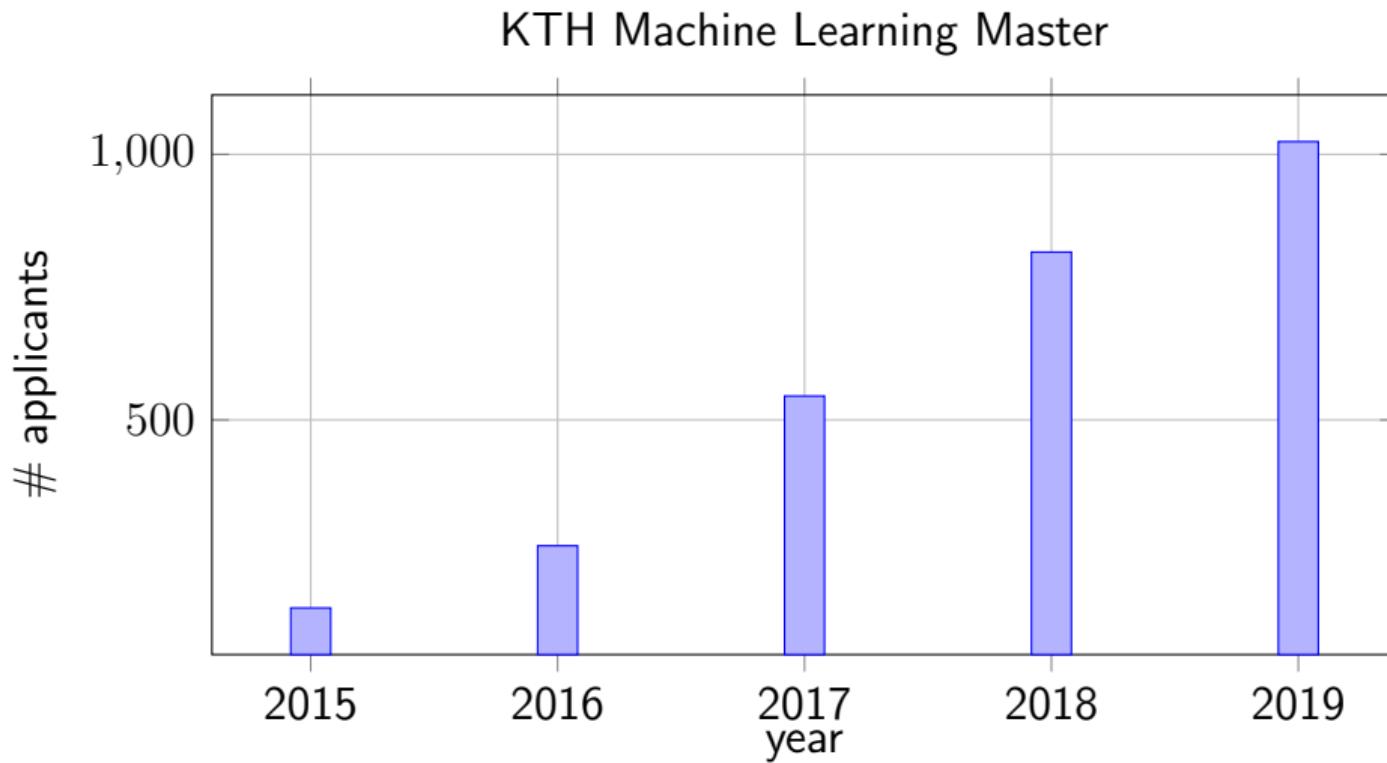
Abstract thinking is much more recent

- often conscious
- we **are aware** of the difficulty

# Why does chess feel harder?

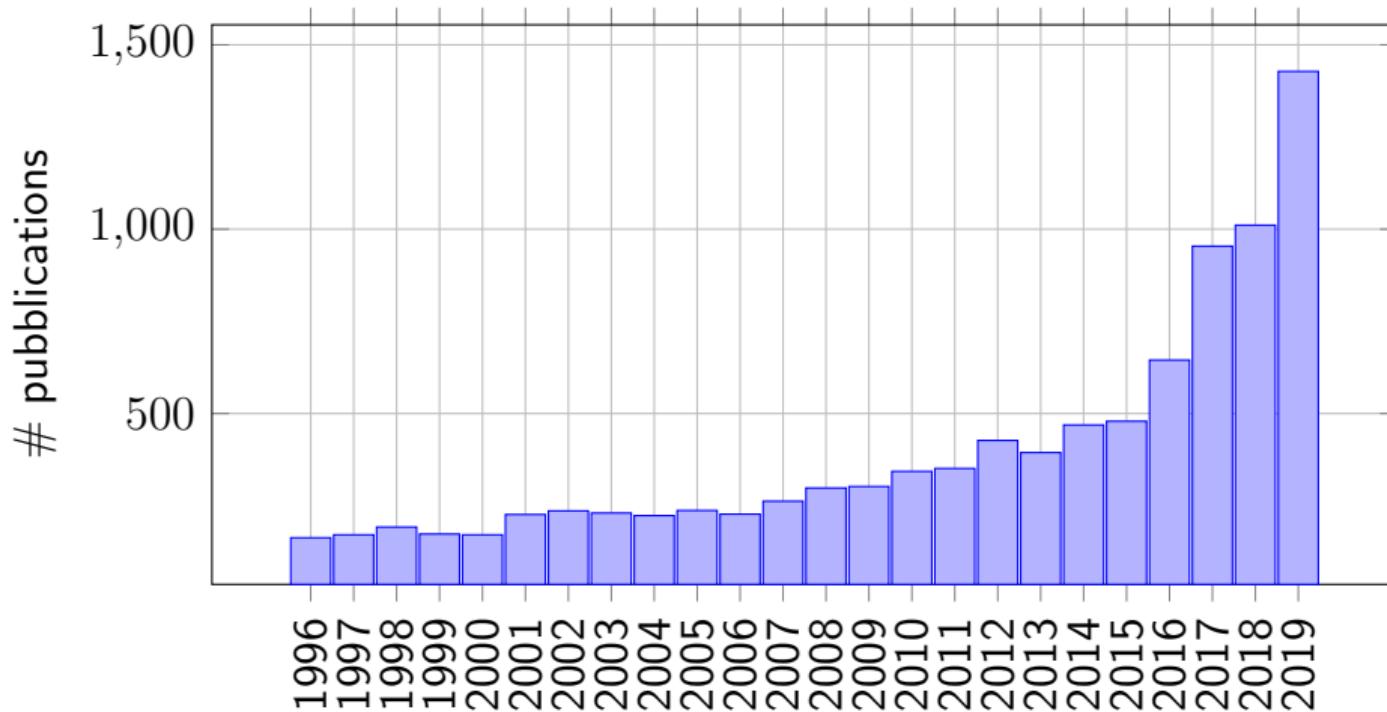


# Number of applicants to ML master (KTH)

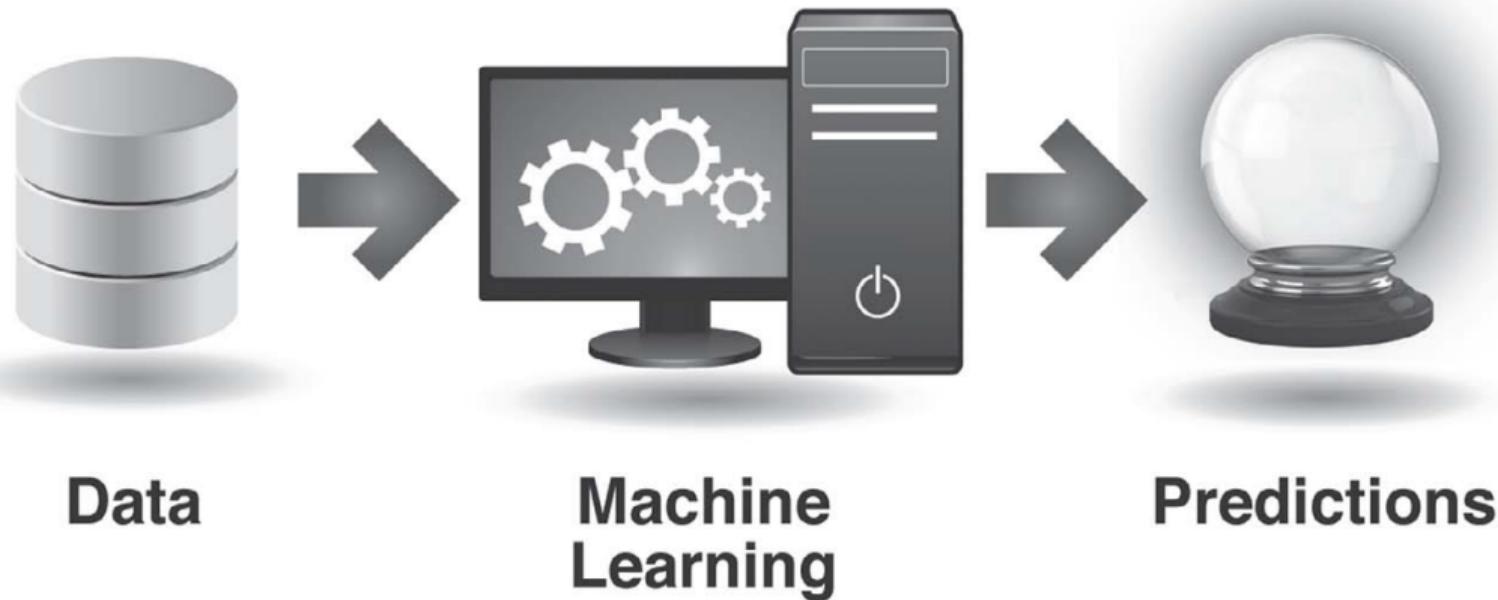


# NeurIPS Publications

Number of Publications per Year

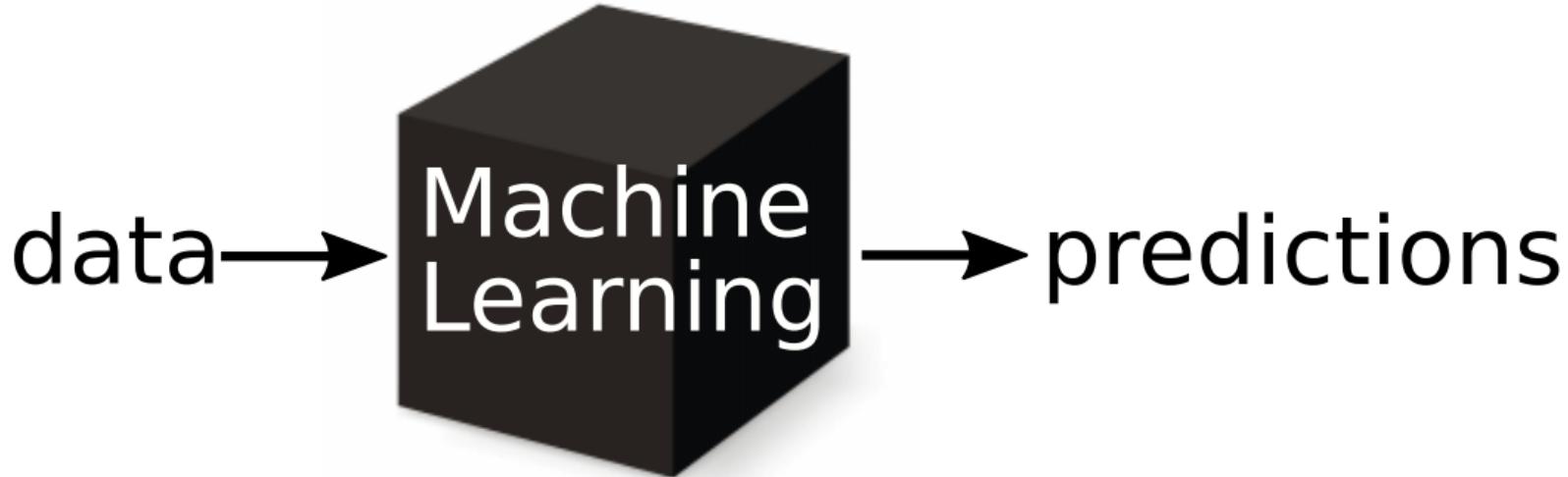


# What is Machine Learning?

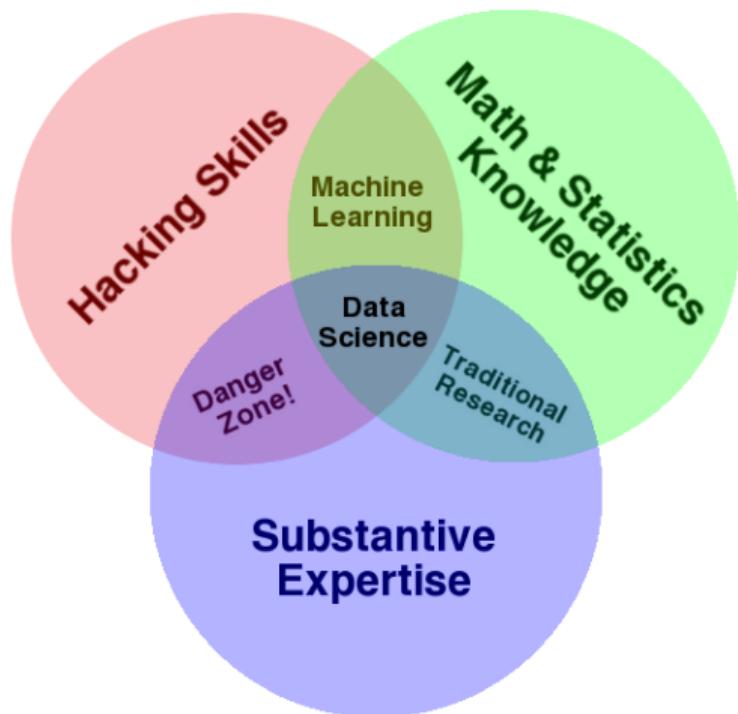


**Source:** *Predictive Analytics* by Eric Siegel

## Challenges: Interpretability



# Required skills



Machine Learning ≡  
Theoretical ML

Data Science ≡  
Applied ML

Source: <http://drewconway.com/zia/2013/3/26/the-data-science-venn-diagram>

# Substantive Expertise

- dependent on the field
- extraction of relevant features
- necessary to double check predictions from ML (especially in high risk applications such as: medical, cyber security, vehicles)
- necessary to interpret ML results

In this course all examples are on **speech technology**

# Why Speech Technology

- Focus of research at the signal processing group since the 70s
- renewed activities at IES:
  - G. Salvi, TB, Svendsen, TA, Myrvoll (20%), M. Siniscalchi (20%)
  - 6 PhD students, 1 postdoc
- complex problem (70 years of research, only recently good results)
- many modalities: acoustic, visual, textual
- many aspects (classification, regression, generation)
- inherently sequential
- all aspects can be approached with machine learning and signal processing

# Practical Information

Lecture times:

- Mondays 10:15–12:00 S8
- Wednesdays 10:15–12:00 S6

Written Examination: 17th of December

Three plus one computer assignments:

- introduction to Python is voluntary
- the others are compulsory
- assessed with a short oral presentation
- likely relevant for the written examination

Prerequisites:

- Linear algebra, probability theory and statistics, signal processing

# Course objectives

After the course, you should be able to

- **discuss** the theoretical foundations for ML
- **describe** the principles behind specific ML methods
- **apply** specific ML methods to a specific domain (speech technology)
- with the help of domain knowledge, **interpret** the results obtained
- **discuss** how the methods may be applied to other domains

# Coarse course plan

## Part 1: Speech analysis

- Speech production and perception
- Speech modelling
- Feature extraction

## Part 3: Neural Networks and deep learning

- Deep neural networks: Definition, training
- Convolutional and Recursive DNNs
- Special networks: Generative Adversarial Networks, auto-encoders...

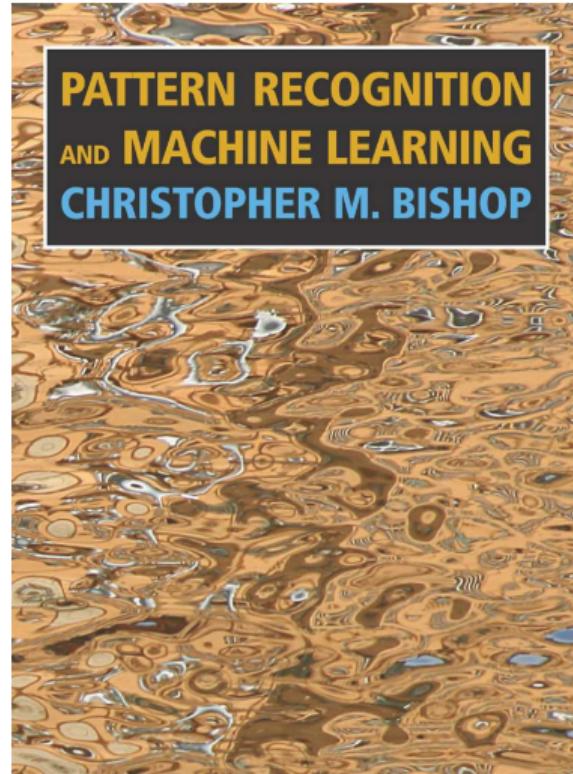
## Part 4: Advanced topics

- Probability reminder
- Linear models for regression
- Linear models for classification

- Kernel methods, graphical models
- Unsupervised learning, EM algorithm, Hidden Markov Models
- Model combination, boosting, trees, forests

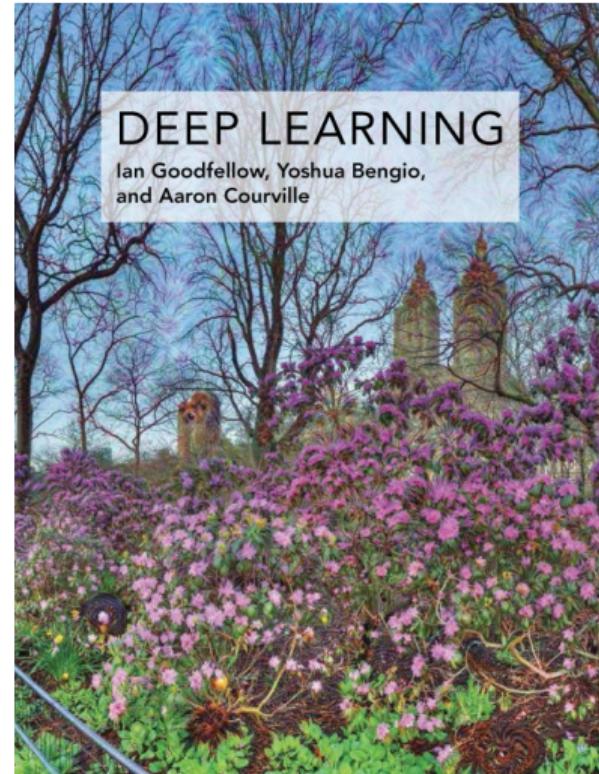
# Literature

C. M. Bishop.  
Pattern Recognition and Machine  
Learning.  
Springer, 2006



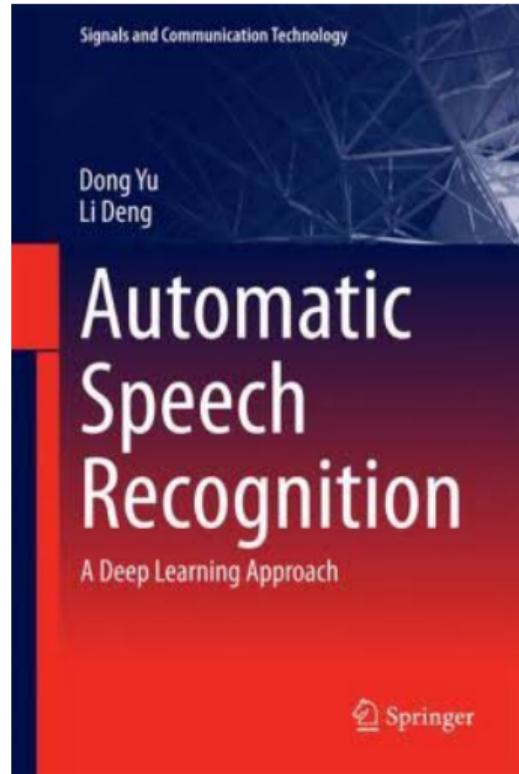
# Literature

Goodfellow, Bengio, Courville  
Deep Learning  
ISBN-10: 0262035618  
Freely available at <https://www.deeplearningbook.org>



# Literature

D. Yu and L. Deng.  
Automatic Speech Recognition, a Deep Learning Approach.  
Springer, 2015  
Available in PDF through NTNU Library

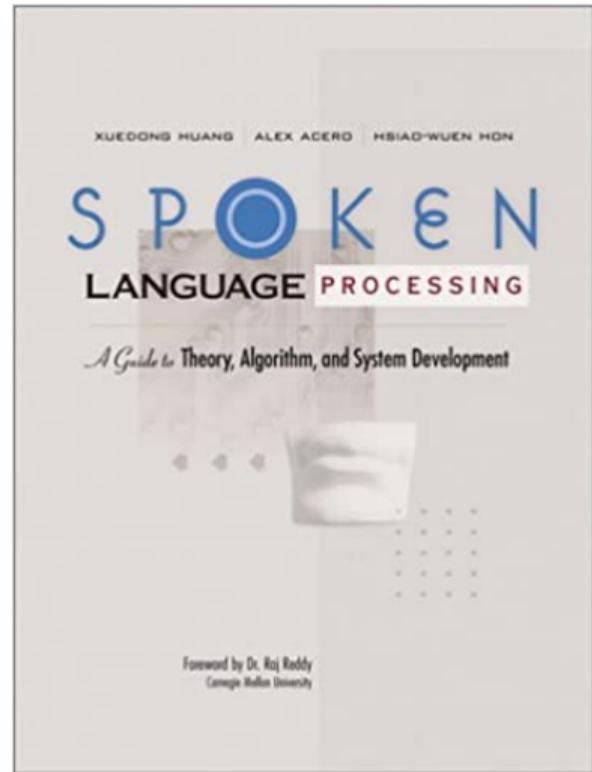


# Literature

X. Huang, A. Acero, H-W. Hon

Spoken Language Processing — A guide to theory, algorithm, and system development

ISBN-13: 978-0130226167



# Computer assignments

- Based on Python:
  - de facto standard language for machine learning
  - large number of very high quality ML libraries (tensorflow, keras, scikit-learn, pytorch, pandas, ...)
  - free software!!
  - no extra work from research to deployment
- no need to be expert Python programmer
- compulsory to be admitted to the exam
- assessed with short oral presentation (arranged by TAs)
- the introduction to python is voluntary

# Course Reference Group

- Need ~ 3 students to take part in 2 short meetings this semester
- you need to be available to other students (collect inputs to the course)

## Benefits

- impact on the course this and later semesters
- valuable collaborations and connections

Sign up at the end or through [giampiero.salvi@ntnu.no](mailto:giampiero.salvi@ntnu.no)

- we will try our best to keep activities in presence
- if not possible, lectures, meetings with TAs, and assignment presentations will be carried out through Zoom (or equivalent)
- always follow NTNU guidelines: <https://www.ntnu.edu/corona>
- all information relevant to the course will be posted in BlackBoard
- the exam form will also be determined by the current rules
- all questions (if not personal) should be posted in the **Course Forum** under **Discussion Board**

# BlackBoard Discussion Board/Course Forum

- ① we will check the forum regularly (whereas email is overloaded)
- ② the answers will benefit all the students
- ③ students are encouraged to answer each other's questions in case they are confident they know the answer. We will, if needed, correct/complete the answers
- ④ questions and answers will not affect your final grade: ask anything freely

# Questions

