Digital Reality:

Using Trained Models of Reality to Synthesize Data for the Training & Validating Autonomous Systems

Philipp Slusallek

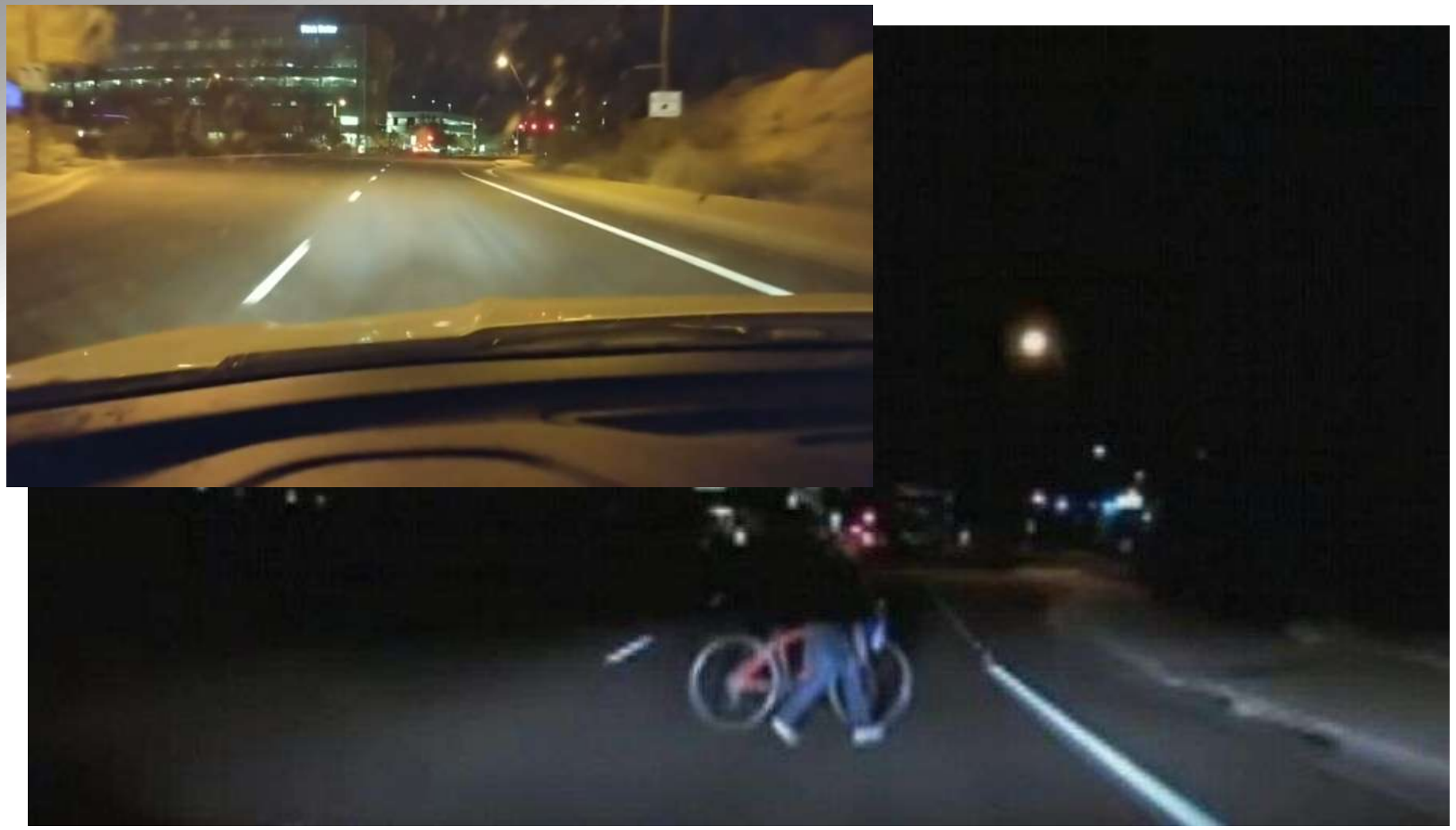
German Research Center for Artificial Intelligence (DFKI)

Saarland University

Excellence Cluster Multimodal Computing and Interaction (MMCI)

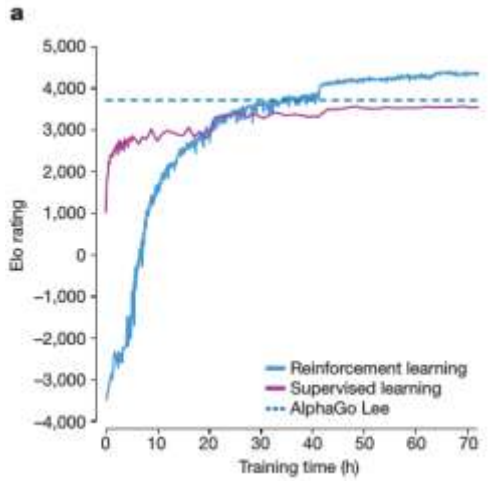
European High-Level Expert Group on AI

Why Do We Need Training and Validation via Synthetic Data?



Playing Go – From Scratch

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



Quality of Gameplay

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

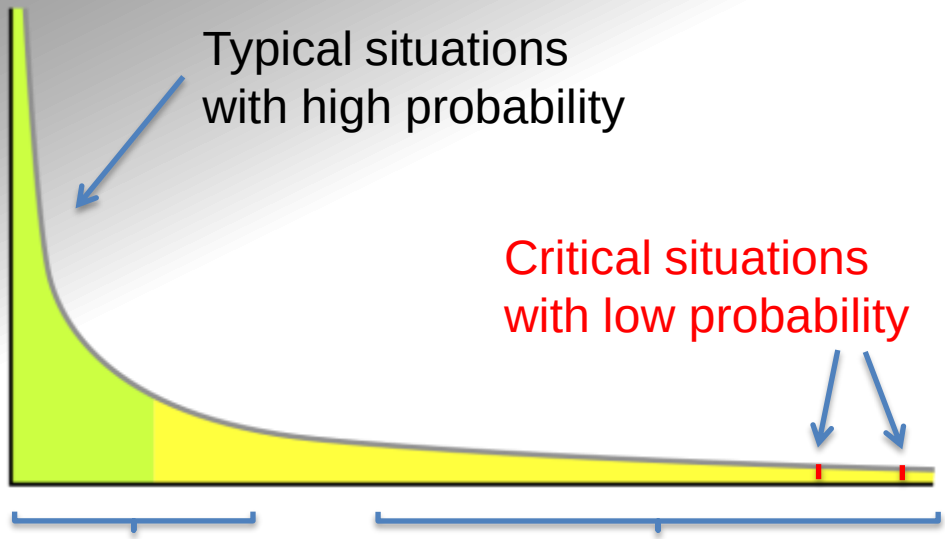
Autonomous Systems: The Problem

- **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**
  - Often little (good) data even for “normal” situations
  - Critical situations rarely happen in reality – per definition!
  - Extremely high-dimensional models

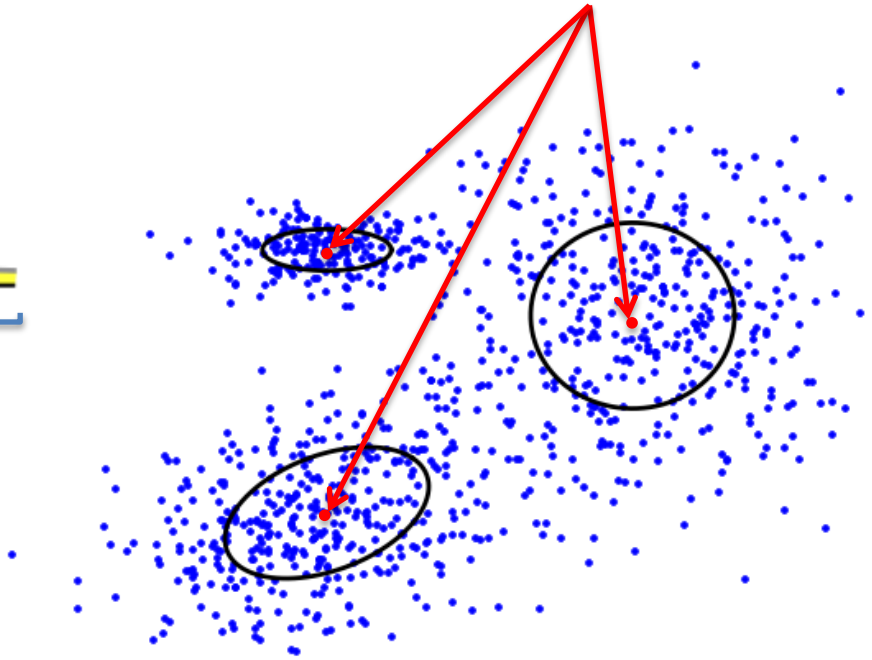
➔**Goal: Scalable Learning from *synthetic* input data**

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

Autonomous Driving: The Problem



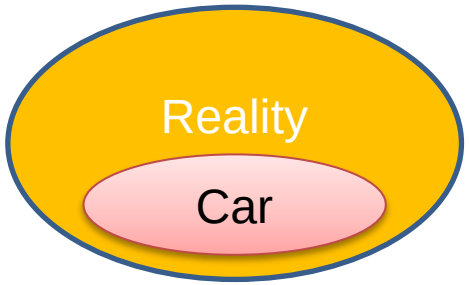
Goal: Validation of correct behavior by covering high variability of input data



Learning for
Long-Tail Distributions

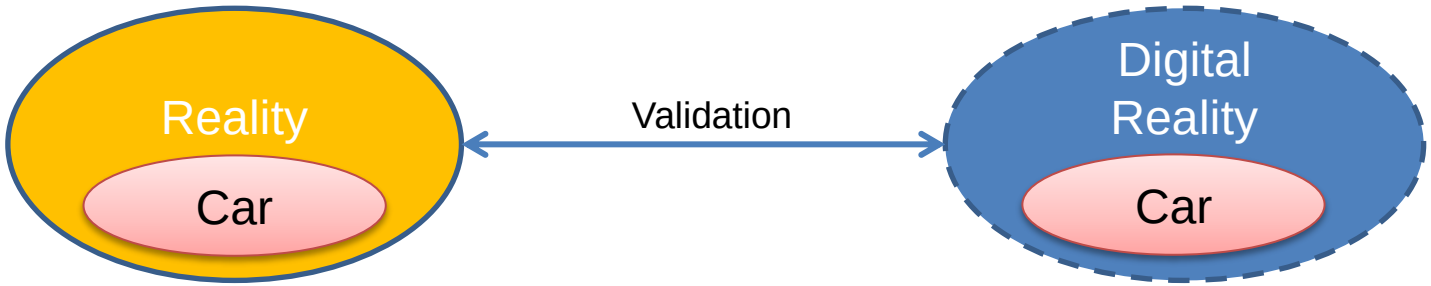
Reality

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

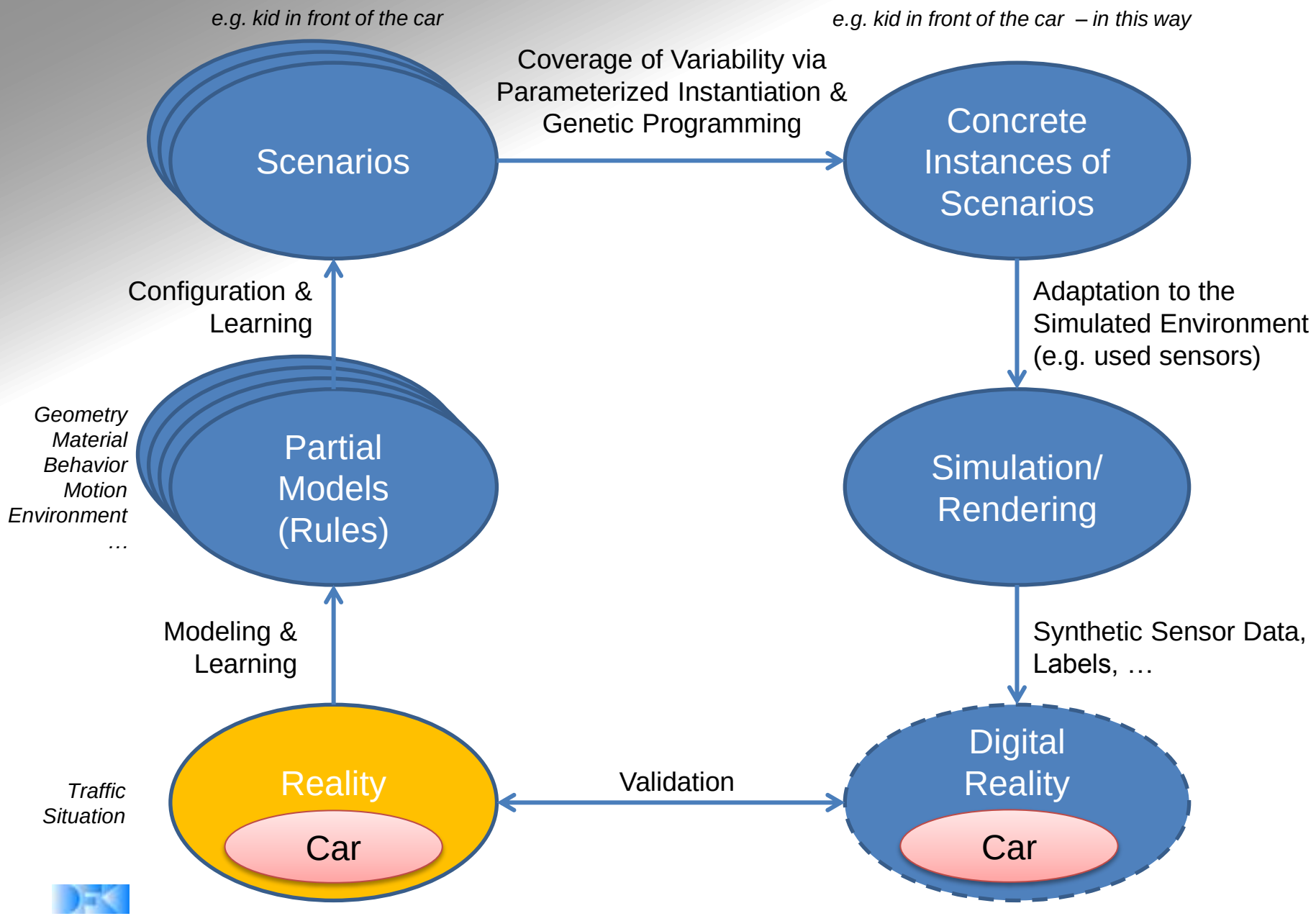


Digital Reality

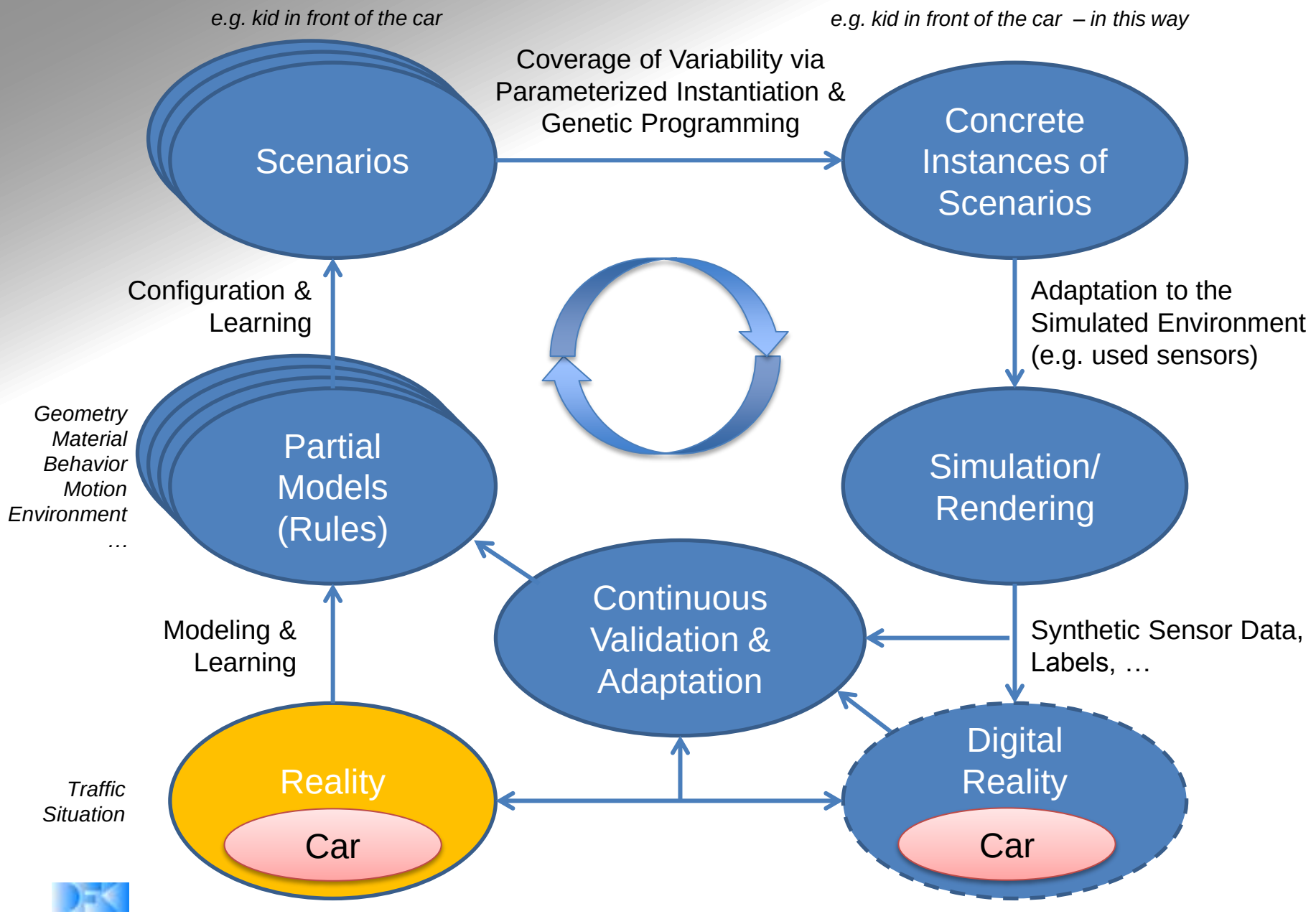
- **Training and Validation in the *Digital Reality***
  - Arbitrarily scalable (given the right platform)
  - But: Where to get the models and the training data from?



Digital Reality: Training

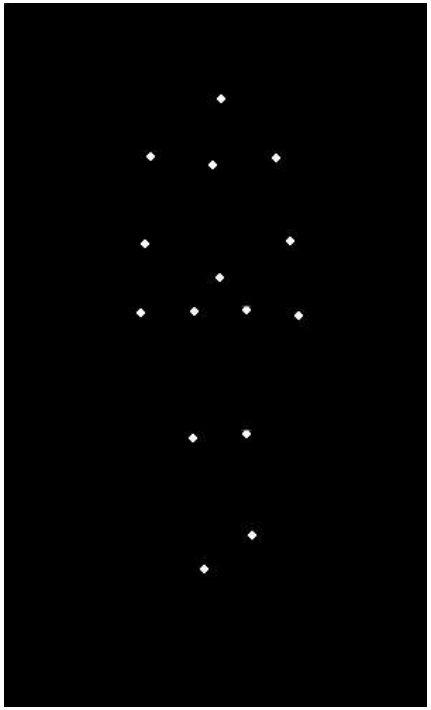


Digital Reality: Training Loop



Challenges: Recognition of Subtle Motion Differences

- **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: Radar Rendering

- **Key Differences**
  - Longer wavelength: Geometric optics (rays) not sufficient
  - Need for *some* wave optics
    - Diffraction at rough surfaces and edges
    - Need for polarization & resonance
  - Highly different goals
    - Optical: Focus on diffuse effects (+ some highlights, reflections, etc.)
    - Radar: Focus on specular transport only (i.e. caustic paths)
- **Recent Work on Caustics [Grittmann, EGSR'18]**
  - Identifying "useful" caustic paths (in VCM context)
  - Guides samples to visible caustic regions
- **Combining research on rendering and radar technology**

Genesis Project

- **Genesis: Open Platform for Training & Validation of AI**
  - Collaboration platform for industry and research
  - Easy testing, evaluation, and exchange of code and data
  - Founded with TÜV Süd, several other partners from EU & Asia
- **Based on OpenDS: Open-Source driving simulation**
  - Highly visible automotive research platform by DFKI
  - Internationally widely used in research and industry
    - Including: Google, Bosch, Continental, Honda, TomTom, Nuance, …
    - Including: CMU, Stanford, Berkeley, MIT, TUM, TU-Berlin, …
- **Hiring 15-20 PhDs**
  - To further develop platform and individual partial models

Genesis: Digital Reality for Autonomous Driving (DFKI)

Intelligent Simulated Reality for Autonomous Systems (BMW)

Using PreScan Data (TASS) for Semantic Segmentation
















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**
  - Loop of model learning, simulation, training, and validation
- **Big Challenges Ahead**
  - Many promising partial results – but largely islands
  - Requires closer collaboration of industry & academia
  - Towards large-scale European initiatives
- **AI will be a Central Component of Future Systems**