Artificial Intelligence & Digital Reality
Do we need a "CERN for AI"

Prof. Dr.-Ing. Philipp Slusallek

German Research Center for Artificial Intelligence (DFKI)

Research Area: Agents and Simulated Reality

Excellence Cluster Multimodal Computing and Interaction (MMCI)

Intel Visual Computing Institute (IVCI)

Saarland University

Overview

- Background on DFKI
- Digital Reality
- Digital Reality for Autonomous Driving
- AI Research Environment in Germany and EU
- Conclusions

German Research Center for Artificial Intelligence (DFKI)

- **Motto**
  - „Computer with Eyes, Ears, and Common Sense“
- **Overview**
  - Largest AI research center worldwide (founded in 1988)
  - Germany’s leading research center for innovative SW technologies
  - 5 sites in Germany
    - Saarbrücken, Bremen, Kaiserslautern; Berlin, Osnabrück
  - 18 research areas, 10 competence centers, 7 living labs
  - More than 510 employees (>900 with research assistants)
  - Budget of more than 44 M€ (2017)
  - More than 80 spin-offs

The Pentagon of Innovation

Bremen

Osnabrück

Berlin

Kaiserslautern

Saarbrücken

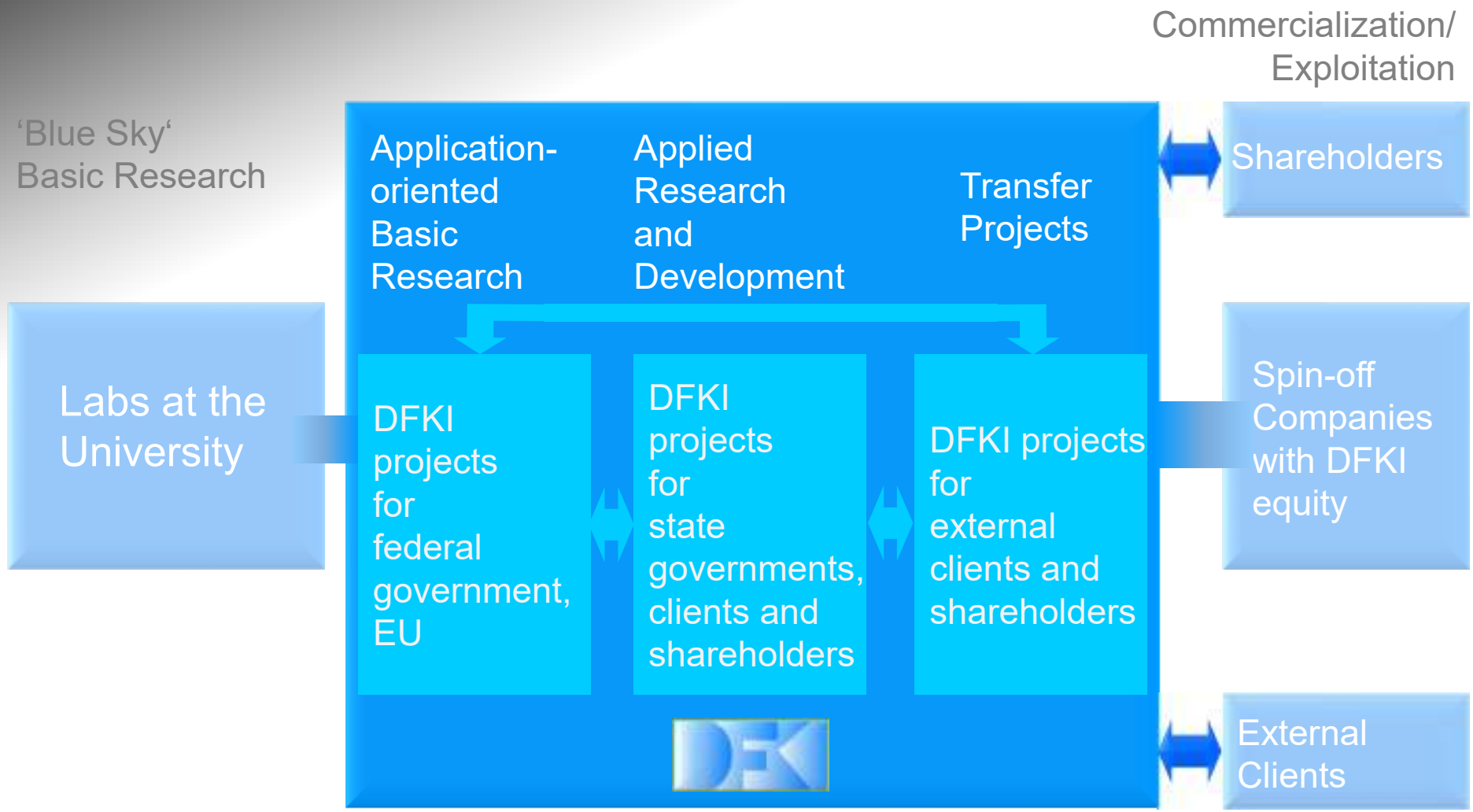
DFKI is a Joint Venture of:

Saarland

Rhineland-Palatinate

Bremen

DFKI Covers the Complete Innovation Cycle



Agents & Simulated Reality:
AI & Graphics & HPC & Security

Scientific Director
Philipp Slusallek

Knowledge- and Technology Transfer

VisCenter	Strategic Relations	SW-Engineering & Organization
Georg Demme	Hilko Hoffmann	Georg Demme

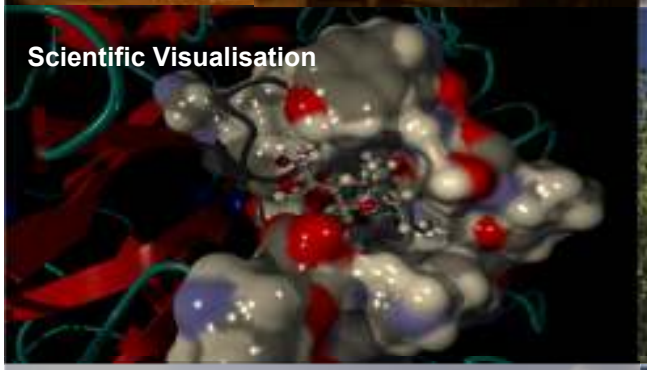
Application Domains

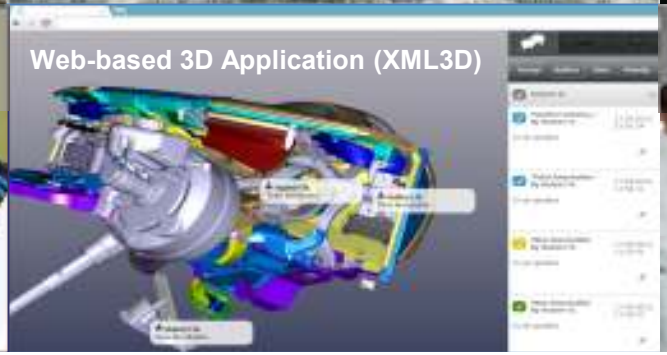
Autonomous Driving	Computational Sciences	Industrie 4.0	High-Performance Computing	Smart Environments
Christian Müller	Tim Dahmen	Ingo Zinnikus	Richard Membarth	Hilko Hoffmann

Research: Topics & Teams

Multi-agent Systems	Intelligent Information Systems	Linked Data Representations	Autonomous Driving
Klaus Fischer	Matthias Klusch	René Schubotz	Christian Müller
Computational 3D Imaging	**High-Performance Graphics & Computing**	**Smart System Security**	**Behavior, Interaction & Visualization**
Tim Dahmen	Richard Membarth	Andreas Nonnengart	Georg Demme
Survivable Systems and Services	**Distributed Realistic Graphics**	**Large-Scale Virtual Environments**	**Visual Computing**
Philipp Slusallek	Philipp Slusallek	Philipp Slusallek	Philipp Slusallek

ASR Research Topics





AnyDSL Compiler Framework

Computer Vision DSL

Physics DSL

Ray Tracing DSL

Parallel Runtime DSL

…

Developer

Layered DSLs

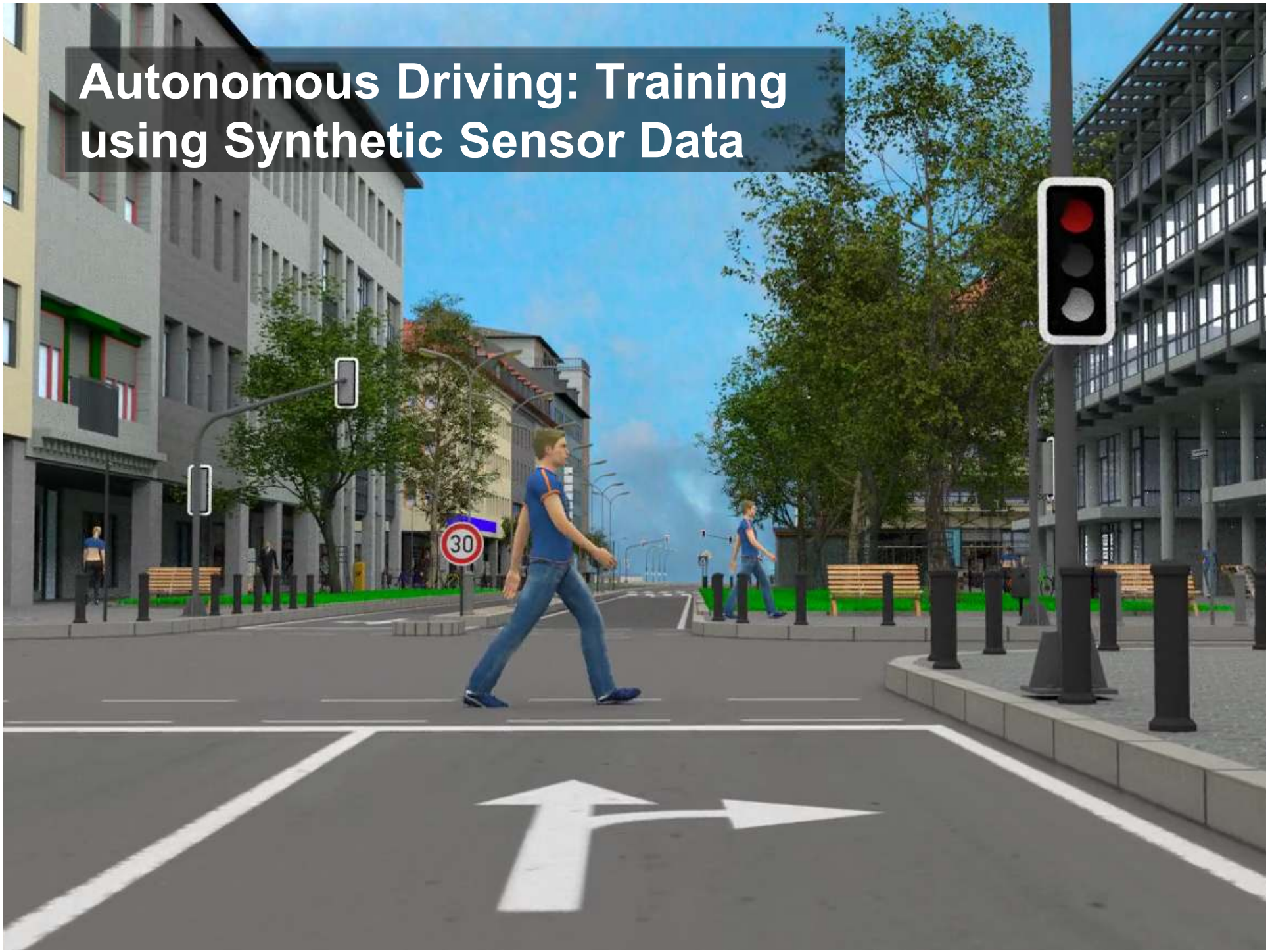
AnyDSL Unified Program Representation

AnyDSL Compiler Framework (Thorin)

Various Backends (via LLVM)


Intelligent Human Simulation,
e.g. in Production Environments

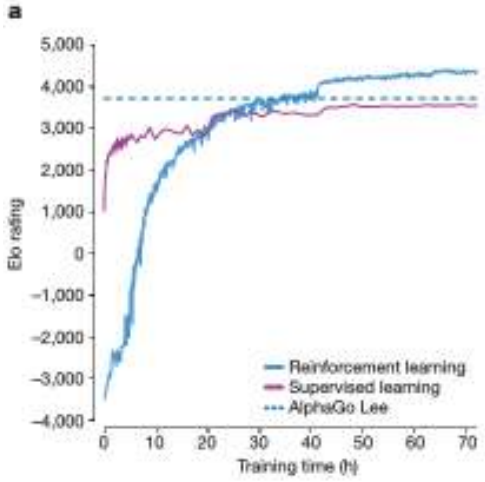
Collaborative Robotics and Simulated Reality


Autonomous Driving: Training
using Synthetic Sensor Data
30

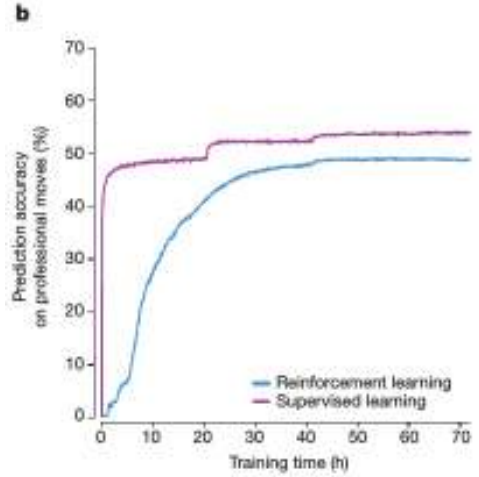
Digital Reality:
Using Synthetic Data to Train Autonomous Systems

Playing Go – From Scratch

- **Paper from Google DeepMind (Nov 2017, in Nature)**
  - Given: Rules + Deep-Learning + Simulation
  - Training via Reinforcement-Learning



Quality of Gameplay



Prediction of
Human Moves

- **But in reality we do not know the (complex) rules!!**

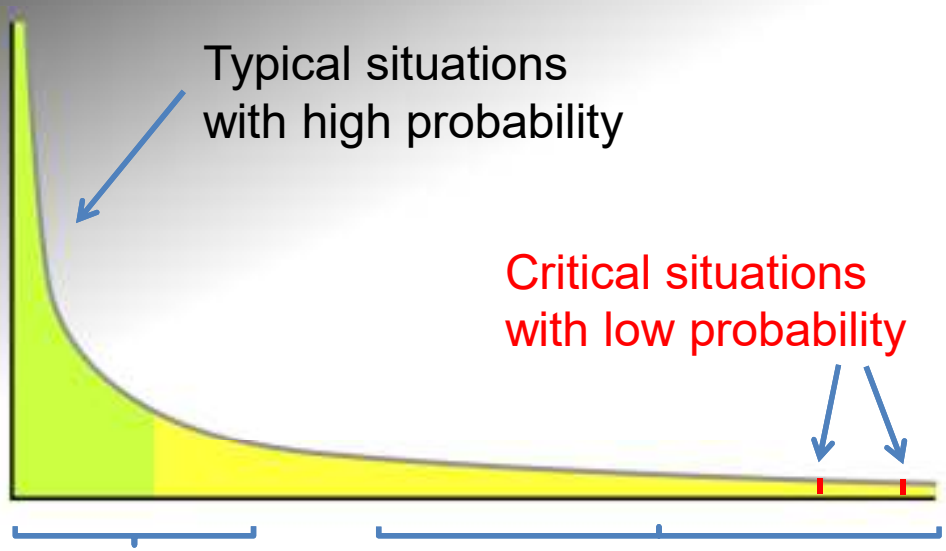
Autonomous Driving: The Problem

- **Our World is extremely complex**
  - Geometry, 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**
  - Too little data even for “normal” situations
  - Critical situations rarely happen in reality – per definition!
  - Extremely high-dimensional models

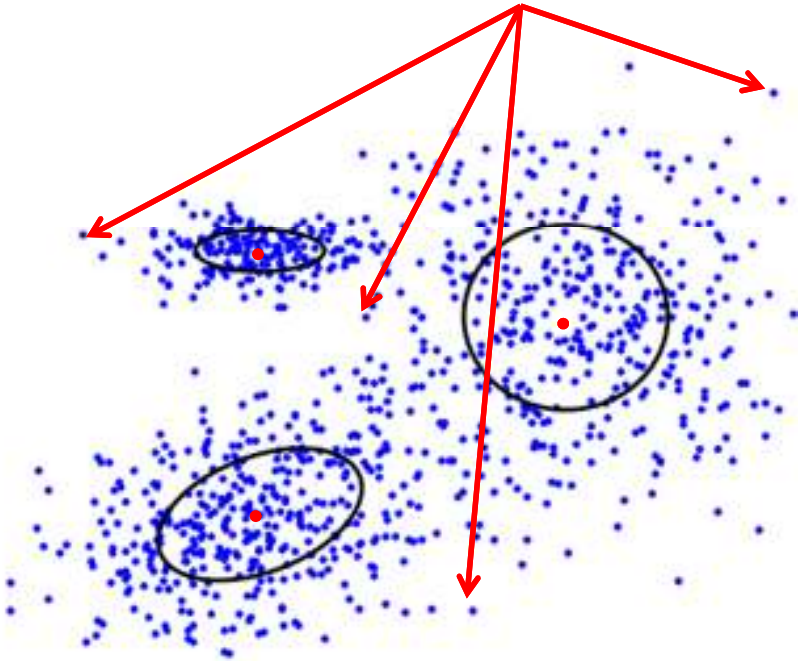
➔Goal: Scalable Learning from *synthetic* input data

  - Continuous benchmarking & validation (“Virtual Crash-Test“)

Autonomous Driving: The Problem



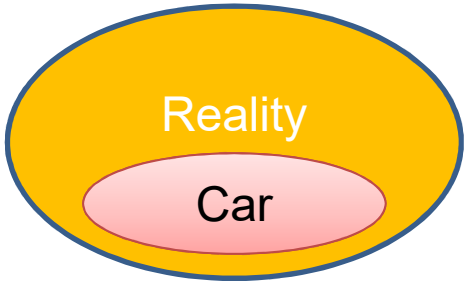
Goal: Validation of correct behavior by covering high variability of input data



Learning for
Long-Tail Distributions

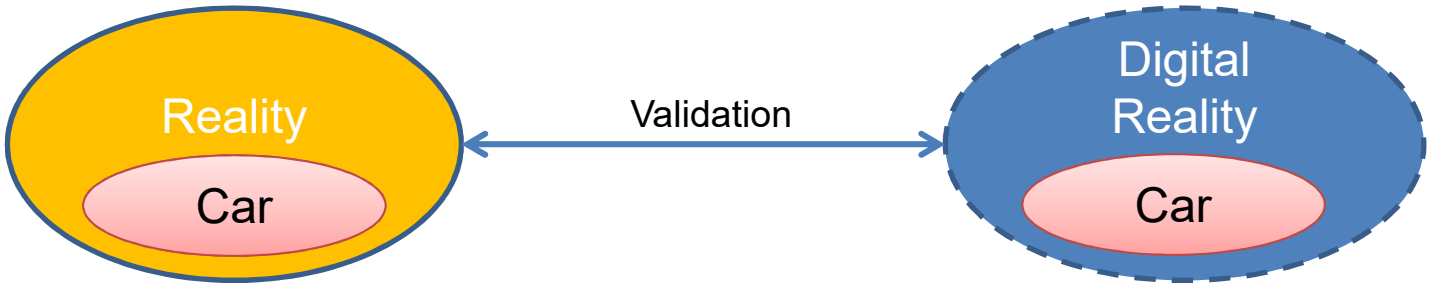
Reality

- **Training and Validation in Reality (e.g. Driving)**
  - Difficult, costly, and non-scalable

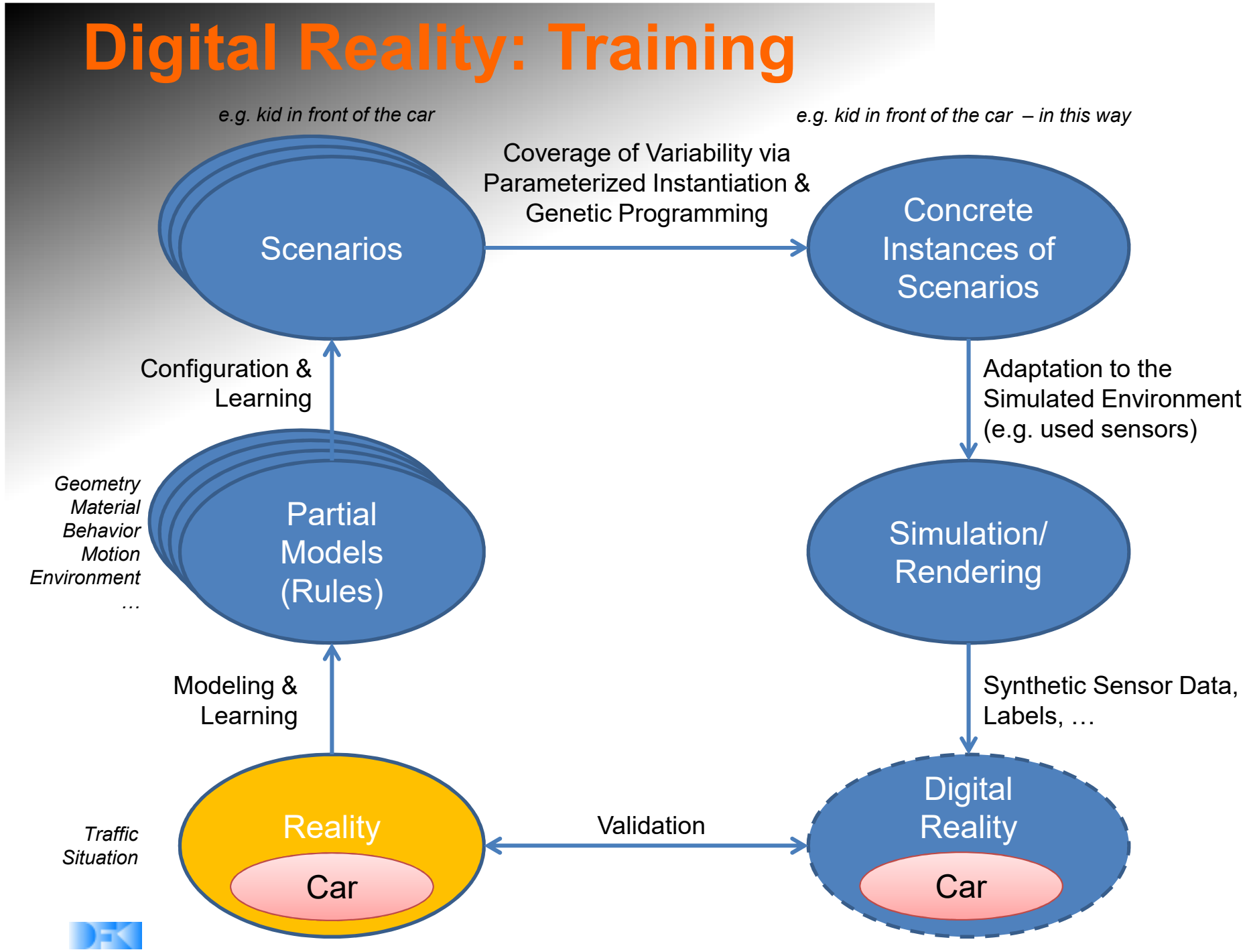


Digital Reality

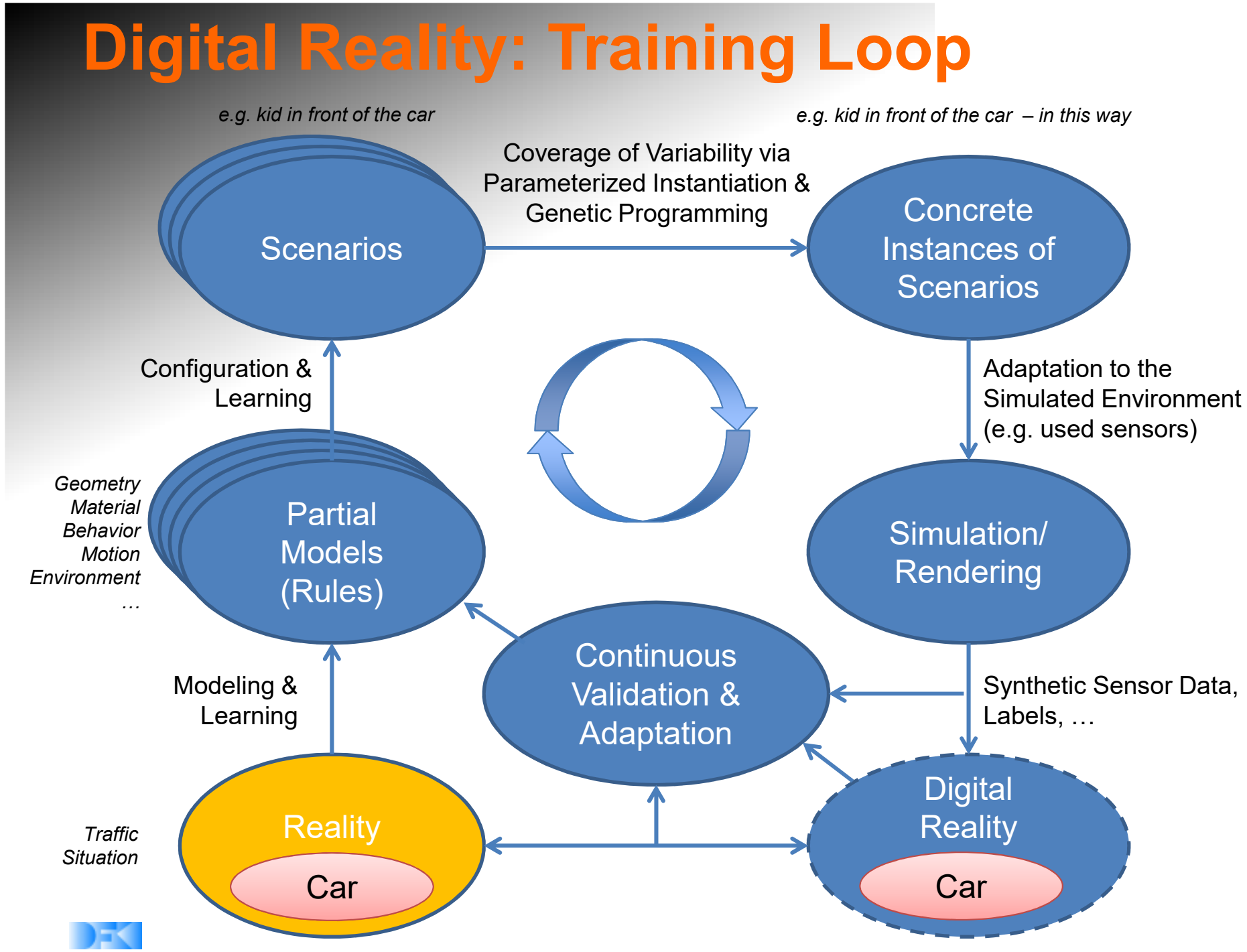
- **Training and Validation in the *Digital Reality***
  - Arbitrarily scalable (given the right platform)
  - But: Where to get the models and the training data from?



Digital Reality: Training



Digital Reality: Training Loop



AI für Autonomous Driving

- **Requirements and Challenges**
  - **Learning** of *critical situations*
    - *Creating proper models of the real world* (via learning)
    - *Generating* the required input data (via models)
    - *Covering the required variability* of the input data
    - Requirements on the *size, accuracy and robustness* of the data?
  - **Benchmarking** the development processes
    - *Reproducible and standardized* test scenarios
    - *Scalable and fast* simulation, rendering, and learning
    - *Open architecture* for integrating different models & simulations
  - **Validating** the learned behavior for autonomous driving
    - *Calibrating* synthetic data against real data
    - *Identifying and adapting insufficient and missing models*
    - Setting up a *"Virtual TÜV"* for autonomous vehicles (systems?)

REACT Project

- **BMBF-funded Project at DFKI**
  - Autonomous Driving: Modeling, Learning & Simulation Environment for Pedestrian Behavior in Critical Situations
- **Exploring Key Challenges**
  - *Motion Models and Motion Synthesis for Pedestrians*
  - *Modeling and Simulating High-Level Behavior*
  - *Hybrid Deep Learning for Agent-Based Simulations*
  - Automated Creation & Evaluation of Critical Situations
  - High-Performance Deep Learning (w/ AnyDSL)

Digital Reality for Autonomous Driving (DFKI)

Digital Reality for Autonomous Systems

Using PreScan Data (TASS) for Semantic Segmentation



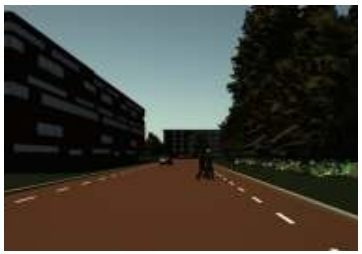










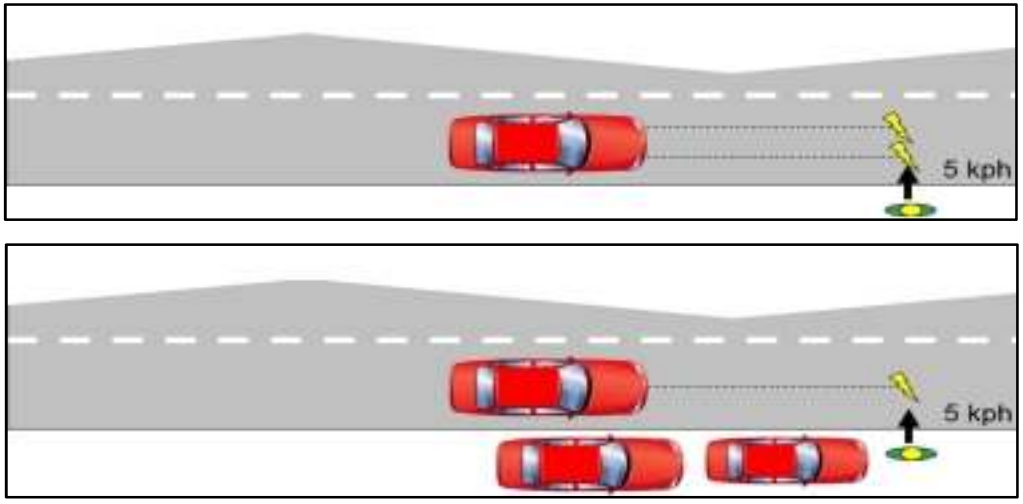
Initial Scenario: Autonomous Breaking System (Euro NCAP)

- **Autonomous breaking test conducted by ADAC**
  - Significant efforts invested in tests in 2016

Images from: https://www.adac.de/infotestrat/tests/crash-test/notbremsassistent_2016/default.aspx?ComponentId=250194&SourcePageId=31956

Initial Scenario: Autonomous Breaking System (Euro NCAP)

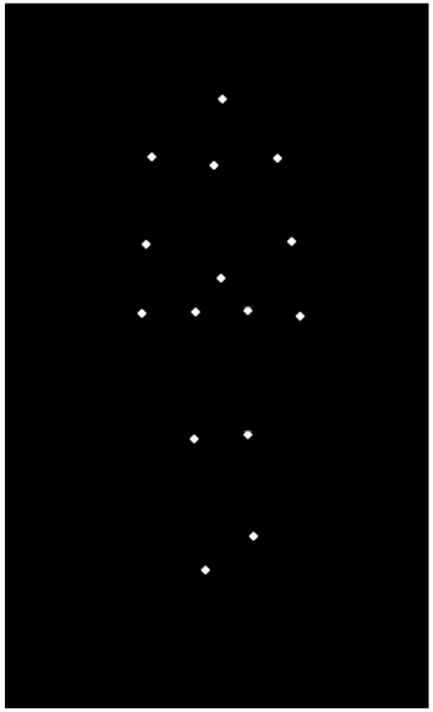
- **Insufficient Results in Recent Test by ADAC (2016)**
  - Problems: Night, speed, moving legs, only forward looking, …
  - But even difficult cases were handled by at least some cars
- **Important for Pedestrian Protection (30% of deaths)**
  - Potentially strong impact with relatively simple setup
  - Easier tests, wider coverage, less false positives, …



[Nils Tiemann, Ein Beitrag zur Situationsanalyse im vorausschauenden Fußgängerschutz, Diss, Uni Duisburg-Essen, 2012]

Challenges: e.g. Recognition of Subtle Motions

- **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



Digital Reality:
Research Environment

Projects in AI and Application Areas (only ASR)

- Deep Learning
  - **High-Performance Deep-Learning on heterogeneous HW**, new ExCluster project
  - **Large-Scale Deep-Learning Framework** (HP-DLF), with FhG-ITWM, TU Dresden
  - **Deep-Learning Training Center**, at UdS and DFKI
  - **Deep-Learning Competence Center**, at UdS and DFKI (submitted)
- Computational Sciences
  - **TransRegio SFB, TR244** (preliminary approval), jointly with UdS, TU Ilmenau, TU Karlsruhe (KIT)
  - **SFB „3D Microstructure Evolution“** (first review), jointly with MS, CS, and Math at UdS
  - **Learning Sensor Systems** (BMBF), jointly with FhG, U. Würzburg, U. Bamberg
  - **Understanding peta-byte data sets from SKA using model-based simulation** (BMBF proposal)
  - **Computational Sciences**: Need for AI in engineering and natural sciences (e.g. DPG and DGM)
- Autonomous Driving
  - **Motion Synthesis for Learning Pedestrian Behavior** (BMW/VW, Intel)
  - **Dreams4Cars**, EU project, together with IUI and RIC
  - **VDA Lead Initiative „Autonomous Driving“** (in all 3 planned projects: AI, V+V, SetLevel4to5)
- Strategic Research Agenda
  - **Excellence Cluster proposal „Digital Reality“**, SL Informatics Campus (final proposal submitted)
  - **EU “AI-on-Demand Platform”** (to be submitted)
  - **EU Flagship proposal “Humane AI”** (to be submitted)

OpenDS

- **Example for highly visible automotive DFKI platform**
  - Open Source driving simulation platform
  - Validated tasks for psychological driver distraction research
  - Internationally widely used in research and industry
    - More than 10k registered users
    - Including: Google, Bosch, Continental, Honda, TomTom, Nuance, …
    - Including: CMU, Stanford, Berkeley, MIT, TUM, TU-Berlin, …
  - Also used for driver education (e.g. developing countries)
  - USP: Highly flexible infrastructure for research

DFKI Competence Center Autonomous Driving (CCAD)

- **Thematic Research Center at DFKI**
  - Cutting across research of several research areas at DFKI
  - Exploiting DFKI-internal synergies
  - Increased visibility in research and industry
  - One-Stop-Shop for external contacts & collaborations
  - Common platform and infrastructure projects
- **Addressing Strategic Interest in Autonomous Driving**

Next Steps

- **Setting up network between industry & academia**
  - DFKI established as coordinator with large industry network
- **Academia:**
  - Short-term validation of the general approach and incr. results
  - Long-term research work on key challenges
  - Partner with focus on one of the partial models
  - Integration and networking between partners
- **Industry:**
  - Creation of initial models, acquisition of real data, validation
  - Integration into their development processes
- **Collaboration Framework**
  - Direct and publically funded activities (EU, national, etc.)
  - ***Open architecture for learning from simulated, synthetic data***

National AI Activities

- **New German Platform for AI: “Learning Systems”**
  - Exchange between research, industry, and society
- **New German AI research initiative**
  - New government: More money for research (3,5% GDP)
  - “National Masterplan for AI”, no details yet
- **German-French AI Collaboration**
  - Planned at the highest level (Macron/Merkel)
  - Details still being defined
  - Budget of may be as large as 2x 250 M€

Future of AI

- **AI as a *fundamental game changer* in many areas**
  - Cars, robots, virt. assistants, urban planning, energy mgmt., …
  - Nat. sciences, data analytics, social, finance, …
  - Needs scientists and experts from many different fields
- **Common approach and challenges**
  - Simultaneously learn models & good actions (given models)
  - Requires large-scale learning, simulation, collaboration
- **Need for a joint research platform & community**
  - We have done this before: Human Genome project & CERN
  - Can we learn from these approaches?

„CERN for AI“

- **Mission:**
  - Collaborative, scientific effort to accelerate and consolidate the development and uptake of AI for the benefit all humans and our environment
  - Continuously improve our understanding of the world around us and use this information to explore and evaluate better ways to act and interact in this world
  - Provide a transparent, open, and flexible platform supporting a wide range of research capabilities while facilitating transfer and exchange with industry
  - Broadly discuss the policies and consequences of using AI
- **Our Vision: „Human^{e} AI“**

Current AI Activities in EU

- **EU Flagship on "Human^e AI" (aka. "CERN for AI")**
  - "Towards AI Systems that Augment Human Intelligence by Understanding Us and the World Around Us"
    - Enhancing human capabilities instead of replacing them
    - Empowering humans instead of telling them what to do
    - Explainable, transparent, validated, trustworthy systems
    - Include at the core values, ethics, social, and other aspects
  - Organizing the AI community in the EU
    - Focus on fundamental research – *with strong impact on economy/society*
  - 10 years, 100 M€/a, starting 2019/2020
- **EU Call "AI-on-Demand Platform" (first step)**
  - Organizing the AI community in the EU
    - Focus on SW platform for non-experts
  - 3 years, one consortium, 20 M€, starting 2018
  - 2 follow-up projects planned for 2020

Conclusions

- **Goal: Ability to Create a "Digital Reality"**
  - Machine Learning is the best known method
  - Still insufficient for many (critical) situations
- **Learning from Synthetic (and Real) Data**
  - Requires learning, modeling, simulation, and validation
- **Big Challenges Ahead**
  - Many promising partial results – but largely islands
  - Requires closer collaboration of industry & academia
  - Need for strategic agenda and investments ("CERN for AI")
- **AI a Central Component of Future Systems**
  - Fundamental changes coming across domains
  - Need to address issues early on (values, ethics, social, ...)