Dejaview

Inverse Physical Reasoning

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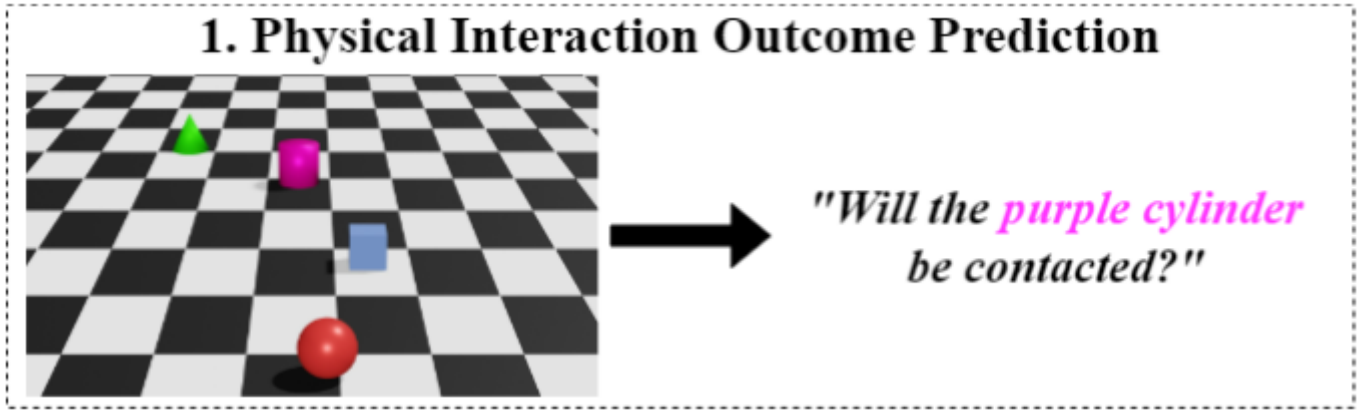
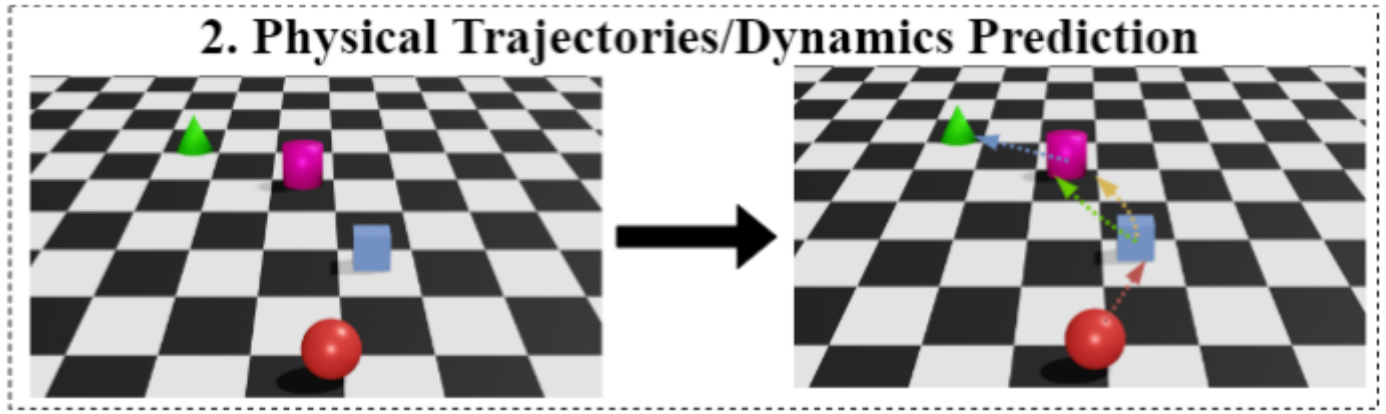
Motivation

- Physical reasoning (initial state given, forward)

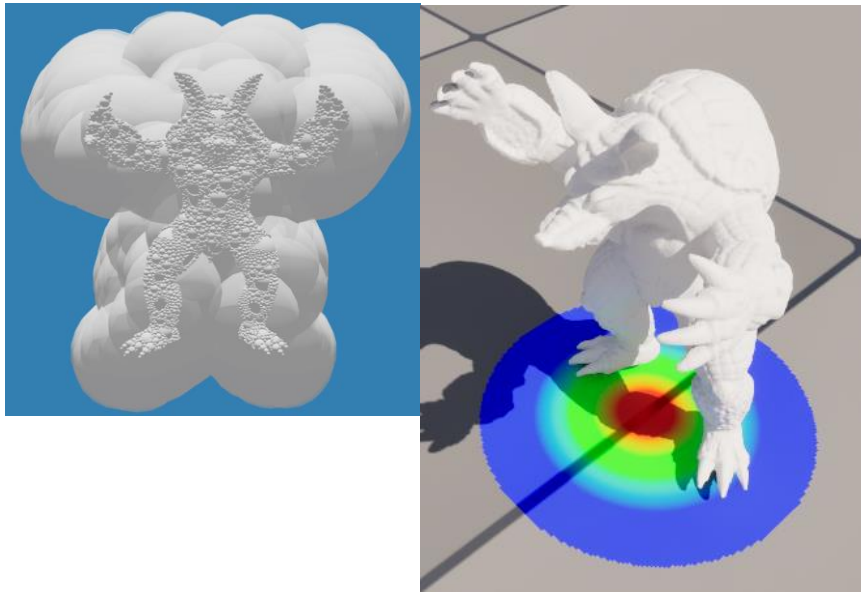




Motivation

Uncertain Physics

- Our knowledge about the world is incomplete or uncertain (sensors are unreliable)
- Often, laws governing the environment are not known

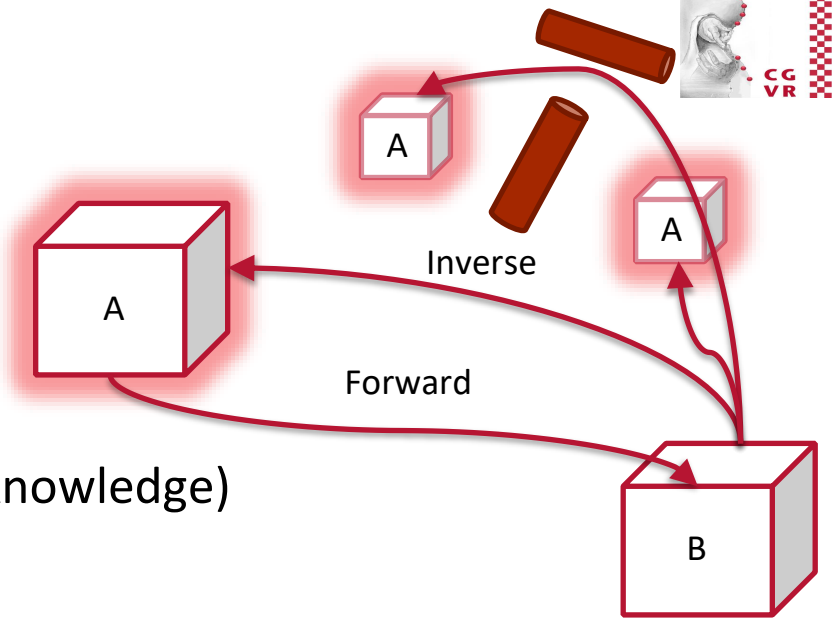


- 3D Rigid Body Simulator „UncertainPhysics“
- Rigid bodies are approximated through spheres
- Positional uncertainty modeled as a Gaussian
- Available as plugin for UnrealEngine 5
- Use cases: Prediction, physical reasoning, speedup of intensive sampling tasks

Task Overview

- Determine some plausible scenarios that can also be simulated
- Develop a general interaction/user interface in Unreal Engine VR
  - Object selection and specify (multiple) initial position/area
- Implement:
  - Live backtracking
  - Train a neural network in kitchen environment
  - Utilize: UncertainPhysics, Brax, tiny-differentiable-simulator

Problem

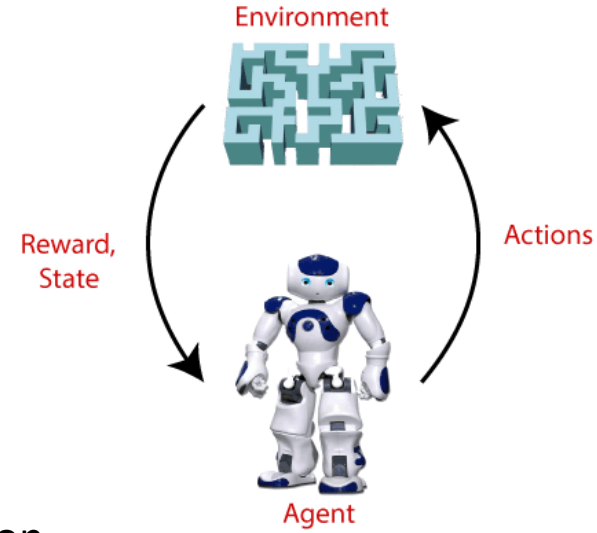


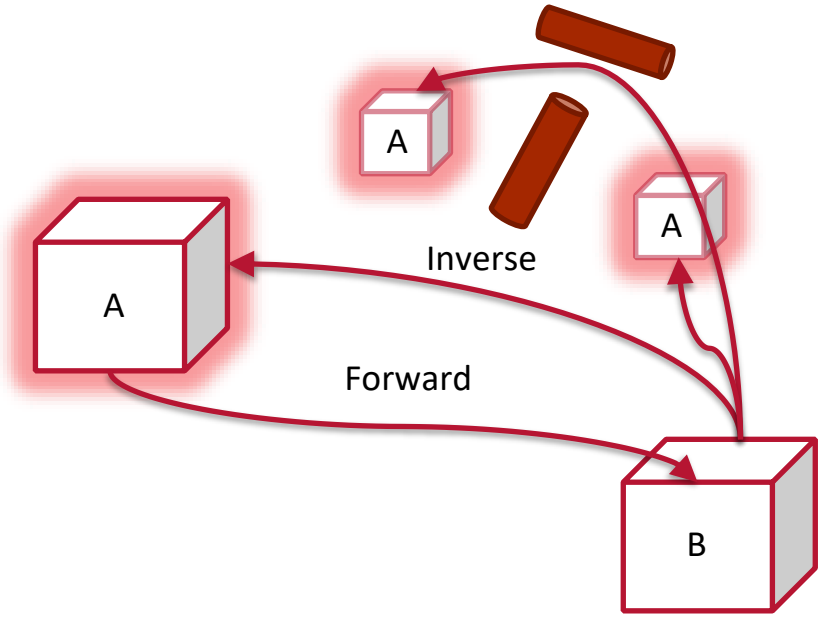
- Given:
  - Final state **B** (position, rotation, velocity, …)
  - Initial state **A**: user-specified, random, ontology (explicit domain knowledge)
- Goal:
  - Can the initial state be reached? Is there an interaction path?

- Inverse problems can be ill-posed, meaning they might have no solution, multiple solutions

Approach

- Reinforcement Learning (RL): Exploration and Exploitation
- Differentiable physics:
  - Allows RL to learn faster
  - Can be used to optimize directly (no neural network training)
- Basic program code can be automatically made differentiable: Automatic Differentiation
- Collisions make optimization harder
  - Penalty method
  - Collision outside optimization as a separate event





This Master's Project will be Embedded in a larger Research Project

Project Infos

- One-semester
- Winter semester 2024/25
- Suitable for profile areas: KIKR, DMI, VMC
- Suitable for study programs:
  - Computer Science
  - Digital Media
  - Systems Engineering
- In case of further questions: don’t hesitate to ask
  - Emails: zach at cs.uni-bremen.de , weller at cs.uni-bremen.de, hmeiss51 at cs.uni-bremen.de

- Nice-to-have prior knowledge/skills:
  - A bit of computer graphics / 3D knowledge / physically-based simulation / optimization methods / machine learning
    - E.g., from one of the courses “Virtual Reality”, "Advanced Computer Graphics”, „Machine Learning“, and many others
  - A bit of programming skills in C/C++ or modelling skills
- Must-have: *Commitment*!
- The ideal project team: mix of CS & DM students
- Great opportunities for follow-up master‘s theses

Ready to teach robots using simulation with us?









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