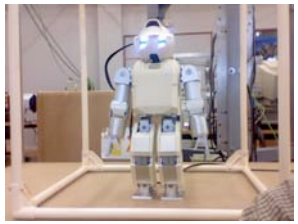
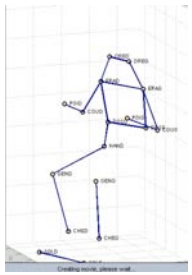
Laboratoire
d'Informatique
de Robotique
et de Microélectronique
de Montpellier

LIRMM

UNIVERSITÉ MONTPELLIER 2
SCIENCES ET TECHNIQUES

Université Montpellier 1





Robotic Closed-Loop Scheme to Model Human Postural Coordination

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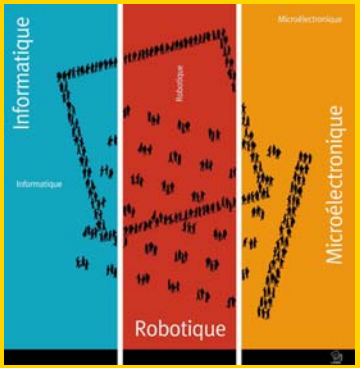
(Université Paris 12)

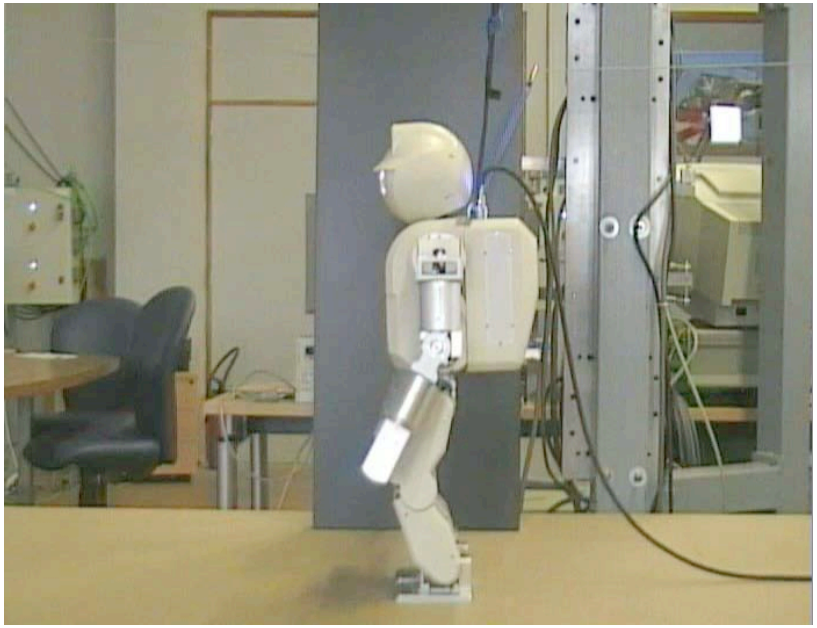


JNRH 2010, Poitiers

3 - 4 Juin 2010

Introduction

- Modeling Human
- Improving design and control of humanoïd robots.
- Improving the knowledge of motor diseases.



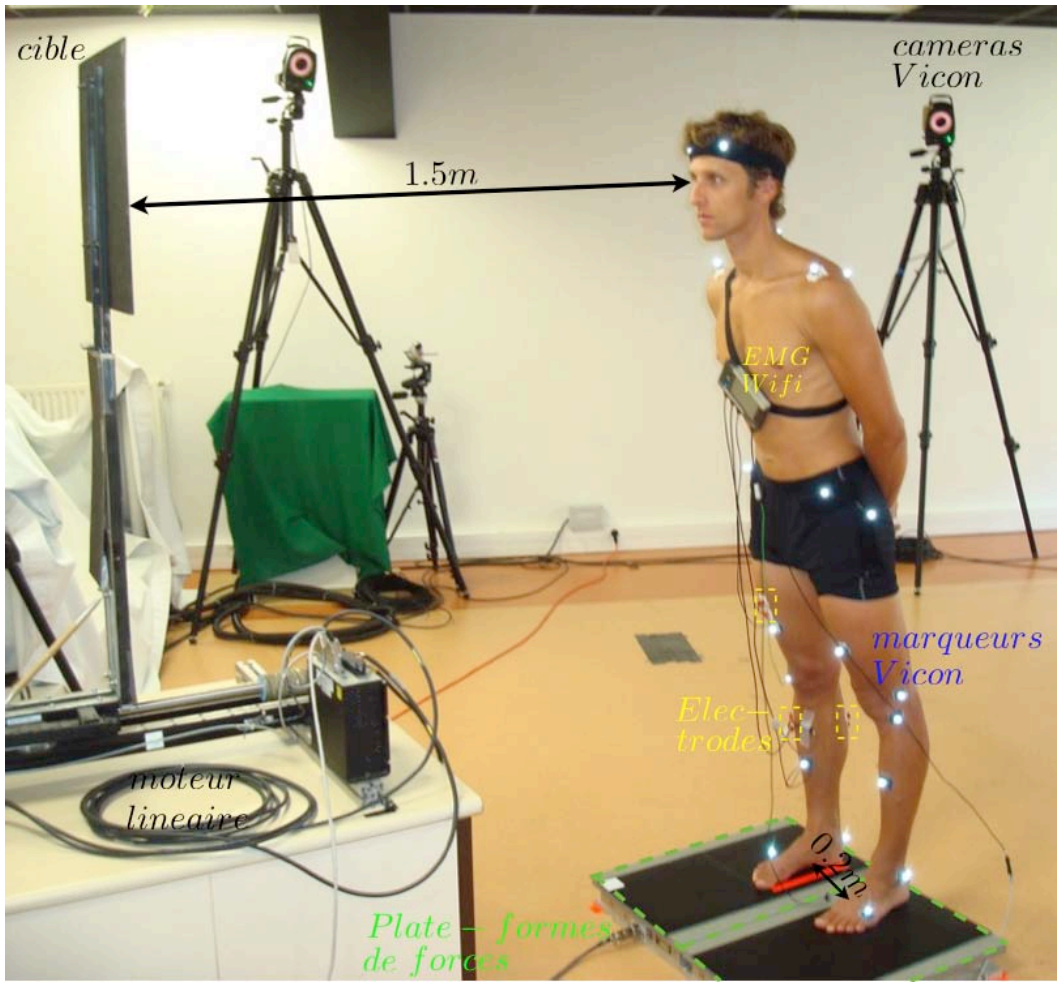
Research on Postural Dynamics

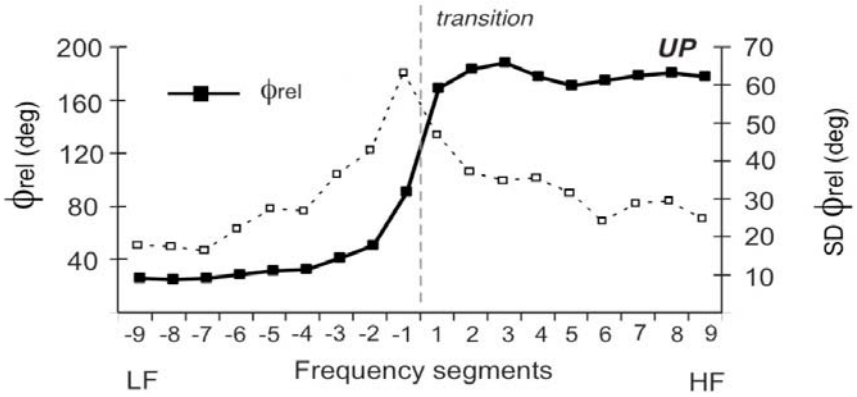
Small amplitude / frequency

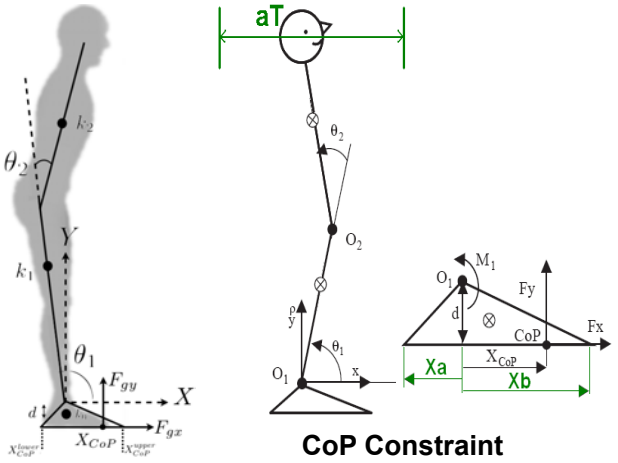
Large amplitude / frequency

Postural Coordination Modeling

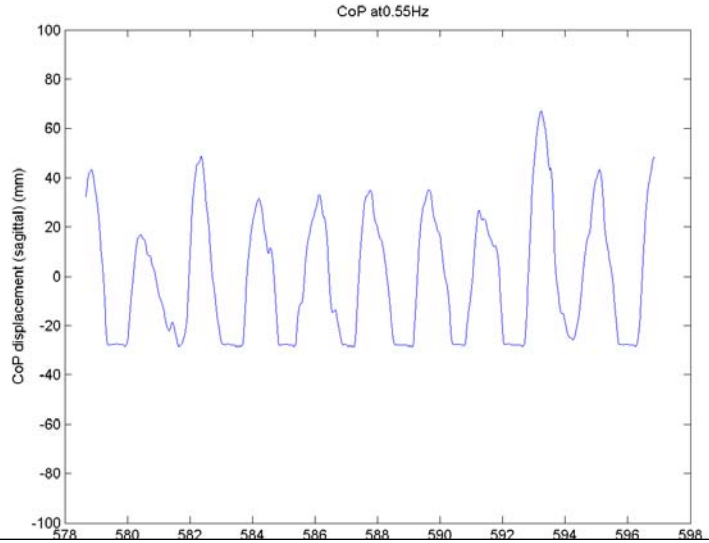
Postural Coordination Experimentation

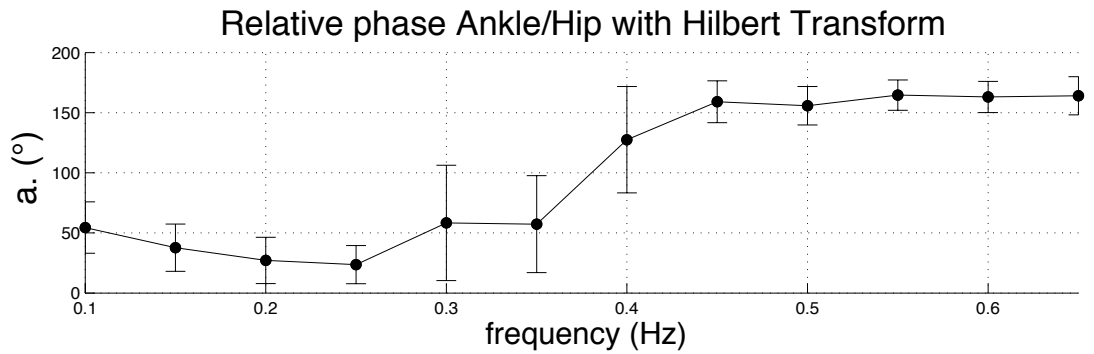


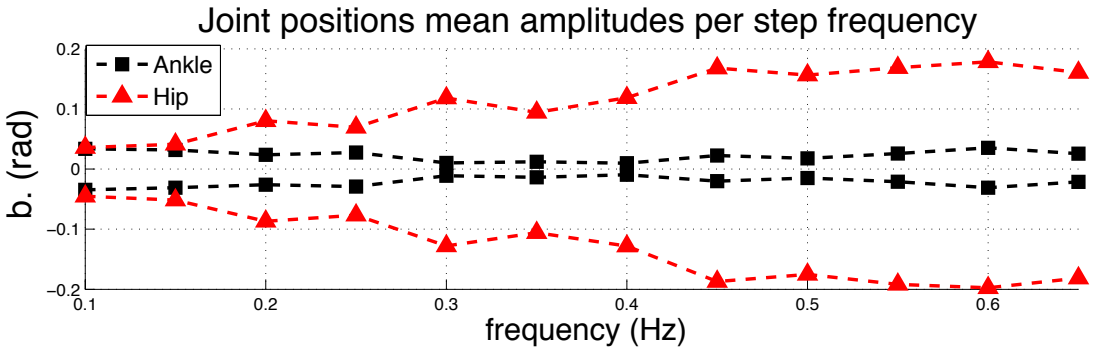


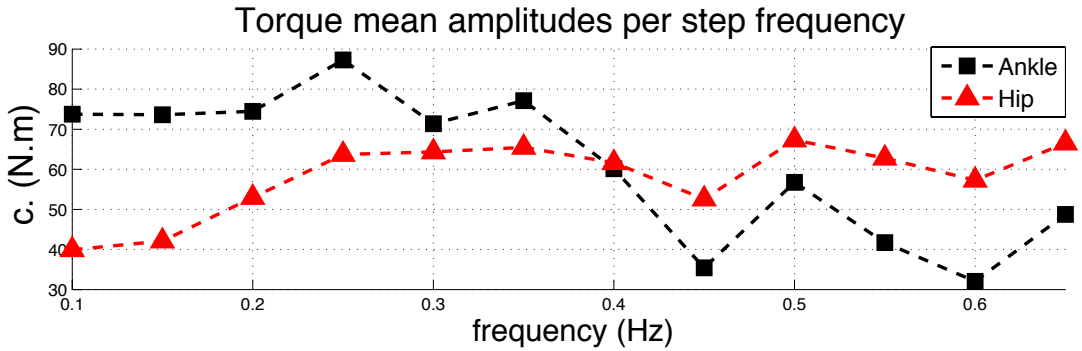


Human modeling



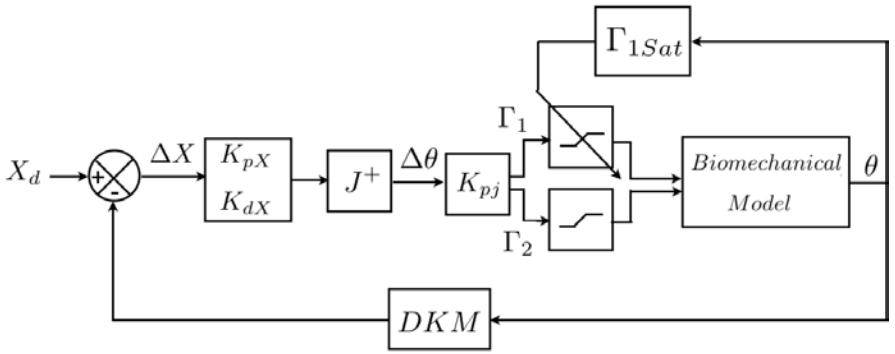






Humanoid Robots

- Postural coordination model based on robotic control scheme: [Bonnet08]



- Torque control is needed
- Torque saturation:

$$\Gamma_{1Sat}^{lower} = F_{gx}d - m_0k_0g + X_{CoP}^{lower}F_{gy}$$

$$\Gamma_{1Sat}^{upper} = F_{gx}d - m_0k_0g + X_{CoP}^{upper}F_{gy}$$

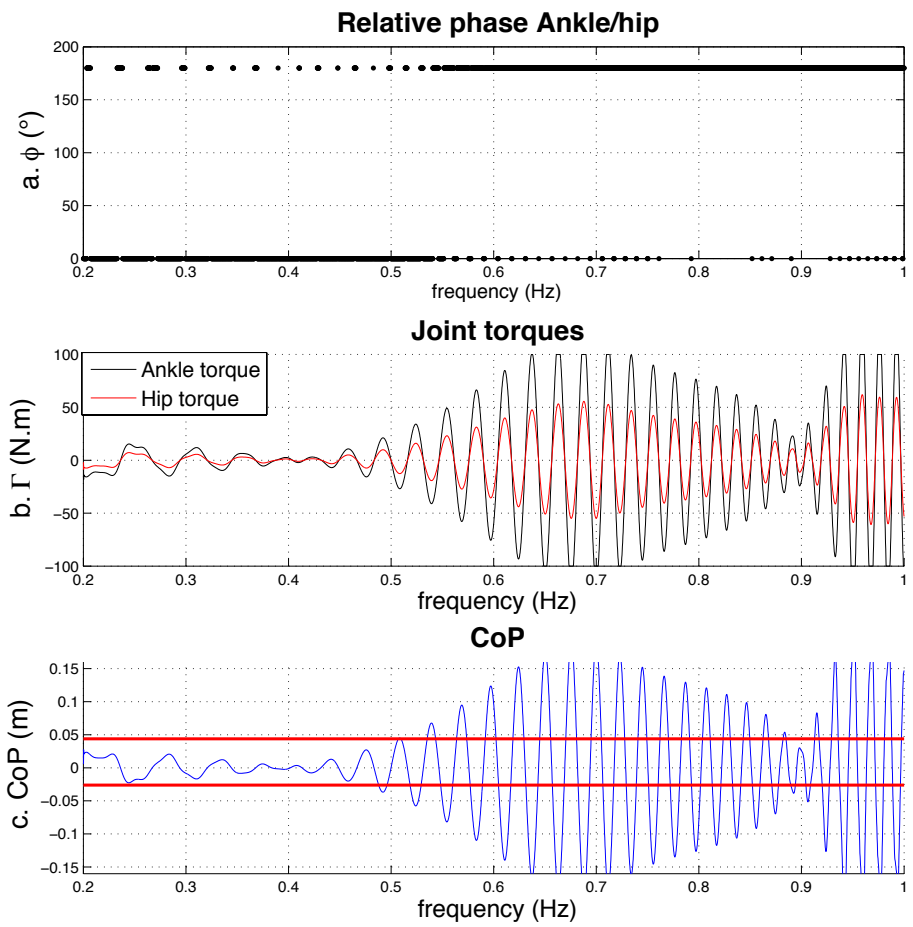
$$X_{CoP} = \frac{(\Gamma_1 - F_{gx}d + m_0k_0g)}{F_{gy}}$$

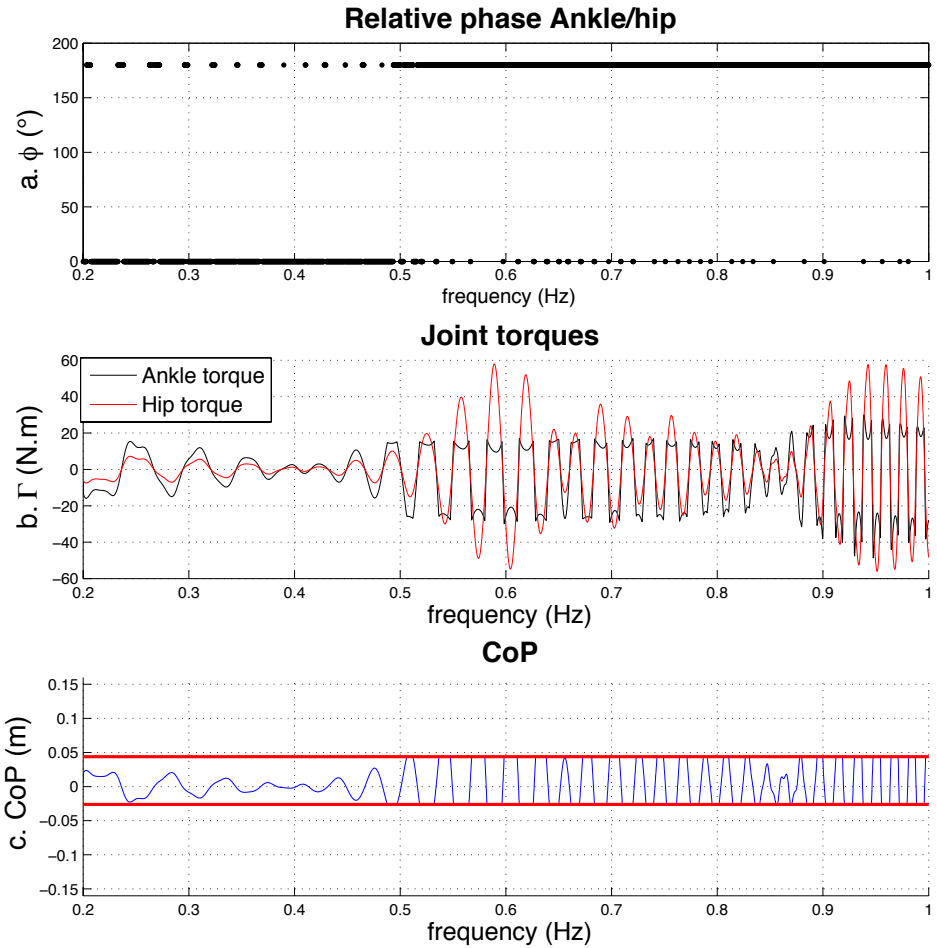
- Pseudo-inverse minimizes

$$||\dot{\Gamma}(t)||^2 \qquad J = \int_0^T \left(\left(\frac{d\Gamma_1}{dt}\right)^2 + \left(\frac{d\Gamma_2}{dt}\right)^2\right)dt$$

Minimum Torque Change

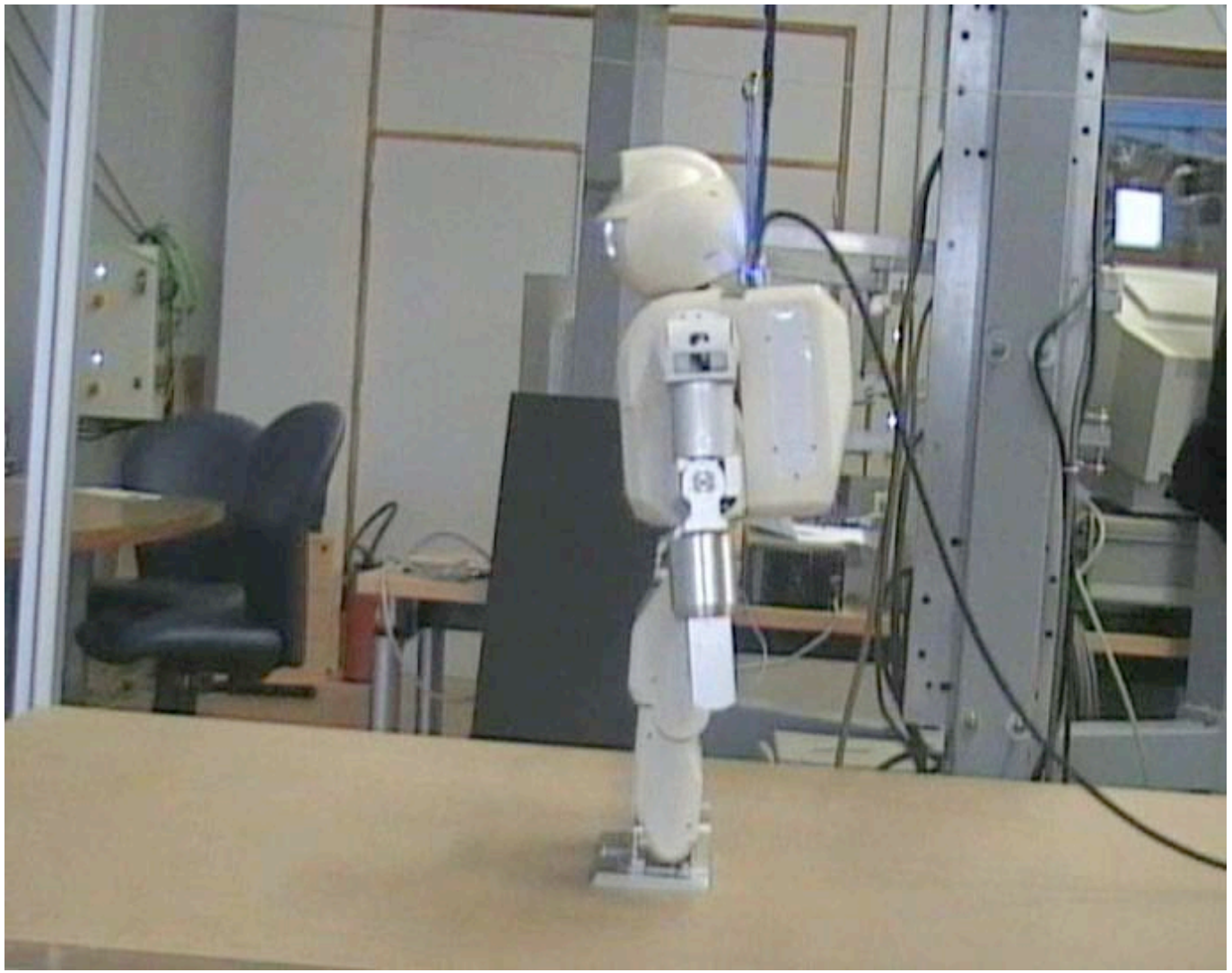
Humanoid Robots





Experimentations

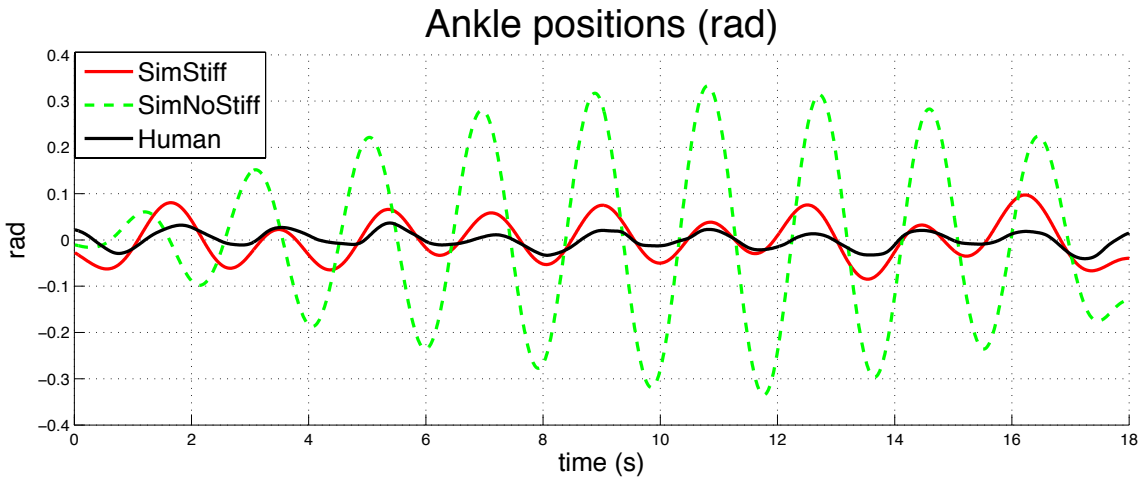
On HOAP3:

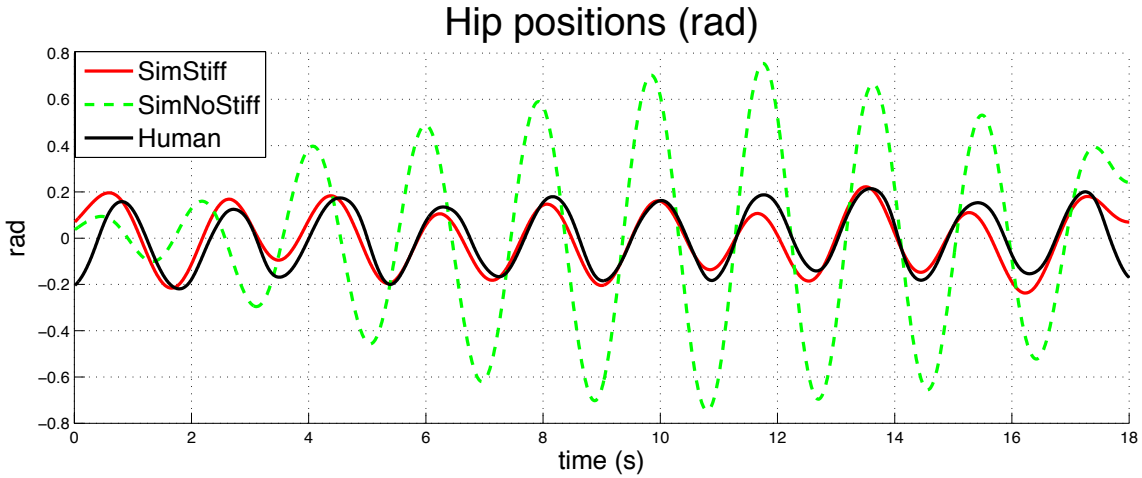


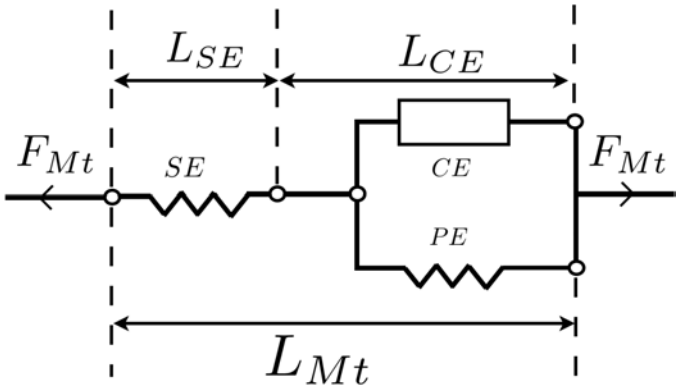
Muscle Model

Passive stiffness (Muscle Model):

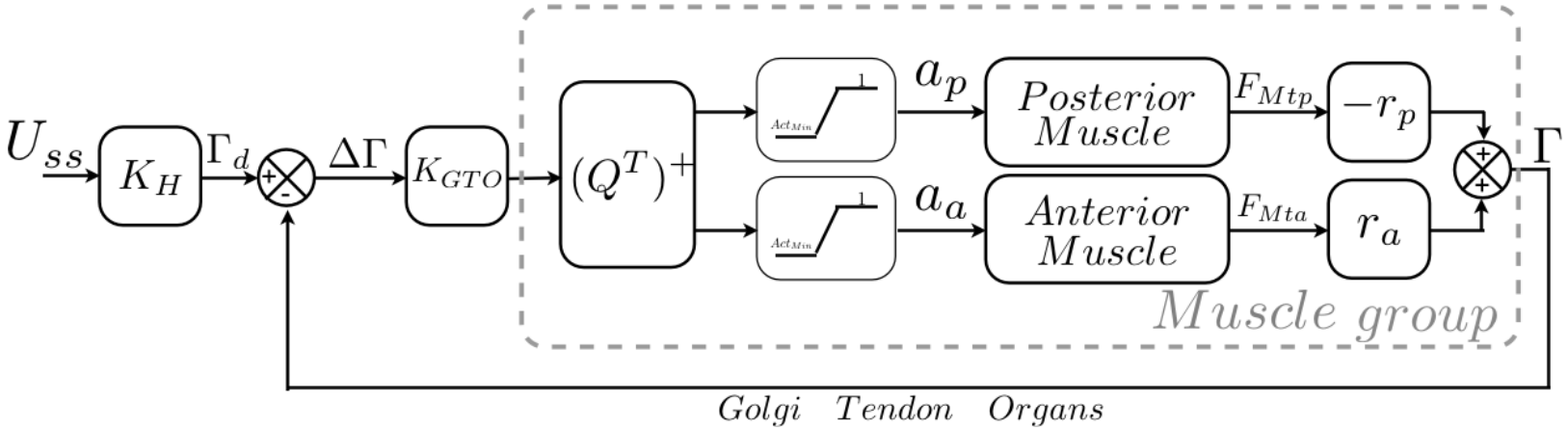
- [Hill38][Huxley69][Zajac89]

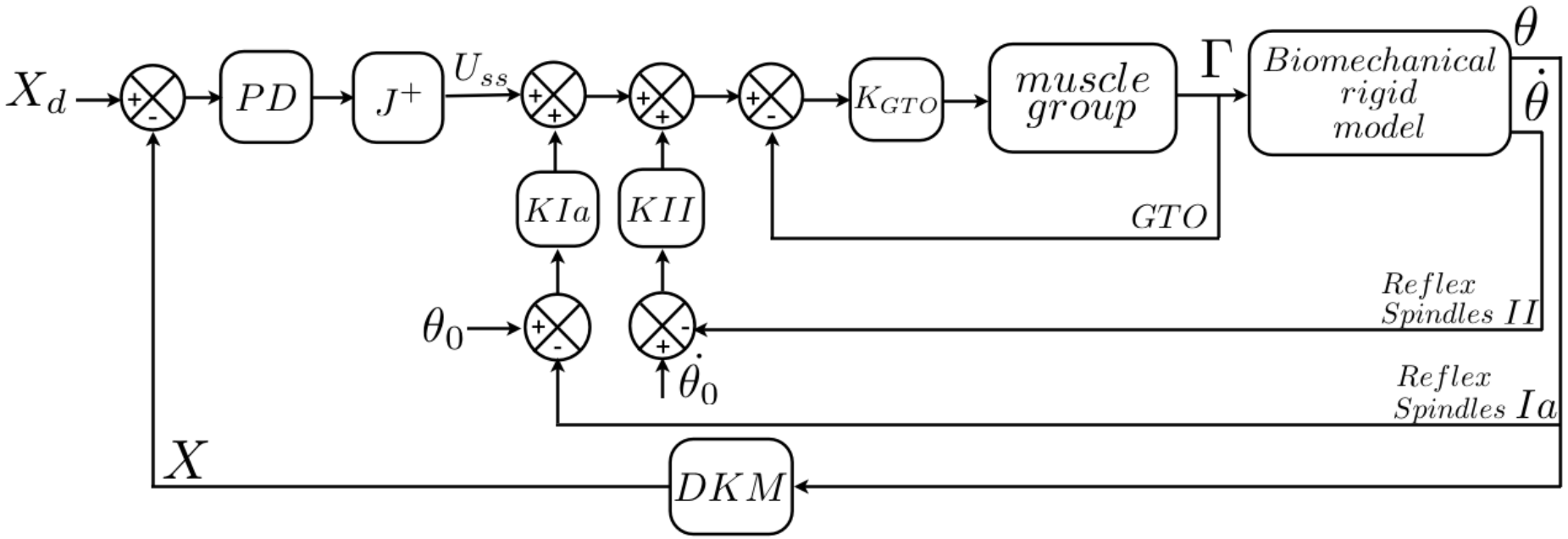




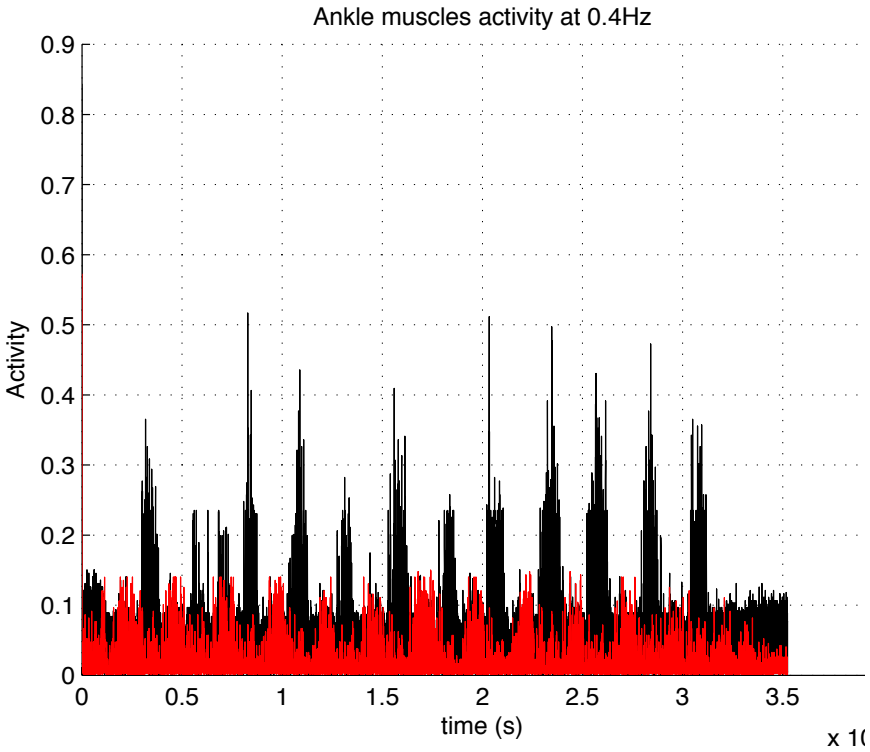


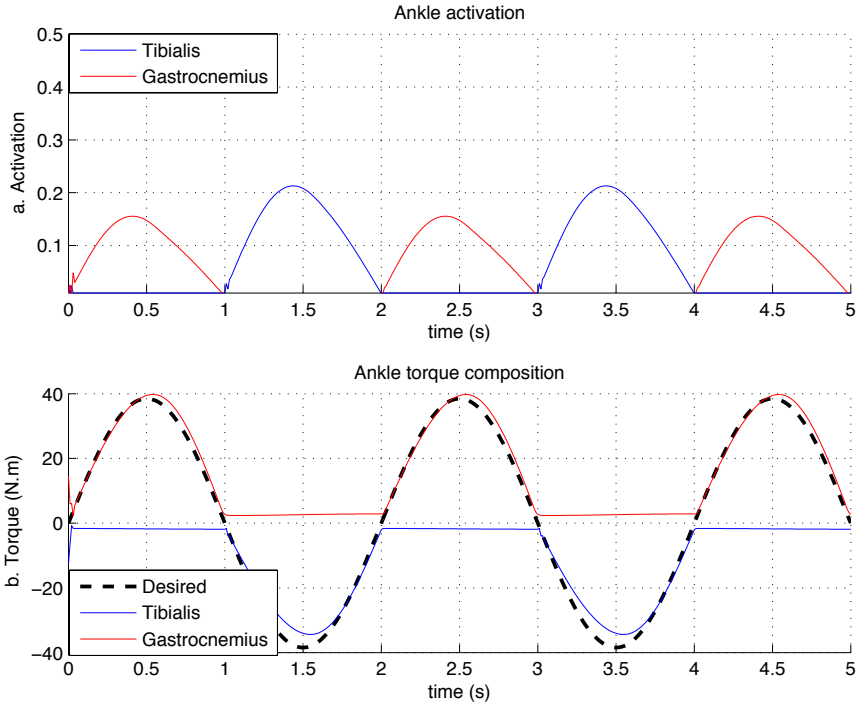
Muscle Model



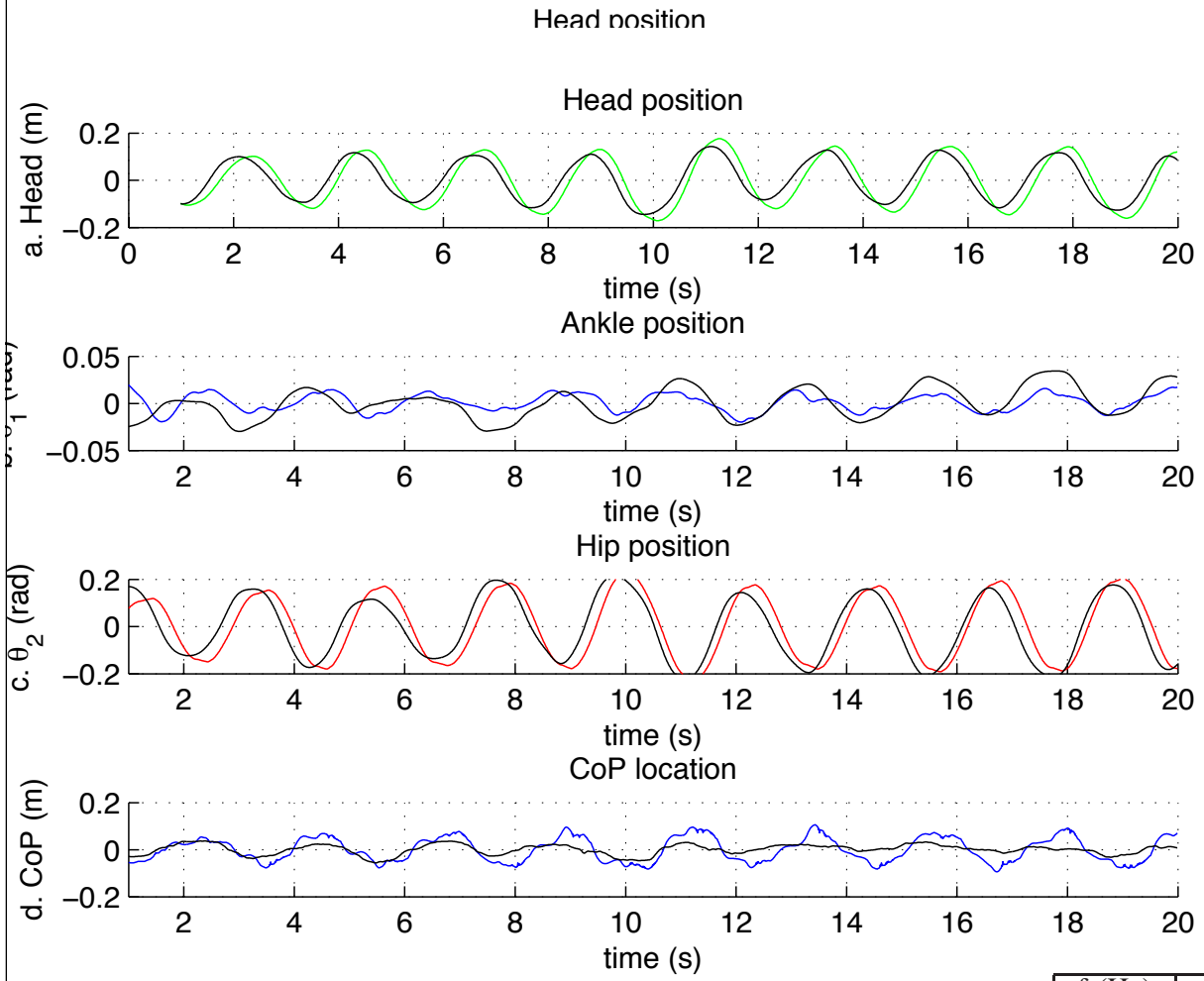


Model


Ankle muscles activity at 0.4Hz
Activity
time (s)
x 1(


Ankle activation
Tibialis
Gastrocnemius
a. Activation
time (s)
Ankle torque composition
Desired
Tibialis
Gastrocnemius
b. Torque (N.m)
time (s)

Assessment

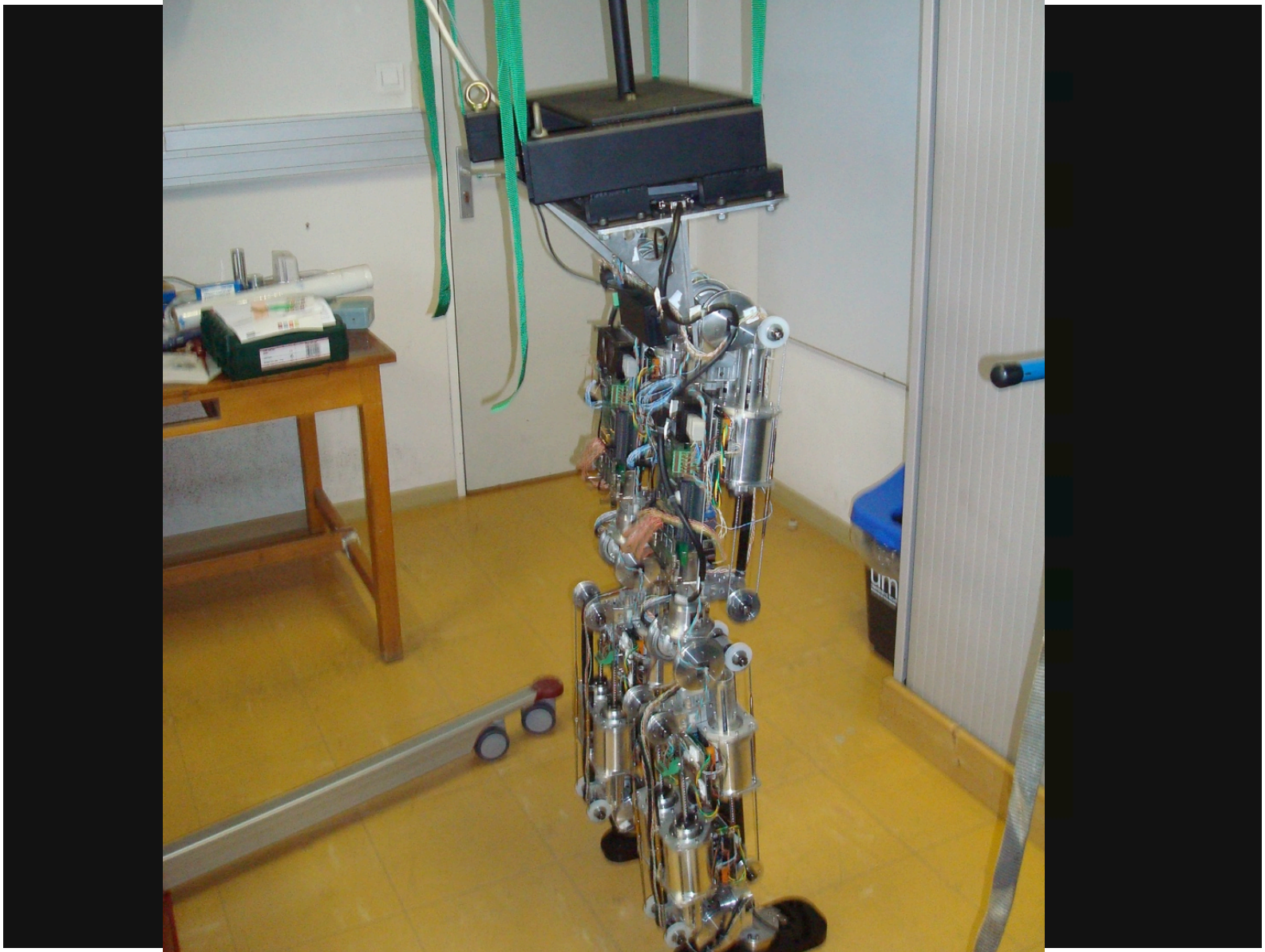


F=0,65 Hz

F=0,45Hz

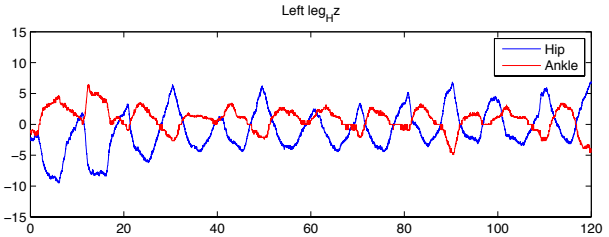
f (Hz)	KII_1	KIa_1	KII_2	KIa_2
0.2	1815 ±0.01	553.4 ±9e-5	132.7 ±0.02	190.8 ±0.04
0.4	1987 ±44.9	257.4 ±0.56	185.6 ±16.4	1.003 ±0.57
0.65	1203 ±8.7	499.9 ±0.16	21.92 ±0.55	4.990 ±0.15

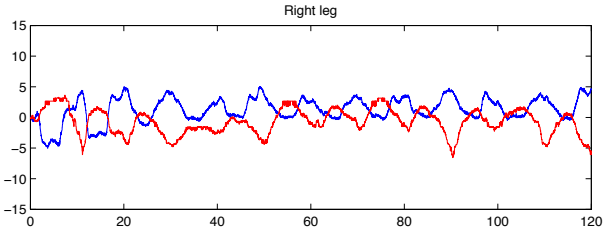
on Sherpa

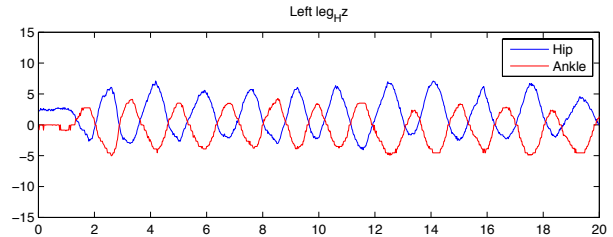


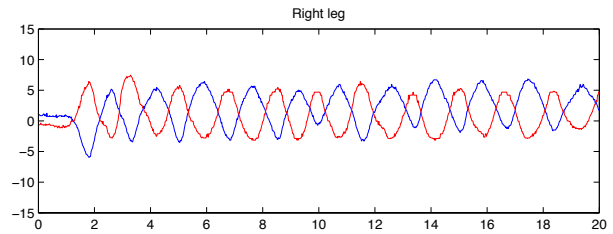
Modeling Postural Coordination of Hemiplegic Patients

- Only antiphase postural coordination for hemiplegic patients.









Conclusion

Conclusion

- Robotic control scheme including torque saturation is able to reproduce human postural coordination.
- Control scheme with pseudo-inverse allows to reproduce minimal torque change behavior.
- Muscle model reduces discrepancy between human and virtual human.
- This model is based on physiological data and can be a tool for decision making in the rehabilitation field. Specifically for quantifying the motor disease and recovery time for hemiplegic patients.

Ongoing work

- model including interaction between handicapped side and healthy side (hemiplegic patient).