



Course and Examination Fact Sheet: Spring Semester 2022

10,378: Theoretical Aspects of Machine Learning

ECTS credits: 4

Overview examination/s

(binding regulations see below)

Decentral - Oral examination (individual) (100%)

Examination time: term time

Attached courses

Timetable -- Language -- Lecturer

[10,378,1.00 \(GSERM\) Theoretical Aspects of Machine Learning](#) -- Englisch -- [Bonev Petyo](#)

Course information

Course prerequisites

Solid knowledge in econometrics/statistics. As an example, participants should be familiar with concepts such as expectations, convergence in probability, estimation and prediction.

Learning objectives

The goal of this course is to provide a comprehensive overview of the mathematical theory behind machine learning. How can we characterize a good prediction? How can we construct good predictions based on Machine Learning methods? What is the relationship between (1) estimation error, (2) sample size and (3) model complexity? How do these abstract concepts apply in particular Machine Learning methods such as Boosting, Linear predictors, Ridge and LASSO? The objective of the course is to give detailed and intuitively clear answers to those questions. As a result, participants will receive a good preparation for theoretical and empirical work with/on Machine Learning methods.

Course content

PART I: Machine learning as statistical learning

1. Principles of statistical learning theory (loss function and risk, approximation vs estimation error, no free lunch theorems)
2. Concentration inequalities for bounded loss functions (Hoeffding's Lemma, Azuma-Hoeffding's inequality, Bounded difference inequality, Bernstein's inequality, McDiarmid inequality)
3. Classification (binary case and its loss function, Bayesian classifier, Optimality of the Bayesian Classifier, Oracle inequalities for the Bayesian classifier, Finite dictionary learning case, The impact of noise on convergence rates, infinite dictionary)
4. Applications and examples

PART II: The math of Ridge and LASSO

1. Non-identified and nearly non-identified linear models: setting the stage for RIDGE and LASSO
2. LASSO
3. RIDGE (if time allows)
4. Application: choosing the penalty term (if time allows).
5. Empirical application (if time allows)

Course structure and indications of the learning and teaching design

Block course and an oral exam at the end.



Course literature

Obligatory: there will be a lecture script.

Supplementary / voluntary: The book "Elements of statistical learning" by Hastie, Tibshirani and Friedman gives a nice introduction into Boosting and Vector Support Machines.

Further topic-specific nonobligatory references will be given during the lecture.

Additional course information

In the case of the President's Board having to implement new directives due to the SARS-CoV-2 pandemic in SpS2022, the course information listed above will be changed as follows:

- The course is conducted online via the platform zoom.
- The recordings of the course are available for 30 days.
- The lecturer informs via Canvas and via e-mail on the changed implementation modalities of the course;

The examination information listed below would be changed as follows:

- The oral examinations are conducted online and are being recorded;

Examination information

Examination sub part/s

1. Examination sub part (1/1)

Examination time and form

Decentral - Oral examination (individual) (100%)

Examination time: term time

Remark

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Examination-aid rule

Extended Closed Book

The use of aids is limited; any additional aids permitted are exhaustively listed under "Supplementary aids". Basically, the following is applicable:

- At such examinations, all the pocket calculators of the Texas Instruments TI-30 series and mono- or bilingual dictionaries (no subject-specific dictionaries) without hand-written notes are admissible. Any other pocket calculator models and any electronic dictionaries are inadmissible.
- In addition, any type of communication, as well as any electronic devices that can be programmed and are capable of communication such as notebooks, tablets, mobile telephones and others, are inadmissible.
- Students are themselves responsible for the procurement of examination aids.

Supplementary aids

A sheet of paper and a pen should be enough.

Examination languages

Question language: English

Answer language: English

Examination content

While the content of the course is very technical, the exam will ask only about **intuition!** The following concepts will be required



provided they are covered in the lecture (their intuitions, i.e. what are the assumptions and intuitively why they are necessary): Calculating a loss function, giving intuition for concentration inequalities, showing optimality of the Bayesian classifier, understanding the intuition behind the finite dictionary case, understanding the intuition of the impact of noise (Massart's noise condition, Mammen-Tsybakov's noise condition), describing the infinite dictionary learning problem, being able to define and explain Rademacher complexity, its relation to cardinality, calculating the VC-dimension, applications to empirical risk, being able to explain symmetrization, its relation to Rademacher complexity in the general case, and giving the intuition of how these concepts apply to Boosting and Linear predictors; the mathematical intuition behind the LASSO and Ridge methods, in particular in the orthonormal design.

Examination relevant literature

The exam follows the lecture script. There will be an exhaustive list of questions given in advance to all participants, out of which questions will be asked.

Please note

Please note that only this fact sheet and the examination schedule published at the time of bidding are binding and takes precedence over other information, such as information on StudyNet (Canvas), on lecturers' websites and information in lectures etc.

Any references and links to third-party content within the fact sheet are only of a supplementary, informative nature and lie outside the area of responsibility of the University of St.Gallen.

Documents and materials are only relevant for central examinations if they are available by the end of the lecture period (CW21) at the latest. In the case of centrally organised mid-term examinations, the documents and materials up to CW 12 are relevant for testing.

Binding nature of the fact sheets:

- Course information as well as examination date (organised centrally/decentrally) and form of examination: from bidding start in CW 04 (Thursday, 27 January 2022);
- Examination information (regulations on aids, examination contents, examination literature) for decentralised examinations: in CW 12 (Monday, 21 March 2022);
- Examination information (regulations on aids, examination contents, examination literature) for centrally organised mid-term examinations: in CW 12 (Monday, 21 March 2022);
- Examination information (regulations on aids, examination contents, examination literature) for centrally organised examinations: two weeks before the end of the registration period in CW 15 (Monday, 11 April 2022).