



FRIEDRICH-ALEXANDER-
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SCHOOL OF ENGINEERING

Numpy Tutorial

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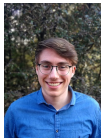
Who are we? - Lab Members



Andreas
Maier



Zijin
Yang



Leonhard
Rist



Merlin
Nau



Srikrishna
Jaganathan



Alexander
Barnhill



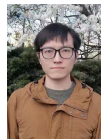
Kai
Packhäuser



Noah
Maul



Mathias
Zinnen



Chang
Liu



Lukas
Folle

Who are we? - Student Members



Paul
Zech



Chengze
Ye



Anna-Sophie
Stephan



Leyi
Tang



Enk
Johannes



Pietro
Foti



Jingyi
Yao



Mohammad
Shanur
Rahman



Karlo Gabriel
Fonseca
Yakovenko



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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
- **Follow the Guide in StudOn**
 - You can also find all information under [Organisational_concepts](#) in StudOn homepage
- 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 are most welcome!

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:
 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
- Materials available in StudOn
- Each exercise takes 2-4 weeks → 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
→ "Finding Group Partners" channel in **MS Teams**
- Personal submission only
- We prioritize the requests, have a look into our online course guide at StudOn
→ Organisational_concepts/03 – MS Teams
- **Required to get the bonus points**
- Explain your code (screen sharing)
- Upload your code to StudOn
- Mind the deadlines !!! → 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%)

	97,23%



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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
 - As a class in its own file
 - Mandatory functions **`__init__()`**, **`forward()`**, **`backward()`**
- Unit tests help to expose bugs and errors
 - Tested and debugged with python3

Second part:

Build some common neural networks with PyTorch

- Some functionality provided
- No exhaustive unit tests

 PyTorch



Schedule

Week	Event
17.10 - 21.10	Handout all exercises
07.11 - 11.11	Deadline Ex.0
21.11 - 25.11	Deadline Ex.1
12.12 - 16.12	Deadline Ex.2
16.01.2023 - 20.01.2023	Deadline Ex.3
06.02.2023 - 10.02.2023	Deadline Ex.4

A detailed time table could be found in StudOn with lecture suggestions
→ Organisational_concepts/05 – Time table

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 recommendation:

Do them all! Why?

1. You do not get confused by dependencies (it's easier to keep an overview if you do them all)

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3. You get the maximum of bonus points - 10% (tentatively two grades).

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4. We will cover content for the exam - thus highly relevant!

Bonus Points - Recommendation

Our recommendation:

Do them all! Why?

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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. Perform way better in the exam

Bonus Points - Recommendation (cont.)

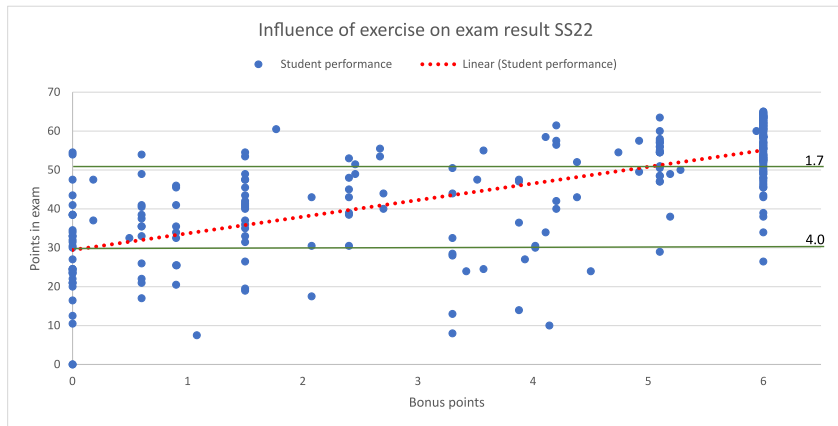


Figure: performance of 267 students from SS22. Students who completed all exercises perform much better than students who haven't completed the exercises



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Python Overview



About Python...

- Programming language with good readability
- Interpreted scripting language
 - Relies on the call of libraries written in lower-level programming languages
 - 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
 - Acts like a matrix/vector
 - Enables all sorts of mathematical operations
 - 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
 - Signal processing
 - Statistical operations





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Recommendations



Package Manager (not needed in CIPs)

We recommend **Anaconda** (Windows)

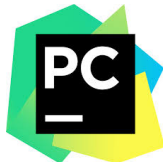
- Open source
- One click installation
- Also installs python
- Easy handling of virtual environments



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.



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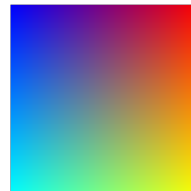
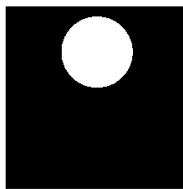
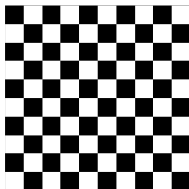
Today's Exercise



1st Task

Use basic numpy functions to create

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



2nd Task

Often it is not possible or desired to train your neural network on the whole data set at once. → Divide your data into smaller portions.

Use numpy to implement an image generator class which also 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. One pass through the whole data set is also known as one epoch.

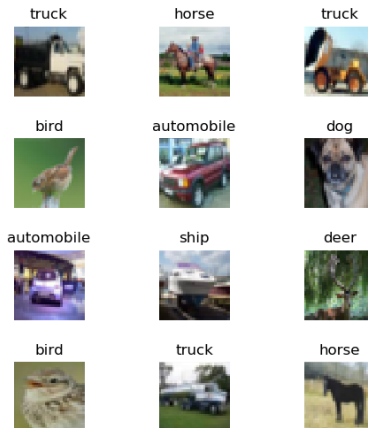


Figure: Example image generator output.

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?