Physics-Based Approach to Pruning Search Space in Multi-Object Pose Estimation Algorithms

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Introduction

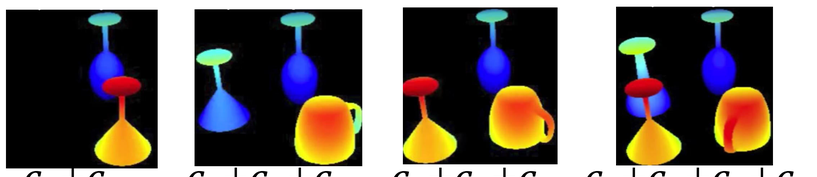
- Perception is a critical part in robotic manipulation
- Important to quickly identify multiple objects and their poses in the environment
- Algorithms like PERCH using generative search can take a long time
- Constraints from physics can be used to reduce search time

PERCH-like Algorithm

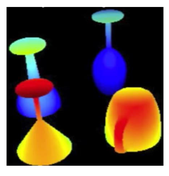
- Access to database of 3-D models and RGB-D image of the environment.
- Searches for set of object configurations that best explain observed scene
- Search space is very large and state expansions (rendering) is expensive

Observed scene

Generated scenes in search space



Objects identified and 6DoF poses determined



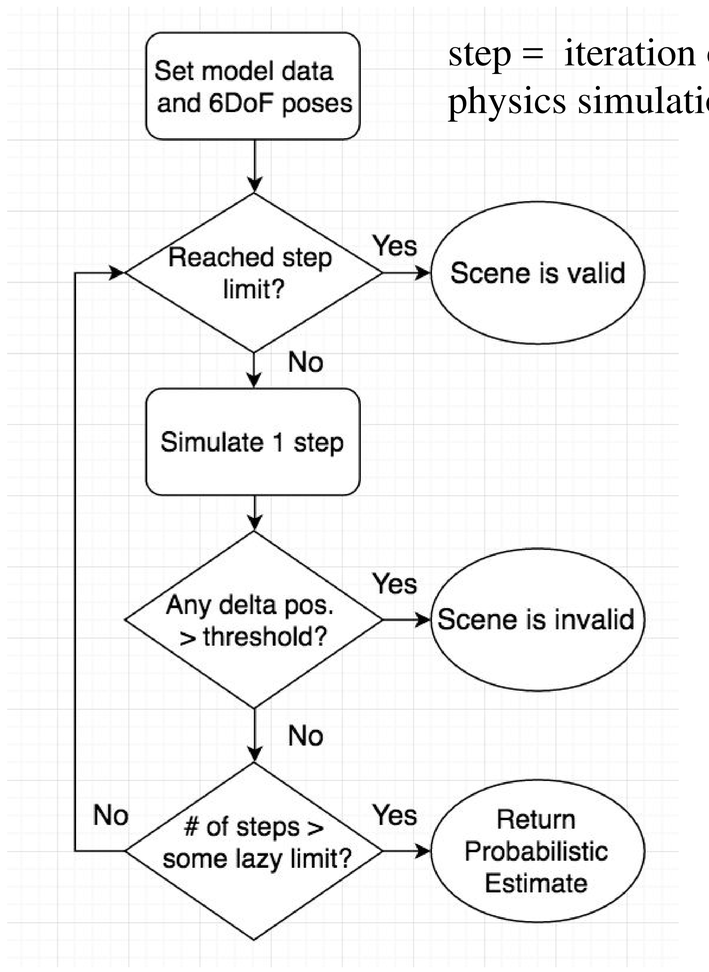
mug
(1,-1.3, 0.7)
(0°, 0°, 32°)

Objectives

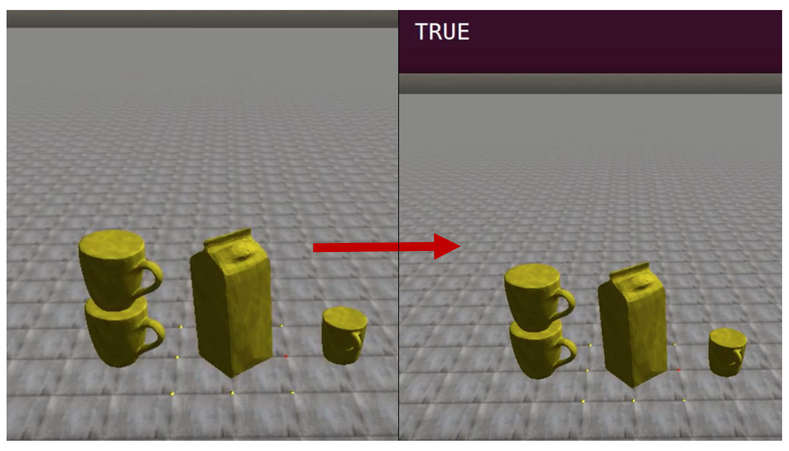
- Reduce computation time by pruning search space
- Before executing rendering step, falsifying generated scenes that would not exist in the real world
- Given scene of 3-D models and their 6DoF poses, determine if scene is valid
- Complete validation as fast as possible

Methods

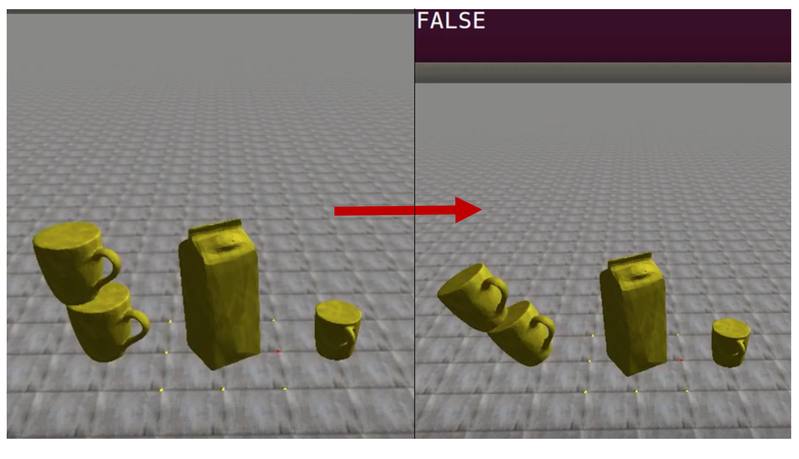
- Simulate using Open Dynamics Engine
- Speed up via series of checks
- Obtain absolute validation certainty or probabilistic estimate



Scene that could exist in real life



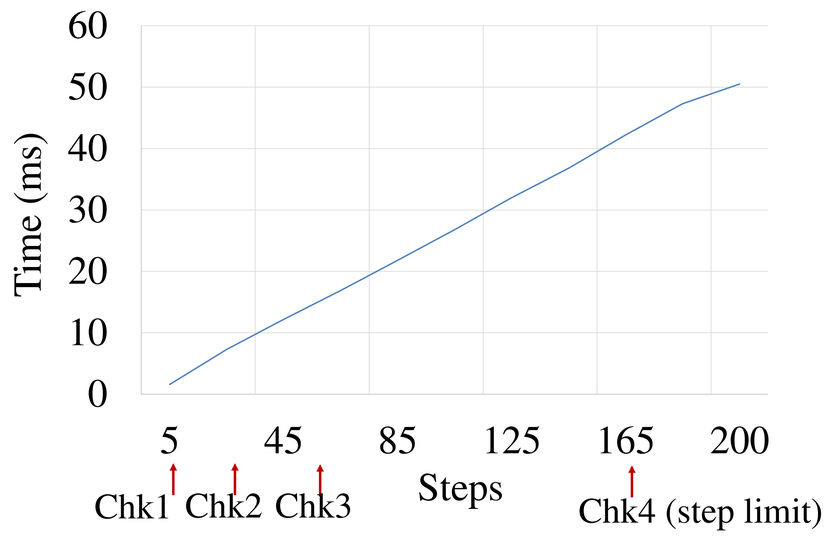
Scene that cannot exist in real life



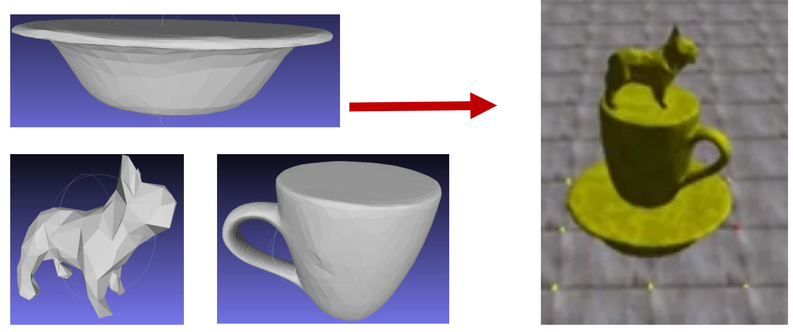
Results

- Determines if scene is false in as little as 1 millisecond. Series of checks are used.

Steps vs Time with Scene of 4 items



- Height reward function maximized in 0.3 sec. using scene validator program



Conclusion

- Achieves fast scene validation
- Proves its merit in a simple reward function maximization search
- Speeds up PERCH or D2P, search can include 6DoF poses
- Probabilistic estimate can be made after only running the simulation for a very short amount of time.
- Allows development of an algorithm which can exploit this probabilistic estimate.

References

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- A. Roennau, F. Sutter, G. Heppner, J. Oberlaender and R. Dillmann "*Evaluation of Physics Engines for Robotic Simulations with a Special Focus on the Dynamics of Walking Robots*" (ICAR) 2016.
- Venkatraman Narayanan and Maxim Likhachev "*PERCH: Perception via Search for Multi-Object Recognition and Localization*" (ICRA) 2016.
- Venkatraman Narayanan and Maxim Likhachev "*Discriminatively-guided Deliberative Perception for Pose Estimation of Multiple 3D Object Instances*" (RSS) 2016.