

# Course introduction

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Moritz Wolter

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High-Performance Computing and Analytics Lab, Universität Bonn

# Overview

Organization

Machine Learning Applications

Course Contents

# Organization

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# Who are we?

## Instructors

- Elena Trunz, Postdoc with the Visual Computing Group
  - [trunz@cs.uni-bonn.de](mailto:trunz@cs.uni-bonn.de)
- Moritz Wolter, Postdoc with the HPCA Lab
  - [moritz.wolter@uni-bonn.de](mailto:moritz.wolter@uni-bonn.de)

## Teaching Assistants:

- Pauline Lion, Bachelor student Computer Science
- Konstantin Gasenzer, Master student Computer Science
- Zahra Ganji, Master student Computer Science
- Lokesh Veeramacheneni, Ph.D. student with the HPCA Lab.

# Course Material

- We will upload Github-Classroom links, Lecture recordings and slides onto Ecampus.
  - <https://ecampus.uni-bonn.de/>
  - To access eCampus, you need a UnilD → helpdesk HRZ.
- You can opt out of GitHub use. We provide zip files via Ecampus.
- We envision a hands-on course experience.
- You should be able to gain an intuition for modern machine learning algorithms and possible applications.
- Many exercises come with unit tests, which allow you to check your work.

We will archive the GitHub Classroom in approximately one year.  
You should still be able to access your material afterward. It's  
probably a good idea to create your own copy.

# Course Philosophy

- Understand key methods
- and use these.
- Understand resource needs.
- Adopt best practices.

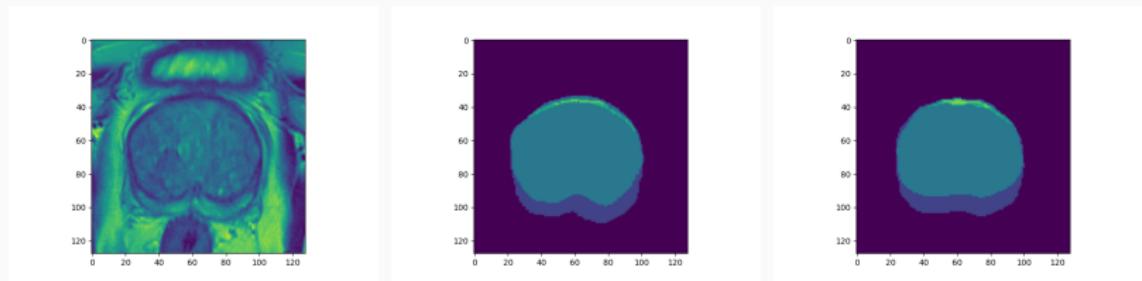
# Machine Learning Applications

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# Machine learning is everywhere

- Image processing
- Protein structure prediction
- Language processing
- Virtual personal assistants
- Fraud detection
- Autonomous robots
- Recommendation systems
- Photo editing
- ...

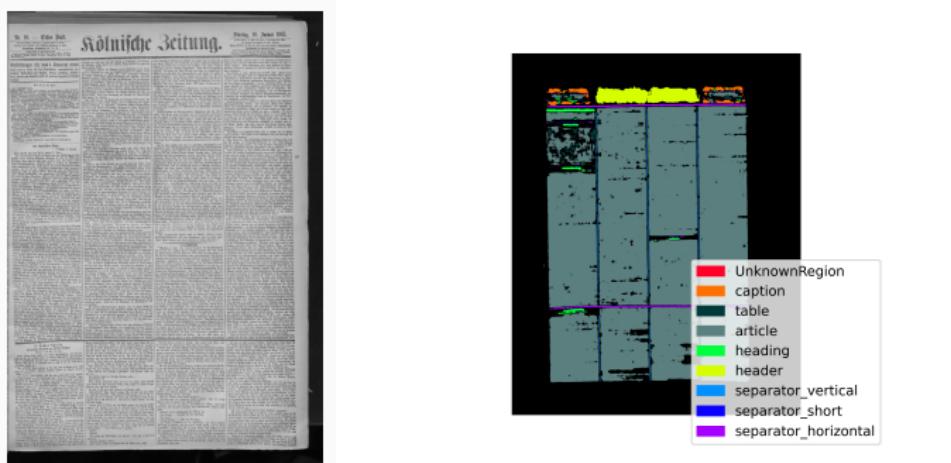
## Example: Medical image processing



**Figure:** A prostate (left) with expert (center) and network (right) annotation.

We thank Barbara Wichtmann for bringing this problem to our attention.

## Example: Processing of historical newspapers



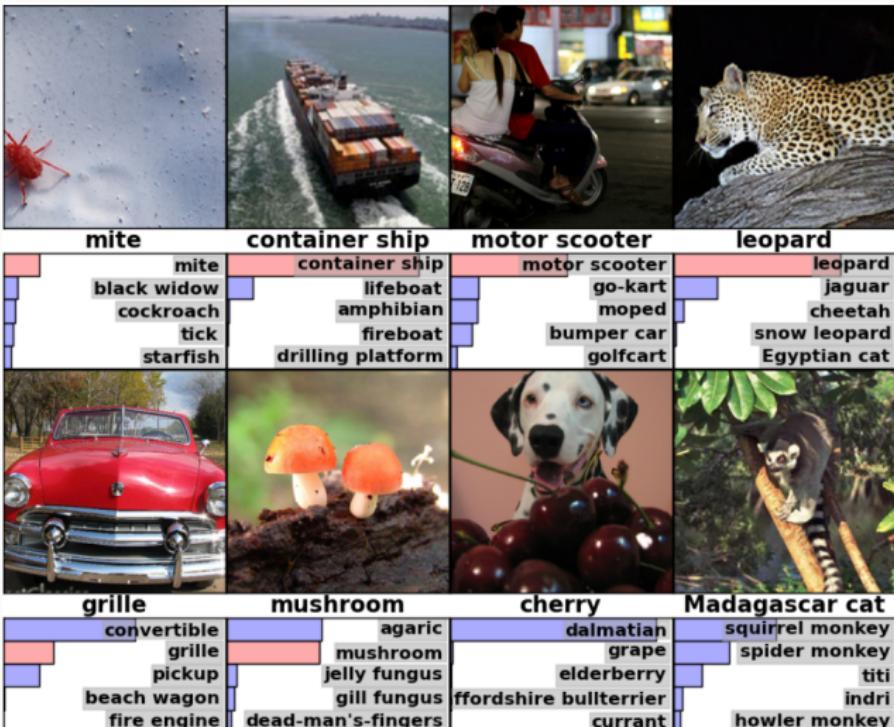
**Figure:** An old newspaper page and its network segmentation.

We thank Felix Selgert for bringing this problem to our attention.

# Stilization [GEB16]



# Image Classification [KSH12]



# Image Captioning [Liu+23]

## Visual input example, Constrained JSON Output:



User

Please read the text in this image and return the information in the following JSON format (note xxx is placeholder, if the information is not available in the image, put "N/A" instead).

```
{"class": xxx, "DLN": xxx, "DOB": xxx, "Name": xxx, "Address": xxx, "EXP": xxx, "ISS": xxx, "SEX": xxx, "HGT": xxx, "WGT": xxx, "EYES": xxx, "HAIR": xxx, "DONOR": xxx}
```

GPT-4V

```
{"class": "C", "DLN": "1234568", "DOB": "08/31/1977", "Name": "Ima Cardholder", "Address": "2570 24th Street, Anytown, CA 95818", "EXP": "08/31/2014", "ISS": "08/31/2011", "SEX": "F", "HGT": "5-05", "WGT": "125 lbs", "EYES": "BRN", "HAIR": "BRN", "DONOR": "VETERAN"}
```

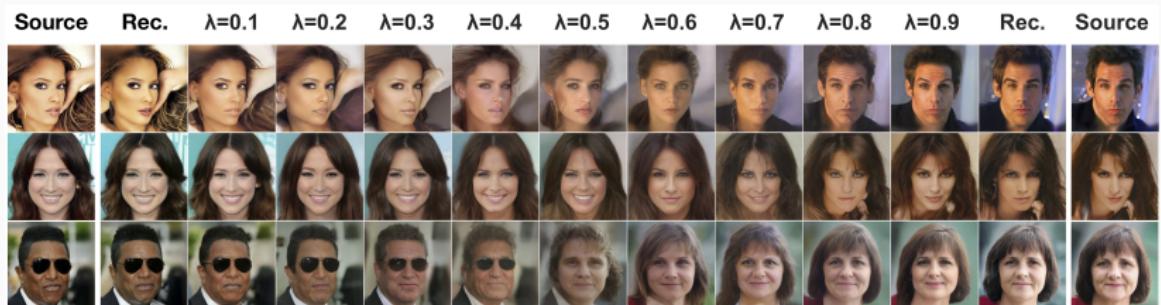
LLaVA

```
{"class": "Driver License", "DLN": "CA123 456 789", "DOB": "01/01/1990", "Name": "Amy", "Address": "Anytown, CA", "EXP": "08/31/2023", "ISS": "Veteran", "SEX": "F", "HGT": "5'5", "WGT": "130", "EYES": "Brown", "HAIR": "Brown", "DONOR": "Unknown"}
```

LLaVA-  
1.5

```
{"class": "C", "DLN": "1132456789", "DOB": "08/23/1971", "Name": "Ima Cardholder", "Address": "Anytown, State, Zip", "EXP": "08/23/2014", "ISS": "California", "SEX": "F", "HGT": "5'5", "WGT": "123", "EYES": "Brown", "HAIR": "Brown", "DONOR": "N/A"}
```

# Media Synthesis [HJA20]



## Course Contents

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# Course Outline

- Mathematical foundations, based on [DFO20]
  - Day 1, Introduction, Optimization.
  - Day 2, Linear Algebra, Statistics
- Foundations of machine learning, based on [DFO20]
  - Classic Methods
  - Support Vector Machines and Principal Component Analysis
- Deep learning, based on [GBC16]
  - Convolutional neural networks (CNN) for image classification
  - CNN for image segmentation

## Bonn transdisziplinäre Ausbildung in künstlicher Intelligenz Bonn transdisciplinary training in artificial intelligence

- We offer interdisciplinary machine learning projects.
- With CS-department: project groups/ labs, Bachelor or Master Thesis projects.

Website: <https://trainee.informatik.uni-bonn.de/>

Contact:

- Elena Trunz: [trunz@cs.uni-bonn.de](mailto:trunz@cs.uni-bonn.de)
- Moritz Wolter: [moritz.wolter@uni-bonn.de](mailto:moritz.wolter@uni-bonn.de)

We offer new projects at the start of each semester.

## References

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- [DFO20] Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong. *Mathematics for Machine Learning*. <https://mml-book.com>. Cambridge University Press, 2020. DOI: 10.1017/9781108679930.
- [GEB16] Leon A Gatys, Alexander S Ecker, and Matthias Bethge. “Image style transfer using convolutional neural networks.” In: *Proceedings of the IEEE conference on computer vision and pattern recognition*. 2016, pp. 2414–2423.

- [GBC16] Ian Goodfellow, Yoshua Bengio, and Aaron Courville.  
*Deep Learning*. <http://www.deeplearningbook.org>.  
MIT Press, 2016.
- [HJA20] Jonathan Ho, Ajay Jain, and Pieter Abbeel. “Denoising  
Diffusion Probabilistic Models.” In: *arXiv preprint  
arxiv:2006.11239* (2020).

## Literature iii

- [KSH12] Alex Krizhevsky, Ilya Sutskever, and Geoffrey E. Hinton.  
“ImageNet Classification with Deep Convolutional  
Neural Networks.” In: *Advances in Neural Information  
Processing Systems 25: 26th Annual Conference on  
Neural Information Processing Systems 2012.*  
*Proceedings of a meeting held December 3-6, 2012,  
Lake Tahoe, Nevada, United States.* Ed. by  
Peter L. Bartlett, Fernando C. N. Pereira,  
Christopher J. C. Burges, Léon Bottou, and  
Kilian Q. Weinberger. 2012, pp. 1106–1114. URL:  
[https://proceedings.neurips.cc/paper/2012/  
hash/c399862d3b9d6b76c8436e924a68c45b-  
Abstract.html](https://proceedings.neurips.cc/paper/2012/hash/c399862d3b9d6b76c8436e924a68c45b-Abstract.html).

- [Liu+23] Haotian Liu, Chunyuan Li, Qingyang Wu, and Yong Jae Lee. “Visual instruction tuning.” In: *arXiv preprint arXiv:2304.08485* (2023).