AI-based modeling and optimization for industrial systems, 7.5 credits

AI-baserad modellering och optimering för industriella system 7.5 högskolepoäng

Course code:	FOES019
Third-cycle subject:	Energy and Environmental Engineering
School:	EST
Valid from:	240101
Established by:	EST
Decision date:	240119
Last modified:	240319
Level of education:	Third cycle level
Language:	English
English version:	Yes

Course objective

Mälardalen University and the Future Energy Center (FEC) will organize a training course on AI-based modeling and optimization for industrial systems. The course comprises ten-day modules on the current state-of-the-art AI-based modeling and optimization methods including application case studies. Special focus is given to educational applications and modeling and optimization for industrial systems.

Course content

1. Course introduction : Basics for Python (Supporting videos for Python coding)
2. Introduction to AI methods for classification/regression , supervised vs unsupervised learning , regression methods
3. Artificial neural networks (ANN) for diagnostics, Example on ANN based diagnostics , Case studies
4. Time sequential prediction Case studies

5. Case studies on ML application by Guest lecturers
6. Genetic algorithms and AI-based optimization
7. Linear optimization, production planning, and data-driven control
8. Dynamic programming and optimal control.
9. Uncertainty quantification, Monte Carlo dropouts and Deep Ensembles methods
10. Course summary and briefings on the mini-project(s)

Intended learning outcomes

The purpose of the course is to familiarize students with the basics of Python as a platform to use AI/data- driven methods and optimization for energy systems. Current practices and future developments will be discussed along with a diverse array of application case studies.

The learning outcomes of the course are to be able to:

- Describe basic syntax, computer types and structure in Python.
- Develop algorithms in Python code using open-source libraries (numpy, scipy, matplotlib), with the purpose of calculating and presenting results graphically.
- Discuss the basic principles and applications of AI/data-driven methods.
- Introduce the basics of dynamic programming and control optimization with respect to AI methods.
- Discuss and develop ANN and CNN concepts with case studies.
- Discuss the basics of uncertainty analysis using Monte Carlo dropouts and Deep Ensembles methods.
- Examine case studies of AI-based modeling and optimization applications across diverse domains.

The intended qualitative targets in relation to the Higher Education Ordinance, appendix 2.

Knowledge and understanding

For the Degree of Doctor, the doctoral student shall demonstrate:

- A1: broad knowledge and systematic understanding of the research field as well as advanced and up-to-date specialised knowledge in a limited area of this field, and

- A2: familiarity with research methodology in general and the methods of the specific field of research in particular.

Competence and skills

For the Degree of Doctor, the doctoral student shall demonstrate:

- B1: the capacity for scholarly analysis and synthesis as well as to review and assess new and complex phenomena, issues, and situations autonomously and critically,
- B2: the ability to identify and formulate issues with scholarly precision critically, autonomously, and creatively, and to plan and use appropriate methods to undertake research and other qualified tasks within predetermined time frames and to review and evaluate such work,
- B5: the ability to identify the need for further knowledge.

Teaching formats

The course will be given on Västerås Campus.

Examination

NAR1: 3hp, Participation in the course lectures, grade Fail (U) or Pass (G)
INL1: 4.5hp, Individual mini project, grade Fail (U) or Pass (G)

For Pass (G) on the course, the participant must have pass in both NAR1 and INL1.

Grade

Examinations included in the course are assessed according to a two-grade scale, fail or pass.

Grades are to be decided by a teacher specially appointed by the university.

A person who has not passed the regular examination shall be given the opportunity to retake the test.

Requirements

To participate in the course and the examinations included in the course, the applicant must be admitted to doctoral studies at Mälardalen University.

Selection criteria

Doctoral students admitted to other subjects at Mälardalen University may be admitted to the course, subject to availability. The same applies to doctoral students admitted to other higher education institutions within and outside of Sweden. Selection of applicants will be made in accordance with the ranking below (*delete if not applicable or change in the ranking below).*

1. Doctoral students in Energy and Environmental Engineering
2. Doctoral students at Mälardalen University
3. Doctoral students at other universities in Sweden
4. Doctoral students at other higher education institutions outside Sweden
5. Researchers at Swedish or international organizations

Transitional and other provisions