GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2023-2024

Deep Generative Models (E061350)

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

Credits 4.0 **Study time 120 h**

Course offerings and teaching methods in academic year 2023-2024

A (semester 2)	English	Gent	lecture
			seminar

Lecturers in academic year 2023-2024

Dhoedt, Bart	TW05	lecturer-in-charge

Offered in the following programmes in 2023-2024	crdts	offering
Master of Science in Computer Science	4	A
Master of Science in Computer Science Engineering	4	A
Master of Science in Computer Science Engineering	4	A
Exchange Programme in Computer Science (master's level)	4	A

Teaching languages

English

Keywords

Machine learning, deep learning, neural networks, recurrent neural networks, autoencoders, variational inference, autoregressive models, generative adversarial networks, flow models, active inference

Position of the course

This elective course is located in the major Artificial Intelligence of the Master of Science in Computer Science Engineering, and we extend the knowledge acquired in the compulsory courses Machine Learning. Furthermore, the course is closely related to the elective courses Deep Learning, Robotics, Artificial Intelligence and Machine Learning based Natural Language Processing. In this course, we will zoom in on a specific class of models within machine learning, namely generative models. Naive Bayes, (Hidden) Markov Models and Bayesian Networks have already been discussed in the Machine Learning course, and in this course we expand the family of generative models with powerful and recent techniques from the field of deep learning.

Contents

- Introduction and review: what are generative models, position within the field of machine learning, graphical models, probability distributions.
- Deep learning: multilayer perceptrons (MLP), convolutional neural networks (CNN), loss functions, backpropagation, stochastic gradient descent.
- Autoregressive models: recurrent neural networks (RNN), LSTM and GRU, temporal convolutions, dilated convolutions, transformer networks.
- Variational autoencoders: learning low-dimensional data representations, data compression, reparameterization trick, ELBO, variational inference, discrete latents, priors.
- Adversarial models: generative adversarial networks (GAN) and variants, training algorithm stabilization, evaluation of generative models, anthology from literature.
- Flow models: change of variables theorem, invertible transformations, normalizing flows, coupling layers, autoregressive flows.
- Diffusion models: forward and reverse processes, evidence lower bound (ELBO), model paramterisation, examples
- Active inference: state belief models, reinforcement learning, world models, preferred state as a reward alternative, free energy.
- Applications will be covered in all previous topics, including examples from robotics, image

processing, anomaly detection, natural language processing, audio, etc.

Initial competences

A thorough knowledge of basic machine learning concepts; programming skills in Python; elementary probabilistics, linear algebra and information theory.

Final competences

1 Understanding and clearly explaining the inner mechanisms and aspects of the covered generative models.
2 Comparing advantages, disadvantages and other properties of the covered generative models and selecting the most appropriate model for a given application.
3 Being able to implement a standard variational autoencoder, generative adversarial network, flow model and recurrent neural network in a deep learning framework, and being able to train and evaluate the models, and use the models to generate (new) data.
4 Understanding and clearly explaining the main findings of a recent scientific publication within the field of generative modeling.

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

Seminar, Lecture

Extra information on the teaching methods

Each subject of the course is introduced in a lecture in which we will cover the theoretical foundations, practical applications and recent examples from academic literature. Each subject is accompanied by a hands-on PC exercise in which we will implement some of the models that were covered in the lecture. The models will be trained and evaluated on a standard dataset. In addition, the students are required to independently read one scientific article and write a summary of its findings.

Learning materials and price

Slides, interactive notebooks, scientific publications

References

- Deisenroth, Faisal en Soon Ong (2020). Mathematics for Machine Learning. Cambridge University Press.
- Goodfellow, Bengio en Courville (2016). Deep Learning. MIT Press.
- Barber (2012). Bayesian Reasoning and Machine Learning. Cambridge University Press.

Assessment moments

end-of-term assessment

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

Oral assessment

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

Oral assessment

Possibilities of retake in case of permanent assessment

not applicable

Extra information on the examination methods

Oral examination covering theory, lab session work

Calculation of the examination mark

Exam: 100%