Computer Graphics Course
Wrap-Up

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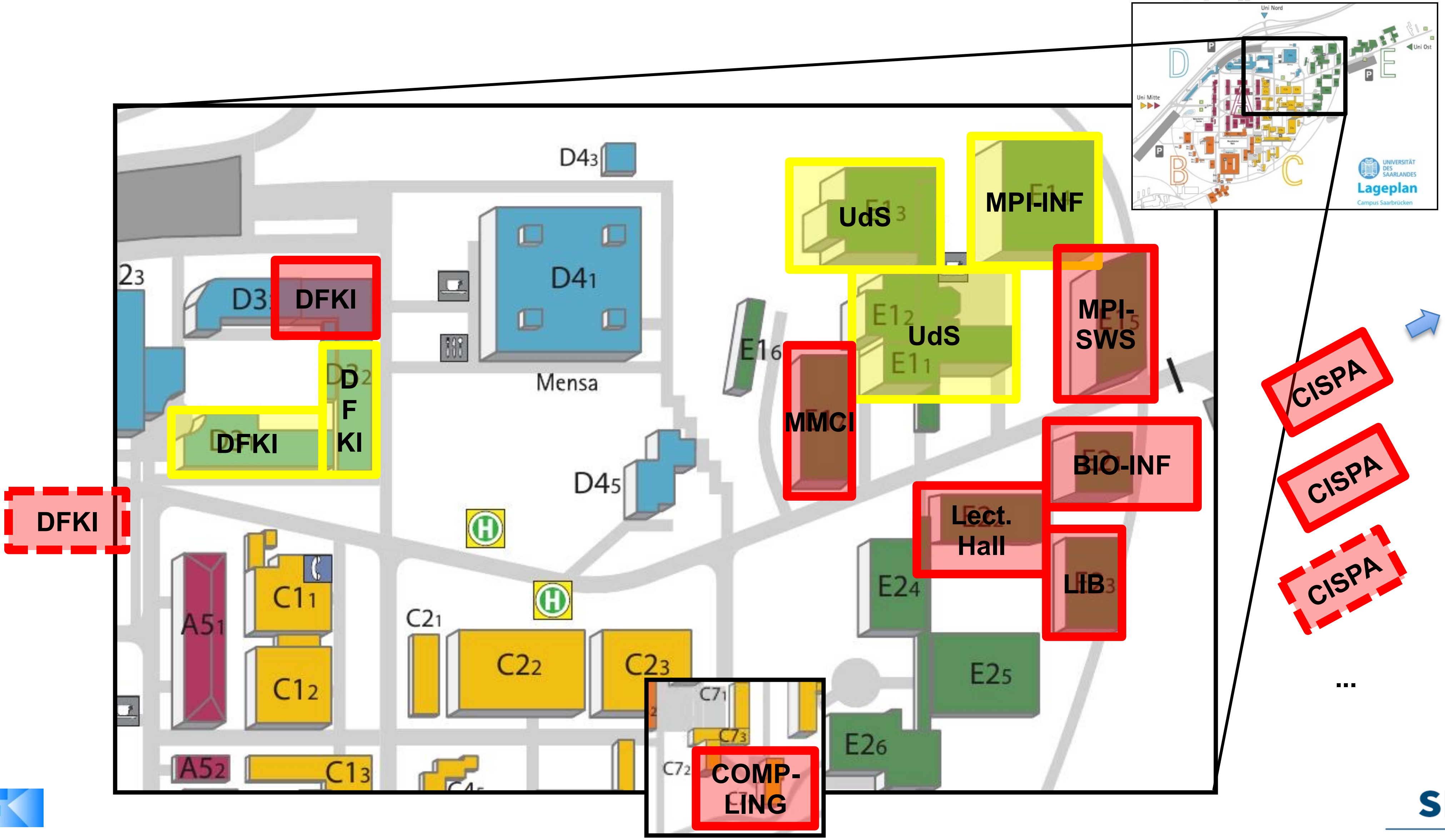
Saarland Informatics Campus

Computer Science
on the Saarland Campus



DFKI: An Overview

German Research Center for Artificial Intelligence (DFKI)

- **Overview**
  - Largest independent AI research center worldwide (founded in 1988)
  - Germany’s leading research center for innovative software technologies
  - Multiple sites across Germany
    - Saarbrücken, Kaiserslautern, Bremen, Osnabrück/Oldenburg
    - Labs in Berlin, Darmstadt; Offices in Lübeck, Trier
  - 27 research areas, 9 competence centers, 8 demonstration centers (living labs)
  - More than 1400 research staff & support
  - Research funding: ~83 M€ (2022, LAV)
    - Almost 50% growth over three years: 76 M€ (+19%, 2021), 64 M€ (+12%, 2020), 57 M€ (2019)
  - More than 100 spin-offs, more than 2500 new high-tech jobs





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Germany Has a Head-Start

DFKI: The World´s Largest Center for Research & Application in AI

intel
NVIDIA
SCHWARZ
LIDL
Kaufland
HARTING
ZF
JOHN DEERE
CLAAS
VOLKSWAGEN AKTIENGESELLSCHAFT
BMW GROUP
MINI
Rolls-Royce Motor Cars NA, LLC
DAIMLER
BOSCH
RICOH
AIRBUS GROUP
VSE
SARTORIUS
BILFINGER
ROSEN empowered by technology
Munich RE
TECHNISCHE UNIVERSITÄT KAISERSLAUTERN
Universität Bremen
UNIVERSITÄT DES SAARLANDES
Fraunhofer
KIBG
Deutsche Messe
cerence
EMPOLIS INFORMATION MANAGEMENT
accenture
DEUTSCHE BÖRSE GROUP
Google
Microsoft Deutschland GmbH
software AG
Deutsche Telekom
SAP

DFKI

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DFKI Covers the Complete Innovation Cycle

DFKI-Portfolio: Deep Expertise in AI for a Broad Innovation Spectrum

Max Planck Society	Fraunhofer	Helmholtz Society
Application-Oriented Basic Research	**Applied R&D and Transfer**	Large Test- and Demonstration Centers

The entire innovation chain in the horizontal spectrum of DFKI

The vertical specialisation of DFKI on methods and applications of Artificial Intelligence

Deep knowledge and excellence in one important section of Computer Science

DFKI Employees

Broad Methodological and Systems Competence in Artificial Intelligence

Deep Scientific Expertise in AI Technology

Deep Domain Knowledge in an Area of Application

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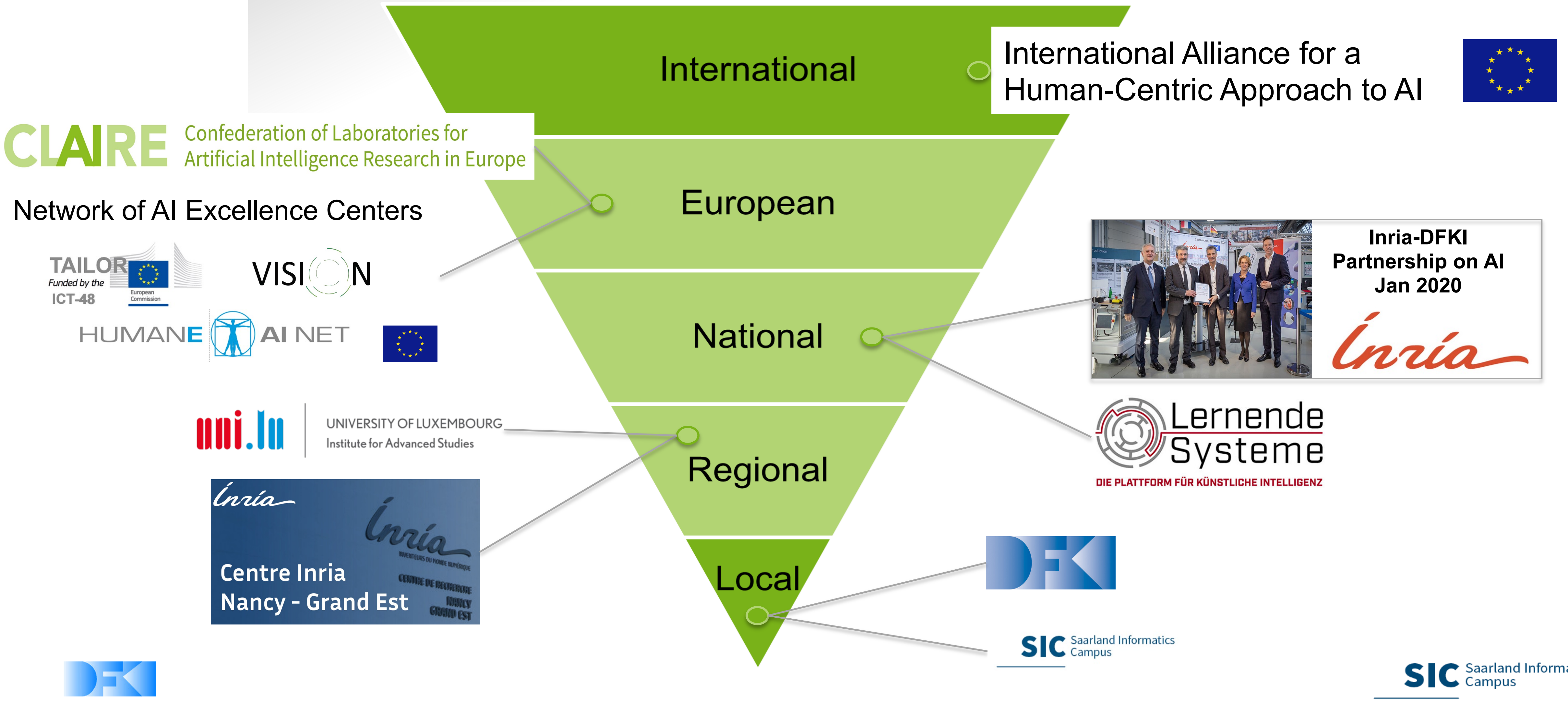
DFKI-SB: From Local Strengths to a European Strategy



Strategic Cooperation with INRIA & France

- **Five Application-Oriented Projects (Total Investment: ~6 M€ @ DFKI only, similar @ INRIA)**

2020	**MePheSTO** Digital Phenotyping for Psychiatric Disorders from Social Interaction	**IMPRESS** Improving Language Embeddings with Semantic Knowledge	**Moveon** Towards robust spatial scene understanding in dynamic environments using intermediate representations
2021	**ENGAGE** Next Generation High-Performance Computing for Hybrid AI (→ LEAM-Initiative)	**R4Agri** Reasoning on Agricultural Data: Integrating Metrics and Qualitative Perspectives	**Other Projects already in Preparation** (e.g. Green-AI)

- **Joint Activities**

Weekly **Coordination Meetings** & Regular **Alignment with Executive Level**

DFKI-INRIA Summer-School (IDESSAI 2021, 2022, …)

At least one joint workshop per year

- **Tight Collaboration at European Level**

CLAIRE · Adra – The AI Data Robotics Association · BDV Big Data Value Association · eu ROBOTICS · EurAi · …

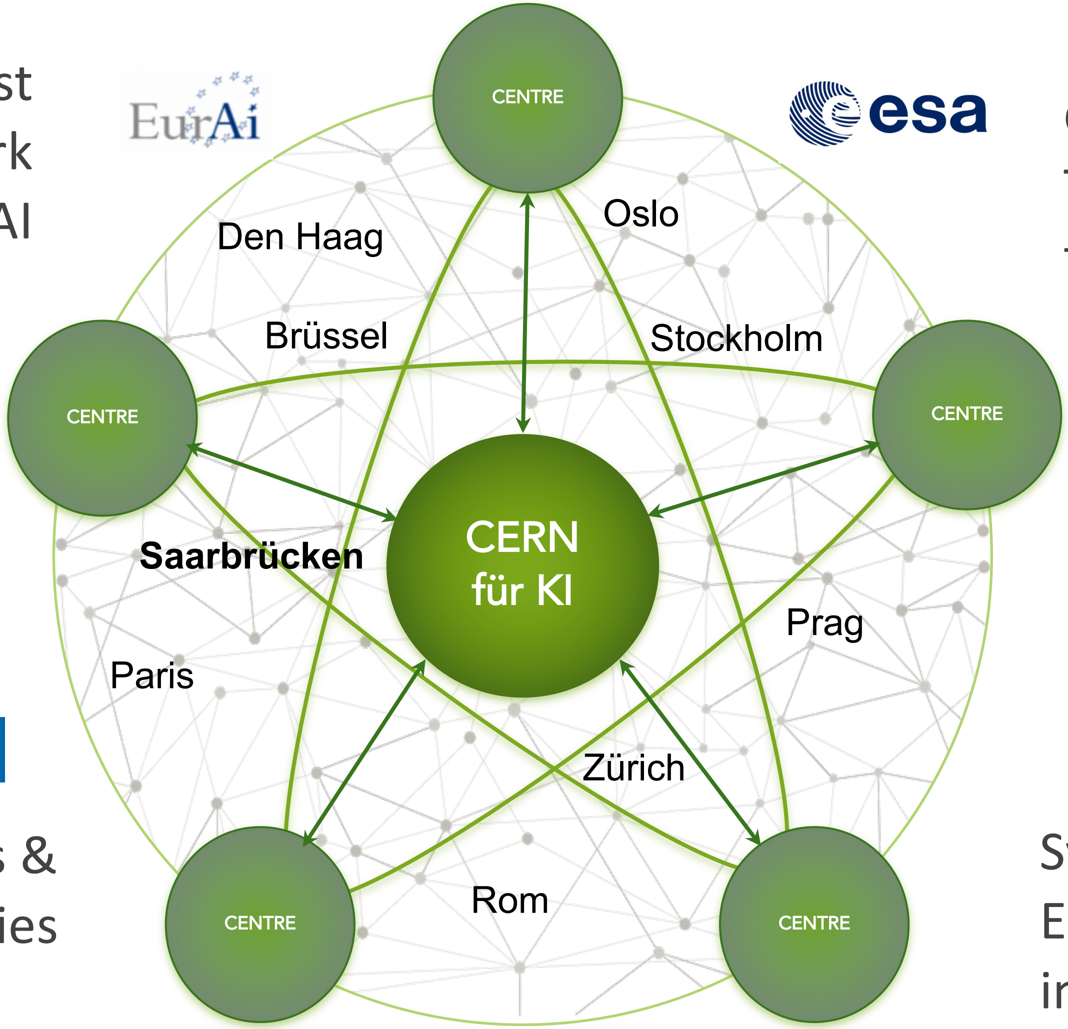
DFKI

CLAIRE-Network & "CERN for AI"

Worldwide Largest Research Network for AI

>440 Research Groups and Organizations from Across All of Europe

24.000+ AI Researchers & Staff from 37 Countries



Global Attractor for Talents from across the Globe

„Place to be“ for AI Talents, for Interaction & Innovation

Symbol for European Excellence & Ambition in AI

CLAIRE Confederation of Laboratories for Artificial Intelligence Research in Europe

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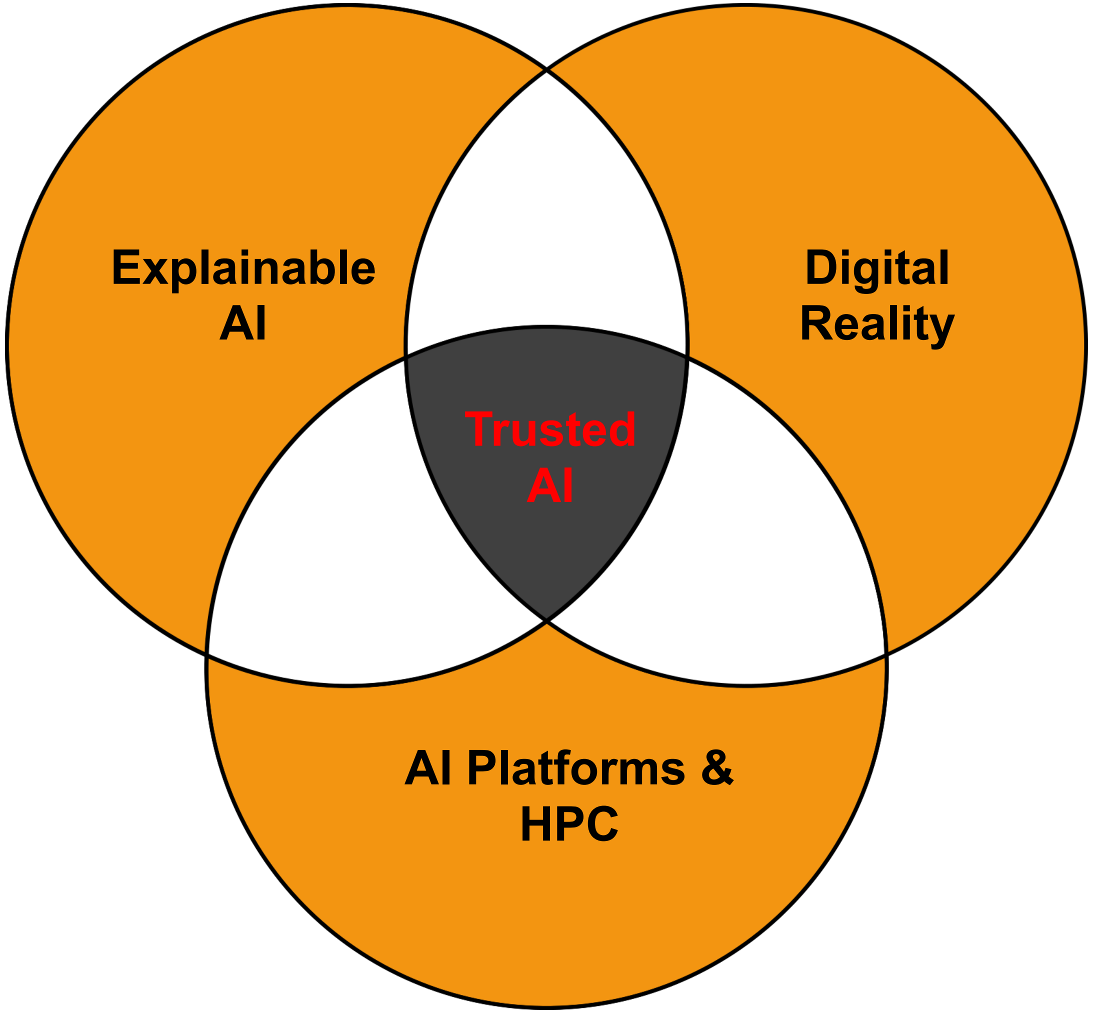
DFKI Research Area:
Agents and Simulated Reality (ASR)

DFKI-ASR: Agents and Simulated Reality

How to design AI systems that can provide guarantees and that humans can understand and trust?



How can synthetic data from parametric models and simulations be used for *training, validating, and certifying AI systems?*

How can AI-systems be realized technically in a *reliable and efficient way?*

Flexible Production Control Using Multiagent Systems at Saarstahl, Völklingen

DFKI multi-agent technology is running the steelworks, 24/7 for >12 years, 5 researchers transferred

Physically-Based Image Synthesis with Real-Time Ray Tracing

RT-HW in EVERY GPU now

Technical Oscar, Feb 2021

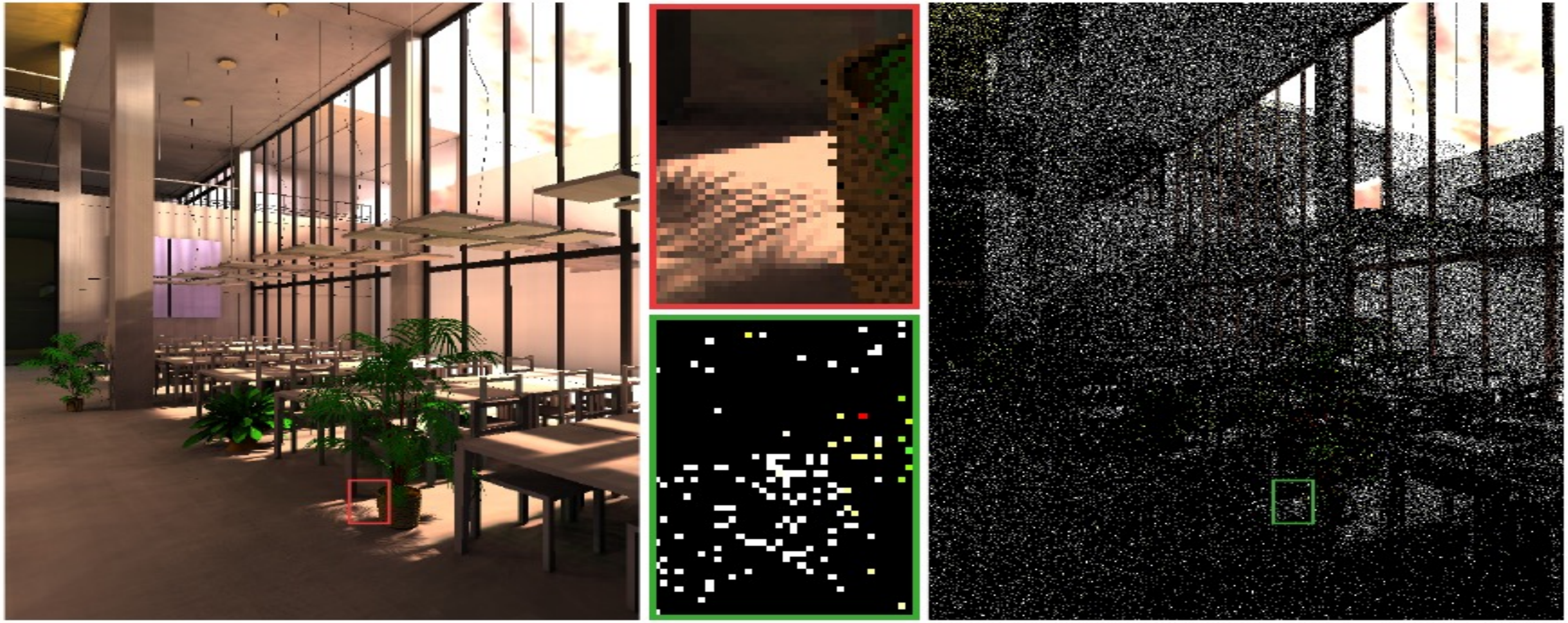
Key product offered now by all major GPU/HW vendors:
e.g. Intel (Embree), Nvidia (OptiX), AMD (Radeon Rays) , …

Efficient Simulation of Illumination: Light Propagation and Sensor Models

VCM/MC now part of most commercial renders:
e.g. RenderMan, V-Ray, … + Radar Simulation

Recent Advances in Lighting Sim.

- **Importance Caching for Complex Illumination**
  - By Iliyan Georgiev et al., Eurographics 2012



Recent Advances in Lighting Sim.

- **Light Transport Simulation with Vertex Connection and Merging (VCM)**
  - By Iliyan Georgiev et al., Siggraph 2012

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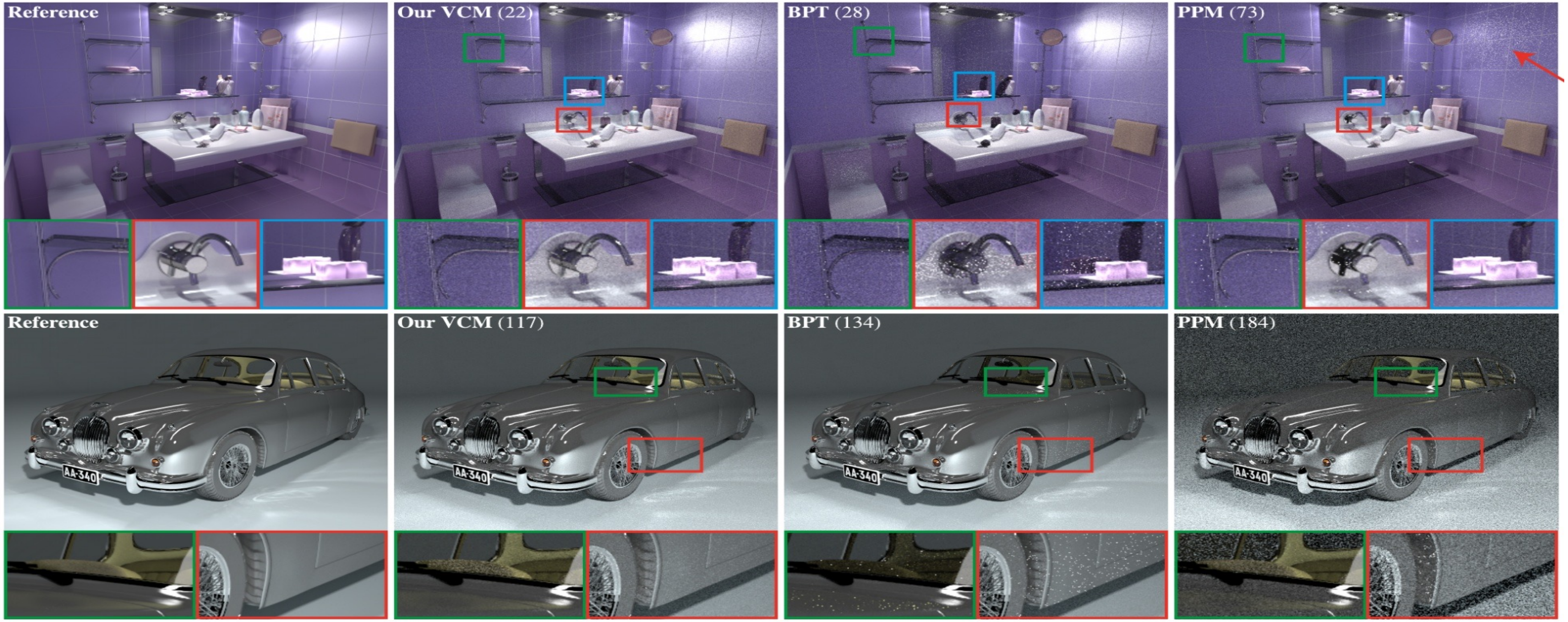
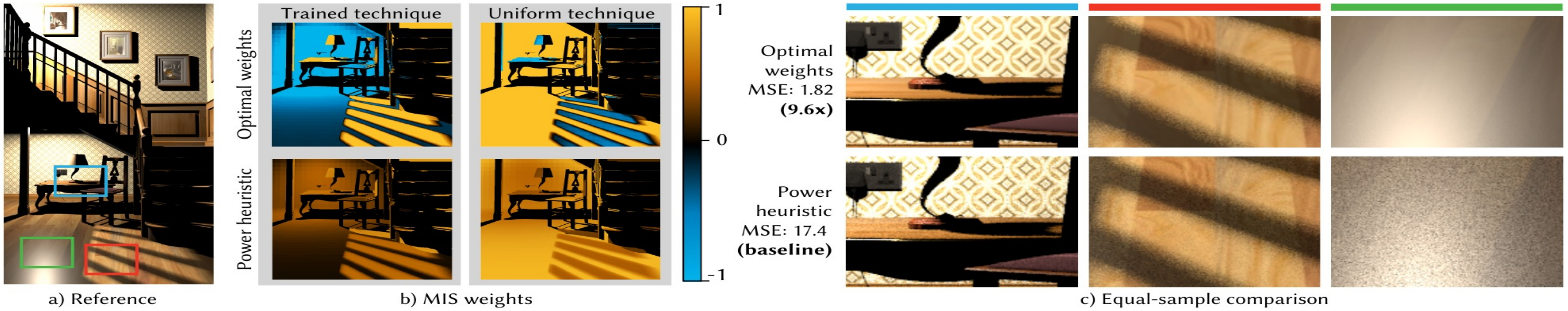


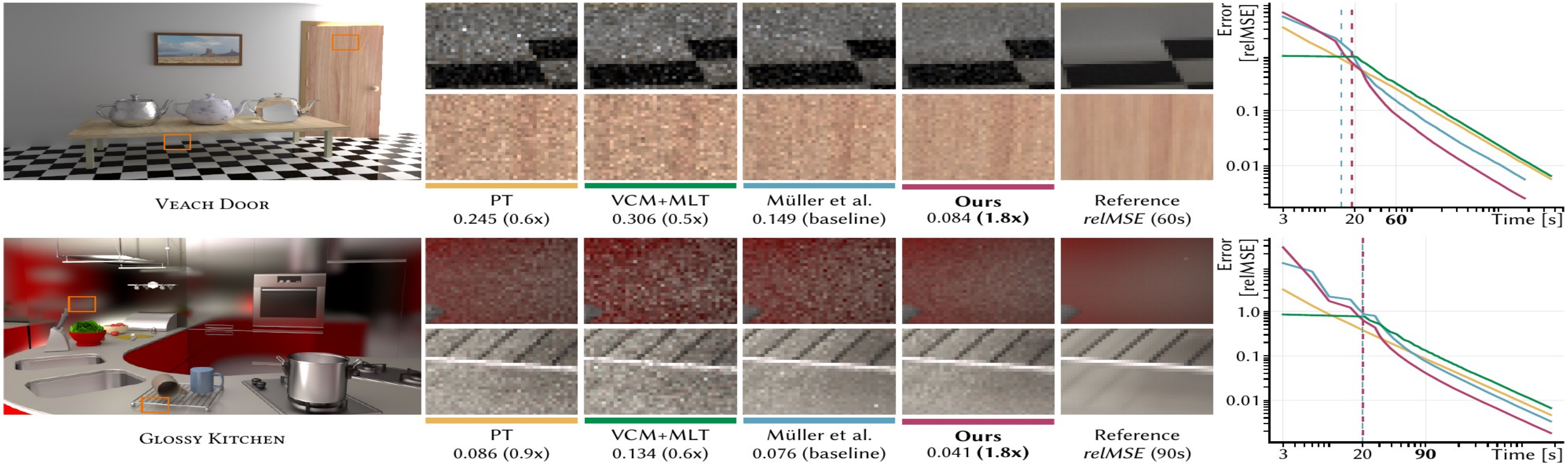
Recent Advances in Lighting Sim.

- **Optimal Multiple Importance Sampling**
  - By I. Kondapaneni, P. Vévoda, P. Grittmann, et al., Siggraph 2019



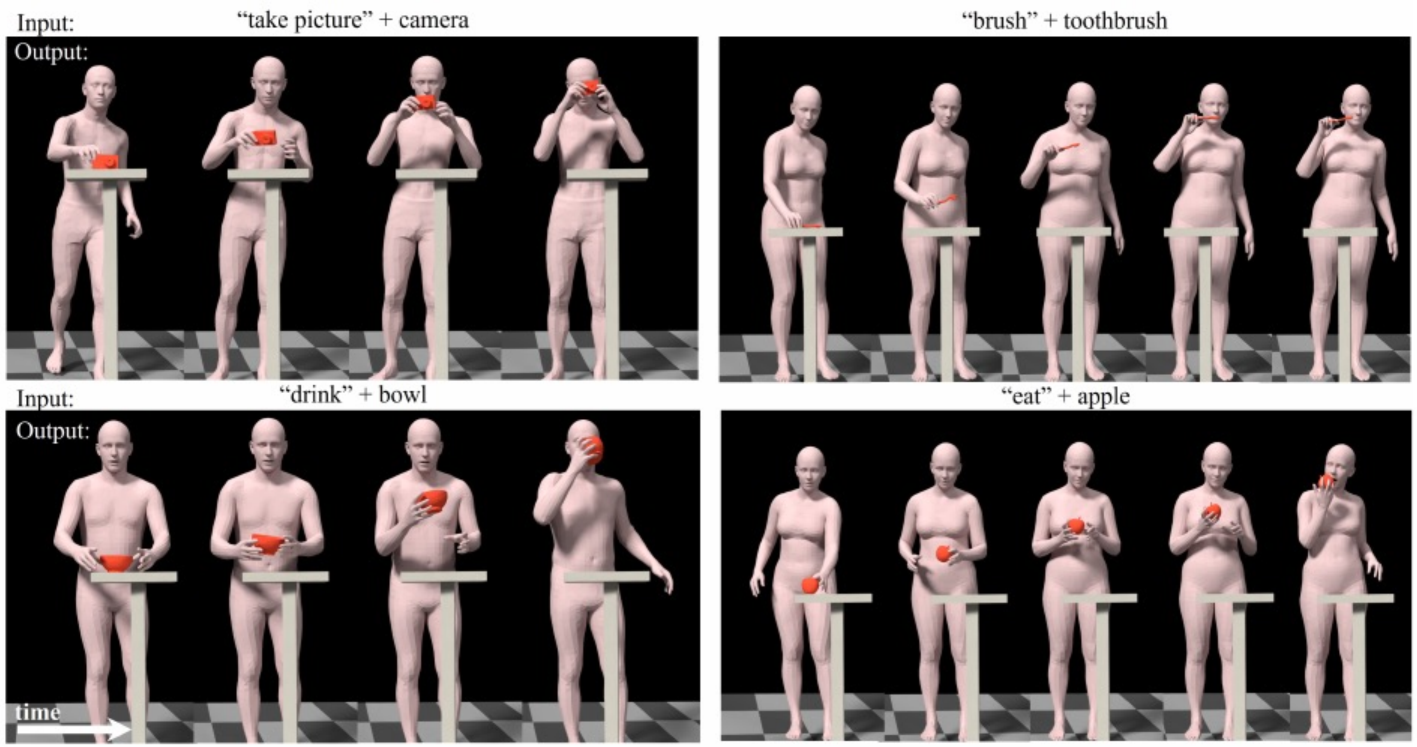
Recent Advances in Lighting Sim.

- **Variance-Aware Path Guiding**
  - By A. Rath, P. Grittmann, S. Herholz, P. Vévoda, et al., Siggraph 2020

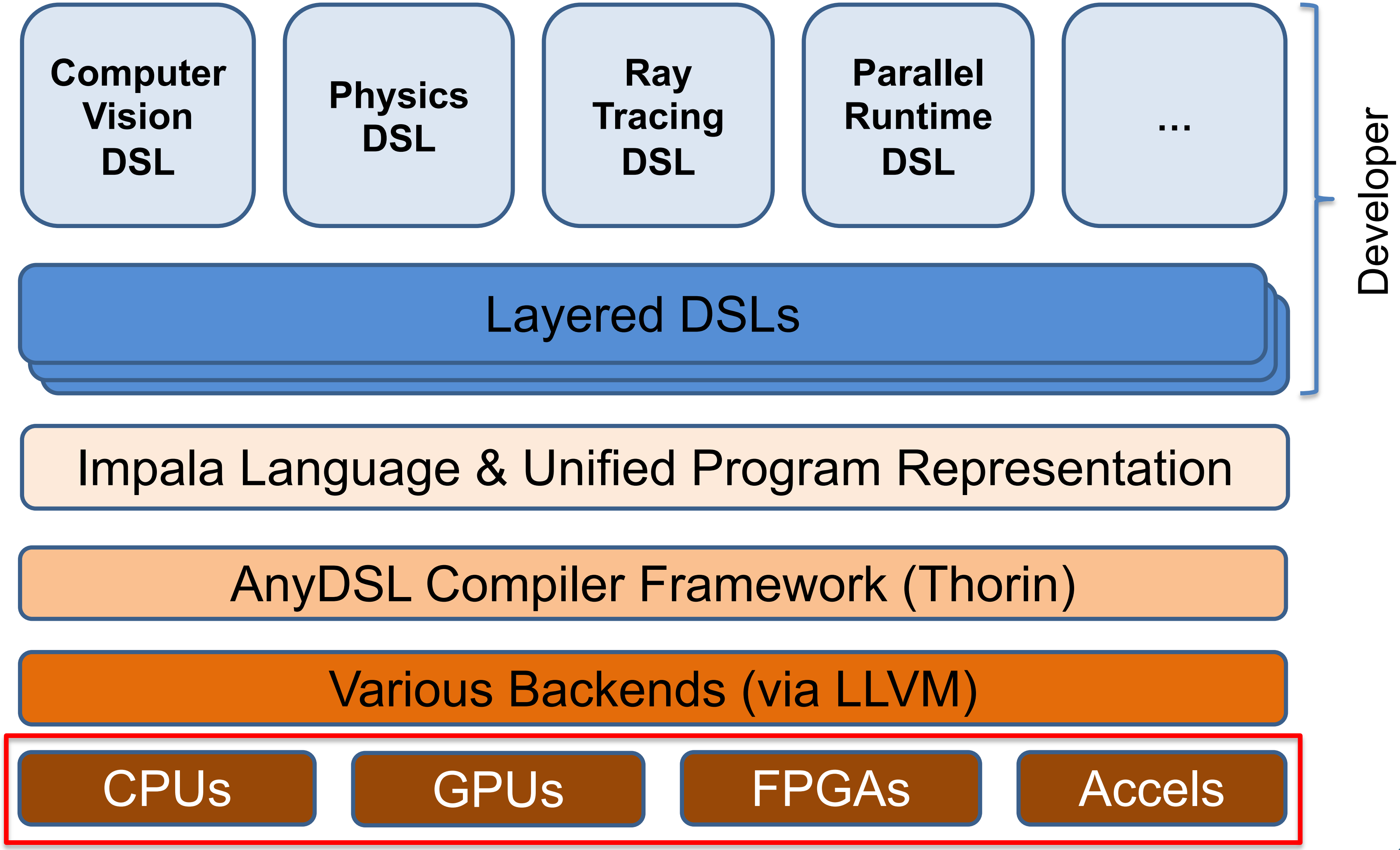


Recent Advances in Motion Synthesis

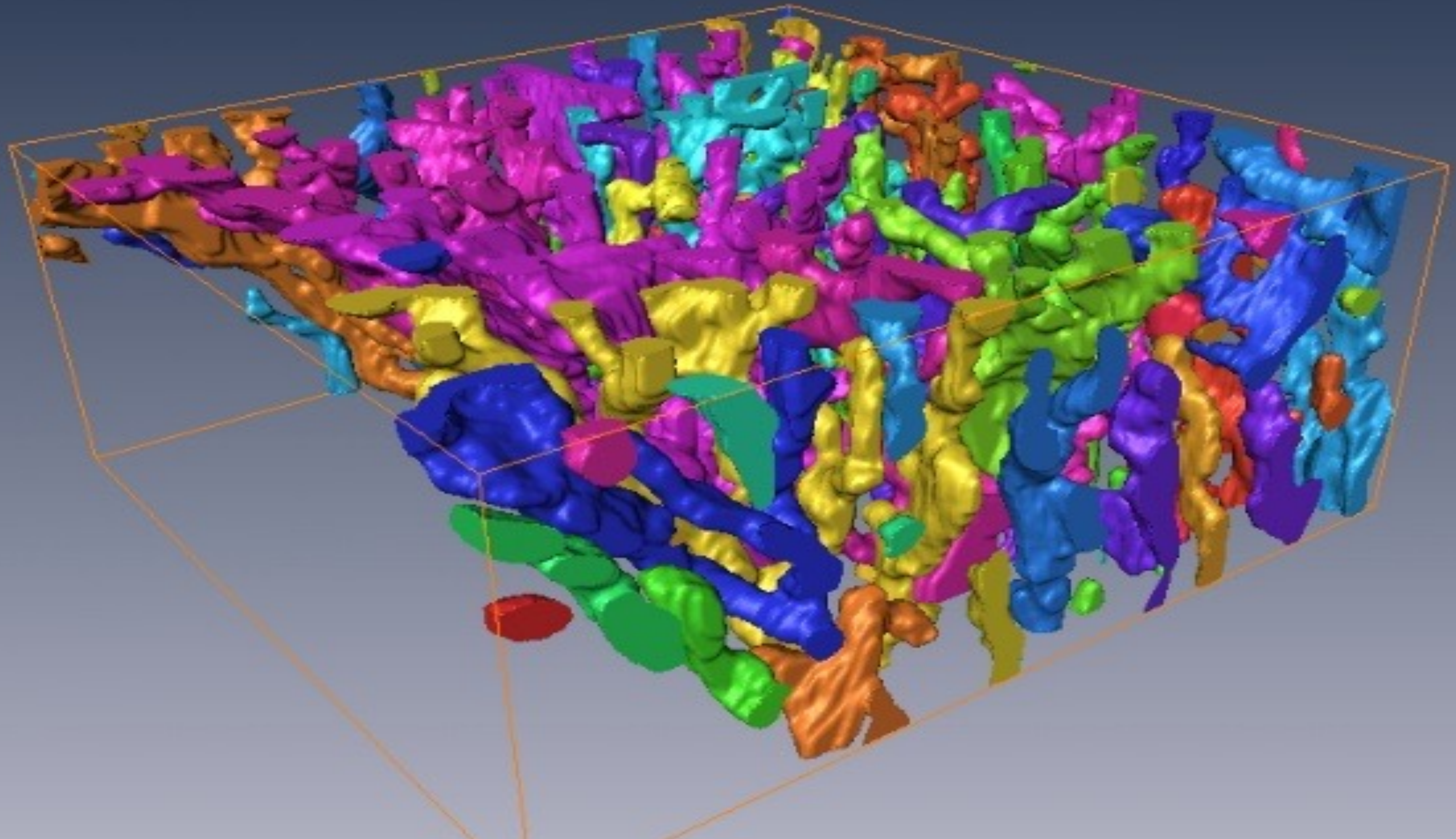
- **IMoS: Intent-Driven Full-Body Motion Synthesis for Human-Object Interactions**
  - By Anindita Ghosh, Rishabh Dabral, Vladislav Golyanik, Christian Theobalt, Philipp Slusallek, at Eurographics 2023



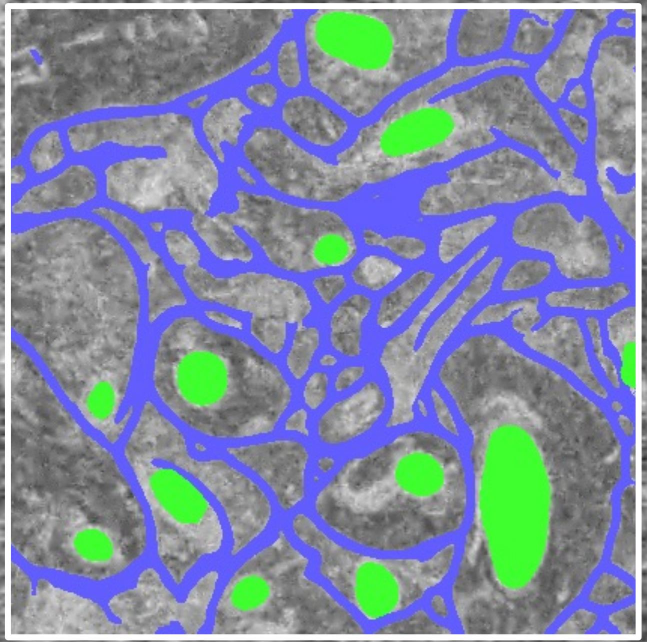
AnyDSL Compiler Framework

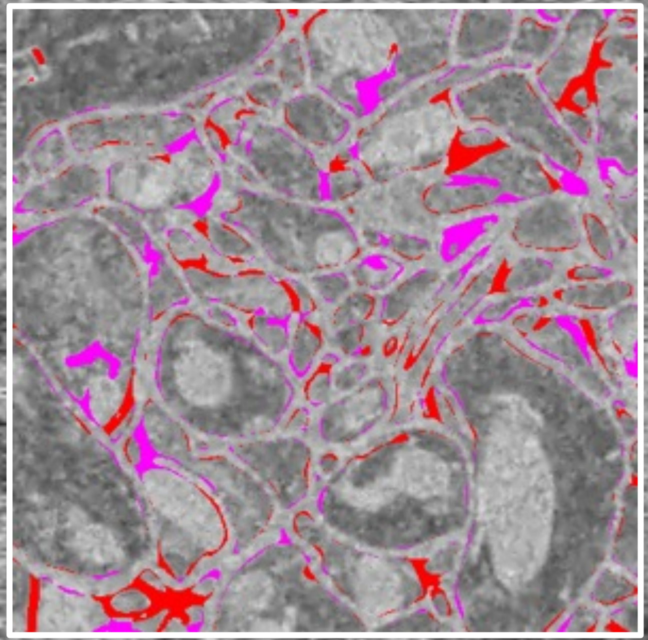


Material Science: Understanding & Predicting Effects of 3D Structures Across Scales

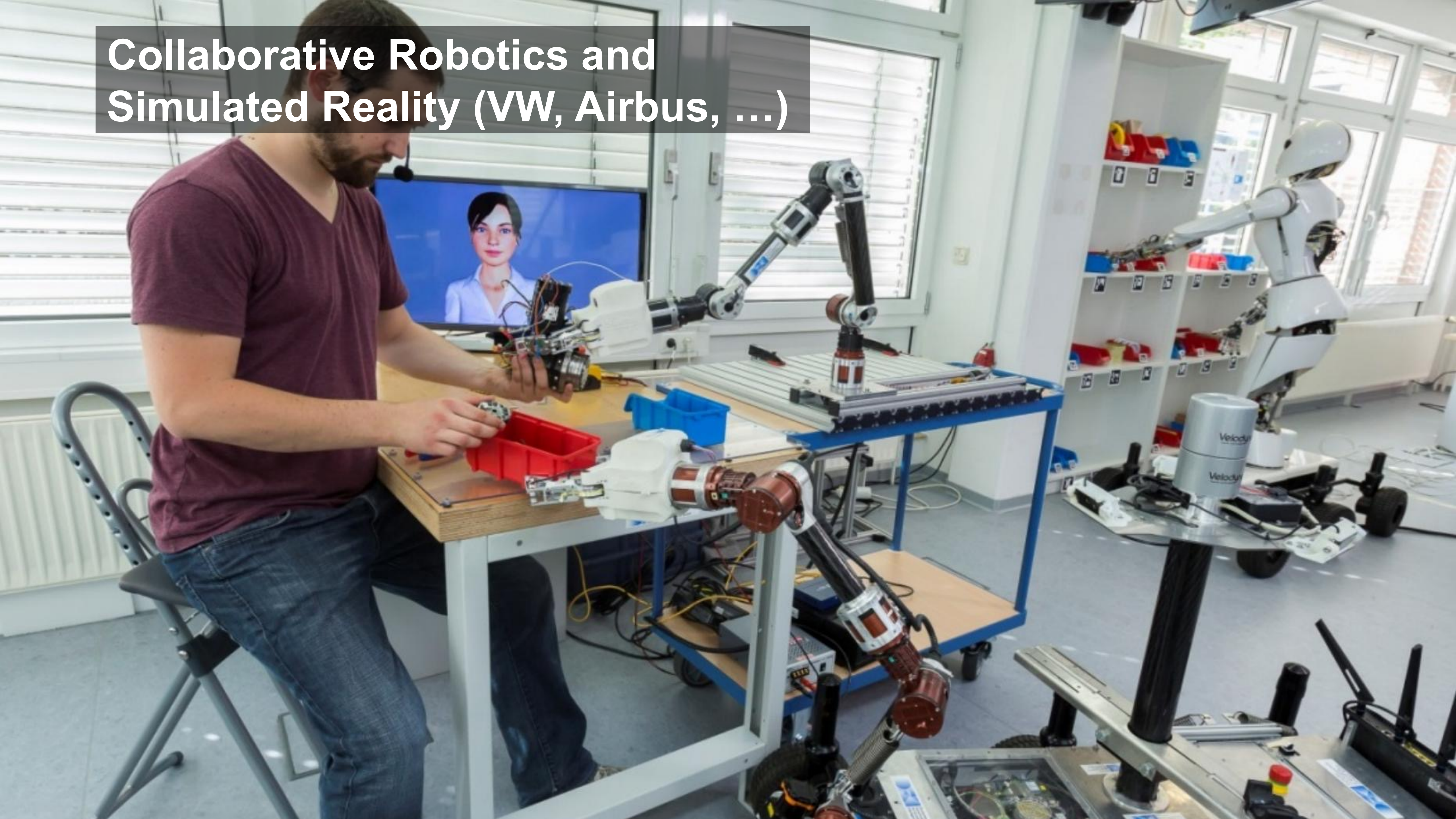


Efficient Use of AI in Health and Life Sciences





Collaborative Robotics and Simulated Reality (VW, Airbus, …)

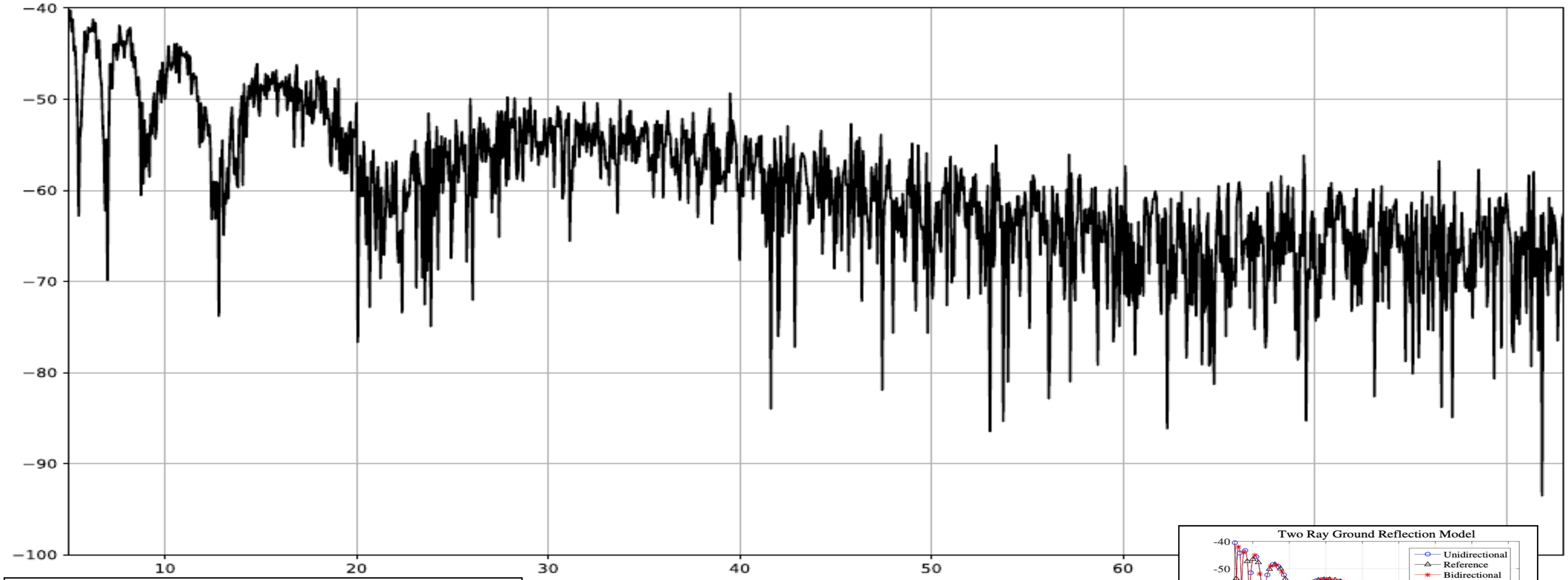


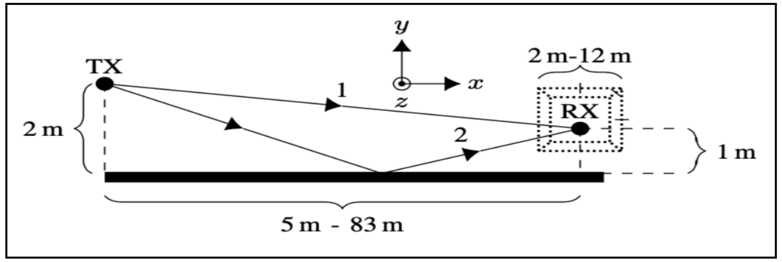
Autonomous Driving: Training using Synthetic Sensor Data and Realistic Models (TÜV, VDA, ZF, Conti, …)

Challenge: Better Simulation (e.g. Radar Rendering)

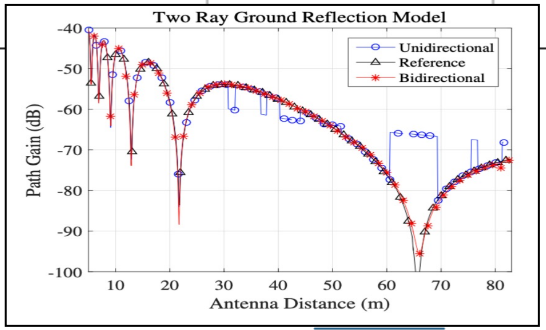
- **Key Differences**
  - Longer wavelength: Geometric optics (rays) not sufficient
  - Need for *some* wave optics
    - Interference of multi-path interactions (coherent radiation, GO/PO)
    - Need for polarization and phase information
    - Diffraction from rough surfaces and edges
  - Highly different goals
    - Optical: Focus on *diffuse* effects (+ some highlights, reflections, etc.)
    - Radar: Focus on *specular* transport only (i.e. caustic paths)
- **Completely novel approach (beyond ray tracing)**
  - Using latest Monte-Carlo techniques (BiDir, MIS, VCM, …)
  - Using recent work on Path Guiding [Rath et al., Siggraph´19]
- **Bringing together radar & latest research on MC rendering**

Radar Simulation
Using Modern Monte-Carlo Algorithms

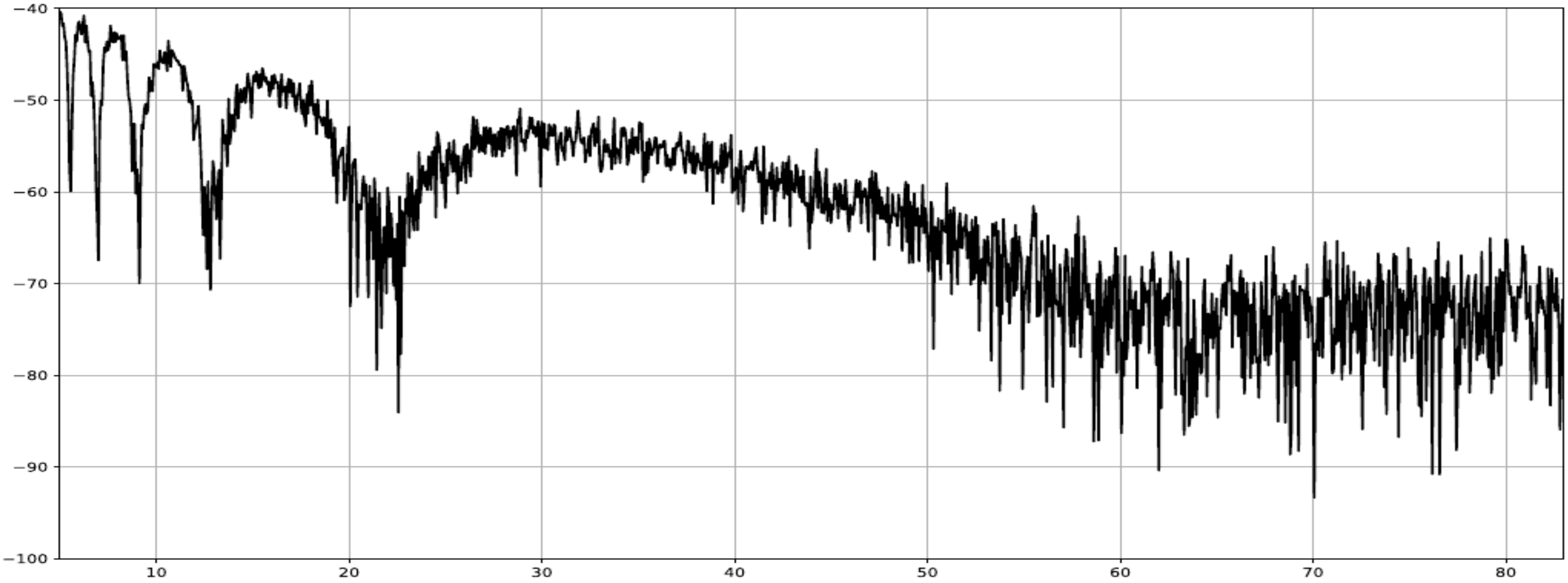




Path Tracing

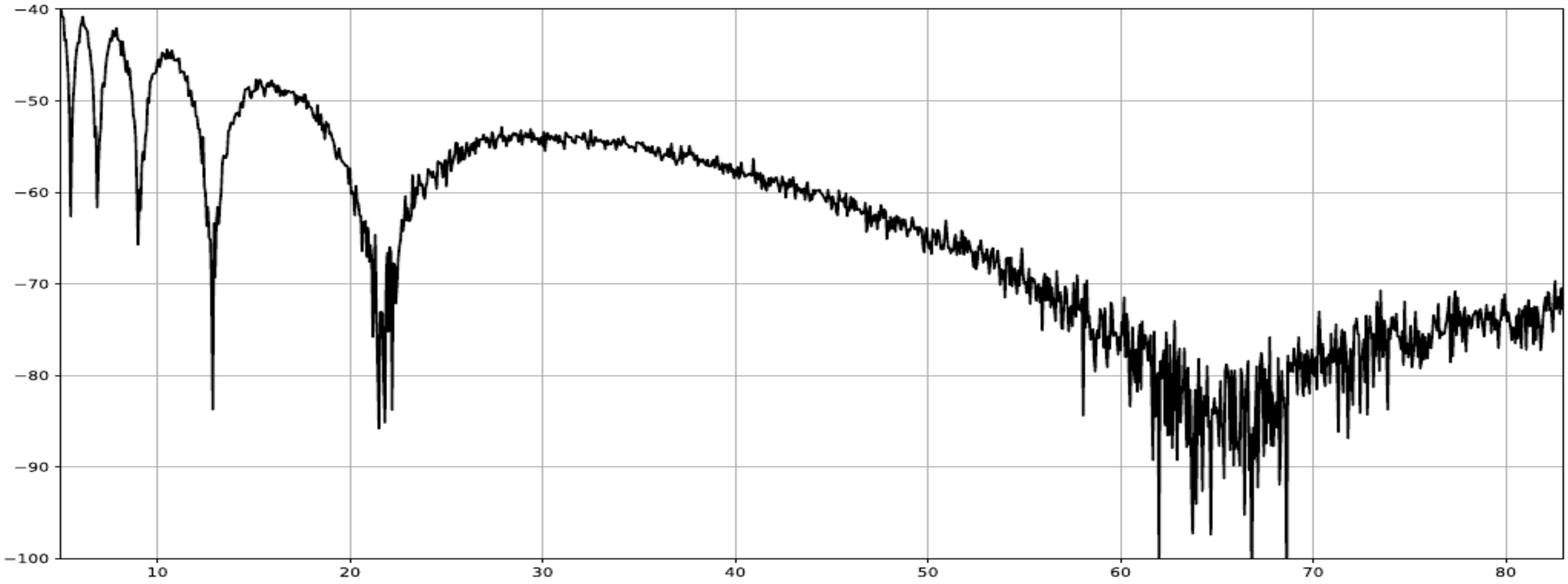


Radar Simulation
Using Modern Monte-Carlo Algorithms



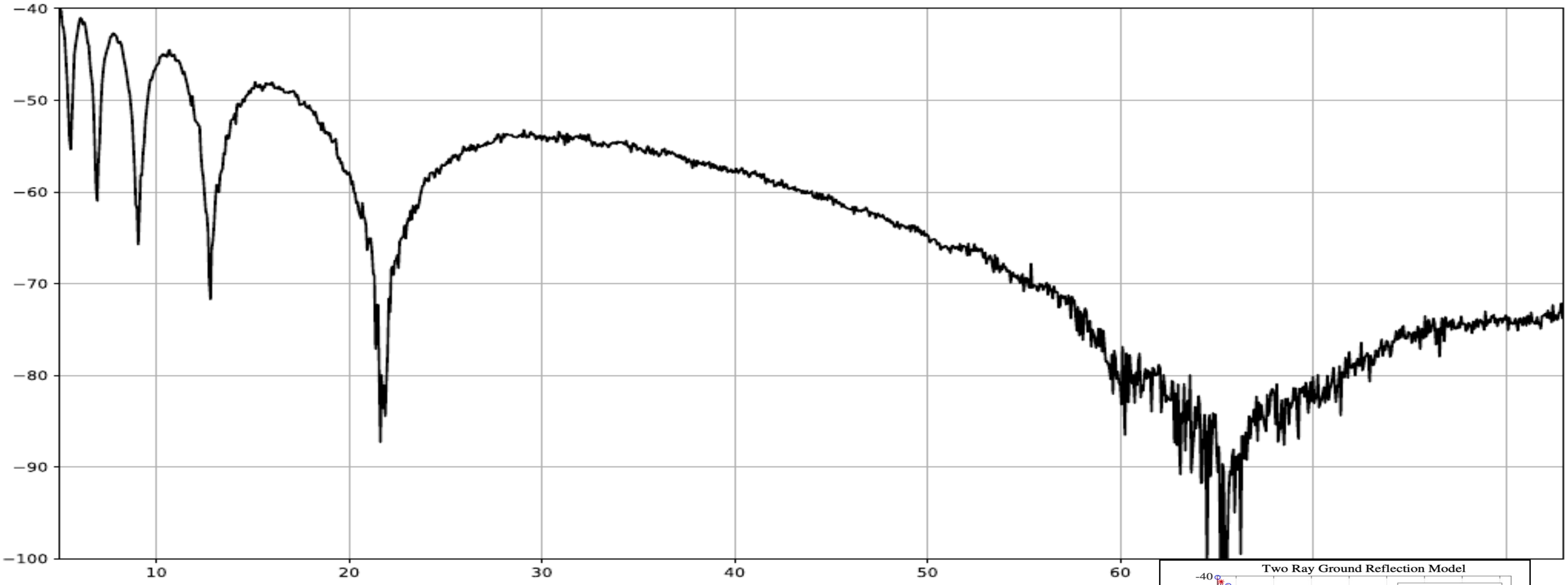
Path Tracing + "Texture Filtering"

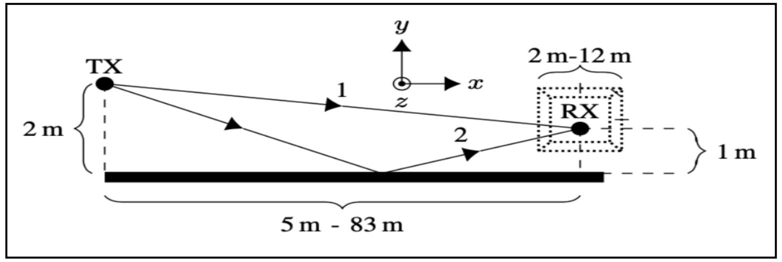
Radar Simulation
Using Modern Monte-Carlo Algorithms



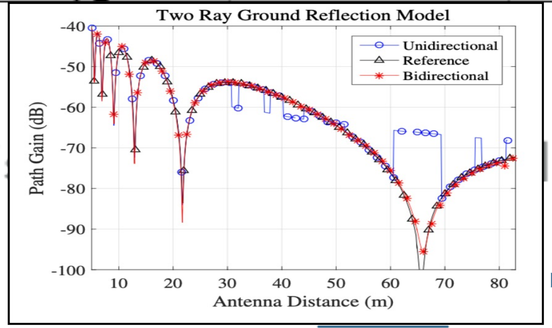
Path Tracing + "Texture Filtering" + Guiding

Two-Way Ground Reflection



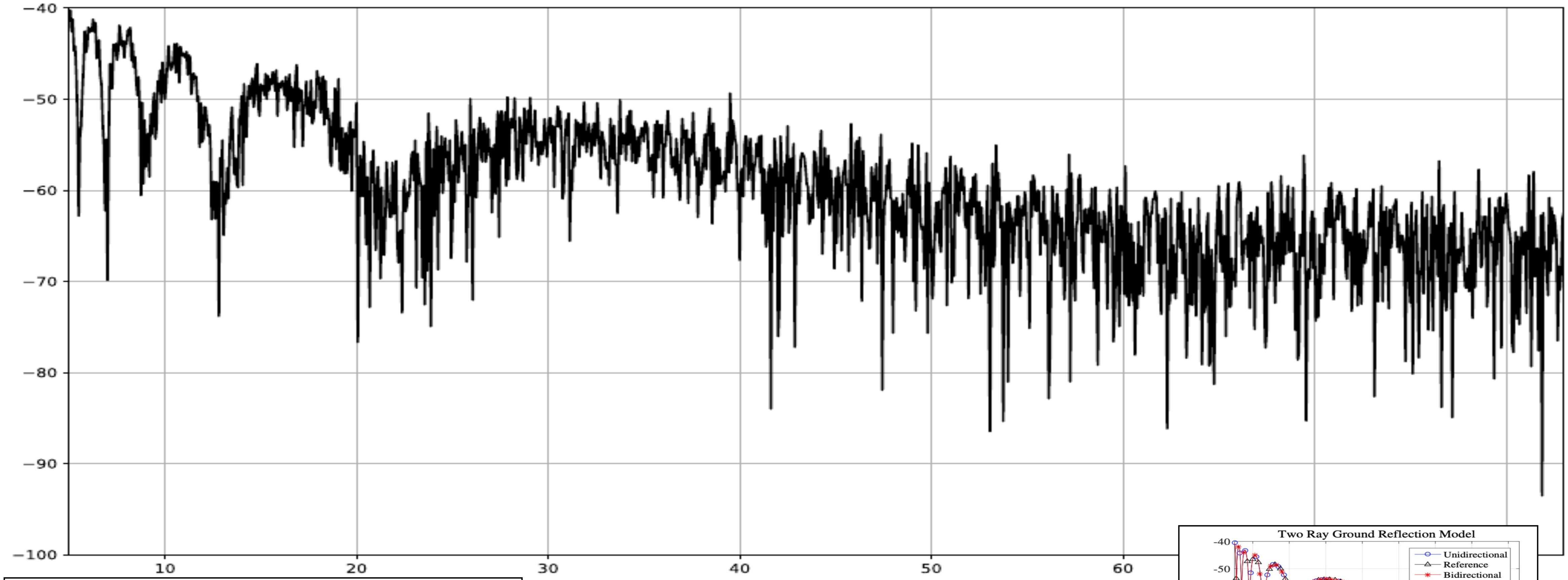


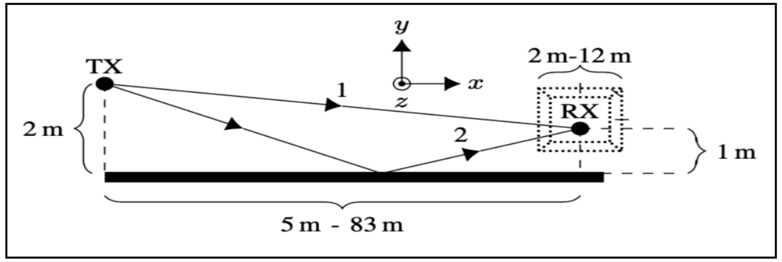
Filtering" + Guiding + Low Di ling



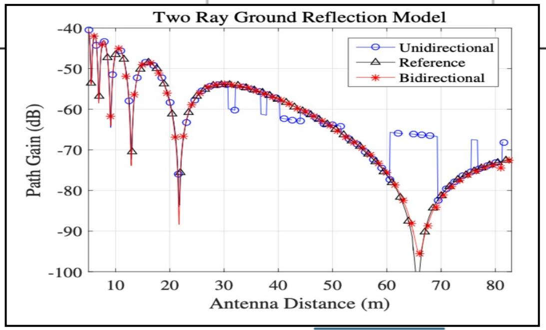
Informatics

Radar Simulation
Using Modern Monte-Carlo Algorithms





Path Tracing



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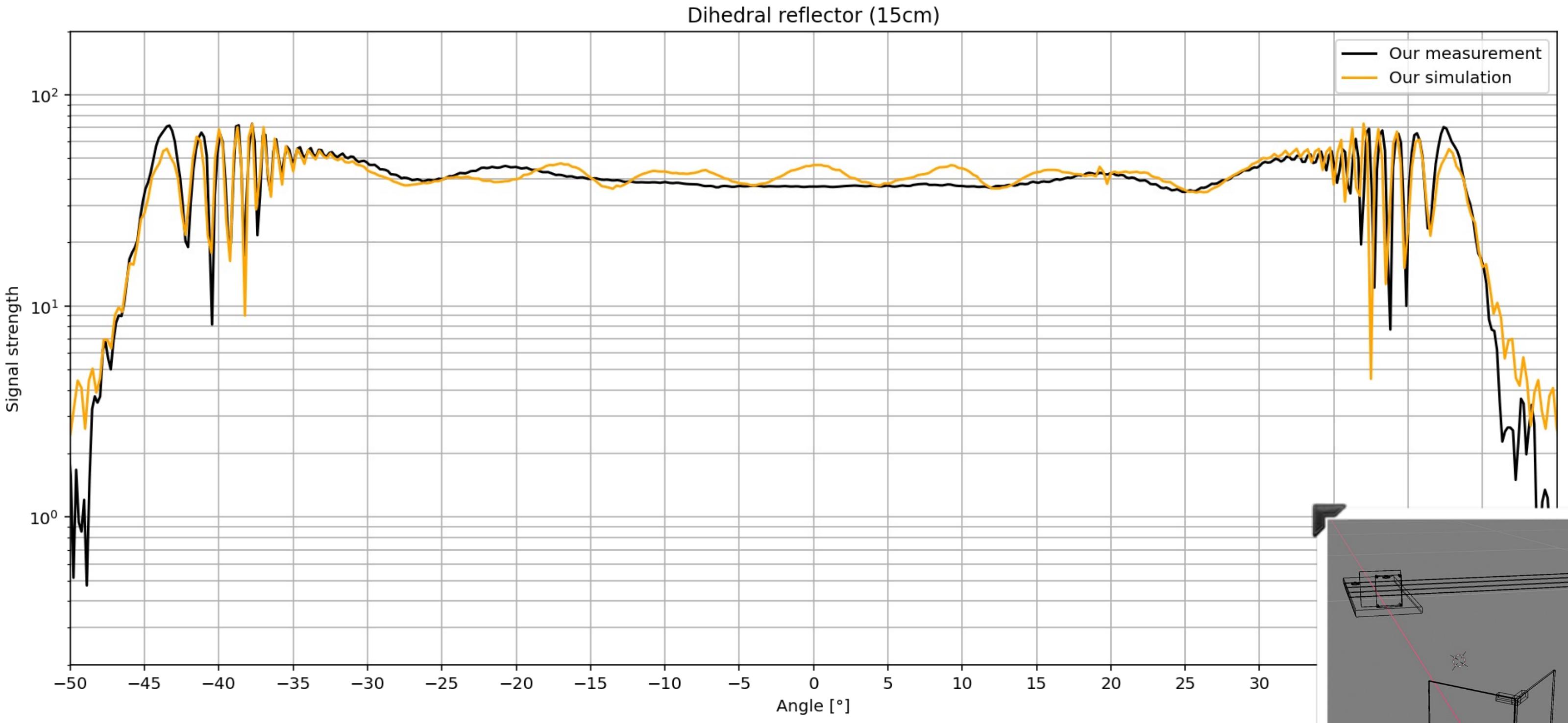
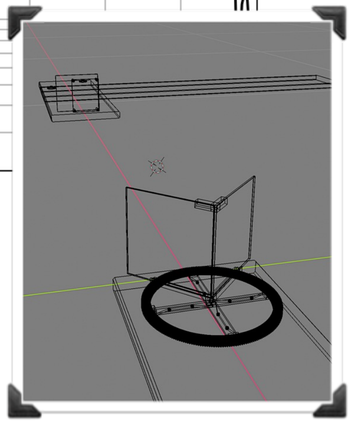
Our Simulation

Ours (Physical Optics + Monte Carlo)

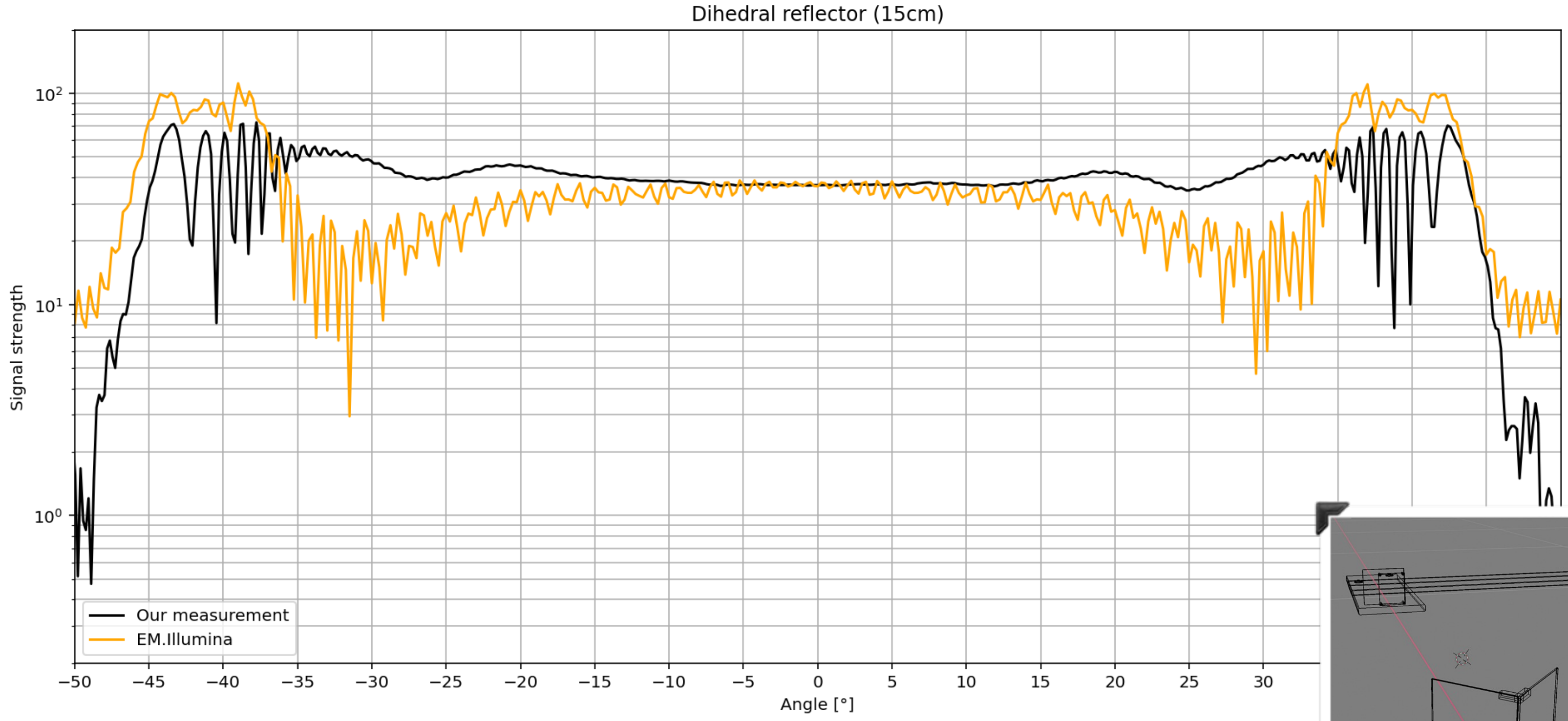


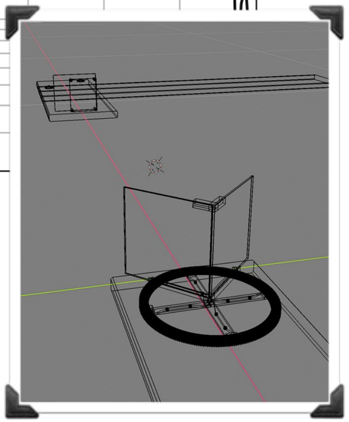


runtime: 33 seconds

Commercial Software

EM.Illumina (Physical Optics + Finite Elements)



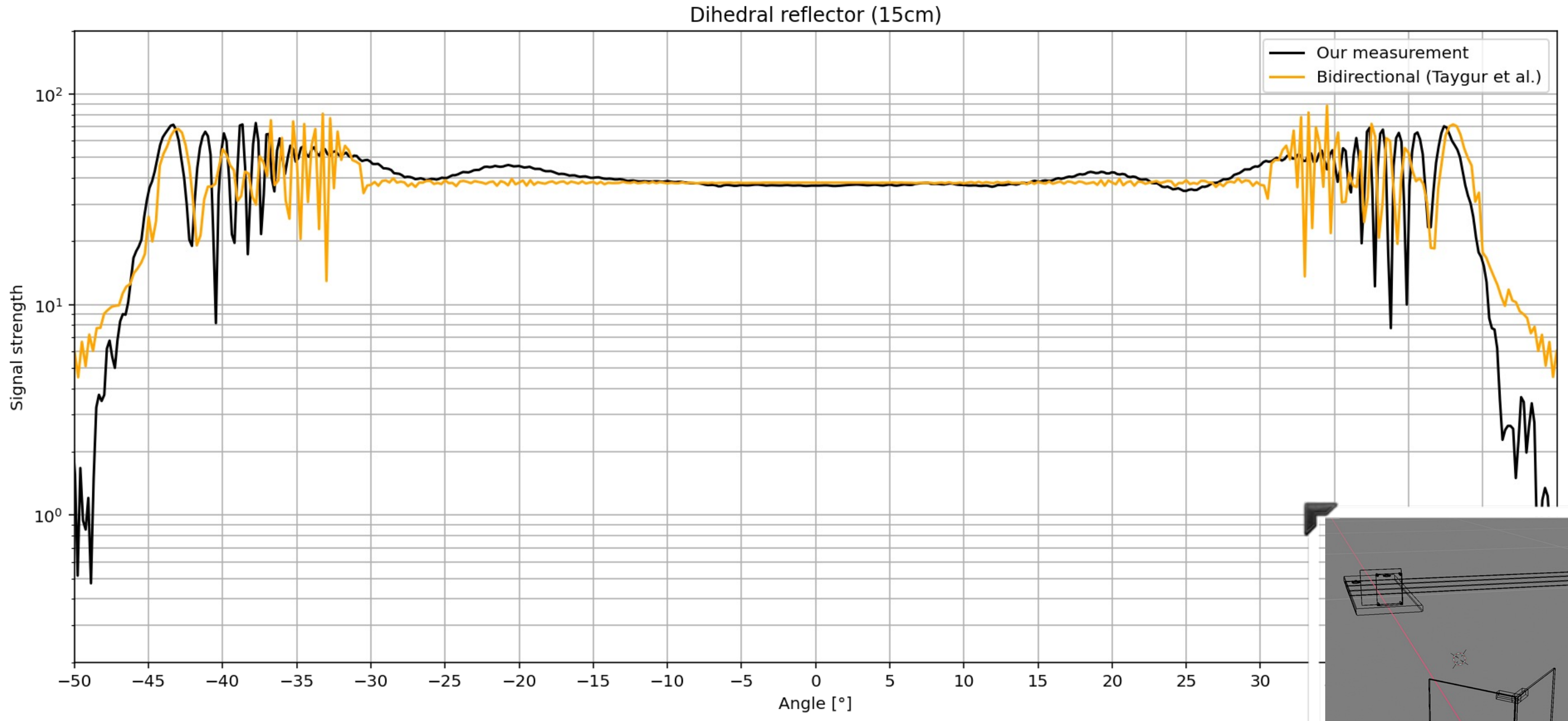


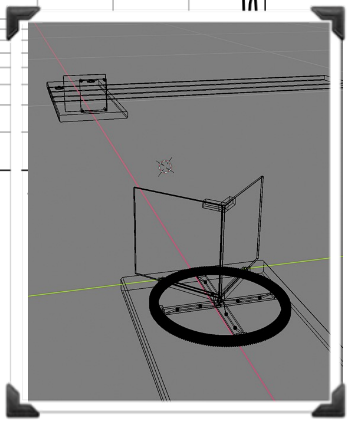
runtime: 13.4 hours

- *EM.Illumina is based on the same physical model (physical optics), but – like virtually all available simulators – uses Finite Elements instead of Monte Carlo*
- *This makes it a lot slower than our method (by a factor of 1,400) and produces results that are not as accurate*

Other Results from Academia

Bidirectional Antenna Coupling (Taygur et al.)





- *Bidirectional Antenna Coupling* (Taygur et al.) is a state-of-the-art algorithm that find connections between RX and TX antenna by starting paths from both sides and connecting them in the middle
- Unfortunately, it makes asymptotic assumptions and is therefore also less accurate for smaller features

Challenge: Do we Need a Better Basis for our Simulation?

- **In the past: Two big markets, focused on nice images**
  - *Gaming*: Very nice images (at 60+ Hz)
    - Must compromise realism for frame rate
  - *Film & Marketing*: Even nicer images (at hours per image)
    - Will compromise realism for the story and artistic expression
  - Both are being used for simulations for Autonomous Driving
- **But: Strong need for *correct* images**
  - Lidar, radar, multi-spectral, polarization, measured materials, …
  - Need for “error bar per pixel” & validation
  - Existing engines unlikely to adapt to these fundamental changes
- **Towards “Predictive Rendering” engine**
  - Focused on physical accuracy (“sensor realistic”) & high throughput
  - Based on latest graphics research results (and GPU-HW)

Digital Reality:
Using AI to Optimize and Certify AI
(using autonomous driving as an example)

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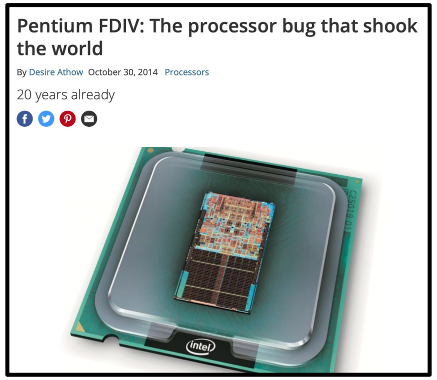
State of AI

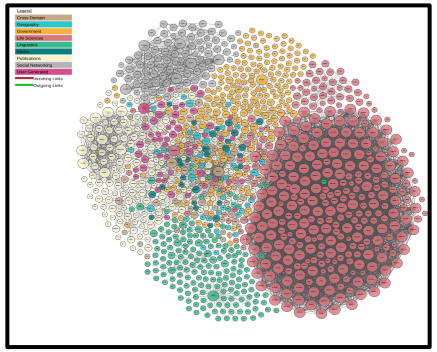
- **Success stories**
  - HW Verification, Knowledge Graphs, Search & Optimization, …
  - Perception: Vision, Speech, …
  - Game playing: Chess, Go, video games, …
  - Some complex tasks: translation, autonomous driving, …
- **Amazing progress in recent years**
  - Most visible due to Deep Neural Networks (DNNs)
  - Focus shifting to hybrid/neuro-symbolic/neuro-explicit approaches
- **Still many fundamental challenges**
  - With severe consequences to the practical use of AI

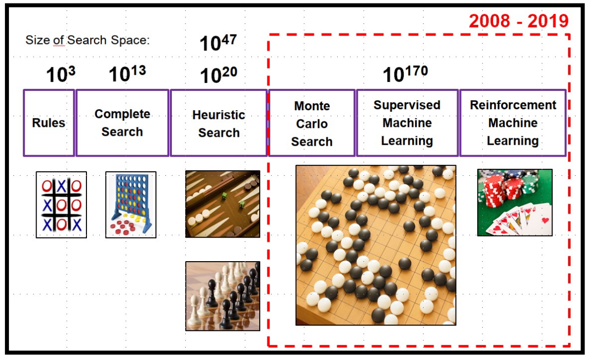


Pentium FDIV: The processor bug that shook the world

By Desire Athow October 30, 2014 Processors

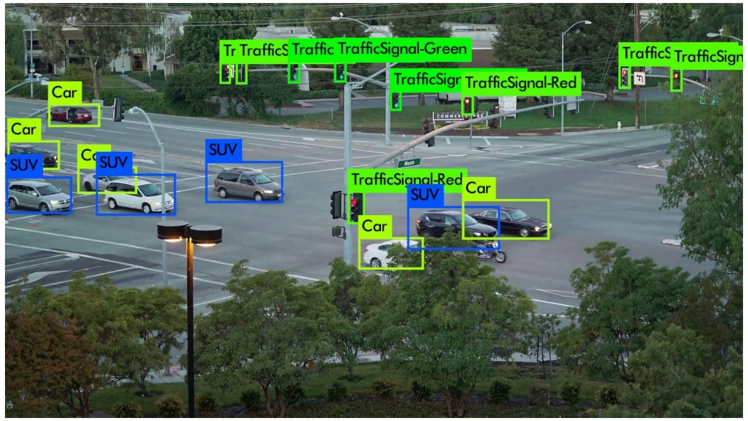
20 years already



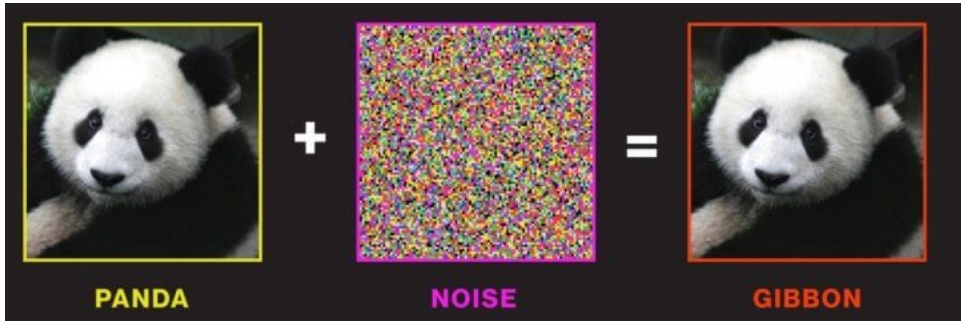


Challenges:
Functionality vs. Robustness

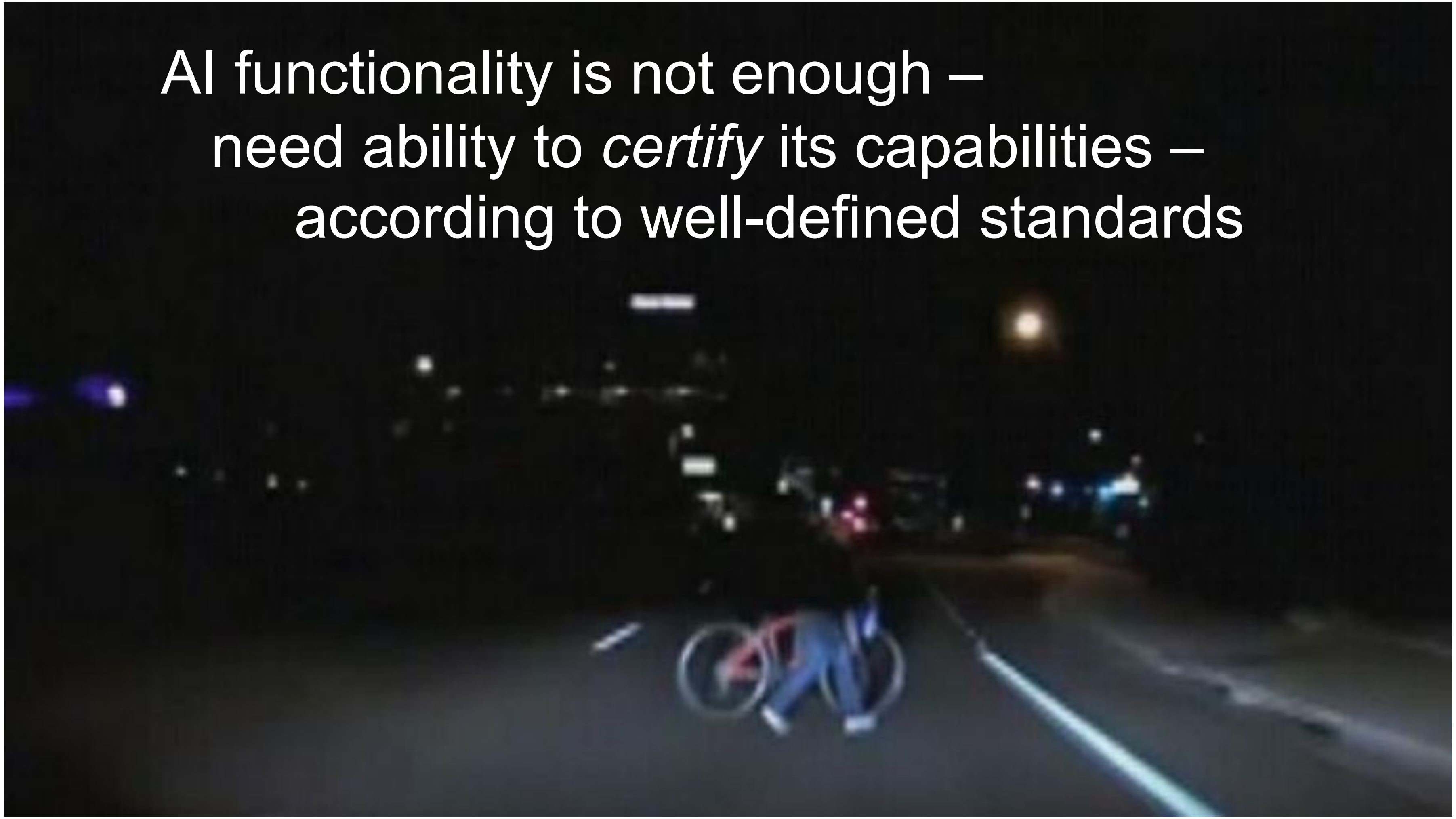
- AI/DL is highly capable already …



- … but we often cannot guarantee even basic functionality



Trusted AI via Digital Reality:
Using AI to Optimize & Certify AI



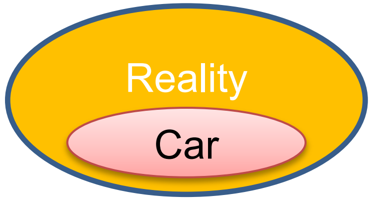
Autonomous Systems: The Problem

- **Our World is extremely complex**
  - Geometry/Shape, Appearance, Motion, Weather, Environment, …
- **Systems must make accurate and reliable decisions**
  - Especially in ***Critical Situations***
  - Increasingly making use of (deep) machine learning
- **Learning of critical situations is essentially impossible**
  - Often little (good) data even for "normal" situations
  - Critical situations rarely happen in reality – per definition!
  - Extremely high-dimensional models

➔**Goal: Scalable Learning from *synthetic* input data**
  - Continuous benchmarking & validation ("Virtual Crash-Test")

Reality

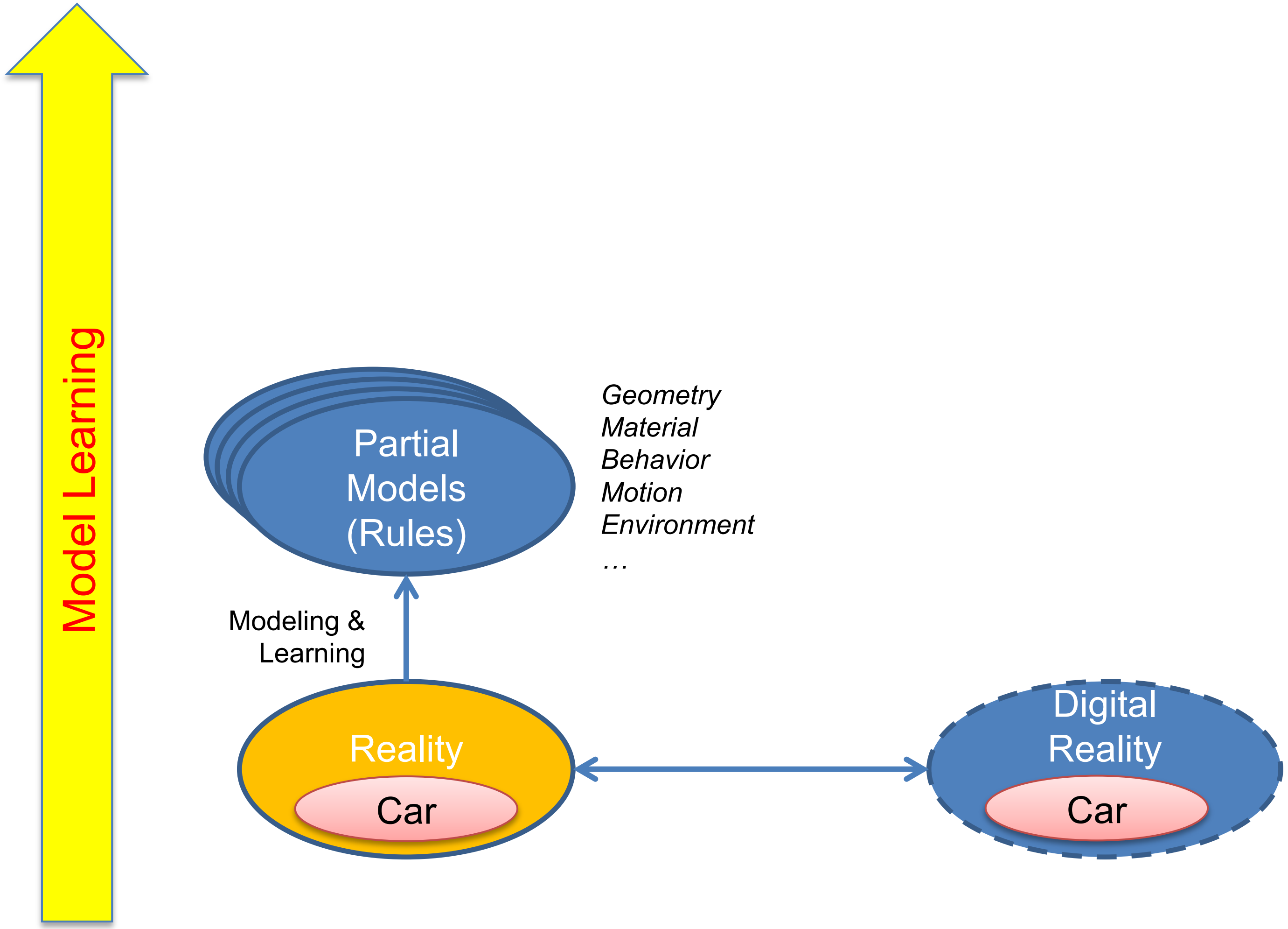
- **Training and Validation in Reality**
  - E.g. driving millions of miles to gather data
  - Difficult, costly, and non-scalable



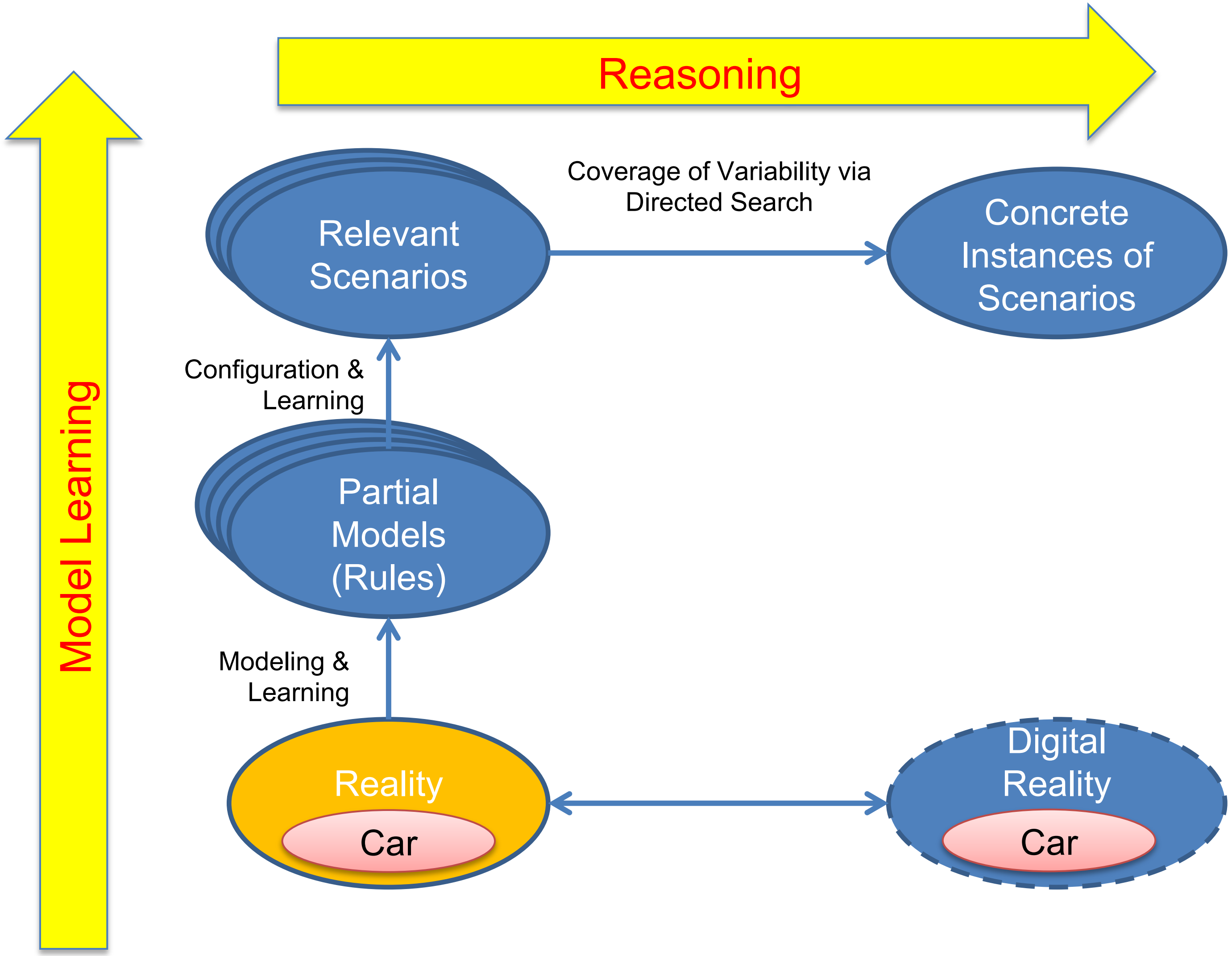
Digital Reality

- **Training and Validation in the *Digital Reality***
  - Arbitrarily scalable (given the right platform)
  - But: Where to get the models and the training data from?

Digital Reality: AI to Optimize and Certify AI



Digital Reality: AI to Optimize and Certify AI



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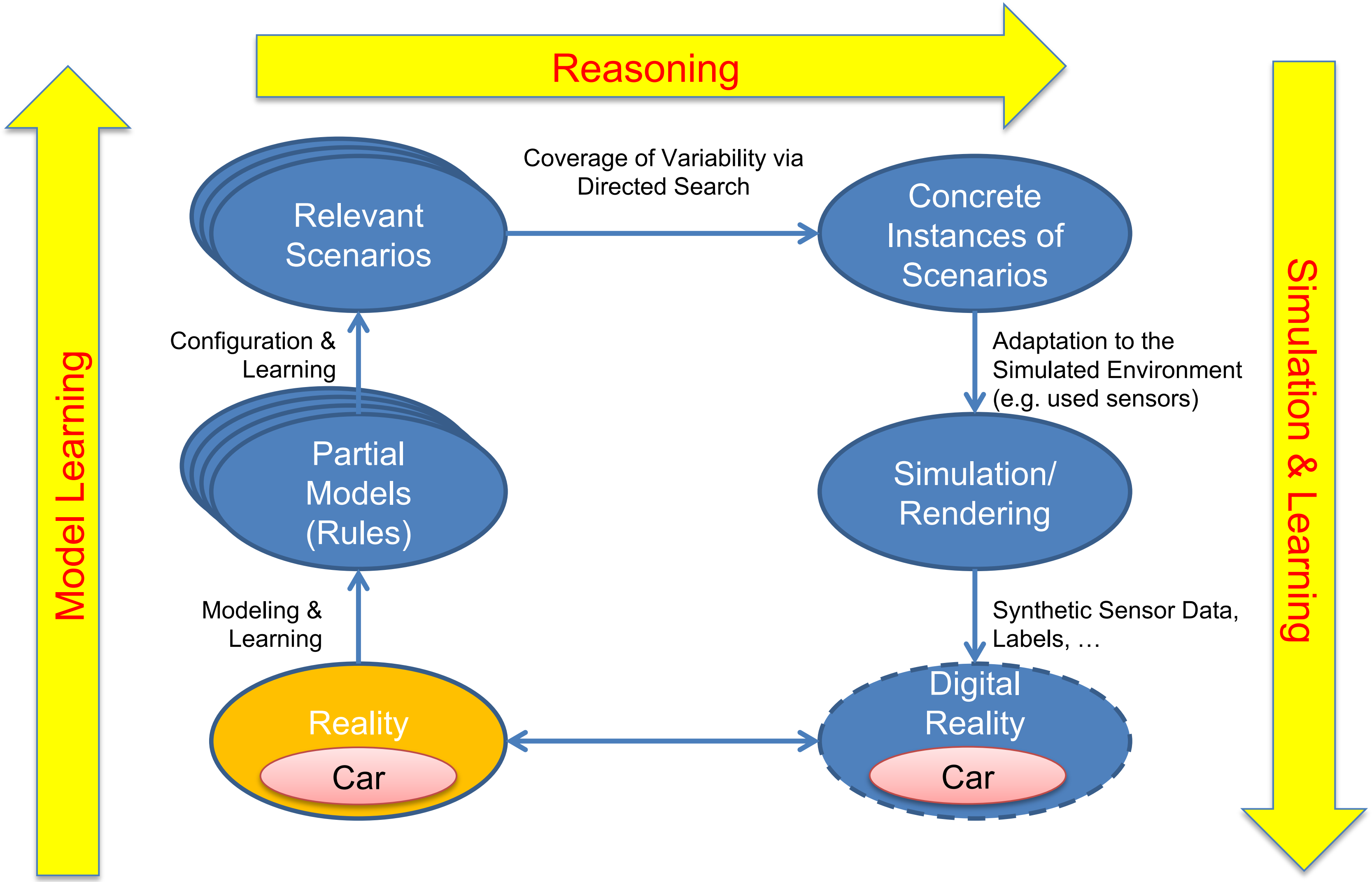
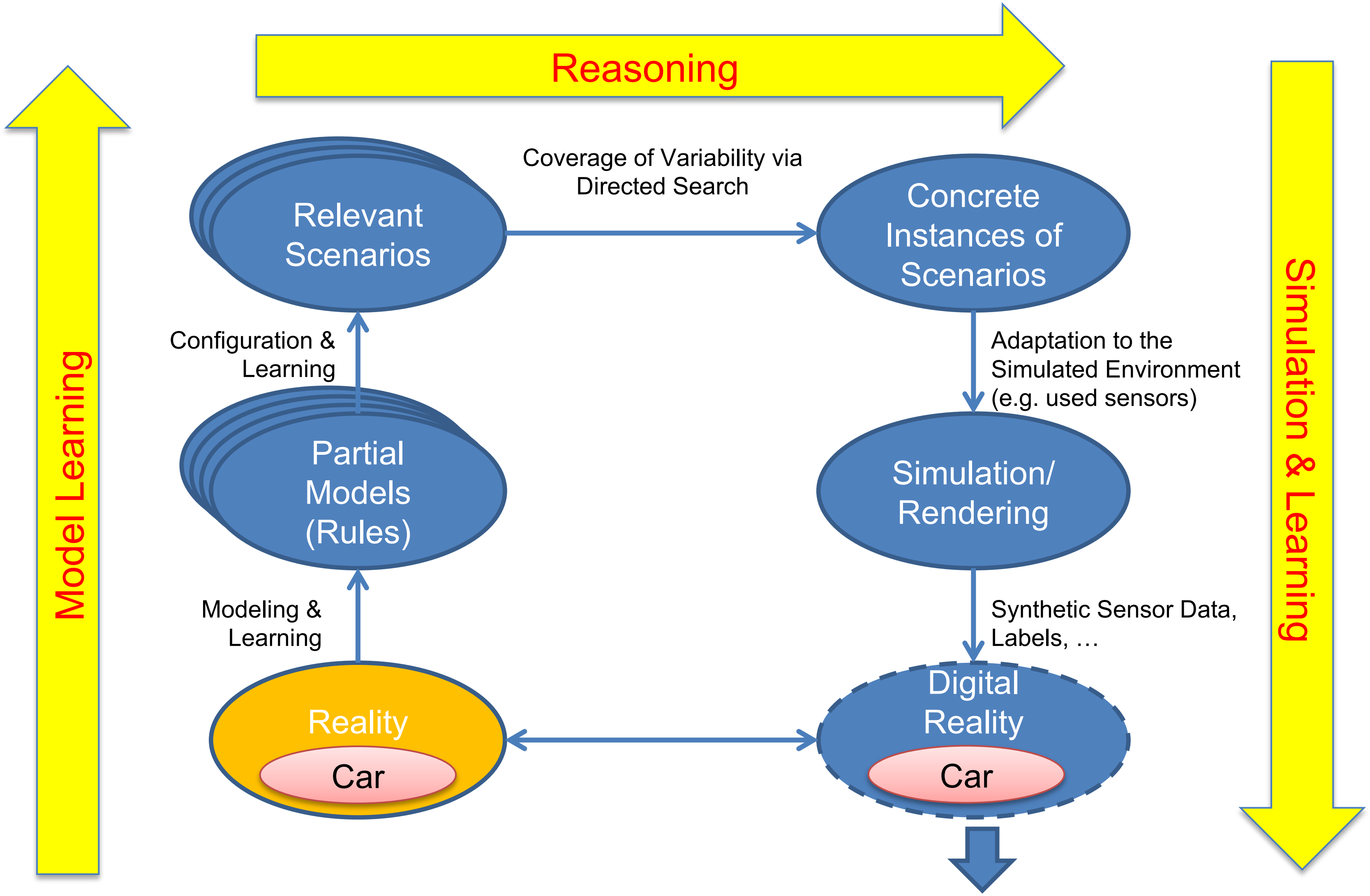
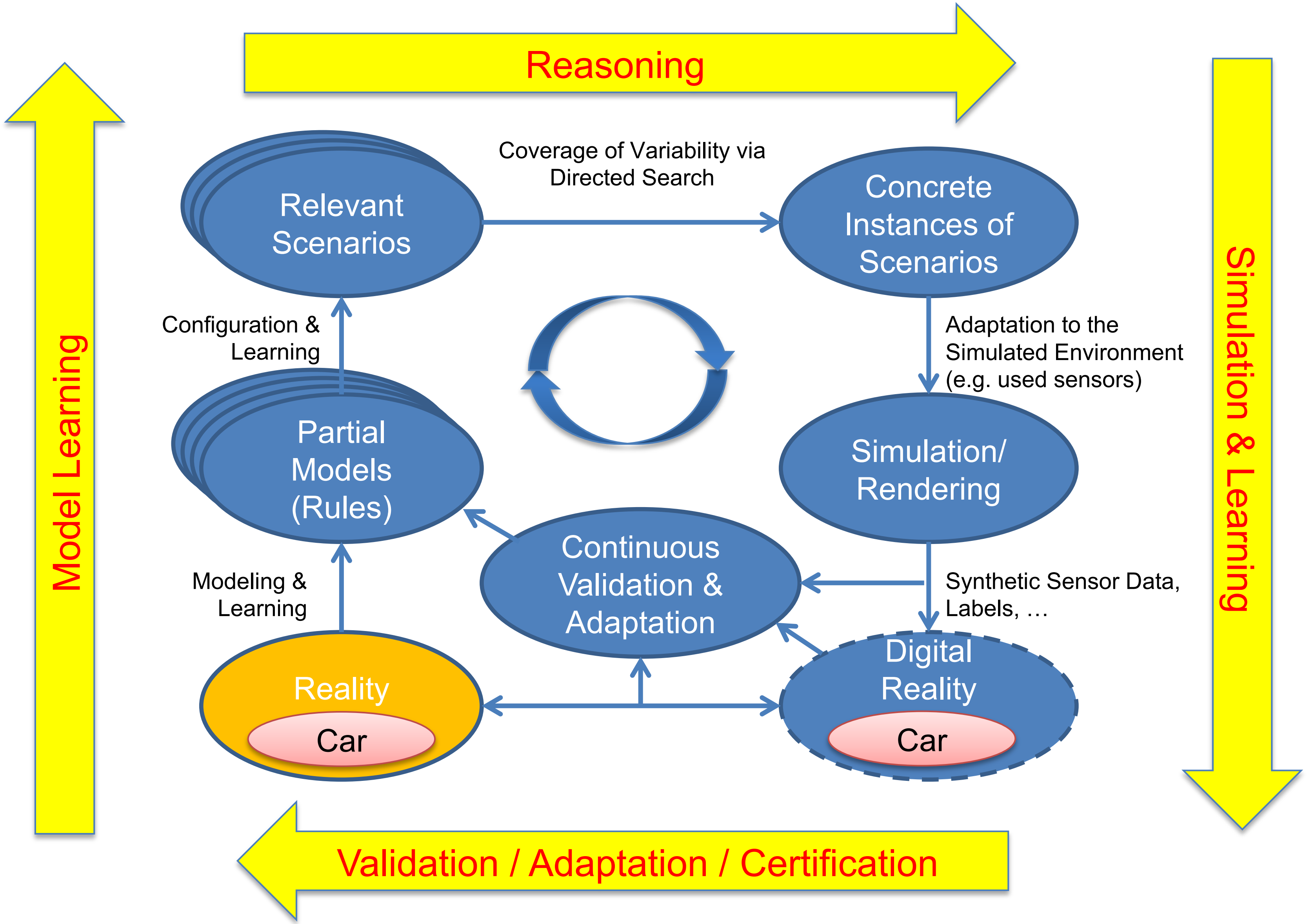


Digital Reality: AI to Optimize and Certify AI

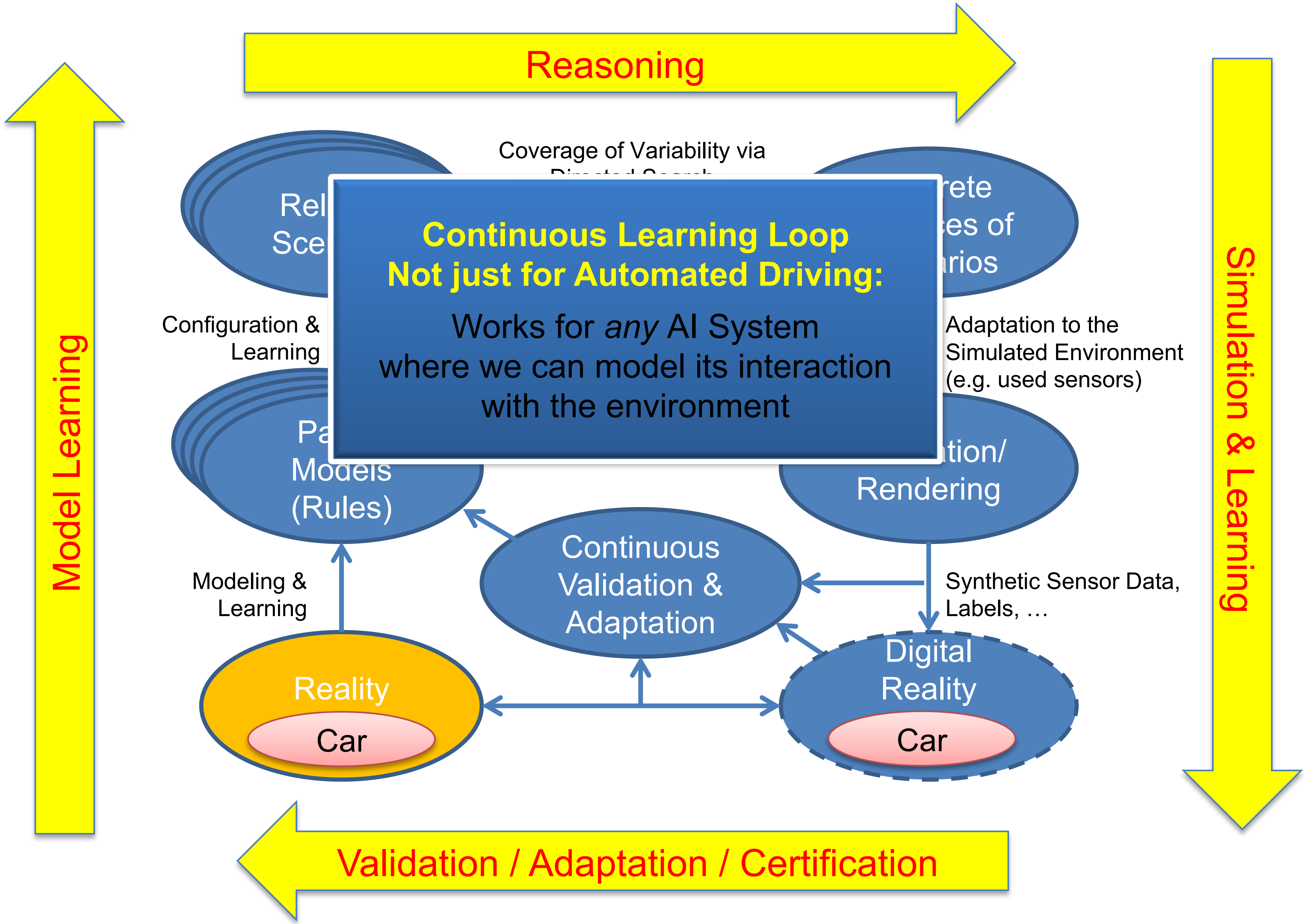


Training, Validation, and **Certification** of AI Systems ➔ **Trusted AI**

Digital Reality: AI to Optimize and Certify AI

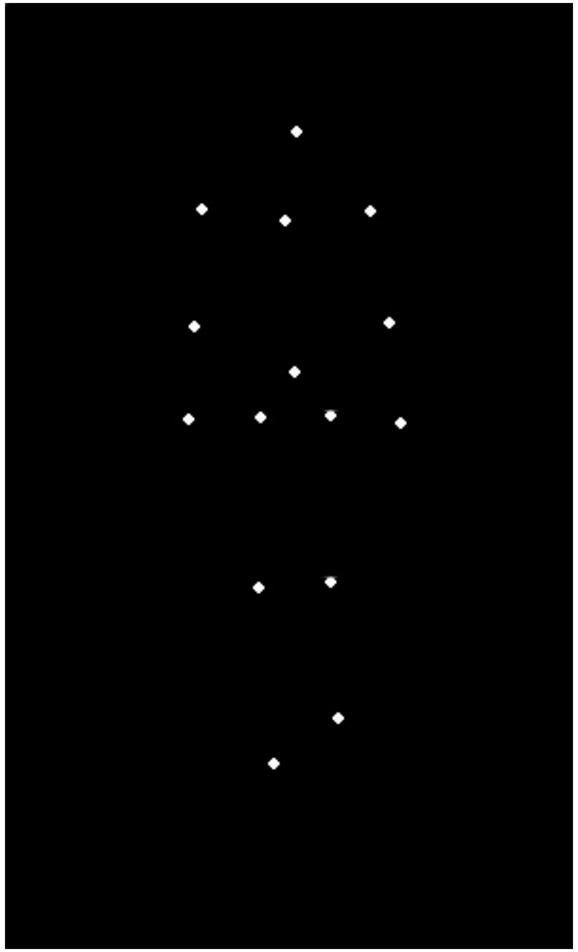


Digital Reality: AI to Optimize and Certify AI



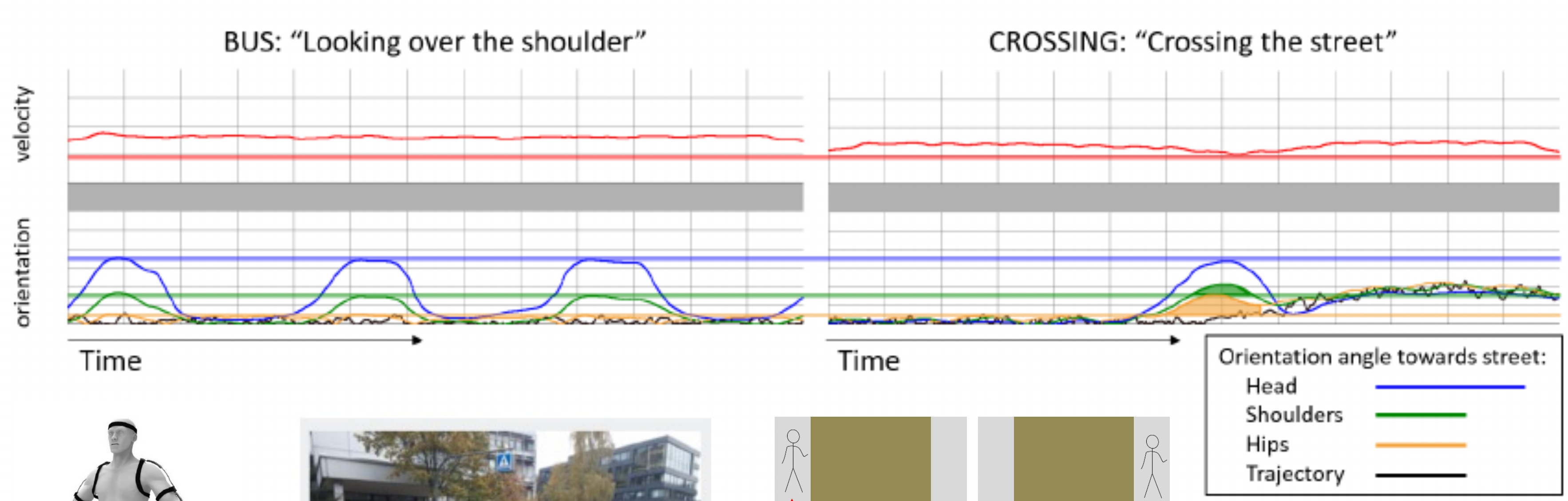
Challenge: Better Models of the World (e.g. Pedestrians)

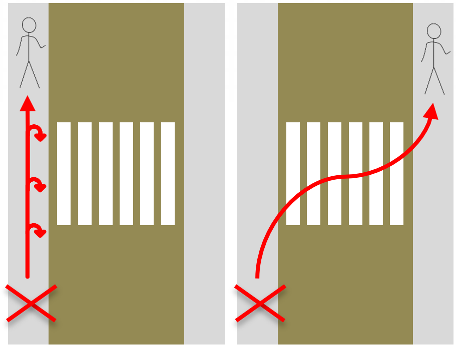
- **Long history in motion research (>40 years)**
  - E.g. Gunnar Johansson's Point Light Walkers (1974)
  - Significant interdisciplinary research (e.g. psychology)
- **Humans can easily discriminate different styles**
  - E.g. gender, age, weight, mood, ...
  - Based on minimal information
- **Can we teach machines the same?**
  - Detect if pedestrian will cross the street
  - Parameterized motion model & style transfer
  - Predictive models & physical limits



Challenge: Pedestrian Motion

- **Characterizing Pedestrian Motion**
  - Clear motion differences when crossing the street

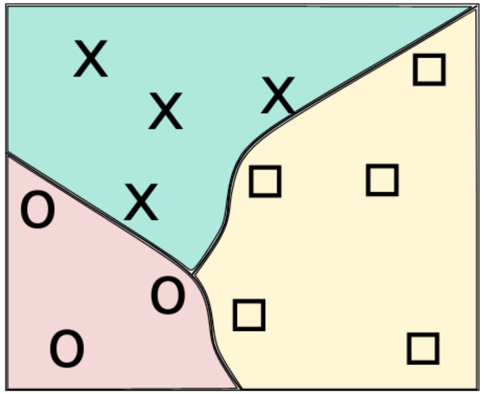


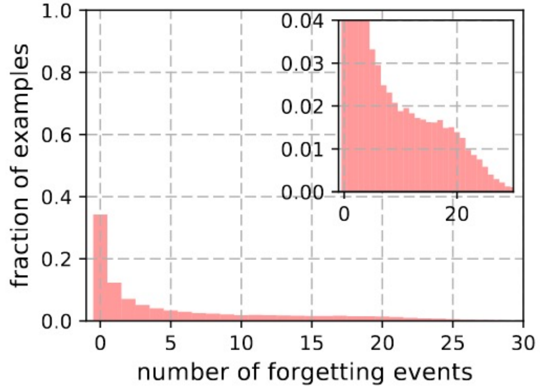


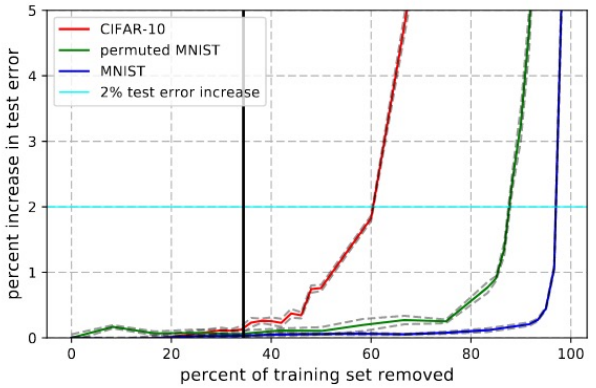
Bus Crossing

Improved Sampling Strategies for NN Training in Sparse Environments

- **How can we train more efficiently**
  - by focusing on the most relevant training data
  - particularly near decision boundaries

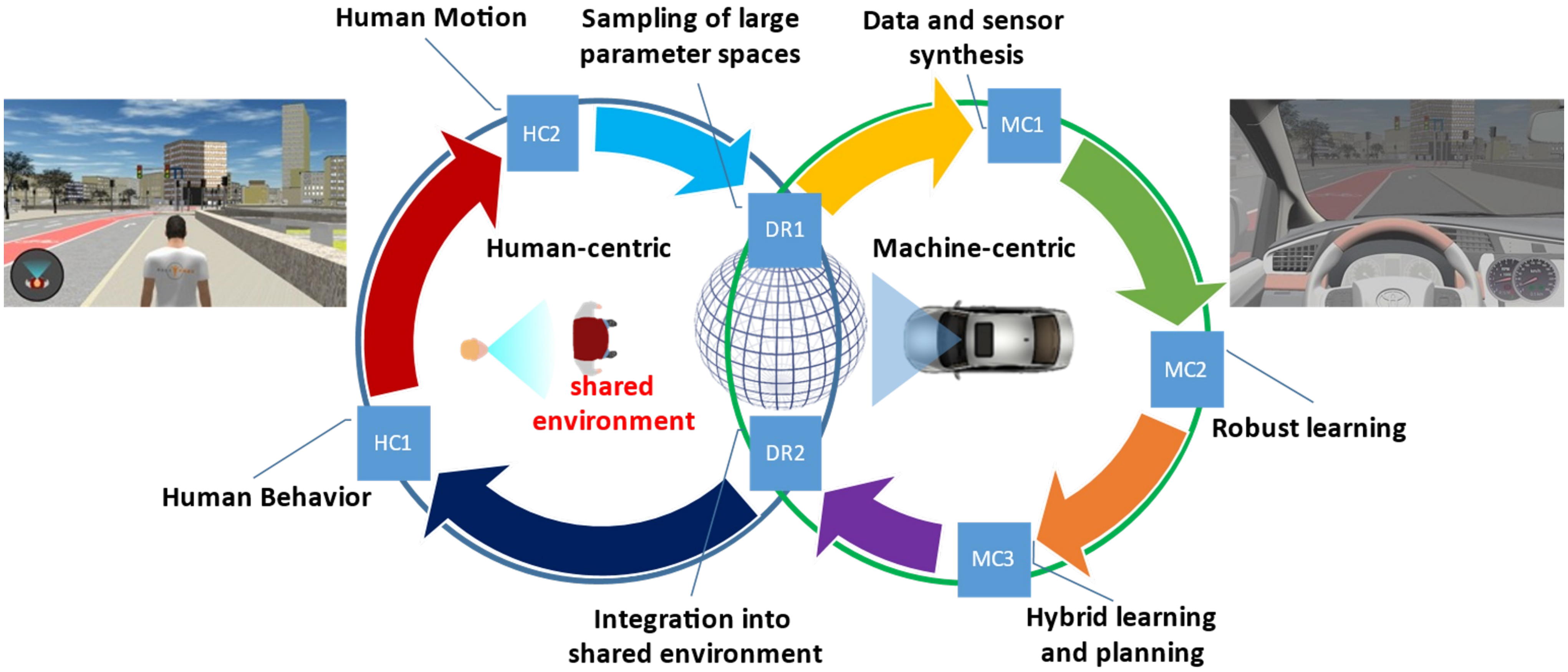






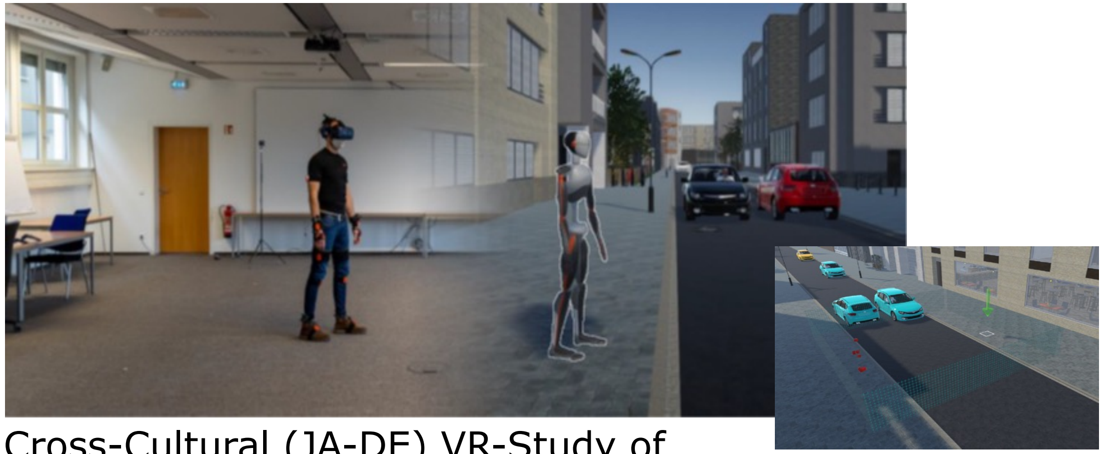
- **How can we train more robustly by adversarial perturbations?**

Structure of MOMENTUM

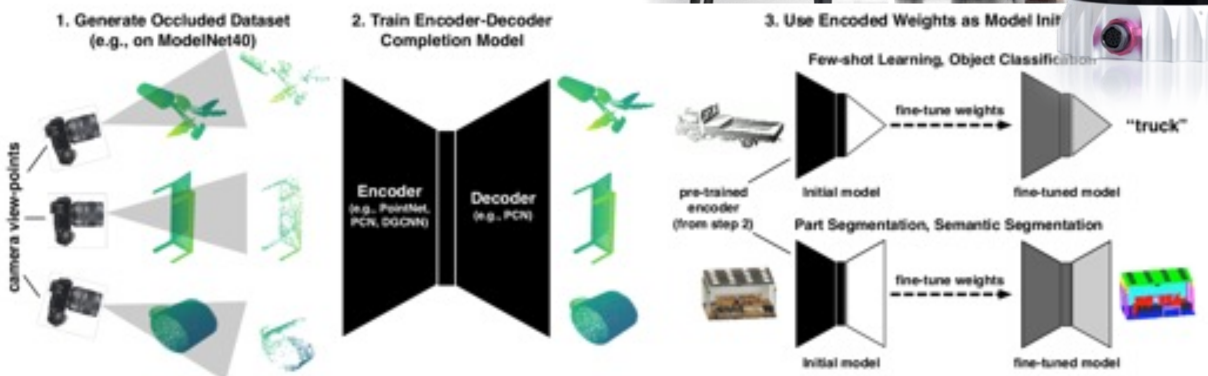


HC: Human-Centric
MC: Machine-Centric
DR: Digital Reality (Integration)

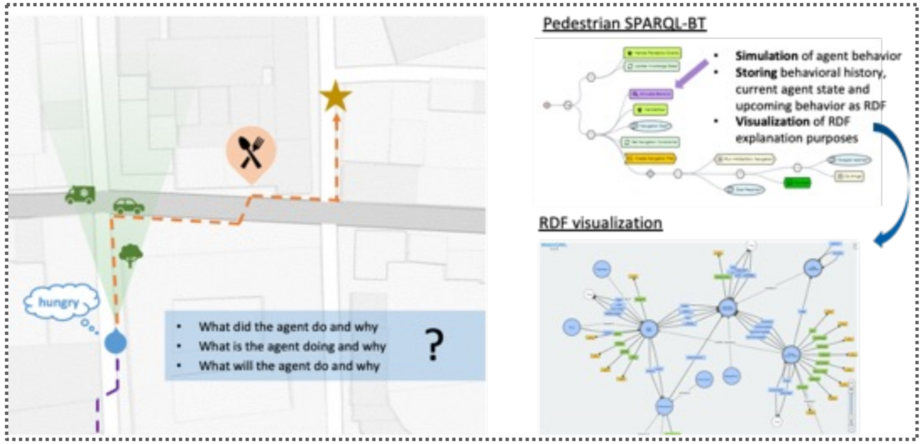
Key Research Questions (Selection)



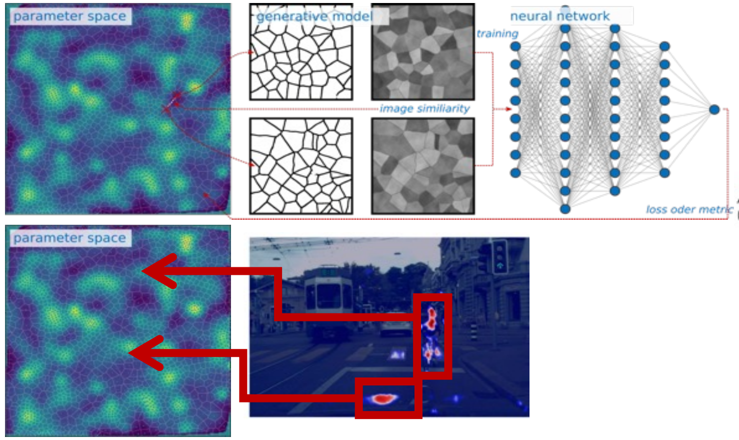
Cross-Cultural (JA-DE) VR-Study of Pedestrian Behavior & Motion in the Real World



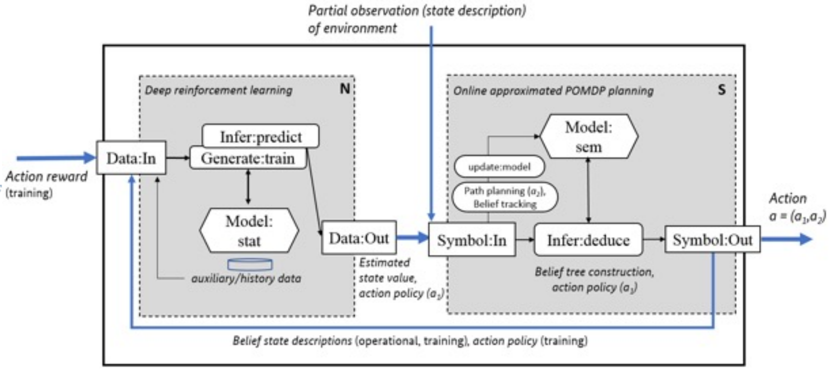
Robust Semi- & Self-Supervised Learning and Unsupervised Domain Adaptation for Improving Difficult Object Detection from Varying Sensor Data (Lidar, Radar, ...)



Novel Agent Framework for Modelling and Synthezising Realistic High-Level Behavior



Directed and Adaptive Sampling of High-Dimensional Parameter Spaces



Neuro-Explicit AI Approaches: e.g. Hybrid Planning and Learning

DFKI

SIC Saarland Informatics Campus

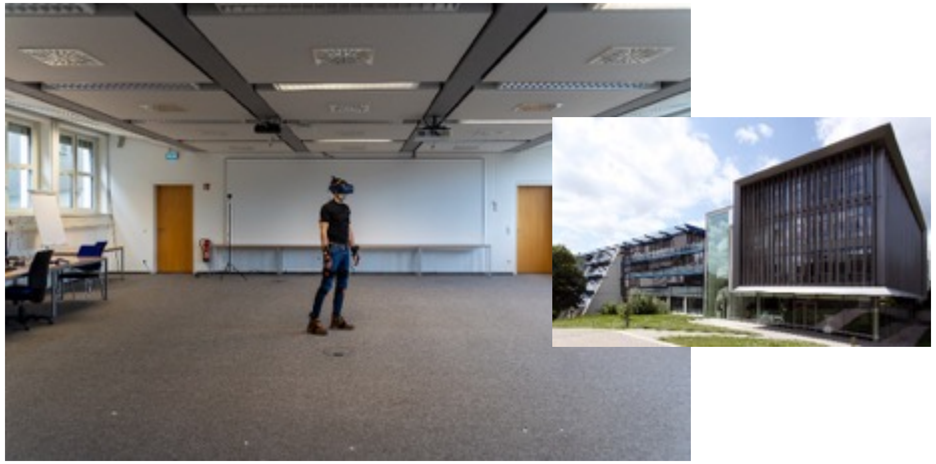
Cross-Cultural Pedestrian Models

Studying Motion, Behavior & Intentions in VR

- CrossCDR user study **in Germany**
  - DFKI Saarbrücken, room „Reuse“
  - 11.11.2021 – 16.12.2021

  - 30 Japanese participants, recruited via AIST / professional company
  - COV19-induced hygenic concept and entry restrictions for Japan
  - Data privacy and ethical issues checked for JP
  - Instructors: **Janis Sprenger, Saori Ohtani**, **André Antakli**, Shoma Kudo

Coordination: Matthias Klusch (DFKI), Yoshi Kobayashi (AIST)



Thank you very much for your attention !

Human Centric AI.


Einkaufsliste