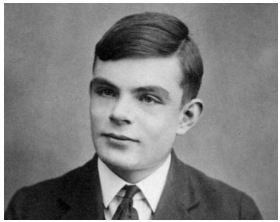
Helmholtz AI

Markus Götz, Marie Weiel, Benjamin Schäfer, Felix Laufer

Local Unit Energy / 2023-10-18

Artificial Intelligence
What is AI?

“It is not difficult to devise a paper machine which will play a not very bad game of chess. Now get three men as subjects for the experiment. A, B and C. A and C are to be rather poor chess players, B is the operator who works the paper machine[..., A] game is played between C and either A or the paper machine. C may find it quite difficult to tell which he is playing.”, 1947.



Alan Turing

Artificial Intelligence

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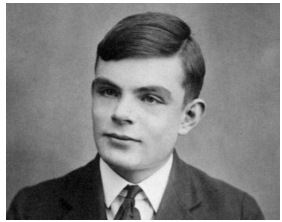
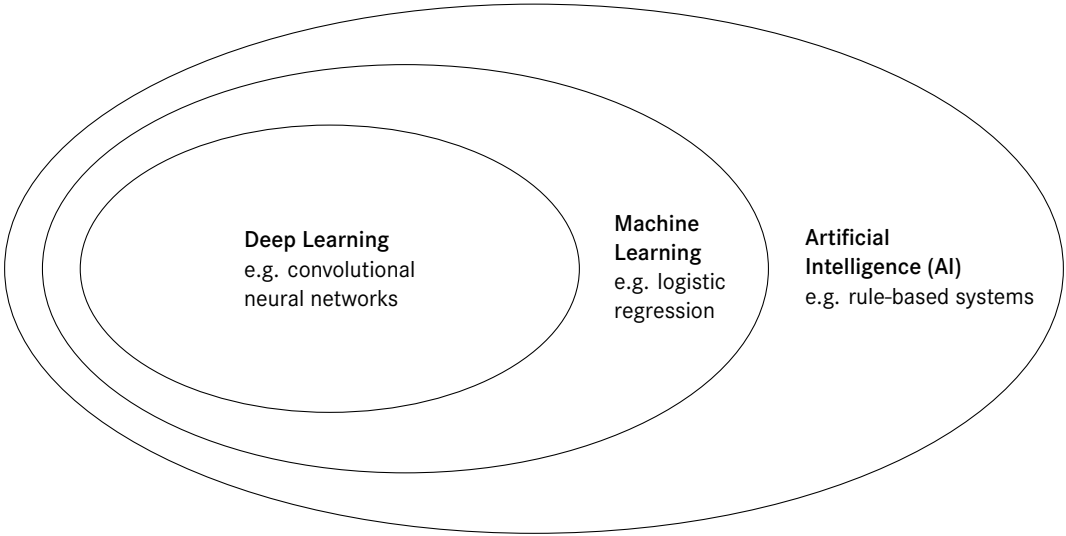


Alan Turing

“Every aspect of learning or any other feature of intelligence can be so precisely described that a machine can be made to simulate it.”, 1956.

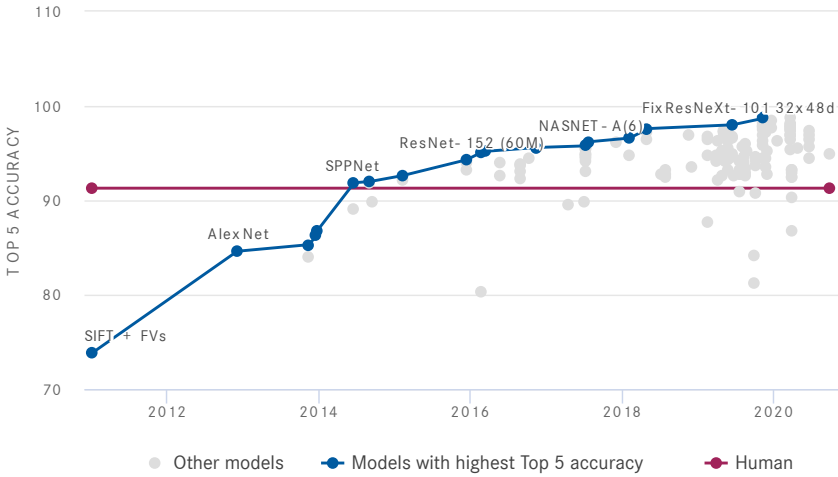
Dartmouth Conference on Artificial Intelligence

Artificial Intelligence
Terminology



Artificial Intelligence

Image Net – Super Human Performance



Modified version plot taken from https://paperswithcode.com/sota/image-classification-on-imagenet

Artificial Intelligence
Neural Style Transfer

Gatys, L. A., Ecker, A. S., & Bethge, M. (2016). Image style transfer using convolutional neural networks. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 2414-2423).

1. **Technology revolution** – parallel processors (e.g. GPUs), auto-gradient software
2. **Data availability** – large-scale, publicly available and labeled data
3. **Methodological advances** – new neuron types, training approaches, embeddings

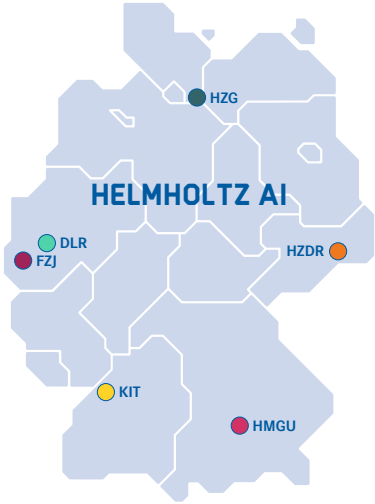
Helmholtz AI

Helmholtz AI
Goals

1. **Interdisciplinary** platform for innovative **research** in **AI**

2. Compile, develop, and foster **applied AI** methods nationwide across all **Helmholtz centers**

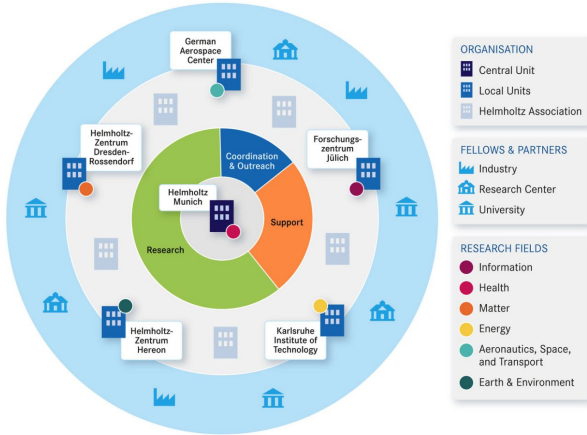
3. **International leadership** in **applied AI**



→ **Democratizing AI within the Helmholtz Association**

Helmholtz AI
Structure

- **Helmholtz incubator (INF)** platform
  - Launched **mid 2019**
  - **12M € per year** (overall)
- One **central** unit (30 FTEs)
  - 3 YIGs, 2 YIGs, 2 consultant groups
  - Harbors scientific management
- Five **local** units
  - Young investigator group (3 FTEs)
  - Consultant group (5 FTEs)



Research on novel AI methods and applications

- **High risk, high gain AI research**
- At least **two Helmholtz centers**, external partners possible

- Duration: **1-3 years** (usually: 2)
- Annual, 50:50 matched funding
  - Up to 250.000 € from the INF
  - Same amount in own contribution

- Next call ends: **Dec, 1st 2023**
- Information: https://events.hifis.net/event/927/

Support for applied AI activities

- **Collaborative** work between **research group** and **consultant group**
- Often different **Helmholtz centers**
- **Duration: 2–26 weeks**
- **Free of charge,** conditionally consultants acceptance
- Sprint to applied AI **publication**

Examples of voucher services

- **Brainstorming** on AI approaches
- **Advice** on technology
- **Implementation** of pipelines
- **Optimization** of existing code
- **Networking** in Helmholtz AI
- **Support** for HAICORE compute time

→ **Bring SOTA AI approaches to domain-specific research**

Helmholtz AI COmputing REsources

- **Free-of-charge** GPU cluster
- Installation sites
  - Forschungszentrum Jülich (**FZJ**)
  - Karlsruhe Institute of Technology (**KIT**)
- Technical access
  - KIT: self-registration
  - FZJ: light-weight project
  - Jupyter Notebook

Source: HAICORE at KIT in FH2

HAICORE
Hardware Setup

- **3x** NVIDIA DGX-A100
  - 2x AMD EPYC, 1 TB RAM
  - **8x NVIDIA A100 GPUs**, 40 GB VRAM
  - 9x Mellanox Infiniband HDR
- **12x** Lenovo ThinkSystem SD650Nv2
  - 2x Intel Ice Lake CPU, 512 GB RAM
  - **4x NVIDIA A100 GPUs**
  - 1x Mellanox Infiniband HDR

- **16x** Atos BullSequana XH2000
  - 2x AMD EPYC, 512 GB RAM
  - **4 × NVIDIA A100 GPUs**, 40 GB VRAM
  - 1x Mellanox Infiniband HDR

Local Unit Energy

Local Unit Energy@KIT
Profile

1. **Energy 4 AI, AI 4 Energy**
   - Applied AI, mostly renewables and grid
   - Reduce electrical energy required for AI
2. **Parallel** and bio-inspired AI
   - Faster training and larger models
   - Optimization process usually bottleneck
   - Host place of **HAICORE@KIT**
3. **Image** and **time series** processing
   - Most data is image(-like) over time
   - Remote sensing, cameras, simulations

Solar cell test park KIT Campus North

HoreKa supercomputer with HAICORE@KIT

Local Unit Energy@KIT

The Team

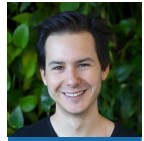
CONSULTANTS

Markus Götz
Consultant team leader

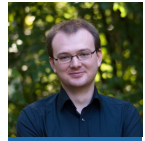
Mishal Benz
Consultant

Daniel Coquelin
Consultant

Katharina Flügel
Consultant



Juan Muriedas
Consultant



Oskar Taubert
Consultant

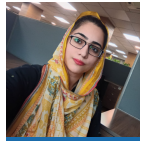
Marie Weiel
Consultant

YOUNG INVESTIGATOR GROUP (YIG)

Ralf Mikut
Unit head

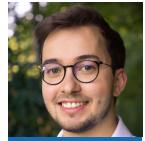
Benjamin Schäfer
YIG head

Hadeer El Ashhab
PhD student

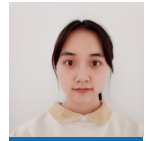


Hallah Butt
PhD student

Ulrich Oberhofer
PhD student



Sebastian Pütz
PhD student



Xinyi Wen
PhD student

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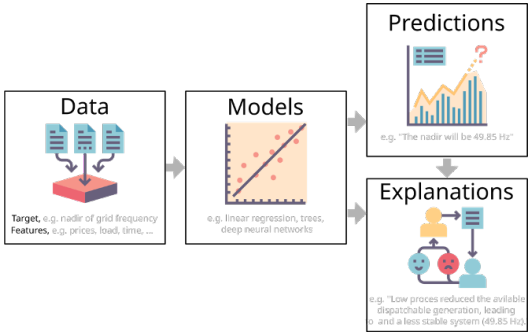
YIG Research Overview



- Combining machine learning, modelling expertise and domain knowledge for insights
- What we work on:
  - Control of residential battery systems (reinforcement learning)
  - Analysing electricity prices and electricity markets (regression, anomaly detection)
  - Predicting power grid frequency (forecasting)

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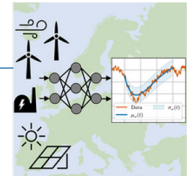
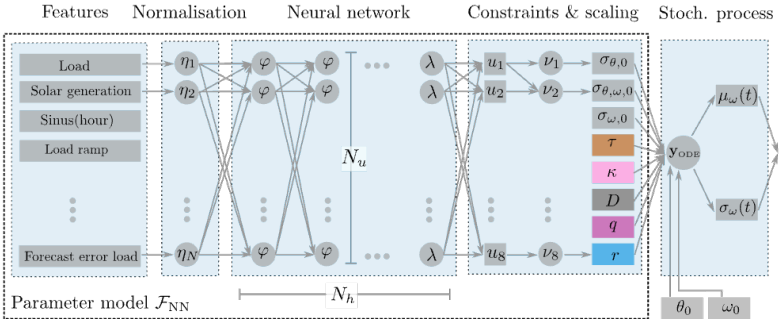
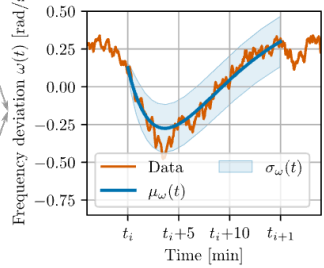
YIG highlight: Physics-Informed Machine Learning







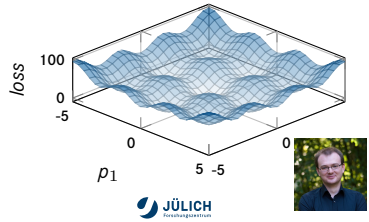
- Learn model parameter with machine learning (regression, forecasting)
- Explain parameter fits based on external information (influence of renewables, prices, ...)

Johannes Kruse, Eike Cramer, Benjamin Schäfer, and Dirk Witthaut (2023). "Physics-Informed Machine Learning for Power Grid Frequency Modeling". In: PRX Energy 2, 043003 doi:https://doi.org/10.1103/PRXEnergy.2.043003

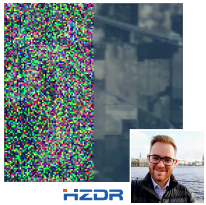
Local Unit Energy@KIT
Consulting Overview

Merit Order Principle Prediction

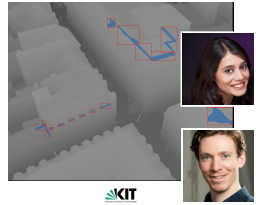
Scalable Hyperparameter Optimization



HyDe – Hyperspectral Image Denoising Toolbox



Thermal Leakages



Highlight: AI Consulting at KIT-LTI

Helmholtz AI
Achievements 2019-2022

56
HELMHOLTZ AI PROJECTS

250+
CONSULTANCIES

240+
TRAININGS & WORKSHOPS

260+
PAPERS

110+
RESOURCES

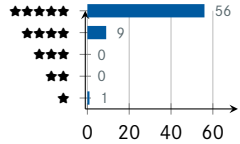
30+
AWARDS & PRICES

150+
SUPPORTED TEAMS

91%
CONTRIBUTIONS REUSE*

250+
CONSULTANCIES

88%
HIGH ADDED VALUE*



Net promoter score 9.7/10.0*

*customer survey (66 responses)

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https://mattermost.hzdr.de/helmholtz-ai

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