Extraction of grasp-related features by human dual-hand object exploration

Krzysztof Charusta, Dimitar Dimitrov, Achim J. Lilienthal and Boyko Iliev

Center of Applied Autonomous Systems (AASS)
Department of Technology, Örebro University, Sweden
Introduction
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Motivation

- Overcome drawbacks of vision/scanning based methods
  - object recognition/localization is compromised if visual clues are absent
- Utilize benefits of Programming by demonstration
  - “Human Touch” in object exploration
- Extract intrinsic properties of the object
  - mass center
- We try to capture features that contain “intuitive knowledge” about the object.
Experimental Setup
Setup

- Motion Capture System
Setup

- Motion Capture System
  - Set of stereo cameras
Setup

- Motion Capture System
  - Set of stereo cameras
  - Gloves
Setup

- Motion Capture System
  - Set of stereo cameras
  - Gloves

- System output:
Setup

- Motion Capture System
  - Set of stereo cameras
  - Gloves

- System output:
  - Visible LEDs' 3D position
**Setup**

- Motion Capture System
  - Set of stereo cameras
  - Gloves

- System output:
  - Visible LEDs' 3D position
  - Fingertips contact (binary)
Object exploration
a sequence of fingertip grasps registered by the tactile sensors and the motion capture system
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Output: A Point cloud of all contact points.
It is a sequence of fingertip grasps registered by the tactile sensors and the motion capture system.

Assumption: Hand is treated as a rigid body.
Accuracy improvements

- Two major problems:
  - LED position reading is inaccurate
    Because of the skin softness.
  - LEDs might be occluded.
    Used system is vision based.
Accuracy improvements

- Improvements:
  - Take average of a few frames
Accuracy improvements

- Improvement:
  - Take average of a few frames
Features of an object
Features

Graspable regions

• Based on geometric criteria
• Segmentation of an object

Approach vectors

• Human-like approach direction
Features

**Graspable regions**
- Based on geometric criteria
- Segmentation of an object

**Approach vectors**
- Human-like approach direction

For every Approach vector in a Graspable region let us generate:
Features

Graspable regions

• Based on geometric criteria
• Segmentation of an object

Approach vectors

• Human-like approach direction

For every Approach vector in a Graspable region let us generate:

• It's grasp oriented
• Easily graspable
• Any other primitive can be used
To segment collected grasps we find criteria:

- Grasp Direction
- Grasp Center
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- Grasp Direction
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To segment collected grasps we find criteria:

- Grasp Direction
- Grasp Center
Feature extraction – graspable regions

To segment collected grasps we find criteria:

- Grasp Direction
- Grasp Center
To segment collected grasps we find criteria:
- Grasp Direction $D_i$
- Grasp Center $c_i$

Unsupervised clustering based on:
1. Cosine distance between Grasp Directions
2. Cartesian distance between Grasp Centers
Feature extraction – approach vectors

- Approach vectors
Feature extraction – approach vectors

Approach vectors
Feature extraction – approach vectors

- Approach vectors

![Diagram showing approach vectors and their relationships with distinct points and lines.](image-url)
Feature extraction – GOBB

- Collected points
- Grasp centers $c_i$
- Middle hand point $a_i$
- Approach vectors $i$
Feature extraction – GOBB

- Collected points
- Grasp centers
- Grasp centers $c_i$
- Middle hand point $a_i$
- Approach vectors $i$
Feature extraction – GOBB

- Collected points
- Grasp centers
- Grasp centers $c_i$
- Middle hand point $a_i$
- Approach vectors $\mathbf{v}_1$, $\mathbf{v}_2$
Feature extraction – GOBB

- Collected points
- Grasp centers
- Grasp centers $c_i$
- Middle hand point $a_i$
- Approach vectors $i$
Feature extraction – GOBB

- Collected points
- Grasp centers
- Grasp centers $c_i$
- Middle hand point $a_i$
- Approach vectors $i$
Explored objects

Experimental results
Explored objects I

- Cluster I
- Cluster II
- Unclustered
- Approach vectors
Explored objects II

- Cluster I
- Cluster II
- Unclustered
- Approach vectors
Explored objects III

- Cluster I
- Unclustered
- Approach vectors
Conclusions & future work
Conclusions & Future work

- This is “human touch” in object exploration.
- Dual hand exploration, convenient for human operator.
- We don't neglect vision solutions but present complementary method.

- System's precision evaluation
- Grasping tests