Biomedical Robotics Applications

BETER REHAB & TRUE REHAB

Tassos Natsakis

21 November 2021

Universitatea Tehnica din Cluj-Napoca
Robotics and Nonlinear Control

The need for rehabilitation

By Blausen Medical Communications, Inc.

- Strokes are a leading cause of disability [WHO]

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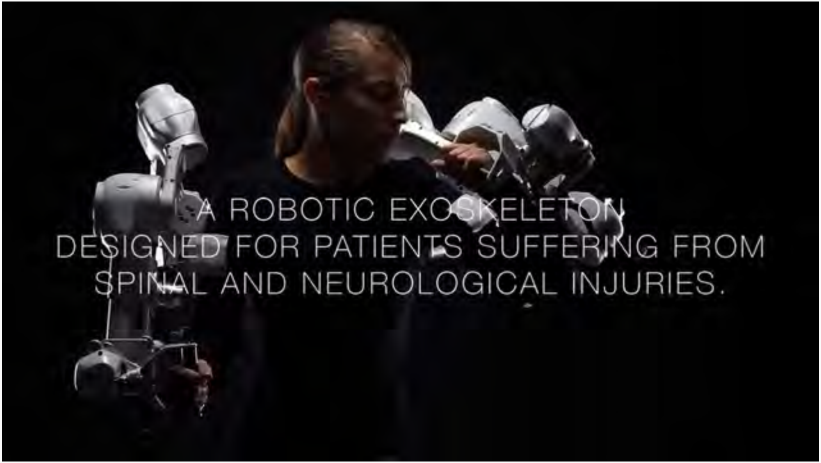
- Impact on quality of life of patients
- Impact on quality of life of **physiotherapists**

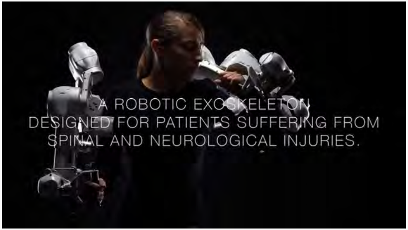
Rehabilitation::Traditional rehabilitation

Robotic rehabilitation::Exoskeletons



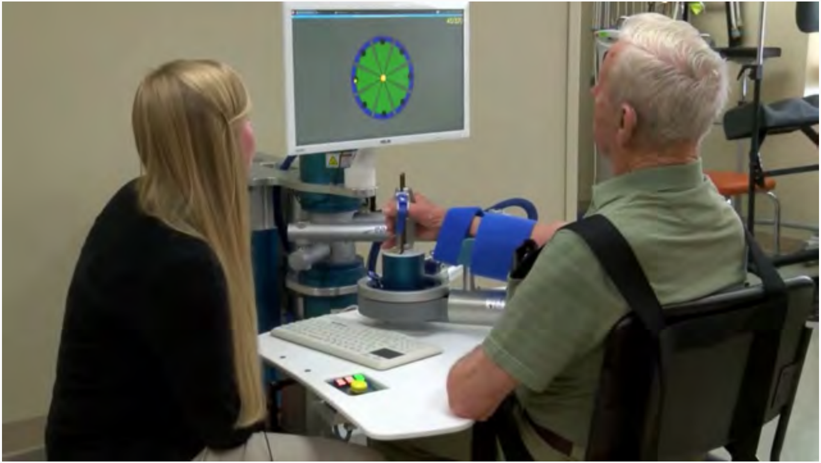
Harmony: Upper-limb Exoskeleton for Stroke Rehabilitation

Robotic rehabilitation::Exoskeletons



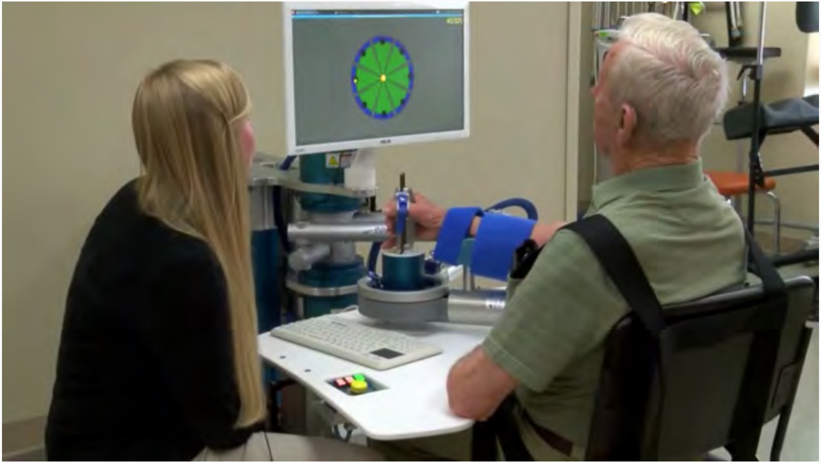
- Very complex mechanics
- Long development times
- Very costly
- Sizing issues
- Long attachment/detachment times (dead time)

Robotic rehabilitation::End-effectors



InMotion Robot

Robotic rehabilitation::End-effectors



InMotion Robot

- Very specific types of motion

Robotic rehabilitation

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- Goal of BETER REHAB project: assist patient along intented trajectory
- Goal of TRUE REHAB project: patient along muscle optimized trajectory [Caiozzo et al.]

Robotic rehabilitation::Collaborative robotic arms

- Lower development costs
- Much faster attachment
- Patient specific
- Safe

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Disadvantage
More complex control is necessary

Talk Overview

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- Intention of motion

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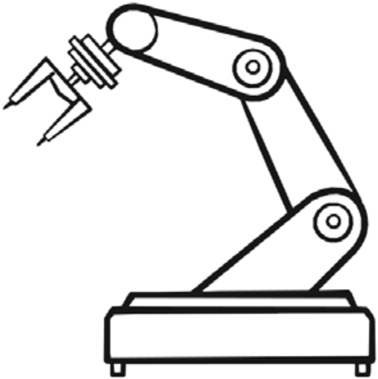
Intention of motion

Intention of motion::How?



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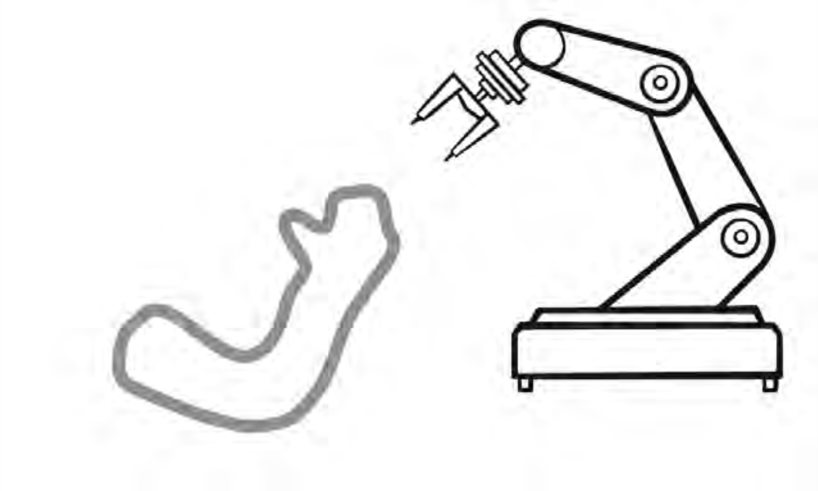

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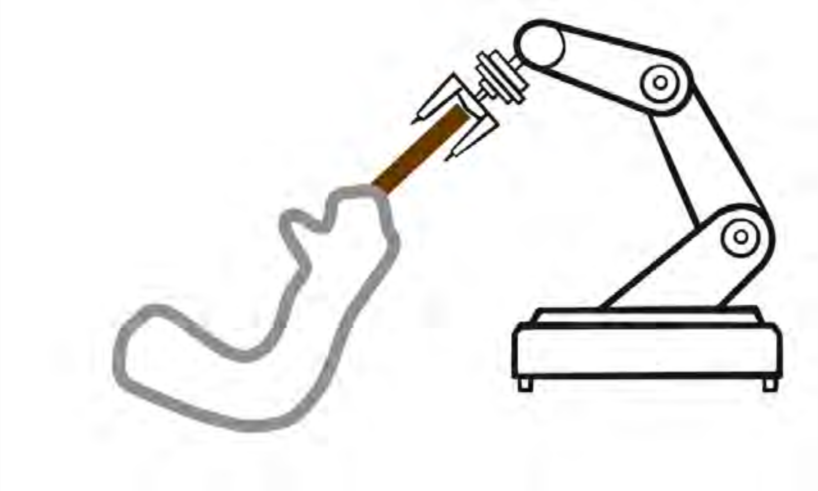

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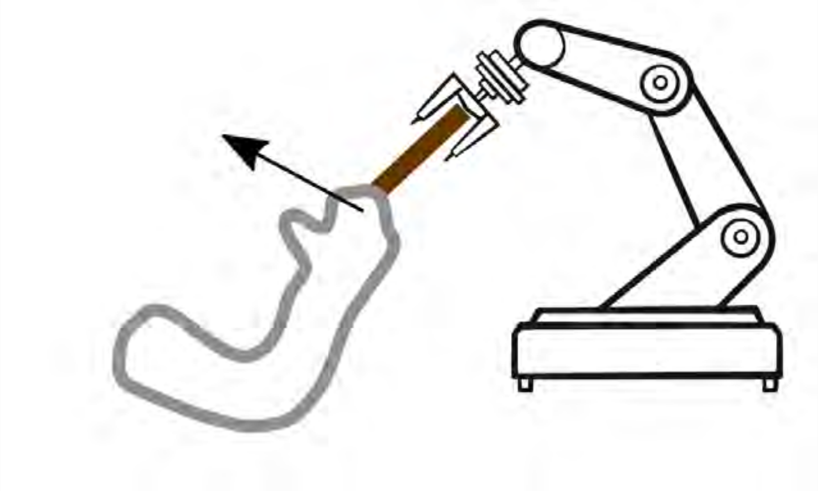

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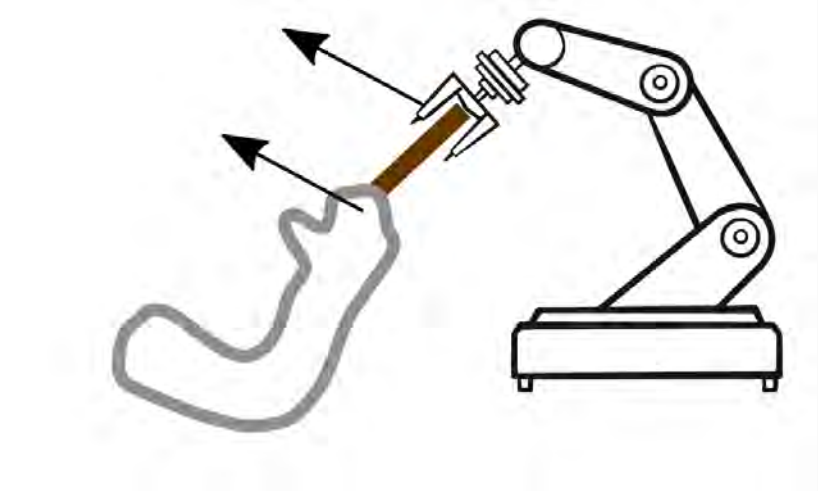

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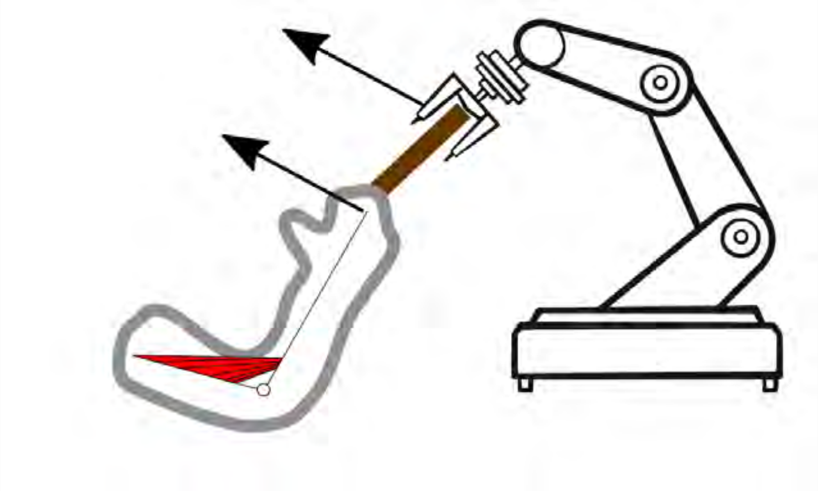

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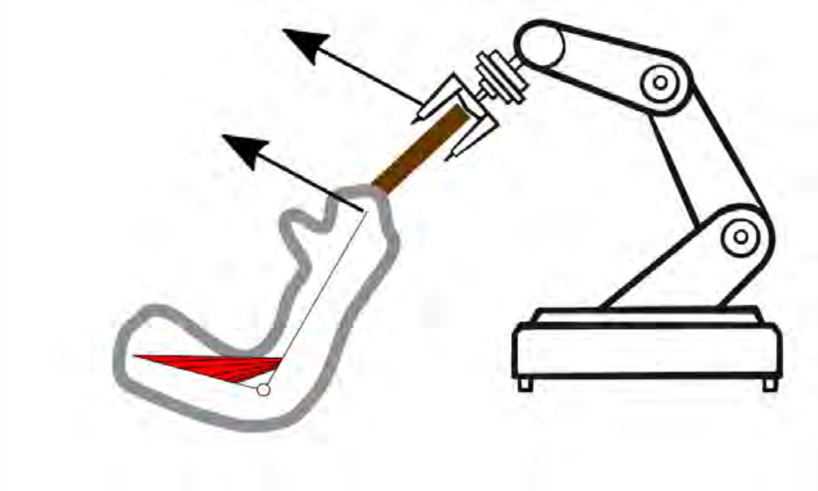
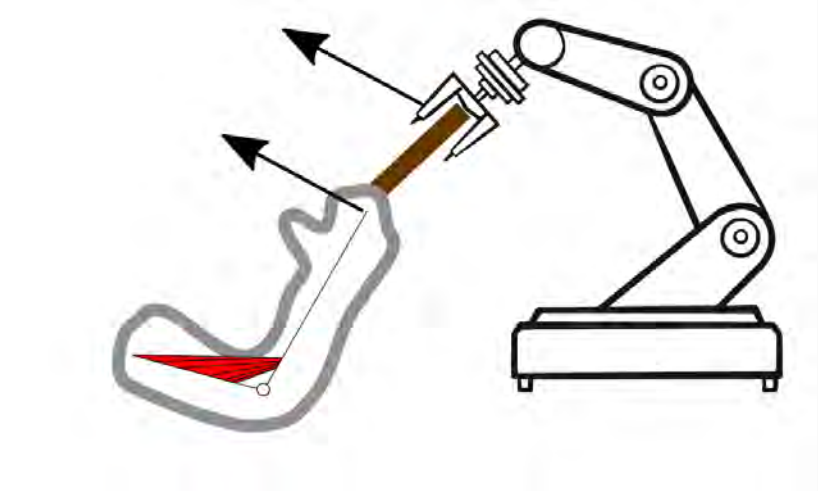


EMG can help us predict the intention of a person

Intention of motion::How?



EMG can help us predict the intention of a person

The robot can then assist in the right direction by the desired amount

Intention of motion::Measurements

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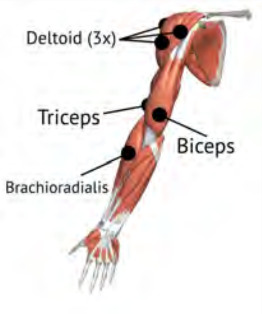
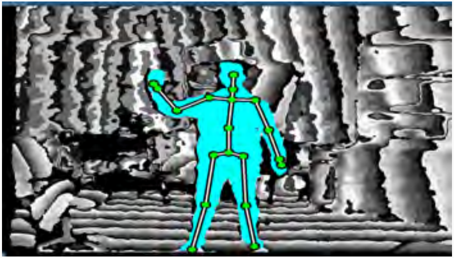
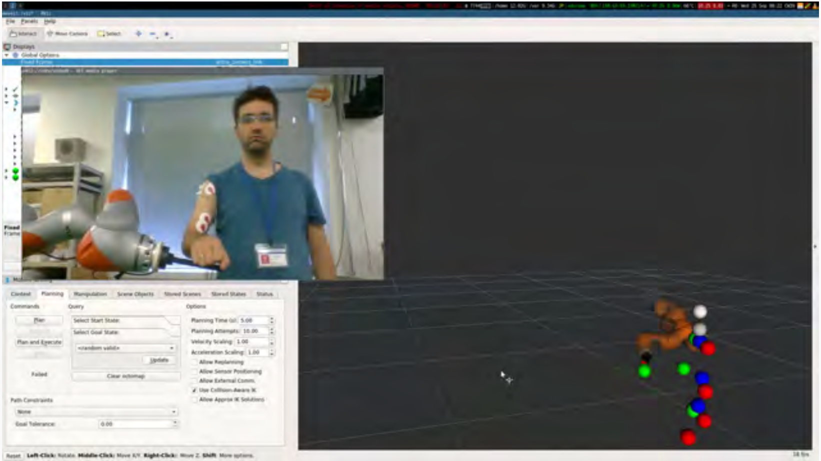




Intention of motion::Prediction



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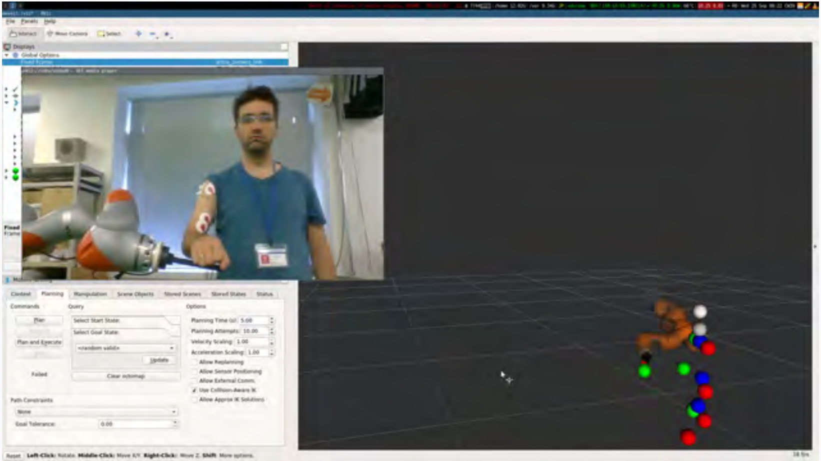
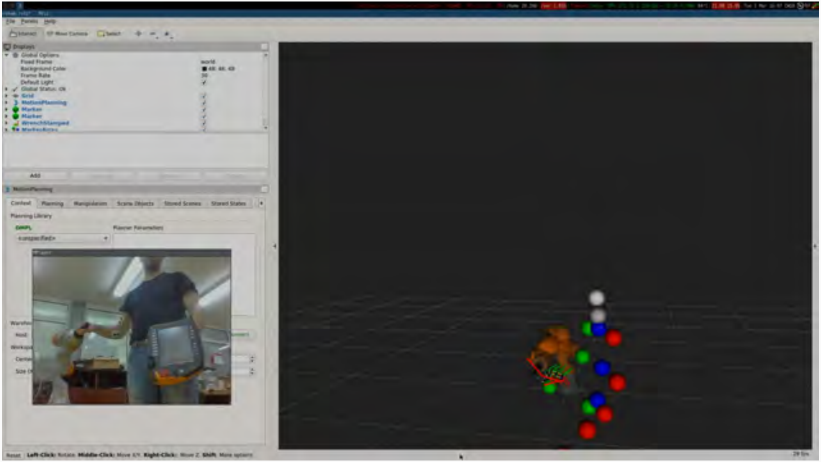


43rd International Conference of the IEEE Engineering in Medicine and Biology Society

Intention of motion::Experimental validation



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Quantifying the human-robot force interaction

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IEEE Robotics Automation Magazine

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Rehabilitation::Muscle forces estimation

Operation principle

Calculate trajectories for maximizing/minimizing force production of specific muscle forces

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- Increase effeciency of rehabilitation
- Train specific muscles
- Minimize load on sensitive areas (e.g. surgery)

Muscle forces::Estimation

Relationship between muscle activation (EMG) and force is not known

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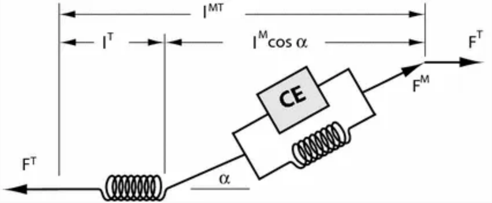

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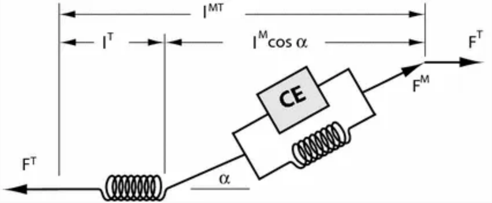

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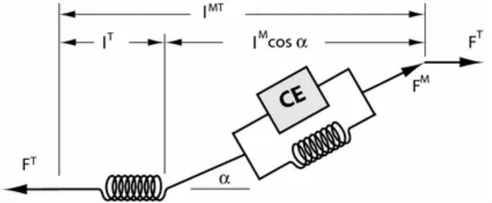

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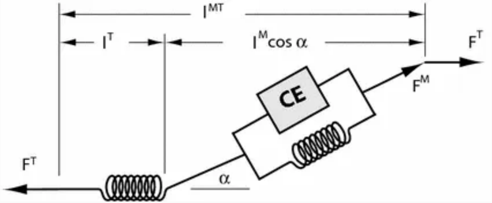

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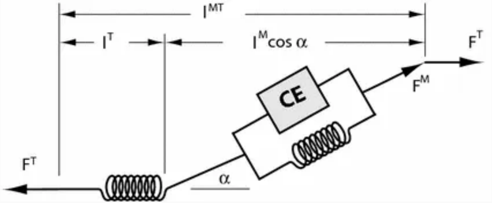

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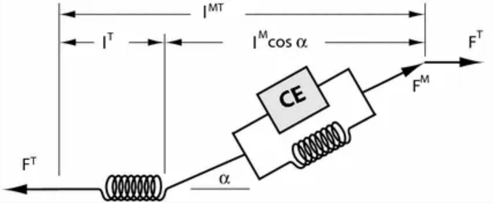

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Muscle parameters::Identification

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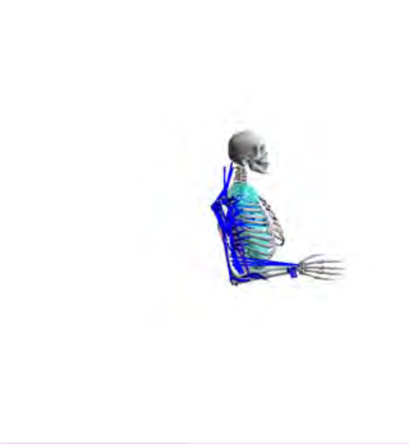
Musculoskeletal modelling [Reed et al.; Blana et al.]



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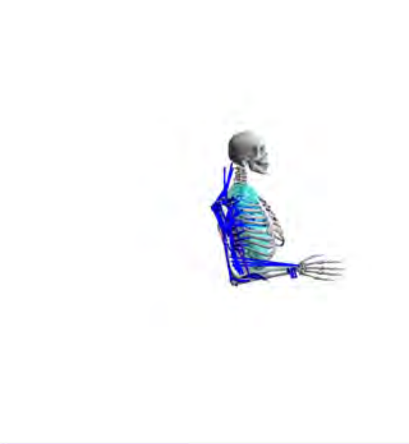

Global Search Optimization methods [Kennedy and Eberhart; Falisse et al.]

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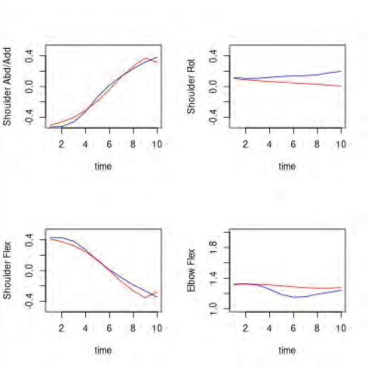

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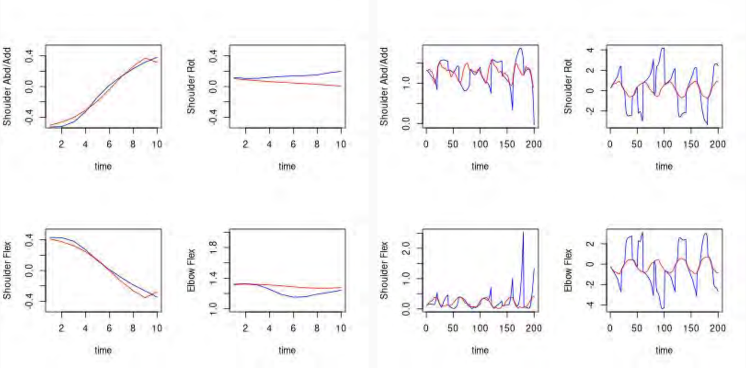

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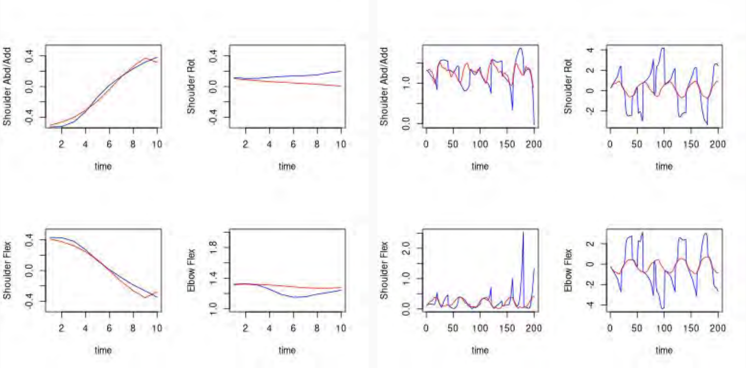
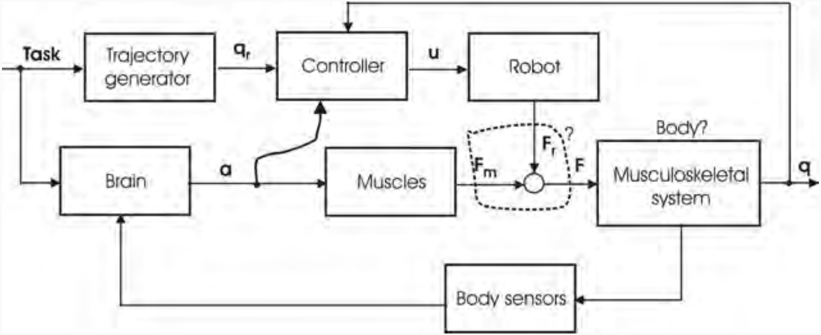


Preparing for *Computer Methods in Biomechanics and Biomedical Engineering*

Robot control

Control::Scheme



Control::Robot model

Control::Practical problems

- No torque control available on the UR5

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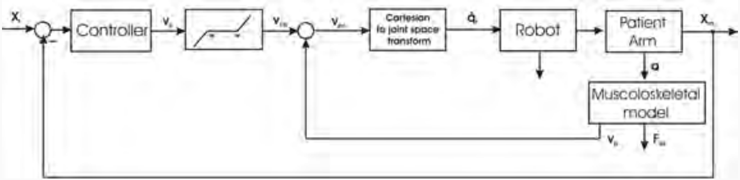

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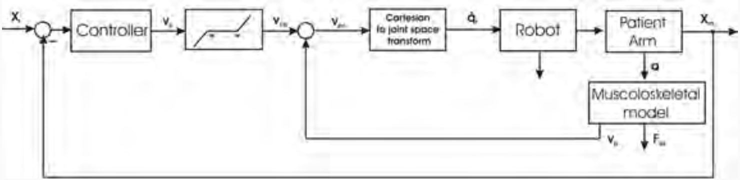

Preparing for *Mathematical Problems in Engineering*

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Controller identification

We have successfully identified the structure and parameters of the internal controllers of the robot

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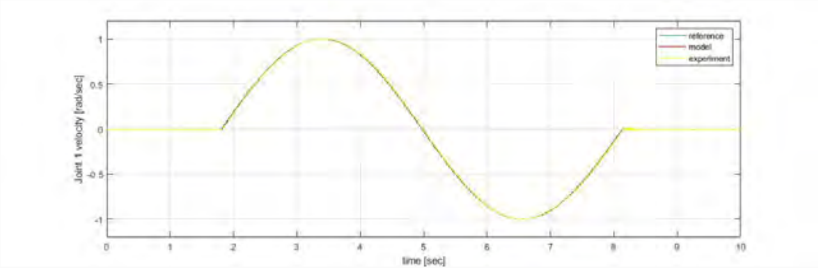

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Motor parameters identification

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- Staic and dynamic friction

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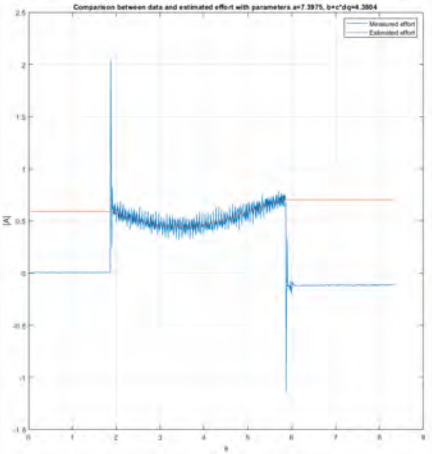

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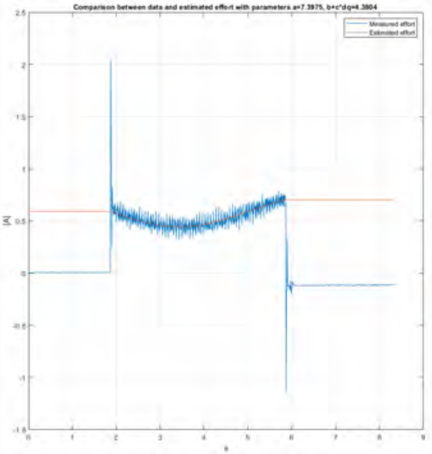
Preparing for *ICONS 2022*



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Questions?

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