Course Introduction

16-899 Hands: Design and Control for Dexterous Manipulation
Spring 2016

Opening thoughts on robot hands

- We have had high degree of freedom robot hands in humanlike form since the 80's
- There have been many exciting new ideas about hand design throughout the past decades
- Yet we still do not have highly dexterous robots
- Why is this the case?
- What are the gaps?
- How can we close them?

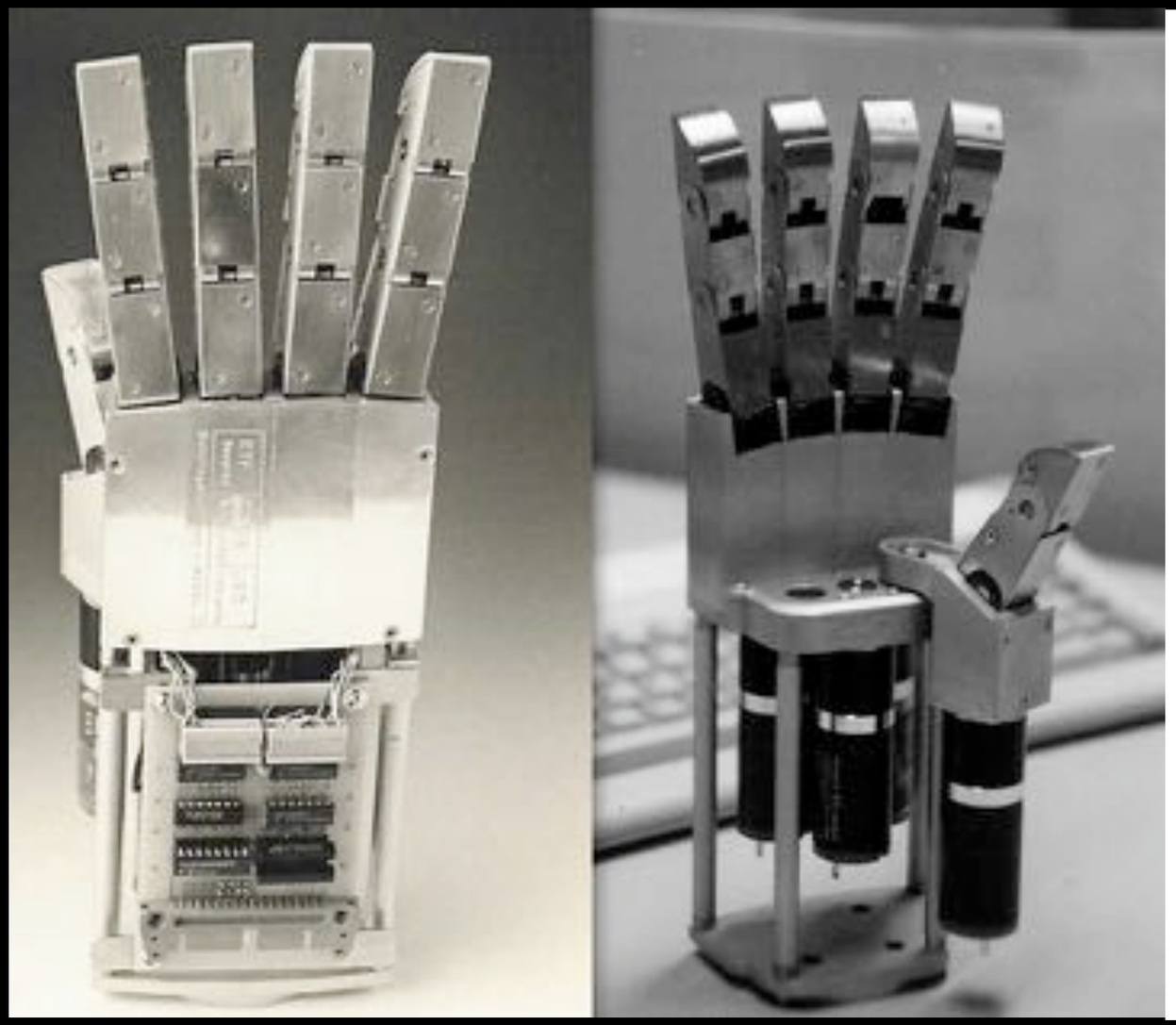
Hands of the 80’s

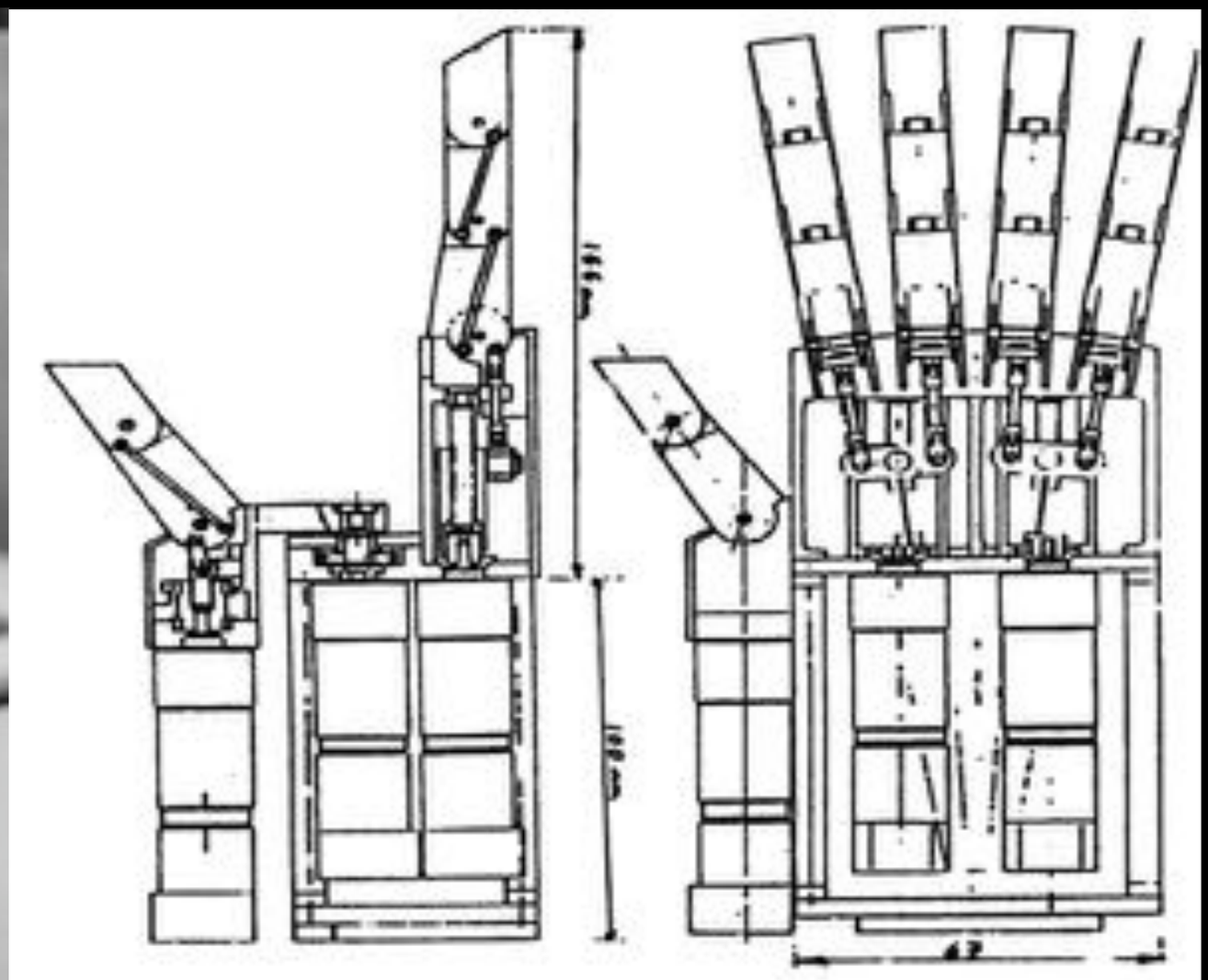
Hirose Soft Gripper (Shigeo Hirose, Tokyo Inst. Technology)

Soft gripper development began in the 70’s
1 DoF
Graduated pulleys at joints create evenly distributed forces

Hands of the 80’s

Belgrade / USC hand (Rajko Tomovic and George Bekey)

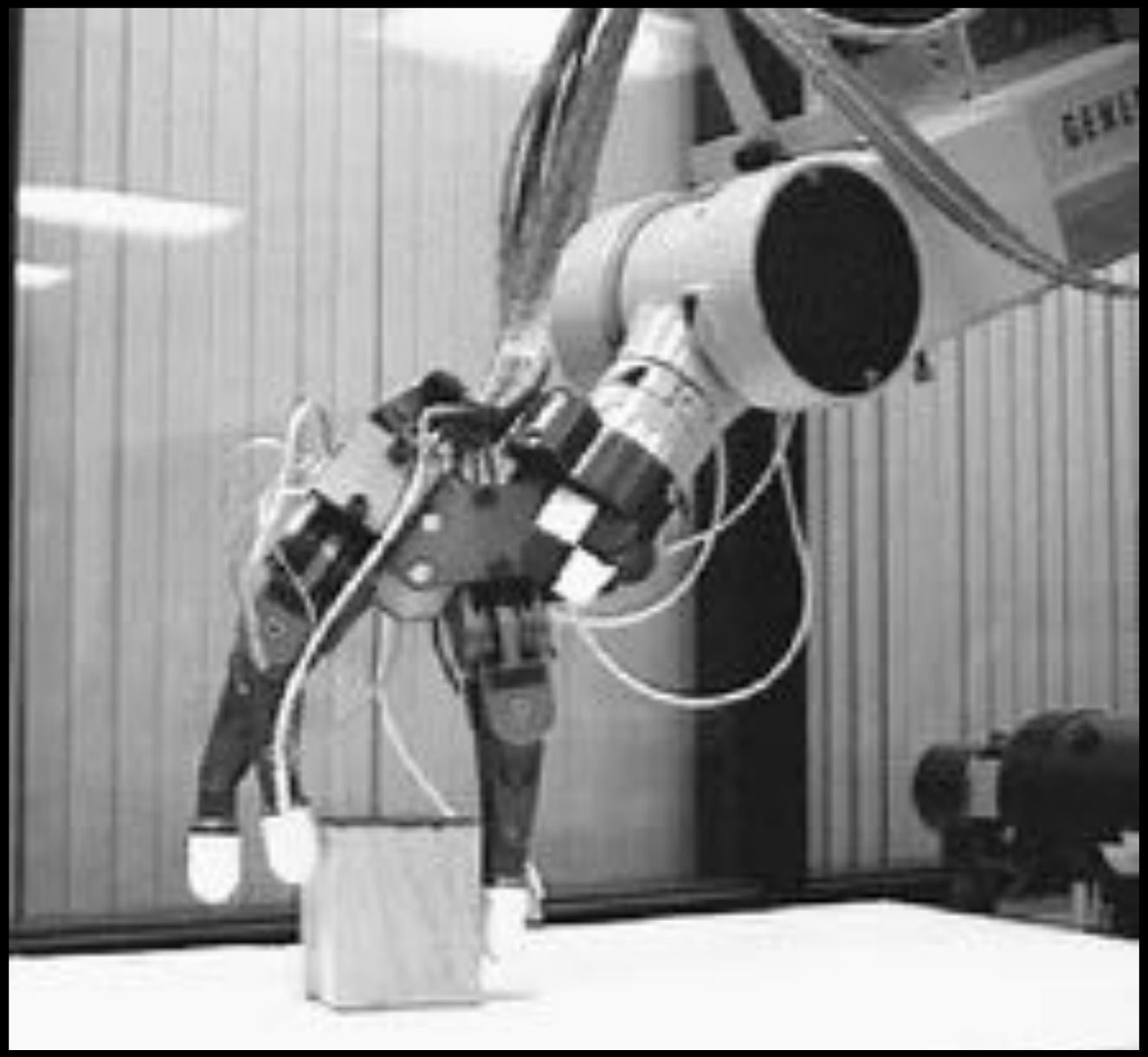


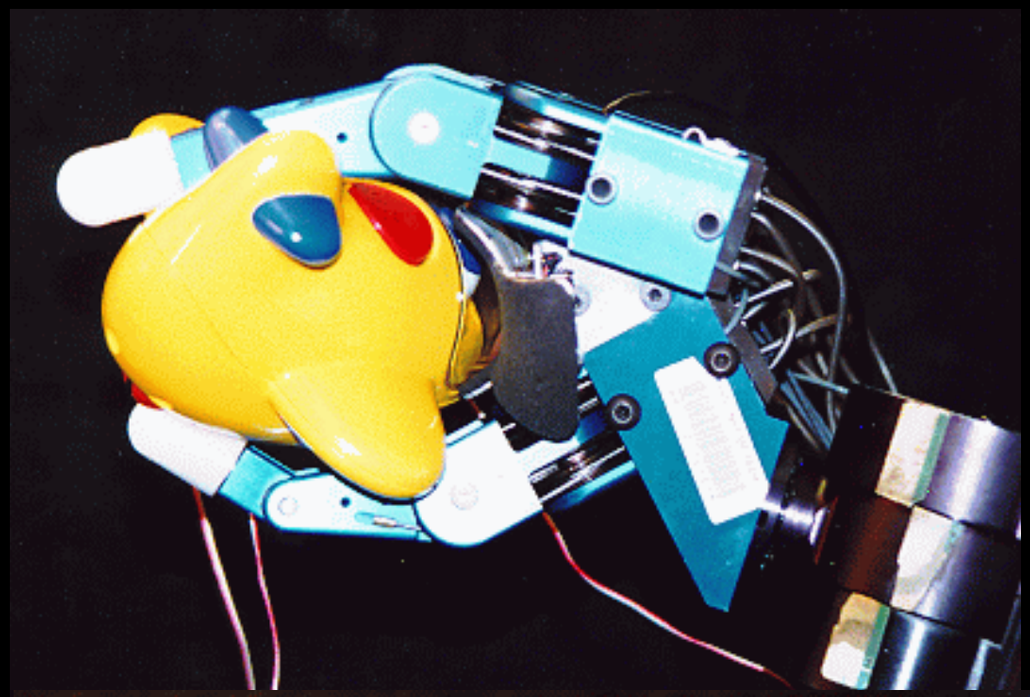


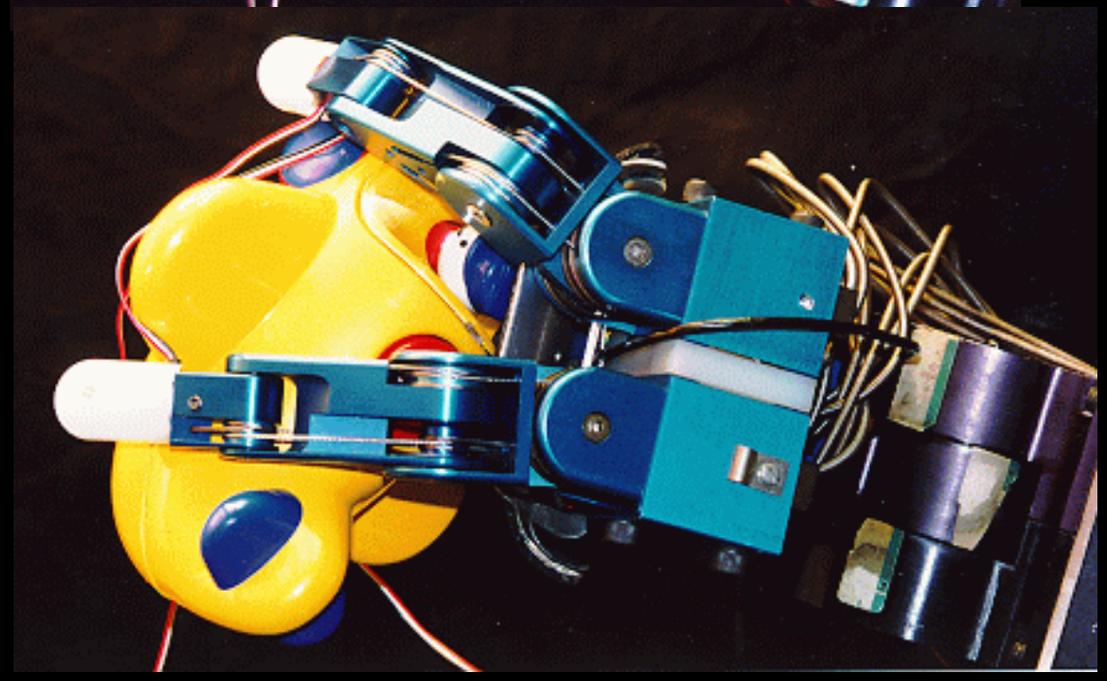
Pioneering effort – development of first prototypes after WWII
4DoF (1 for each pair of fingers, 2 for thumb)
Some adaptability (e.g., flex one finger in a pair if other stalls)

Hands of the 80’s

Stanford / JPL hand







9 DoF, 4 tendons/finger, designed for fingertip manipulation
Strain gauge fingertip sensors

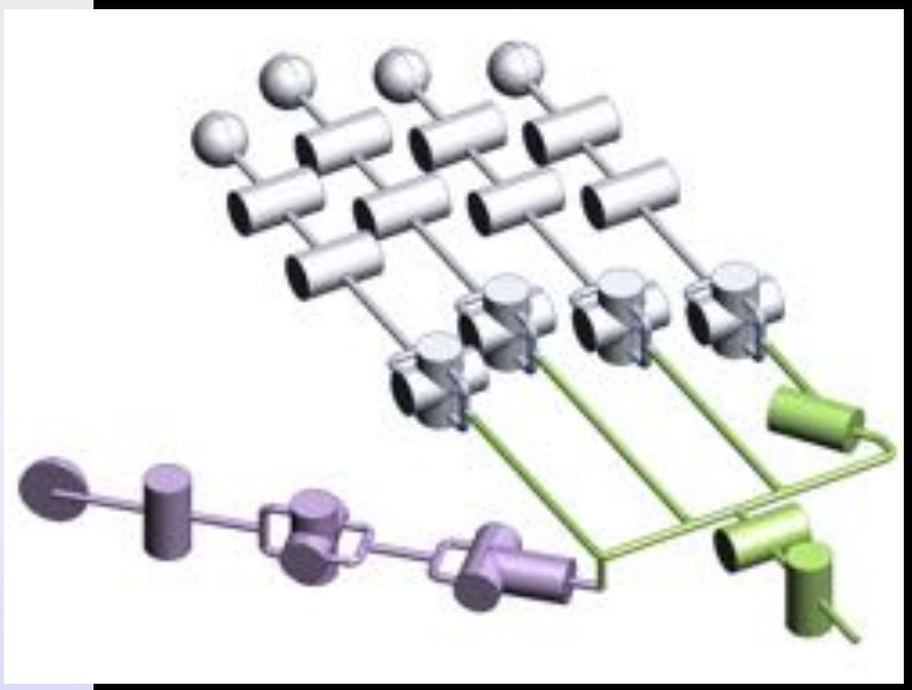
Hands of the 80’s

Utah / MIT hand

16 DoF, 32 tendons
position and tendon tension sensing (Hall effect)
7lb fingertip force (human level)
Complex tendon mounting scheme

Commercial Hands

Shadow hand (Shadow Robot Company)



working on highly backdrivable, low inertia electric motors
(electric artificial muscle)

picked up by British MoD for research into bomb disposal
(e.g., for cutting wires)

Research Hands

ACT Hand (Yoky Matsuoka, University of Washington)

3 fully actuated fingers with human musculoskeletal structure
(redundant actuation)
passive and active dynamics consistent with human hand
goal: study human control of hand movements

Research Hands

SDM hand (Aaron Dollar and Robert Howe, Harvard)

single controlled DoF for 8 joints
compliant joints and fingerpads
shape deposition manufacturing
embedded sensors (hall effect position, optical contact force)
robust, lightweight, inexpensive

Research Hands

Universal Gripper, University of Chicago

The Maker Movement

- 3D printing
- Soft hand technologies
- Anyone can make a hand?

Yale OpenHand Project

YALE OPENHAND PROJECT

Hand Designs

Model T

About · Performance · Build

Based on the original SDM Hand, the Model T is the OpenHand Project's first released hand design, initially introduced at ICRA 2013. the four underactuated fingers are differentially coupled through a floating pulley tree, allowing for equal force output on all finger contacts.

Model T42

About · Performance · Build

A more dexterous alternative to the Model T, the Model T42 incorporates two underactuated, flexure-based fingers, each driven independently by either a Dynamixel or hobby servo. This type of hand has been shown to be adept at both in-hand manipulation and precision grasping.

Model O

About · Performance · Build

Based on our lab's work with iRobot and Harvard on the iHY hand, which won the DARPA ARM program, the Model O replicates the hand topology common to several commercial hands, including ones from Barrett, Robotiq, and Schunk (among others). A commercial version of this hand is currently for sale by Right Hand Robotics.

Model M2

About · Performance · Build

The Multi-Modality (M2) gripper employs a single underactuated finger driven by both agonist and antagonist tendons, as well as a modular thumb that can be swapped out for different tasks. The actuated finger may exhibit either underactuated or fully-actuated behaviors, depending on the actuation scheme. A single-actuator version (Model M) is also available as a minimalist design alternative.

Enabling the Future

http://enablingthefuture.org/upper-limb-prosthetics/

Soft robot hand

Raphael Deimel and Oliver Brock. A Novel Type of Compliant and Underactuated Robotic Hand for Dexterous Grasping. International Journal of Robotics Research 2015 (in print).

However….

- We still do not have fully dexterous robots
- We cannot teleoperate robots seamlessly with full dexterity
- We cannot even portray completely convincing hands in computer graphics

In this class:

- We will study human, robot, and graphical / virtual hands
- Attempt to understand where there are gaps between the dexterity we have and the dexterity we wish for
- Discuss how can we can close these gaps

What do you notice in this video?

1/4 speed (captured at 120fps)

What is needed?

- Sensing
- Hand shape
- Joint limits
- Compliance
- Control (reflexes?)
- Learning
- Design for specific tasks
- Data!
- New teleoperation interfaces

Expectations for this course

- One hour of prereading or independent research per class
- Active participation in discussions etc.
- Grades:
    - 10% Participation / contributions to class
    - 30% One in-class research presentation
    - 60% Final project

Assignment 0

- 3 topic / paper requests to me by Tuesday, Jan 19th (earlier is better!)

Next Time..

- Human grasping — how many grasps are there anyways?