Machine Learning II

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Machine Learning for Computer Vision
TU Dresden

https://mlcv.cs.tu-dresden.de/courses/25-summer/ml2/

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Machine Learning II

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- Course consisting of
  - lectures in APB/E023/U on Mondays, 11:10–12:40
  - exercises in APB/E023/U on Tuesdays, 11:10–12:40, **starting April 22nd**
  - self-study
  - final examination (covering lectures and exercises).
- Registration:
  - All participating students need to register through OPAL
  - All participating students enrolled in the study program Computational Modeling and Simulation need to register additionally via SELMA.
- No recordings/reproductions of the lectures or exercises

Machine learning is a is a branch of computer science focused on the research and engineering of mathematical models and algorithms for analyzing, understanding and interpreting data, and for deciding and acting based on data.

Motivation for studying machine learning:

- poses challenging problems
- combines insights and methods from
  - mathematics (esp. optimization, probability theory, statistics)
  - computer science (esp. algorithms, complexity, software engineering)
- provides an opportunity for developing analytical and engineering skills
- has impact on applications (scientific, robotic, medical, consumer)
- develops dynamically

Machine Learning II

The elective course **Machine Learning II** focuses on a selection of specific topics:

1. Deep learning
   - Attention
   - Transformers
2. Partial optimality and ML
   - Mathematical foundations
   - Clustering
   - Ordering
   - Graphical model inference
3. Integer linear optimization and ML
   - Mathematical foundations
   - Clustering
   - Ordering
   - Graphical model inference
4. ML for biomedical image analysis
   - Classification and the CellMap Challenge
   - Clustering and image segmentation for connectomics
   - Quadratic assignment and the recognition of organoids

Prerequisites:

- Mathematics
  - Linear algebra
  - Multivariate calculus (basics)
  - Probability theory (basics)
- Computer Science
  - Algorithms and data structures (basics)
  - Theoretical computer science (basics of complexity theory)
  - Machine Learning I

Literature:

- Leading scholarly journals:
  - Journal of Machine Learning Research (JMLR)
  - Transactions on Machine Learning Research (TMLR)
  - Transactions on Pattern Analysis and Machine Intelligence (TPAMI)
- Leading academic conferences:
  - International Conference on Machine Learning (ICML)
  - Neural Information Processing Systems (NeurIPS)
  - International Conference on Learning Representations (ICLR)

https://mlcv.cs.tu-dresden.de/teaching.html

Related courses we are offering this term:

- Research Project Machine Learning
  INF-MA-PR and INF-PM-FPG
- Research Project Machine Learning (CMS)
  CMS-PRO
- Research Project Applied Machine Learning
  INF-MA-PR and INF-PM-FPA

Notation:

- For any $m \in \mathbb{N}$, $m = \{0, \dots, m-1\}$.
- For any finite set A, let $|A|$ denote the number of elements of A.
- For any set A, let 2^A denote the power set of A.
- For any set A and any $m \in \mathbb{N}$, let $\binom{A}{m}$ denote the set of all m-elementary subsets of A, that is, $\binom{A}{m} = \{B \in 2^A \colon |B| = m\}$.
- For any sets A, B, let B^A denote the set of all maps from A to B.
- For any $f \in B^A$, any $a \in A$ and any $b \in B$, we may write $b = f(a)$ or $b = f_a$ instead of $(a, b) \in f$
- Let $\langle \cdot, \cdot \rangle$ denote the standard inner product, and let $\| \cdot \|$ denote the l_2-norm.
- Given any set J and, for any $j \in J$, a set S_j, we denote by $\prod_{j \in J} S_j$ the Cartesian product of the family $\{S_j\}_{j \in J}$, i.e.

$$\prod_{j \in J} S_j = \left\{ f \colon J \to \bigcup_{j \in J} S_j \;\middle|\; \forall j \in J \colon f(j) \in S_j \right\} \quad .$$