

MACHINE LEARNING

COURSE OUTLINE

JS



August, 2022

Course title : Machine learning
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Lecture time : TBA
Auditorium : TBA
Course website : https://jstriaukas.github.io/ml_course 

Important : please write *Machine learning class* in the subject line when you write to me regarding the course material/questions/etc. Please write questions after each lecture, I will allocate 10-15 minutes at the beginning of the following lecture to answer your questions.

Prerequisites : introduction to statistics, linear regression and some basic computing in statistical software (e.g., R, Python) is assumed, but otherwise it is a self-contained course. I recommend to read through the introductory book (first book in the list of recommended books) before the course to have a rough idea on what we will cover during the course.

Books: I try to make material self-contained so that you don't need to buy any book for the course. However, if you like the course and want to have a deeper understanding on a particular topic or machine learning in general, I suggest the following books:¹

- (great introductory book) James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). *An introduction to statistical learning* (Vol. 112, p. 18). Springer (New York).
 ► online copy: [pdf](#) .
- (moderate level overview book) Hastie, T., & Friedman, J. H., Tibshirani, R. (2009). *The elements of statistical learning: data mining, inference, and prediction* (Vol. 2, pp. 1-758). Springer (New York).
 ► online copy: [pdf](#) .
- (main book for the course – covers more recent topics) Fan, J., Li, R., Zhang, C. H., & Zou, H. (2020). *Statistical foundations of data science*. Chapman and Hall/CRC.

Software: students need to install statistical software R or some other program (Python, Matlab, Julia, Octave, ...). I will be showing examples mainly in R and Python. I advise you to install the statistical software before the course starts (if you don't have it already). See below for the instructions how to install R and Python. You are free to use Matlab or Julia or other language of your choice to code the examples we cover in the class.

Exam: TBA

¹I list additional set of books for students who want to learn more about statistical learning methods, statistical theory, etc., at the end of this outline.

Information about the course

Topics

The course will cover the following main topics:

- **Topic 1:** Introduction to learning, multiple and nonparametric regression
▶ Material: [slides shinyapps](#) [slides pdf](#) [tablet friendly slides pdf](#)
- **Topic 2:** High-dimensional linear regression
▶ Material: [slides shinyapps](#) [slides pdf](#) [tablet friendly slides pdf](#)
- **Topic 3:** High-dimensional regression properties and generalized linear models (GLMs)
▶ Material: [slides shinyapps](#) [slides pdf](#) [tablet friendly slides pdf](#)
- **Topic 4:** Prediction, loss functions and M-estimators
▶ Material: [slides shinyapps](#) [slides pdf](#) [tablet friendly slides pdf](#)
- **Topic 5:** Introduction to deep learning
▶ Material: [slides shinyapps](#) [slides pdf](#) [tablet friendly slides pdf](#)
- **Topic 6:** Introduction to causal machine learning
▶ Material: [slides shinyapps](#) [slides pdf](#) [tablet friendly slides pdf](#)

Details on each topic

Topic 1: *Introduction to learning, multiple and nonparametric regression.*

The section starts with reviewing challenges and advantages of *Big data* and a brief introduction to learning (theory).² The section then covers multiple and nonparametric regression methods which are central to learning. Specific examples of the techniques that ...

Instructions to install R

The main R software is available at <https://cran.r-project.org>. Once on this website, you need to select an file to download for your operating system (OS), so if you work on Windows you need to download and install Window `.exe` file. Please install the most recent version of R. I also strongly advise to install RStudio (free version of it) from <https://rstudio.com>. You need to install R prior to RStudio.

Install R packages: suppose you need to install an R package called ‘forecast’. You should write in RStudio console:

```
install.packages("forecast")
```

²**IMPORTANT:** I write theory in brackets as throughout the course theoretical derivations serve us the purpose of understanding certain learning technique, how and why it works for certain data types. I do not expect that you reproduce more complicated proofs, however, I expect that you understand them and can interpret results, i.e. can argue why certain methods work for certain data types.

List of useful books for curious students

- (introductory book on high-dimensional stats) Giraud, C. (2021). *UItroduction to High-Dimensional Statistics* (Vol. 112, p. 18). Chapman & Hall/CRC Monographs on Statistics and Applied Probability.
- (great book for LASSO methods) Bühlmann, P., & Van De Geer, S. (2011). *Statistics for high-dimensional data: Methods, theory and applications*. Springer Science & Business Media.
- (more advanced book for LASSO methods) Wainwright, M. J. (2019). *High-dimensional statistics: A non-asymptotic viewpoint* (Vol. 48). Cambridge University Press.
- (introductory probability theory for high-dimensional problems) Vershynin, R. (2018). *High-dimensional probability: An introduction with applications in data science* (Vol. 47). Cambridge university press.
- (reference book for concentration inequalities) Boucheron, S., Lugosi, G., & Massart, P. (2013). *Concentration inequalities: A non-asymptotic theory of independence*. Oxford university press.