Module Description, available in: EN

Bayesian Machine Learning

General Information

Number of ECTS Credits

3

Module code

TSM_BayMachLe

Valid for academic year

2024-25

Last modification

2023-10-11

Coordinator of the module

Cedric Huwyler (FHNW, cedric.huwyler@fhnw.ch)

Explanations regarding the language definitions for each location:

- Instruction is given in the language defined below for each location/each time the module is held.
- Documentation is available in the languages defined below. Where documents are in several languages, the percentage distribution is shown (100% = all the documentation).
- The examination is available 100% in the languages shown for each location/each time it is held.

	Lausanne			Lugano	Zurich		
Instruction					**X** E 100%		
Documentation					**X** E 100%		
Examination					**X** E 100%		

Module Category

TSM Technical scientific module

Lessons

2 lecture periods and 1 tutorial period per week

Entry level competences

Prerequisites, previous knowledge

Basic probability and statistics, basic programming skills (R and/or Python), linear algebra and multivariate calculus, basic concepts of machine learning.

Brief course description of module objectives and content

Bayesian statistics provides an alternative viewpoint to the classical ‘frequentist’ statistics by using a different, more subjective interpretation of probability. This brings various advantages in solving typical industry problems, such as the inclusion of prior knowledge, more intuitive hypothesis tests or modeling uncertainty given small amounts of data. With increasing computational power, the popularity of Bayesian statistics and machine learning has grown significantly over the past decade. This course provides students with a solid understanding of the fundamental concepts of Bayesian statistics, introduces various computational methods required in Bayesian statistics and Bayesian machine learning, and discusses

numerous examples and applications of Bayesian machine learning. Bayesian as well as Gaussian process regression models are introduced and explored, with a particular focus on graphical models and Bayesian networks to model relationships and to infer causality. In addition, advanced topics and their applications are covered, such as Bayesian optimisation, non-parametric mixture models for clustering, and Bayesian neural networks.

Aims, content, methods

Learning objectives and competencies to be acquired

Students are able to formulate their problem setting on the basis of Bayesian models and to include their prior understanding. They are able to explain how Bayesian models balance between prior understanding and data towards a posterior understanding of a problem. They are aware of the advantages and disadvantages of the Bayesian approach and know in which situation it is better suited than standard frequency statistics. Since Bayesian models can rarely be computed in closed form, they are experienced in approximating posterior distributions by means of sampling-based approaches

Module content with weighting of different components

Fundamental concepts of Bayesian statistics: Reasoning under uncertainty, probability theory, Bayes theorem, prior, likelihood, posterior, conjugate families (beta-binomial, gamma-poisson, normal-normal), sequential learning, inference, prediction

Sampling methods: Markov chains, Metropolis algorithm, Gibbs sampling, Hamiltonian MC, sequential MC

Bayesian and Gaussian Process regression: kernels, model selection, state-space models, variational inference

Bayesian networks: graphical models, causality

Selection of advanced topics: Bayesian optimisation, Bayesian non-parametric mixture modeling, Bayesian neural networks, physics-informed ML models

Teaching and learning methods

Lecture and practical work on computer.

Literature

Lecture notes and notebooks will be available in addition to recommended book chapters.

Assessment

Certification requirements

Module does not use certification requirements

Basic principle for exams

As a rule, all standard final exams are conducted in written form. For resit exams, lecturers will communicate the exam format (written/oral) together with the exam schedule.

Standard final exam for a module and written resit exam

Kind of exam

Written exam

Duration of exam

120 minutes

Permissible aids

Aids permitted as specified below:

Permissible electronic aids

personal computer (open book, no communication, no AI-based chatbot assistance)

Other permissible aids

written summary of 8 pages (4 sheets)

Special case: Resit exam as oral exam

Kind of exam

Oral exam

Duration of exam

30 minutes

Permissible aids

Aids permitted as specified below:

Permissible electronic aids

None

Other permissible aids

None