Statistical Machine Learning

Course Information and Foreword

MATH-412 - Statistical Machine Learning

Course key facts

- Lectures : Tue 13 :15-15 :00 in MA A330
- Lecturers and TA :
  - Yoav Zemel, Bernoulli Instructor, Math department
  - Guillaume Obozinski (Swiss Data Science Center)
  - Yunho, PhD student, Math department.
  - Might have additional TA if needed.
- Exercises sessions : Tue 15 :15-17 :00 in MA A330
  - Number of key examples and important ideas seen as exercises
  - Working on the exercises is key to succeed at the exam
  - Some in exercises in R/Python (or similar). Solutions provided in R.
- Evaluation :
  - Final exam 70% (questions similar to exercise sessions)
  - Project 30% (article to read on classical technique or algorithm+numerical investigation)
- Moodle
  - Slides + link to the video channel
  - Exercise sheets + Solutions (later)

Evaluation

Final Exam (70%) :

- 3 hours written in class in January
- short questions + problems

Projects (30%) :

- Groups of 3
- To be chosen mid-semester
- Research or review article to read on classical technique/algorithm
- + some implementation / application on data (Python/R or other)
- Goal : show that you can leverage your understanding of the concepts of the course to understand and use well new methods.
- Very short presentation on Dec 9 or 16.
- Report due in January.

Syllabus (Tentative)

Sep 9	1. Intro, Decision theory, Linear regression
Sep 16	2. Linear model
Sep 23	3. Regularization
Sep 30	4. Validation procedures, Local averaging
Oct 7	5. Linear binary classification + List of projects available
Oct 14	6. Evaluation of Classifiers
Oct 21	break
Oct 28	7. Splines + Kernel methods I Team formed + Projects selected
Nov 04	8. Kernel methods II + PCA
Nov 11	9. Clustering, EM
Nov 18	10. Gaussian mixture models + Help session on project
Nov 25	11. Decision trees + Random Forests
Dec 2	12. Decision trees + Random Forests + Boosting II
Dec 9	13. Project presentations
Dec 16	14. Deep learning

Style of the course

- Laying foundations of Machine Learning
- Mathematical approach
- Statistical perspective
- Goal : understanding the underlying principles behind the algorithm
- Not a course that teaches you how to use libraries

Organisation

- The following info is further detailed on the Moodle page :
- **Videos on EPFL mediaspace** (almost the) Entire course in video
- **Warnings :**
  - Some lectures (PCA, Deep Learning II) do not have videos.
  - Some of the lectures available as videos will not be covered this year in class. The corresponding material is completely optional, and will not be on the exam.
    - → Model selection (was lecture 3 a few years ago) will be not covered this year.
    - → There are videos on Statistical learning theory (Rademacher complexity and Vapnik dimension) but this will be not covered this year.
- **Ed** We will communicate via Ed on Moodle.

Intro...

What kind of learning ?

Learn to :

- Recognize different kinds of butterflies from specimens
- Detect pedestrians on the street with an on board camera
- Read postal codes/checks
- Produce the syntactical relations between words in a sentence
- Predict which chemical components can react with a given protein
- Translate from a language to another
- Recognize speech
- Fly a helicopter

Learn *empirically* from a flow of experience, i.e. from a data stream

Early machine learning

Arthur Lee Samuel testing his checkers-playing program on the IBM 704

He coined the expression "machine learning" in 1959.

A definition of machine learning

"A computer program is said
to
learn from experience $\mathcal{E}$
with respect to some class of tasks $\mathcal{T}$
and performance measure $\mathcal{P}$
if
its performance at tasks in $\mathcal{T}$,
as measured by $\mathcal{P}$,
improves with experience $\mathcal{E}$*"*.

Tom Mitchell
chair of CMU ML dpt.

A broad spectrum of techniques

- Empirical risk minimization
- Local averaging
- Kernel methods
- Probabilistic modeling and Bayesian methods
- Neural networks & deep learning
- Decision trees
- Ensemble methods
- PAC Bayesian techniques