MASTER OF SCIENCE IN ENGINEERING

Module Description

Deep Learning

General Information

Number of ECTS Credits

3

Module code

TSM_DeLearn

Responsible of module

Dr. René Müller, BFH

Language

Explanations regarding the language definitions for each location:

- Instruction is given in the language defined below for each location/each time the module is held.
- Documentation is available in the languages defined below. Where documents are in several languages, the percentage distribution is shown (100% = all the documentation).
- The examination is available 100% in the languages shown for each location/each time it is held.

	Berne	Lausanne		Lugano	Zurich		
Instruction	☐ E 100%	☐ E 100%	☐ F 100%	☐ E 100%	☒ E 100%		☐ D 100%
Documentation	☐ E 100%	☐ E 100% ☐ E %	☐ F %	☐ E 100%	☒ E 100%	☐ E %	☐ D %
Examination	☐ E 100%	☐ E 100% ☐ E 100%	☐ F 100%	☐ E 100%	☒ E 100%	☐ E 100%	☐ D 100%

Module category

☐ FTP Fundamental theoretical principles

☒ TSM Technical/scientific specialization module

☐ CM Context module

Lessons

2 lecture periods and 1 tutorial period per week

Entry level competencies

Prerequisites, previous knowledge

Linear algebra: vector and matrix operations, Eigenvectors and –values

Multivariate calculus: partial differentiation, chain rule, gradient, Jacobian and Hessian

Statistics and probability theory: discrete and continuous distributions, multi-variate distributions, probability mass and density functions, Bayes' Rule, maximum likelihood principle

Programming: Experience in a programming language (understanding of loops and selection, arrays/lists, and maps/dictionaries. The course is taught using Python. Students should be comfortable with using a command line interface (shell).

Brief course description of module objectives and content

Deep Learning is one of the most active subareas of Machine Learning and Artificial Intelligence at the moment. Gartner places it at the peak in its 2017 Hype Cycle. Deep Learning techniques are based on neural networks. They are at the core of a vast range of impressive applications, ranging from image classification, automated image captioning, language translation such as Google Translate, to playing Go and arcade games.

This course focuses on the mathematical aspects, the implementation of neural networks in Python, and their training. Students will learn the fundamental concepts of Deep Learning and develop a basic understanding of applicability of Deep Learning for Machine Learning tasks. After completing the course, students will have developed the skills to apply Deep Learning in practical application settings.

Aims, content, methods

Learning objectives and acquired competencies

Students will

- have a thorough **understanding of neural network architectures** including convolutional and recurrent networks.
- know **loss functions** (e.g. categorical cross entropy) that provide the optimization objective during training.
- understand the principles of **back propagation**.
- know the benefits of **depths and representation learning**.
- have an overview of **open research questions**.
- develop the ability to decide **whether Deep Learning is suitable** for a given task.
- gain the ability to **build and train neural network models** in a Deep Learning Framework such as TensorFlow.

Contents of module with emphasis on teaching content

- **Introduction**: Logistic Neuron, training and cost functions.
  Architectures: Feed-forward and recurrent networks. Applications of neural networks.
- **Backpropagation:** Multilayer Perceptron (MLP), implementation of an MLP including backpropagation in Python.
- **Optimization**: Minimization of loss functions, gradient descent, stochastic gradient descent, mini-batch gradient descent, implementation of gradient decent optimizers in Python.
- **Training of Deep Neural Networks**: Dataflow graphs, automatic differentiation, special optimizers, such as Nestrov accelerated gradient, AdaGrad, or RMSProp; tricks for faster training, batch normalization, gradient clipping, special activation functions such as non-saturating activation functions, regularization using dropout, training using a Deep Learning frameworks such as TensorFlow.
- **Convolutional Neural Networks (CNNs):** Convolutional and pooling layers, data augmentation, popular CNN architectures, transfer learning, applications.
- **Practical Considerations and Methodology:** Visualizations such as activation maximization, class activation maps, saliency maps; performance metrics, selecting hyper-parameters, debugging strategies.
- **Recurrent Neural Networks**: Vanishing and exploding gradients, special memory cells, such as Gated Recurrent Units (GRU) or Long short-term memory (LSTM), static and dynamic unrolling, sequence classifiers, sequence-to-sequence models, encoder-decoder for language translation.
- **Special and Current Research Topics** such as
  - Autoencoders: principal component analysis using autoencoders; special architectures such as denoising
  - Generative Adversarial Models

Teaching and learning methods

Classroom teaching; programming exercises

Literature

I. Goodfellow, Y. Bengio, A. Courville: “Deep Learning”, MIT Press, 2016. ISBN: 978-0262035613.

N. Buduma: “Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms”, O’Reilly, 2017. ISBN: 978-1491925614.

A. Géron, Hands-on Machine Learning with Scikit-Learn and TensorFlow, O'Reilly, 2017 ISBN: 978-1491962299.

C. M. Bishop: “Neural Networks for Pattern Recognition”. Clarendon Press. 1996. ISBN: 978-0198538646.

J. Hertz, A. Krough, R.G. Palmer: “Introduction to the Theory of Neural Computation”. Santa Fe Institute Series. 1991. ISBN:978-0201515602.

Assessment

Certification requirements for final examinations (conditions for attestation)

75% of handed-in homework passed

Standard final exam for a module and written repetition exam

Kind of Exam	written
Duration of exam	120 minutes
Permissible aids	☐ no aids
	☑ permissible aids:
	☐ Electronical aids: ______________________
	☐ Hardcopy form: _______________________
	☒ 1 A4 page (front and back) of handwritten notes

Special case: Repetition exam as an oral exam

If an oral exam is set (only possible for ≤ 4 students), the following applies:

Kind of Exam	oral
Duration of exam	30 minutes
Permissible aids	closed book = no aids