Module Description, available in: EN

Causal AI

General Information

Number of ECTS Credits

3

Module code

TSM_CausAI

Valid for academic year

2026-27

Last modification

2024-10-01

Coordinator of the module

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Explanations regarding the language definitions for each location:

- Instruction is given in the language specified for each location and module execution.
- Documentation is available in the language(s) listed for each location and module execution. If the documentation is in multiple languages, the percentage distributed is indicated (100% = all documentation provided).
- The examination, including both questions and answers, is provided entirely (100%) in the language(s) specified for each location and module execution. The exams are on-site.

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

Module Category

TSM Technical scientific module

Profile Recommendations

This module is recommended for the following profiles:

	Lugano
Profile	DS

Lessons

2 lecture periods and 1 tutorial period per week

Entry level competences

Prerequisites, previous knowledge

Basics of probability theory and machine learning.

Brief course description of module objectives and content

Automatising causal inference is one of the main challenges for making artificial intelligence (AI) reliable and thus really useful in the real world, as more and more emphasised by scientists and practitioners:

“Machines’ lack of understanding of causal relations is perhaps the biggest roadblock to giving them human-level intelligence.” (Judea Pearl, Turing Award winner and AI pioneer.)

“Causality is very important for the next steps of progress of machine learning.” (Yoshua Bengio, Turing Award winner and “Godfather of Deep Learning”.)

“Causal AI is a key enabler of the next wave of AI, where AI moves toward greater decision automation, autonomy, robustness and common sense.” (Gartner, Analyst Firm.)

The list of applications that can be addressed by causal AI is long and important, e.g.: (medical) treatments; marketing strategies; disparity/fairness/discrimination and AI ethics more in general; information fusion; explainability; robustness; various applications in economics, medicine, epidemiology, the social sciences, etcetera.

In order to having access to these capabilities, the module will introduce students with the most important concepts in causal inference. In particular, after a review of concepts in probability and graph theory, it will focus on the treatment of interventions, counterfactual, and mediation analysis. Lectures will be constantly accompanied by examples and made very concrete through exercises based also on software for causal inference.

Aims, content, methods

Learning objectives and competencies to be acquired

This module will enable students to get a solid understanding of the most important concepts and algorithms in causal inference, and to have hands-on experience on the practical use of causal inference. At the end of the module, students will be able to model problems in a causal fashion and have them solved by state-of-the-art algorithms. They will be able to address many types of applications that are not accessible by engineers with a machine learning curriculum alone and that are more and more relevant in the industry.

Module content with weighting of different components

The module will cover the following topics. Introduction: causal inference vs machine learning; review of elementary concepts in probability and statistics; Bayesian networks. Interventions: observational vs randomised controlled studies; causal effects; causal inference in linear systems. Counterfactuals: structural causal models; personal decision making; discrimination; attribution; mediation.

The topics above will be constantly backed up with practical examples and use of software to make inference with structural causal models. Students will eventually be required to work on a (simulated) applied project where they will test their new competences all the way through the modelling of a problem to its solution and evaluation.

Teaching and learning methods

- Lectures / presence
- Tutorial / presence
- Self-study

Literature

Judea Pearl, Madelyn Glymour, Nicholas P. Jewell. Causal Inference in Statistics, a Primer. Wiley, 2016.

Assessment

Additional performance assessment during the semester

The module contains additional performance assessment(s) during the semester. The achieved mark of the additional performance assessment(s) applies to both the regular and the resit exam.

Description of additional performance assessment during the semester

Students will periodically submit parts of an overall home assignment designed to have them practice concretely with the notions studied during the frontal lectures. The overall assignment will count for 1/3 of exam results.

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

A calculator.

Other permissible aids

A sheet of personal notes.

Exception: In case of an electronic Moodle exam, adjustments to the permissible aids may occur. Lecturers will announce the final permissible aids prior to the exam session.

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

A calculator.

Other permissible aids

No other aids permitted