Grasp planning with anthropomorphic gripper

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Motivation

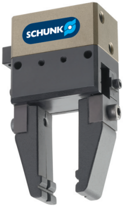
- Human hands can handle several problems
- Service robots interact with human environment
- One gripper for all common tasks

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



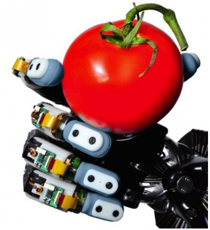
www.schunk.com


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/

What is a grasp?

Oxford dictionary

A firm hold or grip.[1]

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?

[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

Approaches
Compute a grasp

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

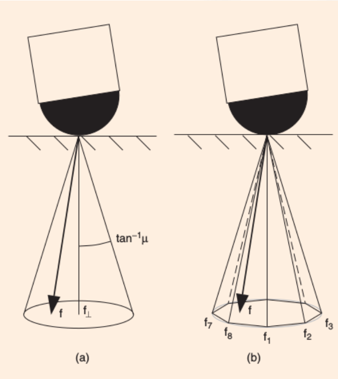
Friction cone

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



GraspIt![MA04]

Friction cone - example

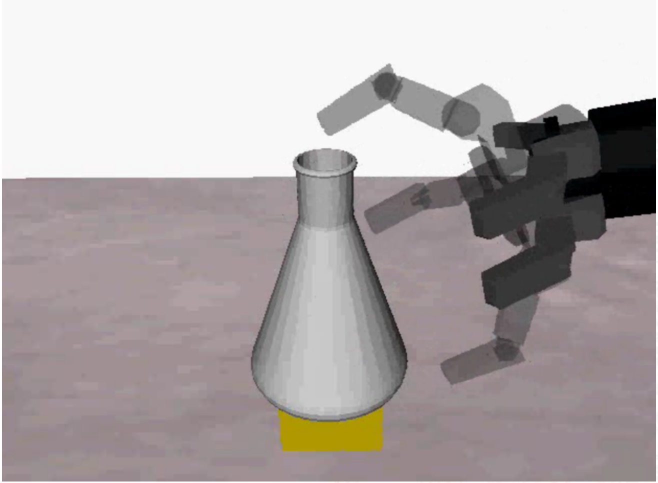
Successful grasp:

- 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

GraspIt!



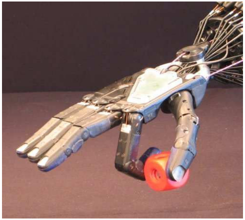
http://www.cs.columbia.edu/%7Eallen/EH08.wmv

Approaches
Learn grasps

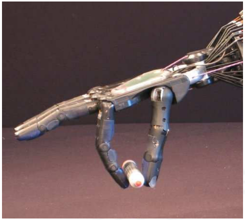
Humans grasp series of objects:

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

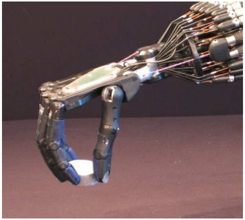
Standard grasp



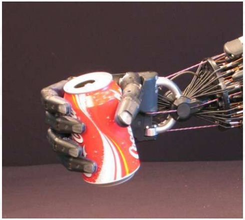
two finger pinch grasp



two finger precision grasp



all finger precision grasp



power grasp

[RHSR07]

Grasp strategy

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

Success-rate

no.	name	grasp type	TUM Hand before & after optimization		Shadow Hand before & after optimization	
1	adhesive tape	power	10	10	10	10
2	toy propeller	3F spec	10	10	10	10
3	toy cube	2F pinch	10	10	10	10
4	can	power	10	10	10	10
5	tissue pack	power	10	10	10	10
6	tennis ball	power	10	10	7	10
7	paper ball	power	9	10	10	10
8	sharpener	AF prec	8	10	10	10
9	remote control	power	8	10	10	10
10	cup	power	9	10	10	10
11	board marker	2F prec	7	10	10	10
12	tea light	AF prec	6	10	8	10
13	golf ball	power	7	10	6	9
14	matchbox	AF prec	7	9	6	10
15	light bulb	power	6	10	8	10
16	chocolate bar	AF prec	5	10	10	10
17	folding rule	2F prec	4	10	10	10
18	voltage tester	2F prec	3	9	8	9
19	eraser	2F prec	4	10	9	10
20	bunch of keys	AF prec	0	0	1	2
21	pencil	2F prec	0	0	0	8

[RHSR07]

Teleoperating grasp learning
An approach from the university of Hamburg

Grasp recording while teleoperating the robot (shadow hand):

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

The goal was it 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

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