



Tactile Feedback in Surgery - an introduction

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Haptic Rendering Workshop, Eurohaptics
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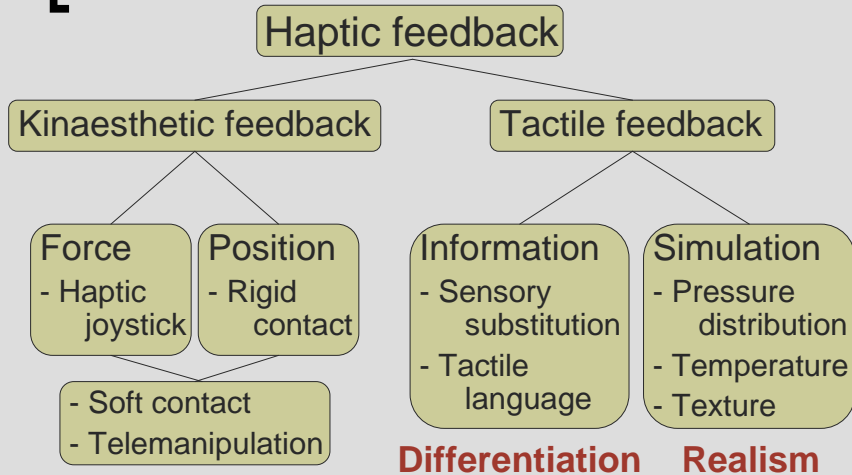
Contents

- Haptic feedback
- Mechanoreceptors in the Skin
- Requirements
- Minimally Invasive Surgery
- Tactile Feedback System
 - Tactile Sensors
 - Tactile Displays



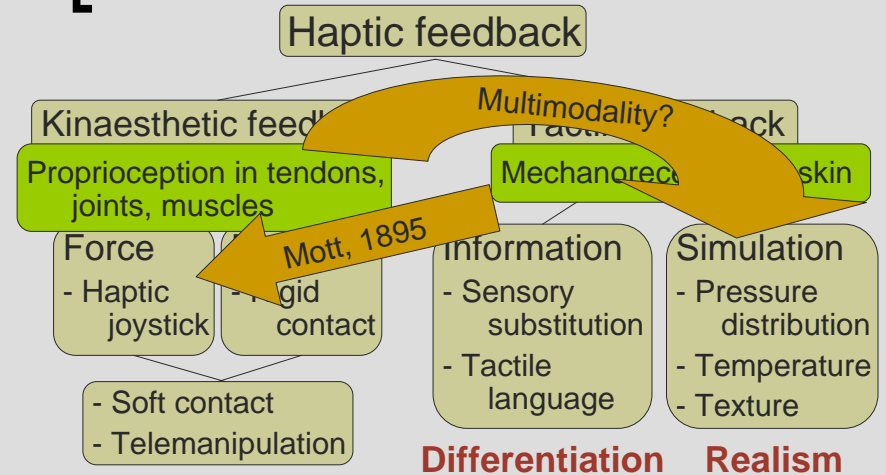
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Haptic Feedback



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Haptic Feedback

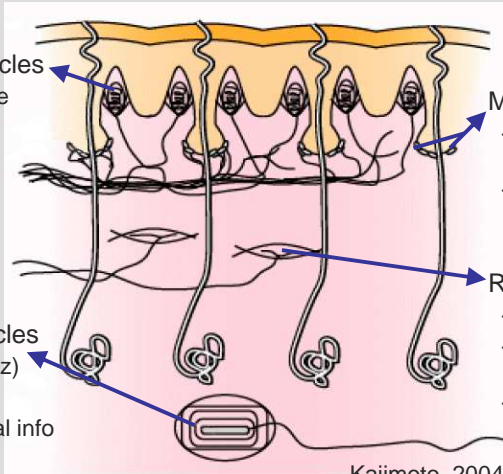


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Mechanoreceptors in the Skin

FA

- Meissner corpuscles
- pressure change
 - rough texture
 - vibrotactile patterns
 - slip detection



SA

- Merkel disks
- small scale shape
 - finest details (e.g. Braille)
- Ruffini endings
- warmth
 - direction of stretch
 - in glabrous skin??

- Pacinian corpuscles
- vibration (250 Hz)
 - fine texture
 - almost no spatial info

Kajimoto, 2004

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Requirements Surgery

- Stroke: 2 mm
- Pressure: 0.8-500 kPa / 10% \rightarrow 10-100 kPa
- Bandwidth: DC to 0-1000 Hz \rightarrow 0-40 Hz
- Resolution: 0.9 mm \rightarrow 1 mm
- # taxels: 200 (skin area: 16x10 mm)
- ~~Heat, cold, skin stretch...~~ \rightarrow 160
- \rightarrow not realistic
- \rightarrow application specific

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Why Tactile Feedback?

- Palpation is one of the main techniques to intraoperatively examine evidence for metastases, and identifying therapeutic margins for curative resection.

P.M.McCormack, et al. 1993

T.S.Ravikumar et al. 1994

C.Nies et al. 1996

J.A.Norton et al. 1990

- Accurate palpation and examination proves to be one of the best diagnostic techniques.

Scott and Darzi 1997

Dunn 1994

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Minimally Invasive Surgery

Palpation is absent in surgical robotics

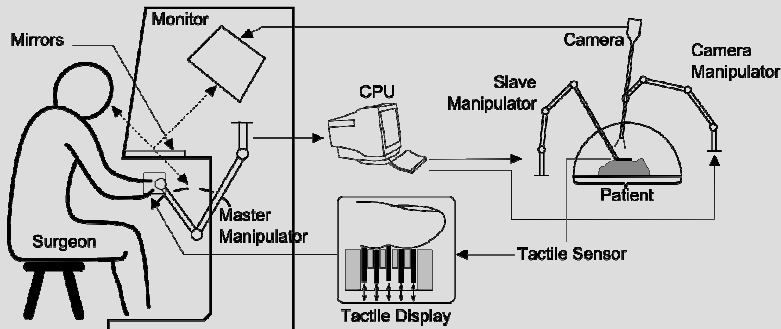


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Tactile Feedback System

- Tactile feedback in MIS

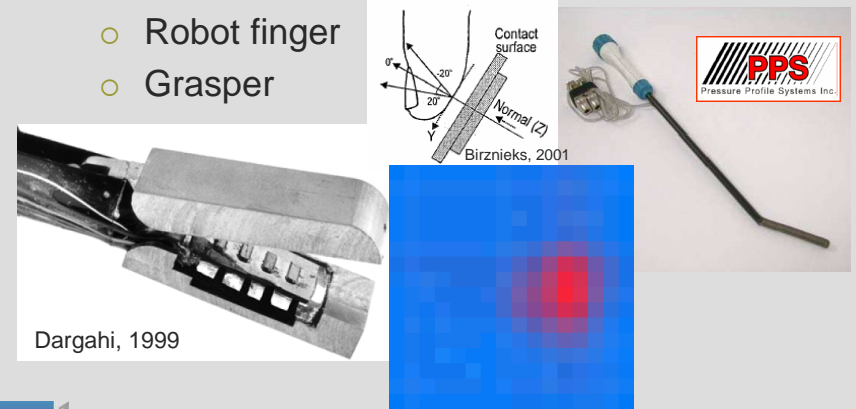


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Tactile Sensor

- Surface sensor: pressure distribution
 - Robot finger
 - Grasper

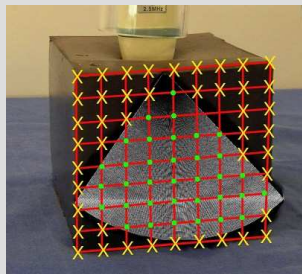


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Tactile Sensor

- Indirect tactile image
 - Elastography
 - Measures deeper in tissue
 - Tactile image reconstructed

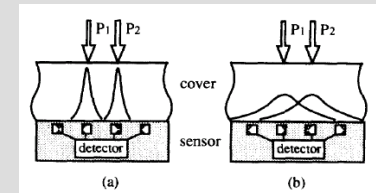
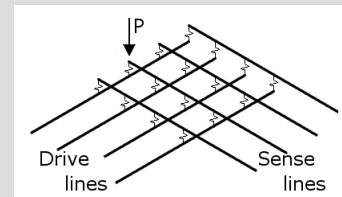


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Tactile Sensor

- Number of wires
 - One wire/fibre per element
 - $N^2 \rightarrow 2N$ (crosstalk)
- Elastomer layer
 - Part of sensing principle
 - Protective layer
 - e.g. fragile silicon
 - Reduce impact force or vibration
- Spatial low-pass filter



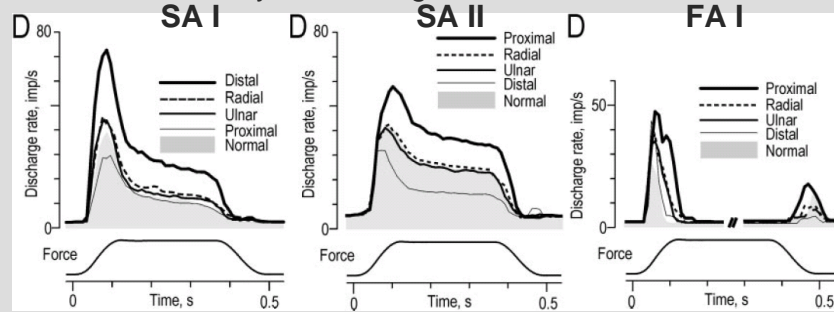
Shimojo, 1994

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Tactile Sensor

- Elastomer layer
 - Creep, hysteresis, temperature dependence...
 - Skin only uses rising force



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Tactile Display

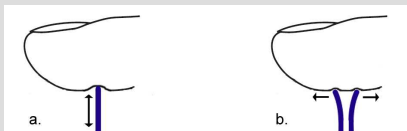
- Design issues
 - Vibrotactile display vs Shape display
 - Easier
 - Texture
 - Fatigue
 - Combination?
 - Difficult
 - Palpation
 - Shape display that can vibrate

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Tactile Display

- Design issues
 - Orthogonal (OI) vs Lateral (LSS)



- Shape simulation with LSS?
 - Peeters, Eurohaptics 2008
- Combination?
 - Moving whole display

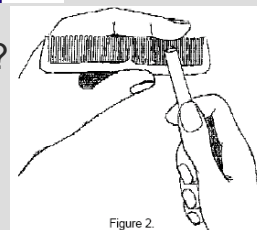


Figure 2
Hayward, 2000

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Tactile Display

- Design issues
 - Position control vs Force control
 - ➔ high stiffness vs low stiffness
 - ➔ connected with actuator principle
 - Force control is more directly connected with pressure distribution tactile sensor

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