Deep Learning

General Information

<table>
<thead>
<tr>
<th>Number of ECTS Credits</th>
<th>3</th>
</tr>
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<tbody>
<tr>
<td>Module code</td>
<td>TSM_DeLearn</td>
</tr>
<tr>
<td>Valid for academic year</td>
<td>2021-2022</td>
</tr>
<tr>
<td>Last modification</td>
<td>2019-01-30</td>
</tr>
<tr>
<td>Coordinator of the module</td>
<td>Jean Hennebert (HES-SO, <a href="mailto:jean.hennebert@hes-so.ch">jean.hennebert@hes-so.ch</a>)</td>
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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.

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<th>Lugano</th>
<th>Zurich</th>
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<td>Documentation</td>
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Module Category

TSM Technical scientific module

Lessons

2 lecture periods and 1 tutorial period per week

Entry level competences

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 with good understanding of loops and data structures such as arrays/lists and maps/dictionaries; understanding of object oriented programming concepts. The course is taught using Python.
**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 has placed it at the peak in its 2017 Hype Cycle and the trend is going on. 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 of neural networks, their implementation (in Python), and their training and usage. Students will learn the fundamental concepts of Deep Learning and develop a good 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.
- know some of the recent advances in the field and some of the 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**

- **Optimization strategies**: 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**: Backpropagation, computational 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.
- **Multilayer Perceptron (MLP)**: implementation of an MLP including backpropagation in Python.
- **Convolutional Neural Networks (CNNs)**: Convolutional and pooling layers, data augmentation, popular CNN architectures, transfer learning, applications.
- **Practical Considerations and Methodology**: Deep Learning frameworks such as TensorFlow; gpu vs cpu; 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 applications such as denoising auto-encoders.
  - Generative Adversarial Models.
  - Learning embeddings for word representations, attention mechanism, transformers.

**Teaching and learning methods**

Classroom teaching; programming exercises

**Literature**


## Assessment

**Certification requirements**

Module uses certification requirements

**Certification requirements for final examinations (conditions for attestation)**

75% of handed-in homework passed

**Basic principle for exams**

As a rule, all the standard final exams for modules and also all resit exams are to be in written form

### Standard final exam for a module and written resit exam

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<td>Permissible aids</td>
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<td></td>
<td>Permissible electronic aids</td>
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<tr>
<td></td>
<td>No electronic aids permitted</td>
</tr>
<tr>
<td>Other permissible aids</td>
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### Special case: Resit exam as oral exam

<table>
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<td>Permissible aids</td>
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