W1. Objectives, Challenges, State of the Art, Technologies

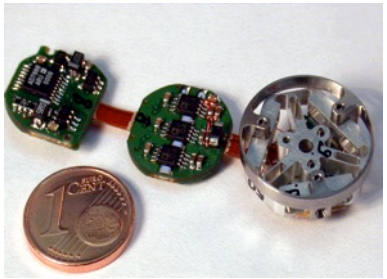
- Socio-economic context
- Technological evolution of Robotics & State of the Art
- New challenges for Robotics in Human Environments
- Decisional & Control Architecture for Autonomous Mobile Robots & IV
- Sensing technologies: Object Detection
- **Sensing technologies: Robot Control & HRI**
- Basic technologies for Navigation in Dynamic Human Environments
- Intelligent Vehicles: Context & State of the Art
- Intelligent Vehicles: Technical Challenges & Driving Skills

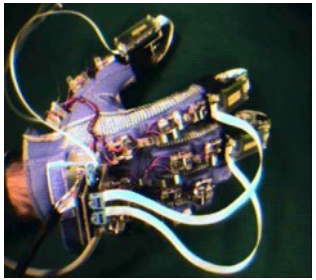
Force & Tactile Sensors for Robot Control & HRI

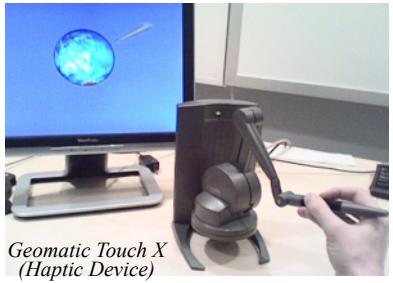
Force & Tactile sensing technologies

- **Force sensors** (wrist, fingers, table, legs, wheels…)
- **Tactile sensors** (fingers, hand, foot, surgical endoscopes…)
- **Haptic feedback for intuitive HRI**

➔ *Miniaturized devices, Advanced integrated H/M interfaces (Haptic feedback)*



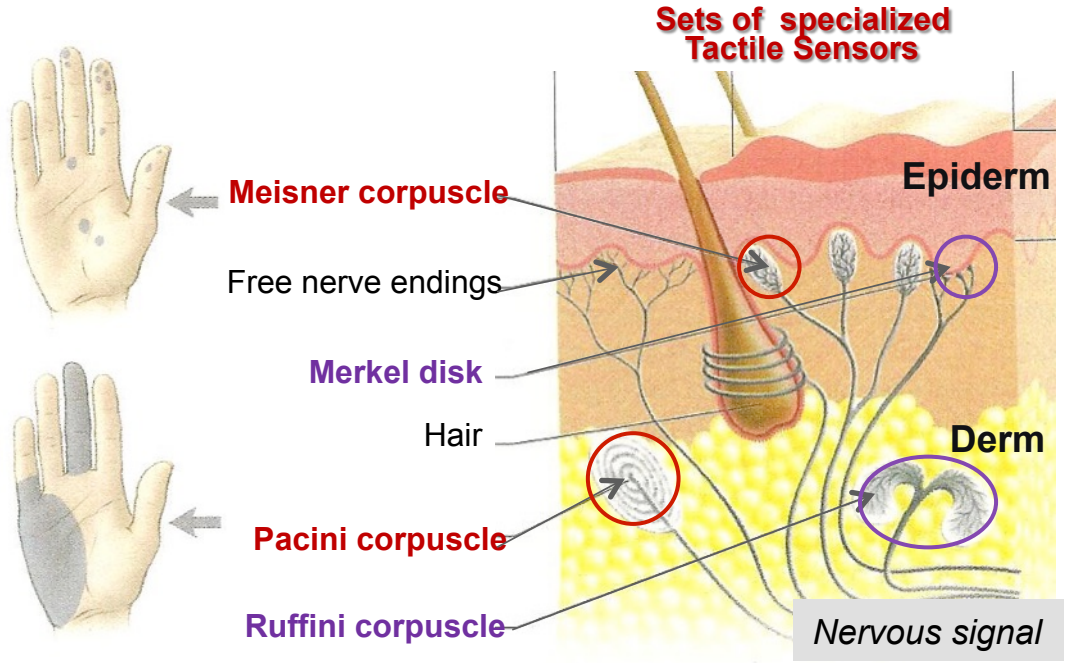




Geomatic Touch X (Haptic Device)

Force & Tactile Sensors for Robot Control & HRI

Biological sense of Cutaneous Touch



Human Tactile Feedback

Tactile signals are obtained by

coupling specialized Epidermal & Dermal sensors

+

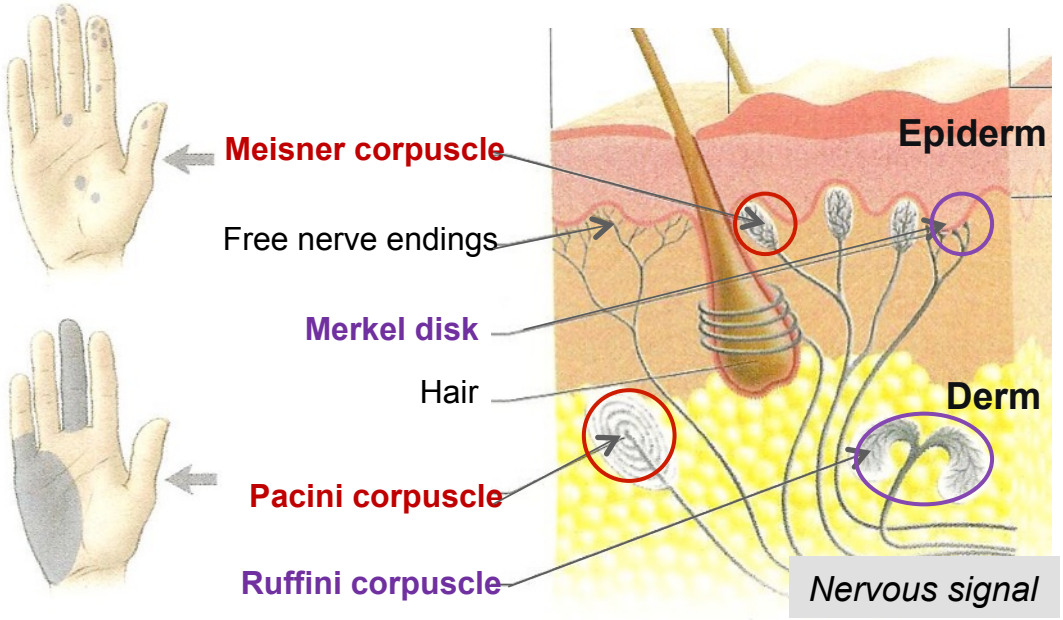
Epidermal free nerves endings

+

Hairs

Force & Tactile Sensors for Robot Control & HRI

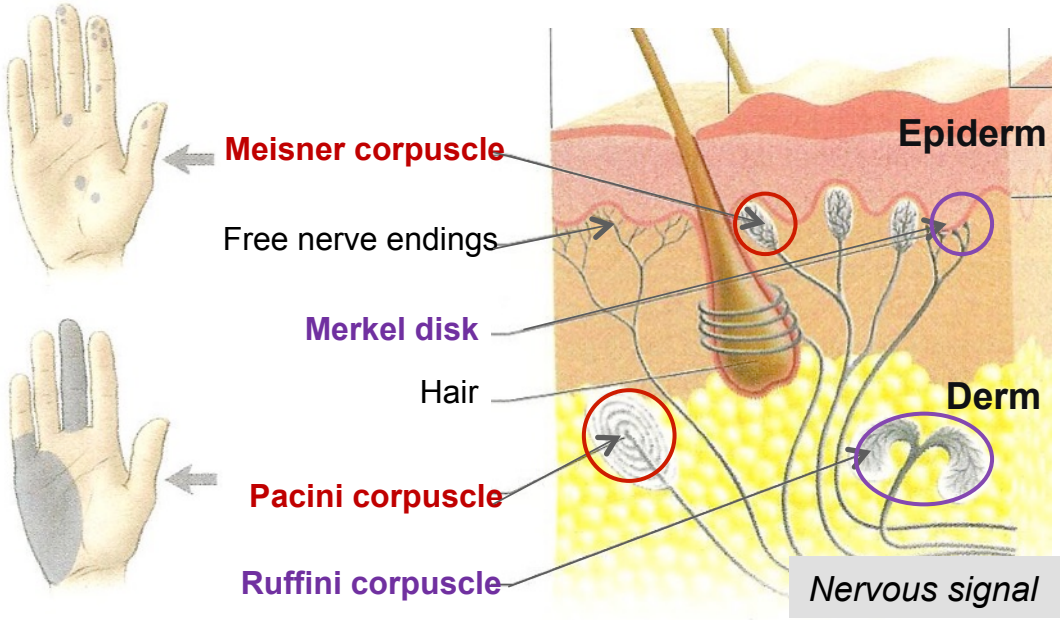
Biological sense of Cutaneous Touch



- **Meisner & Pacini corpuscles**
  - ➔ *Produce Very sensitive & Quick adaptation*
    … But "non-permanent signal"
- **Merkel disk & Ruffini corpuscle**
  - ➔ *Generate a slow adaptation*
    … But "permanent signal"

Force & Tactile Sensors for Robot Control & HRI

Biological sense of Cutaneous Touch



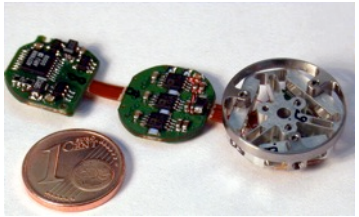
Sensing Resolution

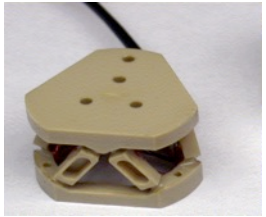
➔ *Depends on the density of sensors & body parts :*

- 1 to 2 mm on top of fingers
- 5 to 10 mm on the hand palm
- until 45 mm on the arms

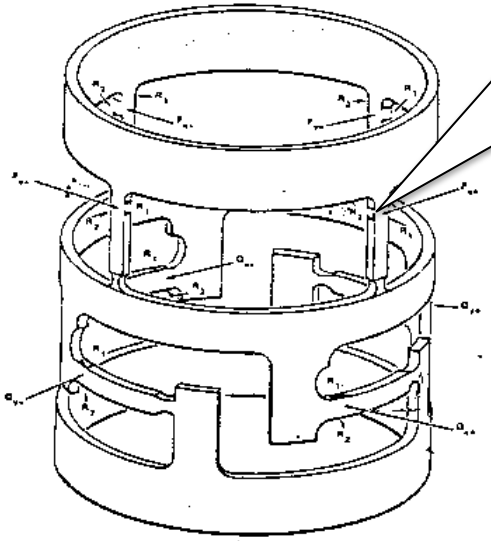
Robotics Force Sensors

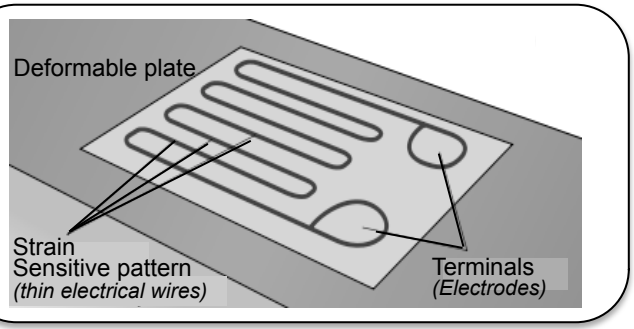
Strain Gauges Technology





Miniaturized wrist sensor (DLR, 2002)





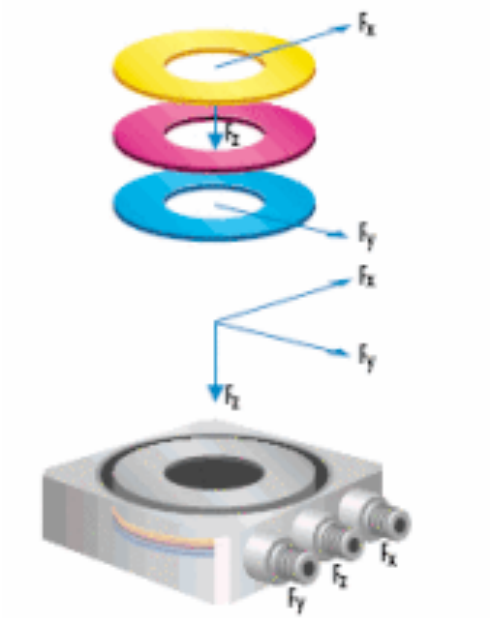
Force ➔ Deformation ➔ Modify wire shape ➔ Modify electric currant ➔ Measurement *(Smart & Costly Electronics)*

Drawbacks

- May be damage by strong forces
- Recalibration may be required
- Smart & Costly Electronics required

Robotics Force Sensors

Piezoelectric Technology



Force ➔ Electrical charge on crystal surface

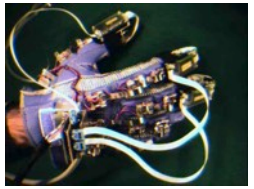
➔Measurement *(Smart & Costly Electronics)*

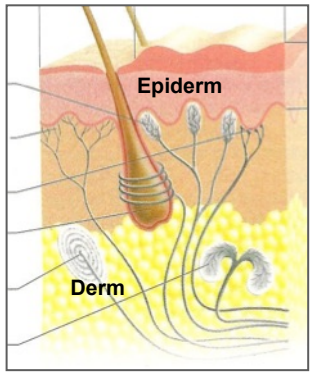
More robust to strong forces

Drawbacks

- Difficult to measure torques
- Several measurements are required *(charge accumulation)*
- Smart & Costly Electronics required

Robotics Tactile Sensors



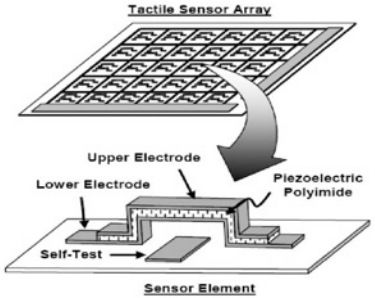


Biological system
➔Sets of specialized Tactile Sensors

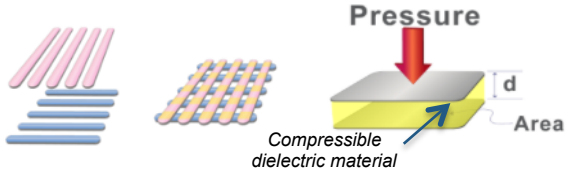
Robotics

Tactile Sensor Array + Deformable compliant material *(Elastomer)*

Piezoelectric components

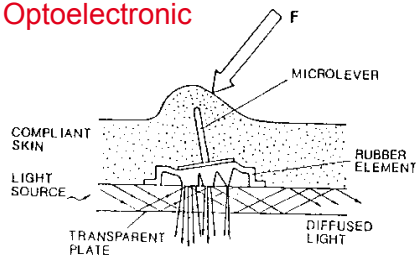


Capacitive tactile sensor (PPS)

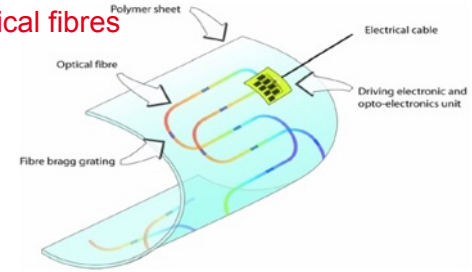


Electrodes arranged as overlapping strips (array)
*=> Capacitance at (row **i**, colomn **j**):* $C \alpha \frac{Area}{d}$

Optoelectronic



Optical fibres



=> Various technologies can be used

How to use Force & Tactile sensing for HRI ?

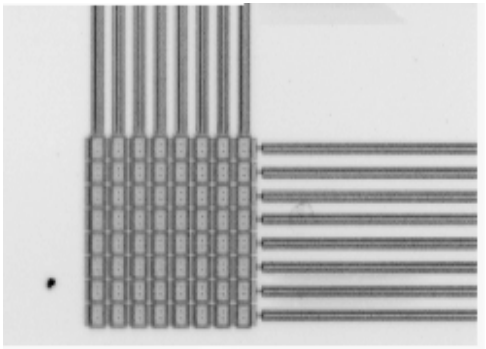
Coupling Sensors data & Human Feedback

- Sensors provide numerical force/tactile information
- Interpretation of this information by human is *difficult (much more easy for images)*

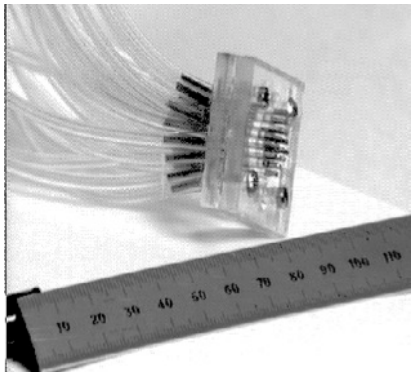
➔ *An "**Active System (e.g. Robotics devices)**"* is required to transfer the force/tactile information to human user

An example: *endoscopic force/tactile feedback system*

Capacitive sensor 8x8 (1mm)
➔ ***sensing***



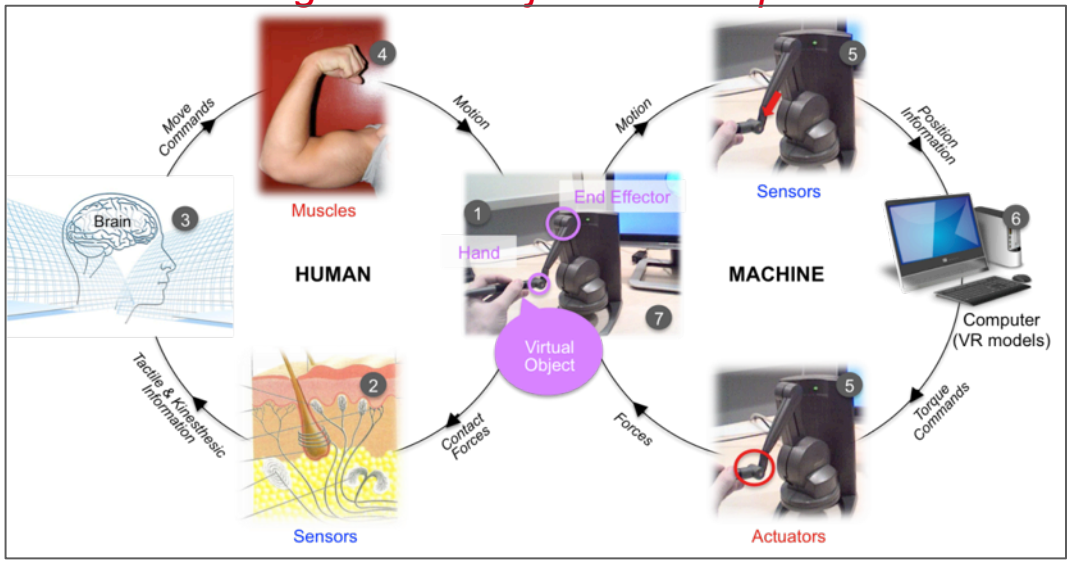
Pneumatic active device5x5 (3mm)
➔ ***Feedback to user***



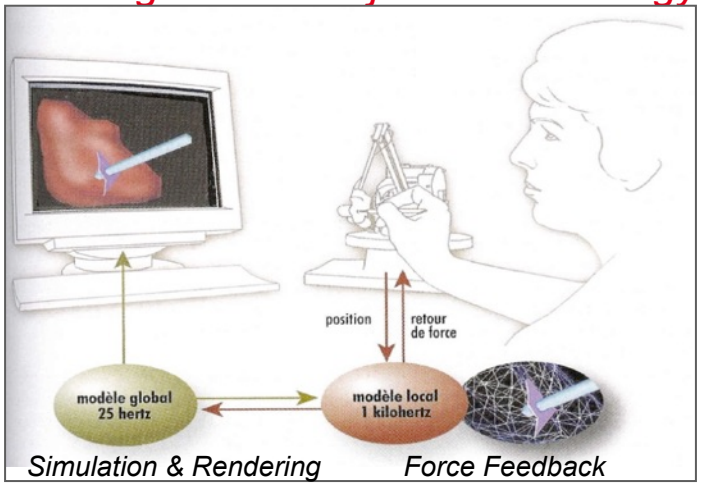
Haptic feedback in HRI

The haptic feedback loop

"Touching" virtual objects: Principle



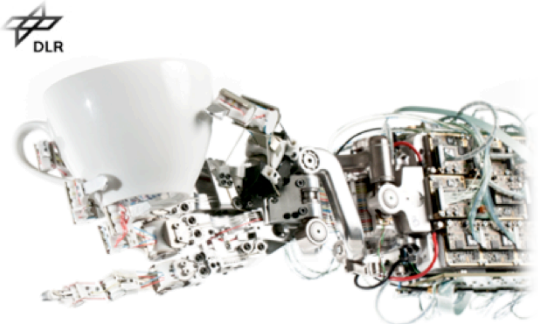
"Touching" virtual objects: Technology



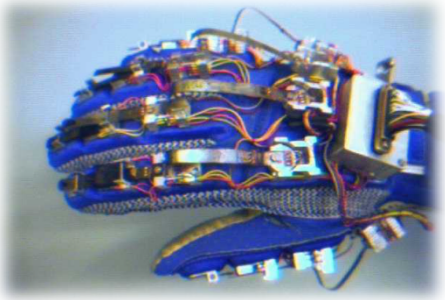
Applications

Virtual Reality, Tele-operation, Simulators, HRI

Examples of equipped Devices & Robots

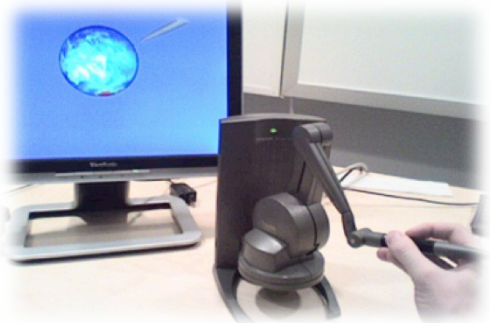


Robotics hand
(Force / Finger)



Sensitive glove
(Position & Tactile feedback)

Intuitive robot guidance
(Force feedback)



Haptic device
(Position & Force feedback)

Autonomous legged robot
(Tactile & Vision sensing)

Pictures & Movies

- p.2: Rights Reserved
- p. 6:
  - Strain gauge: By Izantux – Public Domain, via Wikimedia Commons
  - Miniaturized Wrist Sensor: By DLR, CC-BY 3.0
- p. 7: http://stephane.genouel.free.fr/FT/0%20Dossier%20technique/1%20Texte/Scenari%20capteurs/co/module_DT_19
- p. 8-11: Rights Reserved