Gait rehabilitation based on bio-kinematic signals
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Challenge and Opportunities

Co-contraction index: After the determination of the walking sequence (double support, unipodal phase, …), CCI is computed as a ratio between agonist and antagonist muscles. Numerous definitions of CCI in the literature, focus on the most precise:

\[
CCI_1 = \frac{\int f(t) \text{ENV}(\text{EMG})_A(t) \text{ENV}(\text{EMG})_M(t) \, dt}{\int f(t) \text{ENV}(\text{EMG})_M(t) \, dt} \times 100
\]

\[
CCI_2 = \frac{\int f(t) \text{ENV}(\text{EMG})_M(t) \text{ENV}(\text{EMG})_A(t) \, dt}{\int f(t) \text{ENV}(\text{EMG})_M(t) \, dt} \times 100
\]

Related works

Novel neuro-motor control scheme (NMI)

Inter-active Controller

Needs and Goal

Material and method

bio-Kinematic Study:

- Kinematics study:

Electromyography (EMG) study:

Data for 2 joints, Knee and Hip

on a flat support: in three velocity (slow, normal and fast) Angles "θ" (Flexion /extension) of each joint

only 2 bi-articular muscle groups, hamstring and quadriceps:

Fewer control parameters: biarticular muscle allow to control two joints with limited EMG recording

Results

Conclusion

- Control an rehabilitation exoskeleton should be done with collaboration and secure.
- The effectiveness of bio kinematic-based for control strategy was investigated to achieve the needed secure use and collaboration.
- NMI can find a relation between co-contraction muscles and joint angles.
- CCA can find a new gait angle that takes into account muscle capacity

On our data from healthy subjects, with three velocities (slow, normal, and fast), And for stroke and cerebral palsy subjects

CCA applied at three groups (θ, ι, ϑ) represents the knee joint angle during complete gait cycle, and ι represents NMI

for a three velocities:

- The correlation is almost linear, The percentage of correlation is very high for stroke and cerebral palsy subjects:

- The resulting angle is improved while respecting the muscular capacity

- Find peaks
- Interpolate
- Neuro-Motor Index

Linearize the results using canonical correlation analysis CCA

\[
\text{Corr}(I_x, \theta) = \rho(I, \theta) = \frac{\text{cov}(\text{EMG}_x, \theta)}{\sqrt{\text{cov}(\text{EMG}_x, \text{EMG}_x) \sqrt{\text{cov}(\theta, \theta)}}} = \frac{\text{CC}(\text{EMG}_x, \theta)}{\sqrt{\text{CC}(\text{EMG}_x, \text{EMG}_x) \sqrt{\text{CC}(	heta, \theta)}}}
\]

Conclusion

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On 11 gait cycles for 20 subjects (healthy, stroke and cerebral palsy).

- Has a Fixed trajectories.
- Does not take into account the physical change of patient while moving.
- Operation is not applicable when muscle disorder
- Users give different EMG signals and variations of speed

For both approaches:

- the capabilities and the walk specificity of each patient are not taken into account.

Problems

Existing exoskeleton control

Interaction force controllers using impedance or admittance

Musculoskeletal model based on EMG signals

Needs and Goal

Inter- active Controller

- Assistance where necessary.
- Experience of patient.
- Detection of the patient intention.
- Modularity.
- Stability.
- Security.

Muscular Co-contraction

Challenge and Opportunities

 Assist lower-limb movement during walking for people with spasticity, as in cerebral palsy (CP), stroke (cerebral accident vascular : CA) by the Medical Exoskeleton taking into account the ability of their muscles to bring about a movement.

Bio-Kinematic Study: