

16-899: Reference list for Wednesday, Mar 16th

I started with a couple of papers that attempt to separate out different contributions so passive compliance of the human index finger:

Knutson JS, Kilgore KL, Mansour JM, Crago PE. Intrinsic and extrinsic contributions to the passive moment at the metacarpophalangeal joint. *Journal of biomechanics*. 2000 Dec 31;33(12):1675-81.

<http://www.jbiomech.com/article/S0021-9290%2800%2900159-7/abstract>

Kuo PH, Deshpande AD. Muscle-tendon units provide limited contributions to the passive stiffness of the index finger metacarpophalangeal joint. *Journal of biomechanics*. 2012 Oct 11;45(15):2531-8.

<http://www.jbiomech.com/article/S0021-9290%2812%2900466-6/abstract>

Then I briefly showed some results for how stiffness, mass, and damping of the finger scale with applied force:

Hajian AZ, Howe RD. Identification of the mechanical impedance at the human finger tip. *Journal of biomechanical engineering*. 1997 Feb 1;119(1):109-14.

http://biorobotics.harvard.edu/pubs/1997/hajian_JBE1997.pdf

The higher level questions, though, center around how we actively modulate compliance, e.g., through co-contraction. This paper gives a great overview of research results related to such questions:

Franklin DW, Wolpert DM. Computational mechanisms of sensorimotor control. *Neuron*. 2011 Nov 3;72(3):425-42.

<http://www.sciencedirect.com/science/article/pii/S0896627311008919>

Many of the cited results have to do with arm motion – reaching, tracking, etc. There have also been quite a few results looking at grasp stiffness, going back to the same research team whose stiffness analysis techniques were discussed by Reuben on Monday:

Kao I, Cutkosky MR, Johansson RS. Robotic stiffness control and calibration as applied to human grasping tasks. *Robotics and Automation, IEEE Transactions on*. 1997 Aug;13(4):557-66.

http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=611319&filter%3DAND%28p_IS_Number%3A13344%29

All of the research results we discussed make use of techniques to either measure passive force while manipulating pose or measuring displacement when applying a disturbance force.

It is interesting to think about how stiffness might be measured in performance of natural tasks. This paper from the graphics community attempts to do just this. Take a look at both the paper and their video:

Kry PG, Pai DK. Interaction capture and synthesis. In ACM Transactions on Graphics (TOG) 2006 Jul 30 (Vol. 25, No. 3, pp. 872-880). ACM.
<http://www.cs.rutgers.edu/mcl/ic/siggraph06.html>