Institute for TMDT

BERGISCHE UNIVERSITÄT WUPPERTAL

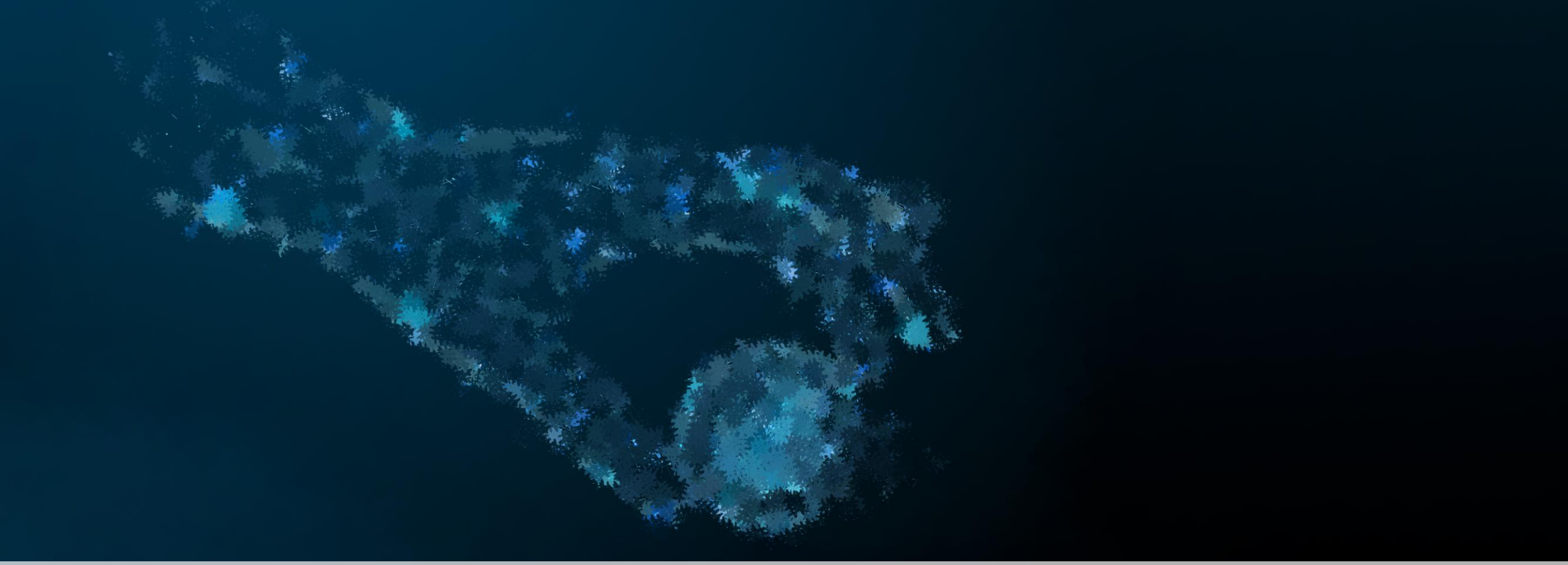
Institute for Technologies and Management of Digital Transformation

Seminar - Selected Topics in Data Science: Kick-Off

30.09.2024, Wuppertal

Agenda

1. Introduction
2. Organization
3. Seminar Topics
4. Next Steps



Introduction

Our Mission

We are pioneers and advisors on digital transformation for research and industrial partners by researching and implementing (semi-)autonomous, technical systems. Our results are made available to the scientific community through publications, and we actively transfer them to industry partners as well as into our educational activities. In this way, we contribute significantly to the development of future technical systems and shape the digital pioneers of tomorrow.

Key Driving Technologies of Digital Transformation

The Institute

Sensor

Connectivity

Information processing

Storage

Intelligent, (semi-)autonomous technical assistants and agents

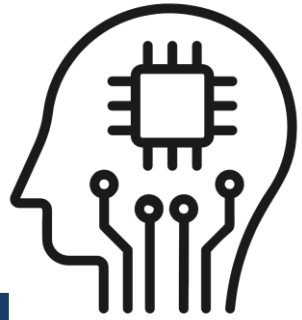
1 **Perception**

2 **Learning**

➔ Decision support

➔ Decision making

3 **Memorizing**



utilizable in a wide range of domains

Das TMDT

Zahlen und Fakten

Lehrstuhlinhaber

Prof. Dr.-Ing. Tobias Meisen

Semantic Systems Engineering

Dr.-Ing. Alexander Paulus und Dr.-Ing. André Pomp

Industrial Deep Learning

Dr.-Ing. Richard Meyes und Dr.-Ing. Hasan Tercan

User Centered Acceptance

Dr. Kathrin Krosch

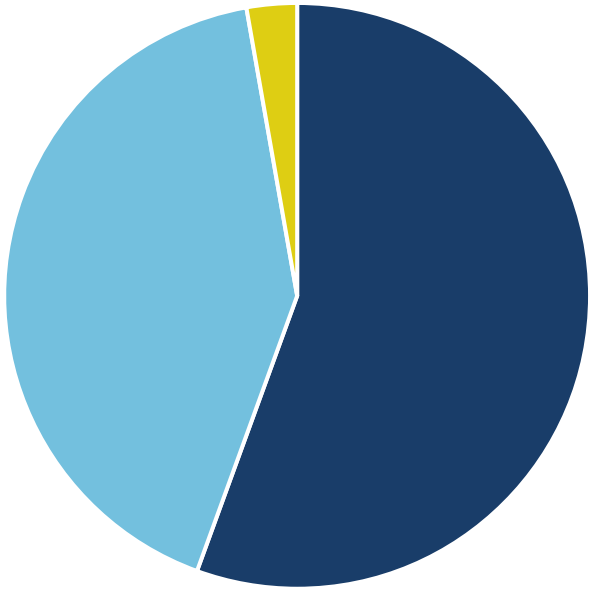
Human Centered Transformation

Dr. Michael Krause

Virtual and Augmented Reality

Marion Rose

Team



Wissenschaftler*innen

40

Hilfskräfte

> 30

Assistenz

2

Drittmittel

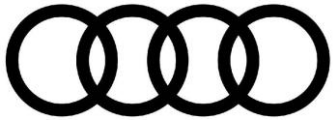
Förderprojekte ca. 2.500.000 € (in 2023)

Auftragsforschung ca. 200.000 € (in 2023)

mehr als 20 laufende, geförderte Projektvorhaben

Our Partners

The Institute



BERGISCHE
STRUKTUR- UND
WIRTSCHAFTS-
FÖRDERUNGS-
GESELLSCHAFT

Where to find us?

The Institute

Visit us at
www.tmdt.uni-wuppertal.de

Visit our demonstrators at
demo.tmdt.uni-wuppertal.de

Find us on

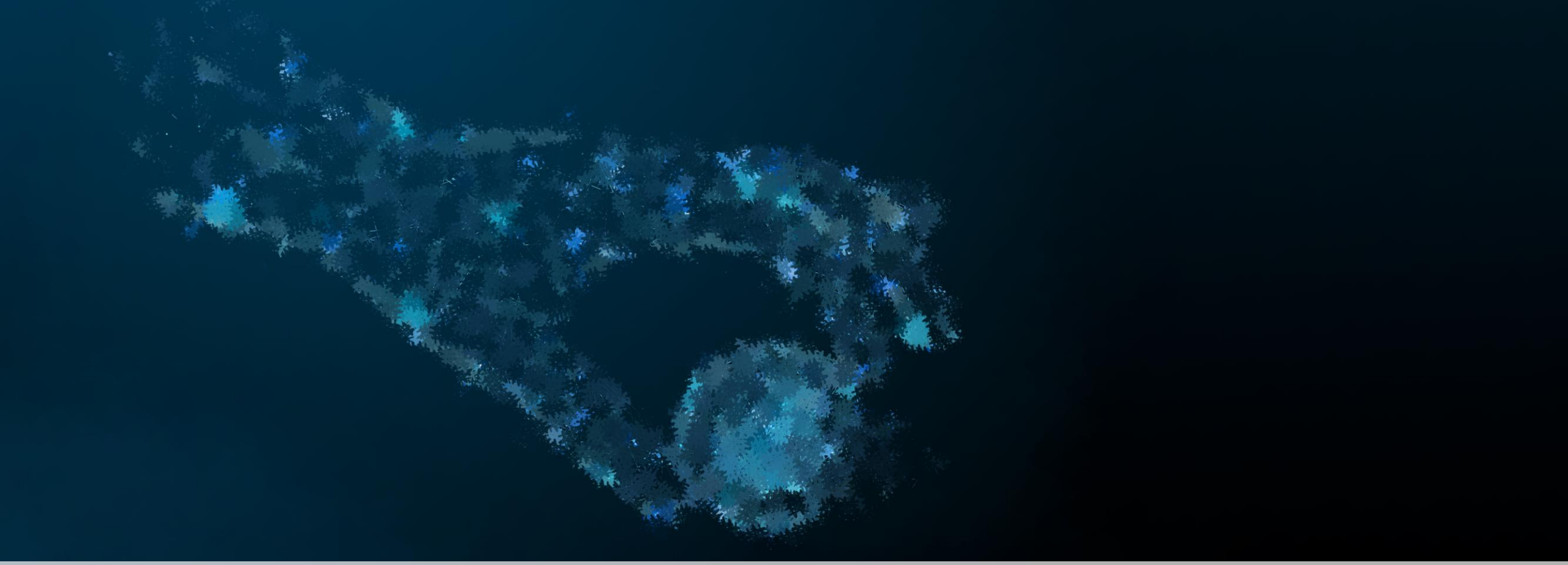
@TMDT
Information and events

Chair of TMDT
Videos

@TMDT_Wuppertal
Pictures and information

@BUW (Lab TMDT)
Research and publications

@tmdt-buw
Code and demonstrators



Organization

Goals of this Seminar

Organization

1. In-depth Knowledge of Current Research

- Overview of state-of-the-art technologies
- Current research trends
- Research challenges
- Open problems (**potential BA/MA projects**)

2. Methodological Skills

- Find & organize literature
- Systematically read research papers
- Analyze, compare and contrast research
- Determine and build upon the most suitable methods and approaches
- Structure, write, and format an academic paper
- Presentation skills
- Discuss work with peers

How?

Organization

- Define your research question / specific research topic
- Independent research of literature or technologies
- Consultations & peer feedback
- Theory track vs. Applied track
- In-classroom presentations
- You will get input and support by an advisor (Scientific Researcher)

Presentations

Organization

- All presentations will be conducted on Tuesdays between 14:15 and 15:45 in lecture hall FH3 (FH.02.06)

- **Milestone presentations**
  - Date: 29.10.2024 (& 05.11.2024)
  - Pitch your topic (5 minutes max. + 1-2 follow-up questions) in your own words. Motivate your topic and talk about what you plan to achieve and what specific steps you plan on taking (milestones).

- **Final presentation**
  - Date: 05.02.2025 (Room – tba)
  - What worked, what was more challenging as expected, what open questions remain? Show us your final results and insights (10 minutes max. + 5 minutes for questions/open discussion)!

Workshop Presentation & Scientific Writing

Organization

- Date: 22.10.2024
- between 14:15 and 15:45 in lecture hall FH3 (FH.02.06)
- How to structure your presentation
- How to write a scientific text

Credit Requirements and Grading

Organization

General

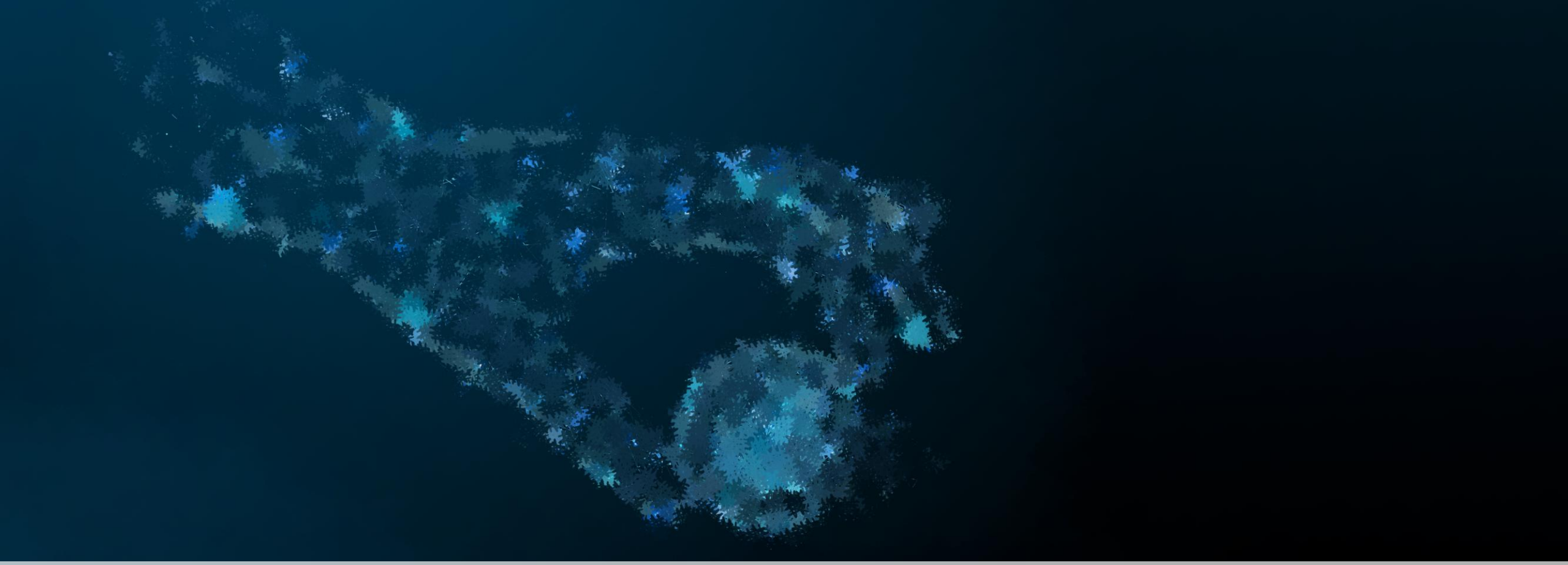
- Three Presentations
  - Milestone presentation (5 min per topic) → 15%
  - Full presentation (10 min per topic) → 35%
  - Participation on all two presentations is mandatory

Theory Track

- Term Report (comparable to 8-10 content pages ACM style + unlimited references)
  - First draft (min. 4 pages) – 21.12.2024 → 10%
  - Final Paper – 26.01.2025 → 40%

Applied Track

- Report (comparable 4-5 content pages ACM style + unlimited references) & Code
  - First draft (min. 2 pages) – 21.12.2024 → 5%
  - Final Paper – 26.01.2025 → 20%
  - Code & Documentation – 26.01.2025 → 25%



Seminar Topics

Legend for Project Icons

Seminar Topics

- Project suitable for the **theory track of the seminar**
  - **Deliverable: Term paper (8-10 pages)**

- Project suitable for the **applied track of the seminar**
  - **Deliverable: Code + Short paper (4-5 pages)**

- Project can be extended to BSc / MSc thesis

Applications of ML and DL in the World of Football

Machine Learning, Deep Learning

Background

In recent years, the world of football has experienced a transformation driven by advancements in Machine Learning and Deep Learning. The surge in data collection, increased computational power, and the growing ability to analyze both individual players and team behaviors have created new opportunities for predictive and prescriptive football analytics. However, while these innovations offer vast potential, the full scope of AI's application in football remains to be fully realized. In this assignment, we will explore the current applications and future possibilities of ML and DL in football.

Focus of work

Goal

Investigate state-of-the-art use cases where ML or DL have been applied to football

Tasks

- ✓ Characterize and describe the various areas in football where DL and ML have been applied
- ✓ Outline the ML and DL methods that have been utilized
- ✓ Document the maturity level of the use cases and their respective years
- ✓ Identify and discuss potential future directions

Project Type

Supervisor:

Mohammed Zoghian
zoghian@uni-wuppertal.de

Deep Neuroevolution - Optimization with Genetic Algorithms

Deep Learning, Optimization, Neural Networks, Genetic Algorithms

Institute for TMDT

BERGISCHE UNIVERSITÄT WUPPERTAL

Background

Deep neural networks are commonly trained using gradient-based optimization algorithms, such as backpropagation. In contrast, population-based Genetic Algorithms (GAs) provide a gradient-free alternative for training neural networks and solving reinforcement learning problems. These algorithms are inspired by the process of natural evolution and employ mechanisms such as selection, mutation, and crossover to evolve a population of candidate solutions. Genetic Algorithms aim to maximize a fitness function that is tied to the optimization objective, enabling their application in environments where gradients are difficult to compute.

Goal

Implementing a GA and evaluating its performance on a basic deep reinforcement learning task

Tasks

- ✓ Identify and analyze existing studies where GAs have been applied to reinforcement learning problems
- ✓ Examine and compare the advantages and disadvantages of GAs relative to traditional reinforcement learning approaches
- ✓ Implement a Genetic Algorithm to address a simple reinforcement learning task
- ✓ Evaluate the performance of the implemented Genetic Algorithm in solving the selected problem

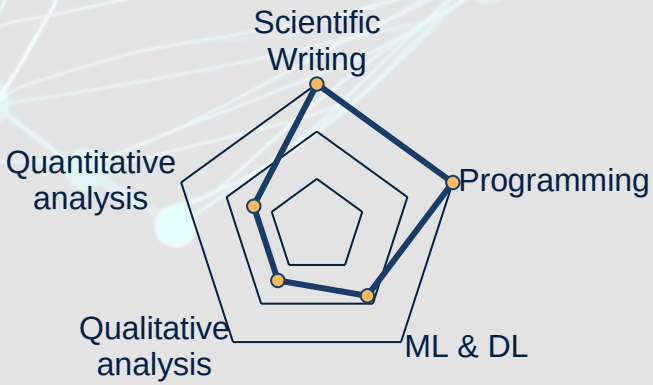
Project Type

Supervisor:

Mohammed Zoghian

zoghian@uni-wuppertal.de

Focus of work



Data Analysis to Protect Against Climate-Driven Extremes

Timeseries

Background

Our university research project focuses on developing a state-of-the-art flood warning system to mitigate the effects of increasingly frequent extreme weather events, intensified by climate change. Inspired by the devastating flood in the Bergisches Land region in 2021, we aim to improve local flood preparedness through advanced precipitation analysis. Using radar data from the German Weather Service (DWD), we will conduct a comprehensive study of precipitation patterns from 2006 to 2024. The aim is to identify critical trends and thresholds in order to develop an early warning system that can better protect vulnerable communities in the future.

Goal

The goal is to do a detailed data analysis on precipitation radar data.

Tasks

Use python, numpy and pandas for a detailed data analysis.

Create insights based on real world data.

Project Type:

Supervisor:

Yannik Hahn – yhahn@uni-wuppertal.de

Recreate 6DoF estimation setup in virtual domain

Computer Vision

Institute for TMDT

BERGISCHE UNIVERSITÄT WUPPERTAL

Background

For 6DoF estimation, one can use ArUco markers. In our research, we have already established a physical setup to create a dataset with that contains the 6DoF pose of an inspected object from multiple views. However, the 6DoF estimation is far from perfect and we would like to investigate the root causes.

Goal

Your goal is to use blender in a procedural way to recreate the physical setup in the virtual domain.

Tasks

- Do a literature review on fiducial markers, intrinsic and extrinsic camera parameters.
- Recreate our setup with procedural generation of blender scenes.
- Evaluate the error of 6DoF estimation under varying conditions (change in camera resolution, distorted camera parameters).

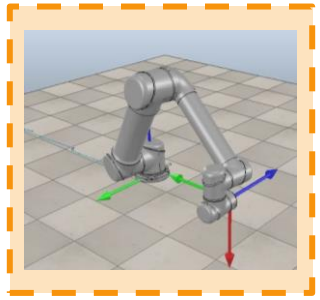
Project Type:

Supervisor:

Robert Maack – rmaack@uni-wuppertal.de

Physical setup

Scene Recreation



Evaluation of 6DoF estimation

Comparison of manual and automatic keypoint estimation

Computer Vision

Background

One of the two main approaches for 6DoF pose estimation is based on the estimation of keypoints. Keypoints are visual features on the surface of an inspected object that have known geometrical relation to each other. By finding a subset of these keypoints, the position and rotation of an object can be estimated.

Goal

Your goal is to evaluate the benefit of using self-learning keypoint estimation in comparison to manual keypoint extraction approaches.

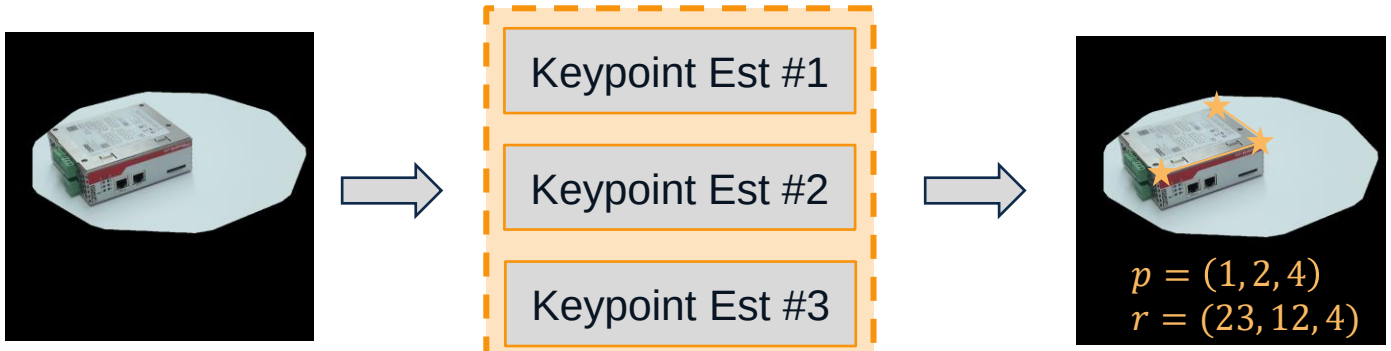
Tasks

- Do a literature research current keypoint estimation approaches and metrics for keypoint estimation and 6DoF.
- Implement different methods of keypoint estimation.
- Evaluate the performance in conjunction with utilization in 6DoF pose estimation.

Project Type:

Supervisor:

Robert Maack – rmaack@uni-wuppertal.de



Raw Image

6DoF Pose Estimation

Visualization Methods of Semantic Models

Semantic Modeling

Background

Semantic models represent knowledge and relationships between concepts in a structured way that is understandable by both humans and machines. They use ontologies to define concepts and their connections, capturing context, hierarchies, and associations. This makes them valuable for applications in knowledge management, artificial intelligence, and natural language processing, enabling more effective data analysis and interpretation.

Goal

Explore state-of-the-art visualization techniques for semantic models, focusing on existing libraries, algorithms that facilitate structured visualization, and the practical implementation of these techniques.

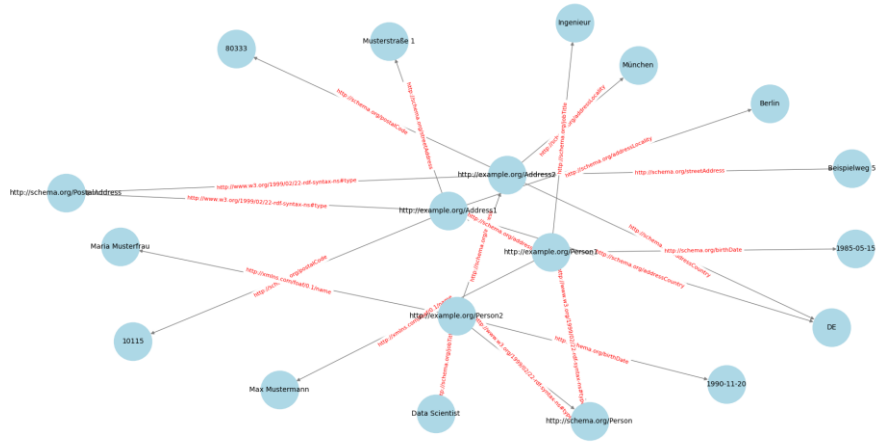
Tasks

1. **Library Exploration**: Identify and analyze existing visualization libraries and tools for the visualization of semantic models.
2. **Algorithm Exploration**: Investigate algorithms that can be used to create organized visual representations of semantic models.
3. **Implementation**: Implement and experiment with the identified libraries and algorithms.

Project Type:

Supervisor:

Florian Hölken – hoelken@uni-wuppertal.de



Evaluating XAI Methods: Which Explanation wins?

Explainable AI, Deep Learning

Institute for TMDT

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Background

In classification problems, Explainable AI (XAI) methods are becoming essential for revealing how models arrive at their decisions. As machine learning systems become more complex, transparency is crucial not only for trust but also for debugging and improving model performance. However, with numerous XAI techniques available, the question remains: how do we effectively compare these methods? What makes one explanation more useful or trustworthy than another? How do factors like the model type, data characteristics, or even user needs impact the selection of the best XAI approach? Addressing these questions is key to advancing the field and ensuring the responsible use of AI systems in critical applications.

Goal

Critically compare and evaluate various Explainable AI (XAI) methods in the context of classification problems, exploring their effectiveness, limitations, and practical applications.

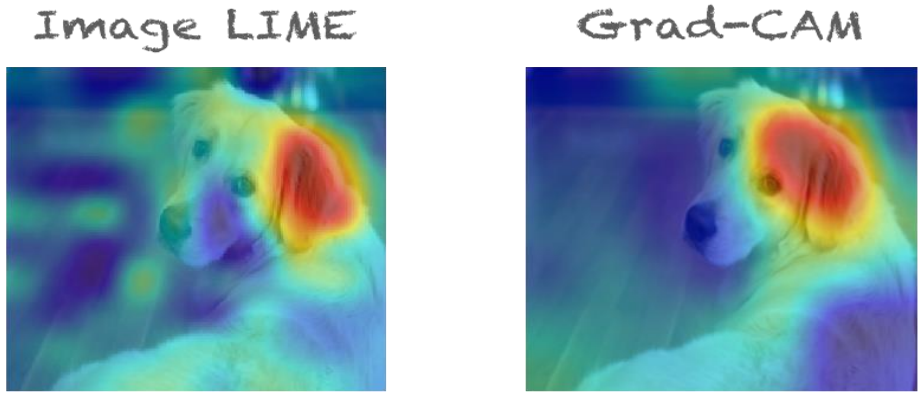
Tasks

Conduct a small literature review of the most widely used XAI methods for classification tasks and their key evaluation metrics. Analyze and compare them based on fidelity, interpretability and consistency, highlighting their applicability and effectiveness.

Project Type:

Supervisor:

Antonin Königsfeld – koenigsfeld@uni-wuppertal.de



Deep Learning Architectures for Efficient Scheduling

Deep Learning, Scheduling

Institute for TMDT

BERGISCHE UNIVERSITÄT WUPPERTAL

Background

Production scheduling (PS) deals with the allocation of machines to production operations (drilling etc.) over time to create an optimal schedule. In recent years, Deep Learning (DL) based solution approaches have produced more and more competitive solutions to this problem compared with traditional mathematical optimization techniques.

Graph Neural Networks and Transformers have been increasingly utilized and trained with very computationally intensive training procedures. We have a new, more efficient way, which allows us to investigate more network deep learning architectures more efficiently.

Goal

Boost the performance of DL based schedulers through tweaked and new DL architectures.

Tasks

Design, implement and test your own advanced DL architectures.

Project Type:

Supervisor:

Constantin Waubert de Puiseau

waubert@uni-wuppertal.de

Semantic standards for the digital product passport

Semantic Technologies, Standardisation, DPP

Background

The Digital Product Passport (DPP) is a key to the circular economy, as it provides comprehensive product information transparently across the entire life cycle. Semantic standards are essential to ensure interoperability between systems and industries. Frameworks such as BuildingSMART (IFC) in the construction industry, Asset Administration Shells (AAS) and E-Class are already laying the initial foundations. However, there is often a lack of consistent application and comprehensive standardization to realize the full potential of the DPP.

Goal

The aim is to provide a comprehensive overview of the current state of semantic standards and identify gaps.

Tasks

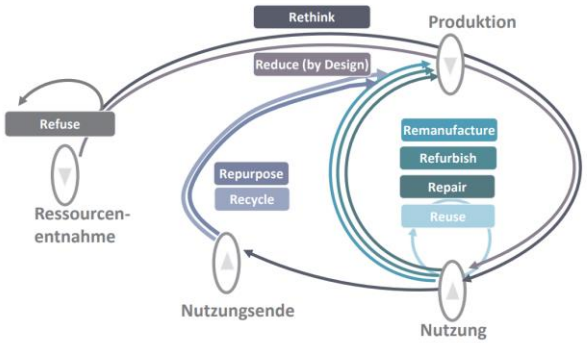
Conduct a literature review for existing semantic standards.

Identify gaps in standardization and application.

Project Type:

Supervisor:

Jakob Deich
deich@uni-wuppertal.de



Deep reinforcement learning for multi-objective scheduling

Computer Vision, Deep Learning

Background

Multi-objective optimization deals with problems where several goals need to be optimized simultaneously, which often conflict. For example, in a delivery service, you might want to minimize cost while also maximizing delivery speed. With deep Reinforcement Learning (deep RL), the system can learn to navigate these competing objectives by exploring various trade-offs. Instead of just aiming for the "best" single solution, Deep RL helps identify a set of optimal solutions. This research area is highly relevant to real-world applications such as supply chain management, where multiple performance metrics need to be optimized together.

Goal

Investigate state-of-the-art deep RL techniques for multi-objective combinatorial optimization tasks using PyTorch.

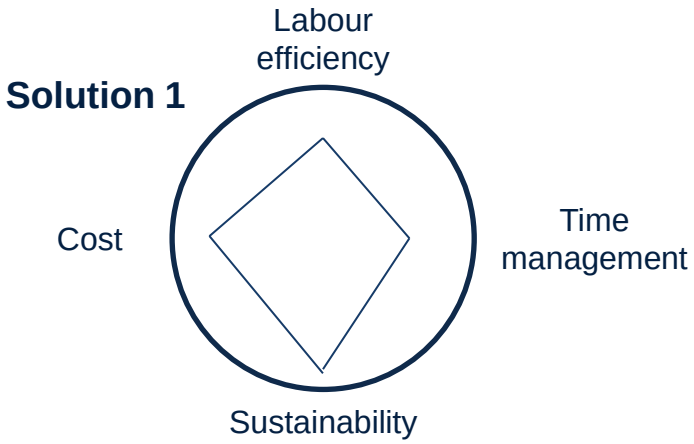
Tasks

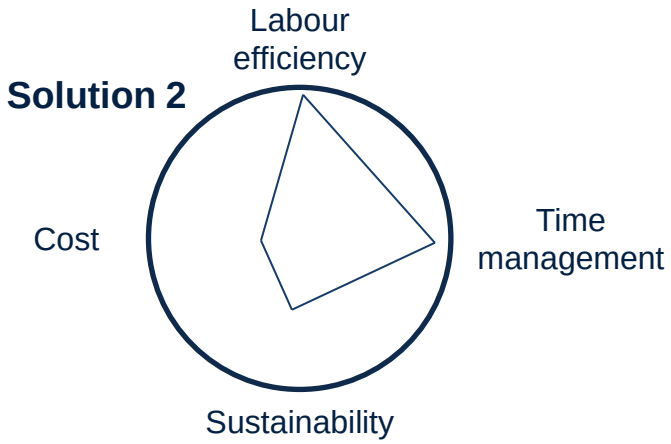
Implementation and comparison of these techniques on a simple combinatorial problem.

Project Type:

Supervisor:

Marvin Brune – brune@uni-wuppertal.de





Adversarial Attacks for Image Recognition Manipulation

Computer Vision, Deep Learning

Institute for TMDT

BERGISCHE UNIVERSITÄT WUPPERTAL

Background

As we delve deeper into the field of computer vision, where machines learn to perceive and classify images, a peculiar phenomenon emerges: adversarial examples. These are similar to optical illusions designed to deceive AI models. Imagine an innocuous panda image subtly tweaked to be confidently identified as a gibbon. These deceptively crafted illusions challenge the robustness of the image recognition systems. Adversarial attacks are a useful technique for examining the weaknesses of image recognition models. By intentionally modifying the inputs (adversarial examples) that cause the model to make mistakes, we gain insights into its decision boundaries and limitations.

Goal

Investigate state-of-the-art adversarial attack techniques for image recognition tasks using PyTorch/Tensorflow.

Tasks

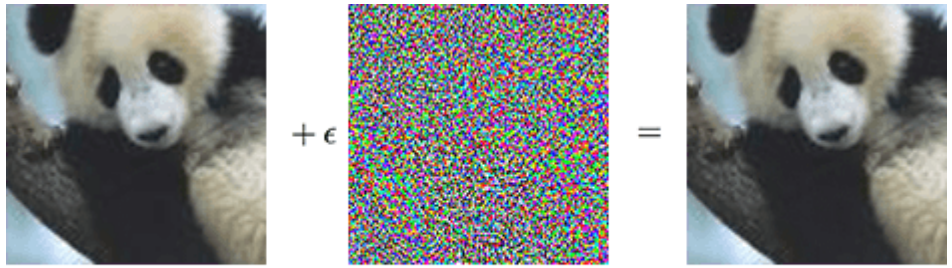
A small literature survey of the existing adversarial attack techniques for image recognition tasks.

Implementation and comparison of these techniques on a most popular image recognition dataset.

Project Type:

Supervisor:

Adwait Chandorkar – chandorkar@uni-wuppertal.de



Adversarial Attacks for object detection

Computer Vision, Deep Learning

Background

As we delve deeper into computer vision, where machines learn to perceive and classify images, a peculiar phenomenon emerges adversarial examples. These are similar to optical illusions designed to deceive AI models. Generating these adversarial attacks for Images is quite intuitive however, attacking computer vision models that process point clouds is challenging. This is because point cloud data is sparse and unstructured hence, modifying this data is tricky. By intentionally modifying the inputs (adversarial examples) that cause the model to make mistakes, we gain insights into its decision boundaries and limitations.

Goal

Literature survey of state-of-the-art adversarial attack techniques for object detection tasks.

Tasks

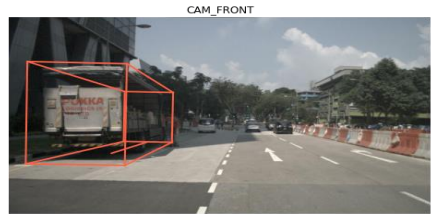
Setup different keywords and eligibility criteria to filter the recent state-of-the-art techniques.

A detailed study of the filtered approaches resulting in an 8-10 page short paper.

Project Type:

Supervisor:

Adwait Chandorkar – chandorkar@uni-wuppertal.de



nuScenes: A multimodal dataset for autonomous driving

Model Compression for 3d Object Detection: Literature Survey

Computer Vision

Background

In the recent years, computer vision models have grown in complexity, with millions of parameters. However, deploying these large models on resource-constrained devices (like mobile phones or edge devices) poses challenges. Model compression techniques address this issue by reducing model size and at the same time ensuring minimum loss in performance. Some of the key methods of compression include Pruning, quantization, knowledge distillation etc. We want to explore model compression techniques to transform large models into smaller, faster models.

Goal

Literature survey of the state-of-the-art model compression techniques for 3D object detectors.

Tasks

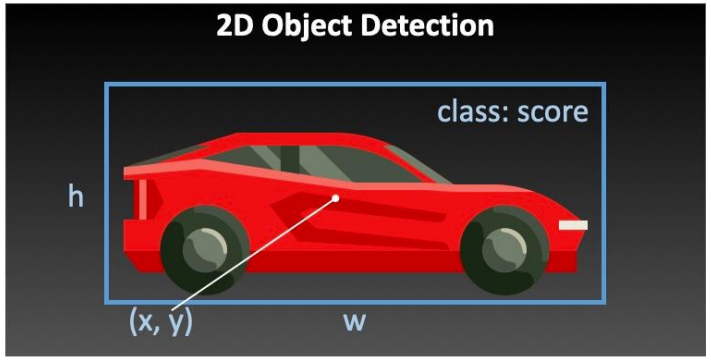
Setup different keywords and eligibility criterion to filter the recent state-of-the-art approaches.

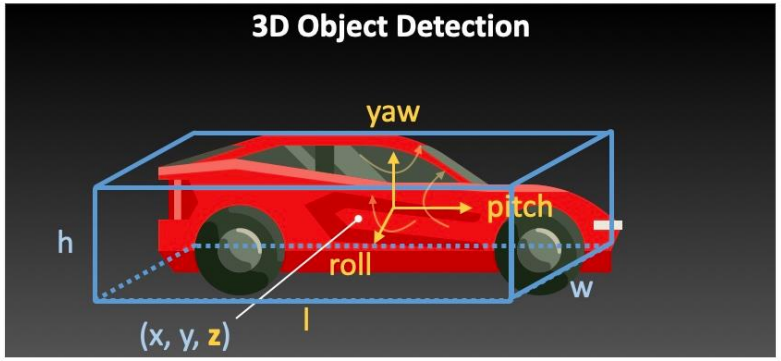
A detailed study of the filtered approaches resulting in a 8-10 page short paper.

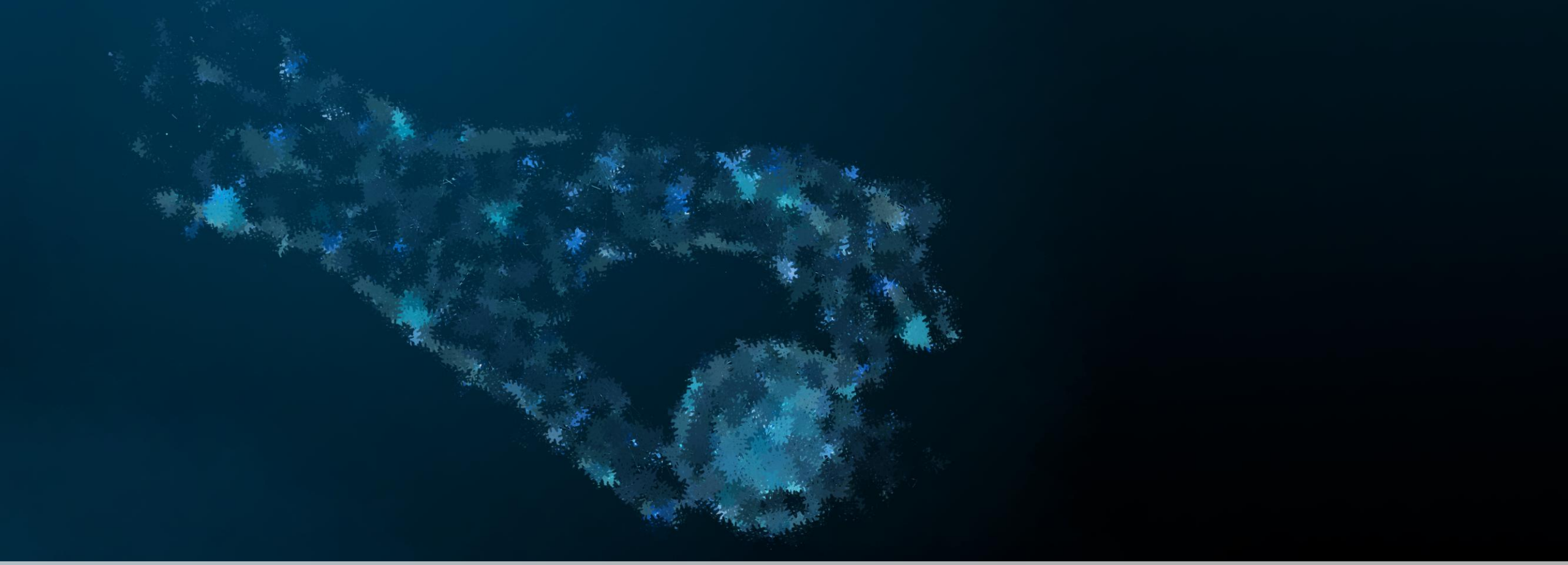
Project Type:

Supervisor:

Adwait Chandorkar
chandorkar@uni-wuppertal.de







Next Steps

So what happens now?

Next Steps

1. Talk to the supervisor(s) of the topic(s) you are interested in
   - Clarify any open questions
   - Talk about requirements and expectations
   - You may modify the scope of the topic (**if accepted by your supervisor!)**

2. Select your topic
   - Find the voting form in Moodle starting Wednesday, 16.10.2024, 8:00 am
   - Select the topic you want! Note: First Come First Serve!

3. Contact your topic supervisor and clarify the next steps before your milestone presentation.

4. Start working on your topic!

5. Next important deadline: Topic & milestone presentations! (29.10.2024 and/or 05.11.2024)

Questions?

Next Steps

On specific projects: **see project slides**

Seminar organization:
Adwait Chandorkar, M.Sc.
chandorkar@uni-wuppertal.de

Prof. Dr.-Ing. Tobias Meisen
meisen@uni-wuppertal.de

Institute for TMDT

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Thank you for your attention!