

MATHEMATICAL FOUNDATIONS OF MACHINE LEARNING

(NMAG469, FALL TERM 2024-2025)

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In Machine Learning one develops mathematical methods for modeling data structures, which express the dependency between observables, and designs efficient learning algorithms for estimation of such dependency. The most advanced part of Machine Learning is statistical learning theory that takes into account our incomplete information of observables, using probability theory, or preferably, using measure theory and functional analysis. In this way we not only unveil hidden structure of data but also make a prediction for the future. Machine learning techniques are applied in search engine, speech recognition and natural language processing, image detection, robotics etc. In our course we address the following questions: What is the mathematical model of learning? How to quantify the difficulty/hardness/complexity of a learning problem? How to choose a learning model and learning algorithm? How to measure success of machine learning?

The syllabus of our course:

1. Supervised learning, unsupervised learning, reinforcement learning.
2. Generalization ability of machine learning.
3. Support vector machine, Kernel machine.
4. Neural networks and deep learning.
5. Bayesian machine learning.

Recommended Literature.

1. S. Shalev-Shwartz, and S. Ben-David, Understanding Machine Learning: From Theory to Algorithms, Cambridge University Press, 2014.
2. M. Mohri, A. Rostamizadeh, A. Talwalkar, Foundations of Machine Learning, MIT Press, Second Edition 2018.
3. L. Deveroye, L. Györfi and G. Lugosi, A Probabilistic Theory of Pattern Recognition, Springer 1996.

Lecture notes shall be provided during each lecture. During the course we shall discuss topics for term paper assignment which could be qualified as the exam and more advanced topics for Master or PhD Thesis.

The first meeting shall take place at 10:40 AM Tuesday October 1, in the seminar room K358 MUUK.

Date: September 26, 2024.

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