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Exploring Haptic Feedback for the Pisa/IIT SoftHand

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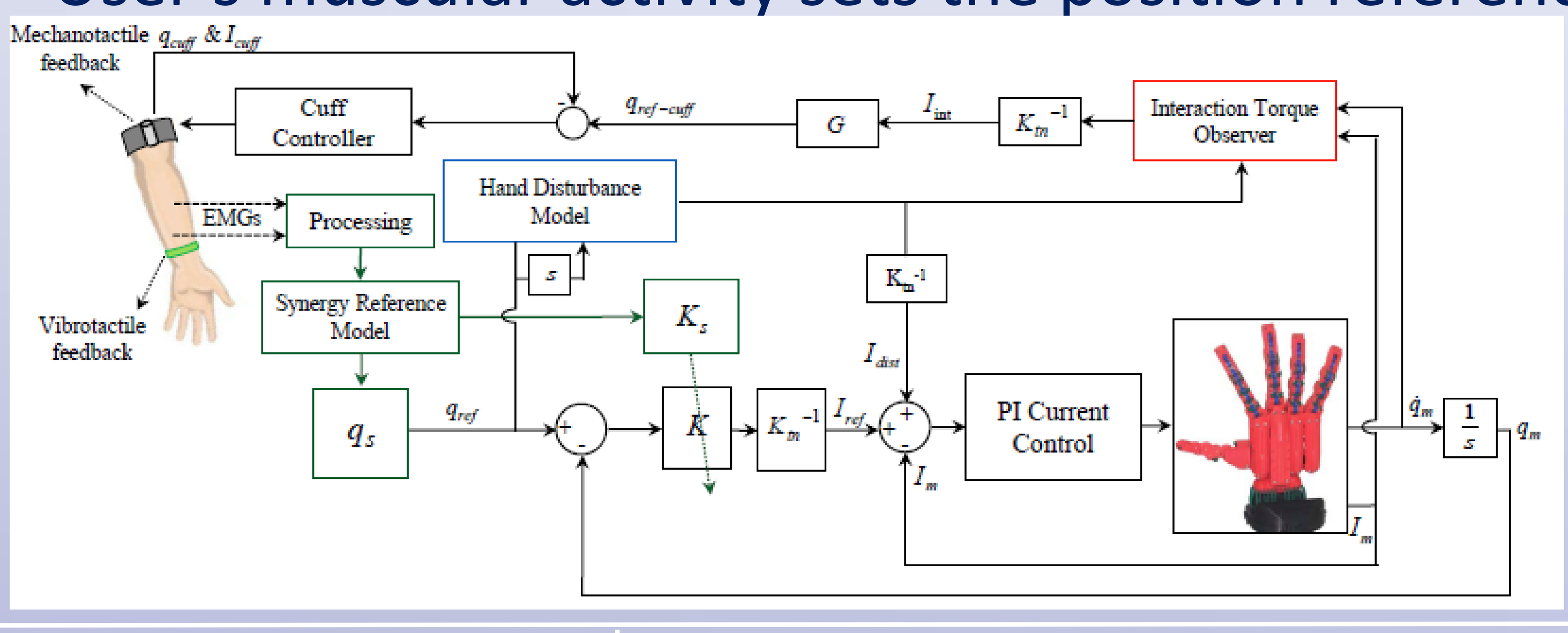
Pisa/IIT SoftHand

The Pisa/IIT SoftHand [1] was designed to be a safe and robust robotic hand that moves along physiologically accurate trajectories. Built into the mechanical design is the first hand movement synergy, as determined by Principal Component Analysis. The SoftHand's soft-robotics design allows it the flexibility to move along this path and adjust to the contours of the environment it encounters, resulting in a grasp molded around the target object. An anthropomorphic hand that is easy to control and flexible offers an ideal starting point for a new prosthetic hand. **The purpose of this demo is to show several types of feedback we have been working on [2] to make SoftHand use more intuitive and comfortable.**

SoftHand Demo Videos

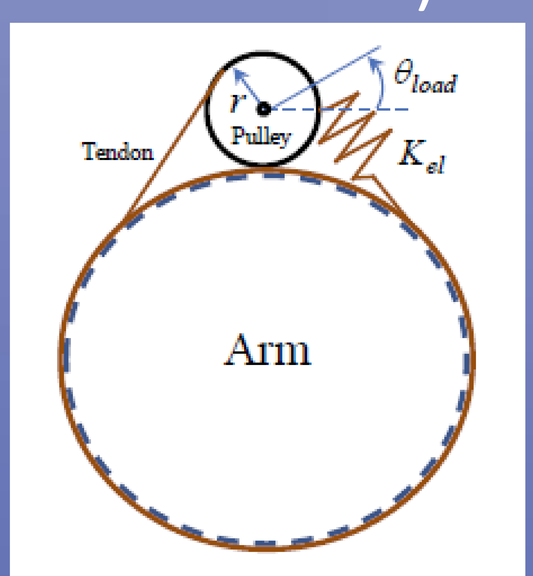
- Inner motor control loop is a high bandwidth current regulator
- Outer loop implements the impedance controller, updated by the user's stiffness profile (from co-contractions)
- User's muscular activity sets the position reference.

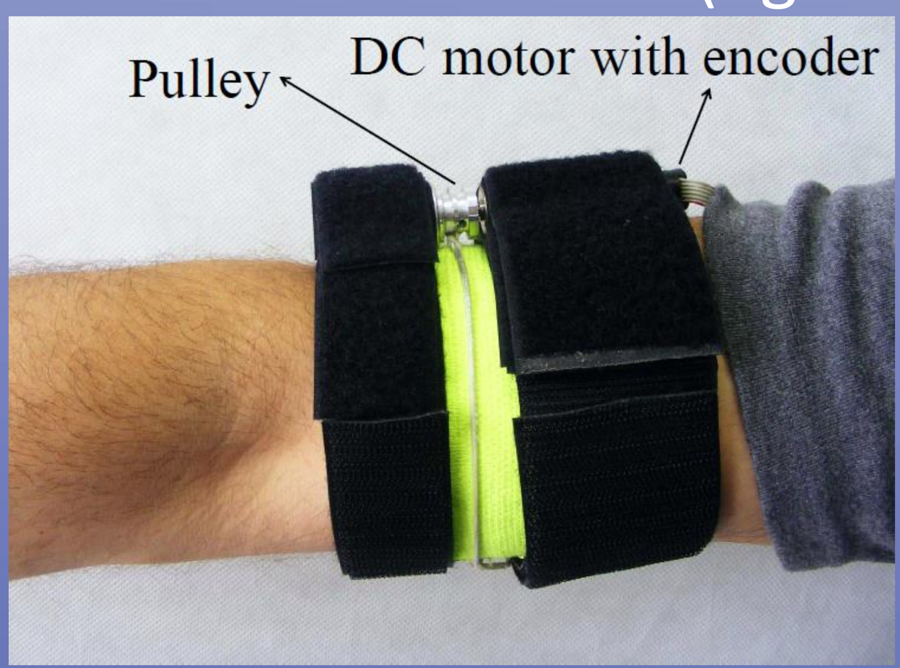


•The interaction torque observer estimates grasp force to be fed back to the user (more details below)

Force Feedback

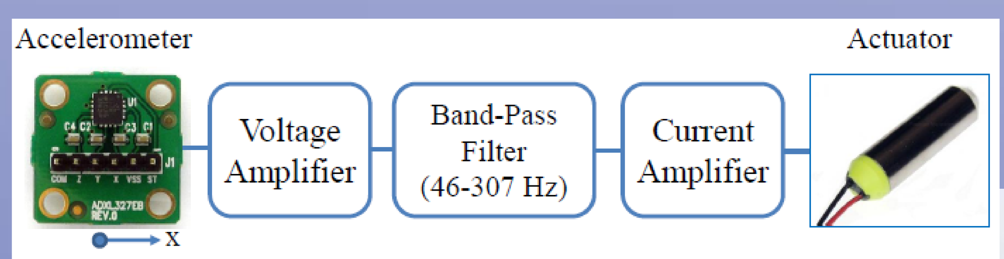
- ❑ Goal: provide sense of grasp force to user to enable more secure grasp and allow grasp without visual feedback
- ❑ Method: The interaction torque observer is used to determine the grasp force. This force is then experimentally scaled and delivered to:
  - ❑ Small (24 x 7 mm) eccentric mass motor for vibrotactile feedback
  - ❑ Small DC motor attached to a band encircling the arm for mechanotactile feedback (figs below)

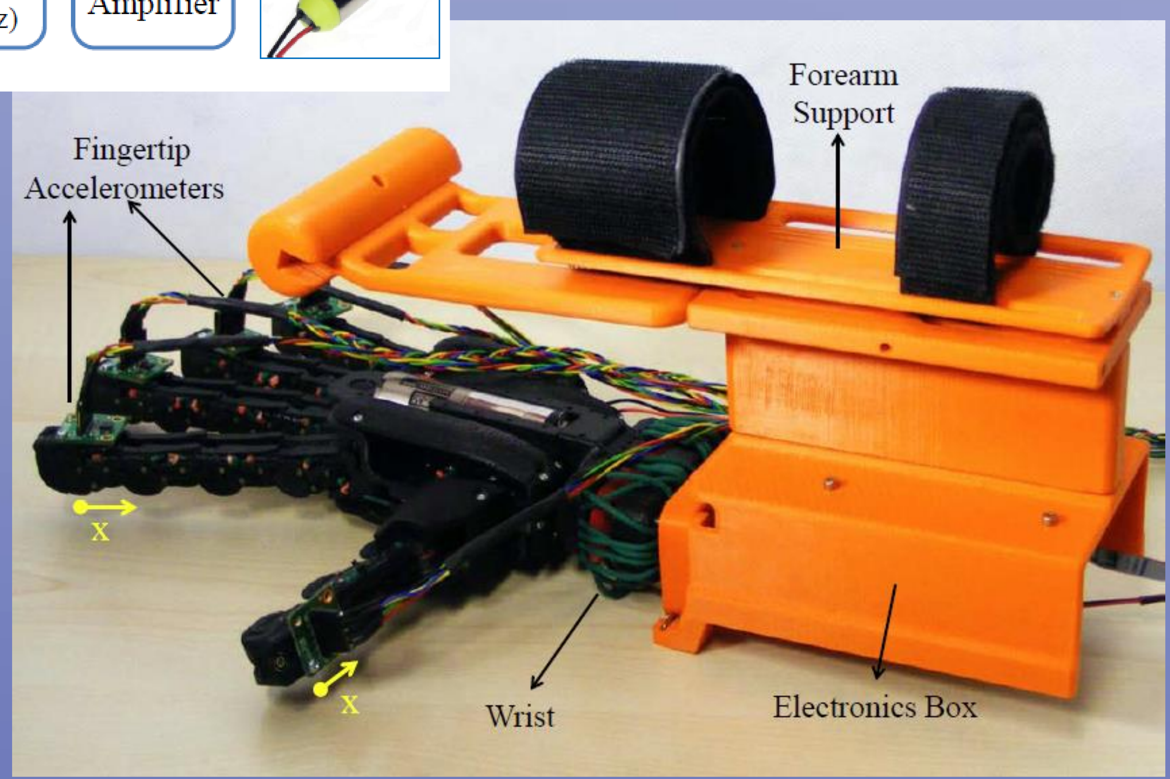




Surface Texture Feedback

- ❑ Goal: provide knowledge of surface texture to aid in exploration and grasping without visual feedback [3]
- ❑ Method: Accelerometers (range ± 2g) on the dorsal part of the SoftHand phalanges registered variations in surface texture. Data from the x-axis was then replicated on the user side with small eccentric mass motors worn on the dorsal side of the forearm





Refs. [1] Catalano M, Grioli G, Farnioli E, Serio A, Piazza C, and A. Bicchi. (2013) Adaptive synergies for the design and control of the Pisa/IIT SoftHand, International Journal of Robotic Research. In press, 2013

[2] A. Ajoudani, S.B. Godfrey, M. Bianchi, M. Catalano, G. Grioli, N. Tsagarakis, and A. Bicchi. Exploring Teleimpedance and Tactile Feedback for Intuitive Control of the Pisa/IIT SoftHand. Transactions on Haptics. In press. 2014.

[3] K. Kuchenbecker, J. Gewirtz, W. McMahan, D. Standish, P. Martin, J. Bohren, P. Mendoza, and D. Lee, "Verrotouch: High-frequency acceleration feedback for telerobotic surgery," in Haptics: Generating and Perceiving Tangible Sensations, ser. Lecture Notes in Computer Science, A. Kappers, J. Erp, W. Bergmann Tiest, and F. Helm, Eds. Springer Berlin Heidelberg, 2010, vol. 6191, pp. 189–196.