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Reflex-based model for Walking assistance

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Objective

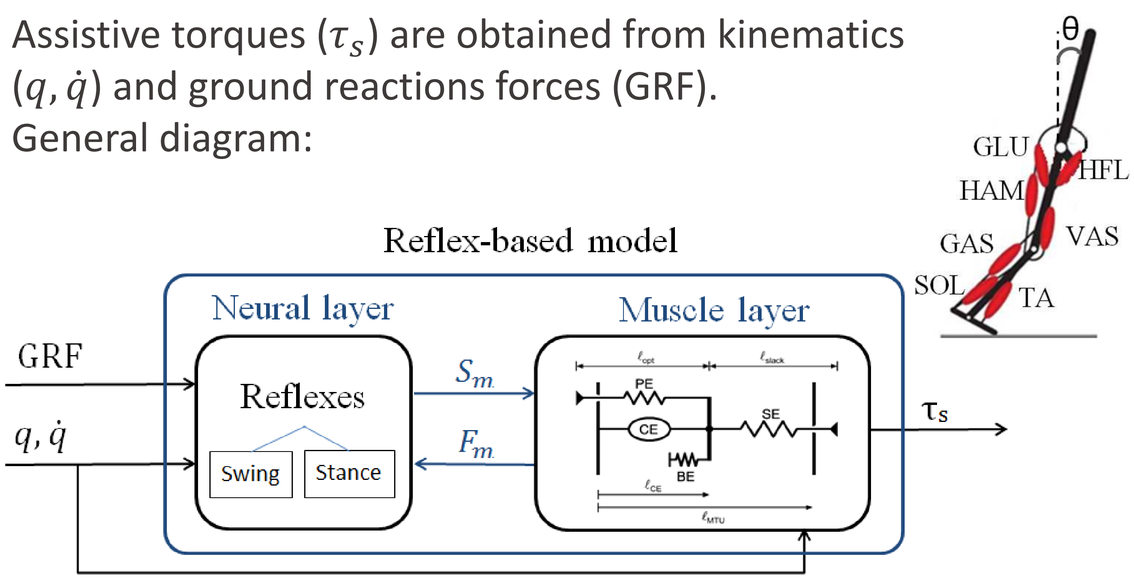
Obtaining a framework able to provide bio-inspired torque assistance to disabled humans during walking from wearable sensors.

The method is based on a bio-inspired model copying natural dynamics of the leg muscles, and containing a torso stabilization mechanism.

Method

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

General diagram:



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

1) The Neural layer provides Muscle Stimulations (S_m)

$S_{m_{SOL,TA,GAS,VAS}} = S_{0,m} + G_m F_m$ (positive force feedback)

$S_{m_{GLU,HAM,HFL,}} = S_{0,m} + G_m F_m + \{K_p(\theta - \theta_{ref}) + K_d\dot{\theta}\}$

(trunk stabilization mechanism)

2) The Muscle layer provides the assistive torques

- Muscle Forces (F_m)

$$F_m = F_{SE} = F_{CE} + F_{PE} - F_{BE}$$

$$F_{CE} = S_m^* F_{\max} f_l(l_{ce})\, f_v(v_{ce})$$

S_m^* → low-pass filtered S_m

- Torques (from the geometric model)

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

Conclusions

The proposed method allows to compute the virtual muscle stimulations and torques to assist locomotion from kinematics recorded with wearable sensors.

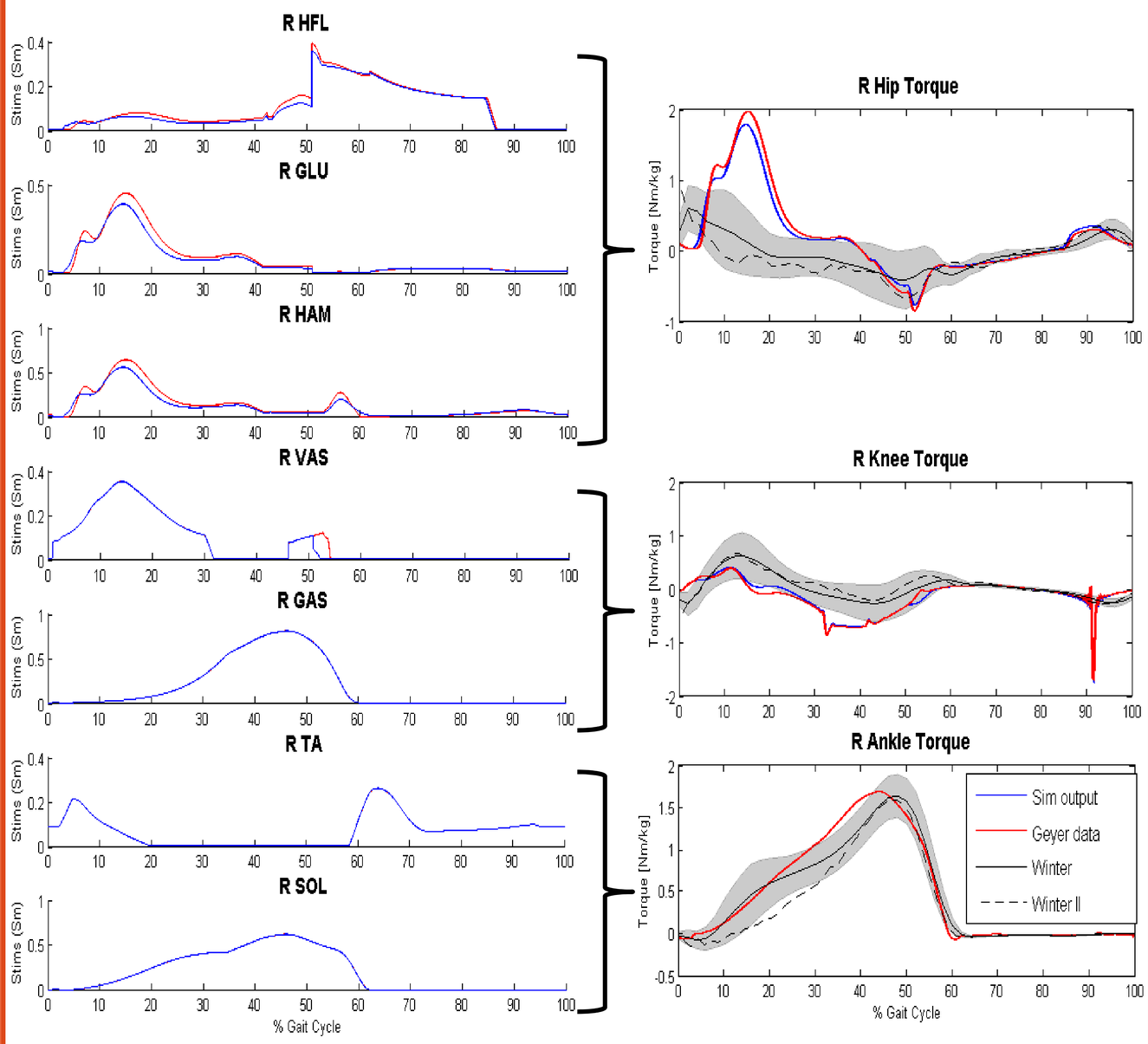
The produced knee and ankle torques are very close to standard profiles found in the literature, while the hip torques likely require some fine tunings to provide effective assistance.

Future work

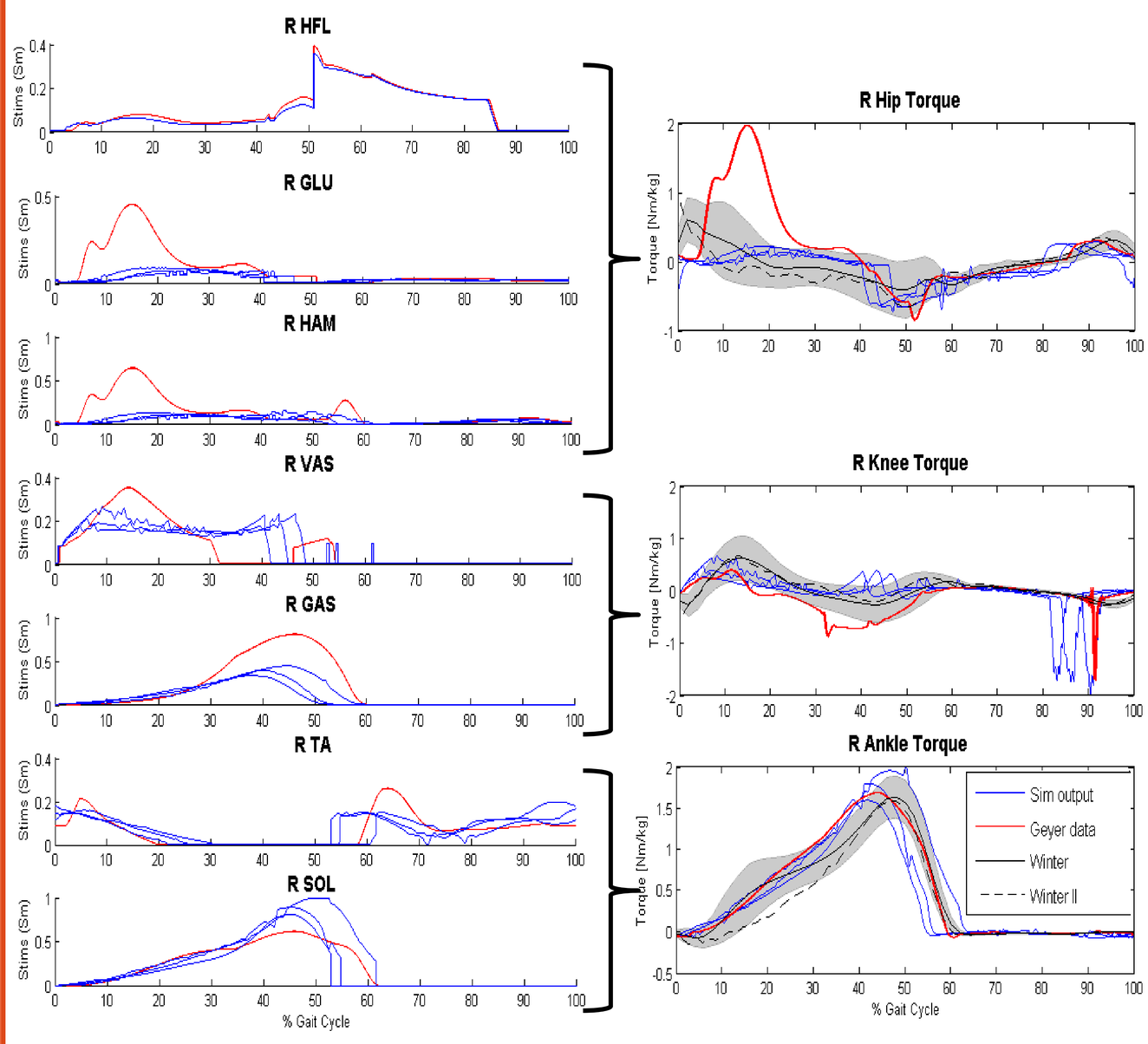
A portion of these torques could be applied to the desired joints as a function of the required level of assistance. Future work will consist in testing this approach by using a torque-driven assistive device.

Results

- Using the kinematics produced by the original model and $\theta_{ref} = 6^o$:



- Using kinematics from wearable sensors and $\theta_{ref} = 0^o$:



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