UNIVERSITY OF GOTHENBURG

DEPARTMENT OF PHYSICS

FYM345 Advanced simulation and machine learning, 7.5 credits

Avancerad simulering och maskininlärning, 7,5 högskolepoäng

Second Cycle

Confirmation

This course syllabus was confirmed by Department of Physics on 2020-05-04 to be valid from 2020-07-01, autumn semester of 2020.

Field of education: Science 100%
Department: Department of Physics

Position in the educational system

The course can be part of the following programmes: 1) Complex Adaptive Systems, Master's Programme (N2CAS) and 2) Physics, Master's Programme (N2PHY)

Main field of studies	*Specialization*
Physics	A1N, Second cycle, has only first-cycle course/s as entry requirements

Entry requirements

Bachelors degree in physics or equivalent. Recommended courses: "Learning from data" and "Computational physics" or equivalent

Applicants must prove their knowledge of English: English 6/English B from Swedish Upper Secondary School or the equivalent level of an internationally recognized test, for example TOEFL, IELTS.

Learning outcomes

The course covers a selection of machine learning algorithms and statistical methods for simulating physical systems. The course is based on a set of projects, which are accompanied by lectures, and hands-on computer exercises. During the course, the students will be exposed to advanced scientific research problems, with the aim to

reproduce state-of-the-art scientific results. The students will use e.g. the Python programming language and relevant open-source libraries, and will learn to develop and structure computer codes for carrying out scientific and statistical data analyses.

Learning outcomes (after completion of the course the student should be able to)

critically examine the description of systems in the physical sciences by different mathematical models
rationalize the numerical representation of such models at multiple levels of sophistication
employ statistical inference and machine learning (ML) methods to evaluate and compare models
explain, using appropriate terminology, methods from ML and statistical inference
analyze data and write code in scientific and ethical fashion

Course content

Advanced simulations in the physical sciences can benefit from ML methods in multiple ways:

Uncertainty quantification via Bayesian inference
Representation of mathematical models via ML models, e.g., neural networks and Gaussian processes
Parametrization and selection of ML models via regression techniques

with the following subtopics

Dimensionality reduction and descriptors for physical systems
Bayesian inference and model selection
Generalized linear models including Gaussian processes
Advanced regression and regularization techniques
Neural networks

All of these aspects will be introduced and examined in the context of modelling in the physical sciences.

Form of teaching

Lectures
Supervised computational exercises (group work on computational projects)
Selected number of small hand-in assignments
Computational projects with written reports

Language of instruction: English

Assessment

The final grade is based on the combined performance on hand-in assignments and computational projects.

A student who has taken two exams in a course or part of a course without obtaining a pass grade is entitled to the nomination of another examiner. The student needs to contact the department for a new examiner, preferably in writing, and this should be approved by the department unless there are special reasons to the contrary (Chapter 6 Section 22 of the Higher Education Ordinance).

If a student has received a recommendation from the University of Gothenburg for special educational support, where it is compatible with the learning outcomes of the course and provided that no unreasonable resources are required, the examiner may decide to allow the student to sit an adjusted exam or alternative form of assessment.

In the event that a course has ceased or undergone major changes, students are to be guaranteed at least three examination sessions (including the ordinary examination session) over a period of at least one year, but no more than two years, after the course has ceased/been changed. The same applies to placements and professional placements (VFU), although this is restricted to just one additional examination session.

Grades

The grading scale comprises: Pass with Distinction (VG), Pass (G) and Fail (U).

Course evaluation

The results of and possible changes to the course will be shared with students who participated in the evaluation and students who are starting the course.