

Computer Vision I

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Machine Learning for Computer Vision
TU Dresden



<https://mlcv.cs.tu-dresden.de/courses/26-winter/cv1/>

Winter Term 2026/2027

Computer Vision I



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- ▶ Course consisting of
 - ▶ lectures in HSZ/AUDI/H on Mondays, 11:10–12:40
 - ▶ exercise group sessions with David Stein **starting this week**
 - in SCH/A251 on Tuesdays, 13:00–14:30
 - in HSZ/0002/E on Thursdays, 13:00–14:30
 - ▶ self-study
 - ▶ final examination (covering lectures and exercises).
- ▶ Course registration:
 - ▶ All participating students need to register through OPAL
 - ▶ Additional rules for registration may apply, depending on the study program.
- ▶ No recordings/reproductions of the lectures or exercises!

Computer Vision is an area of computer science devoted to the research of mathematical models, algorithms, software, and systems for analyzing and interpreting visual data (images, volume images, videos, point clouds, etc.). It

- ▶ poses challenging problems
- ▶ combines insights and methods from multiple disciplines
 - ▶ mathematics (esp. optimization, probability theory, statistics)
 - ▶ computer science (esp. algorithms, complexity, software engineering)
 - ▶ engineering (optical, electrical, mechanical)
- ▶ provides an opportunity for applying analytical and engineering skills
- ▶ typically yields visual results
- ▶ has impact on applications (scientific, medical, robotic, consumer, etc.)

Operators on digital images

- ▶ Digital images
- ▶ Point operators
- ▶ Linear operators
- ▶ Non-linear operators, including edge and corner detection

Machine learning for computer vision

- ▶ Logistic regression
- ▶ Deep learning for computer vision
- ▶ Attention and transformers for computer vision

Classification of digital images

- ▶ Classification of digital images and image patches
- ▶ Supervised learning and inference

Segmentation of digital images

- ▶ Image segmentation
- ▶ Semantic segmentation

Object recognition in digital images

- ▶ Single object recognition
- ▶ Multiple object recognition

Object tracking in digital images

- ▶ Single object tracking
- ▶ Multiple object tracking

Embedding of digital images

- ▶ Principal component analysis
- ▶ Auto-encoders
- ▶ Variational auto-encoders

Mathematical foundations

(Exercise Sessions 1–2!)

- ▶ Basic linear optimization for computer vision
- ▶ Basic integer linear optimization for computer vision

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► Textbooks:

- Torralba A., Isola P. and Freeman. W. T. *Foundations of Computer Vision*, 2024, MIT Press.
- Szeliski, R. *Computer Vision: Algorithms and Applications*, 2nd ed., 2020, available online at <http://szeliski.org/Book/>

► Scholarly journals:

- Transactions on Pattern Analysis and Machine Intelligence (TPAMI)
- International Journal on Computer Vision (IJCV)
- Journal on Mathematical Imaging and Vision (JMIV)
- Journal on Machine Learning Research (JMLR)

► Academic conferences:

- Computer Vision and Pattern Recognition (CVPR)
- International Conference on Computer Vision (ICCV)
- European Conference on Computer Vision (ECCV)
- International Conference on Machine Learning (ICML)
- Neural Information Processing Systems (NeurIPS)
- International Conference on Learning Representations (ICLR)

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<https://mlcv.cs.tu-dresden.de/courses/26-winter/ml1/index.html>

Related course we teach:

- ▶ **Machine Learning I** in TRE/PHYS/E on Fridays, 9:20–10:50

Basic mathematical notation:

- ▶ 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 , i.e., the set of all subsets of A .
- ▶ For any set A and any $m \in \mathbb{N}_0$, let $\binom{A}{m}$ denote the set of all subsets of A with precisely m elements.
- ▶ For any sets A, B , let AB be shorthand for the ordered pair (A, B) .
- ▶ 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 $ab \in f$.
- ▶ For any $f \in B^A$ and any $U \subseteq A$, let $f|_U := f \cap (U \times B)$, i.e., the restriction of f to the domain U .
- ▶ Let $\langle \cdot, \cdot \rangle$ denote the standard inner product, and let $\| \cdot \|$ denote the l_2 -norm.
- ▶ We identify any $m \in \mathbb{N}$ with the set $m = \{0, \dots, m-1\}$. In particular, we may write $j \in m$ instead of $j \in \{0, \dots, m-1\}$.