Artificial Upper Limbs

Lecture 2

Prof.Dr.Jenan Sattar

Upper-Extremity Prostheses (UEP)

UEP consist of two components:
- terminal device
- crane.

The terminal device (end effector) performs the function of the hand.

The crane is used to position the terminal device.

Activities, performed by the prostheses:
- Personal care and hygiene
- Work or school related activities
- Lifting and manipulating objects
- Body support (for example in the bus).

The design of the prostheses is directly related to the residual functions and the functions desired by the user.

Terminal devices

Classifications:

A./ Regarding the functionality:

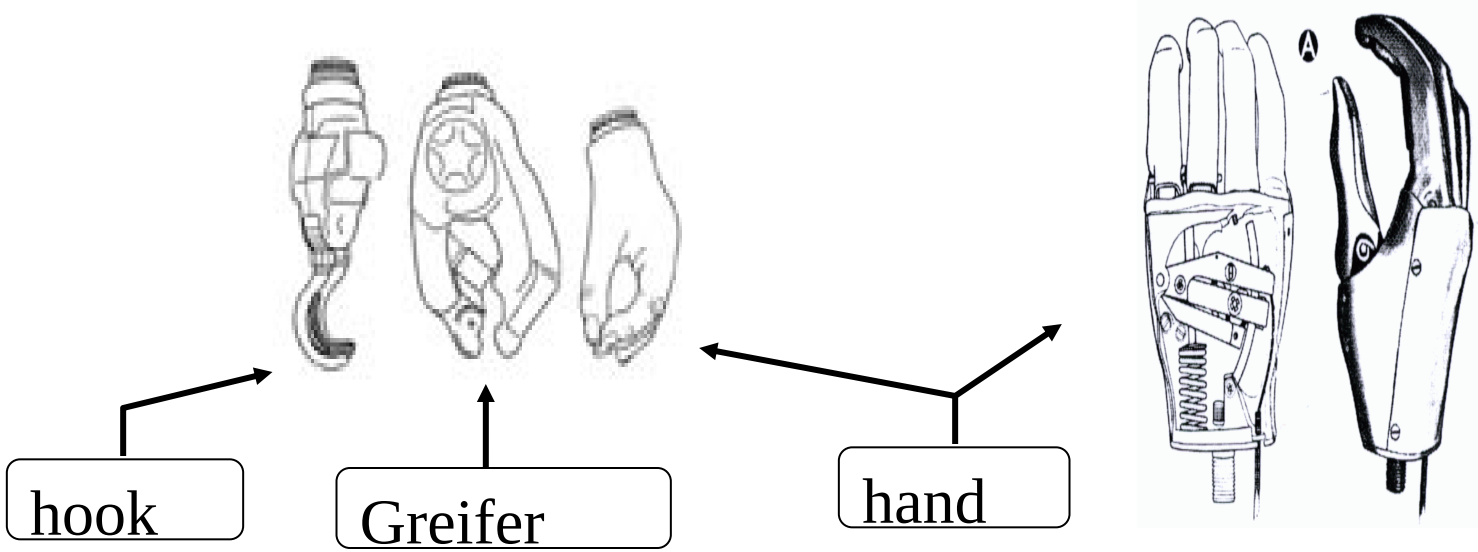
- *Terminal devices for simple motions* – only simple functions can be performed, simple operation; short time for learning;
- *Terminal devices for complex grasp* (e.g. four finger grasp) – some period is needed for learning the properly operation with such device, much adaptive grasping devices
- *Special terminal devices* (screwdriver) – for performance of specific tasks.

B./ Regarding the power supply

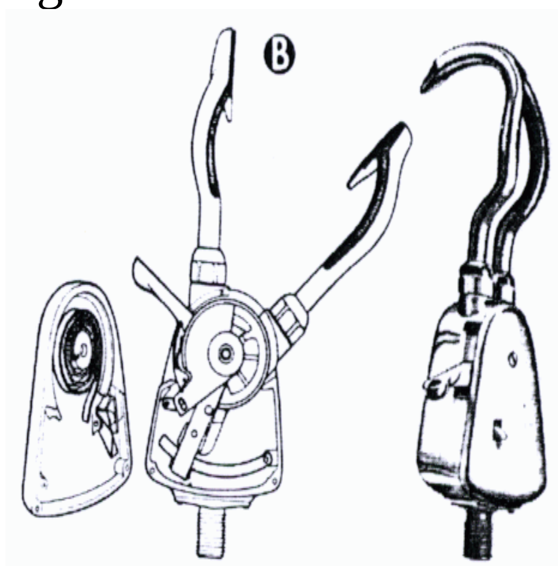
Internally powered – by transferring motion from another part of the body to the terminal device

Externally powered – by batteries.

Combined power .



Two concept of hook design:
Movable finger
Lyre shape designed



Hook or hand?

Hook – firm grip, durability, slim, access to narrow places , much functional than the hand

Hand – cosmetic acceptability. The palm causes additional support.

The goal – design of a dexterous hand with high durability and good cosmetic appearance

Two conceptions for operation of the terminal devices:

- *Voluntary opening* - automatic closing
- *Voluntary closing* – preferable in case of body activated prostheses; sensing of the gripping force; requires that the patient maintains tension during the object grasping

External power for terminal devices
Electric or pneumatic powering

Compressed gas in gas cylinder – CO_2

Electric batteries

DC motors, geared motors

Noise of the gear and motors – significant problem

Motorized hands, motorized wrist motions

Feedback

direct

Sensitivity of the residual limb

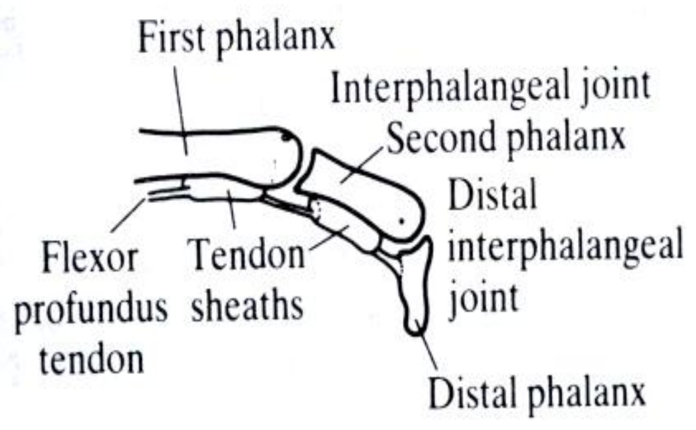
indirect

Sensors, mounted to the terminal device and interface devices

Hands:

- Three fingers, multi-fingers
- Immobile fingers and fingers with one or more finger joints

The human hand



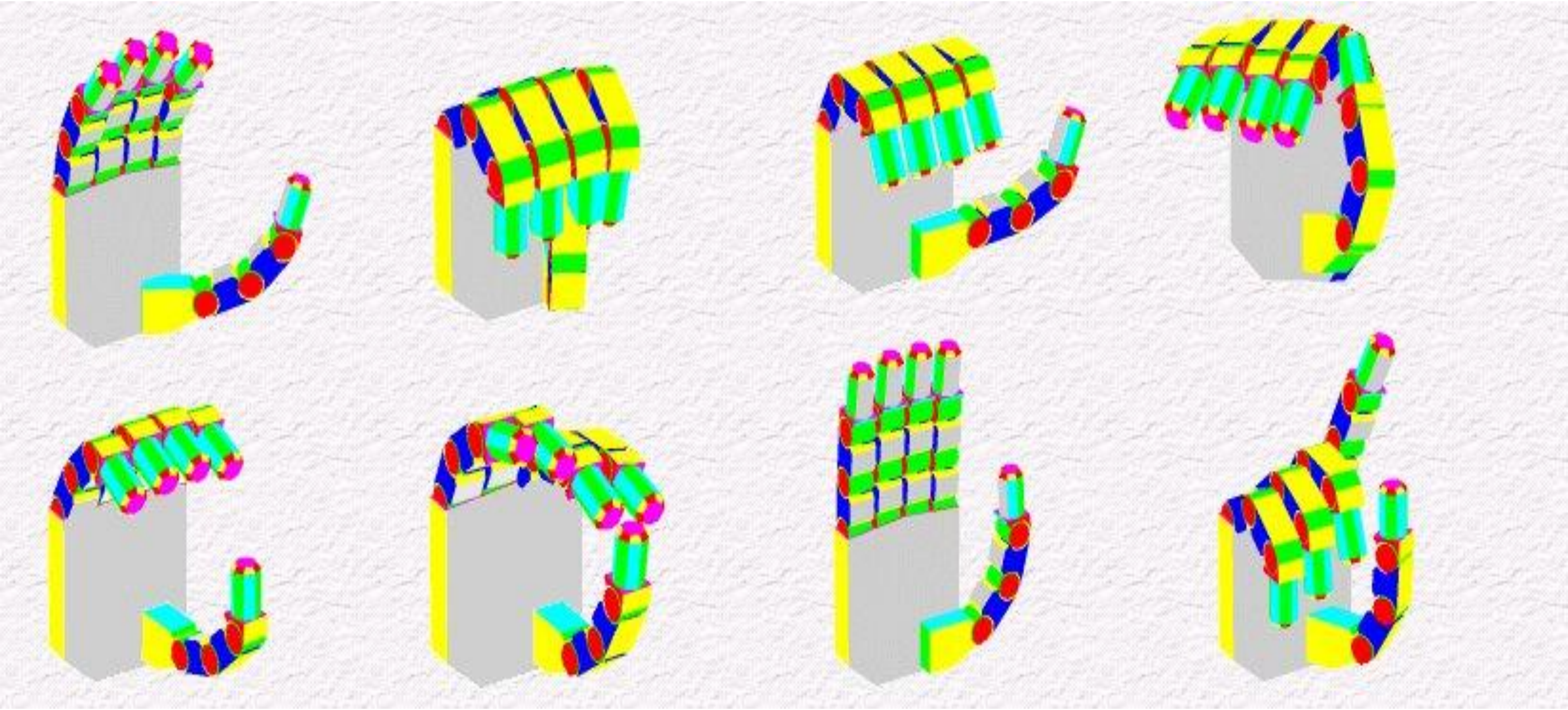
Michele

Two muscle sets acts to the hand:

- Extrinsics – located in the forearm
- Intrinsics – located within the hand itself (less powerful)

Flexor tendon – connect the proximal phalanx to a muscle

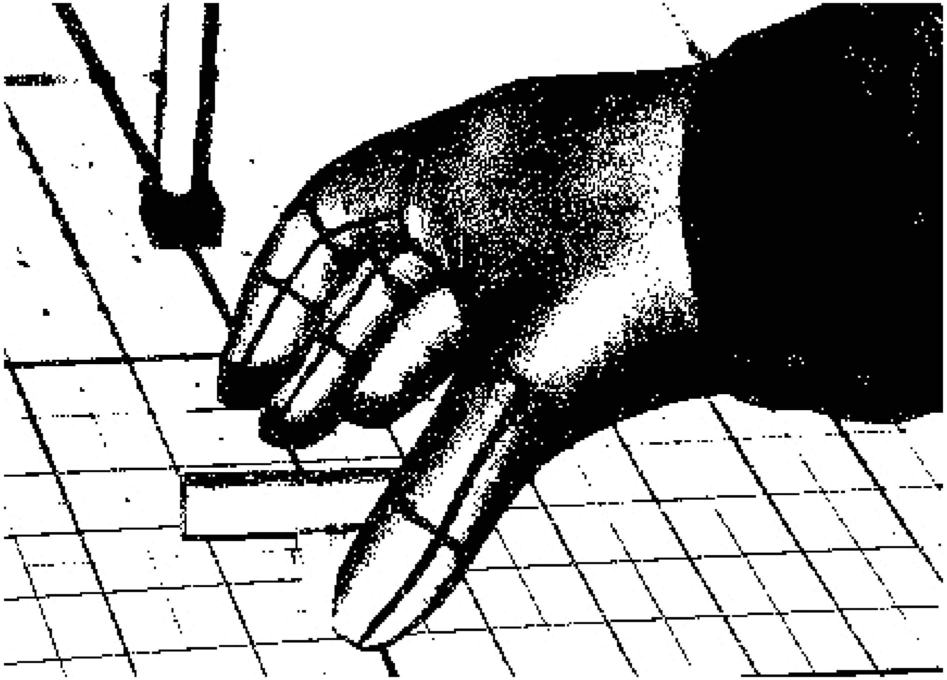
Eight types of hand movements: such as *three-jaw chuck, lateral hand, hook grasp, power grasp, cylindrical grasp, centralized grip, flattened hand and wrist flexion* are often used in daily life.



Segmentation of grasping structure

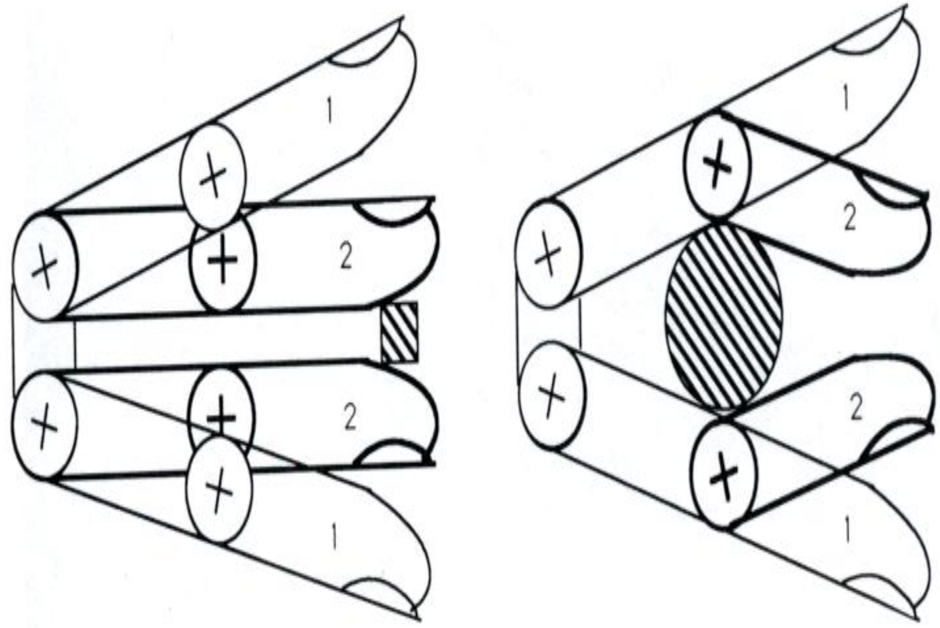
Segmentation of grasping structure

Hugh MacMillan Rehabilitation Centre, 350 Rumsey Road,
Toronto, Ontario M4G 1R8



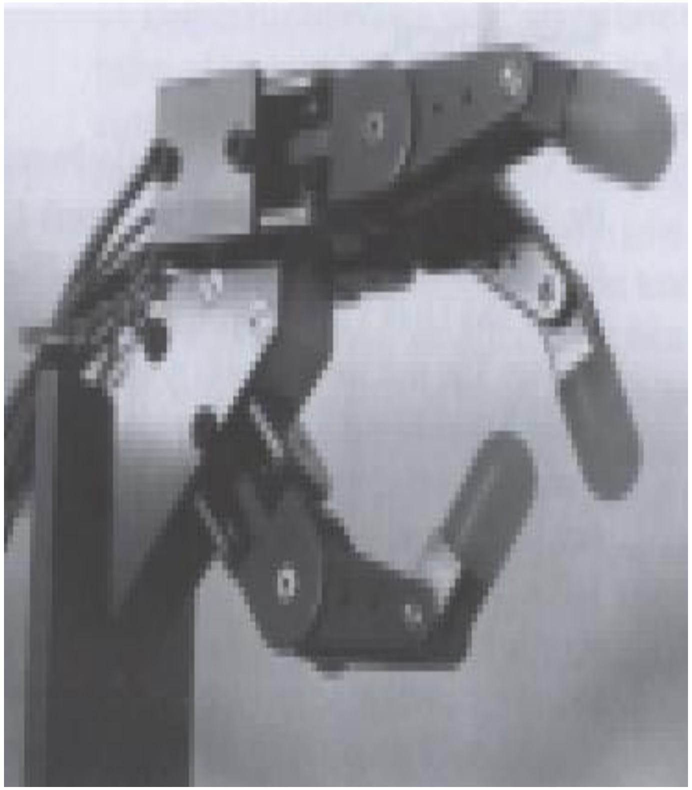
Powered Prosthetic Hand Function: Design Issues and Feedback
Gary F. Jacques
http://www.mie.utoronto.ca/staff/projects/cleghorn/Research/hmrc2.html

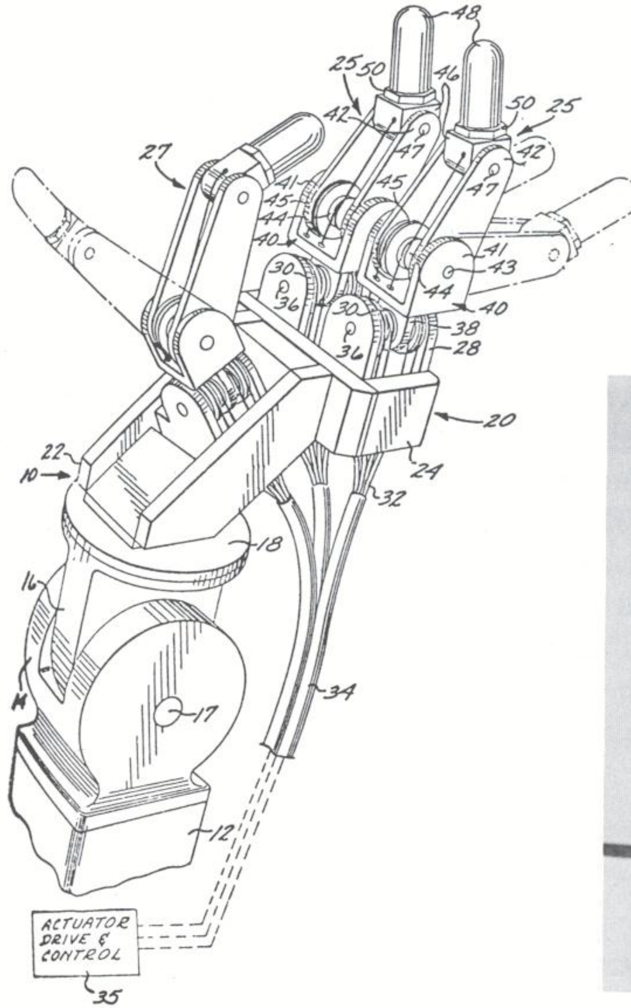
Tomovic’s prosthetic hand (1969)

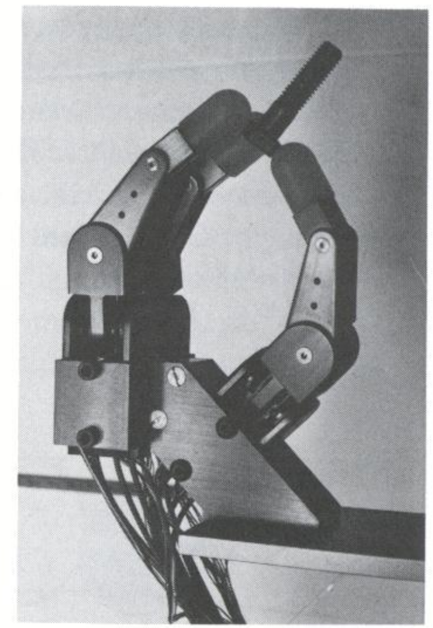


The hand demonstrated simple hierarchical control.
Wearer determines where the object will be grasp.
If the object is first touched at the distal end of the fingers, the hand closes with fingers unbent.

Stanford/JPL hand

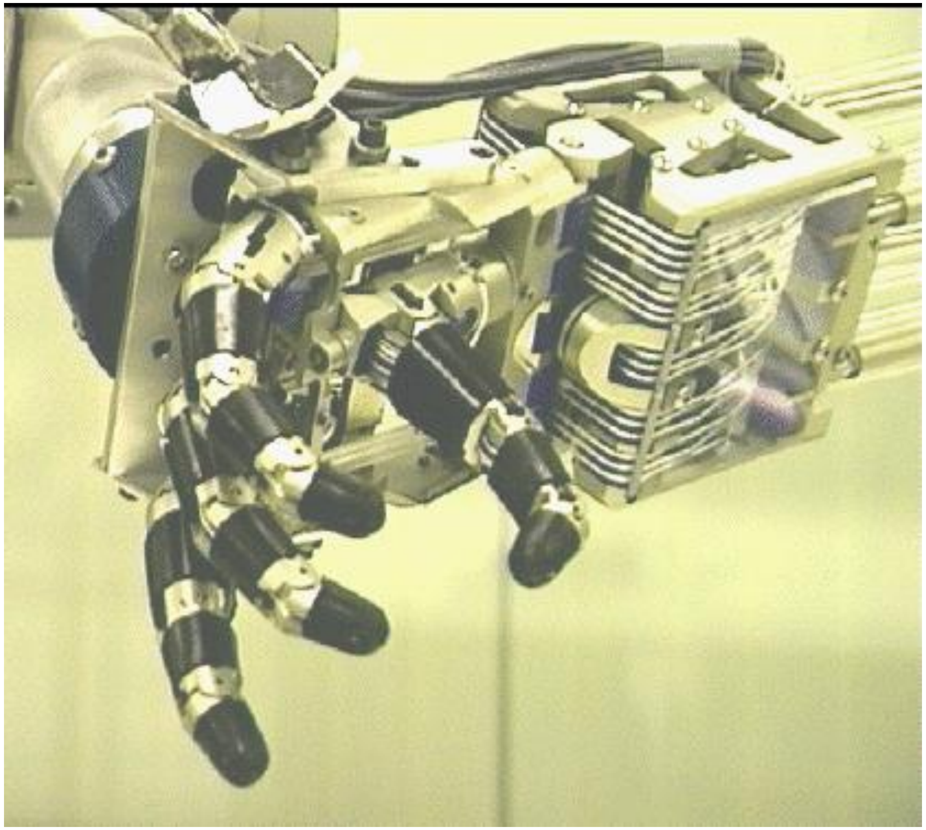




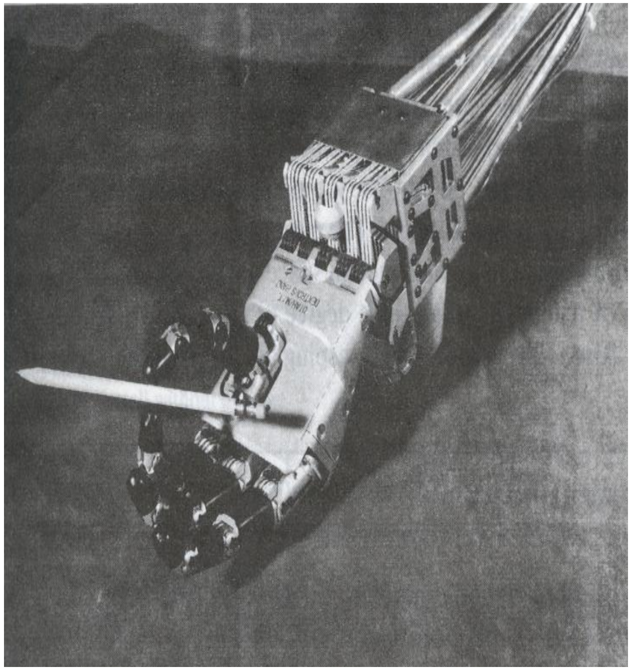


•Designed by K. Salisbury
• Hand has three fingers, each of them has three DOF and four control cables.
•12 DC geared motors

The Utah/MIT hand

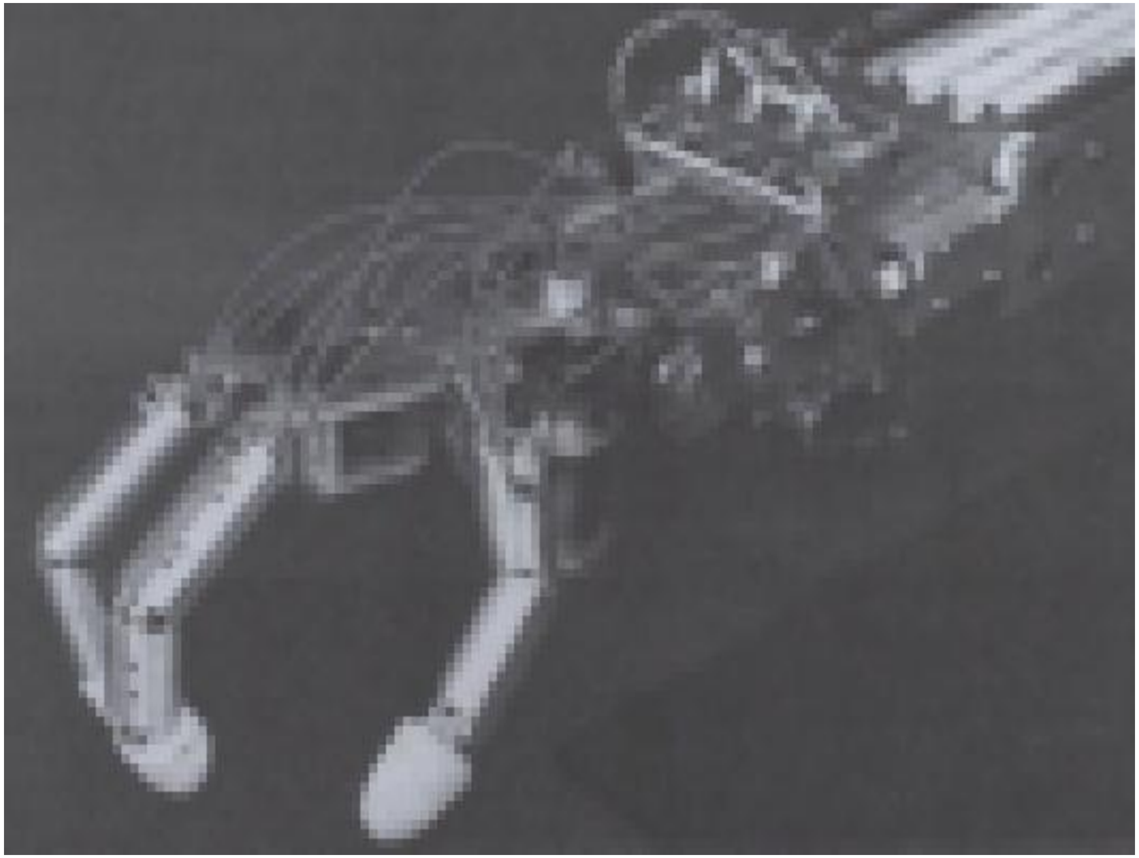


http://www-robotics.cs.umass.edu/p50/utah-mit-hand.html



•four degrees-of-freedom (DOF) in each of three fingers, and a four DOF thumb.
•an antagonistic tendon approach
•a system of 32 independent polymeric tendons and pneumatic actuators

Hitachi Ltd hand



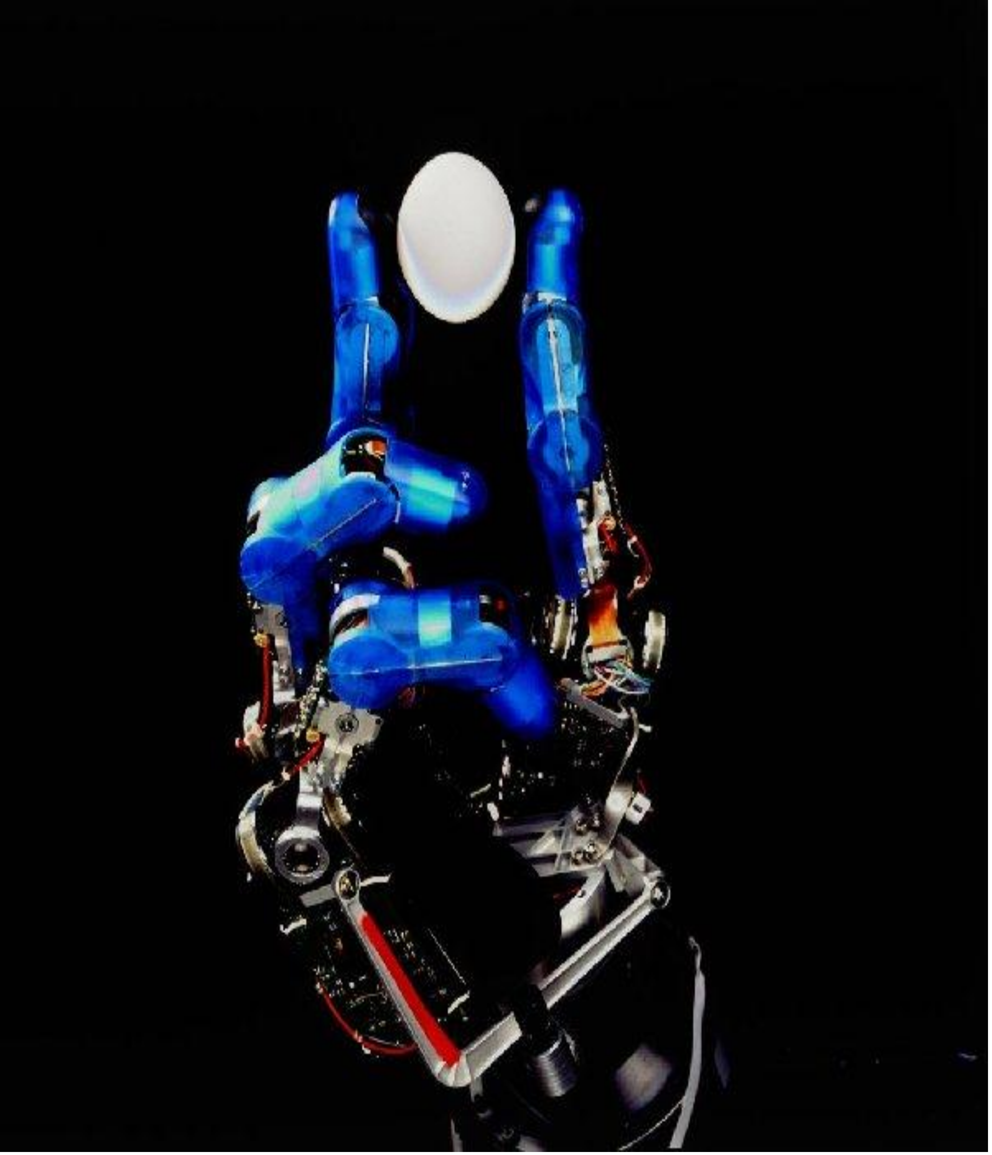
Shape memory alloy (SMA) actuators
High power-to-weight ratio

DRL (Deutsches Centrum fur Luft-and Raumfaerhrt)

Total 12 DOF
Four fingers
All actuators are integrated in the palm or in the fingers

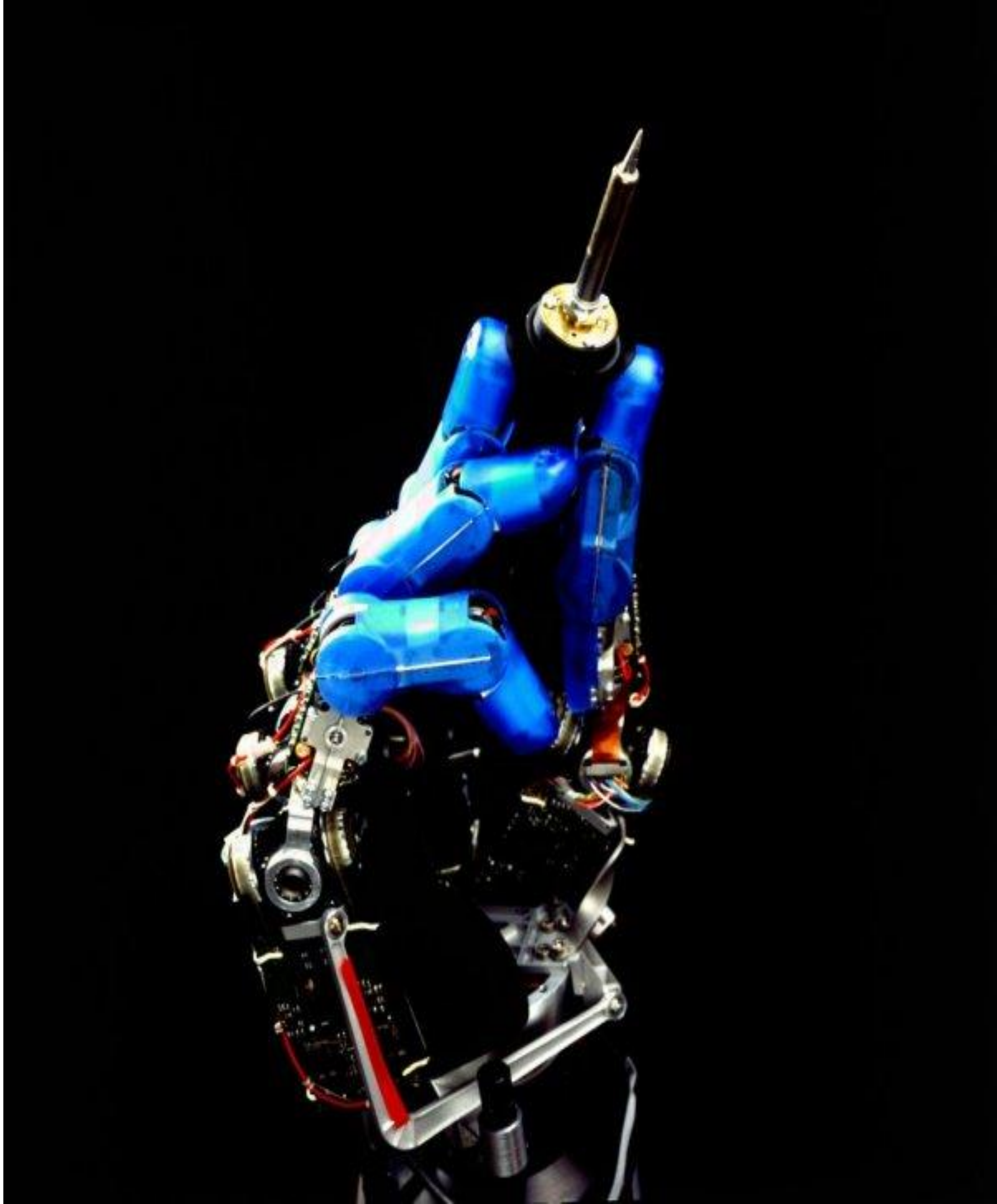
Butterfaß, Hirzinger, G.; Knoch, S.; Liu, H.: DLR's Multisensory Hand Part I: Hard-and Software Architecture, Proceedings of the IEEE Int. Conf. on Robotics and Automation, Leuven, Belgium, 1998, pp. 2081-2086.

DRL (Deutsches Centrum fur Luft- and Raumfaerhrt)

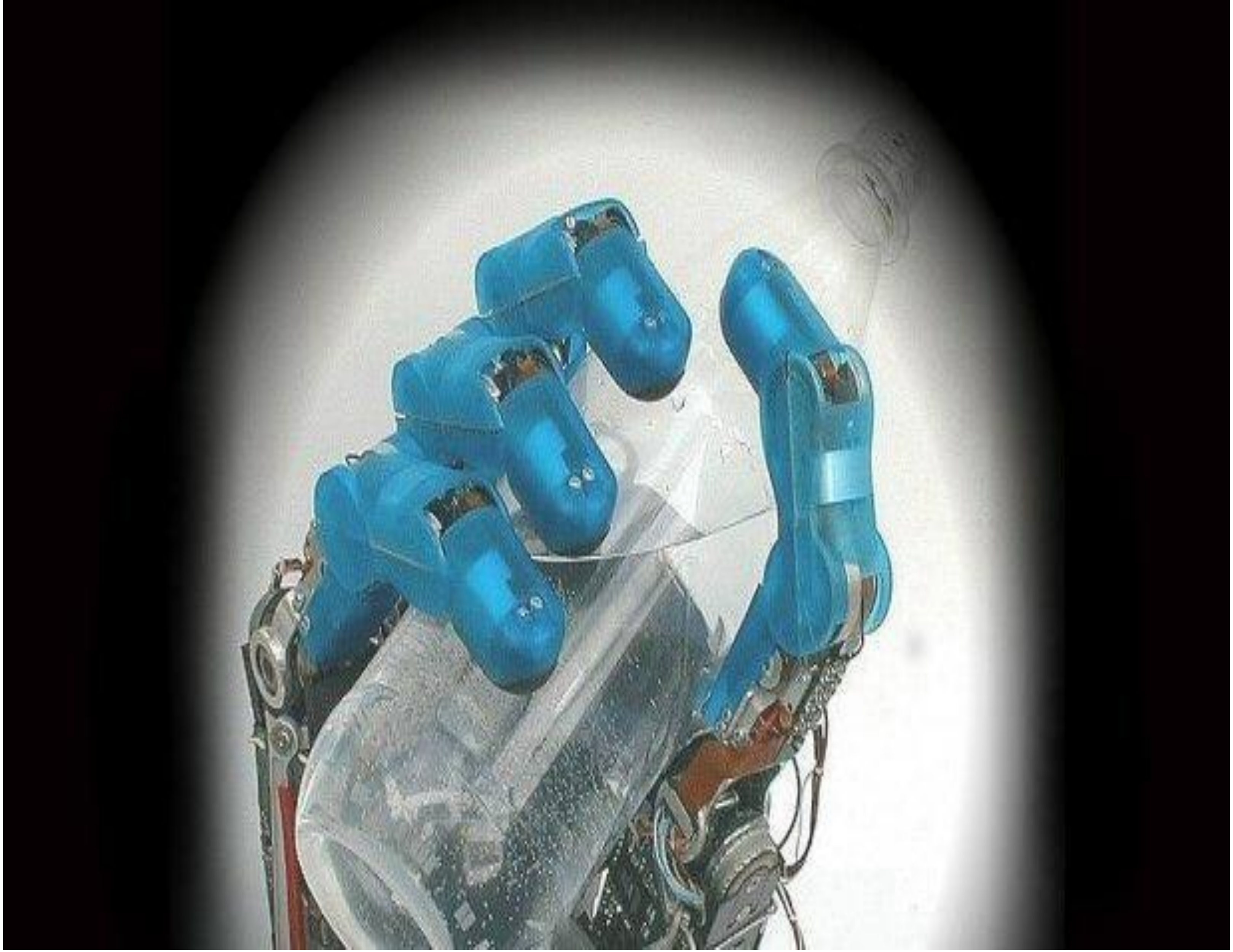


http://www.robotic.dlr.de/HAND/publications.html

DRL (Deutsches Centrum fur Luft-and Raumfaerhrt)



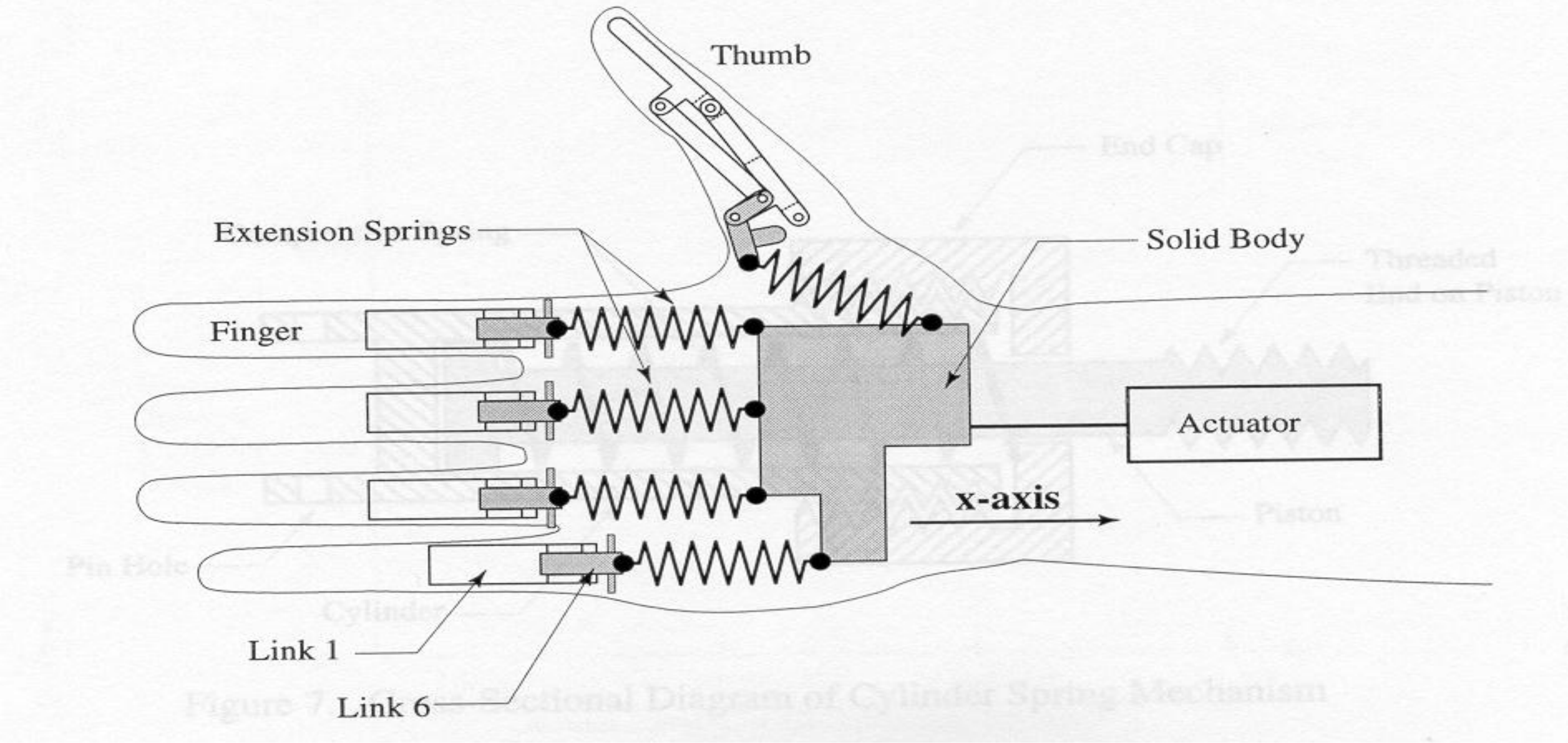
http://www.robotic.dlr.de/HAND/publications.html



Robonaut
flexible, five-fingered hand.

NASA Johnson Space Center

total of fourteen DOF

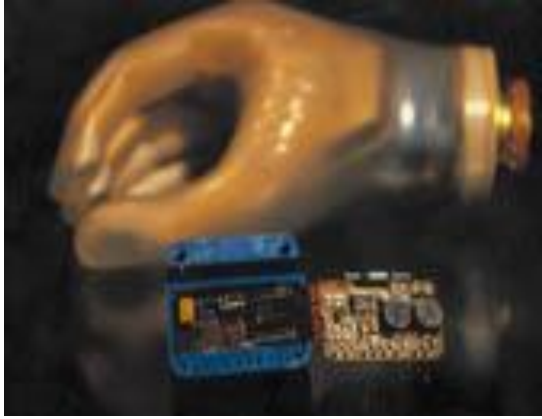


Multi-Fingered, Passive Adaptive Grasp Prosthetic Hand: Better Function and Cosmesis
Dechev, N., Cleghorn, W.L. and Naumann, S.
Proceedings of the Seventeenth Canadian Congress of Applied Mechanics, Hamilton, ON, May 30 - June 3, 1999.
http://www.mie.utoronto.ca/staff/projects/cleghorn/Publish/c129.html

Sensor Hand (Otto Bock)

http://www.ottobockus.com/products/op_ehand.htm

Sensor Hand (Otto Bock)



Key features:

•securely grasping of any objects —even fragile items and liquid-filled containers
•microprocessor-controlled hand
•When the object is about to slip, sensors in the thumb and finger lever detect changes in the object's weight or center of gravity; the microprocessor automatically adjusts the grip force.

A brief myoelectric opening signal stops the SensorHand auto grasp response.
A longer myoelectric signal opens the hand.
Choice from eight control modes, including a proportional opening and proportional closing

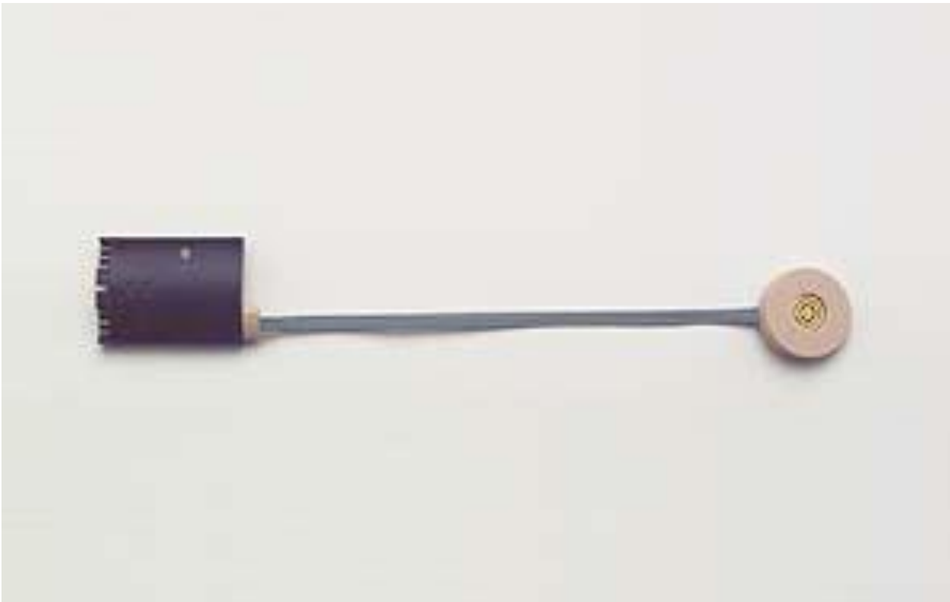
the SensorHand is suitable for dual myo site, single myo site, single switch, or dual switch inputs, and can offer basic digital (one speed) operation or proportional DMC control, as well as Auto-Grasp and Flexi-Grip capabilities—making it one of the most versatile and user-friendly options in the world.

The control mode can be instantly changed by inserting a different Coding Plug (The SensorHand controller can evolve according the client's ability to control).

Otto Bock module design

Ergo Arm

Otto Bock module design



EMG electrodes module

12K44 ErgoArm Elbow

- Hand and battery cables are integrated into the elbow

Liberty Technology

the **Boston Elbow II™**

Elbow prosthesis

http://www.oandp.com/resources/publications/busworld/winter99/fea6d.htm