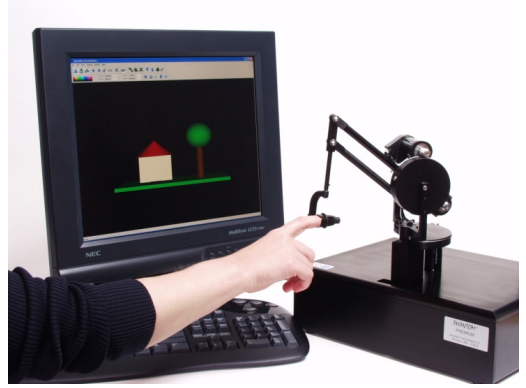
Haptic interfaces

1. Definition, scope and history
2. Haptic display characteristics

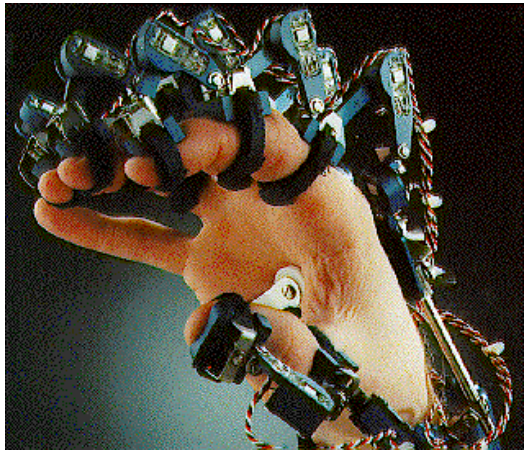
video2

3. Haptic display types
4. Haptic design guidelines
5. Haptic interaction through virtual coupling
6. From Haptic to pseudo-haptic feedback

3. Haptic display types [BKLP 2005]



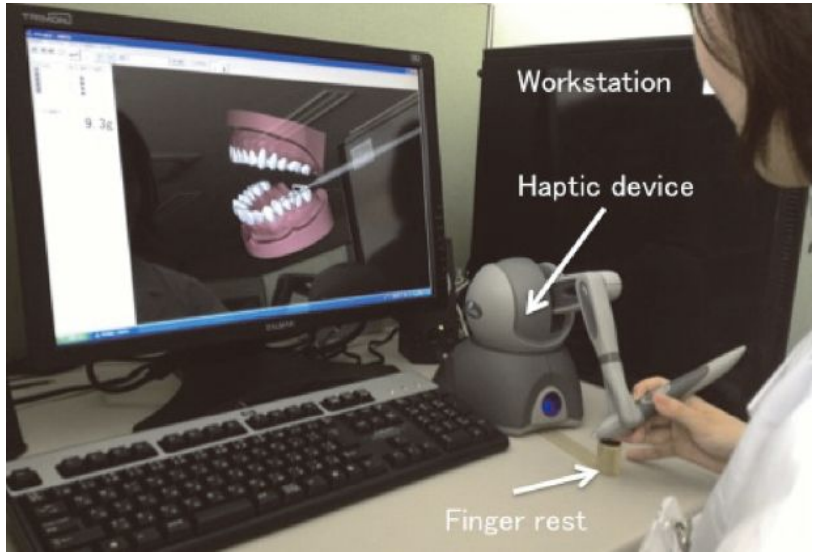
Body-referenced haptic device [Utah hand]



Placed on the user body: exoskeleton with motors or cables. Need calibration to user skeleton.

Ground-referenced haptic device [Phantom]

(on desk, floor, wall, ceiling...)



Dental materials journal 2013, 32(5)

Force-reflecting joystick, pen-based force feedback, stringed devices, motion platform, large articulated arm

3. Haptic display types (2)

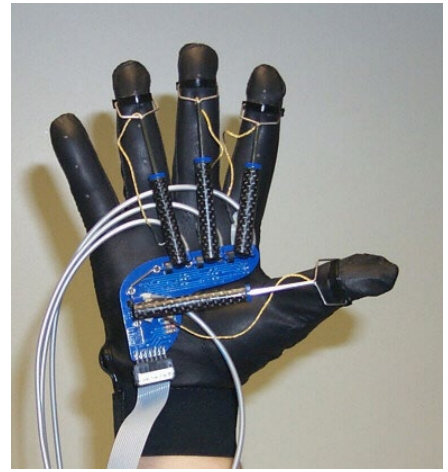
Body-referenced haptic device :

more freedom of motion

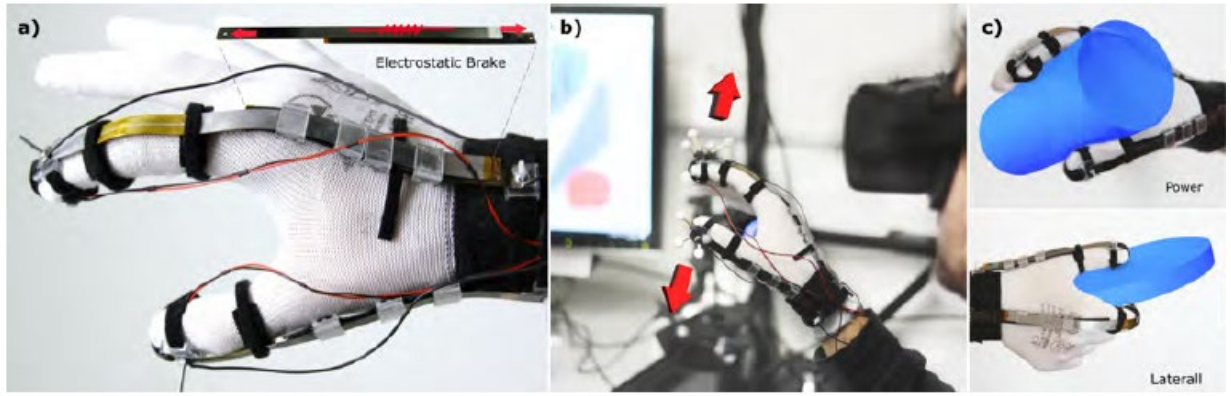
Tradeoff due to weight

Twiice rehabilitation system [EPFL-LSRO]

Rutgers Master II



DextrES: electrostatic brakes [H2018]



The concept of **haptic suit** is popular in science fiction (film «Ready Player One») but limited to vibrating units or muscular electrical stimulation (**teslasuit** below)

Haptic feedback system

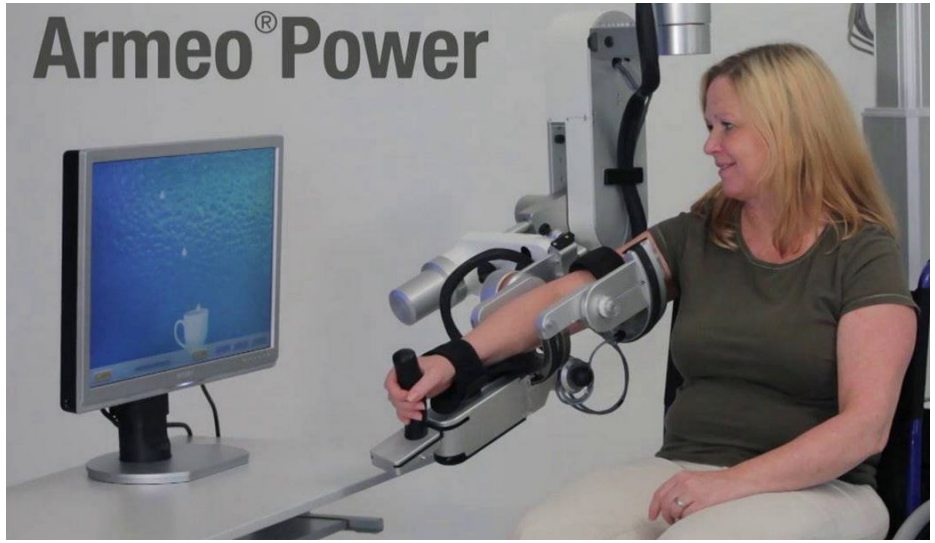
Electrical Muscle Stimulation replicates the small electrical stimulation produced by the brain and carried by the efferent neural signals.

Used in sport and rehabilitation ->

wikipedia.org: Electrical_muscle_stimulation

3. Haptic display types (3) Ground-referenced haptic device

Virtuose from Haption (FR): Cable system allowing human arm scale

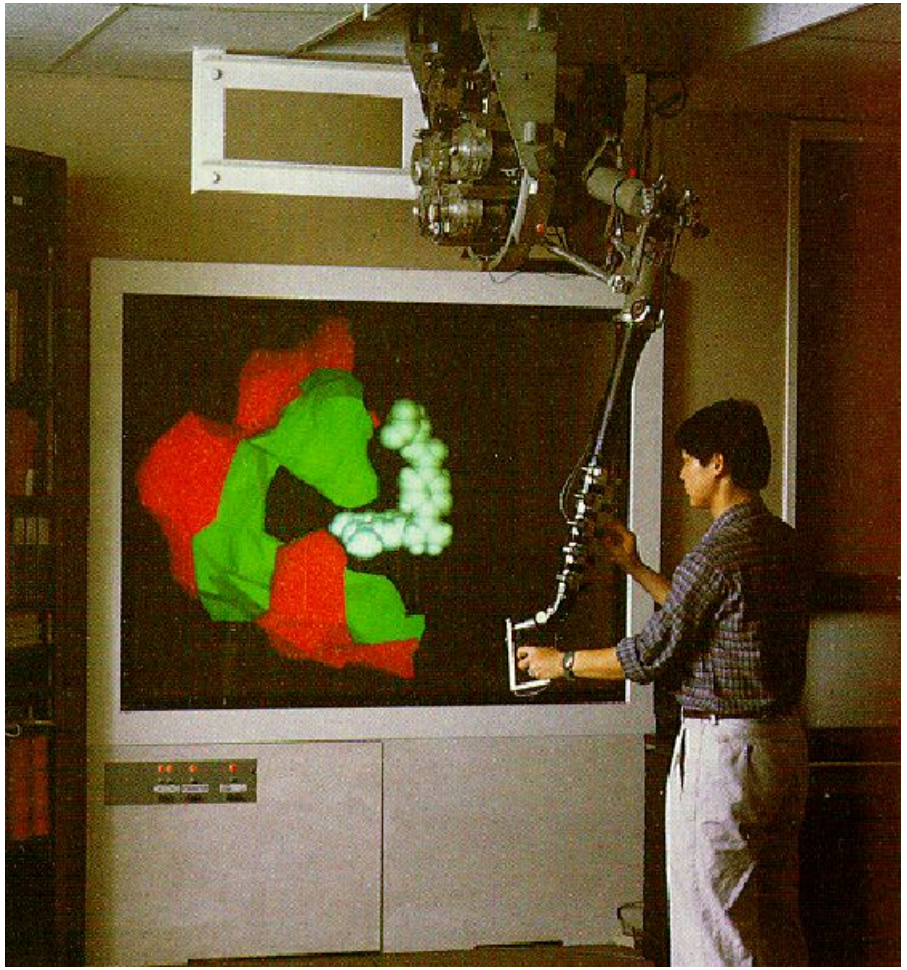


Exoskeleton from Hocoma for rehabilitation

Force Dimension (CH): high stiffness Based on Delta Robot from EPFL

+ recent miniature system *Foldaway* from EPFL-RRL

3. Haptic display types (4)



GROPE III, 6 Degree of Freedom (DoF)
Force & Torque haptic display [B 1990]

Ground-referenced haptic device :

- Research project from UNC by Brooks team, started in 1967.
- Goal: help chemists to find more easily good docking position for news drugs (i.e. relative location of complex molecules at which some receptor can be exploited).
- Results: such task was achieved about twice as fast with haptic feedback compared to only stereo graphics display.
- Chemists have a new understanding of the receptor force field and the docking

3. Haptic display types (5)

Ground-referenced haptic device : using 2 phantom-like devices for bimanual training of stomach laparoscopic surgery (Rensselaer Polytech. / Reuter / 2011)

The 2 devices providing the force feedback

Laparoscopic surgical tools

The interaction must integrate a realtime deformation model of the organ to compute the correct reaction force and mesh deformation

https://www.youtube.com/watch?v=UNRIhgkfMCY

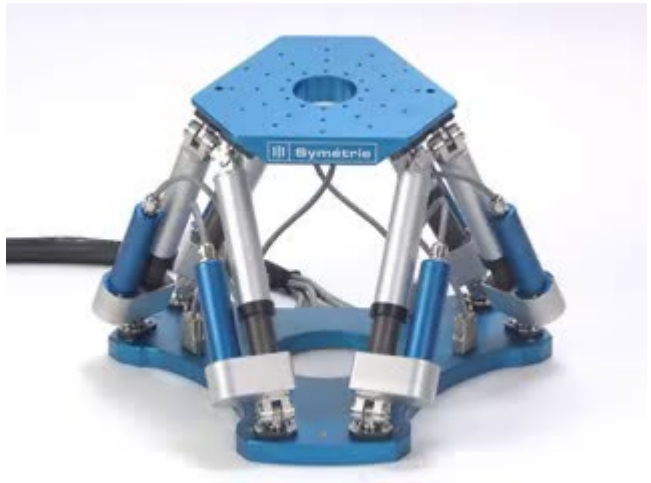
SW platform on physics-based tissu deformation:

https://www.sofa-framework.org/about/story/

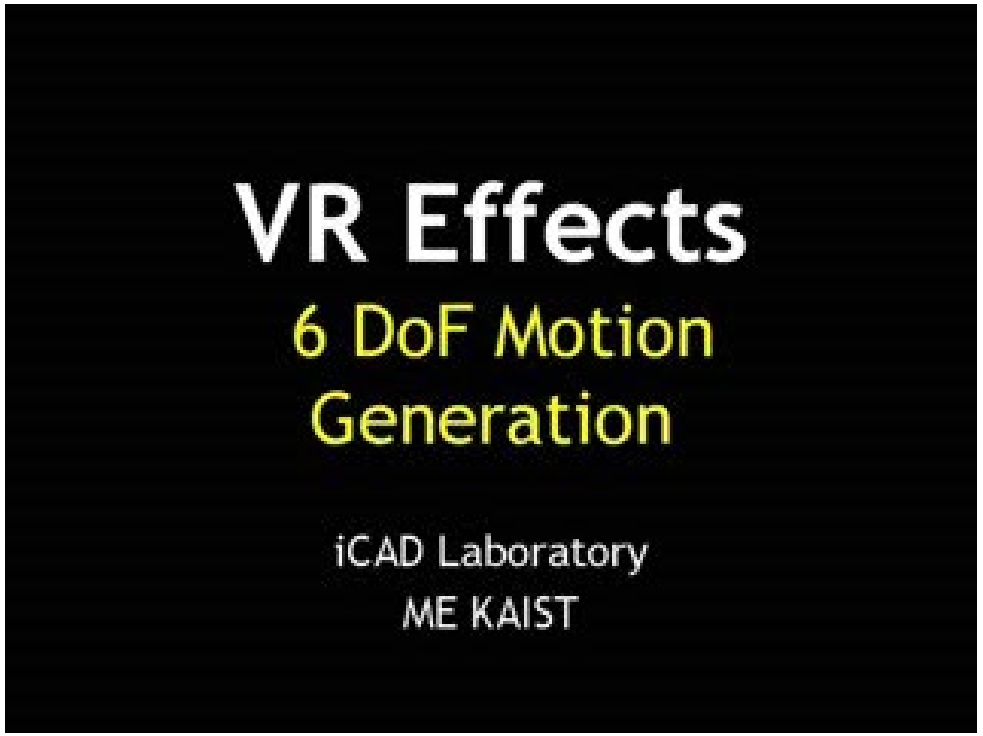
3. Haptic display types (6)

Ground-referenced haptic device exploiting a Stewart Platform are mostly used to stimulate the vestibular system sensitive to accelerations, for driving /flight simulators , arcade games and theme parks:

Stewart Platform=
6 DoFs but with
limited range



Check also:
www.bluetiger.com
www.simbolrides.com



6 DoFs driving platform: KAIST (Korea)

Ferrari F1 simulator: https://www.youtube.com/watch?v=5T_tXG-89IU

3. Haptic display types (7) Research setup

Ground-referenced haptic device : Kuka robot used in MPI Tuebingen for studing human perception, cognition and action [Prof. Buelthoff]

http://www.youtube.com/watch?v=jrvnC6L9nPA&feature=related

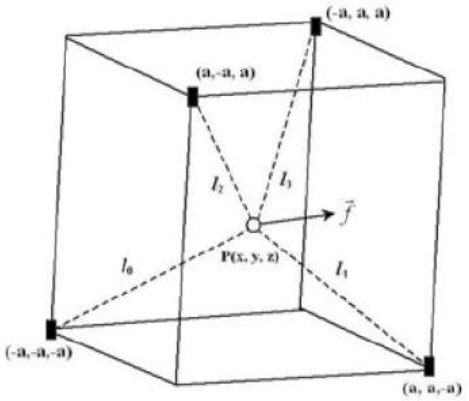
The robot is ideal for producing acceleration stimulations and displacements over a large range

Toward RT aircraft Simulation with the MPI motion simulator, (MPI & Univ. Pisa), Niccolini, Pollini, Innocenti, & Giordano, Teufel, Buelthoff

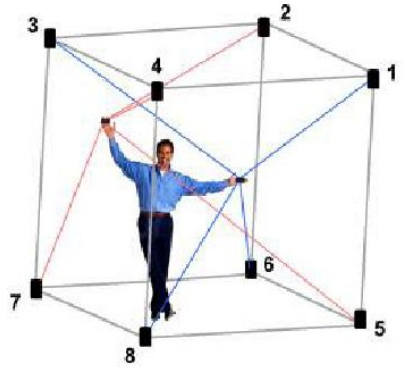
3. Haptic display types (8)

Ground-referenced haptic device : Space Interface Device for Artificial Reality (SPIDAR) is a stringed system [Sato 1989]: a good compromise for large space interaction at low cost, lightness, and high safety

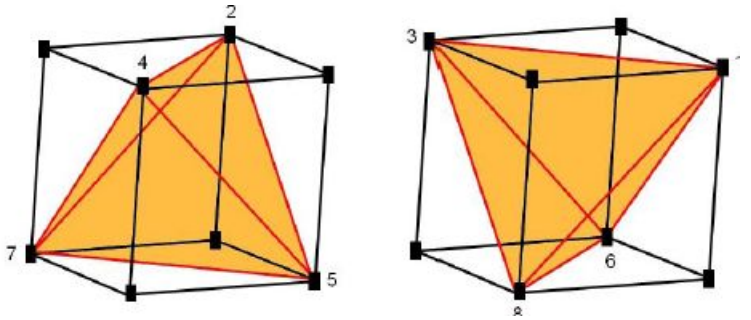
LISA Anger & IBISC Evry [N 2009]



$$\begin{cases} x = \dfrac{(l_0^2 - l_1^2 - l_2^2 + l_3^2)}{8a} \\ y = \dfrac{(l_0^2 - l_1^2 + l_2^2 - l_3^2)}{8a} \\ z = \dfrac{(l_0^2 + l_1^2 - l_2^2 - l_3^2)}{8a} \end{cases}$$

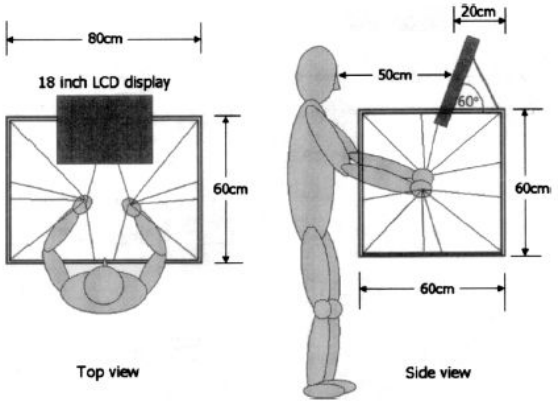


right & left haptic range

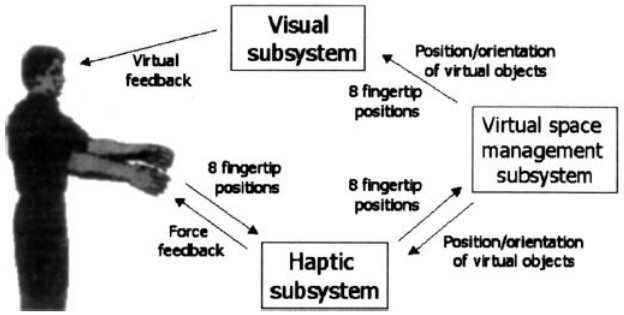


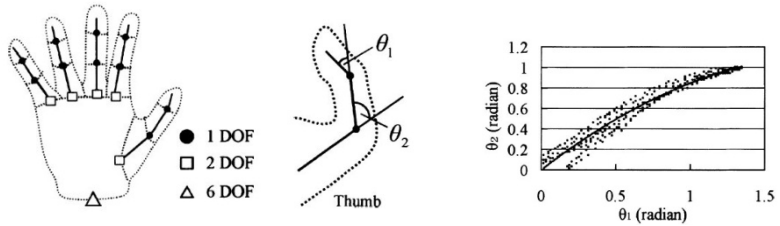
3. Haptic display types (9)

A bimanual SPIDAR system from Tokyo Institute of Technology, Yokohama [W 2004]

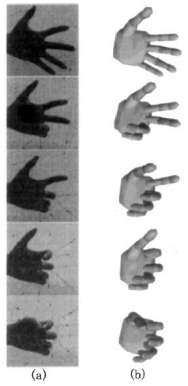


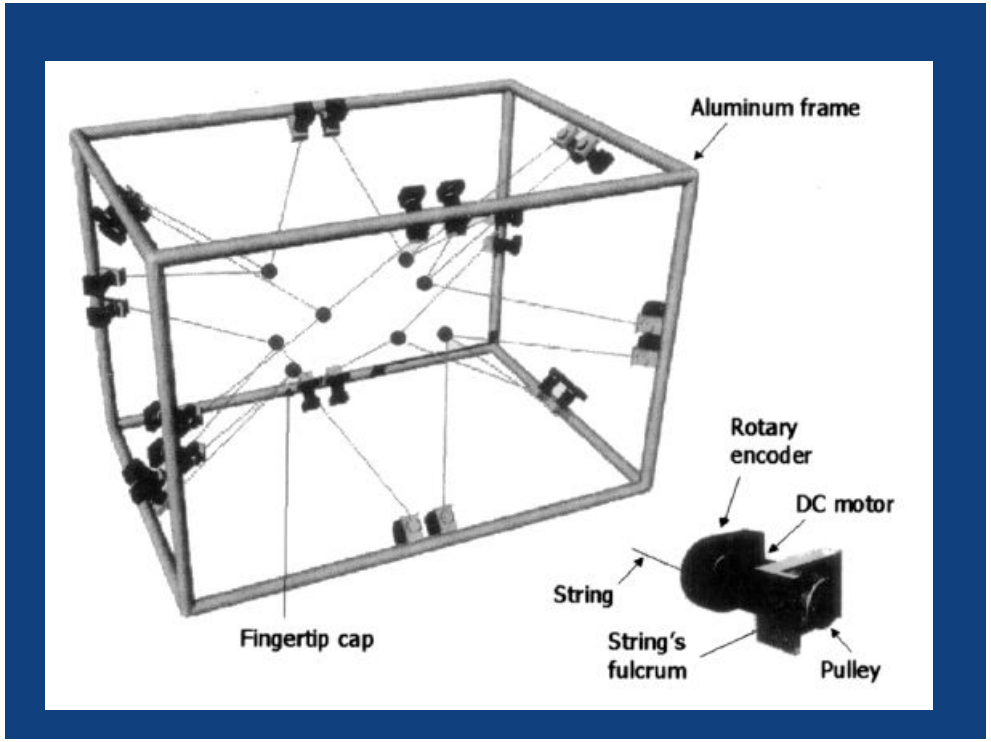
The user interacts by looking at a screen that displays virtual hands estimated from the location of the 8 finger caps





An anatomic model of a 17 DoF hand with finger joint coupling is used to infer the virtual hand with an Inverse Kinematics algorithm





http://www.youtube.com/watch?v=m-DS1U_INpQ

3. Haptic display types [BKLP 2005] (10)

Tactile device

CyberTouch TM: integrate small **vibrotactile** units on each finger of an Immersion CyberGlove.
Each unit can be programmed to generate pulse or sutained vibrations

Finger pulling device

CyberGrasp TM: from Immersion
Each finger can be pulled from the back side of the hand to force it to open. It cannot force the hand to close

Combination: Haptic Workstation
= 2 CyberForce & Cybergrap

CyberForce® is a force feedback armature that not only conveys 3D forces to the wrist and arm but also provides 6 DoF (degre of Freedom) wrist tracking :

3 Dof in translation

+ 3Dof in orientation

Max : 60N

4. Haptic design guidelines [BKLP 2005]

Ground-referenced	+ can produce high level of force if needed
	+ don't have to wear them
	+ accurate trackers
	- limited movement when using them ...
	- ... or high cost (e.g. Kuka from MPI)
	+ some compromise exist, e.g. SPIDAR
Body-referenced	+ more freedom of motion
	+ more control for direct manipulation
	- user has to bear the weight of device
	- can be tedious to put on and calibrate
Tactile /electrical	+ smaller than force display
	- difficult to get sensation correct
	- limited to small skin area
Hybrid	+ combines force and tactile feedback
	- more complex devices

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MPI Tuebingen: lab of Human Perception, Cognition and action

http://www.kyb.tuebingen.mpg.de/research/dep/bu.html

http://www.youtube.com/watch?v=jrvnC6L9nPA&feature=related

SPIDAR

http://www.youtube.com/watch?v=m-DS1U_INpQ

Da Vinci demo and press article about issues with this type of interaction in surgery

http://www.youtube.com/watch?v=VJ_3GJNz4fg

http://www.informationweek.com/healthcare/clinical-information-systems/robotic-surgery-da-vinci-versus-the-ideal/d/d-id/1112732

Rensselaer Polytechnic bimanual surgery training

https://www.youtube.com/watch?v=UNRIhgkfMCY

Hocoma haptic rehabilitation

http://player.vimeo.com/video/26048381?title=0&byline=0&portrait=0&color=ff9933