Grasp planning with anthropomorphic gripper

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Technical Aspects of Multimodal Systems

Outline

1. Motivation

2. Anthropomorphic gripper
   Shadow Dexterous Hand

3. Definition grasp
   What is a grasp?

4. Approaches
   Grasplt!
   Standard grasp
   Teleoperating grasp learning

5. Conclusion
Human hands can handle several problems
Service robots interact with human environment
One gripper for all common tasks
Anthropomorphic gripper

Anthropomorphic $\approx$ human like

Anthropomorphic gripper characteristics:
- Similar mechanical structure like human hand
- Two or more fingers
- Each finger with two or three phalanxes

www.schunk.com  
www.popsci.com  
www.robotiq.com
Shadow Dexterous Hand

- 24 Degrees of Freedom
- Human size
- Open platform
- Optional BioTac (20 DoF)

https://www.shadowrobot.com/products/dexterous-hand/
A grasp needs at least two oppositional forces that are applied on the object.

What is a "good" grasp?

- Stable hold
- Satisfy object constraints
- Object should not be deformed

→ Grasp like a human?

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1 https://en.oxforddictionaries.com/definition/grasp
Approaches

A grasp can be computed:
- Compute contact points
- Apply inverse kinematics for gripper and manipulator
- Evaluate forces and torques with friction cone

A standard grasp can be learned:
- Record human grasping objects
- Evaluate the grasps
- Build a database of standard grasps
→ More human like than computed grasps

Y. Jonetzko
Two stages:

- Find grasping points on the surface of the object
- Match points with fingertips and compute the inverse kinematics

Then try this from any direction and use the best grasp.

Problems:

- Object geometry needs to be known
- Imprecise visual location
- No real time computation for the whole manipulator
Friction cone

Gripper exerts forces and torques through contact points. For a stable grasp, all external forces and torques need to be balanced.

Friction cones contain:

- Forces (3 Dimensions)
- Torques (3 Dimensions)

→ Build wrench space

Grasplt! [MA04]
Friction cone - example

Successful grasp:

▶ Applied forces inside of the friction cones
▶ Quality of grasp depends on the sum of forces and torques

Problems:

▶ Soft fingers or objects
▶ Worst case: maximum finger force
▶ Deformation of the object
http://www.cs.columbia.edu/%7Eallen/EH08.wmv
Humans grasp series of objects:

- Record grasps
- Define standard grasps
- Build database of successful tested grasps
- For new unknown objects, try to find a similar from database
Standard grasp

two finger pinch grasp

two finger precision grasp

all finger precision grasp

power grasp

[RHSR07]
The complete grasping process is divided in 6 phases:

1. Chose standard grasp for unknown object
2. Move manipulator in pre-grasp posture
3. Move to target-pose position
4. Apply target-pose
5. Wait till forces are sufficient (stable grasp)
6. Move to post-grasp position
Grasp strategy

Pre-grasp posture:

- Position near the object, approach distance
- Hand is "open"
- Cartesian collision free movement to the object
- "Simple" plan to the pre-grasp position
- The position relative to the object can be improved by visual feedback (from 3cm up to 1mm)
Typical grasp process

https://www.youtube.com/watch?v=mkGp_V0oDvo
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[RHSR07]
Grasp recording while teleoperating the robot (shadow hand):

- Using a CyberGlove 2 for teleoperating
- On series of objects
- Human can compensate calibration errors
- Using precision grasps

The goal was to get a mean grasp and use the variance for in-hand manipulation. And also the reduction of complexity for the grasps.

http://www.cyberglovesystems.com/cyberglove-ii/
Conclusion

▶ Good grasp
  ▶ Stable grasps
  ▶ Forces inside of friction cones

▶ Grasping strategy
  ▶ Computing grasps is to slow
  ▶ Standard grasps
  ▶ 6 phases of grasping
  ▶ Teleoperated grasps
Future work

These ways of grasping solve just small parts from a complex grasping problem.

Potential Research:

▶ Computing human like intuitive grasps
▶ Grasping without pre-grasp posture
▶ Real-time grasping
Precision grasp synergies for dexterous robotic hands.
In *2013 IEEE International Conference on Robotics and Biomimetics (ROBIO)*. Institute of Electrical and Electronics Engineers (IEEE), dec 2013.

Planning optimal grasps.
In *Proceedings 1992 IEEE International Conference on Robotics and Automation*. Institute of Electrical and Electronics Engineers (IEEE).

Grasplt!

Power grasp planning for anthropomorphic robot hands.
In *2012 IEEE International Conference on Robotics and Automation*. Institute of Electrical and Electronics Engineers (IEEE), may 2012.