ThreeDWorld (TDW) – A Multi-Modal Platform for Interactive Physical Simulation

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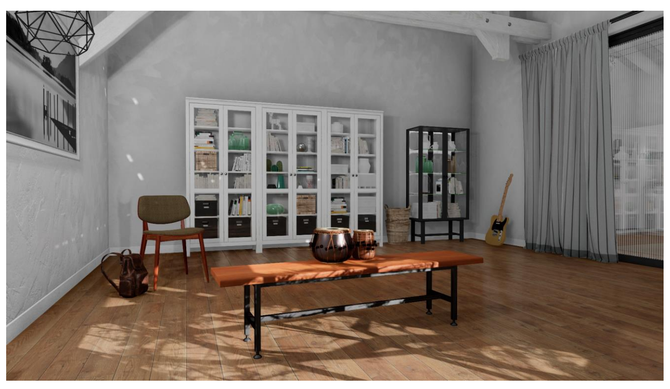
- Addresses the difficulty and cost of acquiring large amounts of labeled data for training machine perceptual systems
- Generating scenes in a virtual world enables full access to all generative parameters
- Uses state-of-the-art videogame technology to collect experimental data and generate large-scale datasets for training AI systems
- Publicly released: *https://github.com/threedworld-mit/tdw* Website: *www.threedworld.org*
- General, flexible design enables a broad range of use cases, including a) visual recognition transfer; b) multi-modal physical scene understanding; c) learnable physics models and d) visual learning in curious agents

For details on use-cases, see paper "*ThreeDWorld: A Platform for Interactive Multi-Modal Physical Simulation*"

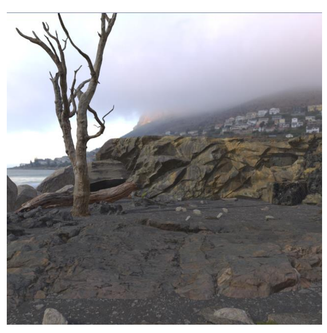
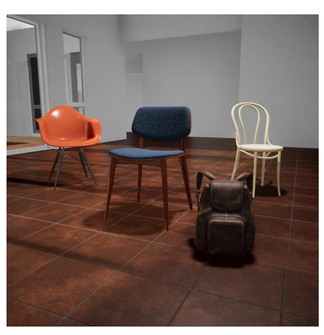
Overview of TDW Features and Capabilities

Visual Modality:
Near-photoreal image rendering using real-time GI, HDRI lighting model and physically based rendering materials

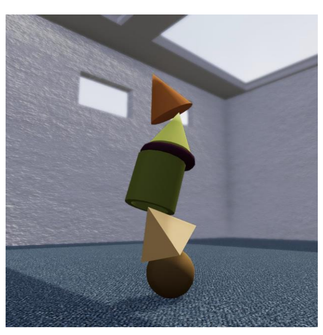


Auditory Modality:
High-fidelity audio, with real-time, physics-based impact sound synthesis via PyImpact python library

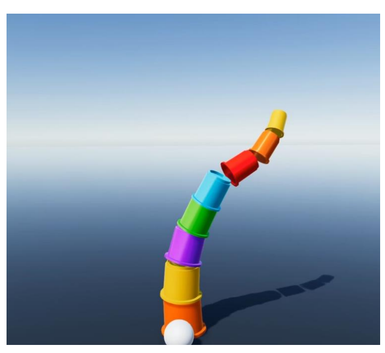
Supports both interior and exterior environments:
- Highly-detailed interiors
- Exterior environments use 3D assets scanned from real-world
- Populate environments with high-quality 3D models, optimized for research purposes -- procedurally or fully scripted

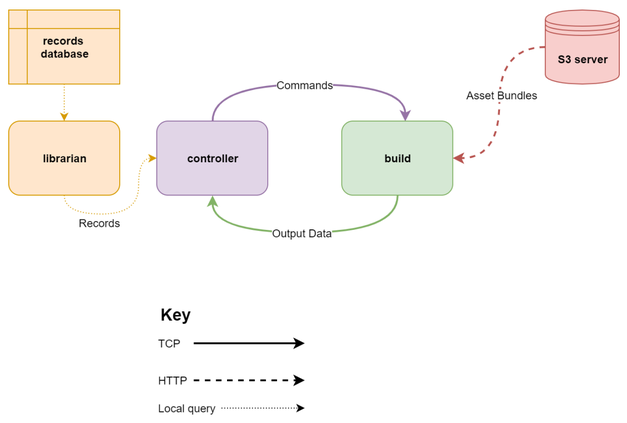
Advanced physical interactions:
- Fast but accurate rigid body collisions
- Uniform, particle-based approach supports rigid body, soft body, cloth and fluids
- Physics benchmark dataset for training and evaluation of physically-realistic forward prediction algorithms



Multiple paradigms for object interaction:
- **Direct** – use API commands, e.g. apply force so ball collides with stack of cups
- **Indirect** – Avatar as embodiment of agent. Range from simple camera to "sticky-mitten" avatar with articulated arms to lift objects
- **Direct Human** – user as Agent in VR; interact with objects using "hands"



High-level architecture:
- The **Build** is a compiled executable running on the Unity3D Engine, responsible for image rendering, audio synthesis and physics simulations
- The **Controller** is an external Python interface to communicate with the build.
- Controller sends commands to Build; Build returns wide range of output data types representing the "state of the world"



Rich command and control Python API:
- Over 200 commands
- Extensive documentation, including multiple example and use-case controllers
- Controller can send multiple commands per time-step, for complex behaviors

Ongoing Development Goals

- Expand capabilities of PyImpact sound synthesis – more audio materials, support for scraping and rolling sounds
- Interface to Robotic Operating System (ROS), enable import of existing robotics assets via URDF
- Add ability to receive haptic feedback from physical interactions
- Integrate NVIDIA GPU raytracing for enhanced photorealism
- Develop a humanoid avatar with fully-rigged skeleton and soft-fine-grained hand gripper

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