

## DL - Deep Learning

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General information	
<b>Module Code</b>	DL
<b>Unique Identifier</b>	DeepLearnA-01-MA-M
<b>Module Leader(s)</b>	Prof. Dr. Schneider, Stephan (stephan.schneider@haw-kiel.de) Prof. Dr. Lüssem, Jens (jens.luessem@haw-kiel.de)
<b>Lecturer(s)</b>	Prof. Dr. Lüssem, Jens (jens.luessem@haw-kiel.de)
<b>Offered in Semester</b>	Sommersemester 2026
<b>Module duration</b>	1 Semester
<b>Occurrence frequency</b>	Regular
<b>Module occurrence</b>	In der Regel im Sommersemester
<b>Language</b>	Englisch
<b>Recommended for international students</b>	Yes
<b>Can be attended with different study programme</b>	No

Curricular relevance (according to examination regulations)
Study Subject: M.Sc. - MCS - Computer Science (PO 2023, V1) Module type: Wahlmodul Semester: 1, 2
Study Subject: M.Sc. - MCS - Computer Science (PO 2023, V1) Study Focus: Artificial Intelligence Module type: Verpfl. Wahlmodul, PVO §3 Semester: 1, 2
Study Subject: M.Sc. - MIE - Information Engineering (PO 2022, V3) Module type: Wahlmodul Semester: 1, 2, 3

Qualification outcome
<i>Areas of Competence: Knowledge and Understanding; Use, application and generation of knowledge; Communication and cooperation; Scientific self-understanding / professionalism.</i>
Students can specifically... <ul style="list-style-type: none"> <li>• explain the term deep learning (DL) and classify it in the context of artificial intelligence (AI),</li> <li>• name, delimit, describe and explain the concepts, methods and models of supervised and unsupervised learning,</li> <li>• understand the mathematical and statistical foundations of the different types of artificial neural networks,</li> <li>• name and explain basic methods of data analysis and data pre-processing, especially acquisition, transformation, cleansing, partitioning, scaling, visualization and static description,</li> <li>• Describe the complete process of carrying out a DL project from analysis and pre-processing of the data to the application of the methods and development of models to the post-processing of the data (e.g. model-based forecast).</li> </ul>

Students have/can generally...

- Significantly expanded their knowledge at the level of university entrance qualifications,
- demonstrate a broad and deep knowledge and understanding of the scientific foundations of content-related teaching areas (e.g. AI, DL, mathematics, statistics) based on the current state of research,
- a critical understanding of the most important theories, principles and methods of the content-related teaching areas,
- Critically reflect on technical and practice-relevant statements and check the plausibility of envisaged solutions to problems.

Students can specifically (in terms of content)...

- identify and assess the application potential of AI or DL in selected and mostly known application contexts,
- solve specific problems using the R or Python languages and applications.

Students can generally...

- formulate technical and factual solutions to problems within their actions and justify them in discourse with specialist representatives and non-specialists with theoretically and methodologically well-founded arguments,
- communicate and cooperate with other subject representatives and non-specialists in order to solve a task responsibly,
- Reflecting on and taking into account the different perspectives and interests of other participants.

Students generally...

- develop a professional self-image that is based on the goals and standards of professional action in professional fields that are primarily outside of science,
- justify their own professional actions with theoretical and methodical knowledge,
- Assess one's own abilities, autonomously reflect on factual design and decision-making freedoms and use them under guidance,
- Recognize the framework conditions of professional action that are appropriate to the situation and justify their decisions in a responsible and ethical manner,
- reflect critically on their professional actions in relation to social expectations and consequences.

<b>Content information</b>	
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Deep learning in the context of artificial intelligence               <ol style="list-style-type: none"> <li>1.1. On the relationship between artificial intelligence (AI), machine learning (ML) and deep learning (DL)</li> <li>1.2. Excursus: data and scale levels</li> <li>1.3. Problem areas: regression, classification and clustering</li> <li>1.4. General Types of Artificial Neural Networks (ANN)</li> </ol> </li> <li>2. General introduction to the structure and functionality of a unit as a component of an ANN               <ol style="list-style-type: none"> <li>2.1. The neuron as a biological model</li> <li>2.2. Mathematical description of the functional units of a unit</li> <li>2.3. Mathematical description of learning an ANN using backpropagation and the gradient descent method</li> </ol> </li> <li>3. Multi-dimensional data structure (array) of the input layer as a passive data supplier</li> <li>4. Exploratory data analysis and pre-processing of the data (pre-processing)               <ol style="list-style-type: none"> <li>4.1. Procurement and Transformation</li> <li>4.2. Statistical description and visualization</li> <li>4.3. Missing Values</li> <li>4.4. Runaway</li> <li>4.5. dumbing down</li> <li>4.6. Unbalanced amount of data</li> <li>4.7. partitioning</li> <li>4.8. scaling</li> </ol> </li> <li>5. Problems and optimization of an ANN               <ol style="list-style-type: none"> <li>5.1. Overfitting and underfitting</li> <li>5.2. Hyperparameter adjustment</li> <li>5.3. Determination of forecast and model quality</li> </ol> </li> <li>6. Multi-Layer Perceptron (MLP) for regression</li> <li>7. Multi-Layer Perceptron (MLP) for classification               <ol style="list-style-type: none"> <li>7.1.1. Binary Classification</li> <li>7.1.2. N-ary classification with single-label assignments</li> <li>7.1.3. N-ary classification with multi-label assignments</li> </ol> </li> <li>8. Long Short-Term Memory (LSTM) for time series               <ol style="list-style-type: none"> <li>8.1.1. regression</li> <li>8.1.2. classification                   <ol style="list-style-type: none"> <li>8.1.2.1. scalar output</li> <li>8.1.2.2. sequence output</li> </ol> </li> </ol> </li> <li>9. Convolutional Neural Network (CNN) handling image data               <ol style="list-style-type: none"> <li>9.1. Image classification</li> <li>9.2. Object Recognition/Detection</li> <li>9.3. semantic segmentation</li> <li>9.4. instance segmentation</li> </ol> </li> <li>10. Self-Organizing Map (SOM) for clustering</li> <li>11. Other model variants (autoencoder, generative adversarial networks (GAN) etc.)</li> </ol>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Haykin, Simon S. (1999): Neural Networks: A Comprehensive Foundation. 2. Aufl., 1999. Upper Saddle River: Pearson Education.</li> <li>• Haykin, Simon S. (2009): Neural Networks and Learning Machines. 3. Aufl., 2009. Upper Saddle River: Pearson Education.</li> <li>• Goodfellow, I., Bengio, Y., Courville, A. (2016): Deep Learning. 2016. Cambridge: MIT Press.</li> </ul> <p>More literature will be announced at lecture time.</p>

<b>Teaching formats of the courses</b>	
<b>Teaching format</b>	<b>SWS</b>
Lehrvortrag	2
Labor	2

<b>Workload</b>	
<b>Number of SWS</b>	4 SWS
<b>Credits</b>	5,00 Credits
<b>Contact hours</b>	48 Hours
<b>Self study</b>	102 Hours

<b>Module Examination</b>	
<b>Examination prerequisites according to exam regulations</b>	None
<b>DL - Technischer Test</b>	Method of Examination: Technischer Test Duration: 120 Minutes Weighting: 100% wird angerechnet gem. § 11 Absatz 2 PVO: No Graded: Yes