VISUAL-HAPTIC INTERACTION FOR ROBOT GRASPING

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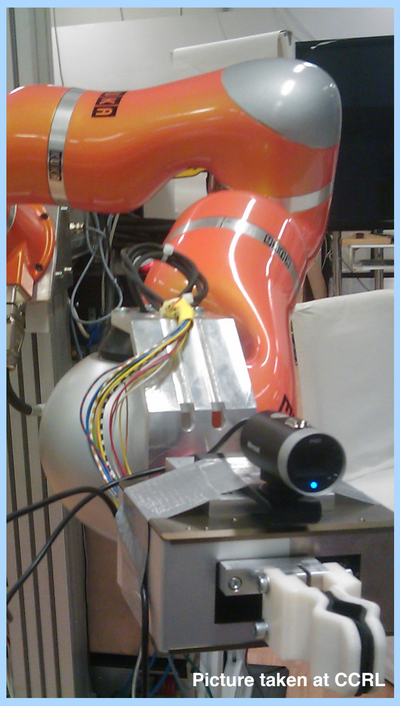
Abstract

Grasping of objects is a fundamental ability for cognitive robotic systems. These systems use vision to detect, locate and reconstruct objects of interest. However, vision can only deliver partial object information and must often be enhanced by haptic data. Using a combined visual-haptic object model, a grasping process adapted to the object can be performed. The goal of this work is to go towards a “Cognitive Grasping System”, which flexibly handles known and new objects.



Overview

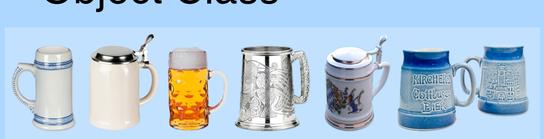
- Grasping is a complex process specific to a certain object
- Adaption of grasping point, pattern and force
- Requirements for a cognitive grasping system
  - Cameras in-hand / head-mounted
  - Reliable (visual) object pose estimation
  - Sophisticated object models
  - Haptic sensors (force, vibration)
  - Control engineering / robot arm
- Fusion of visual and haptic data [5]
  - Vision: Object type, pose
  - Haptics: Weight, elasticity

  ➔ Visual-haptic object representation / model

Visual Object Representation

- Pre-defined object database
- Learning from environment
  - Detection of change in environment
  - Generalization (e.g. different cups)
  - Multi-view: Robot can actively move
- Multi-level representation
  - Texture, Feature Descriptors
  - Contour / Shape [2,3]
  - 3D Model
  - Object Class

Level of Abstraction

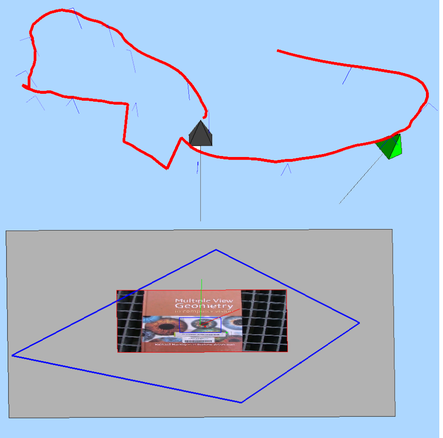


Haptic Representation & Exploration

- Important properties:
  - Weight
  - Elasticity / Deformability
  - Surface Roughness
- Visual data provide priors
- Model supplementation by haptic exploration
  - Carry: Weight measurement
  - Touch: Verify 3D model
  - Slide: Surface structure
  - Squeeze: Deformation model (haptic-haptic / haptic-visual)

Visual Pose Estimation

- Movements of robot arm controlled by object pose
  - E.g. eye-in-hand: Move towards reference view
- Classic Visual Servoing Techniques
  - Image based (2D)
  - Homography based (“2½D”) [1,4]
  - Position based (3D)
- Pose from higher-level representations
  - Pose from contours
  - Pose from class-level
  - Only inaccurate estimation



Grasping Process

- Move towards object location / pose
- Find grasping point or area (from 3D model)
- Adopt grasping pattern (multi-finger hand)
- Adjust grasping force
- Verify save grip (deformation, force feedback)
- Adaptation to object crucial:

References:

[1] N. Alt, S. Hinterstoisser and N. Navab. Rapid Selection of Reliable Templates for Visual Tracking. *CVPR 2010.*

[2] T.F. Cootes, C.J. Taylor, D.H. Cooper and J. Graham. Active shape models – their training and application. *CVIU*, vol. 61, 1995.

[3] V. Ferrari, T. Tuytelaars and L. Van Gool. Object Detection by Contour Segment Networks. *ECCV 2006*.

[4] E. Malis, F. Chaumette and S. Boudet. 2½ D visual servoing. *IEEE Trans Robot Autom*, vol. 15, 1999.

[5] M. Prats, P.J. Sanz and A.P. del Pobil. Vision-tactile-force integration and robot physical interaction. *ICRA 2009.*

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