Haptic Interfaces: New Strategies to Convey Tactile Information

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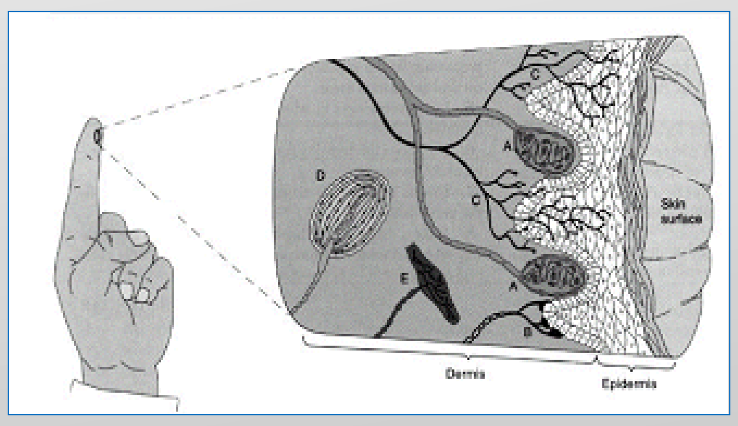
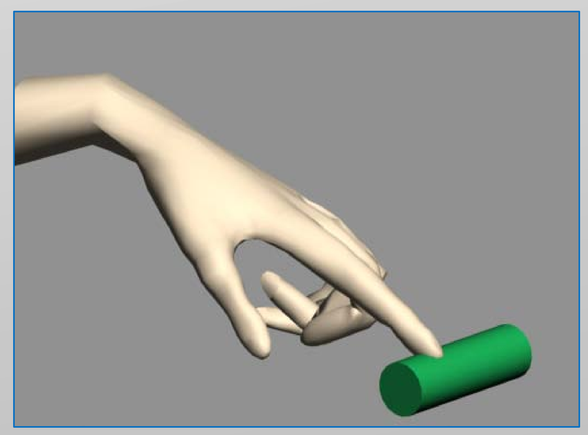
Introduction: Discrimination of Softness

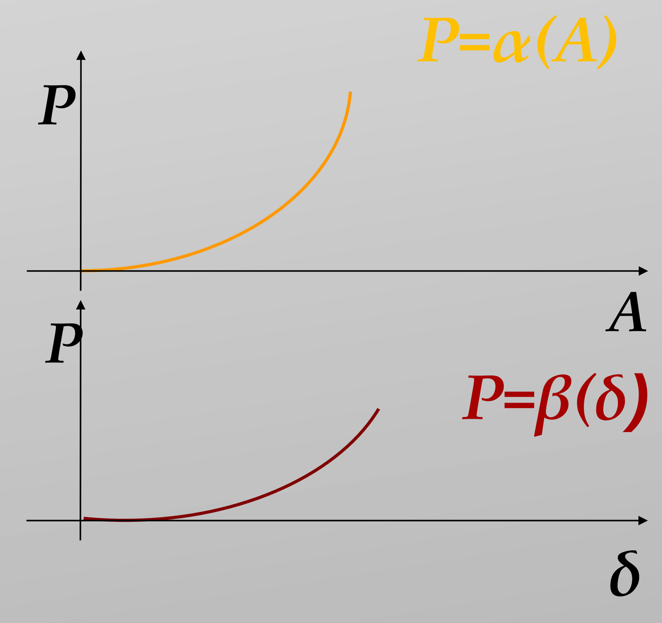


From Paul Paolini’s home page

The two main modalities on which relys the sense of touch:

- **Cutaneous Information** : $P=\alpha(A)$
  (SA1 Merkel, RA Meissner, PC-Pacini, SA2 Ruffini)
- **Kinaesthesia** : $P=\beta(\delta)$
  (Articular Joints, Tendons, Muscles)

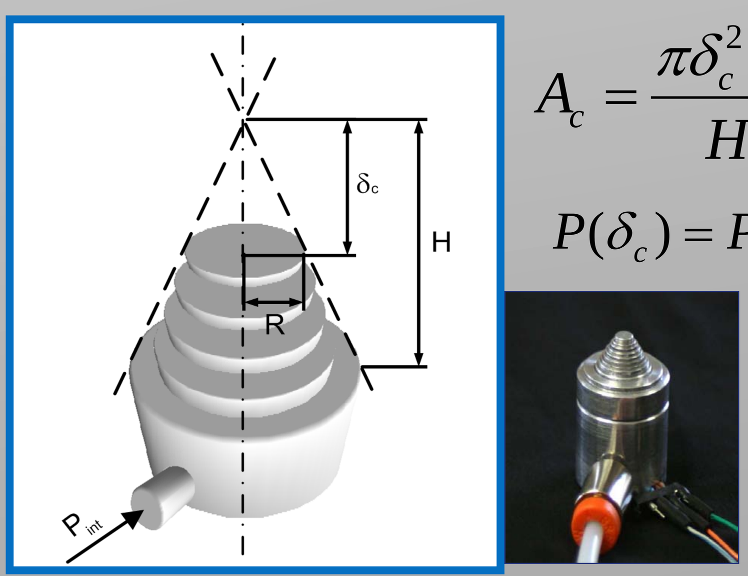




The cutaneous cues are generally predominant [1], but both information channels are fundamental for a fine perception

The Importance of Cutaneous Cues(i): CASR-based Displays

A large part of cutaneous information is described by the rate by which contact area spreads under increasing force (**CASR**)



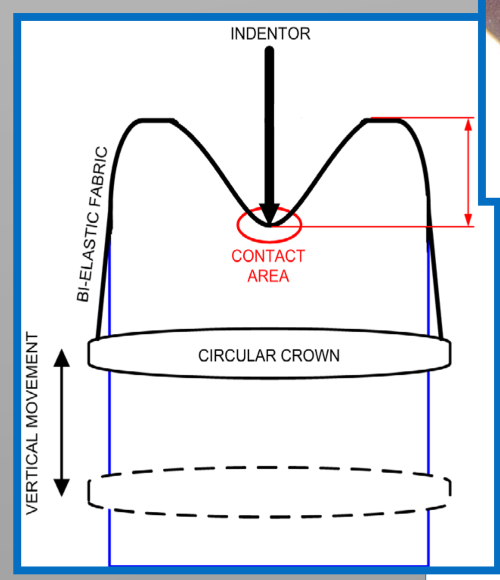
$$A_c = \frac{\pi\delta_c^2 R^2}{H^2}$$

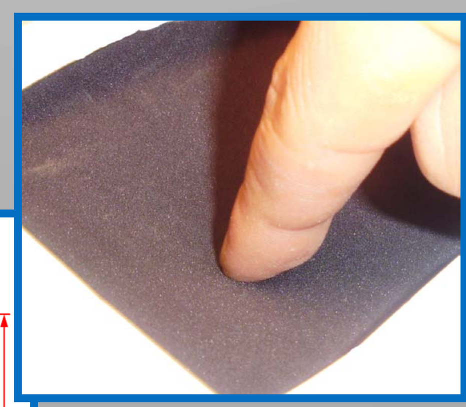
$$P(\delta_c) = P_{int} A_c$$

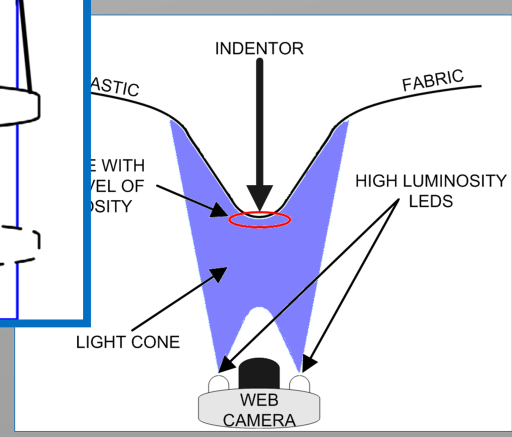
Discrete CASR Display [2]

FYD: Fabric Yielding Display [3]

- Bi-elastic fabric based
- Tissue stretch
- Contact Area Measurement
- Interaction with a deformable surface

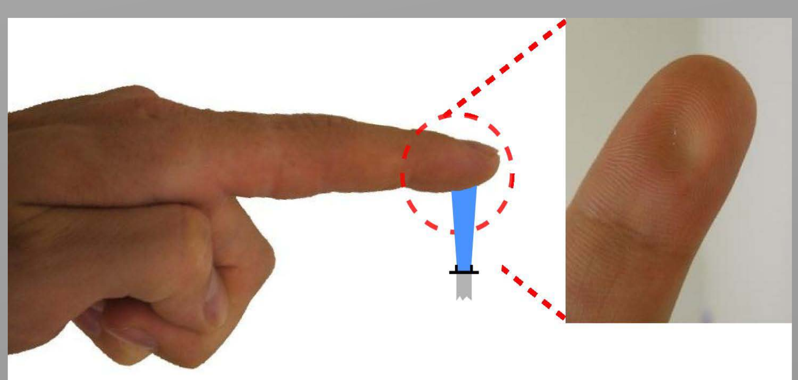




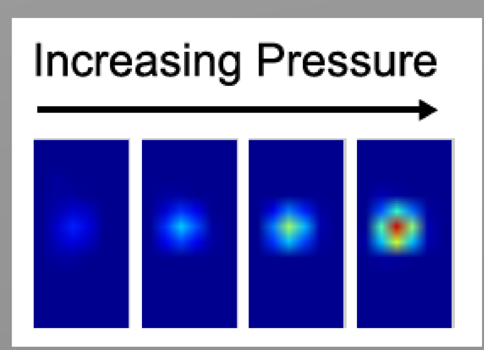


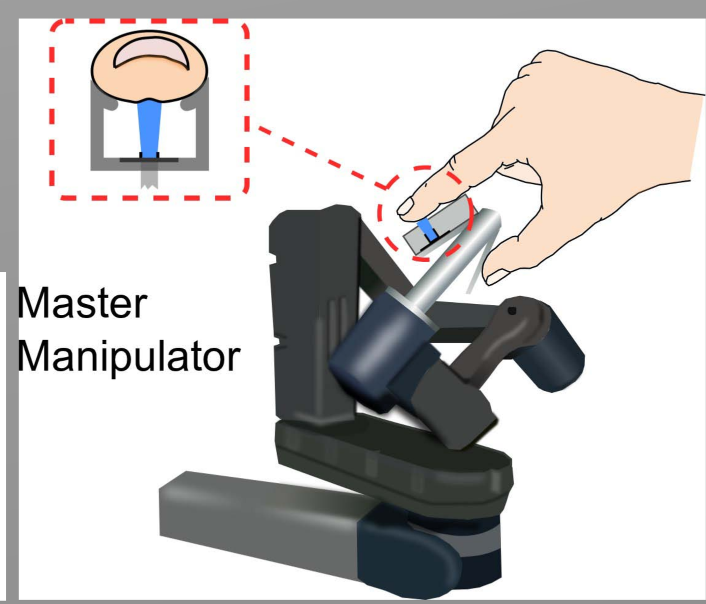
These displays improve accuracy and sensitivity in haptic rendering but, unfortunately they are not able to implement two independent P(A) and P(δ) profiles

The Importance of Cutaneous Cues(ii): Lump Display for RMIS



- Surgical exploration tasks such as lump detection require distributed tactile feedback
- Weight and Size constraints in RMIS (pneumatic approach)
- Skin deformation - feels like a lump
- Control Variables: Aperture Size – Pressure [4]
- Characterization

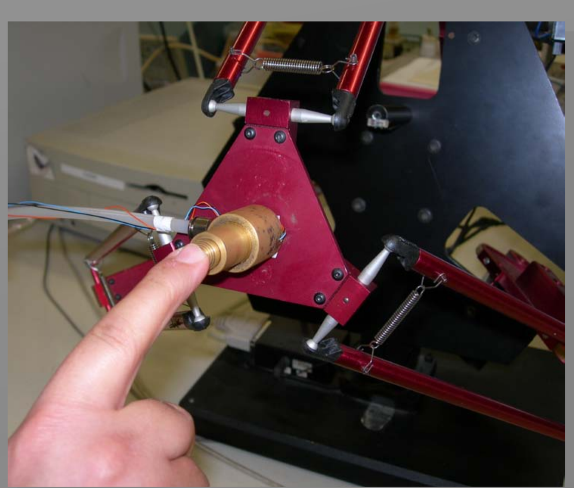




This work has been developed at the Haptics Lab of Prof. A.M. Okamura – Johns Hopkins University

The Integrated Haptic Device: Perceptual Ambiguities

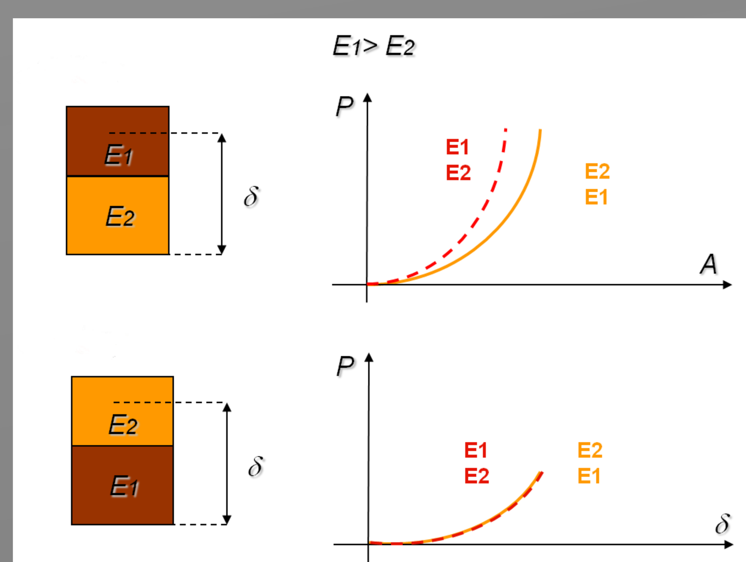
- Distinct objects which, probed for softness, provide identical kinaesthetic information but different cutaneous information (as well as the opposite)
- The integrated haptic approach [5] is fundamental, allowing to enlarge the class of stimuli that can be vehicled to subjects



INTEGRATED DEVICE: SERIES CASR+DHD :
$\delta = \delta S + \delta D$

- Two arbitrary curves: **P** $\alpha m(Am)$ and $P = \beta m(\delta m)$
- Two independent controls: **Pint**, **PD**
- For **A=Am** :
- $$\delta_d = \delta_m = \beta_m^{-1}(P) - \frac{H}{R}\sqrt{\frac{P}{P_{int}\pi}}$$ ***Reference for DHD PID Control Loop***

PERFORMANCE INCREASES



	Class CL1 (I)	Class CL2 (K)	Class CL3 (C)
SS1	0% / 0%	Rigid / 0%	0% / 45%
SS2	10% / 10%	Rigid / 10%	10% / 35%
SS3	20% / 20%	Rigid / 20%	20% / 20%
SS4	35% / 35%	Rigid / 35%	35% / 10%
SS5	45% / 45%	Rigid / 45%	45% / 0%

CL1(I): different P(A) , P(δ)
CL2 (K): same P(A)
CL3(C): same P(δ)

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[1] Srinivasan M.A., LaMotte R.H.: Tactile Discrimination of Softness. J Neurophysiol, vol. 73, n. 1, 88-101,(1995)
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