Course Specifications

Valid in the academic year 2018-2019

Machine Learning (E061330)

Course size (nominal values; actual values may depend on programme)

Credits 6.0 Study time 180 h Contact hrs 60.0 h

Course offerings and teaching methods in academic year 2018-2019

A (semester 1)	Dutch	guided self-study	60.0 h
B (semester 1)	English	seminar: practical PC room classes	20.0 h
		lecture	32.5 h
		guided self-study	5.0 h
		project	2.5 h

Lecturers in academic year 2018-2019

Dambre, Joni	TW06	lecturer-in-charge
Dhaene, Tom	TW05	co-lecturer

Offered in the following programmes in 2018-2019	crdts	offering
Brugprogramma Master of Science in Bioinformatics (main subject Engineering)	6	B
Bridging Programme Master of Science in Industrial Engineering and Operations Research	6	B
Bridging Programme Master of Science in Computer Science Engineering	6	A
Bridging Programme Master of Science in Computer Science Engineering	6	B
Bridging Programme Master of Science in Industrial Engineering and Operations Research	6	B
Master of Science in Electrical Engineering (main subject Communication and Information Technology)	6	B
Master of Science in Business Engineering (main subject Data Analytics)	6	B
Master of Science in Bioinformatics (main subject Engineering)	6	B
Master of Science in Business Engineering (main subject Finance)	6	B
Master of Science in Business Engineering (main subject Operations Management)	6	B
Master of Science in Industrial Engineering and Operations Research	6	A
Master of Science in Computer Science Engineering	6	A
Master of Science in Computer Science Engineering	6	B
European Master of Science in Photonics	6	B
Master of Science in Industrial Engineering and Operations Research	6	B
Master of Science in Engineering Physics	6	B
Exchange Programme in Bioinformatics (master's level)	6	B

Teaching languages

Dutch, English

Keywords

Machine learning, regression, classification, Baysian networks, clustering, PCA, kernel techniques, support vector machines, random forrest, neural networks, deep learning, gaussian processes, robotics, reinforcement learning

Position of the course

The objective of this course is to provide theoretical and practical insights into the use of machine learning in practical applications. First, the fundamental principles of machine learning and learning theory are introduced in the context of linear models. Next, the major historical families of machine learning techniques are addressed. The last part of the course focuses on selected state-of-the-art advanced methods. The theoretical background is given in order to understand the benefits and limitations of each technique, but the emphasis of the course is on the practical use of the different techniques. This is achieved through a number of supervised PC-labs as well as a project in the form of a machine learning competition.
For the applied parts of this course, the Python programming language is used.

Contents

- Introduction to machine learning: types of problems, types of techniques, types of data, introduction to learning theory, approximation versus generalisation, features and feature selection, uncertainty and overfitting, problem and model analysis, ensembles
- Unsupervised learning: clustering, dimensionality reduction, approximating probability density functions, Gaussian mixture models
- Rule-based techniques: decision trees and random forrests
- Model-based techniques: linear regression and classification, logistic regression, neural networks
- Similarity-based techniques: KNN, kernel techniques, SVM
- Probabilistic and Bayesian approaches, maximal likelihood and expectation maximization
- Reinforcement learning
- State-of-the-art topical examples, e.g.: convolutional neural networks, natural language processing, biomedical applications
- Hands-on application to real-world problems

Initial competences

Informatics and programming (Python). Mathematics: calculus and linear algebra. Probability theory and statistics.

Final competences

1 Understand the fundamental principles and challenges of machine learning.
2 Understand the mathematical background of some common and advanced machine learning models.
3 Implement simple machine learning models and correctly apply machine learning libraries for more advanced techniques.
4 Analyse a new machine learning problem and address it by correctly applying the principles of machine learning and selecting suitable common machine learning models.
5 Understand and critically evaluate the techniques presented in scientific literature on machine learning.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Guided self-study, lecture, project, seminar: practical PC room classes

Extra information on the teaching methods

Students are free to complete their assignments independently. Besides the lectures, contact sessions are organised in which the students can workon their assignments at their own pace, ask questions or receive feedback on assignments that have already been graded.

Learning materials and price

Book: "Introduction to Machine Learning (3rd edition)", Ethem Alpaydin, MIT Press (online price: $65.00).
Slides.

References

- Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", Cambridge University Press, 2012
- Sebastian Raschka, "Python Machine Learning", Packt Publishing, 2015
- Yaser Abu-Mostafa et al.,"Learning from data", AMLbook.com, 2012
- Kevin P. Murphy, "Machine Learning, a Probabilistic Perspective", MIT Press, 2012

- Christopher M. Bishop, “Pattern recognition and machine learning”, Springer (2006)
- Trevor Hastie, Robert Tibshirani, Jerome Friedman, “The elements of statistical learning theory”, Springer (2003) (freely available online)
- Richard S. Sutton, Andrew G. Barto, “Reinforcement learning: an introduction”, MITpress (1998) (freely available online)

Course content-related study coaching

By the teachers and the assistants, before, during or after contact sessions, or by appointment or via Minerva.

Evaluation methods

end-of-term evaluation and continuous assessment

Examination methods in case of periodic evaluation during the first examination period

Written examination, oral examination

Examination methods in case of periodic evaluation during the second examination period

Written examination, oral examination

Examination methods in case of permanent evaluation

Participation, assignment, peer assessment, report

Possibilities of retake in case of permanent evaluation

examination during the second examination period is possible in modified form

Extra information on the examination methods

The exam consists of a written part, immediately followed by an oral part (both with closed book). The written part consists of several short questions to test knowledge and understanding (multiple choice or open questions with very short answers), as well as a few questions to evaluate deeper understanding. These last questions serve as a preparation for the oral examination.
The NPE for this course consists of graded programming exercises (individual work) and a project. This is split up into an individual part and a group phase, which builds upon the results of the individual phase. Grading for the project is based on the correct application of the methodology and techniques taught in the course.
Students who do not participate in the individual part or obtain a score below 6/20 will not be allowed to participate in the group phase and can therefore not succeed in the first exam period.
The second exam period only consists of individually graded work (programming exercise - project - exam), but only the parts for which you did not succeed have to be retaken.

Calculation of the examination mark

50% NPE (evaluation during the semester), 50% PE (exam). The NPE consists of programming exercises (15%), the individual part of the project (15%) and the group part of the project (20%).
Participation to all graded assignments is mandatory in order to succeed. Students who fail to hand in assignments or do not take their share of the group work can receive an insufficient grade for the NPE. For the group phase, peer assessment is used to monitor each student's contribution.
You need to obtain a score of at least 9/20 on each of both parts (NPE and PE) in order to obtain a credit. Students who do not fulfill this criterion will obtain the lowest of these two scores as a final score.