On Human Behavioral Data Base and Humanoids

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Humanoids: What’s next?

More toward Humans
More toward Robots

Eventually,
toward Human-Robot Communication
Identification method

Identification with only Unactuated-Body dynamics

[ Venture et al. (2008) ]

\[ Y_B \phi_B = \begin{bmatrix} Y_{B1} \\ Y_{B2} \end{bmatrix} \phi_B = \begin{bmatrix} 0 \\ \tau \end{bmatrix} + \sum_{k=1}^{N_c} \begin{bmatrix} K_{k1} \\ K_{k2} \end{bmatrix} F_k \]

regressor

base parameters (to identify)

\[ Y_{B1} \phi_B = \sum_{k=1}^{N_c} K_{k1} F \]
Identification of Humanoids

Physical consistent identification of Standard Inertial Parameters
Ko Ayusawa, Yoshihiko Nakamura

Basa Parameter Identification
Ko Ayusawa, Gentiane Venture and Yoshihiko Nakamura
IEEE Humanoids2008.

- Using 33 links (Total 39 links)
- Motions used for identification
  - Walking motion (backward, left-side, right-side)
    (Walking forward is used for cross validation)
  - Left and right turning motion
  - Left and right arm motion
  - Head motion

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Application to a flying human

- Using motion data when the subject in the air (150 sec)
  + total body weight of the subject
Realtime Visualization of Progress of Estimation
IEEE IROS2009  G. Venture, K. Ayusawa, Y. Nakamura

- Colored according to the relative standard deviation computed on the fly.
- Shake the bodies of poor estimation!
- Persistent Excitation Trajectories

15 links, 34 DOF

Mutant Mice

A spontaneous mutant carrying the hugger (Bode, 1980; Sidman et al., 1997) allele \((\text{hug}^{\text{brn}})\). Homozygous \(\text{hug/hug}\) mutant shows a queer gait pattern: a duck-like walking pattern (according to human perception), while heterozygous \(\text{hug/+}\) mice are normal.
Neuroethology
Bridge Genotype and Phenotype by Homology

Comparative analyses of motor functions between mouse and human by physics-based models

A new paradigm of experimental neuromusculoskeletal studies

(1) Morphing bones from human to mouse based on feature points on the bones.

(2) Morphing muscles from human to mouse based on the bone morphing

Studying geometrical morphology and evolutilional morphology among the mammals. Obtaining the initial setting of musculoskeletal network in a different mammal.
Mathematical Model of Mirror Neuron


Mimetic Communication Hypothesis

Mimetic Communication for Physical Human Robot Interaction (pHRI)
Life-Long Learning

Unsupervised Realtime Segmentation
Temporal Compression

Realtime Incremental Clustering
Spatial Compression

S. Janus and Y. Nakamura, IEEE ICAR 2005
D. Kulić and Y. Nakamura, IEEE IROS 2008
D. Kulić, W. Takano, Y. Nakamura IEEE ICRA 2008
CMU Motion Database (http://mocap.cs.cmu.edu)

Approximately 14 hours
56,727 motion patterns

W. Takano, H. Imagawa, Y. Nakamura, IFToMM-Japan 2010

Linguistics

- Phonology
- Morphology
- Syntax
- Semantics
- Pragmatics


Use of word labels of behaviors (motion search)

“left_swing run”

Use of word labels of behaviors (motion generation)

“diving stand_up right_throw_pose standing”
Simple morphology system with behavioral symbols

The number of latent state in motion language model : 50
The number of proto symbol : 10  The number of words : 15
The number of word class : 5

Interpretation of Behaviors

Robot observes the motion and interprets the observation as sentences.
What's next?

Connecting Behavioral and Linguistic Reasoning For Communication

1) read body sensation
2) build and grow system of symbols: spatiotemporal compression
3) communicate based on system of symbols
4) interface spoken language and system of symbols
5) communicate using spoken language (TBS)

Machine that Understand Human Body Sensation

1) Biological and medical applications
2) Deeper understanding for human-robot communication

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Taichi-Master: Mr. Jin You
Tap-dancer: Hirobo

S. Oota, K. Mekada, Y. Obata, A. Yoshiki
RIKEN BRC, Tsukuba