

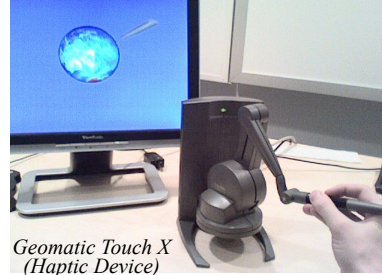
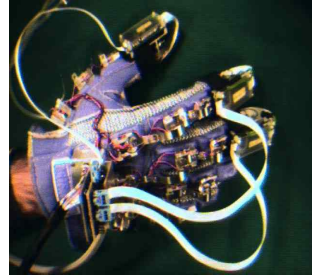
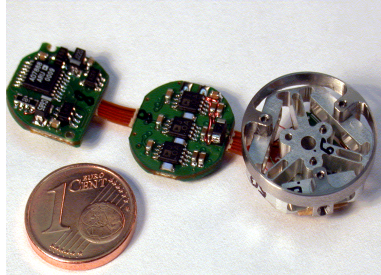
# W1. Objectives, Challenges, State of the Art, Technologies

- 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

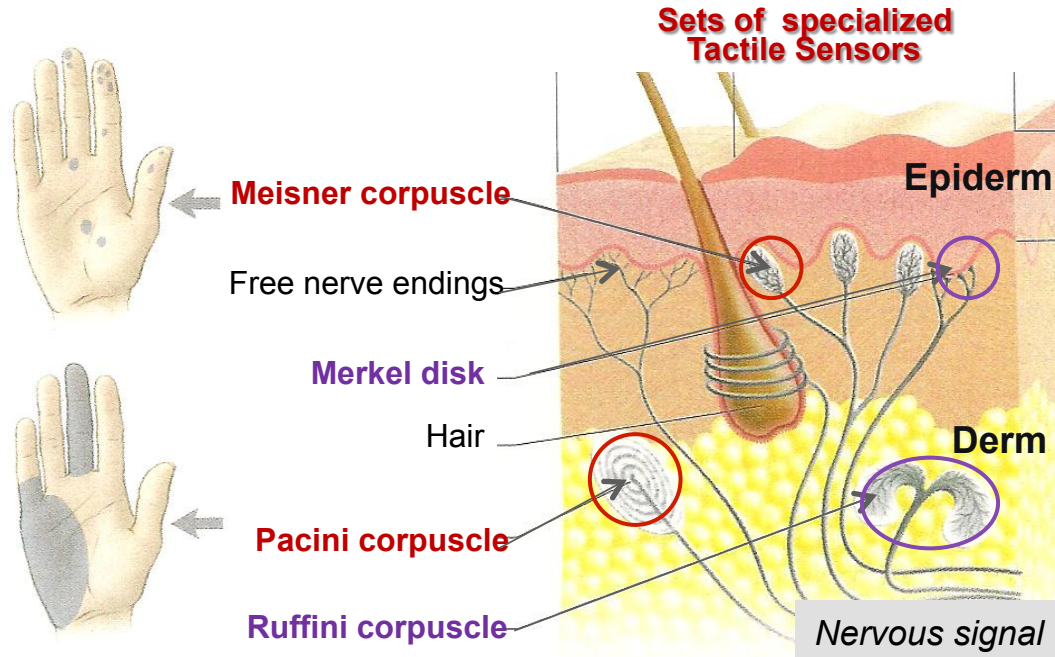
## *Force & Tactile sensing technologies*

- **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)*



# 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*

+

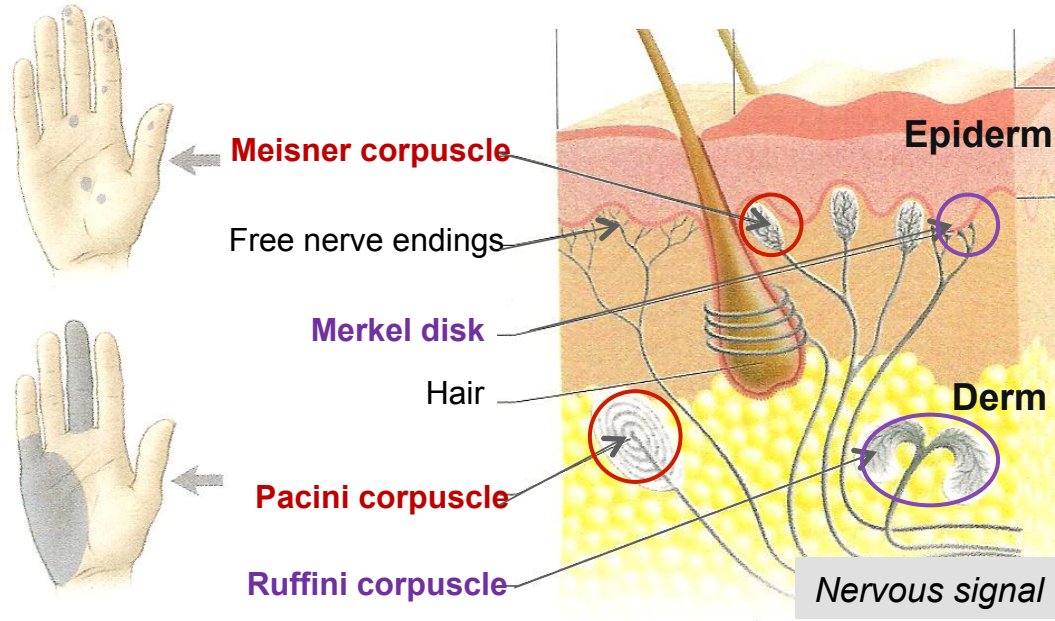
Epidermal free nerves endings

+

Hairs

# Force & Tactile Sensors for Robot Control & HRI

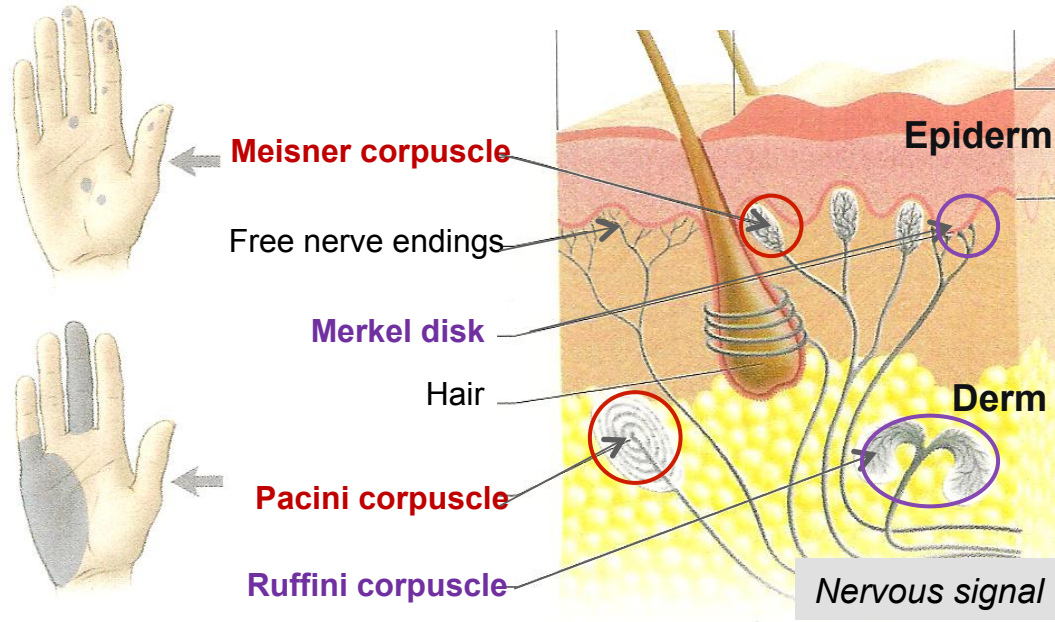
## *Biological sense of Cutaneous Touch*



- **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*



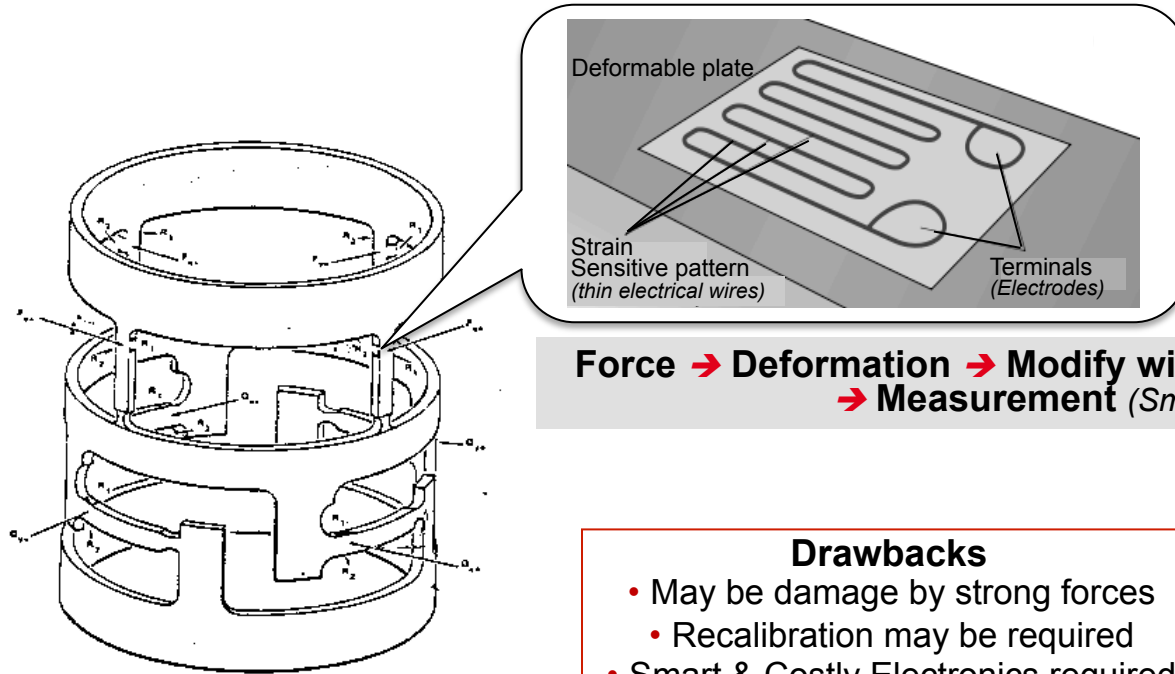
### Sensing Resolution

→ 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

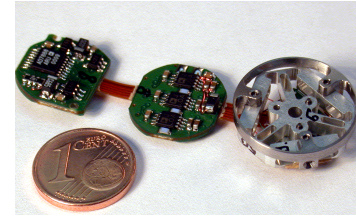
## Strain Gauges Technology



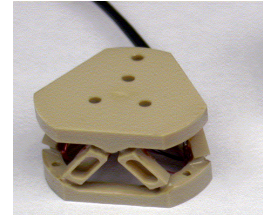
**Force → Deformation → Modify wire shape → Modify electric current → Measurement** (*Smart & Costly Electronics*)

### Drawbacks

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



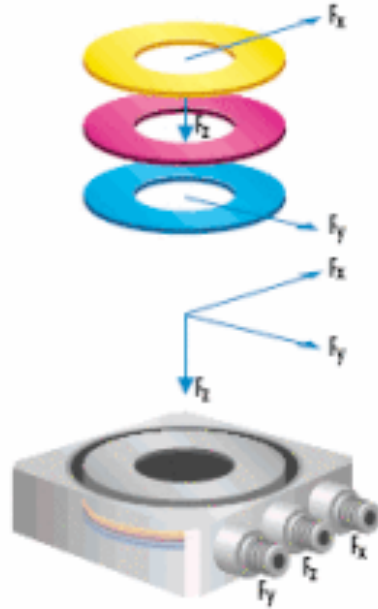
Miniaturized wrist sensor (DLR, 2002)





# Robotics Force Sensors

## *Piezoelectric Technology*



**Force → Electrical charge on crystal surface**

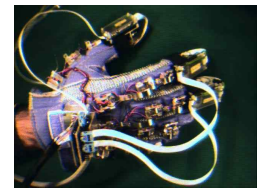
**→ Measurement** (*Smart & Costly Electronics*)

*More robust to strong forces*

### **Drawbacks**

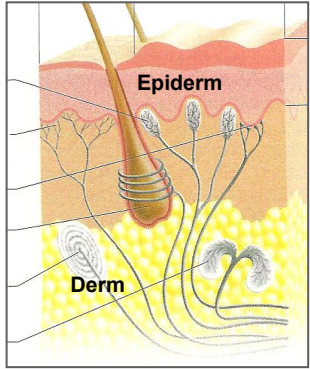
- Difficult to measure torques
- Several measurements are required (*charge accumulation*)
- Smart & Costly Electronics required

# Robotics Tactile Sensors



## Robotics

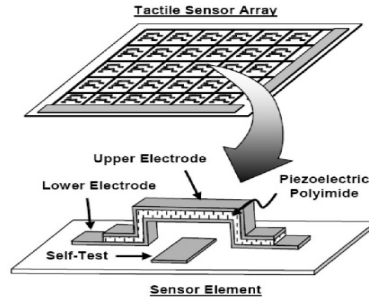
### Tactile Sensor Array + Deformable compliant material (Elastomer)



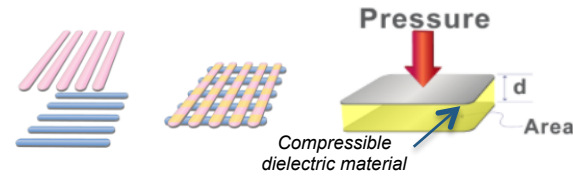
**Biological system**  
→ Sets of specialized  
Tactile Sensors



#### Piezoelectric components

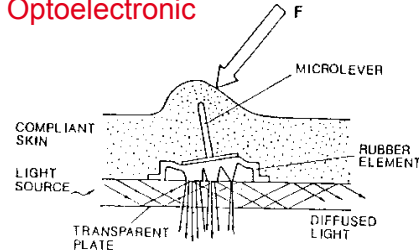


#### Capacitive tactile sensor (PPS)

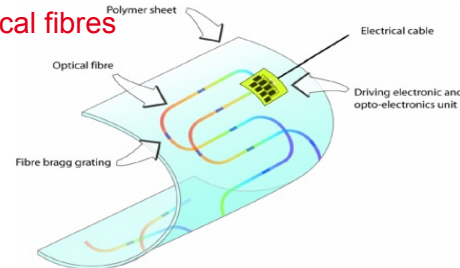


Electrodes arranged as overlapping strips (array)  
=> Capacitance at (row  $i$ , column  $j$ ):  $C \propto \frac{\text{Area}}{d}$

#### Optoelectronic



#### Optical fibres



=> Various technologies can be used



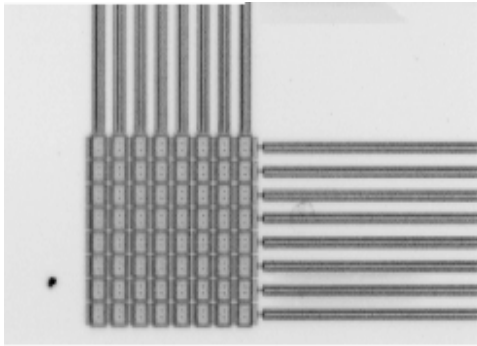
# How to use Force & Tactile sensing for HRI ?

## *Coupling Sensors data & Human Feedback*

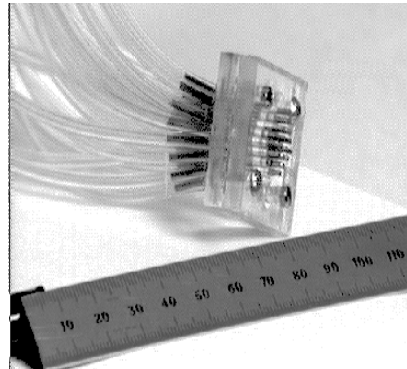
- Sensors provide numerical force/tactile information
  - Interpretation of this information by human is *difficult* (much more easy for images)
- An “**Active System (e.g. Robotics devices)**” is required to transfer the force/tactile information to human user

### **An example:** *endoscopic force/tactile feedback system*

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



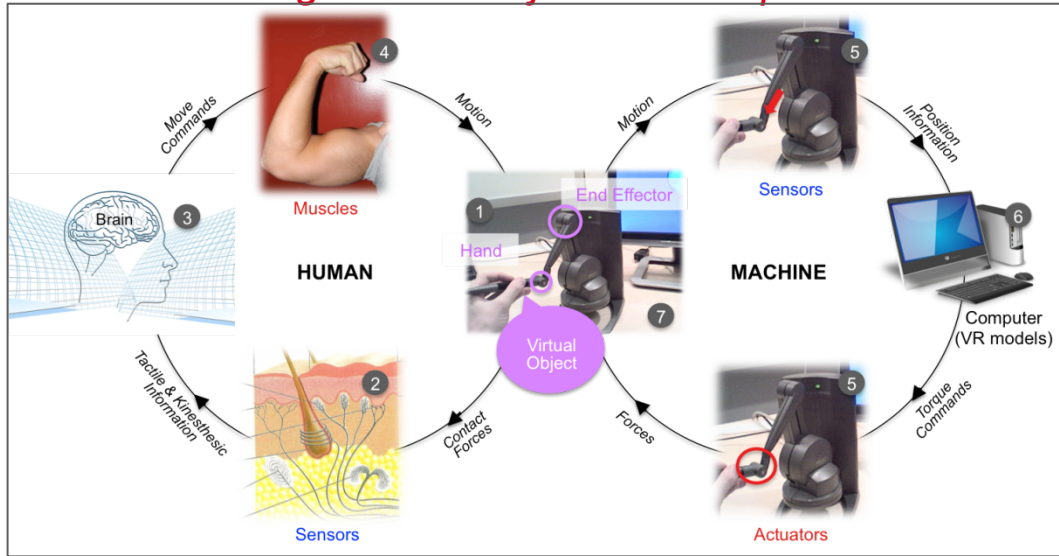
Pneumatic active device 5x5 (3mm)  
→ **Feedback to user**



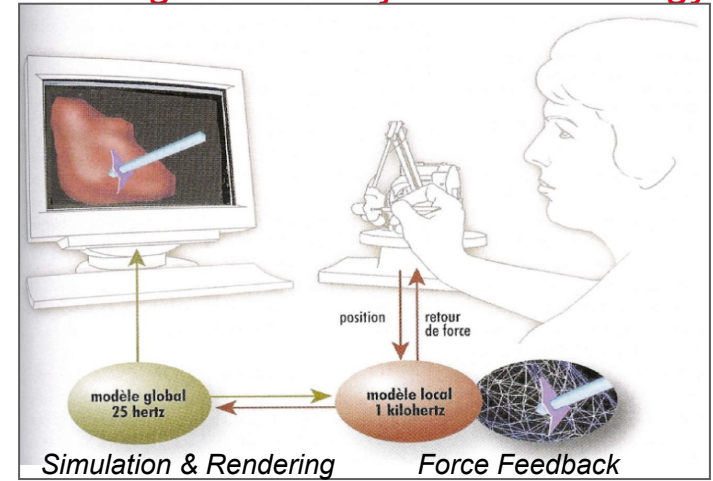
# Haptic feedback in HRI

## *The haptic feedback loop*

### *“Touching” virtual objects: Principle*



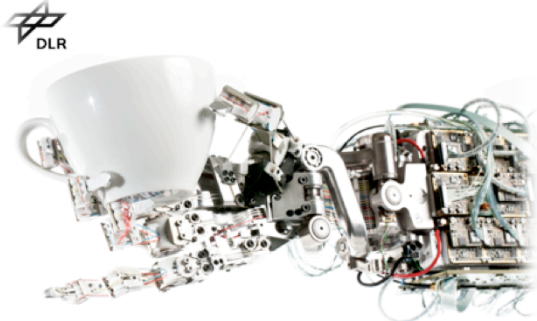
### *“Touching” virtual objects: Technology*



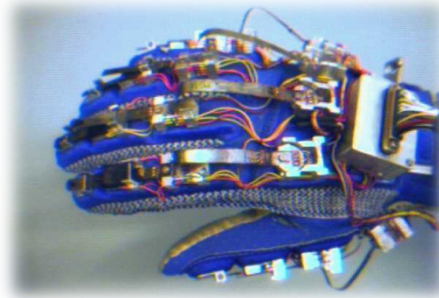
## *Applications*

*Virtual Reality, Tele-operation, Simulators, HRI*

# Examples of equipped Devices & Robots



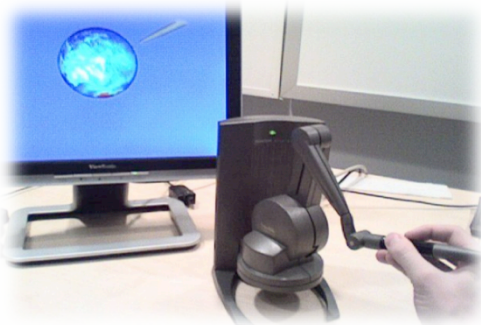
**Robotics hand**  
(Force / Finger)



**Sensitive glove**  
(Position & Tactile feedback)



**Intuitive robot guidance**  
(Force feedback)



**Haptic device**  
(Position & Force feedback)



**Autonomous legged robot**  
(Tactile & Vision sensing)

# Pictures & Movies

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