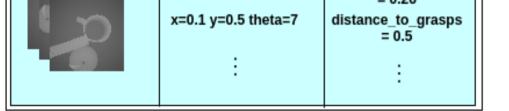
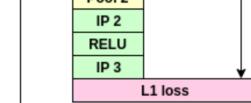
Learning a visuomotor controller for grasping using simulated depth images

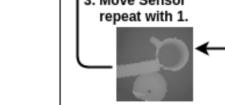
Ulrich Viereck, Andreas ten Pas, and Robert Platt

College of Computer and Information Science, Northeastern University

Problem Definition	Simulation Experiments
 Build a visuomotor controller for guiding a robot hand into a grasp Before running controller After running controller Image: State of the state of	 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
	Distances of grasps to closest true grasp 300 Distances of grasps to closest true grasp
Approach	250 INIT CTR _{no_noise} CTR _{with_noise} 250 250 250
 Train CNN model to predict cost-to-go for grasp poses Generate training data in OpenRAVE Dataset from simulation Object placement Ground Truth Grasp Calculation Wodel (CNN) Image Image	200 y y y y 150 0 0 0 0 0 0 0 0 0 0 0 0 0
Conv 2 x=0.7 y=0.2 theta=15 distance_to_grasps = 0.26	







Ground truth grasp poses from complete point cloud

Example 1 grasp offset pose (x,y,theta) = (0,0,0)

Example 2 grasp offset pose (x,y,theta) = (-0.6,-0.5,45)

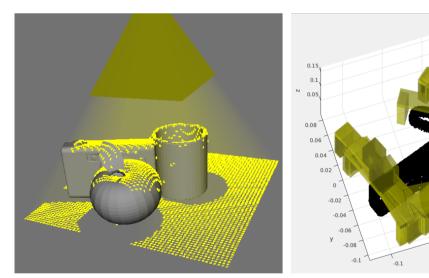
Cost-to-go = Distance to closest ground truth grasp

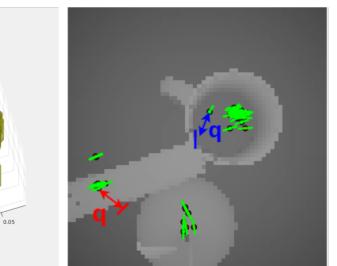
CNN Model

- 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





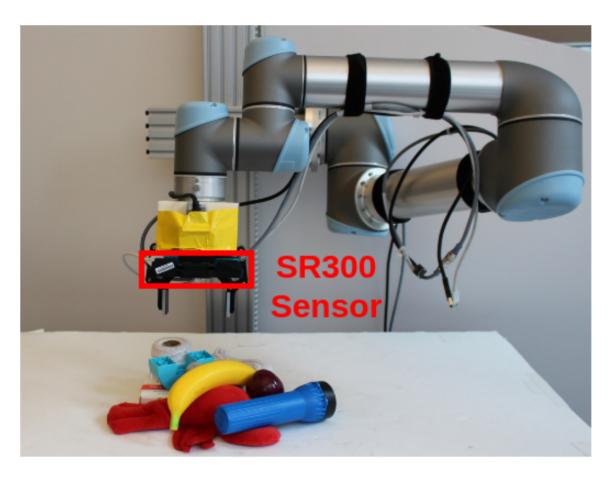
Dataset

- 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

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

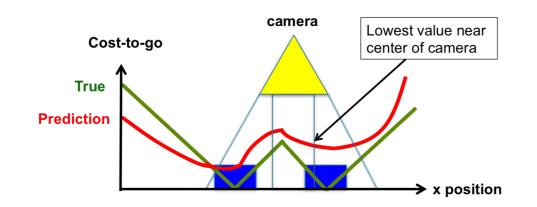
Grasp success rates

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

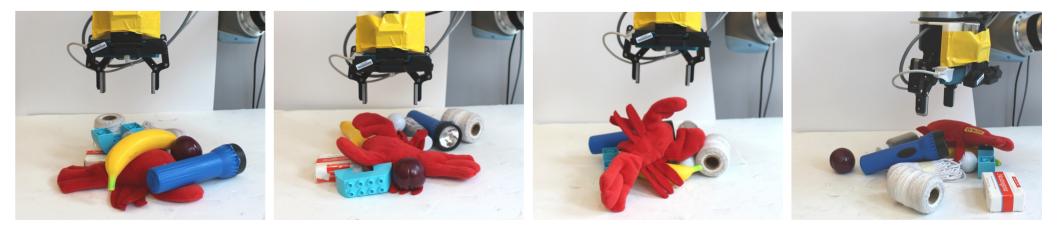
Controller

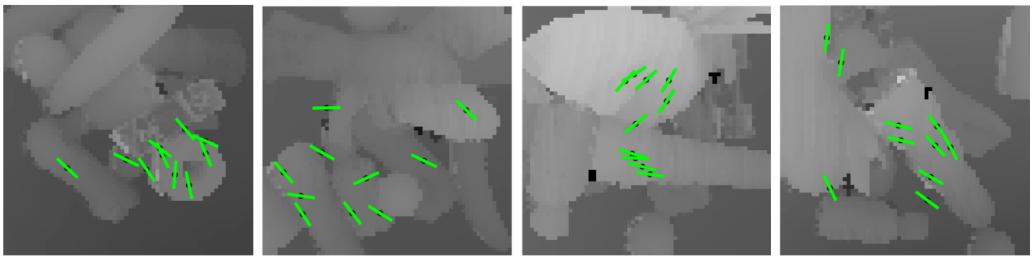
Algorithm:

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



Examples





http://www.ccis.northeastern.edu/research/helpinghands/

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