



LAAS-CNRS

Online Human Motion Imitation by HRP2

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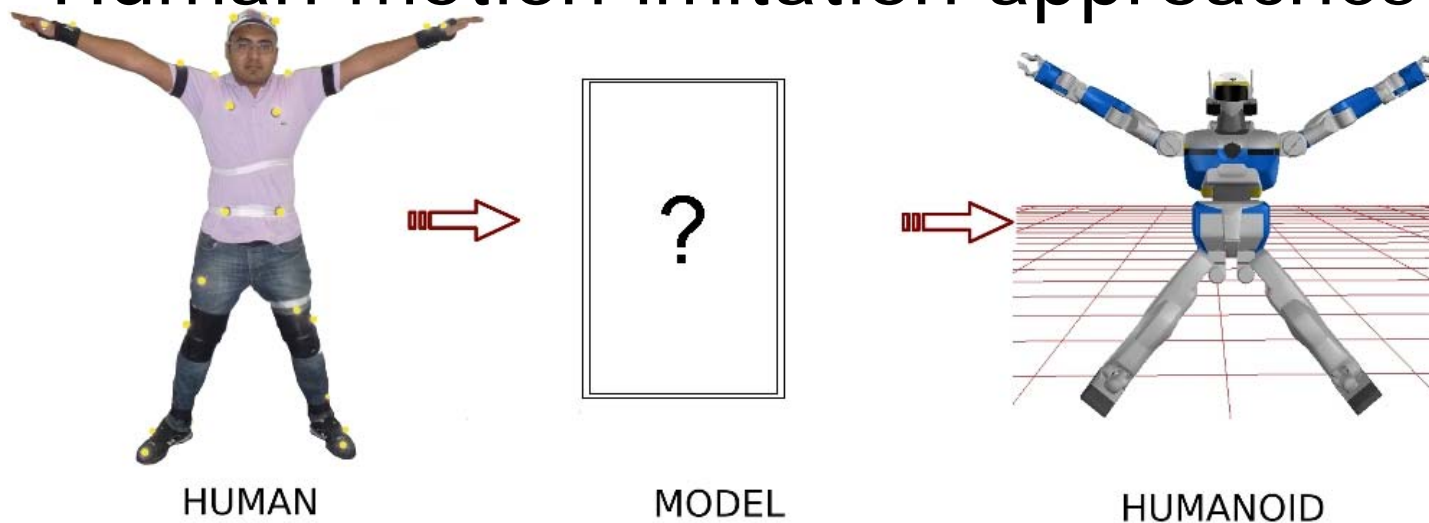
A decorative graphic consisting of several overlapping squares in yellow, red, and blue, with a black crosshair-like structure intersecting them.

Outline

- Introduction
- Human motion representation
- Robot motion generation
- Results

Introduction

Human motion imitation approaches



Offline methods

Motion primitives: [Nakaoka et al., 2005]

Optimization: [Suleiman et al., 2008] [Ruchanurucks et al., 2006]

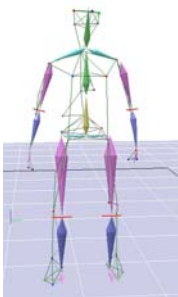
Machine learning: [Schaal et al., 2003] [Shon et al., 2005] [Takano et al., 2007]

Online methods [Dariush et al., 2008] Inverse kinematics

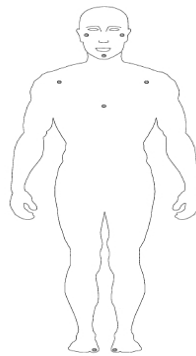
[Yamane and Hodgins, 2009] Balance and tracking controllers

Human Motion Representation

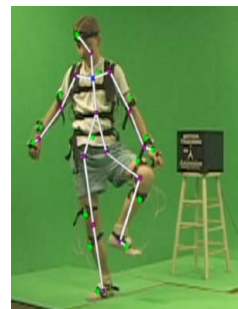
- Joint angles trajectories and a frame, Fig. (a) : skeleton specific
- Marker positions, special marker sets, Fig. (b) : neuroscience research to study motion properties [Patla et al. 1999]
- Joint centers positions, Fig. (c): human body specific [O'Brien et al. 2000]
- Normalized representations, Fig. (d): i.e. MKM [Multon et al. 2008]



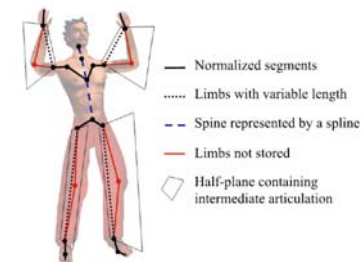
(a)



(b)



(c)



(d)

[Kulic & Nakamura 2009] : Among joint angles represented by Euler, quaternion and joint center positions: it is joint center position that best performs in motion learning.

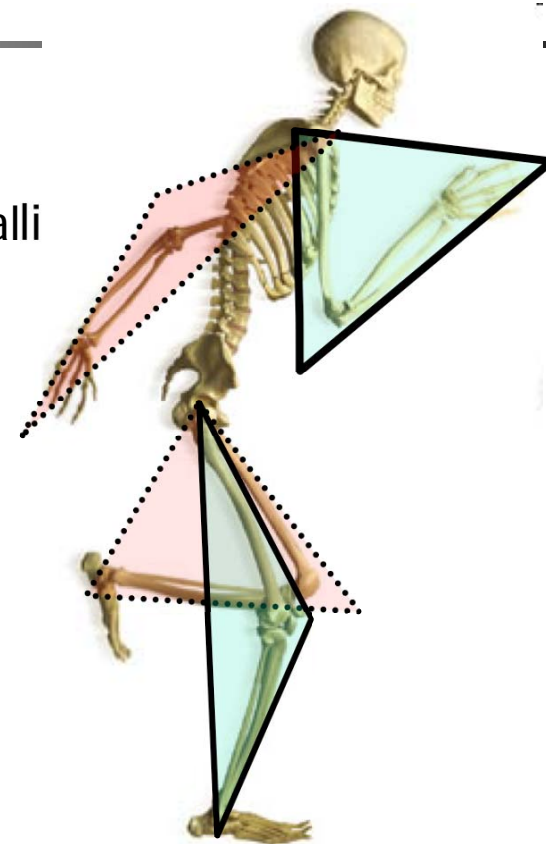
Human Motion Representation

(Humanoid Normalized model)

Coordination between body parts (legs and arms motion, trunk motion, waist motion, head motion) when reaching and walking [Patla et al., 1999] [Valli and McFadyen, 2005] [Sveistrup et al., 2008]

How to represent legs and arms motion, chest motion, waist motion, head motion?

MKM: [Multon et al., 2008]
normalized skeleton, which acts as an intermediate entity to map motion between two different digital actors.
They assumed that there exists planes formed by the arms and legs.



Attach planes to the human body!

Human Motion Representation

(Humanoid Normalized model)

- Head: position, orientation vector
- Arms: hand position, normal to its plane
- Chest: normal to its plane
- Waist: orientation vector

$$[P_h, V_h, N_c, V_w, P_{lh}, N_{la}, P_{rh}, N_{ra}, P_{lf}, P_{rf}]$$

P: position

V: orientation vector

N: normal vector to a plane

h: head

c: chest

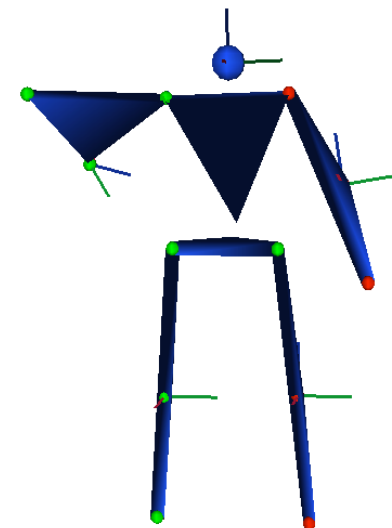
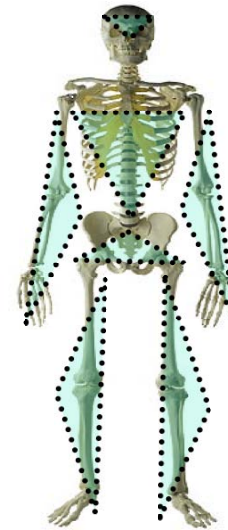
w: waist

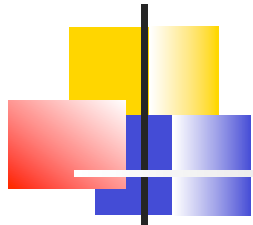
lh, rh: left hand, right hand

la, ra: left arm, right arm

lf, rf: left foot, right foot

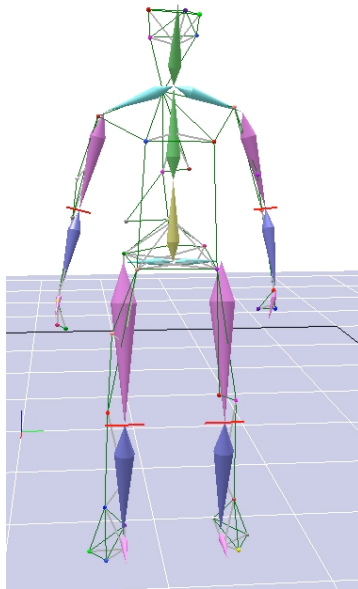
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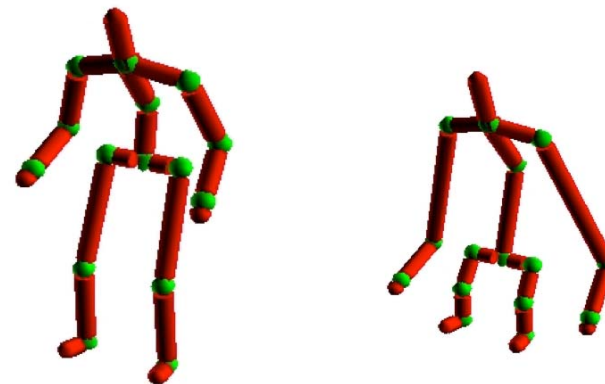


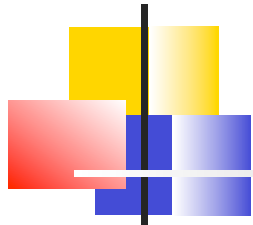
Humanoid Normalized Model: Validation

Motion capture reference



Target avatars



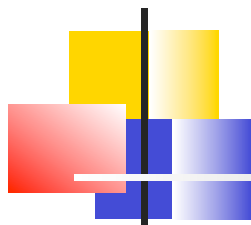


Humanoid Normalized Model: Validation

Prioritized
inverse
kinematics

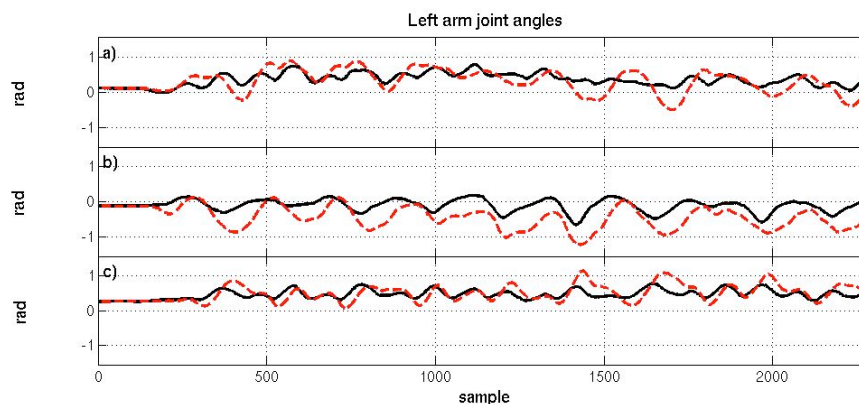
1. Homogenous transformation task for each feet,
2. Position task for the head
3. Homogenous transformation task for the left wrist,
4. Homogenous transformation task for the right wrist,
5. Orientation vector task for the chest,
6. Orientation vector task for the waist,
7. Orientation vector task for the head.

QuickTime™ et un
décompresseur
sont requis pour visionner cette image.



Humanoid Normalized Model: Validation

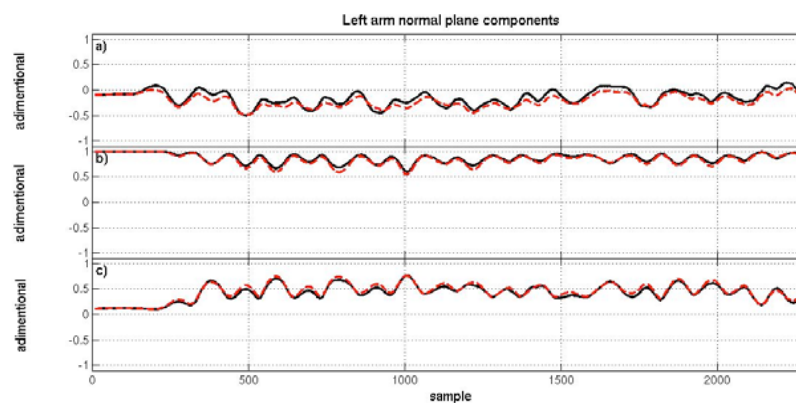
Left arm
Joints:



Solid black line reference
joint values

Dashed red line joint
values generated based
on HN model

Normal vector components, left arm:

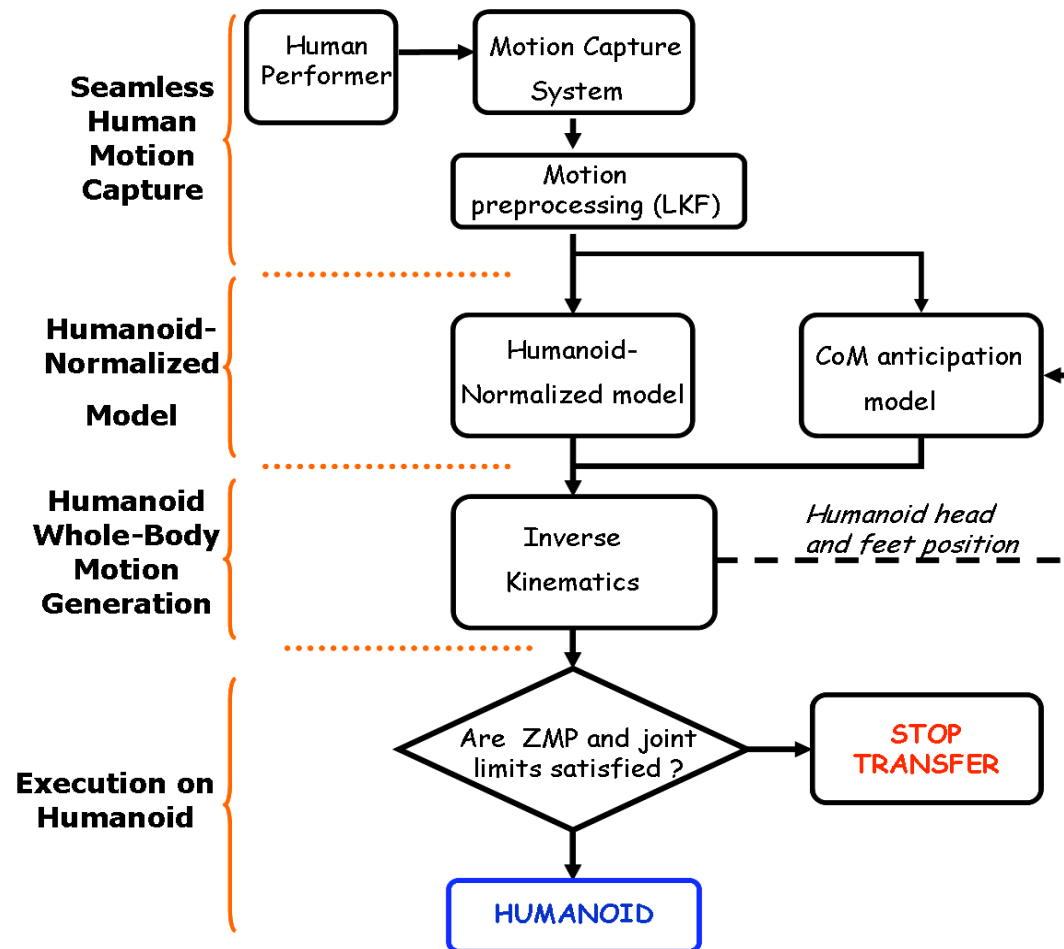


Solid black line reference
left arm normal (joint axis)

Dashed red line joint
normal of our NH model



Robot Motion Generation



Each cycle
takes
20 ms



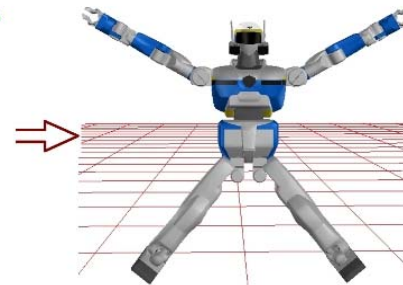
Robot Motion Generation



HUMAN



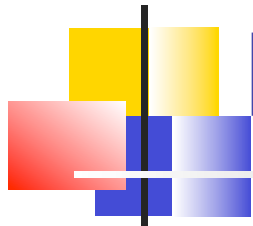
MODEL



HUMANOID

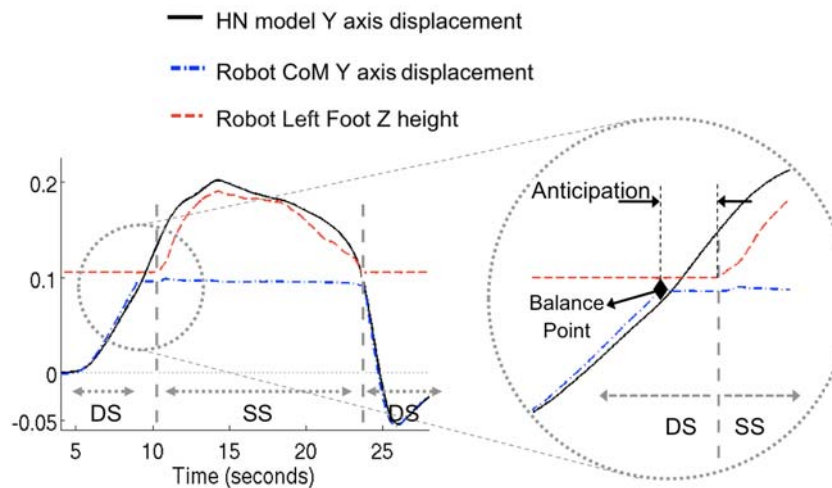
Prioritized
inverse
kinematics

1. Homogenous transformation task for each feet,
2. Position task for Center of Mass (CoM),
3. Position task for the head,
4. Homogenous transformation task for the left wrist,
5. Homogenous transformation task for the right wrist,
6. Orientation vector task for the chest,
7. Orientation vector task for the waist,
8. Orientation vector task for the head.



Robot Motion Generation

Anticipation strategies when walking [Patla et al., 1999], [Vallis and McFadyen, 2005]



$$CoM_i = \begin{cases} CoM_{i-1} + \alpha(V_{head} \cdot V_{feet})V_{feet} & \text{if DS} \\ p_{foot} + \beta V_{head} & \text{if SS} \end{cases}$$

CoM_i = CoM X and Y positions at time step i ,

V_{head} = HN Model head 2D velocity vector,

V_{feet} = Unity vector across robot's feet,

p_{foot} = Humanoid support foot X and Y positions,

α, β are constants.

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Results

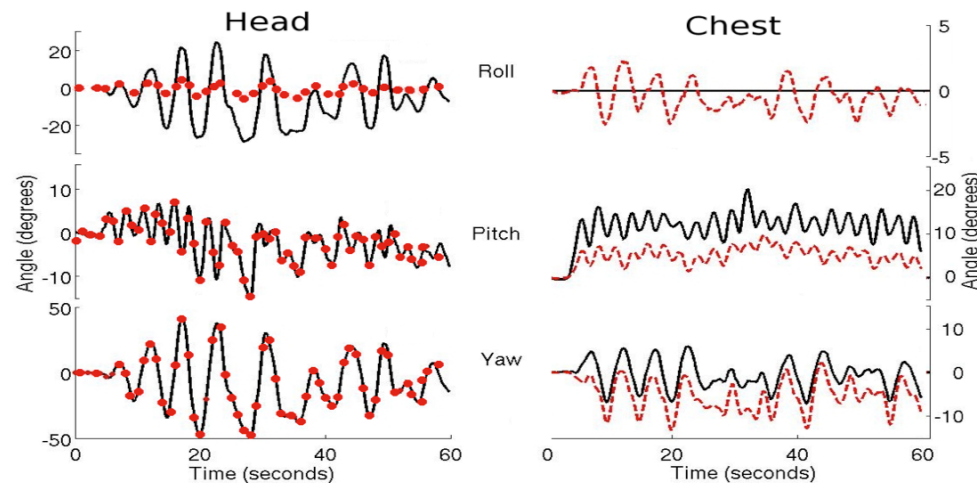
On Real-Time Whole-Body
Human To Humanoid
Motion Transfer

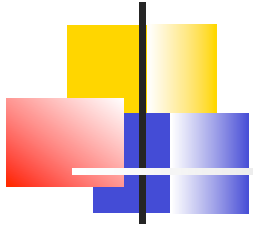
ICINCO 2010

Result

Property	Mean RMS position (m)	Mean RMS orientation (deg)
CoM	~ 0	-
Head	~ 0	4.09 (R:11.8 P:0.22 Y:0.26)
Left wrist	0.02 (X:0.013 Y:0.02 Z: 0.3)	-
Right wrist	0.05 (X:0.05 Y:0.017 Z: 0.08)	-
Chest	-	4.2 (R:1.1 P:6.7 Y:4.8)
Waist	-	6.4 (R:1.1 P:4.62 Y:0.52)

Mean RMS error between HN model and humanoid. Values in brackets denote the mean RMS error in X,Y and Z positions for wrist positions, and roll (R), pitch (P) and yaw (Y) for head, chest and waist orientations





Questions?