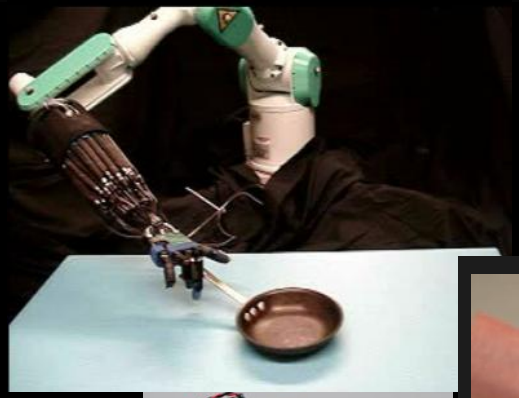
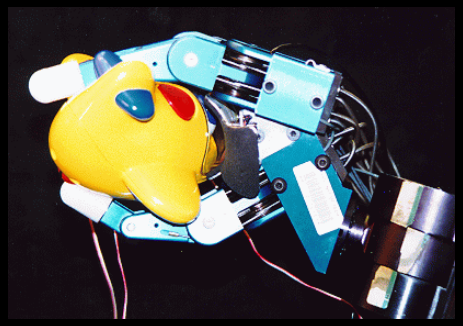
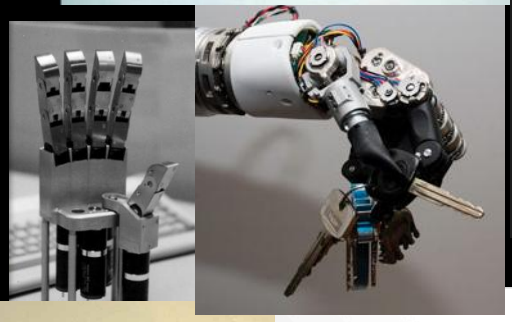
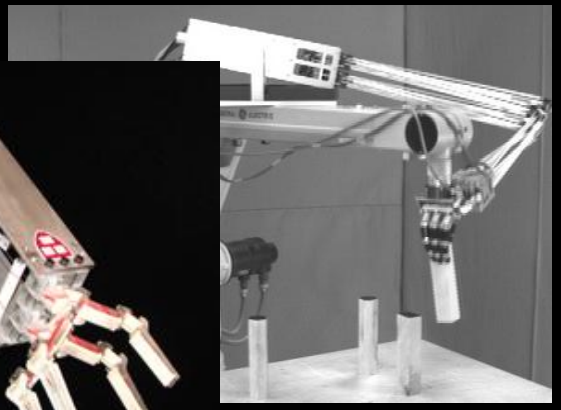
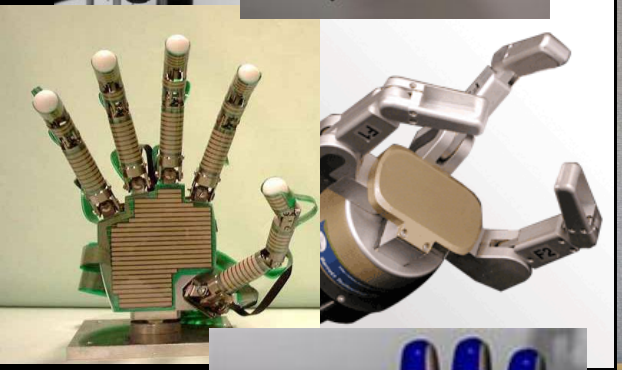
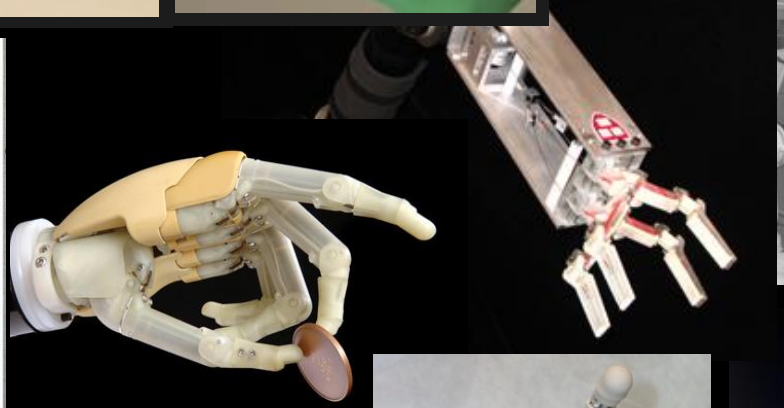
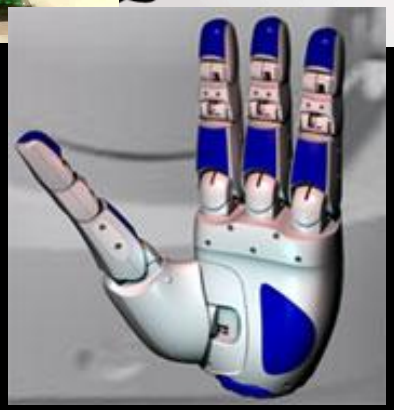
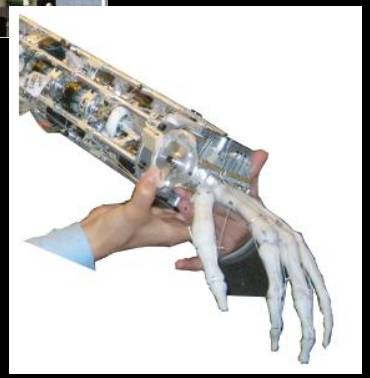
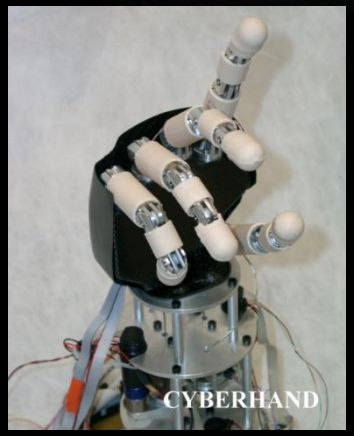
Hands Overview


Outline

- Existing hands
  - Robot hands of the ‘80s
  - Commercial hands
  - Research hands
  - Prosthetics
- Design issues
  - Kinematics
  - Compliance
  - Sensing
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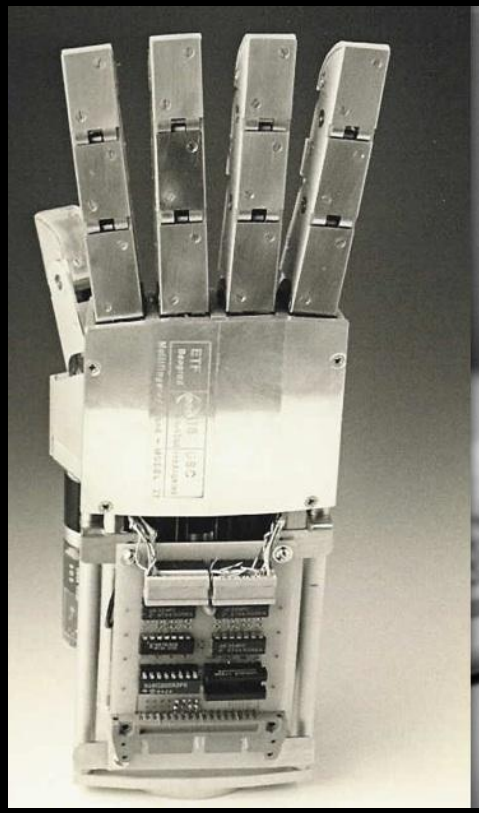
Hands of the 80’s

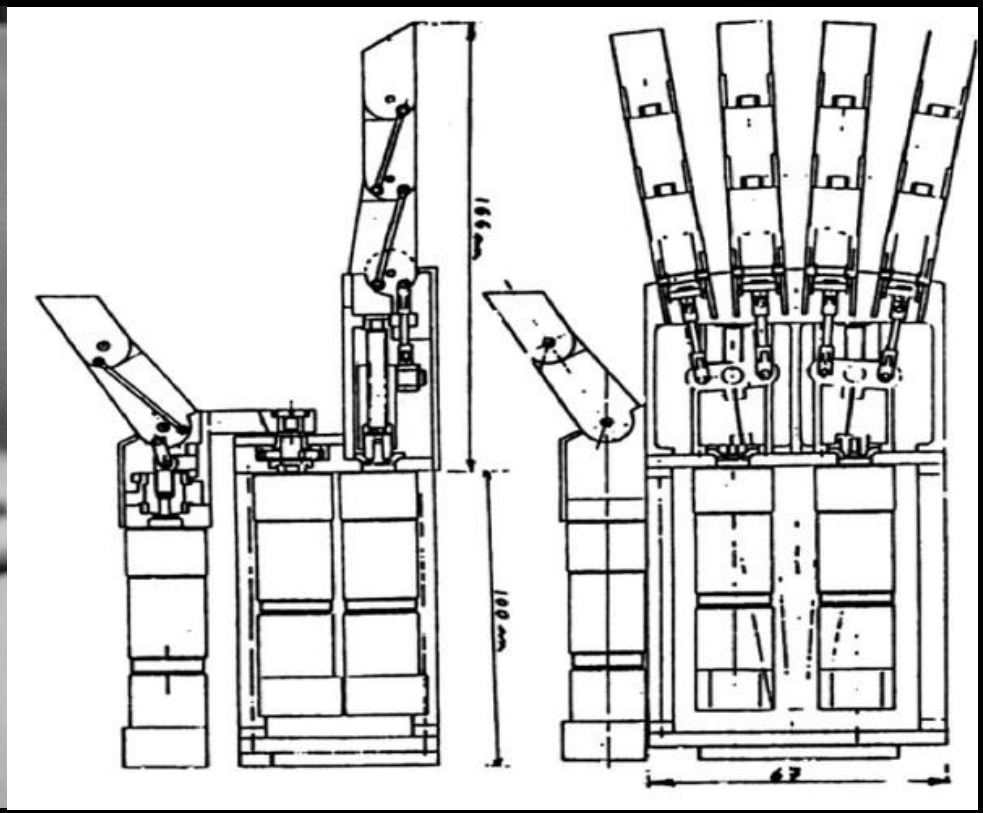
Hirose Soft Gripper (Shigeo Hirose, Tokyo Inst. Technology)

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)

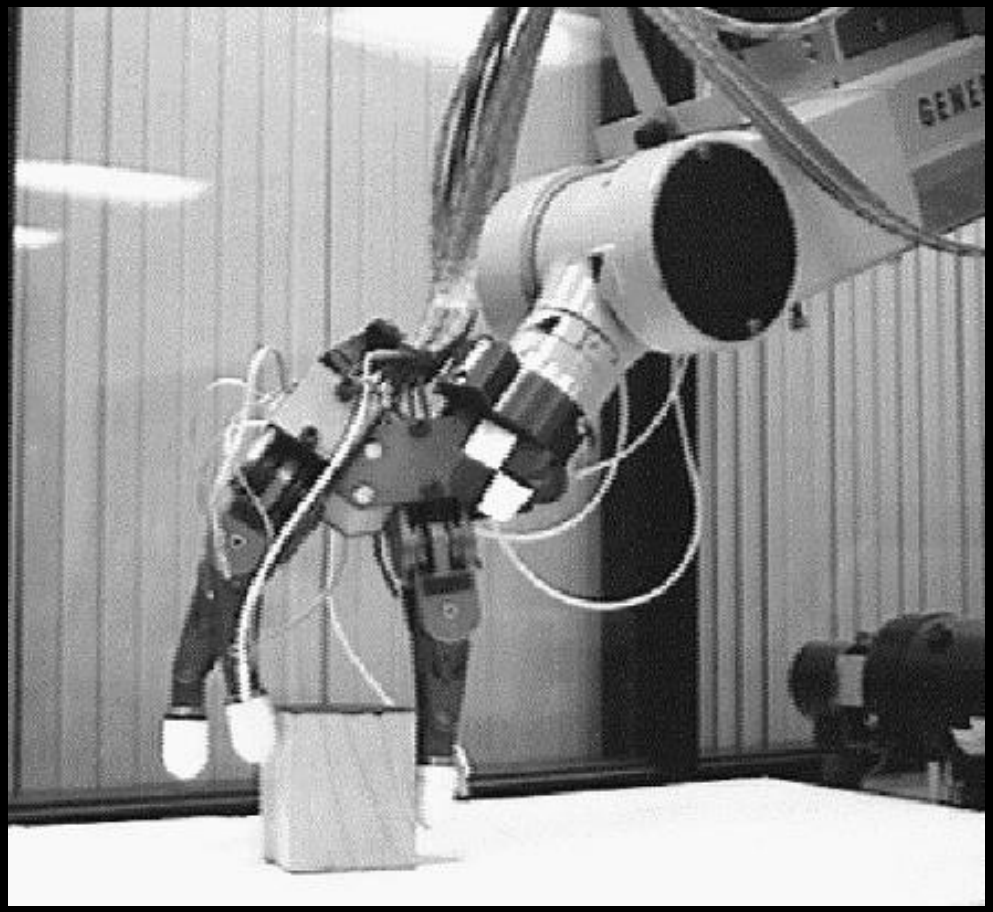


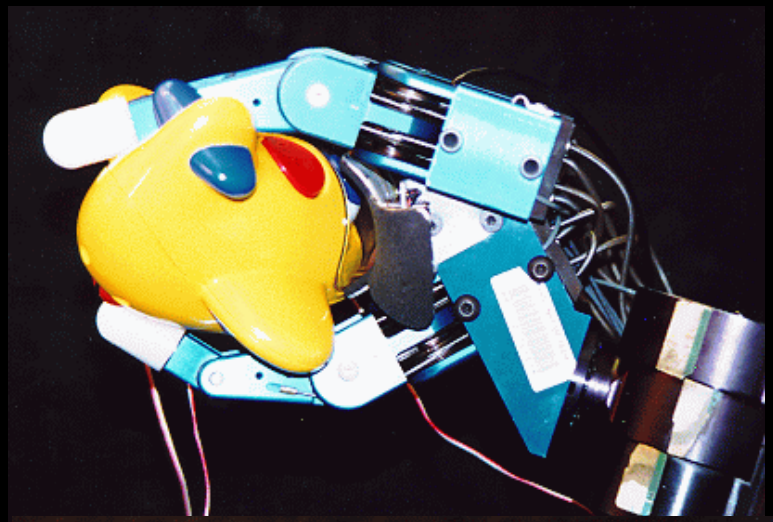


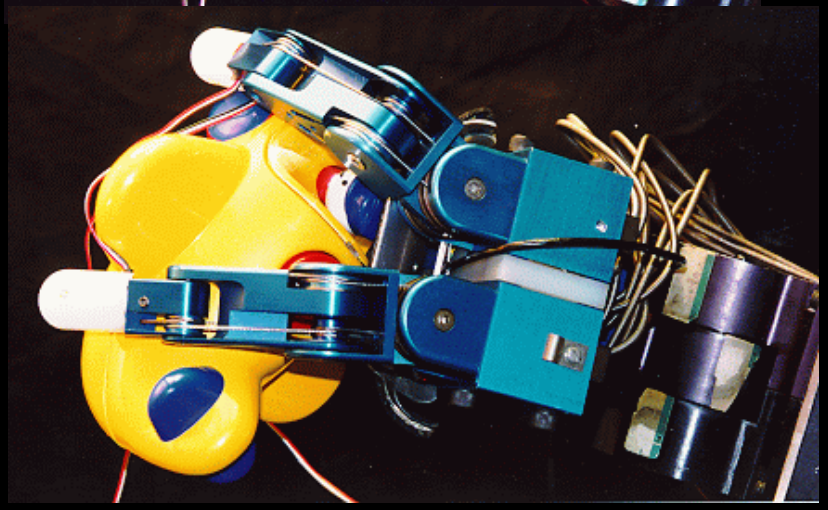
Pioneering effort – development of first prototypes after WWII
4DoF (1 for each pair of fingers, 2 for thumb)
Some adaptability (e.g., flex one finger in a pair if other stalls)

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

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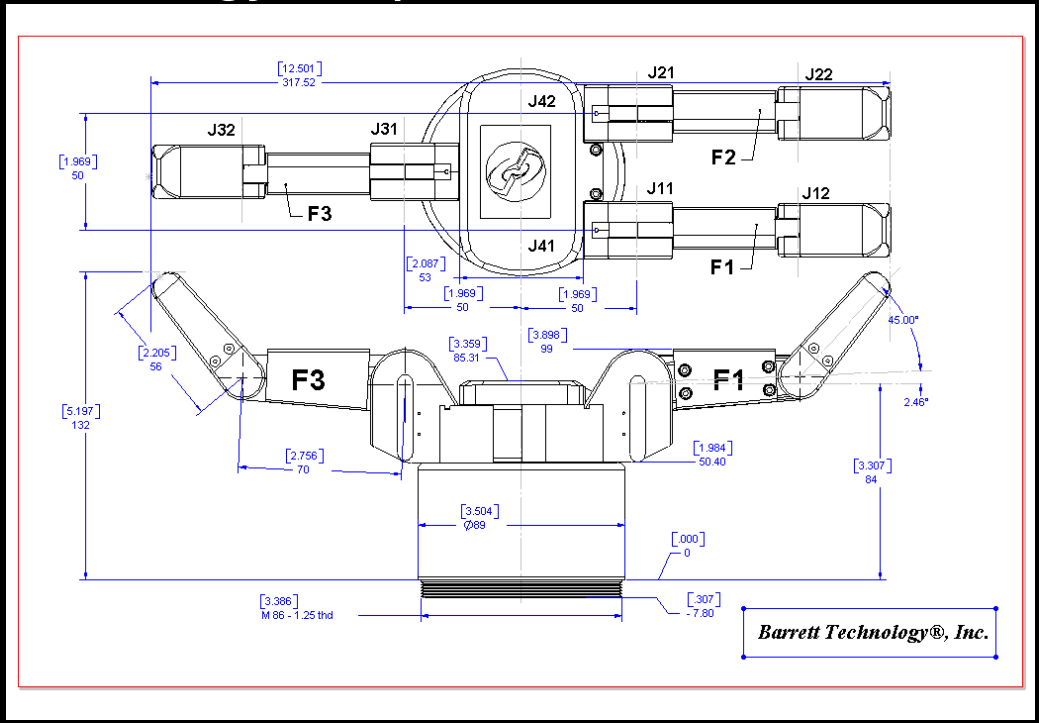
Commercial Hands

Barrett hand (Barrett Technology, Inc)



~$30K

4 motors: 1 per finger plus palm spread

breakaway clutch allows fingers to adapt to object geometry

optical encoder position sensing

3.3lb fingertip force

1.18kg weight

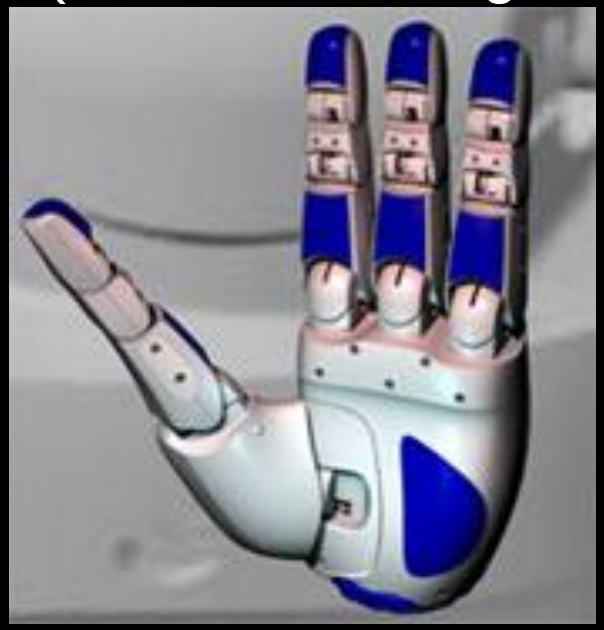
Commercial Hands

Gifu Hand (Kawasaki and Mouri, Gifu Univ. / sold by Dainichi)

~$50K
16 controlled DoF (last two joints coupled except thumb)
pressure sensing, but no accurate position sensing
0.6 lb fingertip force
1.4kg weight
larger than human size

Commercial Hands

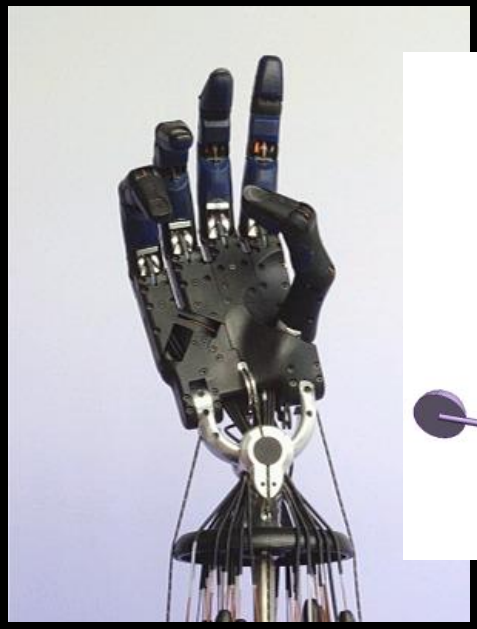
DLR / HIT hand (Gerhard Hirzinger, DLR / sold by Schunk)

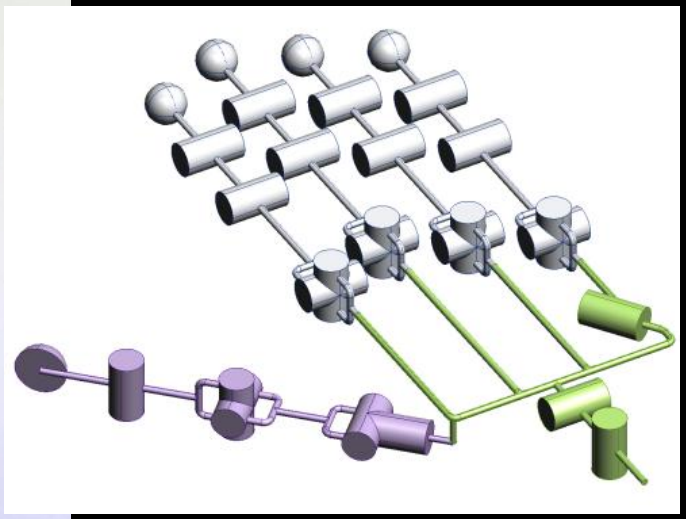


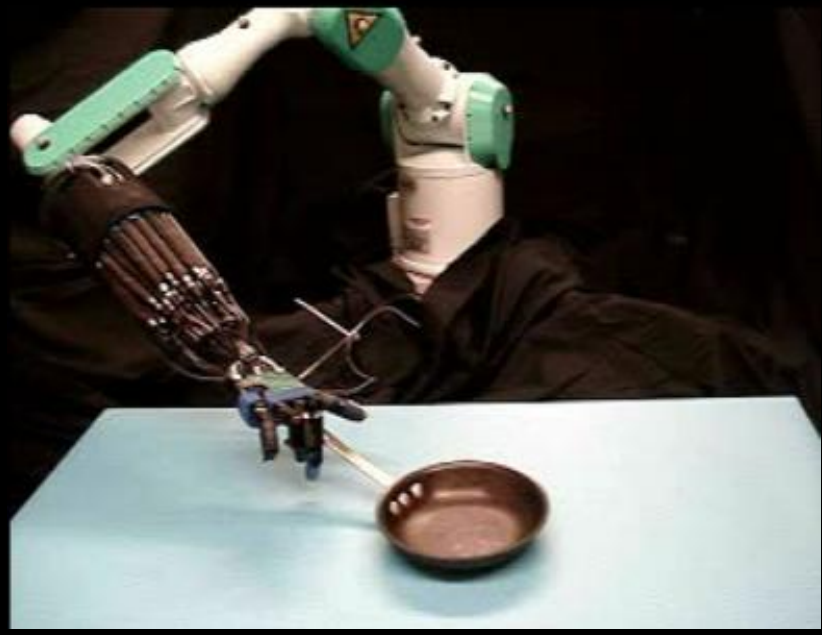
~$60K
13 controlled DoF (last two joints of each finger are coupled)
hall effect position sensors
1.5lb fingertip force
2.2kg weight
larger than human size

Commercial Hands

Shadow hand (Shadow Robot Company)



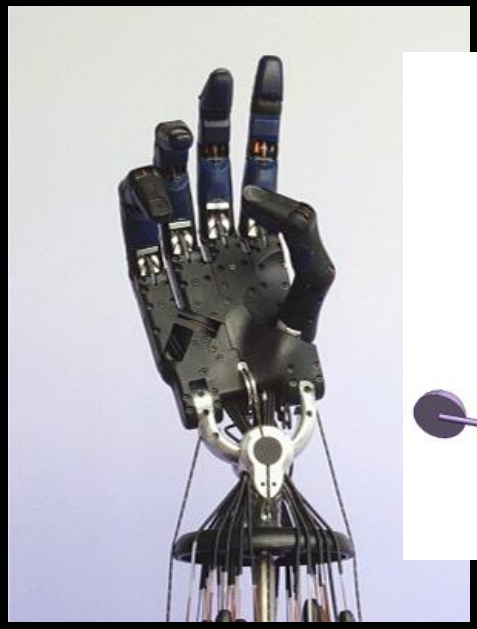


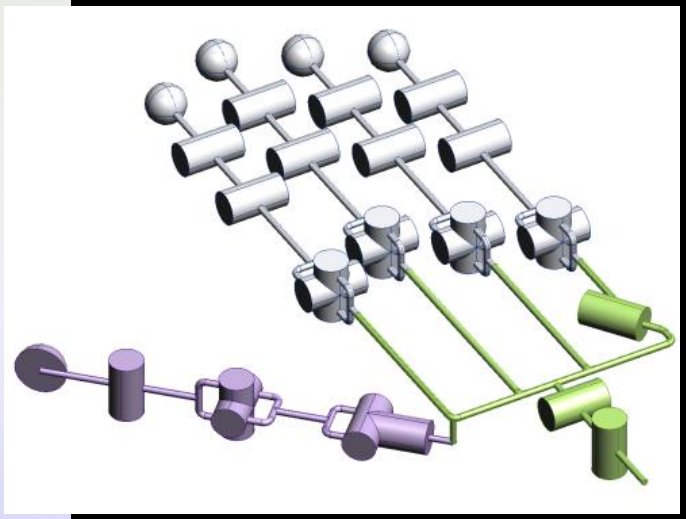


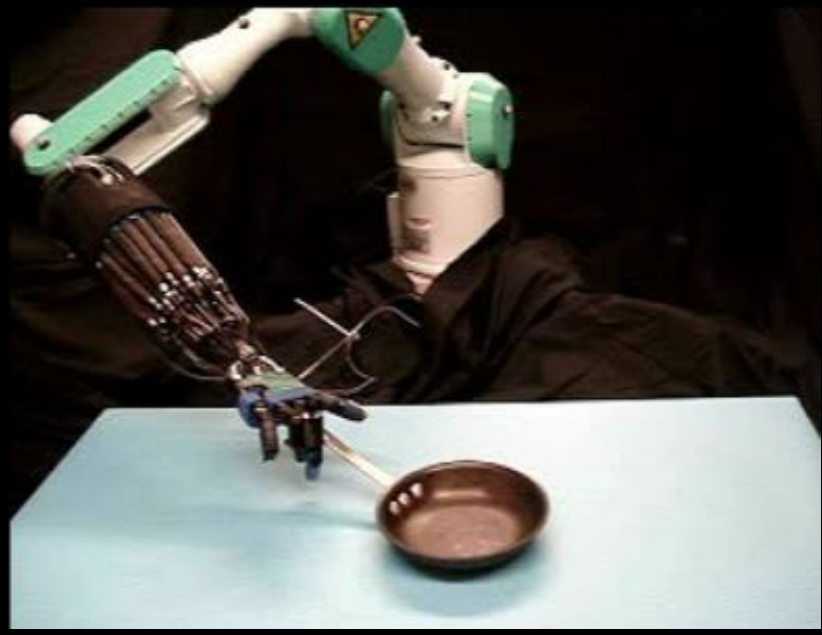
~$100K (~$200K for new motorized version)
20 controlled DoF (last two joints coupled except thumb)
hall effect position sensing, air pressure sensing, tactile array
~1lb fingertip force
3.9kg weight
pneumatic actuators add compliance, wear and control issues

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)

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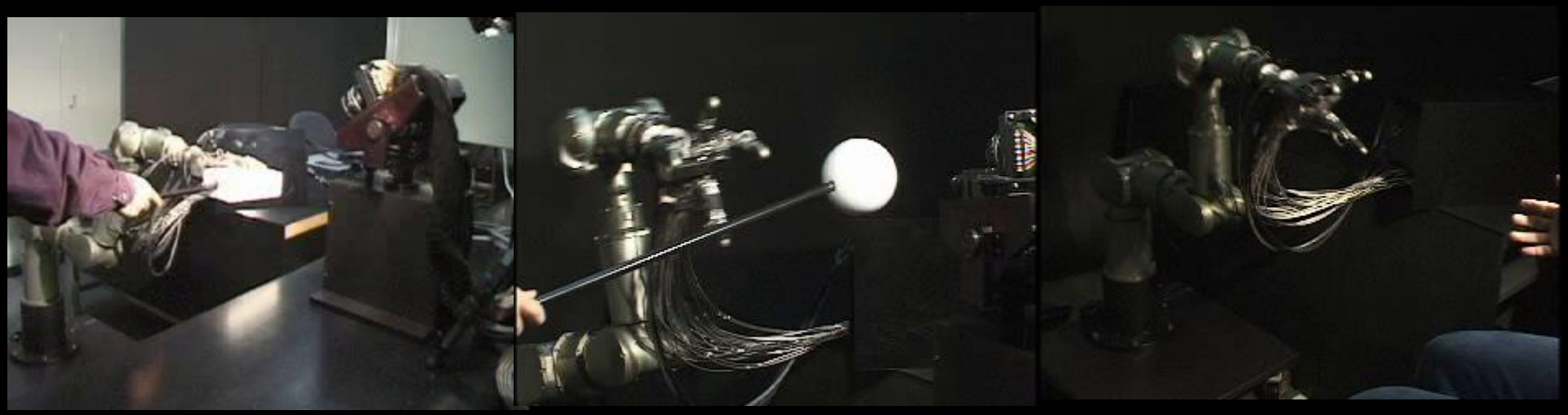
Research Hands

Robonaut hand (Robert Ambrose and colleagues, NASA)

14 controlled DoF (including wrist)
motors in forearm
tactile sensing glove designs with FSR and QTC elements
last two fingers mount at an angle and rotate at CMC joint
successful teleoperation of many complex manipulation tasks

Research Hands

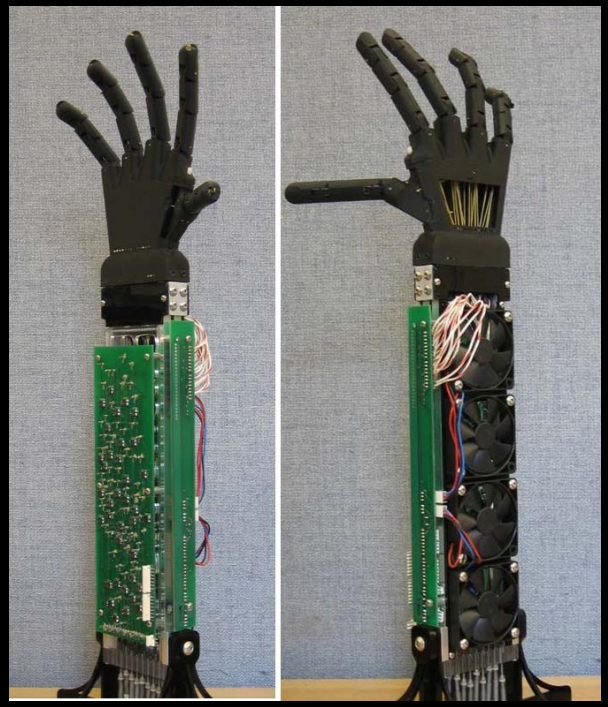
U. Tokyo hand (Akio Namiki, Masatoshi Ishikawa, U. Tokyo)



14 DoF hand
joint force sensors
1ms cycle time for vision based control of entire system

Research Hands

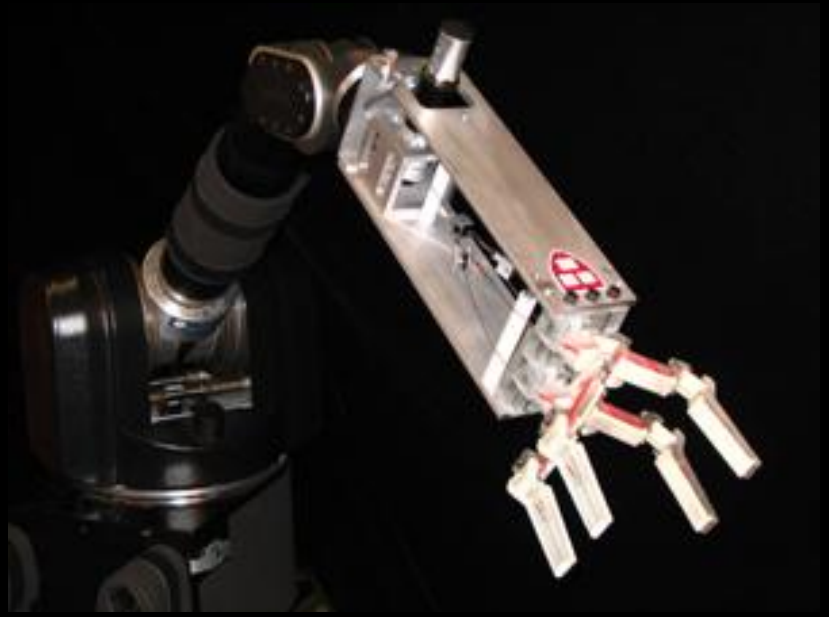
SBC hand (Kyu-Jin Cho and Harry Asada, MIT)

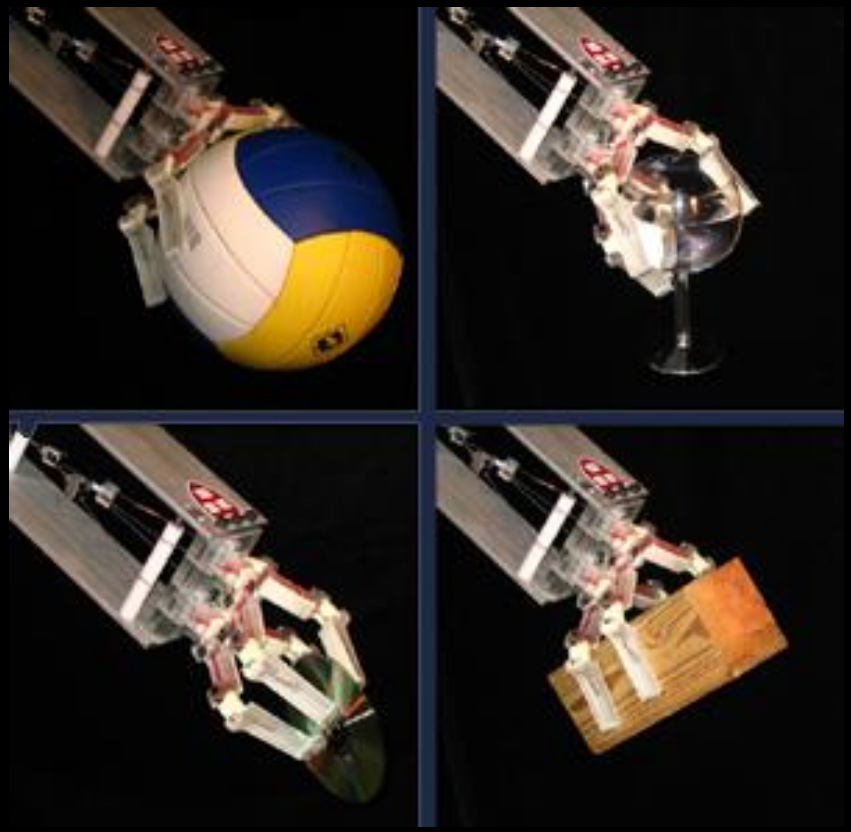


16 controlled DoF, 32 shape memory alloy actuators
segmented binary control to overcome actuator nonlinearities
0.8kg weight
unknown tip force, but force to weight ratio should be high
speed issues, wear issues

Research Hands

SDM hand (Aaron Dollar and Robert Howe, Harvard)

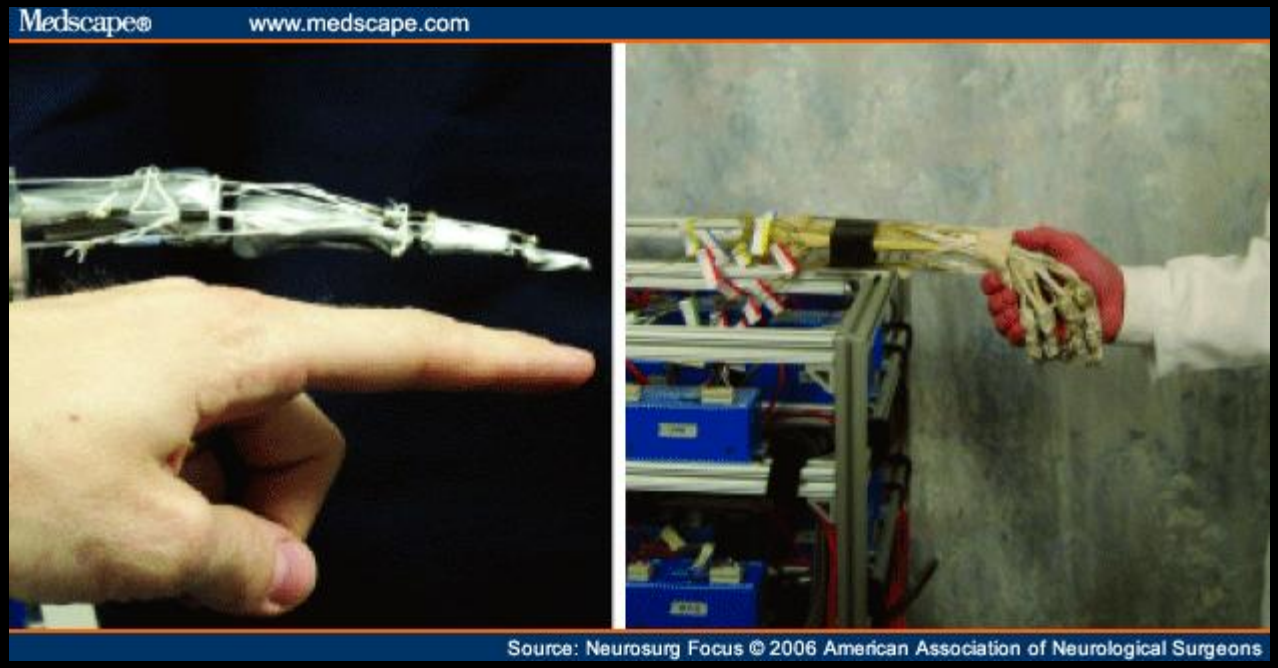


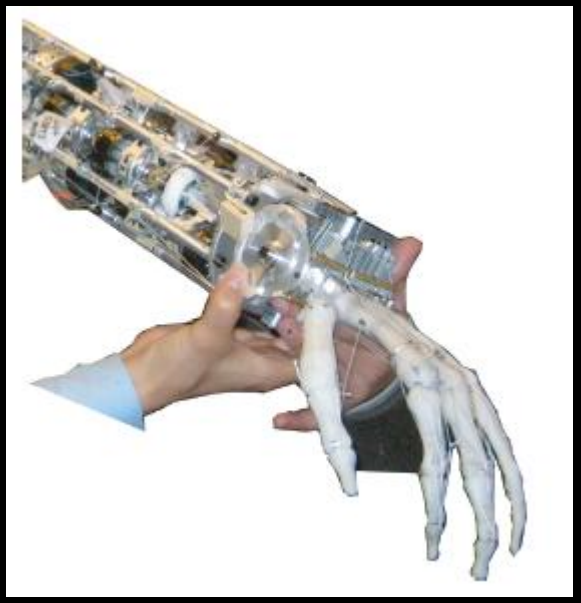


single controlled DoF for 8 joints
compliant joints and fingerpads
shape deposition manufacturing
embedded sensors (hall effect position, optical contact force)
robust, lightweight, inexpensive

Research Hands

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

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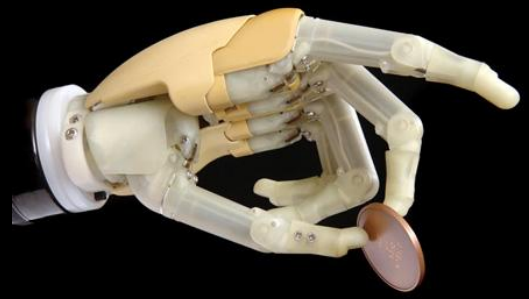
Prosthetic Hands

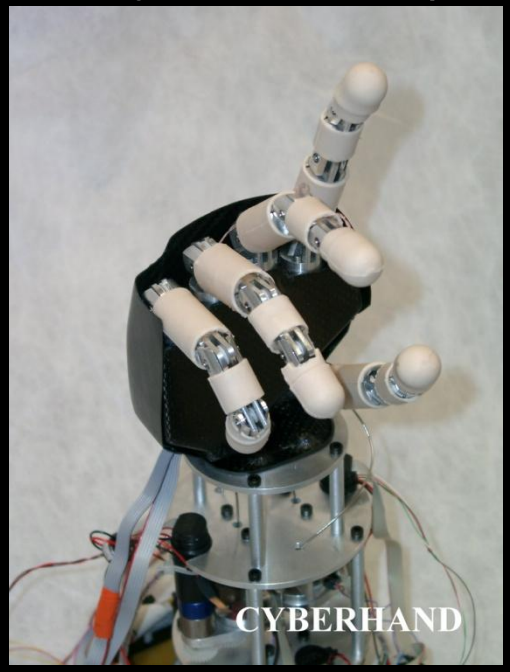
iLimb (Touch Bionics)

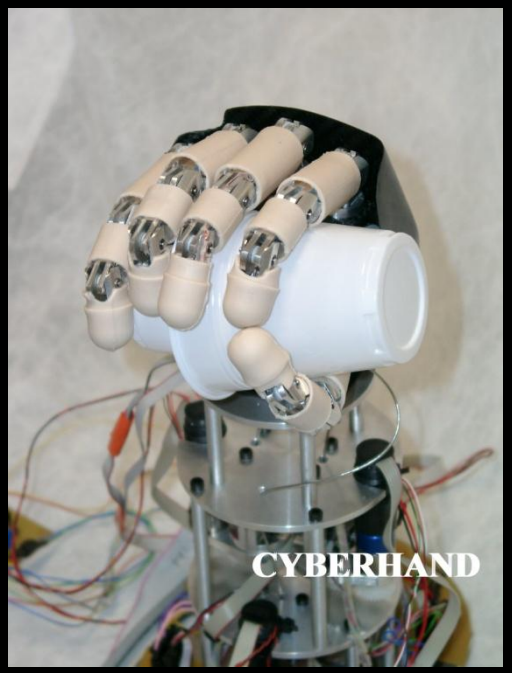


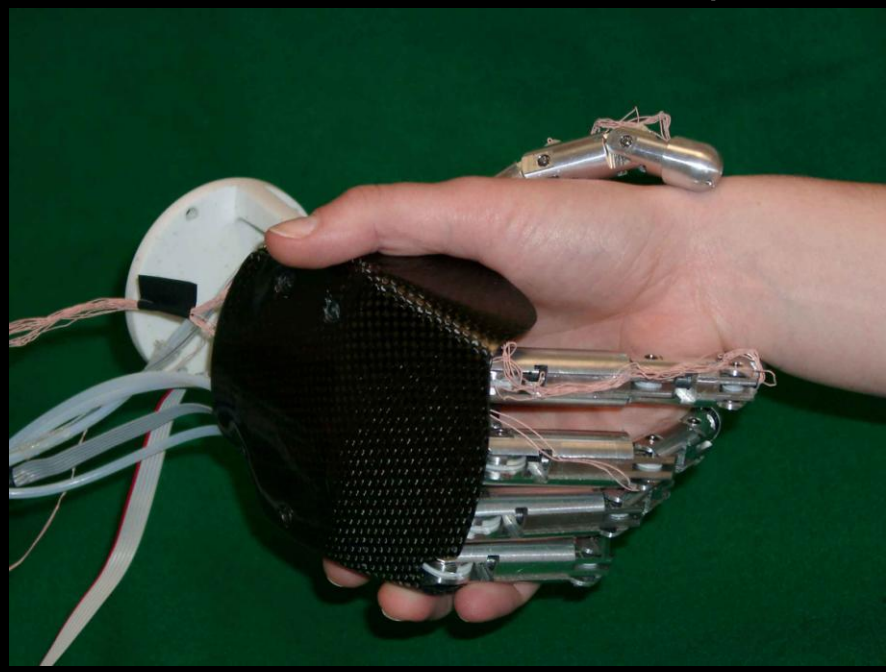
~$18K
5 motors driven from single muscle signal
thumb preshape for power, precision, key grip
motors stall individually for adaptive pose
in use by >250 people

Prosthetic Hands

Cyberhand (Maria Carrozza, Scuola Superiore Sant'Anna)







6 motors control 16 joints, cable driven
designed for prosthetic applications; preshape/close to force
sensors: position, cable force, fingertip force, tactile array
3.3 lb fingertip force, closes in 3 seconds
0.45Kg weight (not including forearm motors)

Prosthetic Hands

DEKA (Dean Kamen)

DARPA Revolutionizing Prosthetics Program
others under development (JHU/APL, RIC, Otto Bock)
http://www.cnn.com/video/data/2.0/video/tech/2009/07/31/eod.artificial.arm.cnn.html