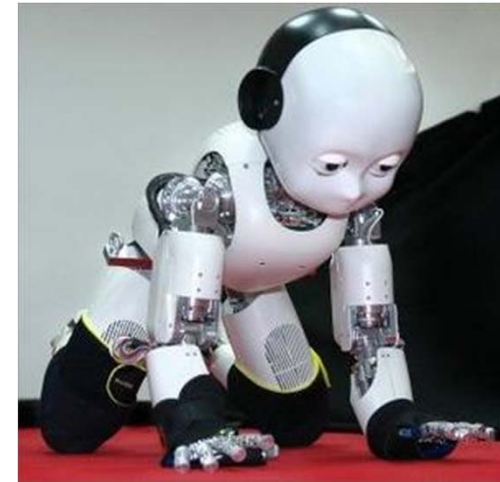
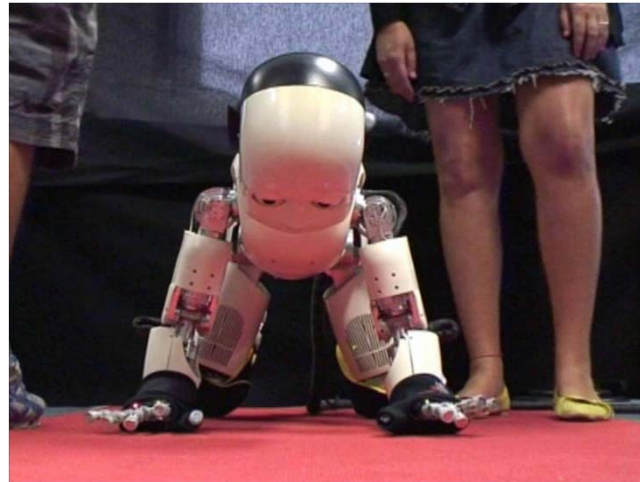


# (Force Controlled) iCub Balancing

Competences:

- Control theory
- Dynamic modeling
- Programming (C++)
- Biomechanics?
- Human motor control?



Humanoid Push Recovery Experiments

Benjamin Stephens

Carnegie Mellon University

11/11/2010

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Full-Body Compliant  
Human-Humanoid Interaction:  
**Balancing** in the Presence of  
Unknown External Forces

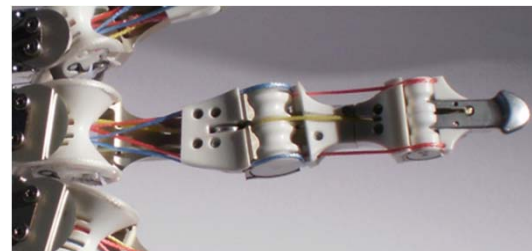
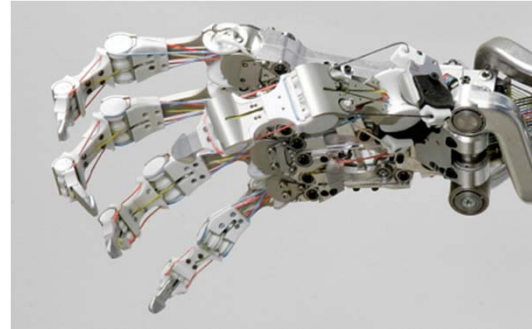
Sang-Ho Hyon  
Joshua G. Hale  
Gordon Cheng

**ATR** Computational Neuroscience  
Laboratories, Japan

# SOFT ROBOTICS



- Growing interest in the research community on the development of “soft” robotic systems
- Other works within RBCS on this topic focused on the design of soft hands



- Antagonistic actuation
- Tendon driven
- Monolateral contact joints

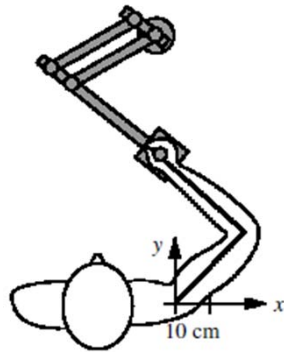
These principles have been successfully integrated in the DLR HAND III system [Greibenstein et al. 2010] (see photos)

#### Competences:

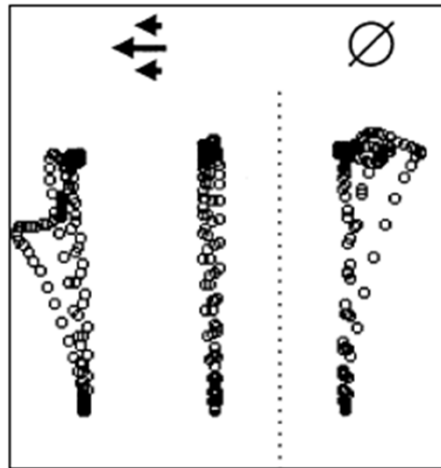
- machine/mechanism design skills
- usage of 3D parametric CAD programs (ideally ProE)
- knowledge of the properties of and processes for polymeric materials

# Muscle Synergies and Cocontraction

## F. Mussa-Ivaldi

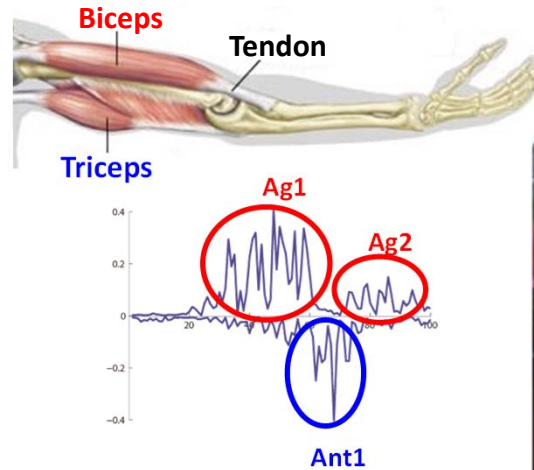


### Velocity Dependent Force Field



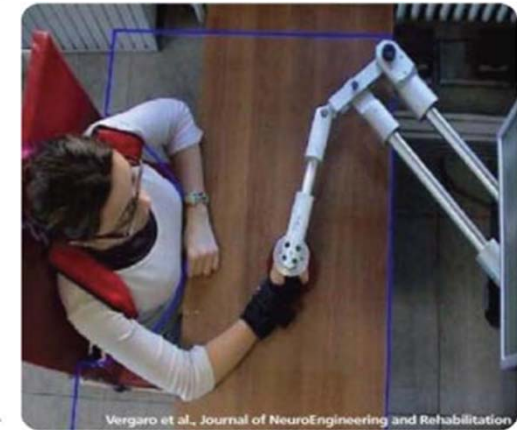
Initial Trials      After Learning      After Effects

## EMG Signals

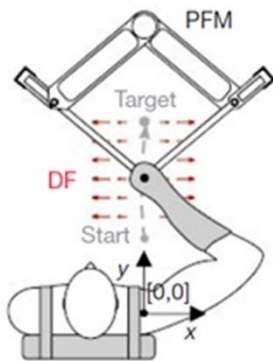


Competences:

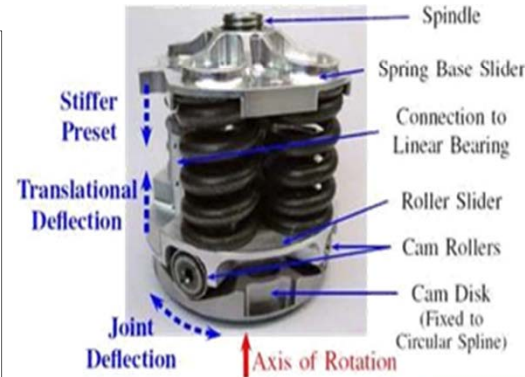
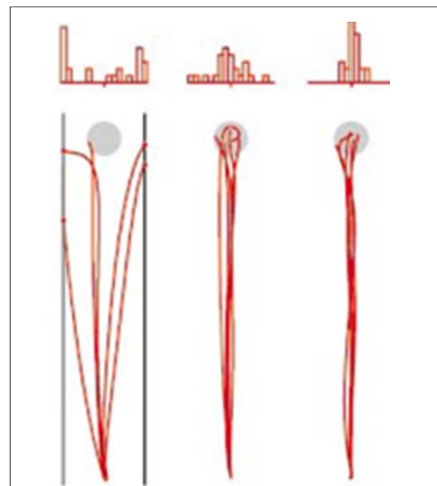
- Human motor control
- Biomechanics
- Dynamic modeling
- Data analysis



## E. Burdet



### Divergent Field



$$X = l_1 \begin{pmatrix} \cos \theta_1 \\ \sin \theta_1 \end{pmatrix} + l_2 \begin{pmatrix} \cos(\theta_1 + \theta_2) \\ \sin(\theta_1 + \theta_2) \end{pmatrix}$$

$$X = l_1 \begin{pmatrix} \cos \theta_1 \\ \sin \theta_1 \end{pmatrix} + (l_2 + \Delta) \begin{pmatrix} \cos(\theta_1 + \theta_2) \\ \sin(\theta_1 + \theta_2) \end{pmatrix}$$

$$X = \begin{pmatrix} l_1 + \Delta \\ l_2 \end{pmatrix} \begin{pmatrix} \cos \theta_1 \\ \sin \theta_1 \end{pmatrix} + \begin{pmatrix} l_1 \\ l_2 + \Delta \end{pmatrix} \begin{pmatrix} \cos(\theta_1 + \theta_2) \\ \sin(\theta_1 + \theta_2) \end{pmatrix}$$