FRIEDRICH-ALEXANDER-
UNIVERSITÄT
ERLANGEN-NÜRNBERG

SCHOOL OF ENGINEERING

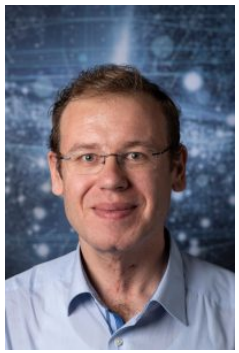
Numpy Tutorial

F. Thamm, Z. Yang, K. Breininger, S. Jaganathan, C. Liu, L. Rist, N. Maul, L. Folle, N. Gourmelon, Z. Pan, B. Geissler, S. Sun, M. Vornehm, J. Wolf, E. Wittmann, W. Karbole

Pattern Recognition Lab, Friedrich-Alexander University of Erlangen-Nürnberg

April 11, 2021

Who are we? - Lab Members



Andreas Maier

Katharina Breininger

Zijin Yang

Srikrishna Jaganathan

Chang Liu

Leonhard Rist

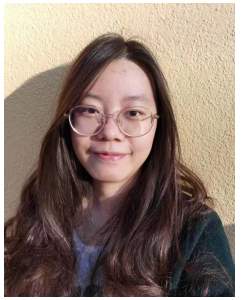
Vincent Christlein

Florian Thamm

Noah Maul

Lukas Folle

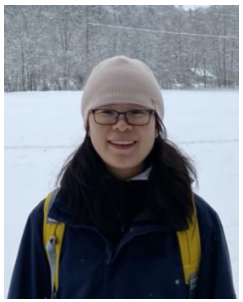
Nora Gourmelon



Zhaoya Pan

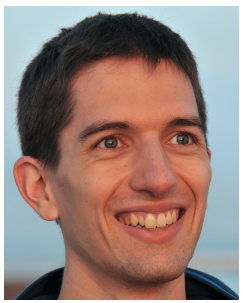
Who are we? - Student Members

Benjamin Geissler



Susu Sun

Ernst Wittmann



Marc Vornehm

Wenke Karbole

Jannis Wolf

Organisation

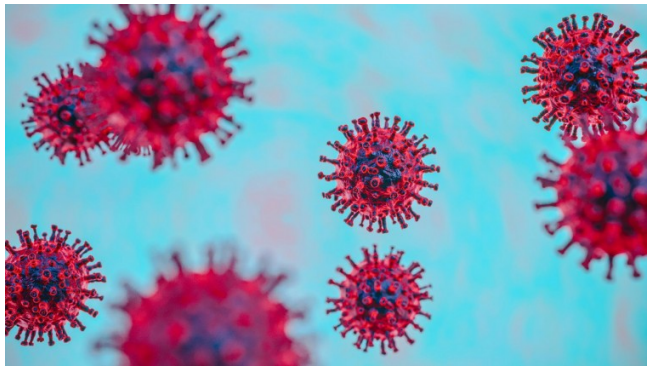
Contact us ...

- in StudOn
- via the tutors mailing list: `cs5-deep-tutors@lists.fau.de`
- in MS Teams

Important: Don't hesitate to ask questions/give comments!

Covid-19 - Online teaching

- Exercise will be online until further notice
- Guide in StudOn $\rightarrow$ **READ IT!**
- We will use MS Teams (caution: link in German)
  - Team activation in IDM required!
  - "General" channel for general questions and comments
  - "Private" channel for each exercise day
  - Direct support during exercise hours can be requested in resp. channel



Important: Feedback and suggestions very welcome!

Super important: Read the Covd Guide in StudOn!

Even more important: Stay healthy!

Semester plan

- Five exercises:
  0. Python + Numpy Recap and Data Generation
  1. Fully Connected Networks
  2. CNNs and Optimization
  3. Regularization and Recurrent Neural Networks
  4. Image Classification with PyTorch
- Platform: MS Teams

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- Five exercises:
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  1. Fully Connected Networks
  2. CNNs and Optimization
  3. Regularization and Recurrent Neural Networks
  4. Image Classification with PyTorch
- Platform: MS Teams
- Materials available in StudOn
- Each exercise takes 2-4 weeks, overlap between assignments
  $\rightarrow$ start early, submit early
- Bonus points for exam up to 10%. Unittests coverage determines your bonus points.
- Written exam (mock exam available in StudOn)

Submission

- Group submission possible - pairs of two
  $\rightarrow$ “Finding Group Partners" channel in **MS Teams**
- Personal submission only
- We prioritize the requests, have a look into our online course guide at StudOn
- **Required to get the bonus points**
- Explain your code (screen sharing)
- Upload your code to StudOn
- Mind the deadlines !!! $\rightarrow$ please use the provided script (*dispatch.py*) to prepare your upload

No Plagiarism!

- Plagiarism is strictly forbidden
- We will check that with plagiarism software!

Verteilung - Exercise 4: AlexNet and ResNet in TF / AlexNet and ResNet

90% - 100%	1	#
80% - 90%	2	#
70% - 80%	13	##
60% - 70%	61	##########
50% - 60%	172	##############################
40% - 50%	245	##
30% - 40%	421	##
20% - 30%	314	##
10% - 20%	46	########
0% - 10%	0	.

Gruppierte Übereinstimmungen (90% - 100%)

[redacted] [redacted] 97,23%

Exercise Setup

First part:

Build a neural network from scratch using test based development

- Implementation task is defined by **description** and **unit tests**
- No skeletons
- Every function and structure is built as a layer

  $\rightarrow$ As a class in its own file

  $\rightarrow$ Mandatory functions **__init__()**, **forward()**, **backward()**
- Unit tests help to expose bugs and errors

  $\rightarrow$ Tested and debugged with python3

Second part:

Build some common neural networks with PyTorch

- Some functionality provided
- No exhaustive unit tests

PyTorch

Schedule

Week (-holiday)	Handout	Deadline
12.04 - 16.04	Handout Ex.0	
19.04 - 23.04		
26.04 - 30.04	Handout Ex.1	Deadline Ex.0
03.05 - 07.05		
10.05 - 14.05 (-13.05)	Handout Ex.2	Deadline Ex.1
17.05 - 21.05		
24.05 - 28.05 (-24.05)		
31.05 - 04.06 (-03.06)	Handout Ex.3	Deadline Ex.2
07.06 - 11.06		
14.06 - 18.06		
21.06 - 25.06	Handout Ex.4	Deadline Ex.3
28.06 - 02.07		
05.07 - 09.07		
12.07 - 16.07		Deadline Ex.4

Bonus Points System

- Exercises contribute to max. 10% of bonus for the final exam
- Unittest coverage corresponds to bonus points
  → Each exercise consists of several TestCases
  → TestCases subdivide the bonus points
  → Each TestCase consist of several unittests
  → **All** unittests of one TestCase must pass to get the respective bonus
- The percentages correlate to effort and difficulty → but also the small bonuses add up
- The unittest files can compute the points for you → have a look in the description
- Be aware, some TestCases depend on others
  → It's impossible to test a neural network without having its layers first
- You only get the bonus if you submit in time! **Mind the deadlines!**

Bonus Points - Ex0

- Ex0 (1% in Exam)
  - (10%) TestCircle
  - (10%) TestSpectrum
  - (10%) TestChecker
  - (70%) TestGen
- Percentage next to Ex0 represents the bonus points in the exam (here 1%)
- E.g., TestCircle contributes with 10% to the 1% (resulting in 0.1% for the exam)
- TestGen seems important with 70% and hence causes the most effort
- TestGen contains also more unittests than the others.

Bonus Points Distribution

- Ex1 (1.5% in exam)
  - (45%) TestFullyConnected1
  - (5%) TestReLU
  - (10%) TestSoftMax
  - (10%) TestCrossEntropy
  - (5%) TestOptimizers1
  - (25%) TestNeuralNetwork1 [1]
- Ex2 (3% in exam)
  - (45%) TestConv [2,3,4]
  - (15%) TestPooling [3]
  - (2%) TestFlatten
  - (5%) TestInitialization
  - (8%) TestOptimizers2 [0]
  - (2%) TestFullyConnected2 [0]
  - (23%) TestNeuralNetwork2 [0, 1]

Bonus Points Distribution

- Ex0 (1% in exam)
- Ex1 (1.5% in exam)
- Ex2 (3% in exam)
- Ex3 (3% in exam)
  - (2.5%) TestSigmoid
  - (2.5%) TestTanH
  - (5%) TestConstraints [2, 5]
  - (5%) TestDropout
  - (25%) TestBatchNorm [2, 3, 4, 6]
  - (40%) TestRNN [2, 4, 6]
  - (20%) TestNeuralNetwork3 [0, 1]
- Ex4 (1.5% in exam)
  - All Tests + Leaderboard 0.6

Bonus Points - Dependencies

- [0] requires its predecessor (e.g. TestOptimizers1 requires TestOptimizers1)
- [1] requires all tests of current exercise
- [2] requires TestOptimizers1
- [3] requires TestFlatten
- [4] requires TestInitialization
- [5] requires TestOptimizers2
- [6] requires TestFullyConnected1

Bonus Points - Recommendation

Our recommmendation:

Do them all! Why?

1. You do not get confused by dependencies (it's easier to keep an overview if you do them all)
2. It is easier to get used to the framework if you do everything
3. You get the maximum of bonus points - 10% (tentatively two grades).
4. We will cover content for the exam - thus highly relevant!
5. If you complete 100% of all tests, means you get all possible bonus points, we will **honor you with an award**! (you can put into your CV)

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Python Overview

About Python...

- Programming language with good readability
- Interpreted scripting language

  $\rightarrow$ Relies on the call of libraries written in lower-level programming languages

  $\rightarrow$ Basic programming semantics exist but are very inefficient
- Huge amount of libraries for all sorts of applications

About Numpy...

- Essential python package
- Central object: Numpy array
  $\rightarrow$ Acts like a matrix/vector
  $\rightarrow$ Enables all sorts of mathematical operations
  $\rightarrow$ Optimised for speed
- A cheat sheet with handy functions for this exercise can be found in the StudOn group

About Scipy...

- Python package closely linked to numpy
- Provides additional functionality
  $\rightarrow$ Signal processing
  $\rightarrow$ Statistical operations

Recommendations

Package Manager (not needed in CIPs)

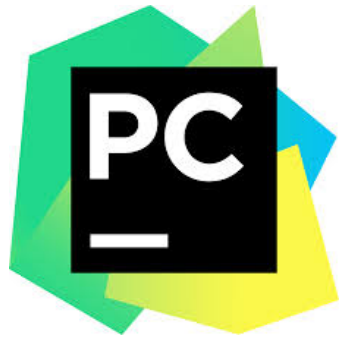
We recommend **Anaconda** (Windows)

- Open source
- One click installation
- Also installs python
- Easy handling of virtual environments

IDE

We recommend **PyCharm**

- Open source
- Easy package handling
- Debugging possibilities
- Free licenses for professional version for students



One alternative: Visual Studio Code with Live Share Plugin (allows remote pair programming)

Version Control

We recommend using GitLab!

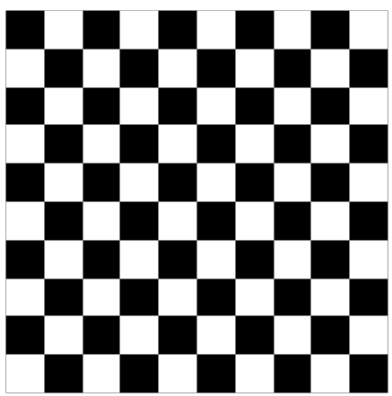
- Please use the university's gitlab server: https://gitlab.cs.fau.de/
- Perfect for co-working
- Compare your code with old versions
- Please use **private projects**! You can add your study partner as additional developer.

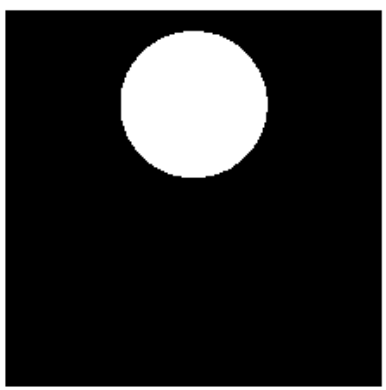
Today's Exercise

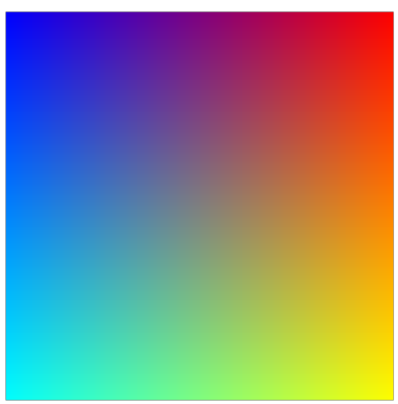
1st Task

Use basic numpy functions to create

- A binary checkerboard pattern
- A binary circle
- An RGB color spectrum







2nd Task

Use numpy to implement an image generator class which enables data augmentation.

- The generator yields so called batches (subsets of the training data) in an iterative manner.
- Batch in this context means a set of images, which are returned at once (by calling "next").
- These batches of images must be returned together with their corresponding labels.
- It returns batches until no training samples are left. That is also known as one epoch.

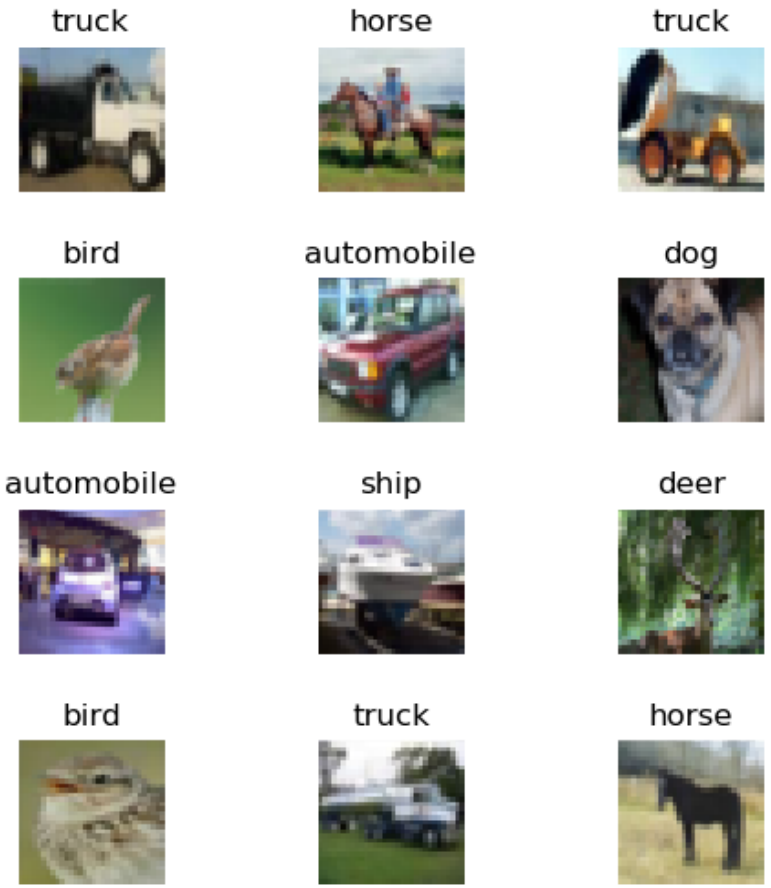


Figure: Example image generator output.

Get Started

- Open the IDE of your choice
- If you want to use PyCharm in the CIP:
  type **module load pycharm-community** into the console and open it by typing **pycharm**
- Follow the instructions of the exercise sheet
- Implement the tasks

Thanks for listening.

Any questions?