Grasping Familiar Objects Using Shape Context

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Goal

- Re-use grasp experience on objects familiar in shape
- Infer grasp hypotheses for an object
  - Precision Grasp with Barrett Hand
  - 6 DoF to determine (Position and Orientation)
- Input: stereo image of the object

Related Work

Two different movements in grasping of unknown/familiar objects:

1. **Reconstruction of Object in 3D** (e.g. Hübner et al. IROS 2008, Detry et al. ICDL 2009, Richtsfeld et al. ECCV 2008)
   - search stable grasp configurations dependent on 3D structure
   - How to select a hypothesis?
   - How to deal with a high reconstruction error?
2. **Reasoning about 2D Information** (e.g. Saxena et al. NIPS 2006, Stark et al. ICVS 2008)
   - exploit structural cues in a monocular image directly to infer a grasp position
   - avoid difficult 3D reconstruction
   - How to infer a hand orientation?

Approach

1. Detect **where** to grasp from 2D shape.
   - 2D Grasping Point Detection
   - Relative Shape Representation
   - Experiments

2. Infer **how** to grasp from position of grasping point within (minimal) 3D reconstruction.

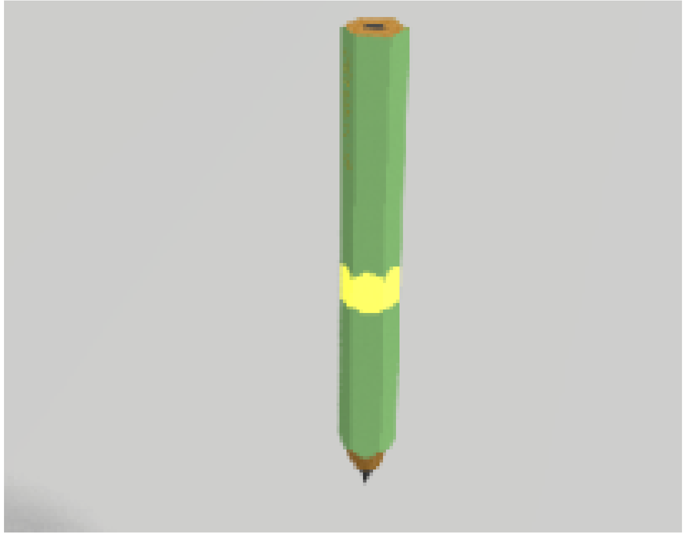
2D Grasping Point Detection

- **Grasping point**: 10×10 px patch in a monocular image, contact point of the palm of the hand
- Supervised training of a grasping point model on labeled database (Saxena et al.)

- 2-class Support Vector Machine: Grasping point/ Non-Grasping point

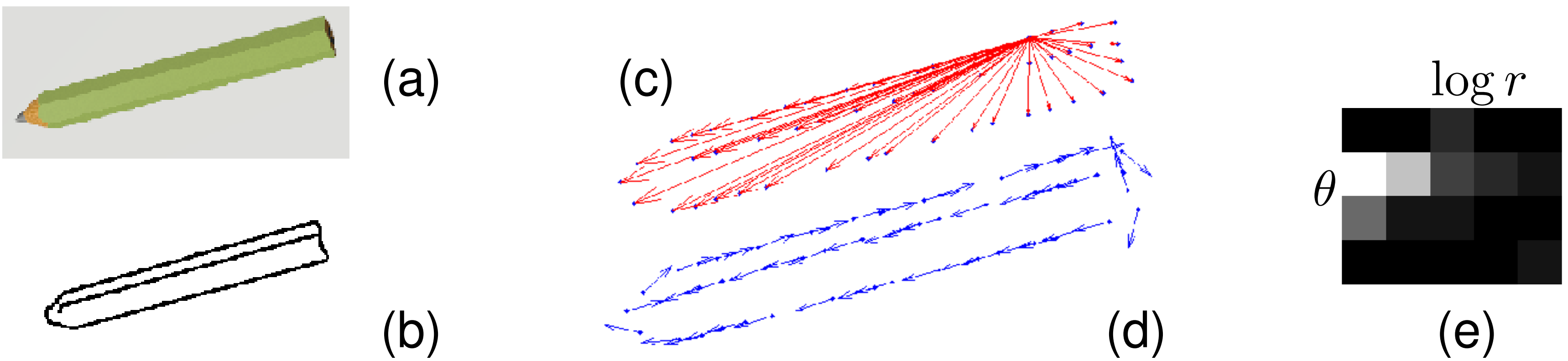
Representation

- Grasping point representation through **relative global shape** as opposed to local appearance



Feature Vector

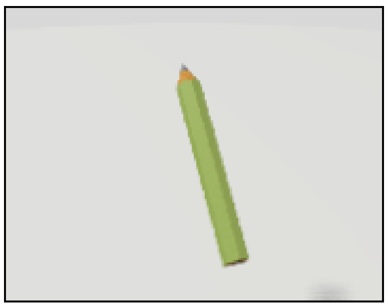
- Shape Context (Belongie et al. NIPS 2000)

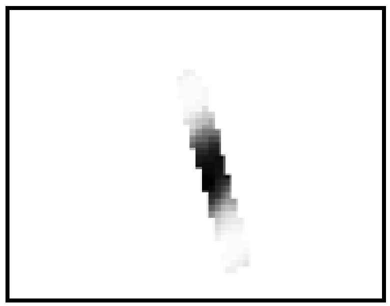


- Feature Vector: merged histograms of all points in a patch and in three spatial scales

Example Result

- Toy example: grasping point model trained on pencils
- *Graspability* distribution over picture of pencil





- Model encodes center of mass
- Local maxima in output are grasping points

Evaluation on Synthetic Images

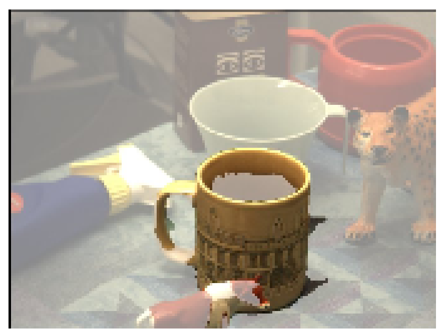
Comparison to appearance based method by Saxena et. al, NIPS 2006

Table 1: Accuracy of the models trained on different objects.

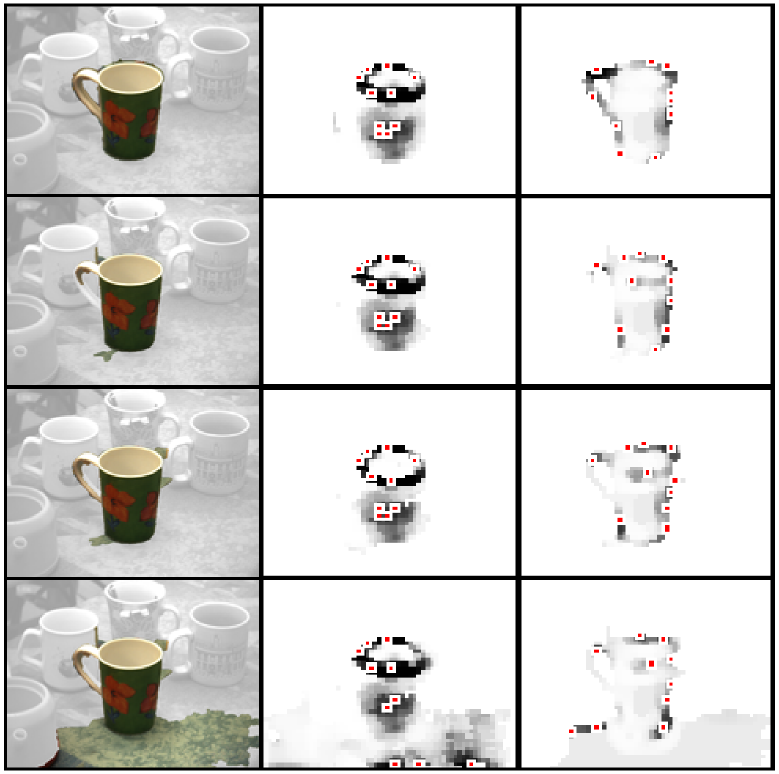
	Shape	Appearance
Pencil	82.55%	77.07%
Cup & Mug	88.01%	83.85%
Pencil, Martini & Eraser	85.65%	74.92%
Pencil & Mug	84.64%	74.32%

Evaluation on Real Images

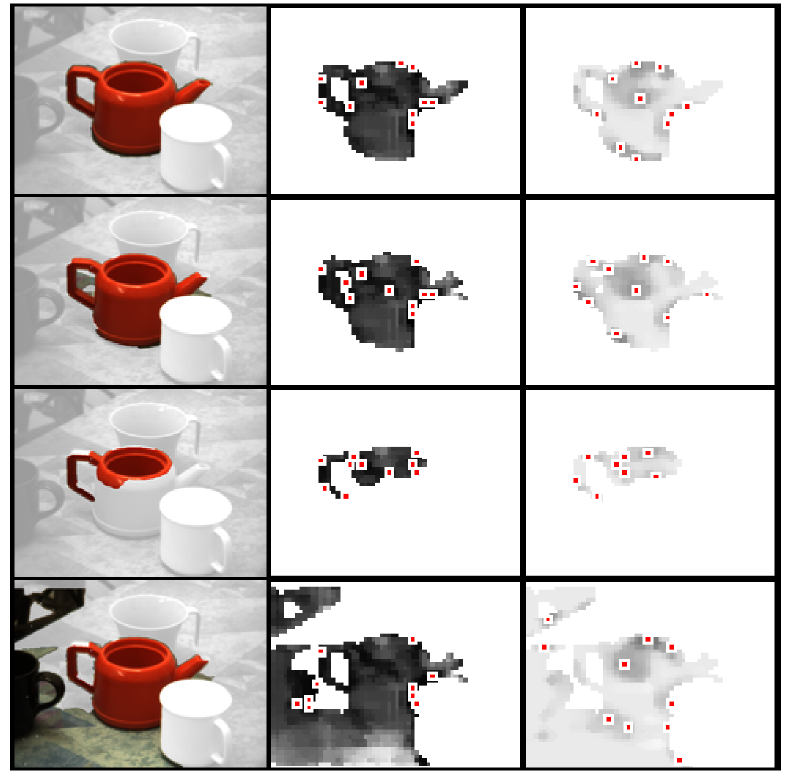
- How does different quality of segmentation affect the selection of grasping points?
- Goal: Grasping points in two images of same object differently segmented should correspond to each other.



Evaluation on Real Images (2)



(a) Textured Cup.



(b) Partly Occluded Teapot

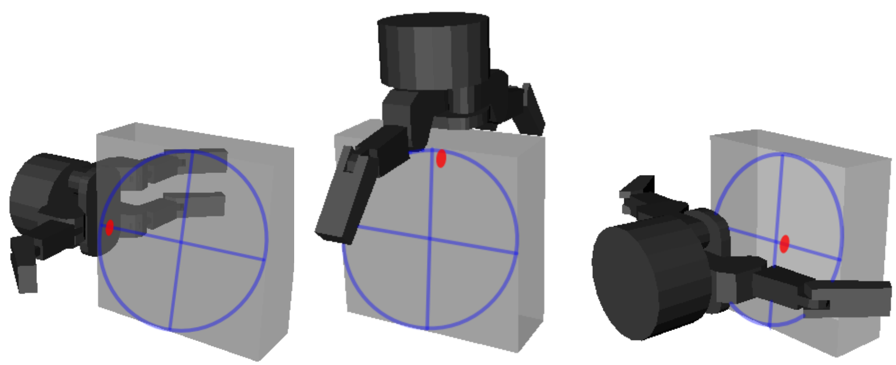
Left: Segmented image, **Middle**: Local Appearance, **Right**: Relative Shape.

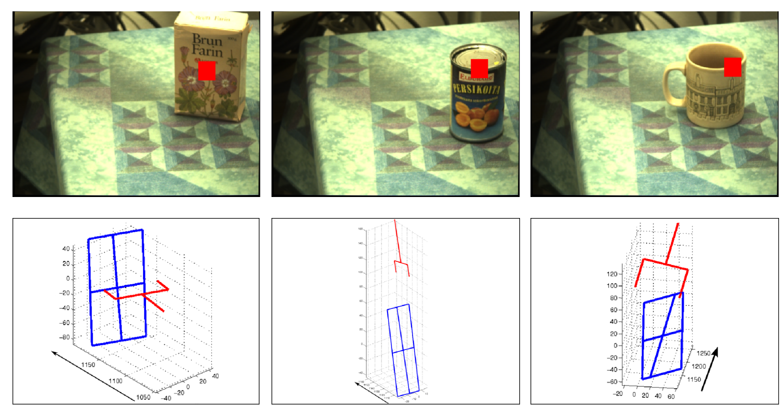
From 2D Grasping Points to 6 DoF Grasp Hypotheses

- Use 2D information as a cue to search for grasp hypothesis in (minimal) 3D reconstruction!

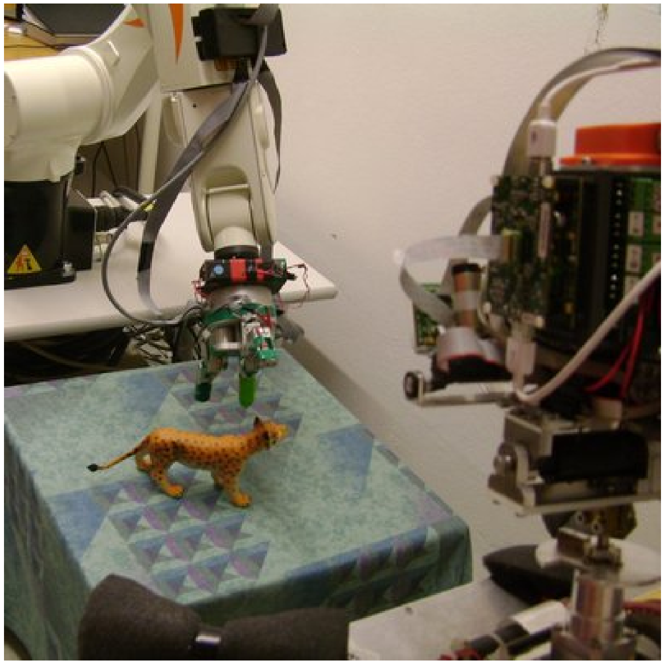
Infer Full Barrett Hand Configuration

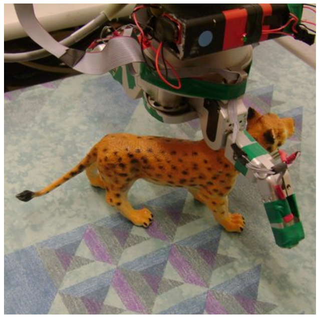
1. 3D Coordinates of Grasping Point through Triangulation
2. Orientation of Barrett Hand
   - object pose approximation through oriented plane
   - hand orientation through grasping position relative to plane

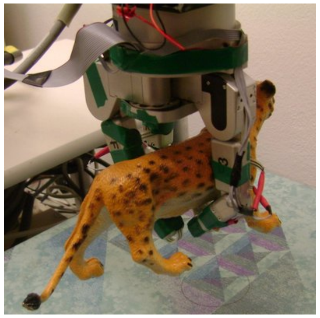


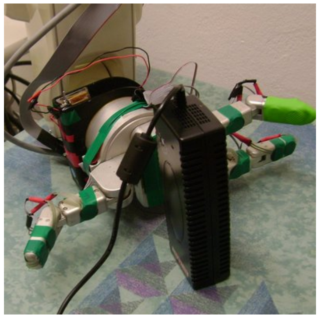


Grasping with the Real System









Conclusions

- 2D object shape provides discriminative features for grasping position
- Based on grasp position within minimal 3D object representation full grasp configuration can be inferred
- Future Work
  - Minimal 3D representation (robust and probabilistic)
  - Integration with tactile grasp controller

Thank you for the Attention!

Questions?

References:

Hübner et al., Selection of Robot Pre-Grasps using Box-Based Shape Approximation, IROS, 2008.
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