Learning a visuomotor controller for grasping using simulated depth images

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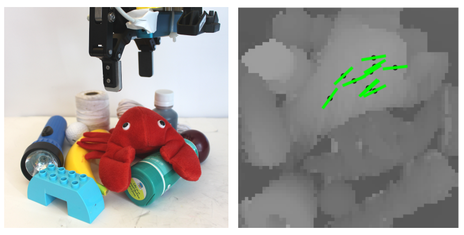
Problem Definition

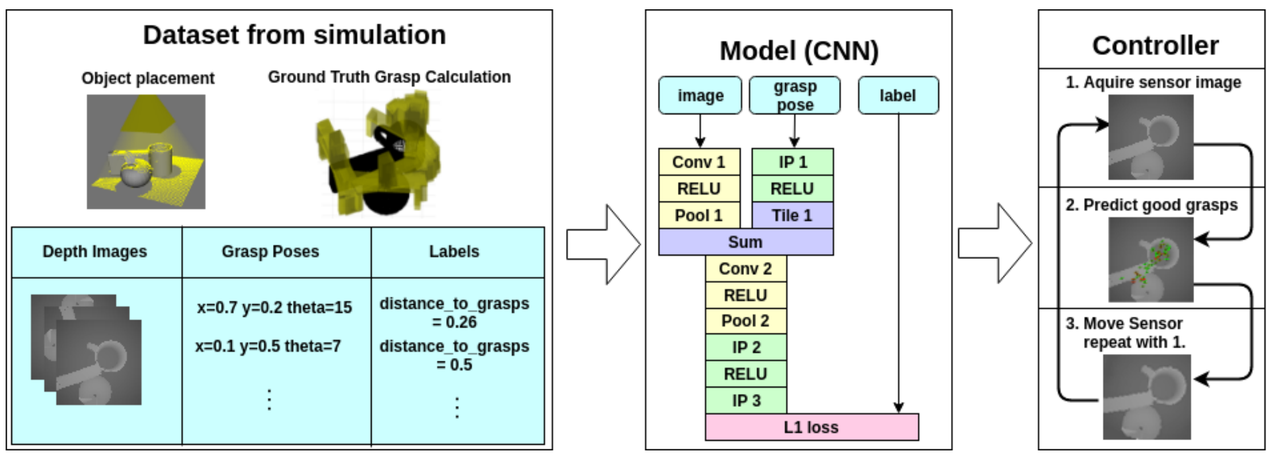
- Build a visuomotor controller for guiding a robot hand into a grasp

Before running controller **After running controller**



Approach

- Train CNN model to predict cost-to-go for grasp poses
- Generate training data in OpenRAVE

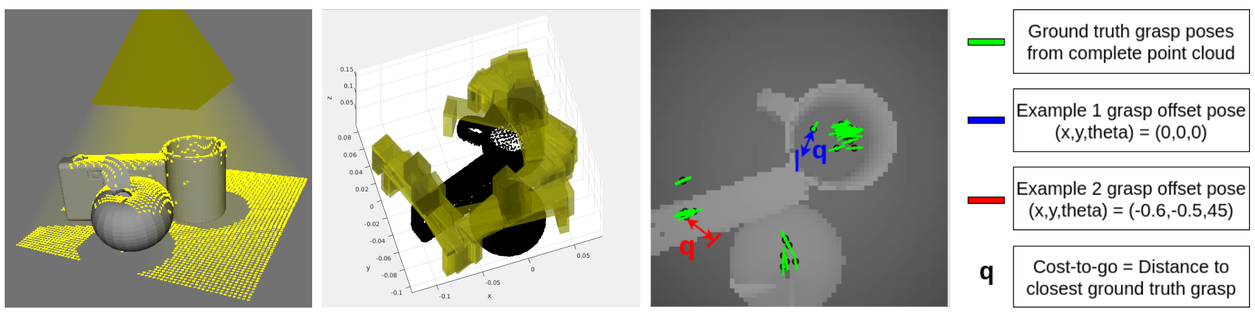


CNN Model

- CNN with 2 Conv and 2 IP layers
- Input: Image and grasp pose (x,y,θ)
- Output: L1-loss regression. Action-value function used by the controller

Training data in simulation

- Random object placement under sensor
- Calculate the ground truth cost-to-go using planning



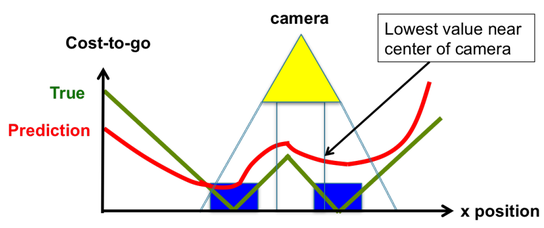
Dataset

- 381 graspable objects from 10 categories
- 500k depth images (64x64 pixels, grayscale)
- 10 offset grasp poses (x,y,θ) per image
- 5M image-grasp pose pairs as input samples

Controller

Algorithm:

1: Camera placed above objects
2: **While:** Object distance $>$ 12 cm
3: Acquire depth image
4: Sample actions near center of image
5: Select min-cost offset pose_top (x,y,θ)
6: Move camera towards pose_top
7: Move fixed step in z-direction towards objects
8: Execute fixed grasp motion (robot)
9: Evaluate distance to closest true grasp (sim)

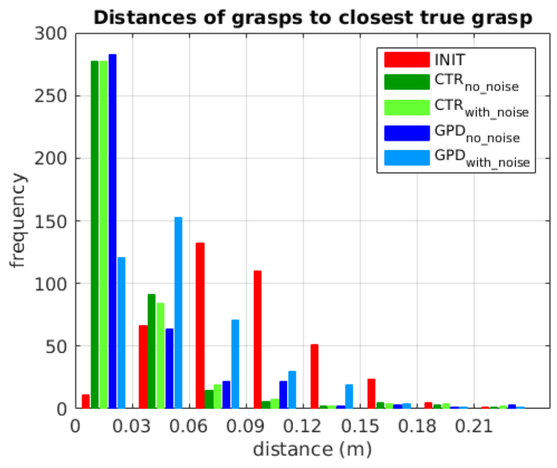


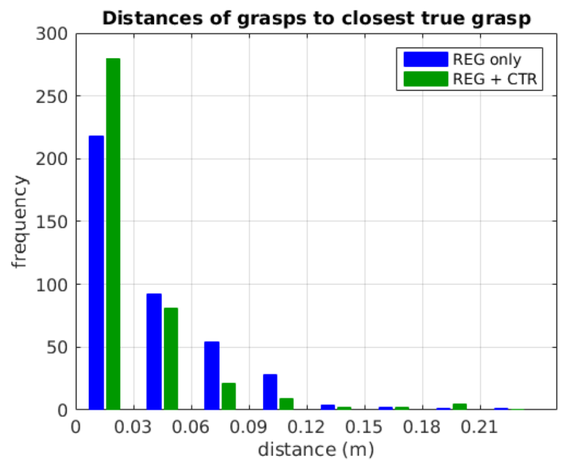
Simulation Experiments

Setup

- 400 simulated trials, 75 control iterations each trial
- Baseline: Grasp pose detection (GPD)
- Scenario 1: Noisy manipulator motion (our CTR vs. baseline GDP)
- Scenario 2: One shot prediction REG vs. REG + CTR

Results

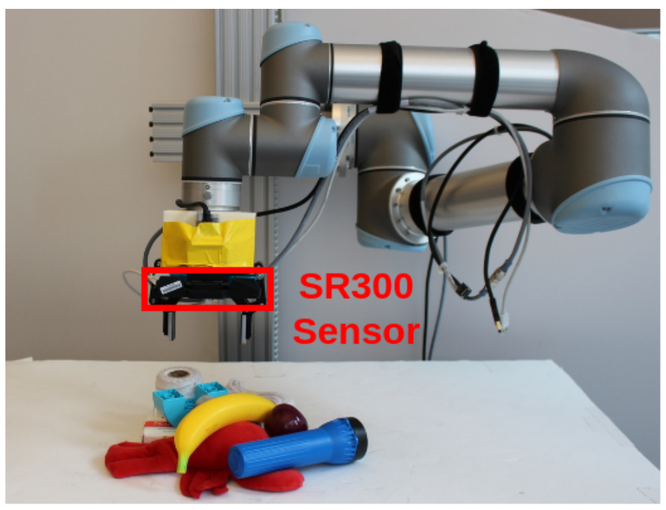


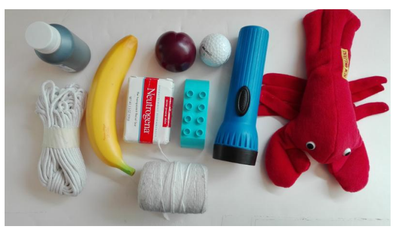


Robot Experiments

Setup

- UR5 robot (6-DOF) and Robotiq 2-finger gripper (1-DOF)
- SR300 depth image sensor mounted to wrist
- Scenarios: single object, clutter, clutter with object movement



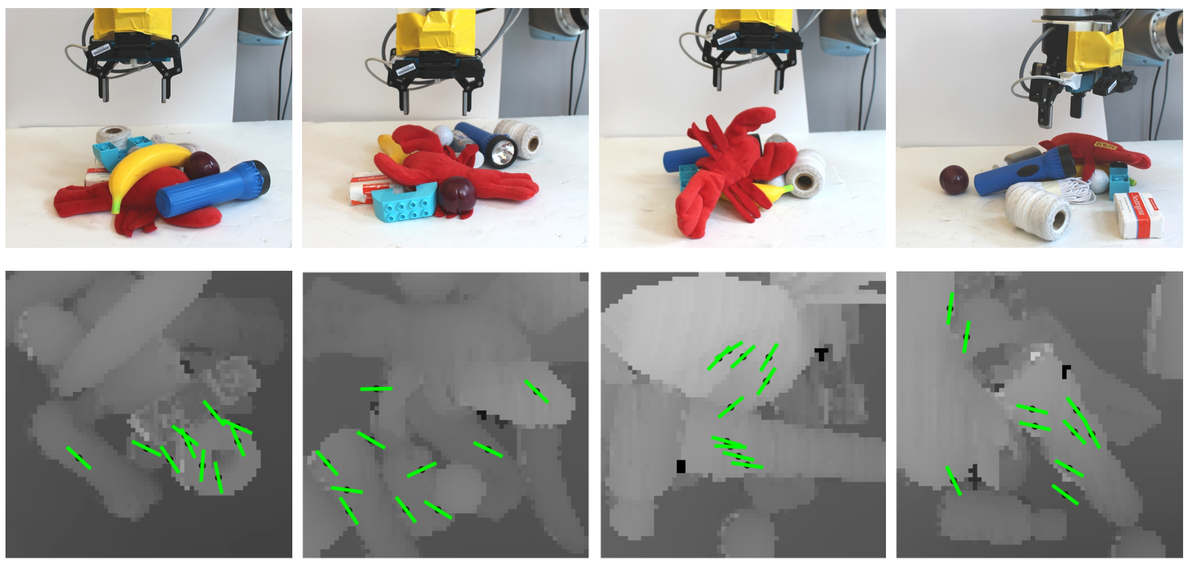


Results

Grasp success rates

Scenario	CTR	GPD
Single objects	97.5%	97.5%
Clutter	88.89%	94.79%
Clutter with movements	77.33%	22.45%

Examples



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