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HANDIVERSITÉ
Le handicap un vecteur pour l'innovation
Colloque
L'innovation pour l'accessibilité
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EN LIGNE

Gait rehabilitation based on bio-kinematic signals

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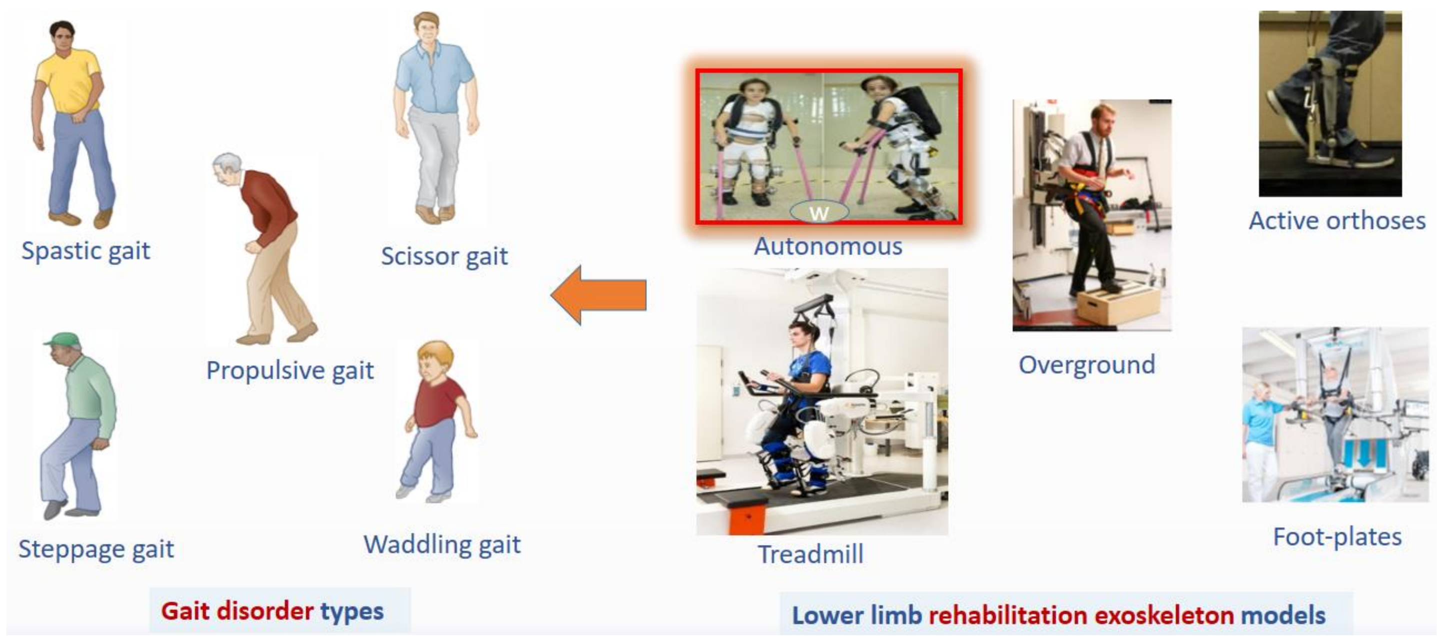
Challenge and Opportunities



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.

Existing exoskeleton control

- Interaction force controllers using impedance or admittance
- Musculoskeletal model based on EMG signals

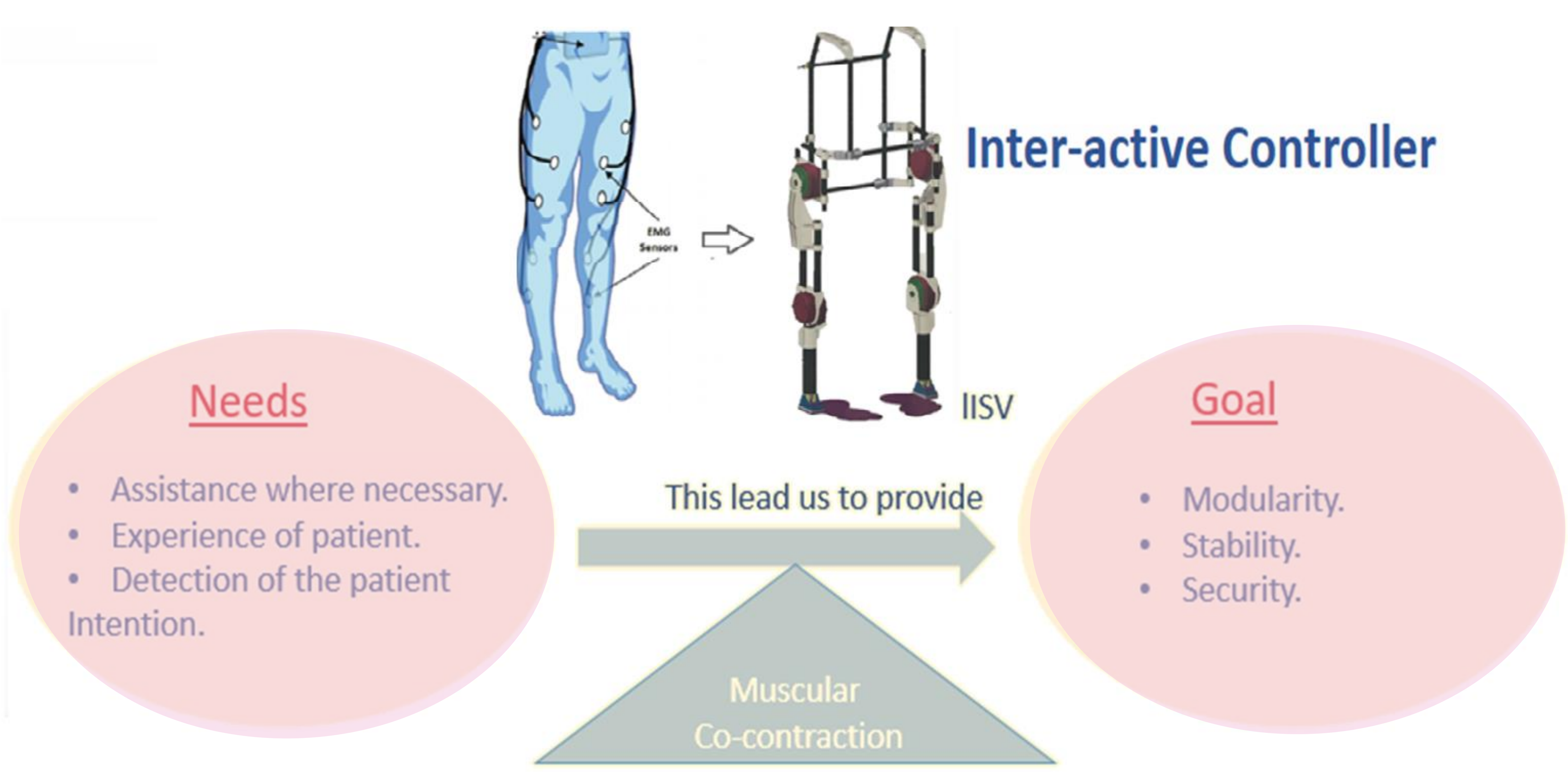
Problems

- Having 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.

Needs and Goal

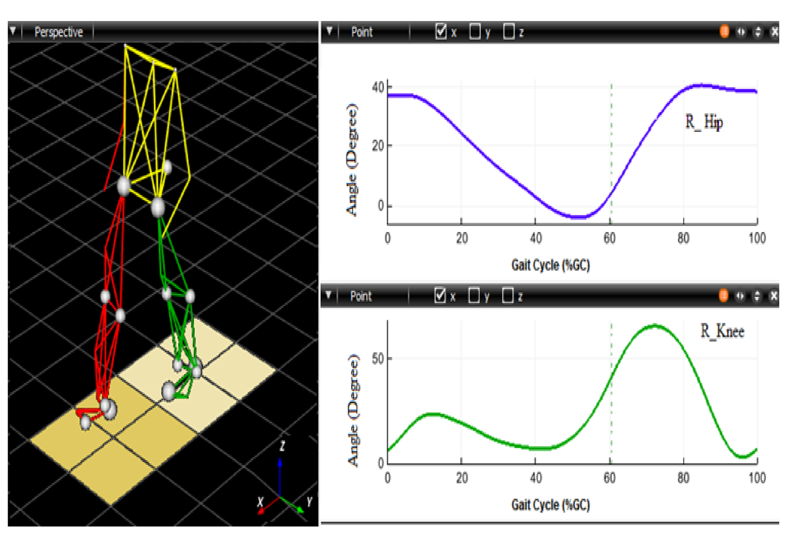


Material and method

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

❑ **Bio-Kinematic Study:**

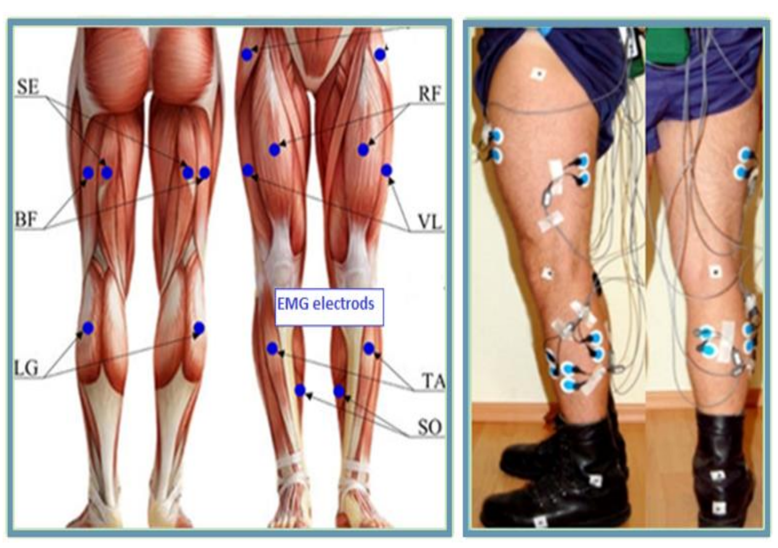
- Kinematics study :



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

- Electromyography (EMG) study :



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

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

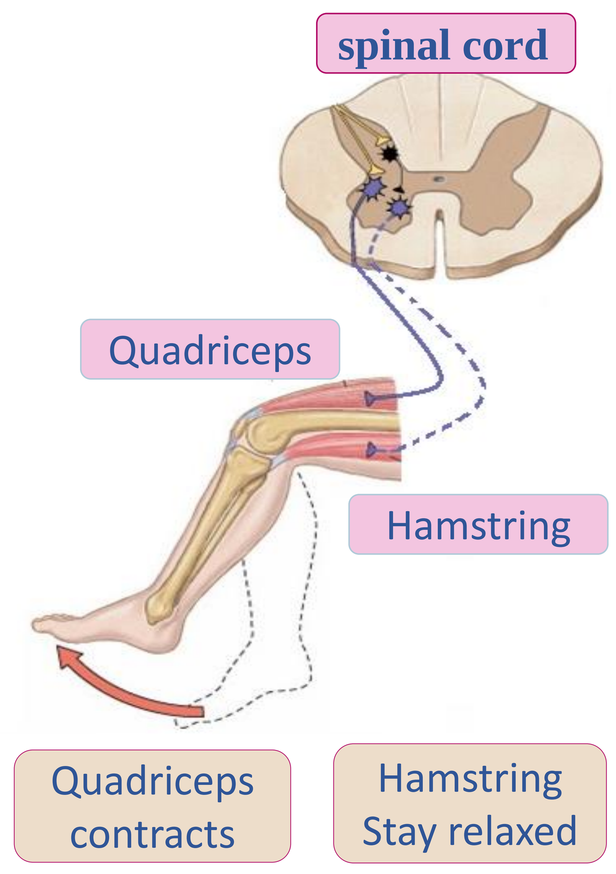
Related works

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.

$$CCI_1 = \frac{2\int_{t1}^{t2}(ENVemg_{AGO}(t) \cap ENVemg_{ANTA}(t))\,dt}{\int_{t1}^{t2} ENV\_emg_{AGO}(t) + ENV\_emg_{ANTA}(t)dt} \times 100$$

$$CCI_2 = \frac{\int_{t1}^{t2}(ENVemg_{AGO}(t) \cap ENVemg_{ANTA}(t))\,dt}{\int_{t1}^{t2}(ENVemg_{AGO}(t) \cup ENVemg_{ANTA}(t))\,dt} \times 100$$

	Movement	Agonists	Antagonists
Hip	Flexion	Quadriceps	Hamstrings
Hip	Extension	Hamstrings	Quadriceps
	Movement	Agonists	Antagonists
Knee	Flexion	Hamstrings	Quadriceps
Knee	Extension	Quadriceps	Hamstrings



Novel neuro-motor control scheme (NMI)

$argmin_t\,|\,f'(t)|$; where $f(t) = ENV(emg_{ATNAGO}(t) \cap emg_{AGO}(t))$

$Rx(t) = h_1(t).f_0 + h_2(t).p_0 + h_3(t).f_1 + h_4(t).p_1$;

where : h_1, h_2, h_3 and $h_4 \in, H_e$; p_0 and p_1 tangent at f_0 and f_1

$NMI = CCI2 + Rx(t).CCI3$

- Find peaks
- Interpolate
- Neuro-Motor Index

Specificities of Neuro-Motor Index (NMI):

- calculate in the joint flexion/extension sequence
- Online method for control

Linearize the results using canonical correlation analysis CCA

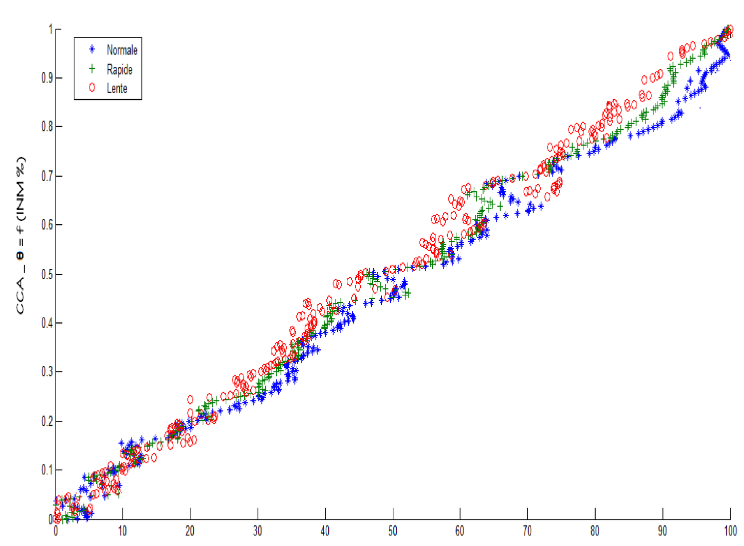
- Extract the underlying correlation of joint angles and co-contraction
- Finds linear combinations such that the is maximized
- Finds a new gait angle using healthy angles for reference

$$Corr(I_k, \Theta_j) = \rho(I, \Theta) = \frac{cov(\Theta, I)}{\sigma_\Theta\,\sigma_I} = \frac{E[(\Theta - \mu_\Theta)(I - \mu_I)]}{\sigma_\Theta\,\sigma_I}$$

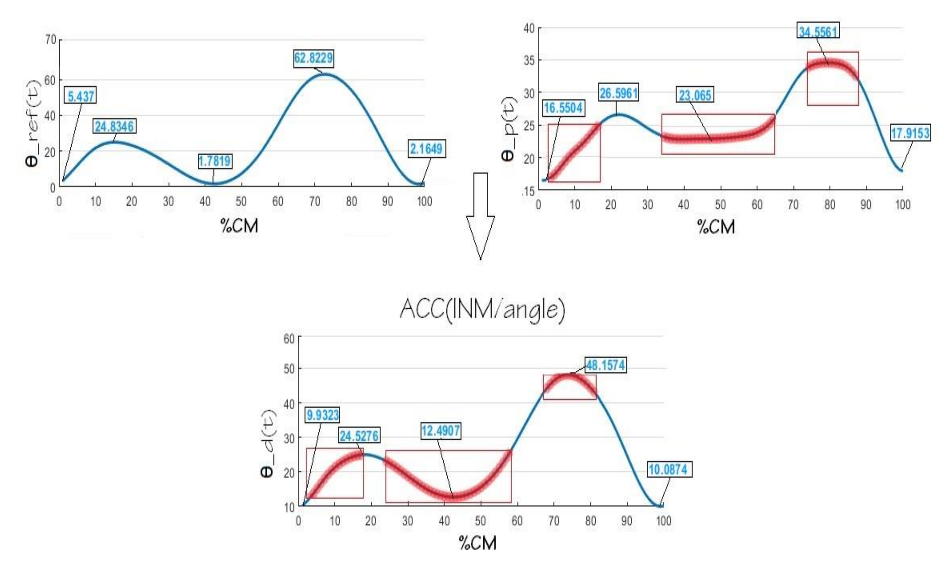
$$CORR(CCA_{ik})_j = \frac{cov(CCA1, CCA2, CCA3)}{\sqrt{cov(CCA1, CCA1, CCA3).cov(CCA2, CCA2, CCA3)}}$$

Results

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, I); ϴ represents the knee joint angle during complete gait cycle, and I represents NMI



CCA applied at NMI and the knee angles for stroke subject. Healthy angles are used for reference

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

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**