CYBERLEGs

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Bio-inspired Model for Walking assistance

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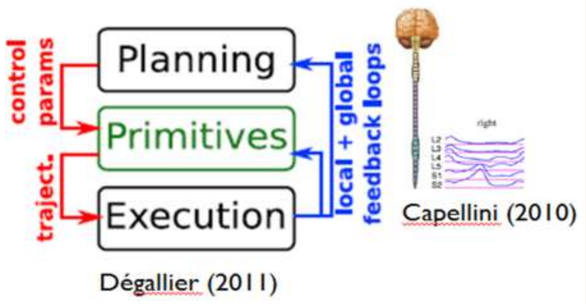
Objective

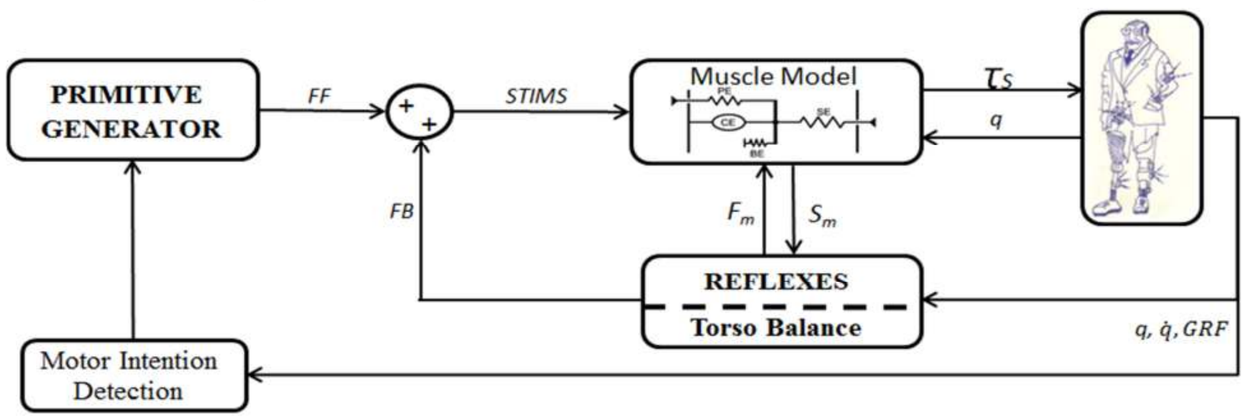
Obtaining a framework able to provide bio-inspired torque assistance to disabled humans during walking. The controller receives data only from wearable sensors.
The method is based on a bio-inspired model copying the natural dynamics of leg muscles, and containing a torso stabilization mechanism.



Methods

Assistive torques (τ_s) are obtained from kinematics $(q, \dot{q})$ and ground reactions forces (GRF).

General diagram:



The **Muscle model** provides the assistive torques

- Muscle Forces (F_m)

$$F_m = F_{SE} = F_{CE} + F_{PE} - F_{BE}$$
$$F_{CE} = S_m^* F_{\max} f_l(l_{ce})\, f_v(v_{ce})$$

- Torques (from the geometric model)

$$\tau_s = r_m(\varphi)\, F_m$$

Stimulations for the muscles have different contributions

- **Feed-forward (FF)** / Primitives generator

$$S_m(k) = \sum_{i=1}^{n} W_{i,m}\, PC_i(k)$$

- **Feedback (FB)**

Short loop reflexes:

$$S_m = S_{0,m} + G_m F_m$$

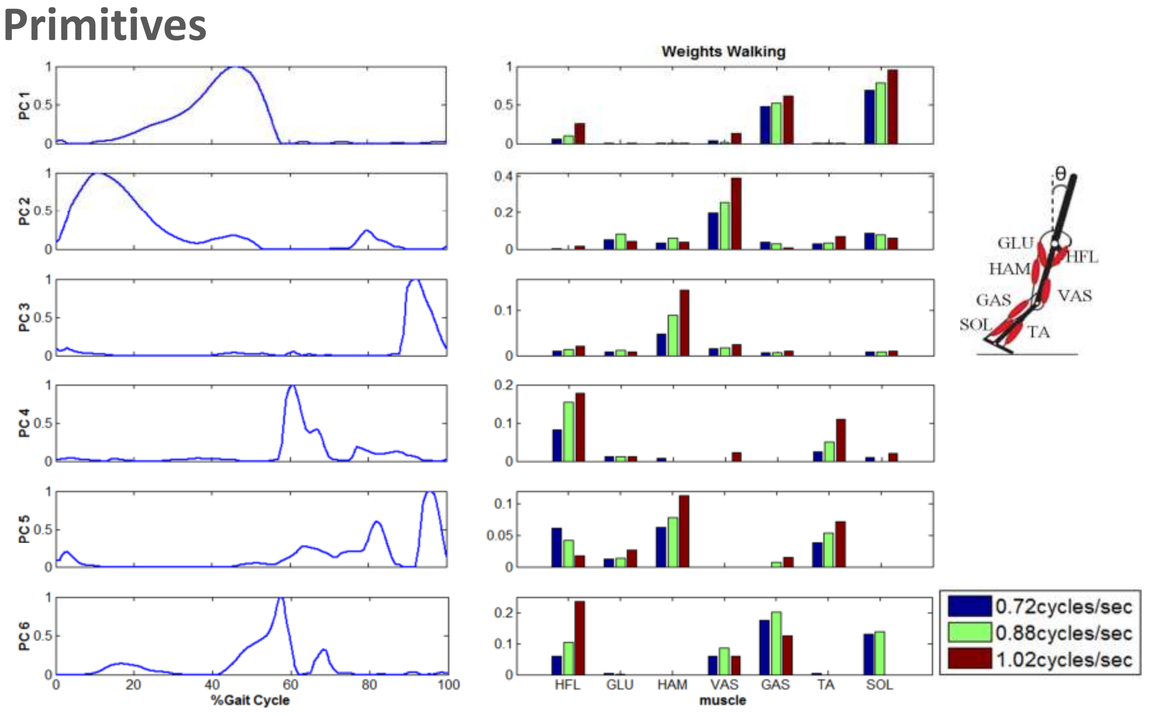
**Reflexes are based on the locomotion model of Geyer and Herr.*

Trunk Stabilization:

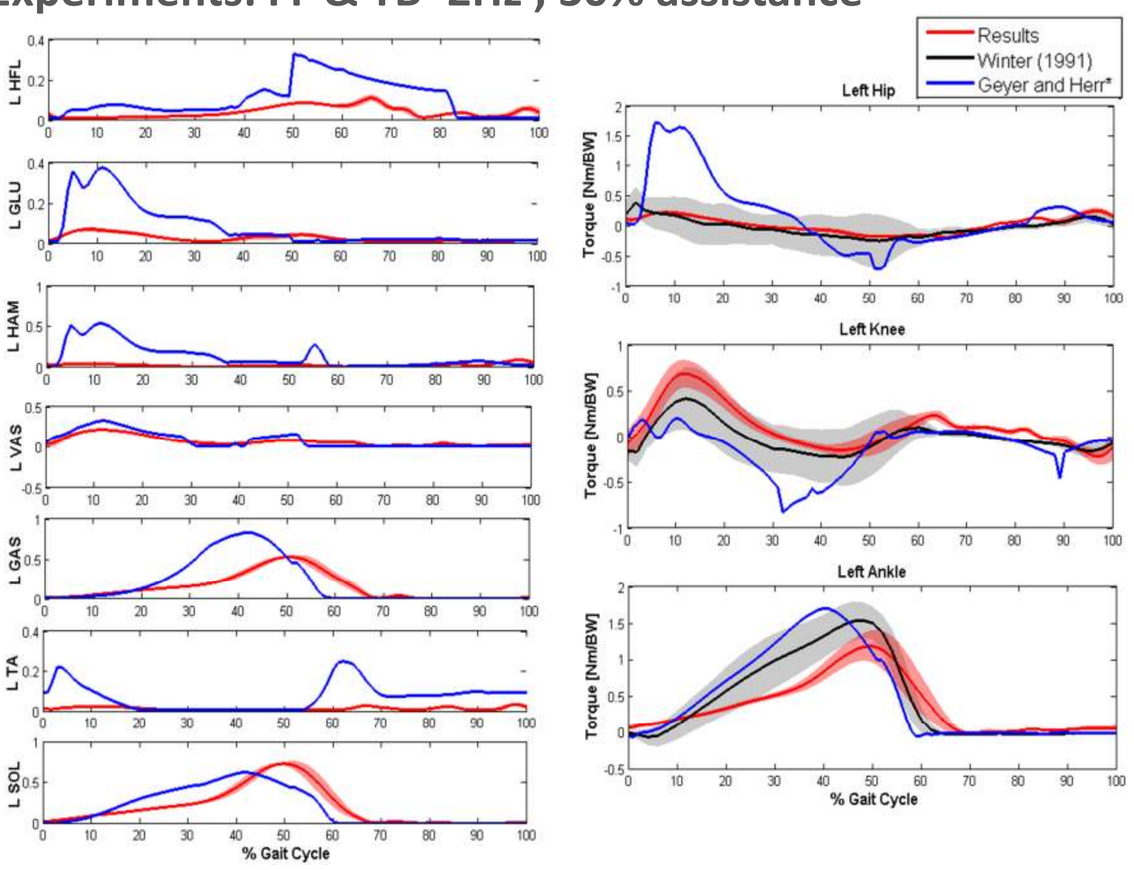
$$S_m = K_{pm}(\theta - \theta_{ref}) + K_{dm}\dot{\theta}$$

Results

Primitives



Experiments: FF & TB=2Hz ; 30% assistance



Conclusions

The proposed method allows to compute the muscles stimulations and torques from kinematics recorded with wearable sensors. A portion of these torques can be applied depending on the desired level of assistance.
This model proved to run in real time while integrated in the general CYBERLEGs cognitive control unit and provided assistance through a pelvis orthosis to healthy subjects.

On-going work

On-going work includes the increase of the stimulation data base for a wider range of walking speeds and including stair ascending and descending.
Also, experiments are scheduled to test the effectiveness of the assistance and compare it to other methods.

Geyer and Herr. IEEE transactions on neural systems and rehabilitation engineering, 2010;18(3): 263-273.

- Harmut Geyer and Hugh Herr. "A Muscle-Reex Model That Encodes Principles of Legged mechanics Produces Human Walking Dynamics and Muscle Activities“. *IEEE transactions on neural systems and rehabilitation engineering, vol. 18(3) , pp. 263-273*, 2010.
- Sarah Degallier and Auke Ijspeert. “Modelling discrete and rhythmic movements through motor primitives: a review». *Biological Cybernetics, 103; DOI 10.1007/s00422-010-0403-9:319-338*, 2010.
- Germana Capellini et al. “Migration of motor pool activity in the spinal cord reflects body mechanics in human locmotion”. *J. Neurophysiol, 104: 3064-3073*, 2010.