Technische Universität München

Module Description

MA4801: Mathematical Foundations of Machine Learning

Department of Mathematics

Module level:	Language:	Module duration:	Occurrence:
Master	English	one semester	summer semester

Credits*:	Total number of hours:	Self-study hours:	Contact hours:
6	180	120	60

* The number of credits can vary depending on the corresponding SPO version. The valid number is always indicated on the Transcript of Records or the Performance Record.

Description of achievement and assessment methods:
The exam will be in written form (60 minutes). Students demonstrate that they have gained deeper knowledge of definitions and main tools and results of machine learning. The students are expected to be able to derive the methods, to explain their properties, and to apply them to specific examples.

Possibility of re-taking:
In the next semester: No
At the end of the semester: Yes

(Recommended) requirements:
MA0001 Analysis 1, MA0002 Analysis 2, MA0004 Linear Algebra 1, MA0005 Linear Algebra 2 and Discrete Structures, MA0009Introduction to Probability and Statistics, MA0003 Analysis 3, MA3001 Funktional Analysis.
Suggested optional: MA2012 Introduction to Optimization

Contents:
A Neural Networks
(1) the perceptron
(2) network architecture (feedforward networks)
(3) Kolmogorov superposition theorem
(4) backpropagation and learning algorithms
(5) approximation properties of different architectures
B Kernel Methods
(1) positive definite kernels
(2) Mercer kernels
(3) reproducing kernel Hilbert spaces
(4) regularization techniques and support vector machines
(5) representer theorem for the minimizer
(6) numerical algorithms for SVM's
C Qualitative Theory
(1) loss functions
(2) risk functionals
(3) empirical risk minimization
(4) bias-variance dilemma
(5) consitency
(6) complexity bounds

Study goals:
After successful completion of the module students are able to understand and apply the basic notions, concepts, and methods of mathine learning. They are able to construct and implement a neural network and to discuss ist approximation properties. They understood the theory of kernel methods in reproducing kernel Hilbert spaces, and they know how to apply it to provide nonlinear regression of data. They know how to assess the statistical efficiency of a machine learning method.

Teaching and learning methods:
lecture, exercise module

Media formats:
The following media are used:
- Blackboard
- Slides

Literature:
C.M. Bishop, Pattern Recognition and Machine Learning, Springer 2006.
D.J.C. MacKay, Information Theory, Inference, and Learning Algorithms, Cambridge Univ. Press 2003.
V.N. Vapnik, Statistical Learning Theory, Wiley 1998.
T. Hastie, R. Tibshirani, J. Fiedman, The Elements of Statistical Learning Theory, Springer 2009.

Responsible for the module:
Massopust, Peter; PD Ph.D.: massopust@mytum.de

Courses (Type, SH) Lecturer:

For further information about this module and its allocation to the curriculum see:
https://campus.tum.de/tumonline/wbModHb.wbShowMHBReadOnly?pKnotenNr=1198646

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