On Grasp Choice, Grasp Models, and the Design of Hands for Manufacturing Tasks

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Outline

- Motivation
- Background
- Analytical Grasp Modeling
- Human Grasp Selection
- Grasp-Exp
- Discussion

Motivation

- As robots become ubiquitous in society, their ability to perform a variety of tasks will be essential.
- Robots will need to master a variety of grasps for performing these tasks.
- We can start by understanding human grasp selection.

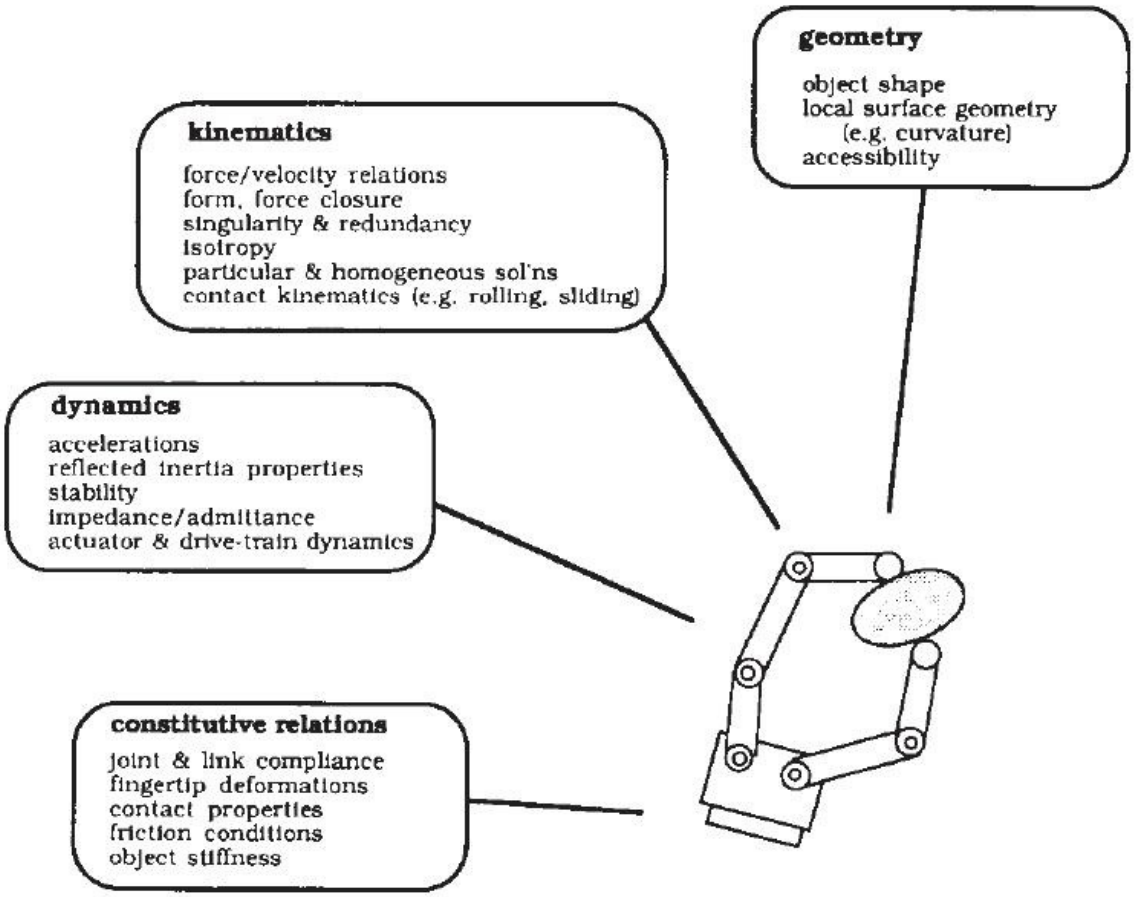
Background

- Robotic hands are growing more complex
- Control hands via a firm understanding of the task to be performed
- By studying human grasps we can discover a large set of the grasps necessary for daily work

Analytical Grasp Modeling

- Earlier work always made various assumptions:
  - Point contact
  - No sliding or rolling of fingertips
  - Static analysis
  - Idealized friction
  - Simplified motor mechanics

Issues in Analytical Grasp Modeling



Analytical Measures

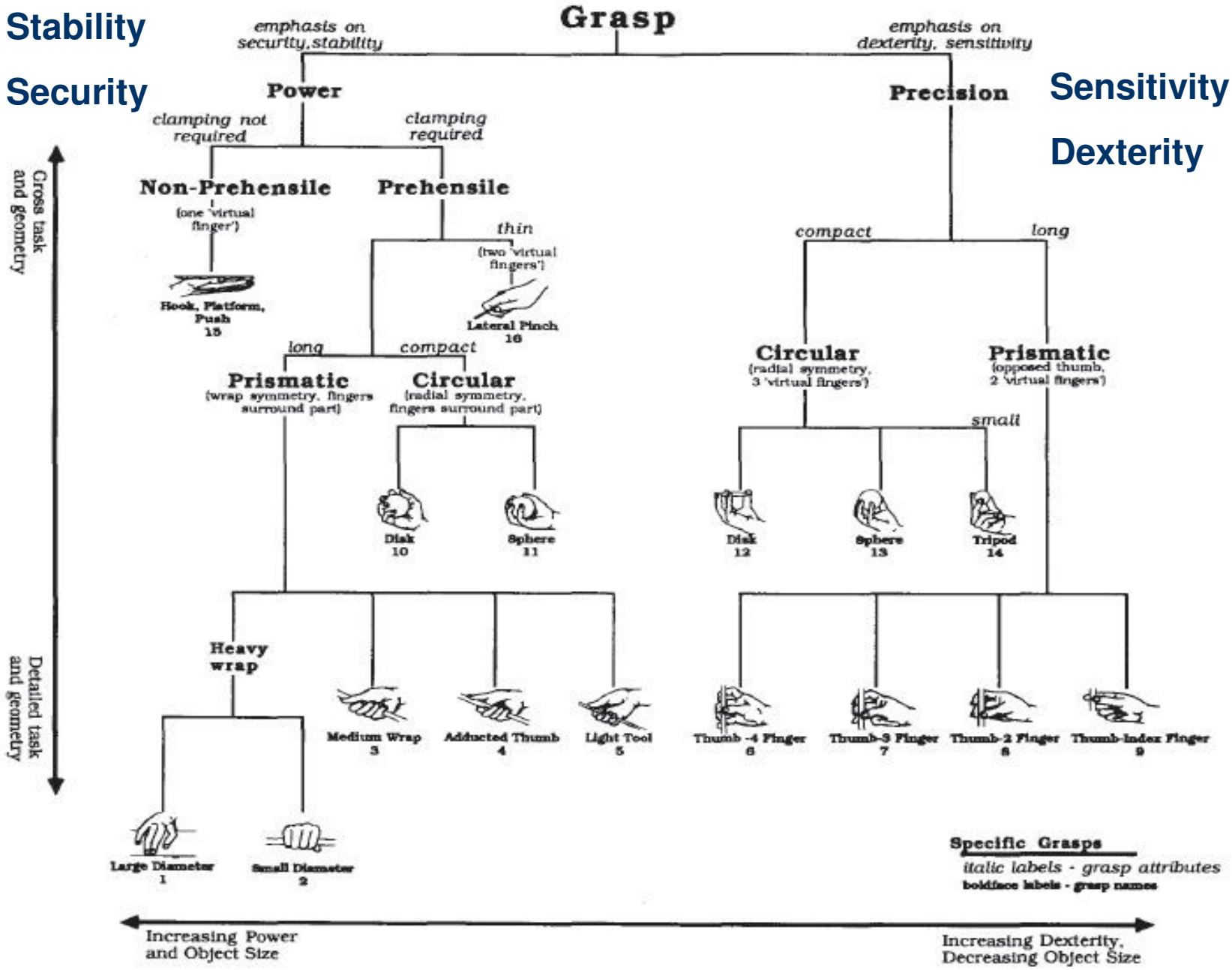
- Compliance
- Connectivity
- Force Closure
- Form Closure
- Grasp Isotropy
- Internal Forces
- Manipulability
- Resitance to Slipping
- Stability

Human Grasp Selection

- Small-batch machining operations
  - Manufacturing grasps
  - Human adaptability allows them to outperform machinery for many tasks
  - Single-handed operations with metal parts and tools
  - Observation and Interviews

Stability

Security



Sensitivity

Dexterity

Grasp-Exp (1)

- At the time of the paper, Grasp-Exp had 50 rules
  - Authors expect 100 would be satisfactory
- Grasp-Exp asks questions to determine grasp needed
  - Will ask further questions for clarification when necessary
- In the end, recommends a grasp and a set of similar grasps

Grasp-Exp (2)

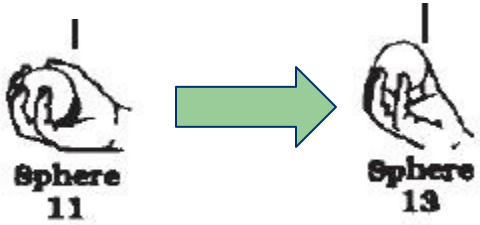
- What is the dexterity requirement?
- What is the stability requirement?
- How important is security in your grasp?
- What is the clamping requirement?
- What is the object-thickness requirement?
- What is the object-size requirement?
- What is the rough-object-shape requirement?
- Which of the following is closest to the shape of the object?

Issues Discovered from Grasp-Exp

- Quantification of “precision”, “dexterity”…
  - Additional questions necessary
- Size terms
  - What is “heavy”, “large”, or “thin”?
  - Relative size more useful
- Vague object descriptions
  - General shapes inadequate
  - Focus on geometry of part being grasped

Sequences of Grasps

- Unscrewing a knob



- Using a tool (e.g. screwdriver)

Video

- Robotic Grasps
- http://www.youtube.com/watch?v=A2dBq0fWCdY

Discussion

- Analytic approaches to grasp choice may not be useful in the real world.
- Human hand has evolved over time for communication etc…, not just factory work. We should be able to outperform the human hand.
- Robotic hand specialization winning out over generality

More Discussion

- This is where we were ten years ago, but how much progress have we really made?

- Learning to Grasp Objects
- http://www.youtube.com/watch?v=mCcTBe3UzRM
- Grasping Unmodeled Objects
- http://www.youtube.com/watch?v=IhnyqMoRbfw

Backup

- Kitchen Robot
- http://www.youtube.com/watch?v=v_Enz3h-xIU