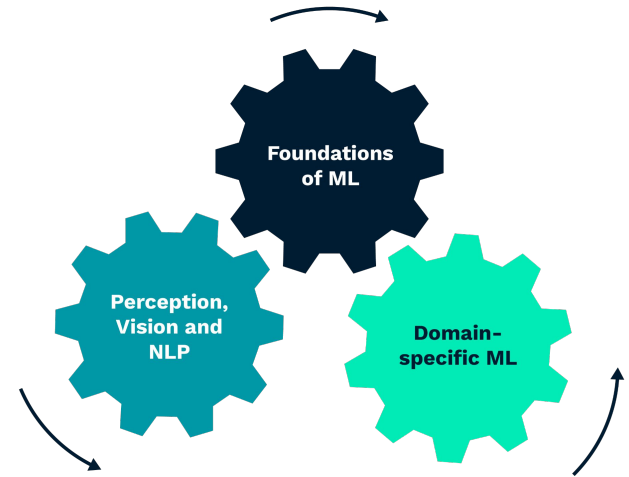# Munich Center for Machine Learning - Research and Transfer

Bernd Bischl, Director MCML

Munich Center for Machine Learning

The Munich Center for Machine Learning is a joint research initiative of Ludwig-Maximilians-Universität München (LMU) and Technische Universität München (TUM). It is part of the German and Bavarian government's AI strategy.

TUM

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

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Our Goals

Advance mathematical, computational, and statistical foundations of ML

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Research Areas

A Foundations of Machine Learning

Statistical Foundations & Explainability
Mathematical Foundations
Computational Models

B Perception, Vision and NLP

Computer Vision
Natural Language Processing
Multimodal Perception

C Domain-specific Machine Learning

Medicine
Biology
Physics and Geo Sciences
Computational Social Science
Humane AI

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Munich Center for Machine Learning

45 PIs – 470 top ranked publications

Prof. Dr. Matthias Althoff
TU München
Cyber Physical Systems

Prof. Dr. Ulrich Bauer
TU München
Applied Topology and Geometry

Prof. Dr. Bernd Bischl
LMU München
Statistical Learning & Data Science

Prof. Dr. Anne-Laure Boulesteix
LMU München
Biometry in Molecular Medicine

Prof. Dr. Alena Buyx
TU München
Ethics in Medicine and Health Technologies

Prof. Dr. Daniel Cremers
TU München
Computer Vision & Artificial Intelligence

Prof. Dr. Angela Dai
TU München
Machine Learning of 3D Scene Geometry

Prof. Dr. Rüdiger Westermann
TU München
Computer Graphics & Visualization

Prof. Dr. Xiaoxiang Zhu
TU München
Data Science in Earth Observation

Prof. Dr. Ralf Zimmer
LMU München
Bioinformatics

Prof. Dr. Mathias Drton
TU München
Mathematical Statistics

Prof. Dr. Stefan Feuerriegel
LMU München
Artificial Intelligence in Management

Prof. Dr. Massimo Fornasier
TU München
Applied Numerical Analysis

Prof. Dr. Alexander Fraser
LMU München
Machine Translation and Multilingual NLP

Prof. Dr. Julien Gagneur
TU München
Computational Molecular Medicine

Prof. Dr. Stephan Günnemann
TU München
Data Analytics & Machine Learning

Prof. Dr. Reinhard Heckel
TU München
Machine Learning

Prof. Dr. Eyke Hüllermeier
LMU München
Artificial Intelligence & Machine Learning

Prof. Dr. Michael Ingrisch
LMU München
Clinical Data Science in Radiology

Prof. Dr. Göran Kauermann
LMU München
Applied Statistics in Social Sciences, Economics and Business

Prof. Dr. Niki Kilbertus
TU München
Ethics in Systems Design and Machine Learning

Prof. Dr. Felix Krahmer
TU München
Optimization & Data Analysis

Prof. Dr. Frauke Kreuter
LMU München
Statistics and Data Science in Social Sciences and the Humanities

Prof. Dr. Helmut Küchenhoff
LMU München
Statistical Consulting Unit (StaBLab)

Prof. Dr. Björn Ommer
LMU München
Machine Vision & Learning

Prof. Dr. Barbara Plank
LMU München
Artificial Intelligence and Computational Linguistics

Prof. Dr. Daniel Rückert
TU München
Artificial Intelligence in Healthcare and Medicine

PD Dr. Fabian Scheipl
LMU München
Functional Data Analysis

Prof. Dr. Volker Schmid
LMU München
Bayesian Imaging & Spatial Statistics

Prof. Dr. Albrecht Schmidt
LMU München
Human-Centered Ubiquitous Media

Prof. Dr. Julia Schnabel
TU München
Computational Imaging and AI in Medicine

Prof. Dr. Gitta Kutyniok
LMU München
Mathematical Foundations of Artificial Intelligence

Prof. Dr. Laura Leal-Taixé
TU München
Dynamic Vision and Learning

Prof. Dr. Stefan Leutenegger
TU München
Machine Learning for Robotics

Prof. Dr. Christian Müller
LMU München
Biomedical Statistics and Data Science

Prof. Dr. Thomas Nagler
LMU München
Computational Statistics & Data Science

Prof. Dr. Nassir Navab
TU München
Computer Aided Medical Procedures & Augmented Reality

Prof. Dr. Matthias Nießner
TU München
Visual Computing

Prof. Dr. Matthias Schubert
LMU München
Database Systems & Data Mining

Prof. Dr. Hinrich Schütze
LMU München
Statistical NLP and Deep Learning

Prof. Dr. Thomas Seidl
LMU München
Database Systems & Data Mining

Prof. Dr. Fabian Theis
TU München
Mathematical Modelling of Biological Systems

Prof. Dr. Nils Thuerey
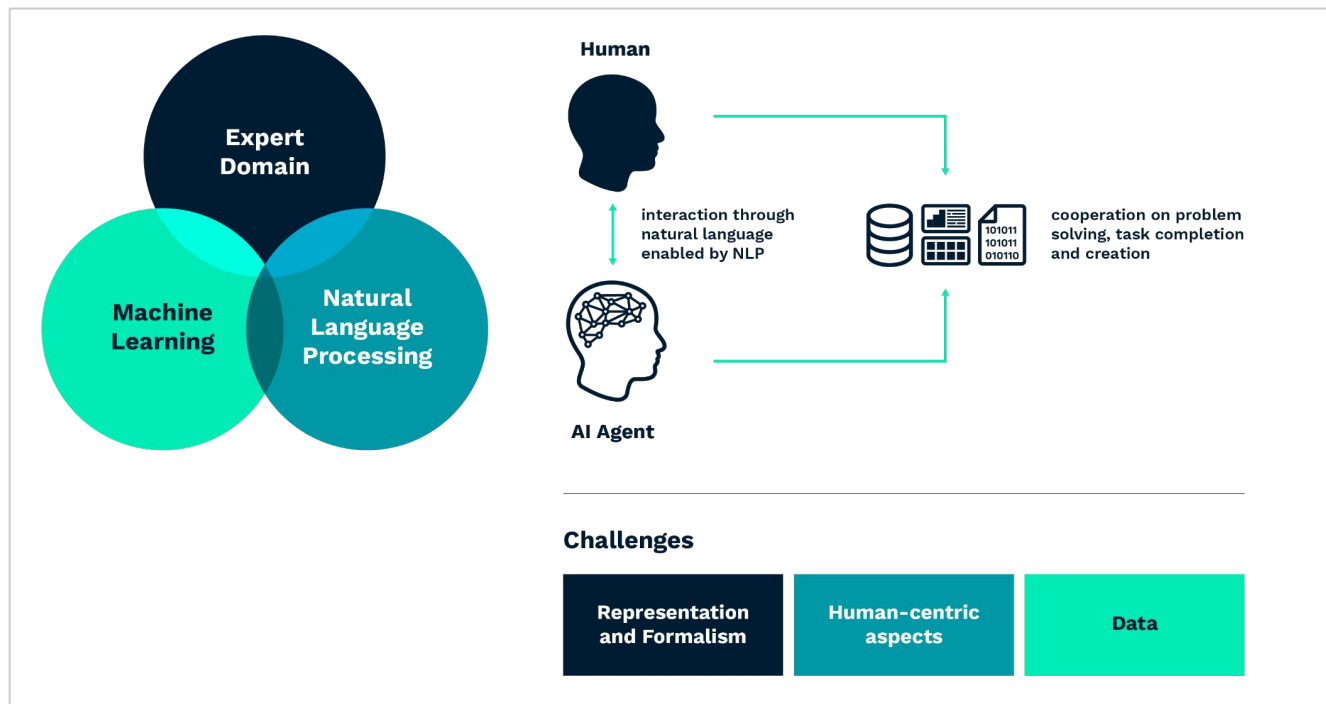TU München
Physics-based Simulation

Prof. Dr. Volker Tresp
LMU München
Database Systems & Data Mining

Prof. Dr. Christian Wachinger
TU München
Artificial Intelligence in Radiology

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Language-based Expert-AI Cooperation

Hinrich Schütze, Barbara Plank et al.

Expert Domain

Machine Learning

Natural Language Processing

Human

interaction through natural language enabled by NLP

cooperation on problem solving, task completion and creation

AI Agent

Challenges

Representation and Formalism

Human-centric aspects

Data

Barbara Plank

Hinrich Schütze

lexic

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Multimodal Research:
Do DALL-E and Flamingo understand each other?

Hang Li, J. Gu, R. Koner, S. Sharifzadeh, Volker Tresp, LMU Munich, Siemens AG
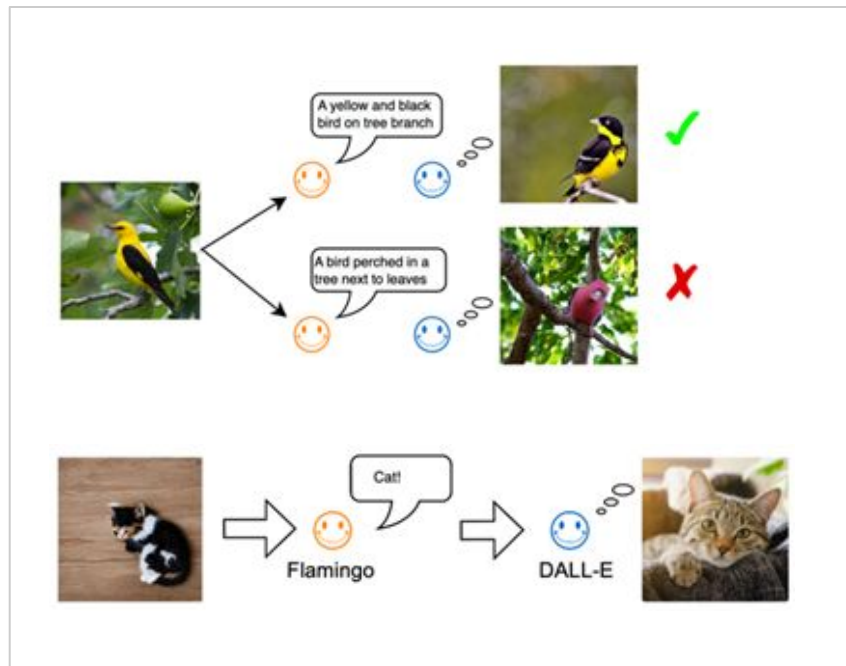
Multimodal Research is to improve machine understanding of images and text: Image captioning, text-to-image generation, vision language representation learning. One way to determine if two agents are able to communicate effectively through language is to have one agent describe an object, such as a cat, to the other.
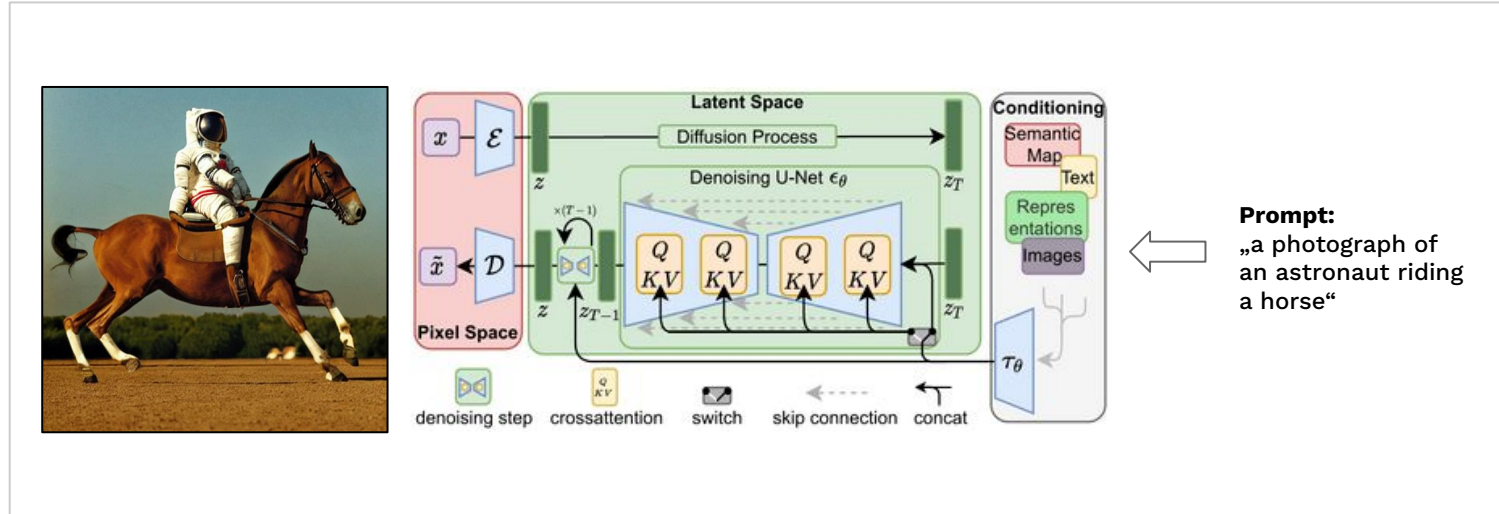

Volker Tresp

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Stable Diffusion

Björn Ommer et al.

The fundamental multimodal research and the cooperation of experts and artificial agents allows for the creation of new tools like Stable Diffusion.
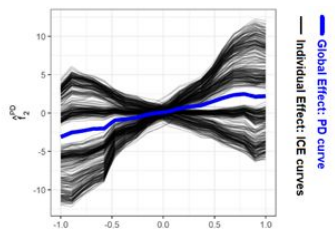

Prompt:
„a photograph of an astronaut riding a horse"
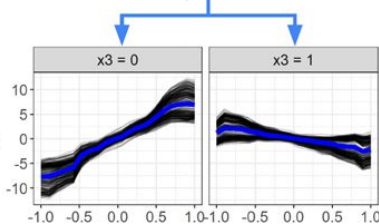
Björn Ommer

Interpretable ML

Bernd Bischl et al.

Motivation: ML models are black boxes
-> produce explanations to increase trust

Research: Develop new model-agnostic interpretation methods for improved insights

Problem: Feature effects are misleading when features interact

**Solution:** Split feature space into regions to obtain *regional effects*

[AISTATS 2022] REPID - Regional Effect Plots with implicit Interaction Detection
[NeurIPS 2021] Explaining Hyperparameter Optimization via Partial Dependence Plot

Interpretability for AutoML

Explanations in AutoML:
- Visualize effect of HP λ on performance $c(\lambda)$
- Introduce *sampling bias* in HP space
- Misleading in regions with few points (high uncertainty)

Solution:
Partition in regions with *similar uncertainty* and add *uncertainty bands*
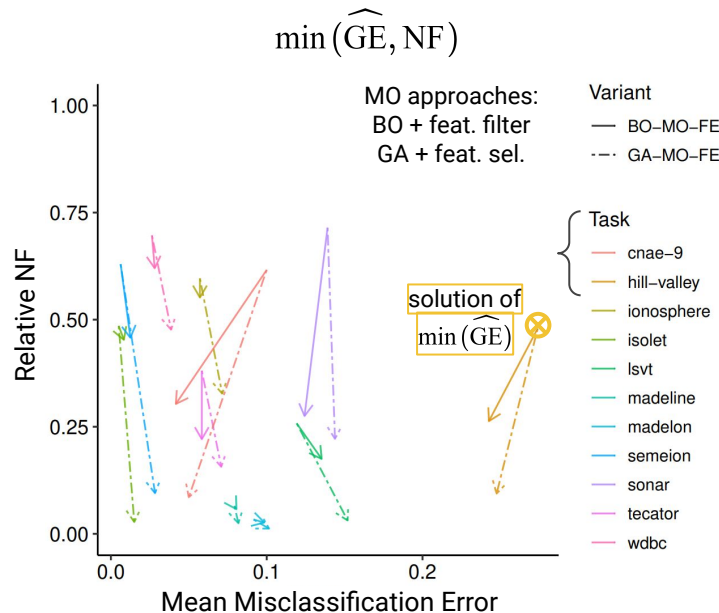

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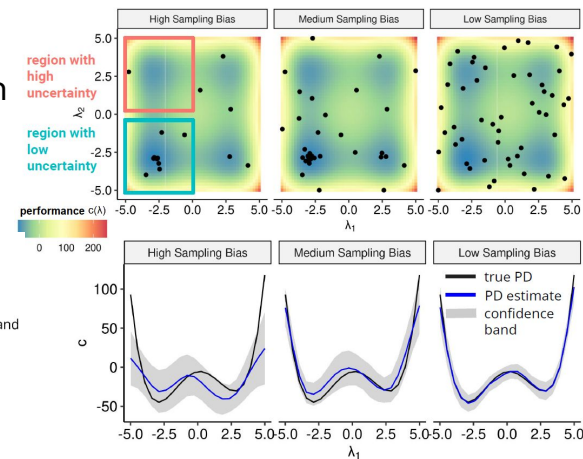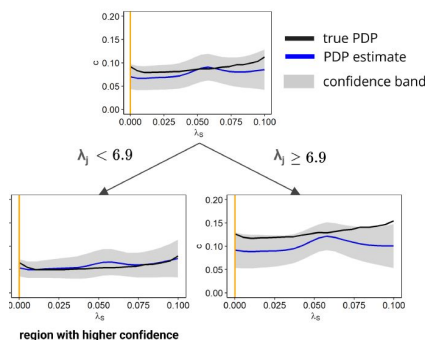
AutoML for Interpretability

Bernd Bischl et al.

Idea: Quantify "interpretability" via functional decomposition for model selection:

$$f(x) = f_0 + \sum_{j=1}^{p} \overbrace{f_{j,ALE}(x_j)}^{\text{MEC: How complex?}} + \overbrace{IA(x)}^{\text{IAS: Interaction strength?}}$$

$$\underbrace{\qquad\qquad\qquad\qquad\qquad}_{\text{NF: How many features were used?}}$$

Dimensions as proxy of "interpretability":
➜   Number of features (NF)
➜   Main effect complexity (MEC)
➜   Interaction strength (IAS)

Multi-objective (MO) optimization of generalization error **(GE)** and rel. num. of used features **(NF)**:

$$\min\left(\widehat{GE}, NF\right)$$

Solution "less complex" (fewer NF), similar performance

[ECML 2019] Quantifying Model Complexity via Functional Decomposition for Better Post-hoc Interpretability
[GECCO 2020] Multi-Objective Hyperparameter Tuning and Feature Selection Using Filter Ensembles

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Our Talent Programs

Postdoc Transfer positions:
PhD & Postdoctoral program

MCML Junior Research Groups:
Focus on research

Thomas Bayes Fellowship:
Focus on teaching

Bring young AI talents to Munich and educate next generations of experts

Our Scientific Transfer

StaBLab
Statistisches
Beratungs
Labor

TUM|Stat
Statistical
Consulting

MLCU@LMU
Machine Learning Consulting

Reproducibility
Open Source Software
Workshops / Training

Accelerate the process of scientific discovery by consulting and open source

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Munich Center for Machine Learning

OSC
LMU Open Science Center

Empirical Sciences   ML Methods

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Teaching ML@LMU

AIM@LMU (AI as major Minor)

Transfer AI/ML/DS education to other domains:

Lectures:
- Introduction to artificial intelligence
- Introduction to machine learning
- Artificial intelligence in science and society
- Practical applications of artificial intelligence

Bsc + MSC Statistics and Data Science

Machine Learning Specialization Lectures:

- Supervised Learning
- Optimization
- Deep Learning
- Advanced Deep Learning
- Deep Learning for Natural Language Processing
- Advanced Machine Learning
- Automated Machine Learning
- Applied Machine Learning
- Interpretable Machine Learning
- Consulting project
- Master thesis

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Machine Learning Consulting Unit (MLCU)
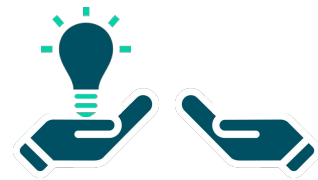
- Machine Learning Consulting within the university and MCML

- Research and Consulting Projects with industry

- Incubator for collaborations and (methodological) research with applied sciences
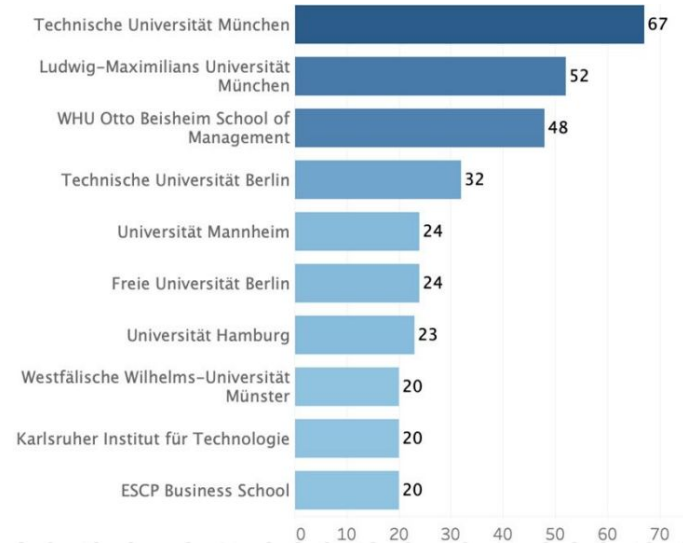
- Knowledge transfer across different disciplines

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Our Partners in Industry

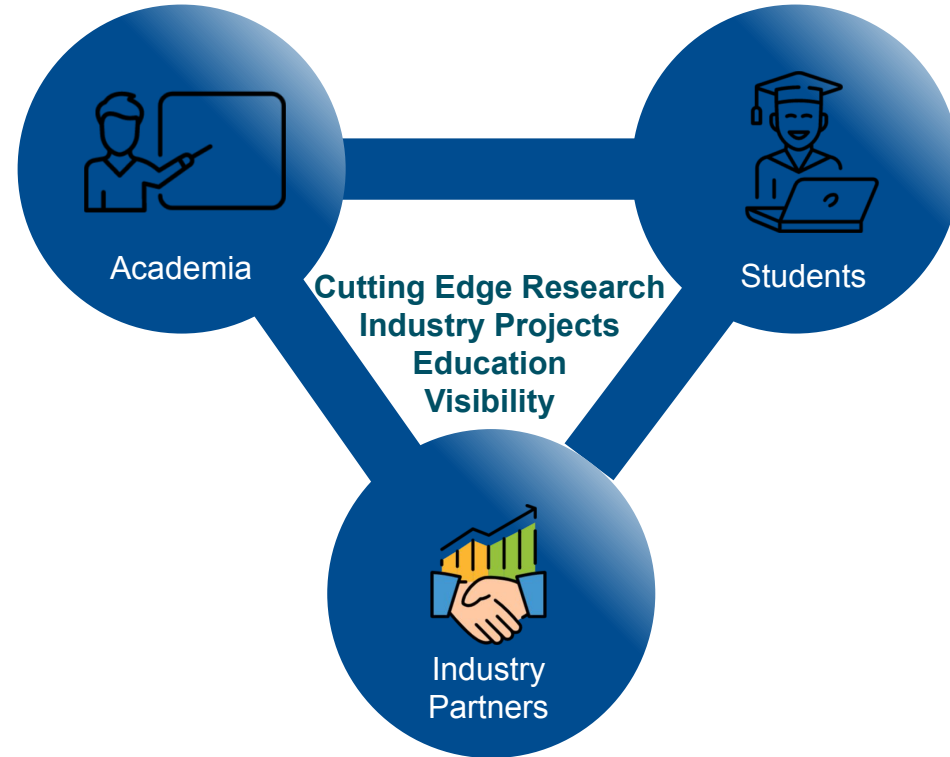Transfer technology to industry including (start-ups) and to society

Stichprobe **Crunchbase Top 500**: Top 10 Hochschulen nach Anzahl der High-Performance Startups:

Hochschule	Anzahl
Technische Universität München	67
Ludwig–Maximilians Universität München	52
WHU Otto Beisheim School of Management	48
Technische Universität Berlin	32
Universität Mannheim	24
Freie Universität Berlin	24
Universität Hamburg	23
Westfälische Wilhelms–Universität Münster	20
Karlsruher Institut für Technologie	20
ESCP Business School	20

Innovationslabor Big Data Science

Website: innolab.ifi.lmu.de

- Statistics, Machine Learning, Data Science
- Teaching of Data Science Toolboxes
- Large-scale computing
- Software development
- Project management
- Use cases from industry, research and development
- Implementation of prototypes

Academia

Students

Cutting Edge Research
Industry Projects
Education
Visibility

Industry
Partners

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Exemplary Transfer and Industry Collaborations

April 14-16th, LMU Main building

DATA SCIENCE FOR SOCIAL GOOD — MUNICH 2023

We are a proud member

Munich — Siemens Research and Innovation Ecosystem — mcml Munich Center for Machine Learning

Munich RE
Co- Sponsors our 2023 DataFest
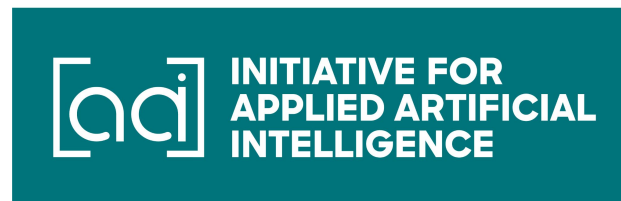
[a] INITIATIVE FOR APPLIED ARTIFICIAL INTELLIGENCE
Joint conferences and hackathons

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Entrepreneurship transfer

One of our missions is to foster transfer

This means transfer to industry & society

And to transfer entrepreneurial thinking into the startup ecosystem

We organize bootcamps and hackathons, to transfer entrepreneurial thinking together with our partners

Our Ecosystem
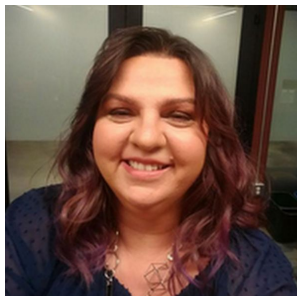

Strengthen the network and increase the visibility of Munich & Germany
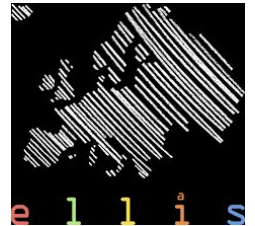
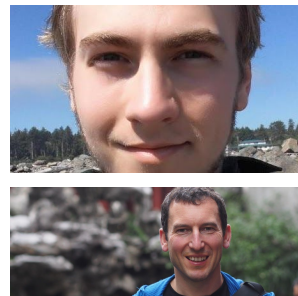# Upcoming: AutoML Fall School 2023 in Munich

Aleksandra Faust
(Google Brain)

Luigi Nardi
(Stanford & Lund
University)

Luc de Raedt
(KU Leuven)

Nick Erickson & Alex
Smola
(Amazon)

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Thank you for your attention.

mcml.ai