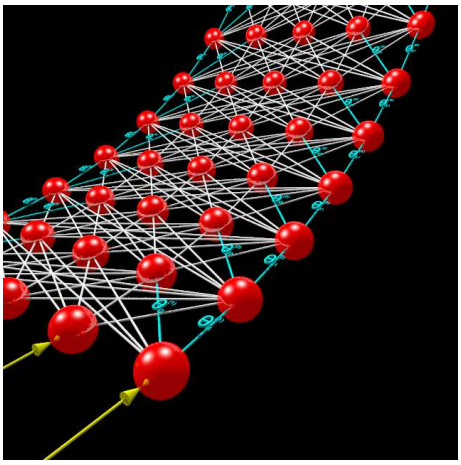
Seminar: Machine Learning



Teacher Education Mathematics – Bachelor Mathematics

Summer Term 2026

Weekly, Mondays 12:00–14:00

Instructor
Prof. Dr. Georg Sebastian Weiss

Content
This seminar provides a mathematically oriented introduction to core concepts of machine learning with a focus on neural networks. Rather than emphasizing implementation aspects, the seminar approaches machine learning from an analytical and structural perspective.
The seminar is based primarily on the following references:

- Christopher M. Bishop, *Deep Learning: Foundations and Concepts*, Cambridge University Press, 2024.
- J. Smets, *Mathematics of Neural Networks*, Lecture Notes, 2023.
  Available online at: `https://arxiv.org/abs/2403.04807`

The main topics of the seminar are:

- Single-layer networks (Bishop, Chapters 4–5; Smets, Section 1.3),
- Deep neural networks (Bishop, Chapter 6; Smets, Sections 1.2 and 2.1),
- Gradient descent methods (Bishop, Chapter 7),
- Backpropagation (Bishop, Chapter 8),
- Convolutional neural networks (Bishop, Chapter 10).

Summary
The aim of the seminar is to develop a rigorous mathematical understanding of neural networks as function classes and approximation operators. Training procedures such as gradient descent and backpropagation are studied from an analytical point of view. Special attention is given to the role of depth and convolutional structures in modern neural network architectures. Connections to analysis, optimization, and approximation theory are emphasized throughout the course.

Language
German or English

Prerequisites
Analysis I and Analysis II, Linear Algebra I and Linear Algebra II

Registration
Students interested in participating are asked to register via email:
`vera.theus@uni-due.de`