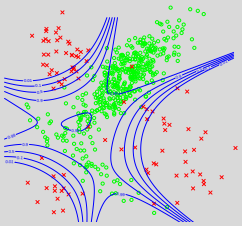
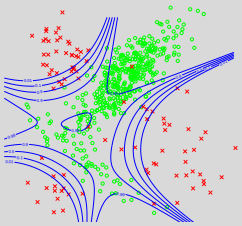


Data Competency Courses: Neural Networks and Deep Learning Introduction

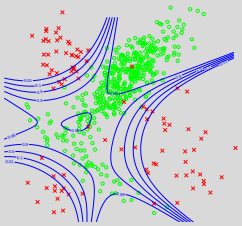
Lecture *Machine Learning* vom 29-31.3.2023

Felix Becker
(material in collaboration with Lars Gabriel and Mario Stanke)
Institut für Mathematik und Informatik
Universität Greifswald



Administratives

- Time frame: 9:00-16:00 from march 29th to 31th
- Lunch break: ∼12:00-13:00
- Course material (slides, code, data sets, ...):
  - `https://github.com/DataCompetency/KI-Block`
  - `https://moodle.uni-greifswald.de/course/view.php?id=5405`
- Questions and feedback outside of the course (moodle forum):
  - `https://moodle.uni-greifswald.de/mod/forum/view.php?id=146549`
- AppHub Uni Greifswald:
  - `https://apphub.wolke.uni-greifswald.de/`
- Course instructors: Felix Becker (Days 1-2.5), Stefan Simm (Day 2.5-3)



Prerequisites

- Connection to the network of the University of Greifswald
- Basic programming skills in any language
- Basic calculus and linear algebra (derivation, matrix multiplication)

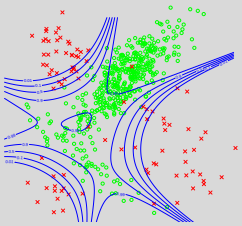
$$\nabla E(\theta) = \left(\frac{\partial E(\theta)}{\partial \theta_0}, \cdots, \frac{\partial E(\theta)}{\partial \theta_n}\right)^T, \quad \begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix} \cdot \begin{pmatrix} 3 & 2 & 1 \\ 4 & 1 & 0 \end{pmatrix} = \begin{pmatrix} 11 & 4 & 1 \\ 25 & 10 & 3 \\ 39 & 16 & 5 \end{pmatrix}$$

- Familiarity with numpy syntax

```
[1]: import numpy as np

[3]: A = np.array([[1,2],[3,4],[5,6]])
     B = np.array([[3,2,1],[4,1,0]])
     C = np.matmul(A,B)
     C

[3]: array([[11,  4,  1],
            [25, 10,  3],
            [39, 16,  5]])
```



However, don't worry too much about your mathematical background...

I strongly believe that there are no difficult ideas in deep learning.
(...) machine learning, and especially deep learning, exhibits comparatively little mathematical theory—maybe too little—and is engineering oriented.

François Chollet (Creator of the keras deep learning library), Deep Learning with Python

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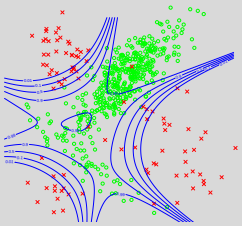


Natural Language Processing, Generative pre-trained transformer (GPT)

F What would be a cool introduction in a machine learning course?

Here's a potential cool introduction to a machine learning course:

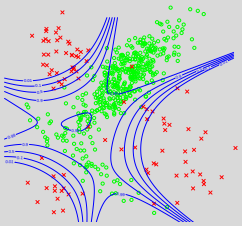
"Welcome to the exciting world of machine learning! In this course, we will explore the cutting-edge techniques that enable computers to learn from data and make predictions. With machine learning, we can analyze vast amounts of information, uncover hidden patterns, and create intelligent systems that can automatically improve themselves over time.

Machine learning is powering many of today's most innovative technologies, from self-driving cars and virtual assistants to personalized medicine and fraud detection. And the demand for skilled machine learning professionals is growing every day, as businesses across industries seek to leverage the power of this transformative technology.

Whether you're interested in pursuing a career in data science, robotics, or artificial intelligence, this course will provide you with a strong foundation in the fundamentals of machine learning. So let's get started and explore the exciting world of machine learning together!"

- *GPT-3*[1]: Task-agnostic language model with 175 billion parameters
- Recently *GPT-4*: Multimodal model with probably even more parameters

[1] Language Models are Few-Shot Learners, Brown et al., 2020



Text-to-image models

Image Credits: Stability AI

- Generate an image from a text prompt

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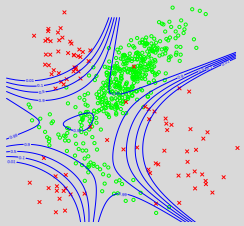
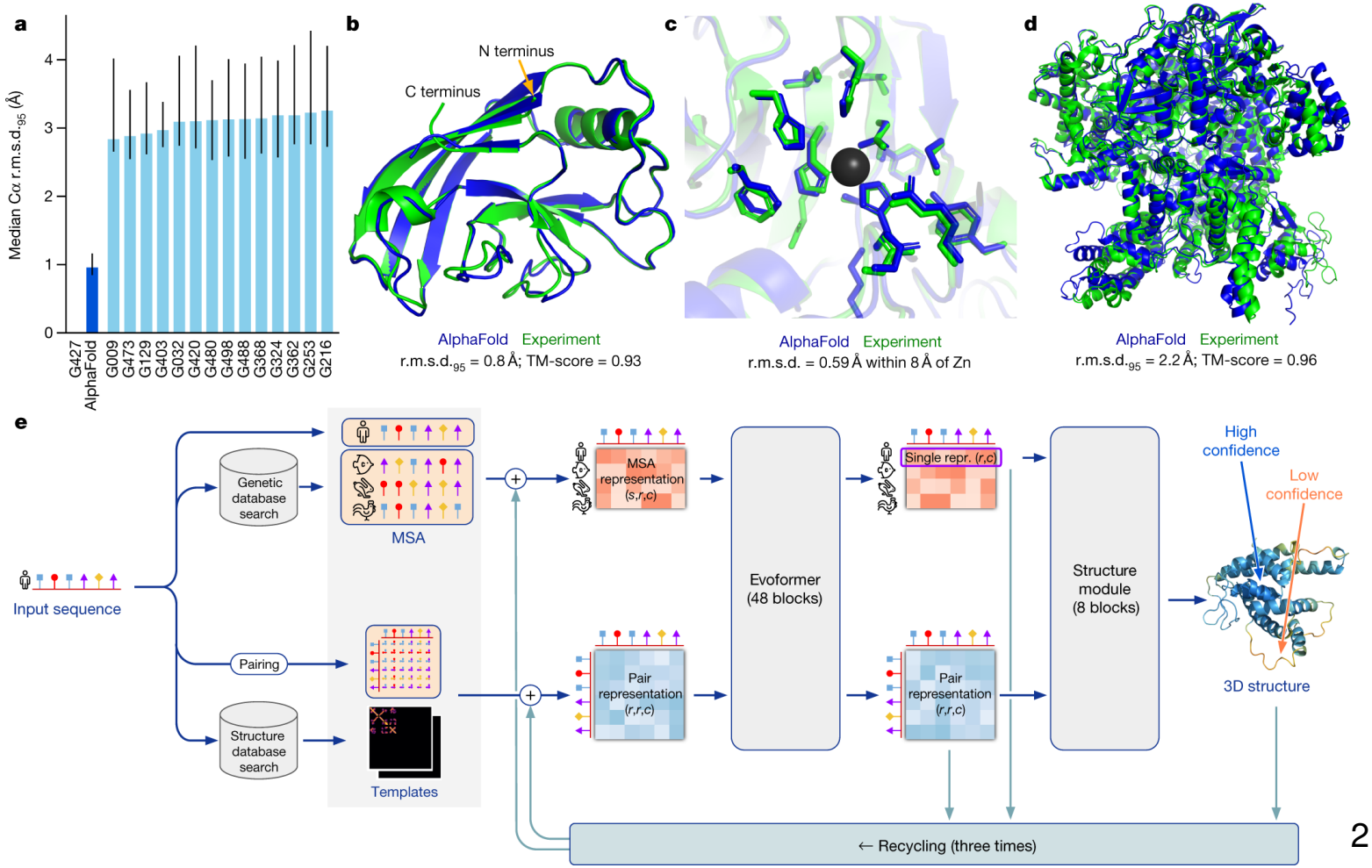


AlphaFold

- End-to-end 3D structure prediction starting from a protein sequence



[2]Highly accurate protein structure prediction with AlphaFold, Brown Mann Ryder Subbiah et al., 2020

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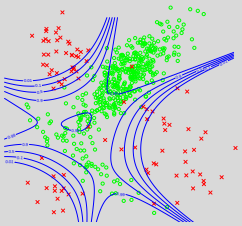
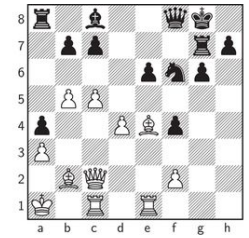
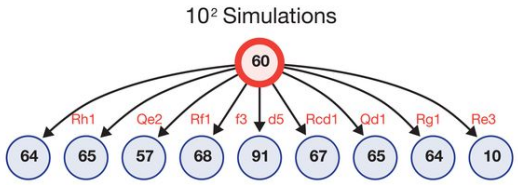
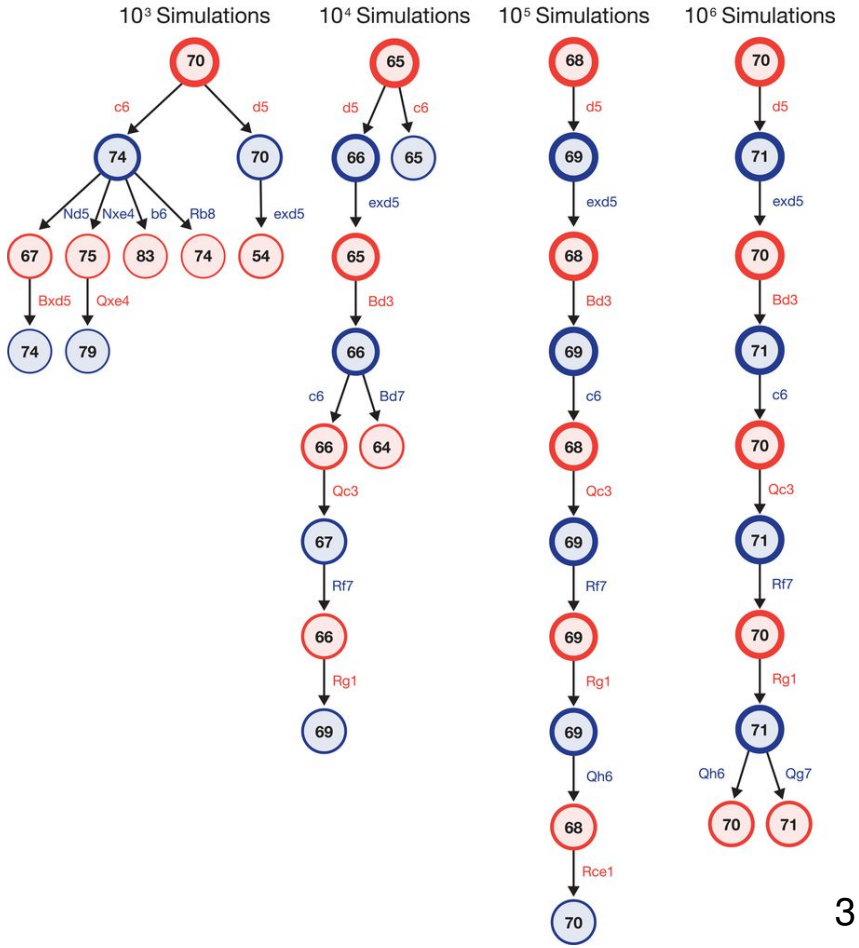


Reinforcement Learning

- AlphaZero: Beat the top ranked Go player in the world ("superhuman")
- Uses neural networks to make an educated guess on the best actions (policy) and their expected outcome







[3]

[3] A general reinforcement learning algorithm that masters chess, shogi, and Go through self-play, Silver et al., 2018

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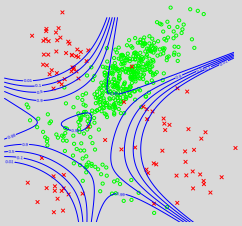
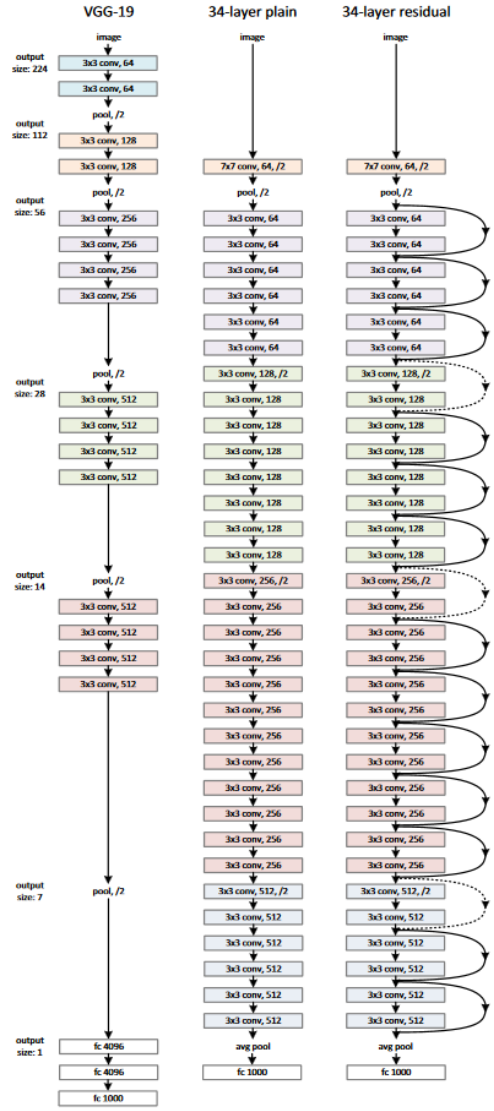


ResNet

- ResNet [4] are very deep networks with great performance in image classification



[4] Deep residual learning for image recognition, He et al., 2016

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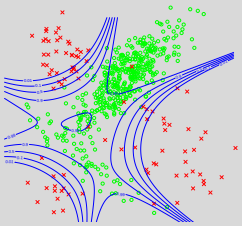
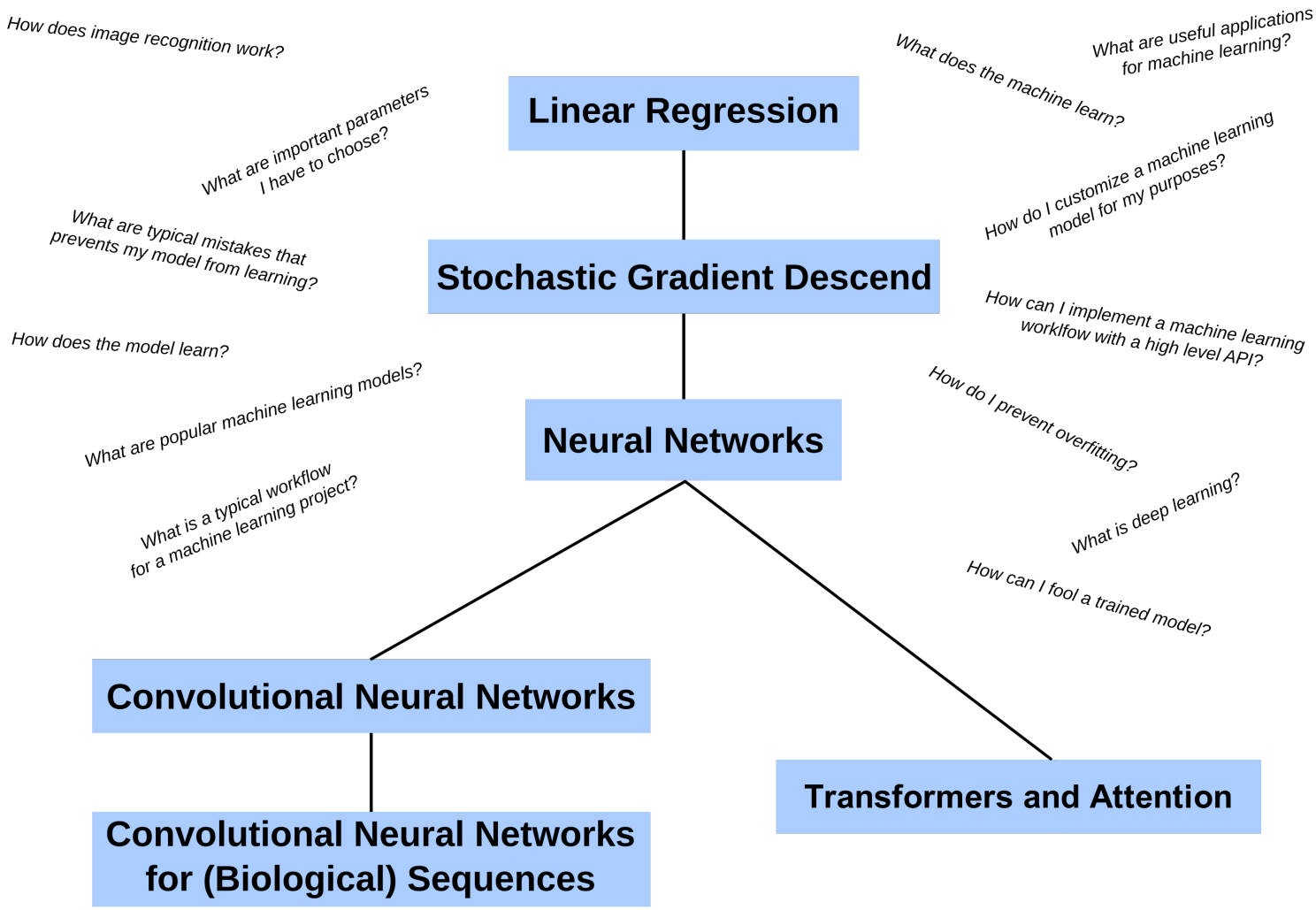
KI-Block 2023 - Overview