Machine Learning I

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Machine Learning for Computer Vision
TU Dresden

https://mlcv.cs.tu-dresden.de/courses/24-winter/ml1/

Winter Term 2024/2025

Machine Learning I

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- Course consisting of
  - lectures in TRE/PHYS/E on Fridays, 9:20–10:50
  - exercise groups starting October 21st

In VMB/0302/U	on Tuesdays, 16:40–18:10
In APB/E001/U	on Thursdays, 16:40–18:10
In APB/E001/U	on Fridays, 14:50–16:20
In APB/E001/U	on Fridays, 16:40–18:10
Online	on Wednesdays, 9:20–10:50

  - 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 CampusNet.
- No recordings/reproductions of the lectures or exercises!

Machine Learning is a is a field within 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.

The introductory course **Machine Learning I** focuses on machine learning *problems* and *algorithms*:

Supervised learning
- Decision trees
- Linear functions
- Composite functions (i.e. Deep Learning)
- Embedding

Unsupervised learning
- Partitioning
- Clustering
- Ordering

Structured learning
- Graphical models

Prerequisites:

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

- Textbooks:
  - Kevin P. Murphy. Machine Learning: A Probabilistic Perspective. MIT Press 2012
  - Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, Jonathan Taylor. An Introduction to Statistical Learning. Springer 2023
  - Christopher M. Bishop, Hugh Bishop. Deep Learning: Foundations and Concepts. Springer 2024
  - Marc Peter Deisenroth. Mathematics for Machine Learning. Cambridge University Press 2020
- Leading scholarly journal:
  - Journal of Machine Learning Research (JMLR)
  - 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)

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 applying analytical and engineering skills
- has impact on applications (scientific, medical, robotic, consumer)
- offers excellent career opportunities
- grows dynamically

Machine Learning I

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

Related courses we are offering this term:

- *Lecture Computer Vision I*
- *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.

$$\prod_{j \in J} S_j = \left\{ f \colon J \to \bigcup_{j \in J} S_j \;\middle|\; \forall j \in J \colon f(j) \in S_j \right\} \tag{1}$$