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 2020-2021

A (semester 1)	Dutch	Gent	guided self-study	60.0 h
B (semester 1)	English		guided self-study	5.0 h
			lecture	30.0 h

Lecturers in academic year 2020-2021

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

Offered in the following programmes in 2020-2021	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 Operations Management)	6	B
Master of Science in Industrial Engineering and Operations Research	6	A, B
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
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 forest, 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. The major historical families of machine learning techniques are addressed and

selected state-of-the-art advanced methods are highlighted. 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
- 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

ICT: Being able to program in Python is a necessary prerequisite for this course!
Mathematics: calculus, linear algebra, analytic geometry, probability theory and statistics (all at university level).

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, group work, lecture, online discussion group, online group work, online lecture, online seminar: practical PC room classes

Extra information on the teaching methods

The lectures will take place on-campus, with limited possibility for physical attendance and online streaming.
A limited number of PC-exercises will have to be made individually, at home, with the possibility to ask questions at pre-set dates.
A more complex machine learning assignment will be made in part individually and in part in groups. This will be split up into intermediate targets. Through regular scheduled (mandatory) contact sessions (online or on-campus depending on circumstances), support will be given and the progress towards the intermediate targets will be evaluated.

Learning materials and price

Non-compulsory book: "Introduction to Machine Learning (4th edition)", Ethem Alpaydin, MIT Press (online price: $65.00).
Slides, lecture recordings.

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", 3rd edition, Packt Publishing, 2019
- 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, by appointment or via the e-learning system.

Evaluation methods

end-of-term evaluation and continuous assessment

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

Written examination

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

Written 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 examination (closed book). It 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.
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, as well as on your personal contribution to the group work.
Students who do not participate in the individual part or obtain a score below 5/20 will not be allowed to participate in the group phase and can therefore not succeed in the first exam period. Not contributing sufficiently to the group's result can also lead to not succeeding.
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).
Participation to all parts of NPE 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 and individual questions are used to monitor each student's contribution. **Students who fail to contribute sufficiently to the assignment, because of lack of effort, understanding or coding skills, will not pass for the course.**
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 the second condition but for whom the calculated score would be 9/20 or more, will receive a score of 8/20 (i.e., the largest score that is smaller than 9/20).