"Bio-inspired Model for Walking Assistance"

Ruiz Garate, Virginia ; Collard, Jean-François ; Ronsse, Renaud

Abstract
The main objective of this work is obtaining a framework able to provide bio-inspired torque assistance to disabled humans during walking. The method is based on a bio-inspired model copying natural dynamics of the leg muscles, and containing top-down primitives, short-loop reflexes, and a torso stabilization mechanism.

Document type : Communication à un colloque (Conference Paper)

Référence bibliographique
Bio-inspired Model for Walking assistance

Virginia Ruiz Garate¹, Jean-Francois Collard¹, Renaud Ronsse¹

¹Center for research in Energy and Mechatronics; Institute of Mechanics, Materials, and Civil Engineering Université catholique de Louvain, Belgium

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 \( (\tau_s) \) are obtained from kinematics \((q, \dot{q})\) and ground reactions forces (GRF).

General diagram:

The Muscle model provides the assistive torques
- Muscle Forces \( (F_m) \)
  \[
  F_m = F_{SE} = F_{CE} + F_{PE} - F_{BE}
  \]
- Torques (from the geometric model)
  \[
  \tau_s = m(l) F_m
  \]

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:
  \[
  S_m = S_{0,m} + G_m F_m
  \]
  Trunk Stabilization:
  \[
  S_m = K_{pm}(\theta - \theta_{ref}) + K_{dm} \dot{\theta}
  \]

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

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.

Results

Primitives

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

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.

