BIOMECHATRONICS

WB2432

Delft University of Technology

Biomechatronics

Delft University of Technology
2006-2007

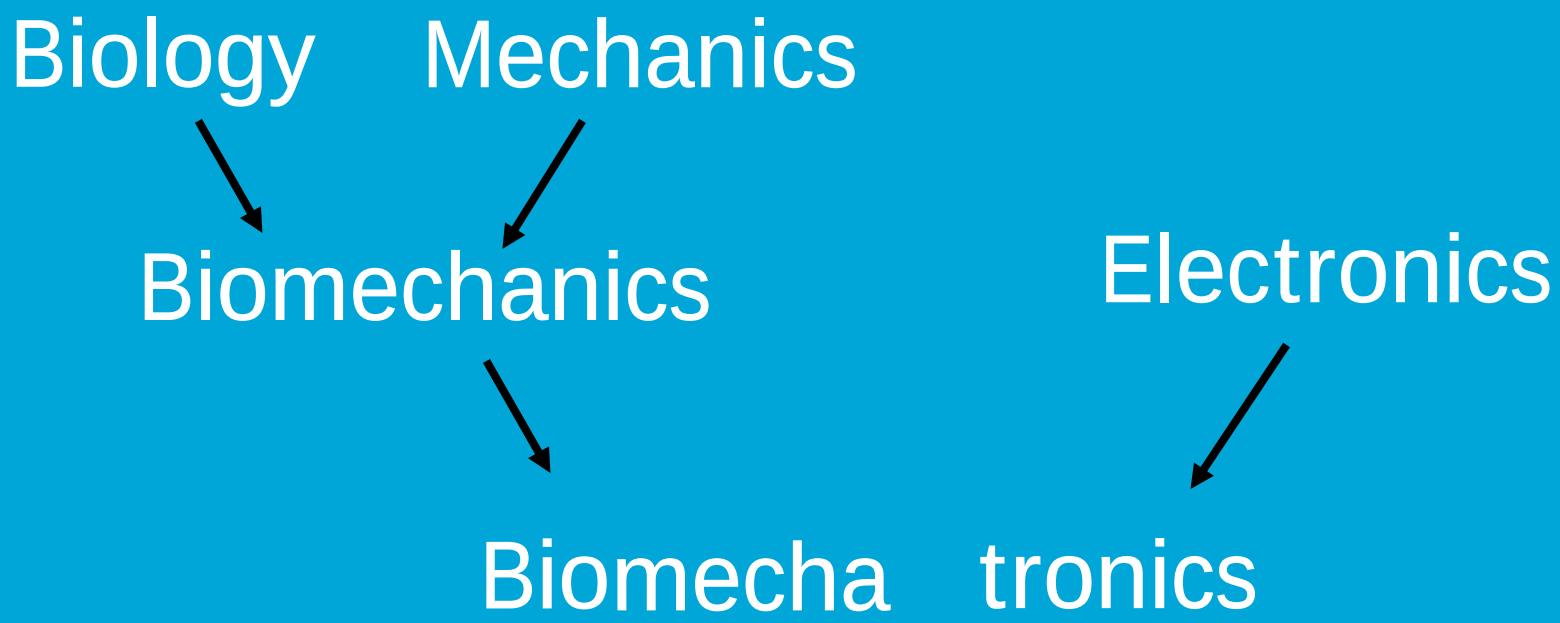
Wb 2432
Lecture 1: introduction

Frans van der Helm
Dick Plettenburg

Goal

- Students should have obtained
  - general knowledge about technical aspects of solutions for the rehabilitation of patients with motoric disorders
  - in particular about prostheses and orthoses and about functional electro-stimulation (FES)
  - with emphasis on the sensoric and actuator interfaces (control)
- Students should be able to make decisions
  - for designing appropriate assistive devices for patients with motoric disorders
  - based on insight on the motor control of these patients

Biomechatronics


Biology
Mechanics
Biomechanics
Electronics
Biomecha
tronics


Biomechatronics

Biomechatronics

- Biomechatronics describes the research and design of assistive devices (mechanical or with electronic compontents) for patients with an impaired motoric system.
- In particular, there will be an emphasis on the dynamics and control of the human in combination with the assistive device.

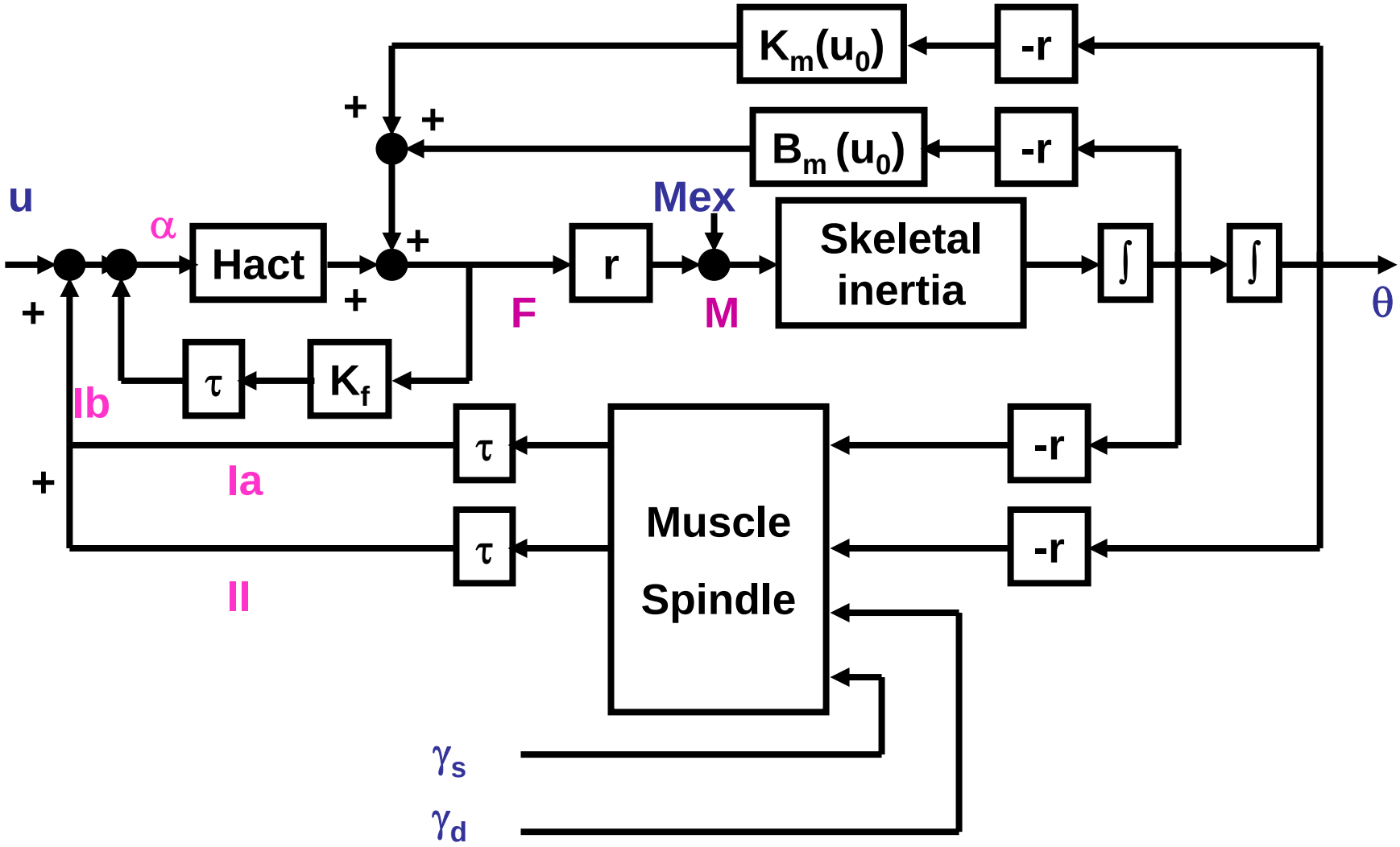
Biomechatronics

- Started at University of Twente (Peter Veltink)
  - Biomedical Technology Institute (BMTI)
    - Electrical Engineering
    - Mechanical Engineering
  - Emphasis on lower extremities
    - Standing
    - Walking
- Together with Delft University of Technology
  - Graduate School Integrated BioMedical Engineering (IBME)
  - Emphasis on upper extremities & motor control

Topics

- (Human motion control)
- Impaired motoric system
  - Neurology
  - Rehabilitation
- Assistive devices
  - Mechanical devices
  - Electrical devices
    - Actuators
    - Sensors
- The human in control: Interfaces
- Training devices
  - Motor system (muscles, joints)
  - Central Nervous System
    - Haptic interfaces
    - Electrical stimulation

Human motion control



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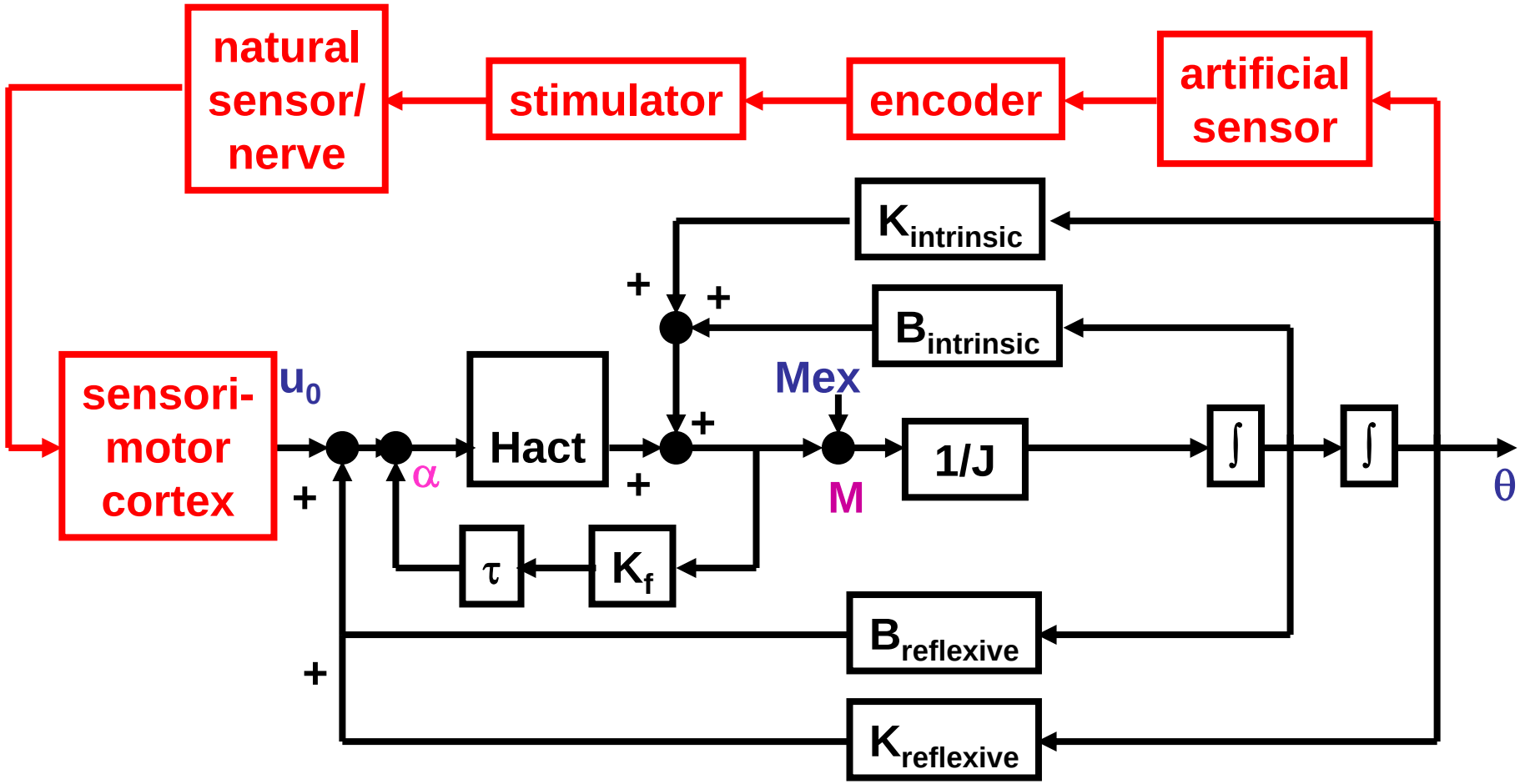
Motion control of artificial sensor



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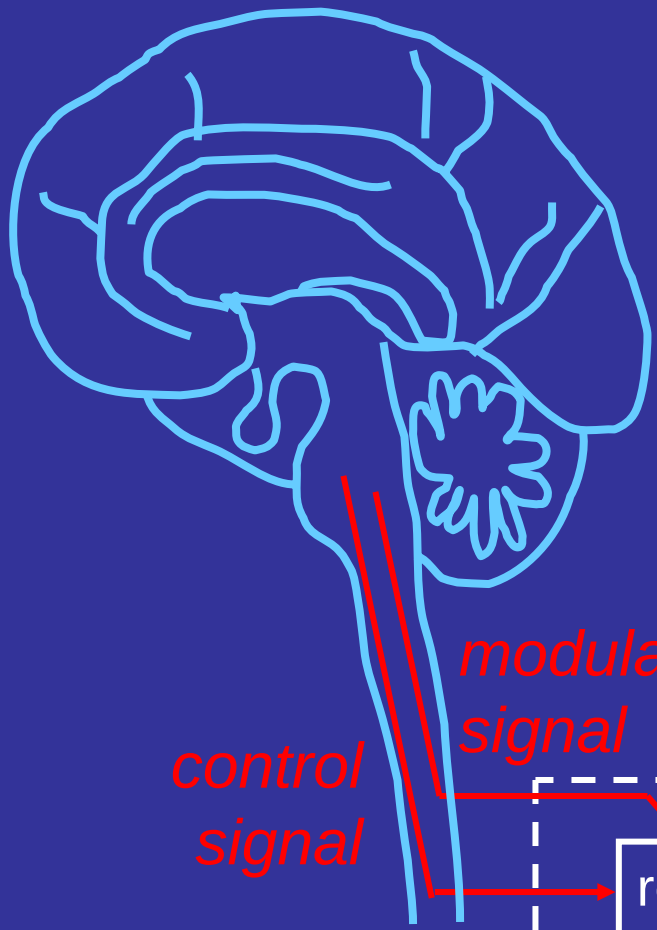
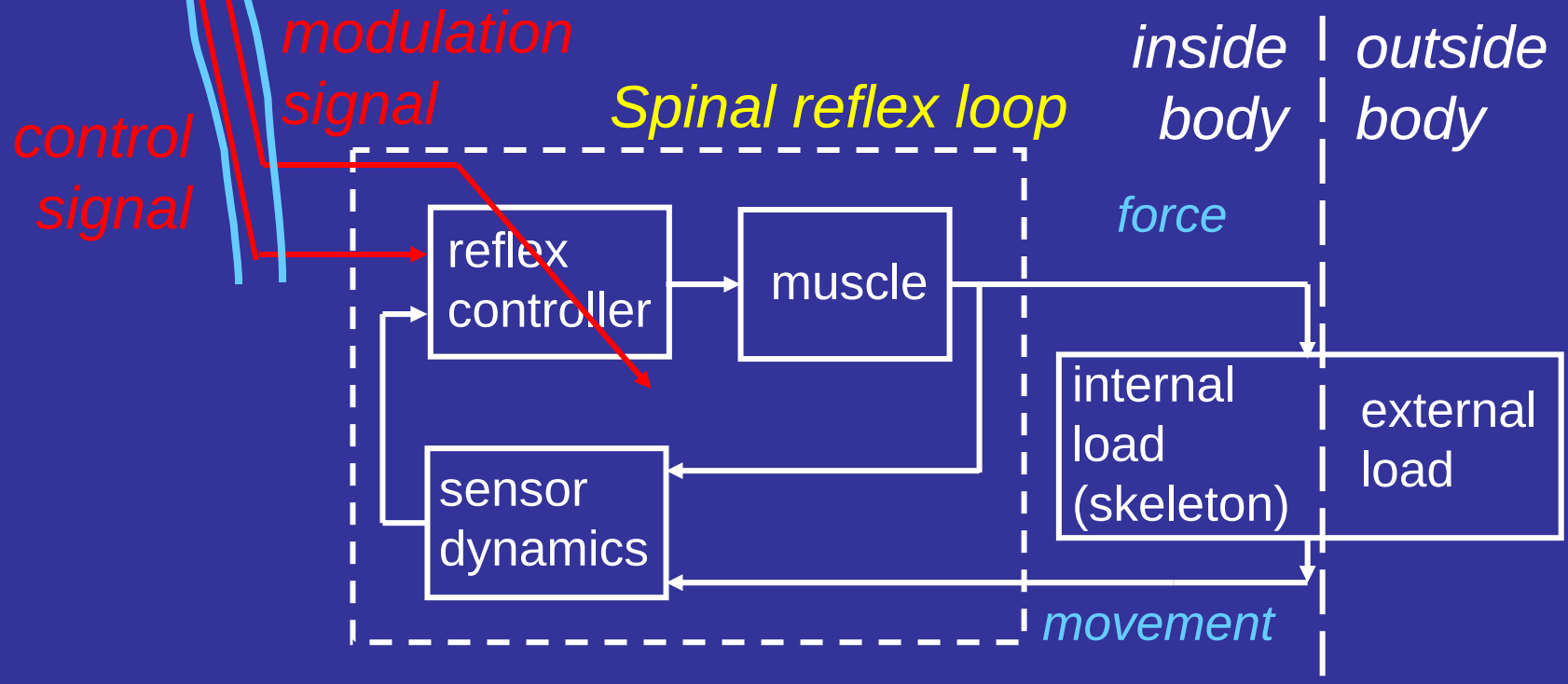
Physiological motor control

the Central Nervous system
is a hierarchical control system





Impaired motor control

Patient groups

- complete SCI
- incomplete SCI
- Stroke
- MS
- CP
- Parkinson
- Amputees
- .....

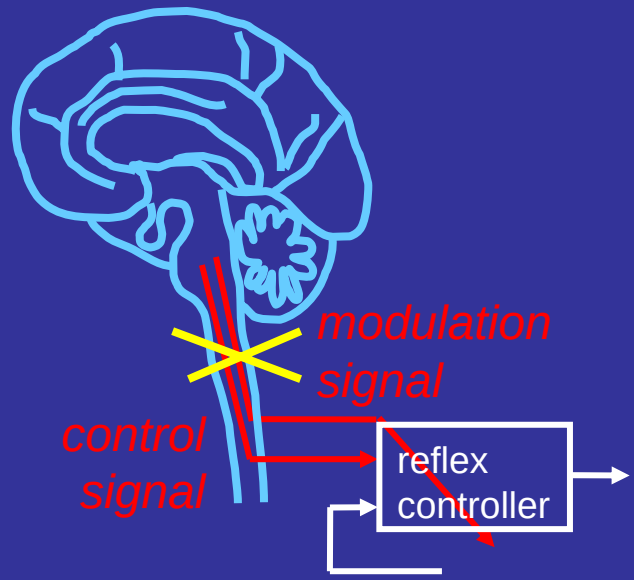
Impairment

↓

disability

↓

handicap



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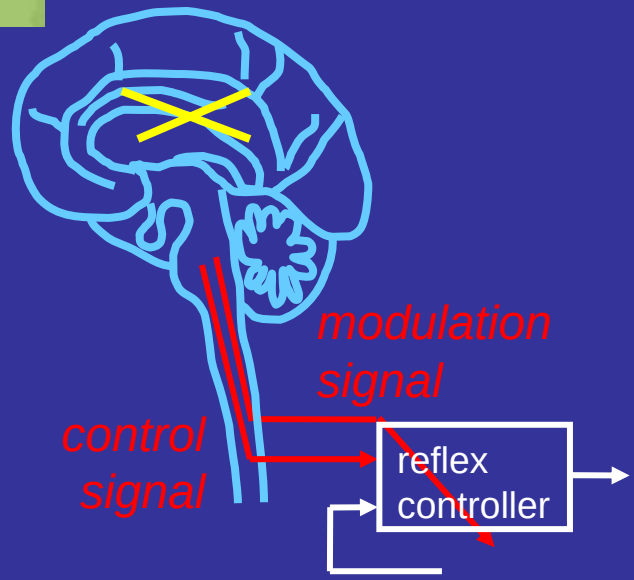
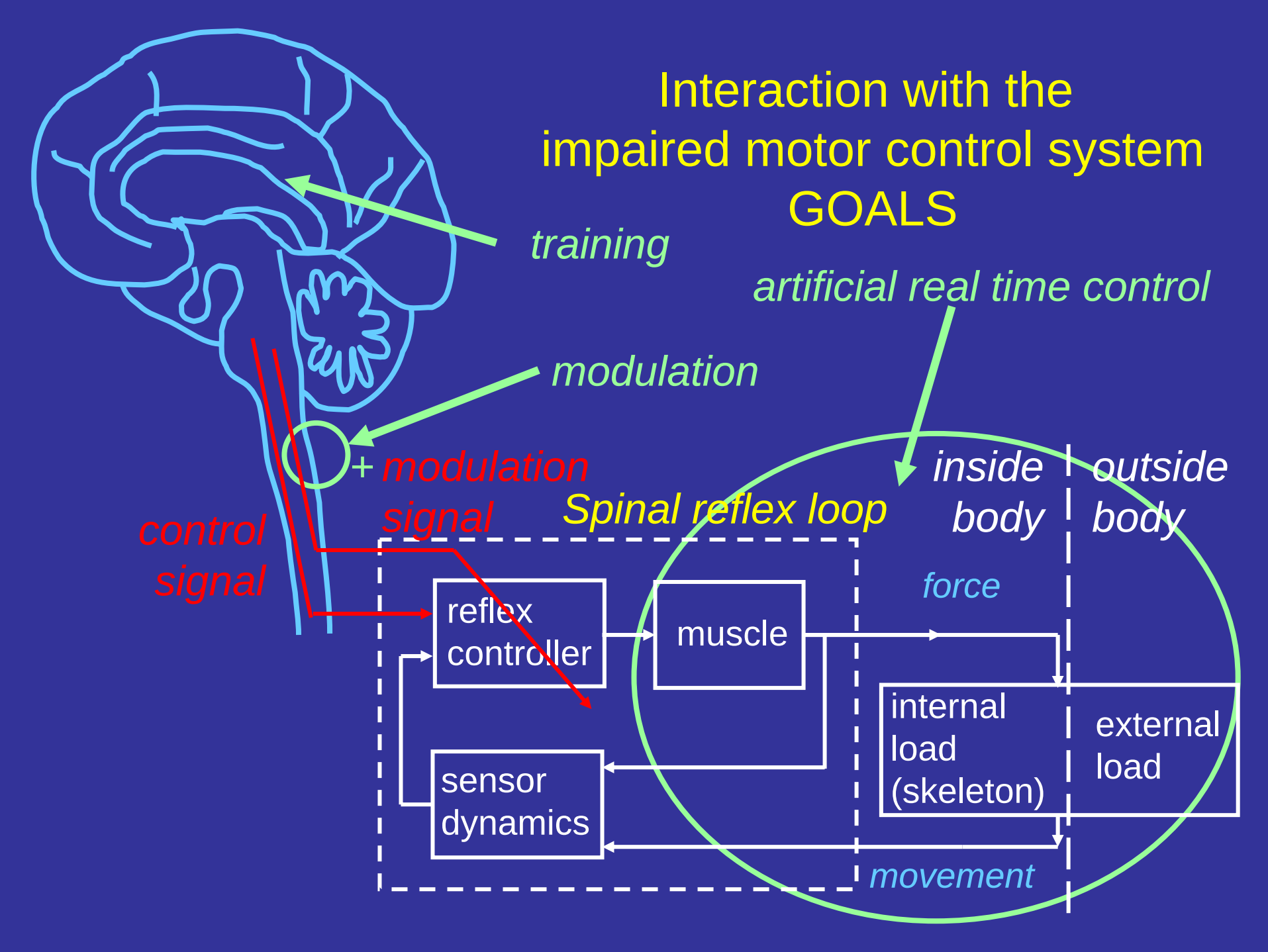
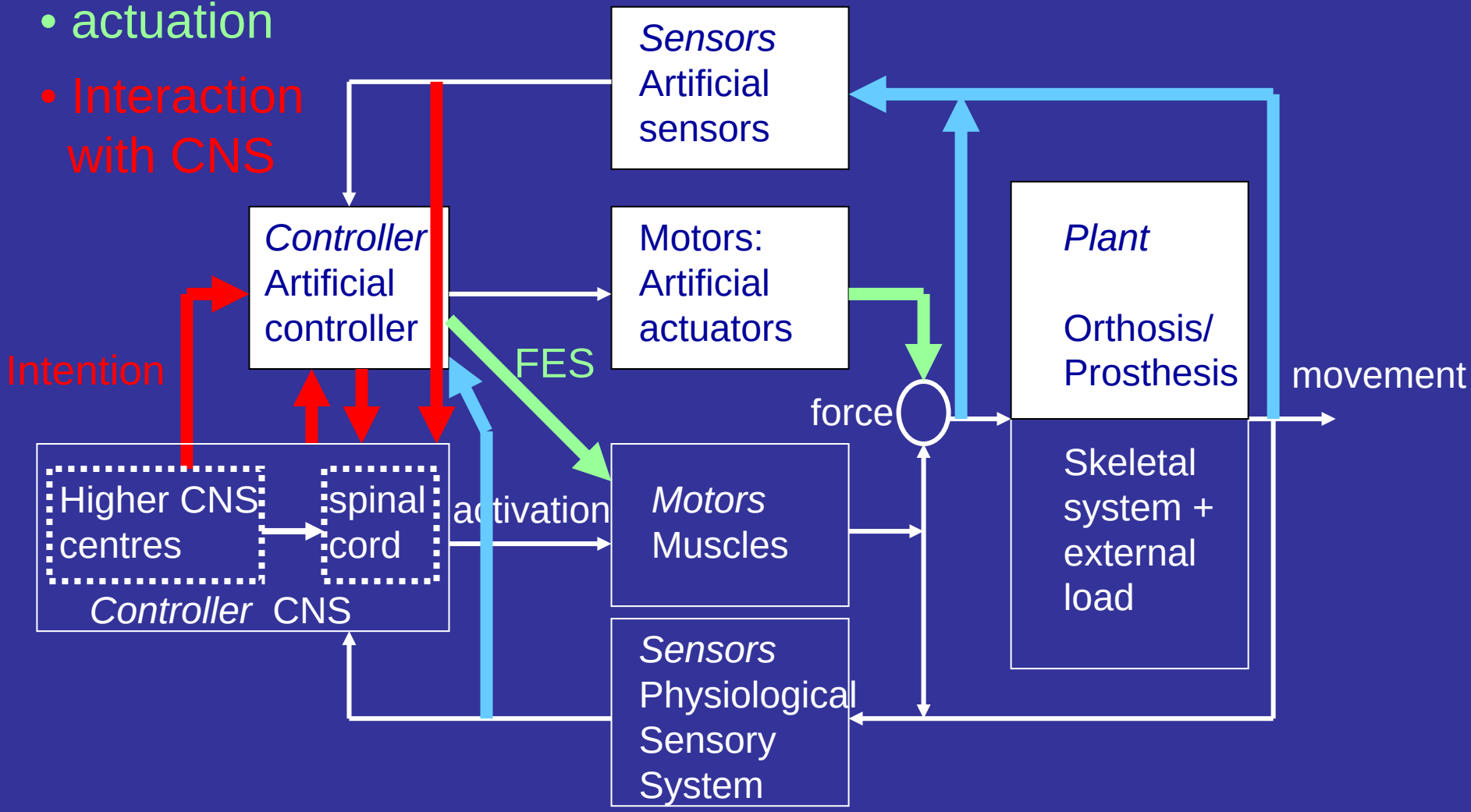



Interaction with the
impaired motor control system
GOALS
training
artificial real time control
modulation
+ modulation
signal
control
signal
Spinal reflex loop
inside
body
outside
body
force
reflex
controller
muscle
internal
load
(skeleton)
external
load
sensor
dynamics
movement

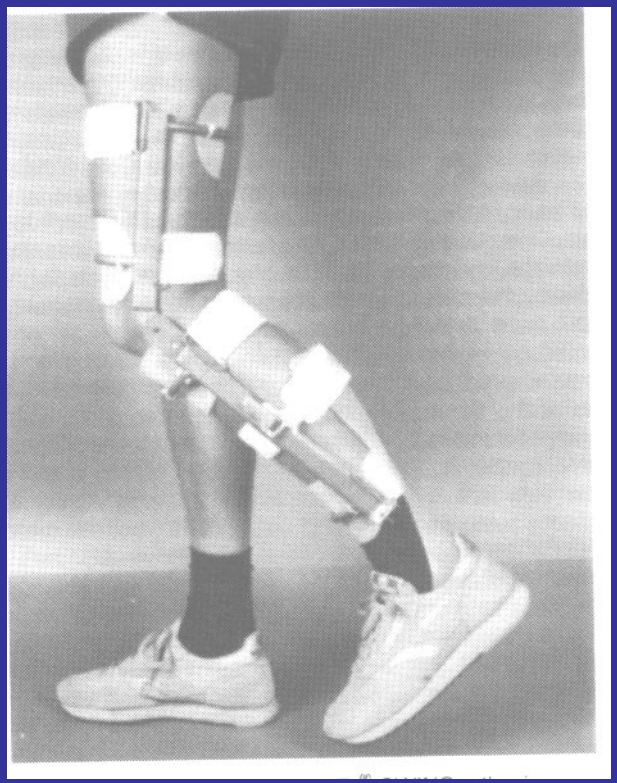
Interaction with the impaired motor control system

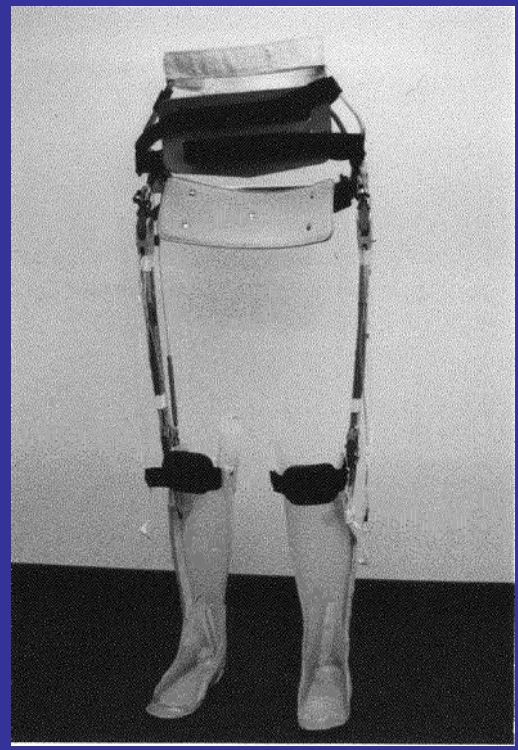
- mechanics
- sensing
- actuation
- Interaction with CNS

MEANS



Interaction with the impaired motor control system
MECHANICS





Interaction with the impaired motor control system
MECHANICS

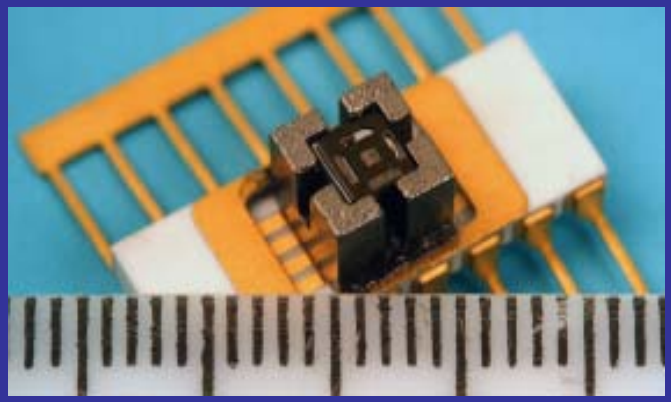
Interaction with the impaired motor control system
MECHANICS

Interaction with the impaired motor control system
MECHANICS

Interaction with the impaired motor control system

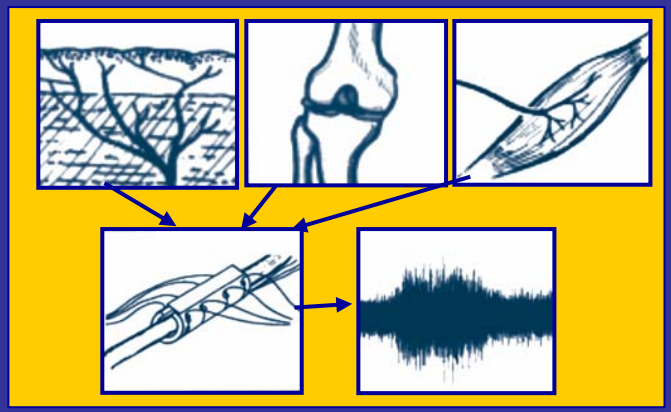
SENSING

artificial sensors



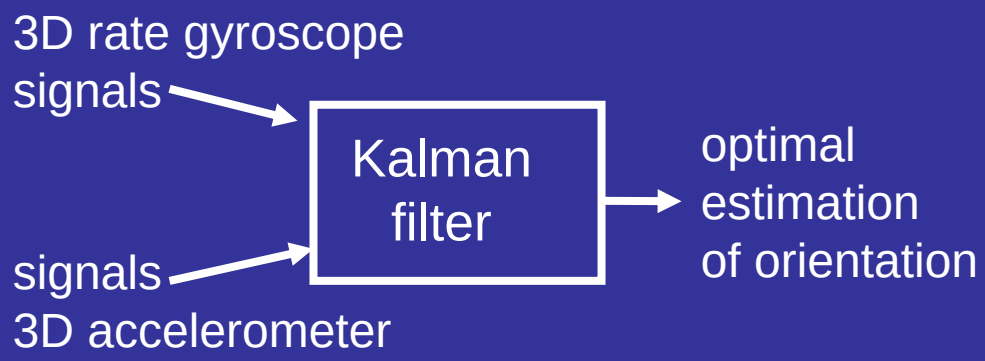
(Lötters et al., 1998, University of Twente)

physiological sensors



(Sinkjaer et al., Aalborg Universtiy)

signal analysis



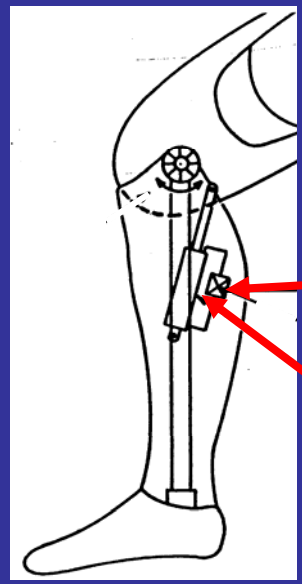
(Luinge et al., 1999, University of Twente)

Interaction with the impaired motor control system
ACTUATION

muscle stimulation

(Franken et al., 1994, University of Twente)

artificial actuators



controllable knee damping

Electromechanically controlled valve

hydraulic cylinder

(Dyck et al, 1975;
Popovic et al, Universities of Belgrade and Alberta)

Interaction with the impaired motor control system
INTERACTION WITH CNS

From CNS

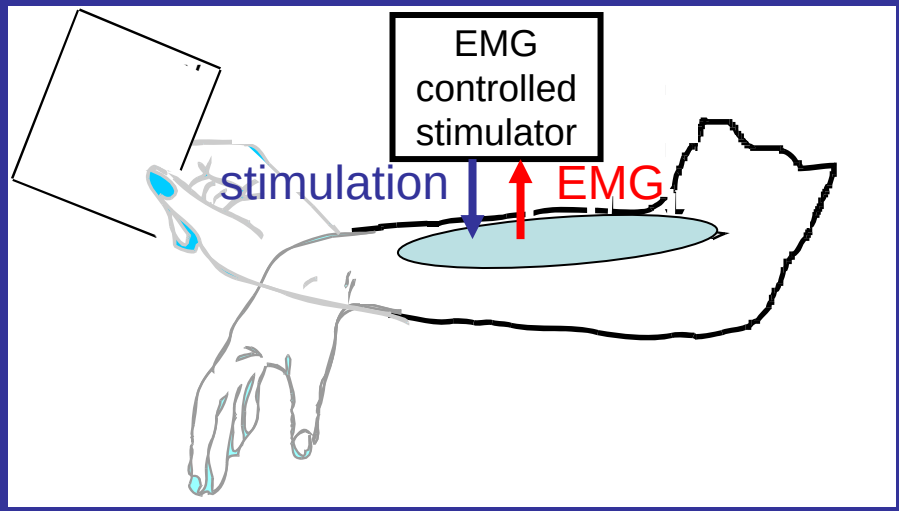
- EEG / MEG
- ENG
- EMG
- movements/forces

to CNS

- stimulation of reflexes
- stimulation of sensors
- mechanical interaction with extremities influence feedback to CNS

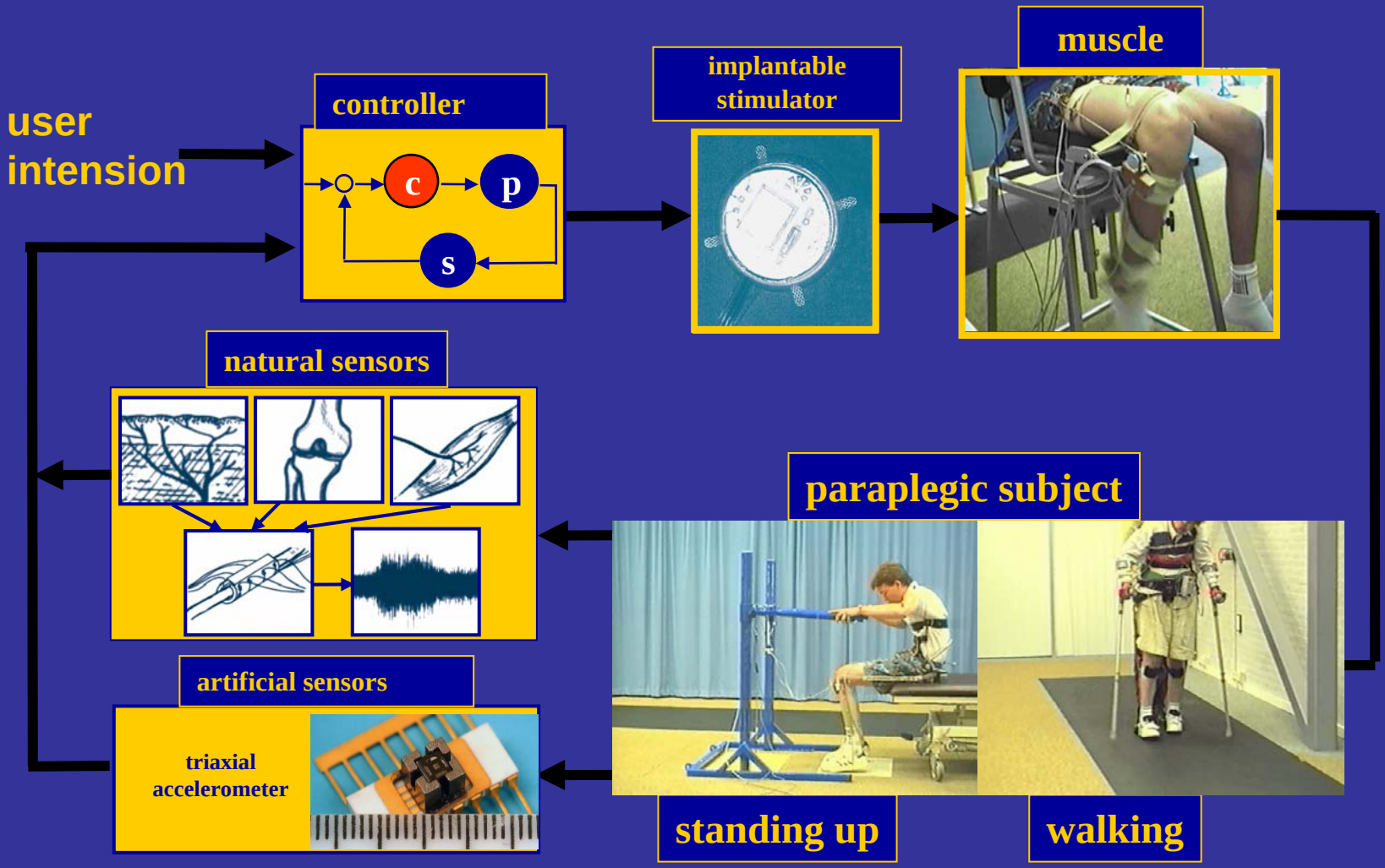
Example

EMG controlled FES



(R. Thorsen et al., University of Twente, Politecnico di Milano 1999)

FES assisted mobility in paraplegics



BMT

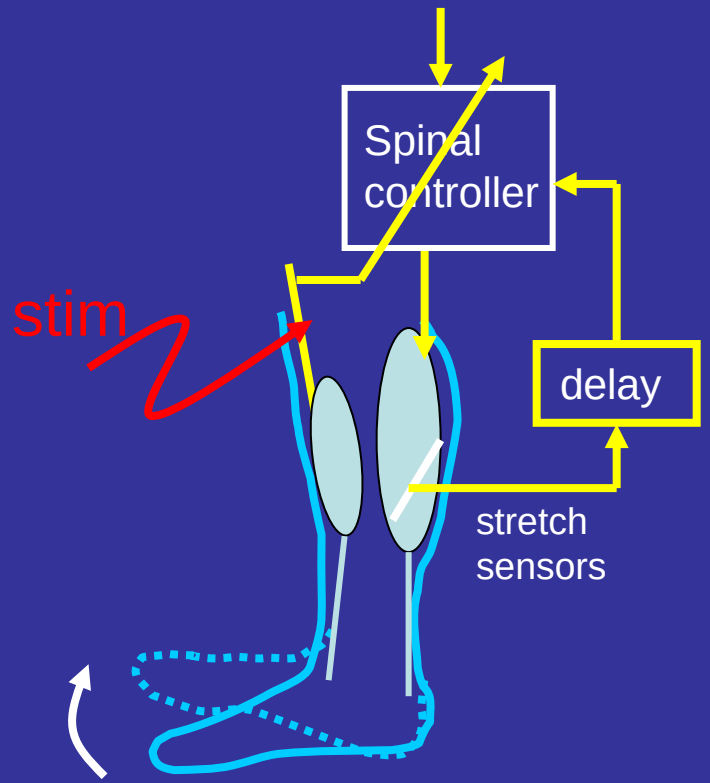
Institute for Biomedical Technology

Modulation of reflexes in stroke patients

Shank front

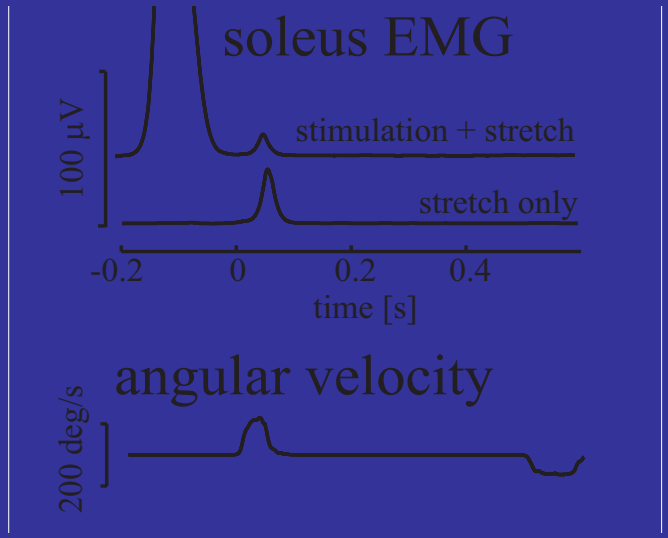
Shank back

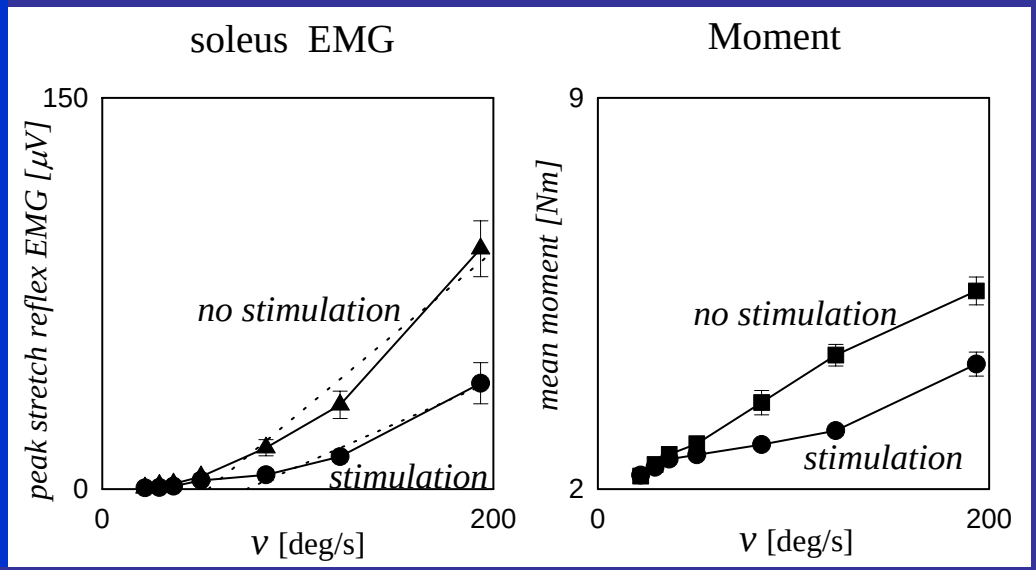
Inhibition of calf muscle stretch reflex in stroke patients by stimulation of the deep peroneal nerve

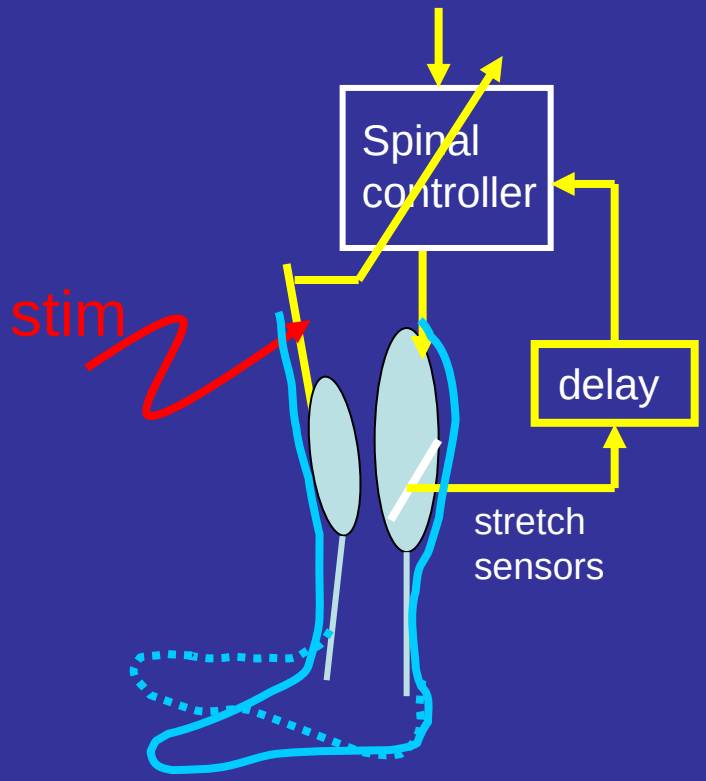


Experiments were performed at Aalborg University

Modulation of reflexes in stroke patients

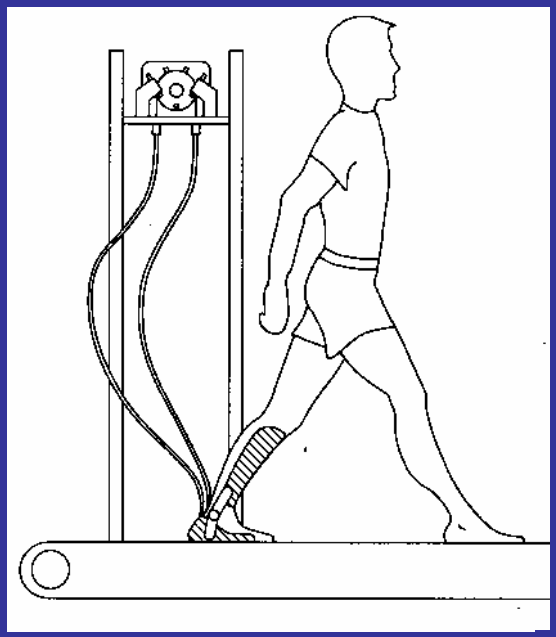


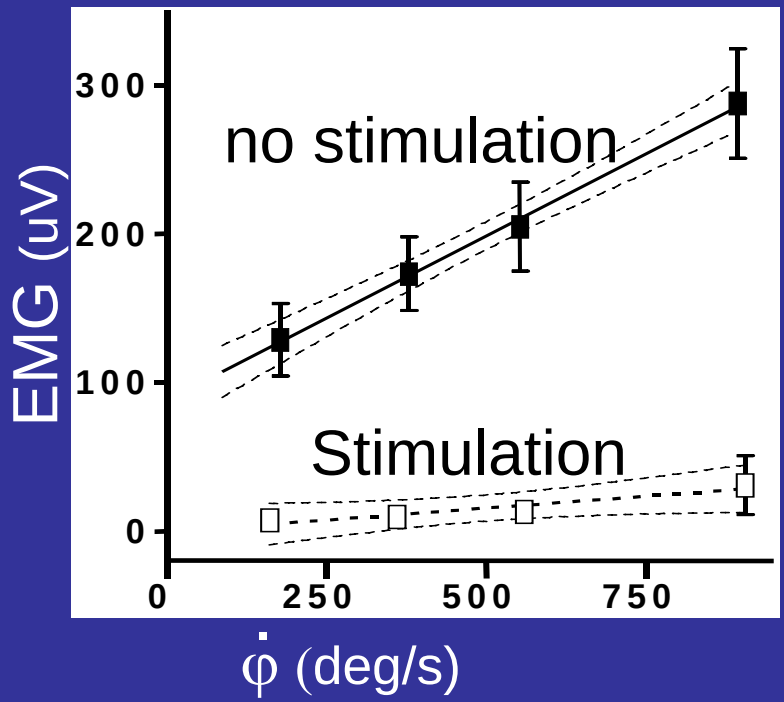




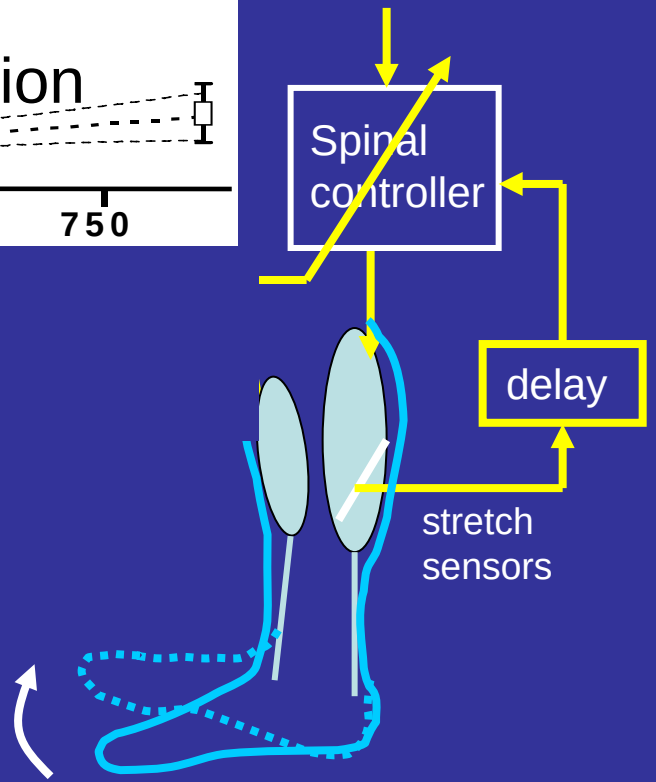
(Veltink et al, 2000)

Modulation of reflexes in stroke patients





(Voormolen et al, accepted)



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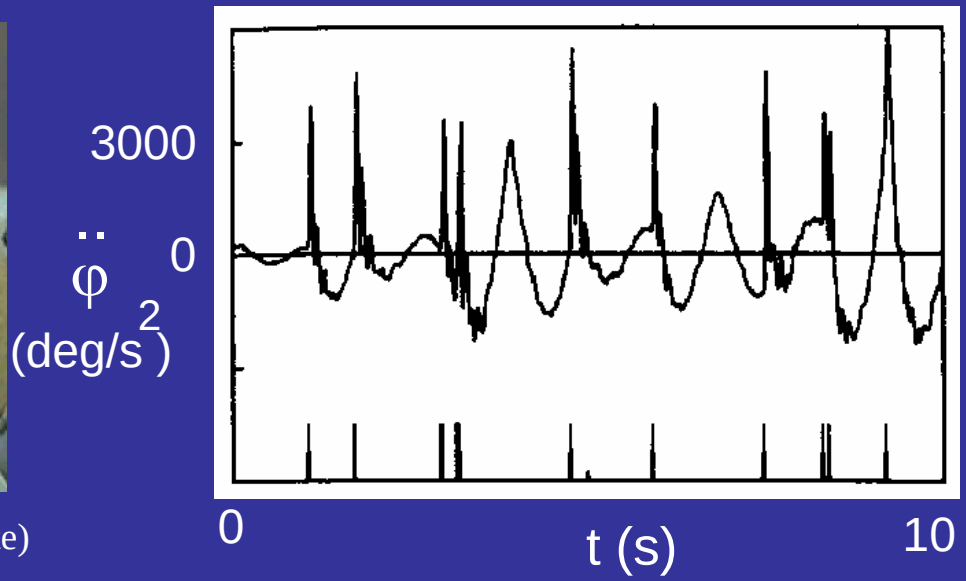
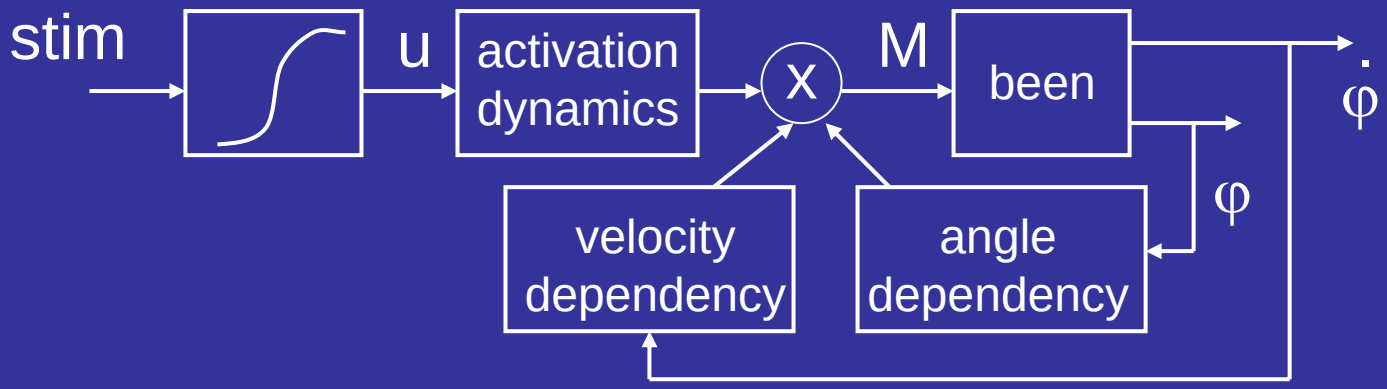
Interaction with the impaired motor control system
ACTUATION

muscle stimulation

(Franken et al., 1994, University of Twente)

identification of muscle dynamics

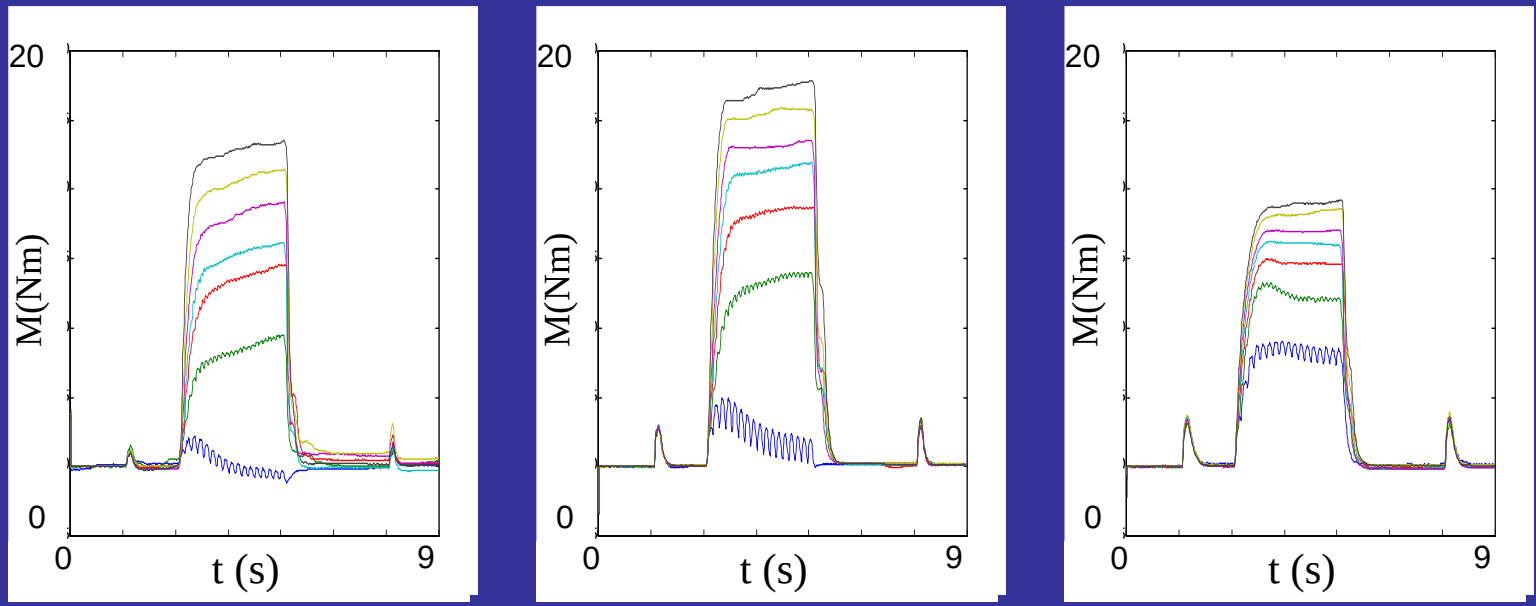




Interaction with the impaired motor control system
ACTUATION

Muscle dynamics:

muscle length and stimulation frequency dependency



Short muscle

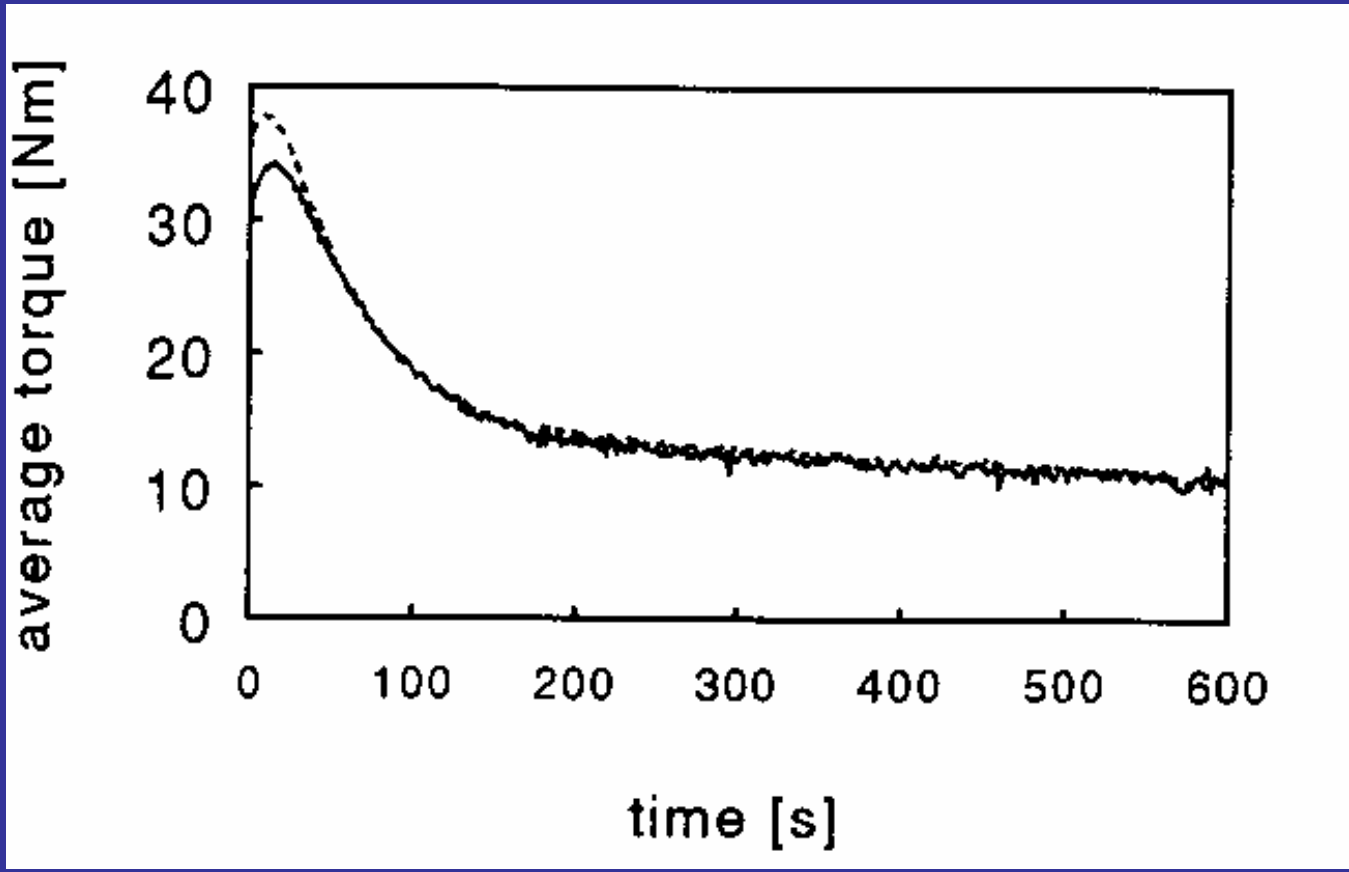
Long muscle

Tibialis anterior, Healthy subject

(Mela, Veltink, Huijing 1999)

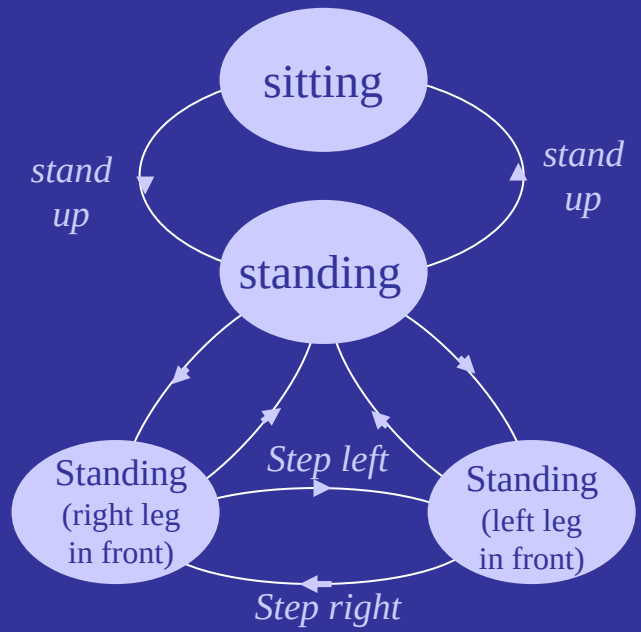
Interaction with the impaired motor control system
ACTUATION

Muscle fatigue:

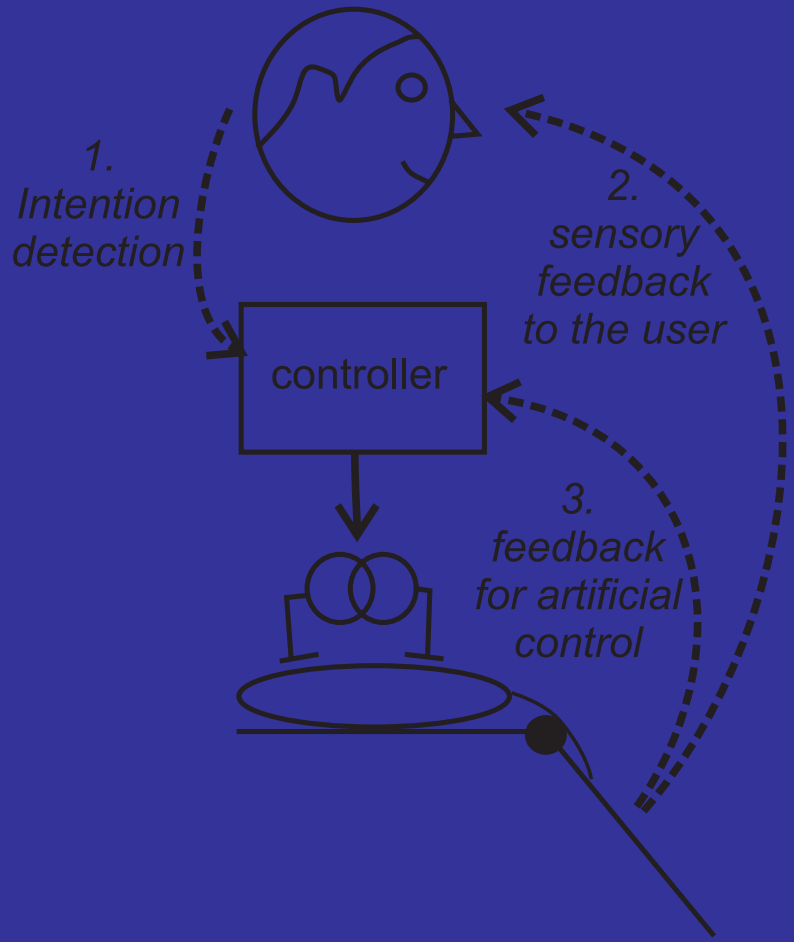


(Franken et al., 1994)

FES assisted mobility in paraplegics



Interaction with the impaired motor control system
SENSING



Challenges FES

- Use FES for open-loop tasks:
  - Bladder control
  - Pain
- Use of FES as source of energy
  - FES cycling
  - FES in combination with orthoses
- Use FES for sensor stimulation
  - Cochlear implants (ear)
  - Skin stimulation
- Use FES in closed-loop tasks
  - Balancing
  - Walking

Course info

Contact:

Dick Plettenburg (D.H.Plettenburg@tudelft.nl)
Frans van der Helm (F.C.T.vanderHelm@tudelft.nl)

3rd quarter:

Wednesday 3rd+ 4th hour (10.45 – 12.30), Room J

4th quarter:

Wednesday 3th + 4th hour (10.45 – 12.30), Room E
Except for April, 25: 14.30 – 16.30 at LUMC!
June 6: 08.45 – 12.30, Room E

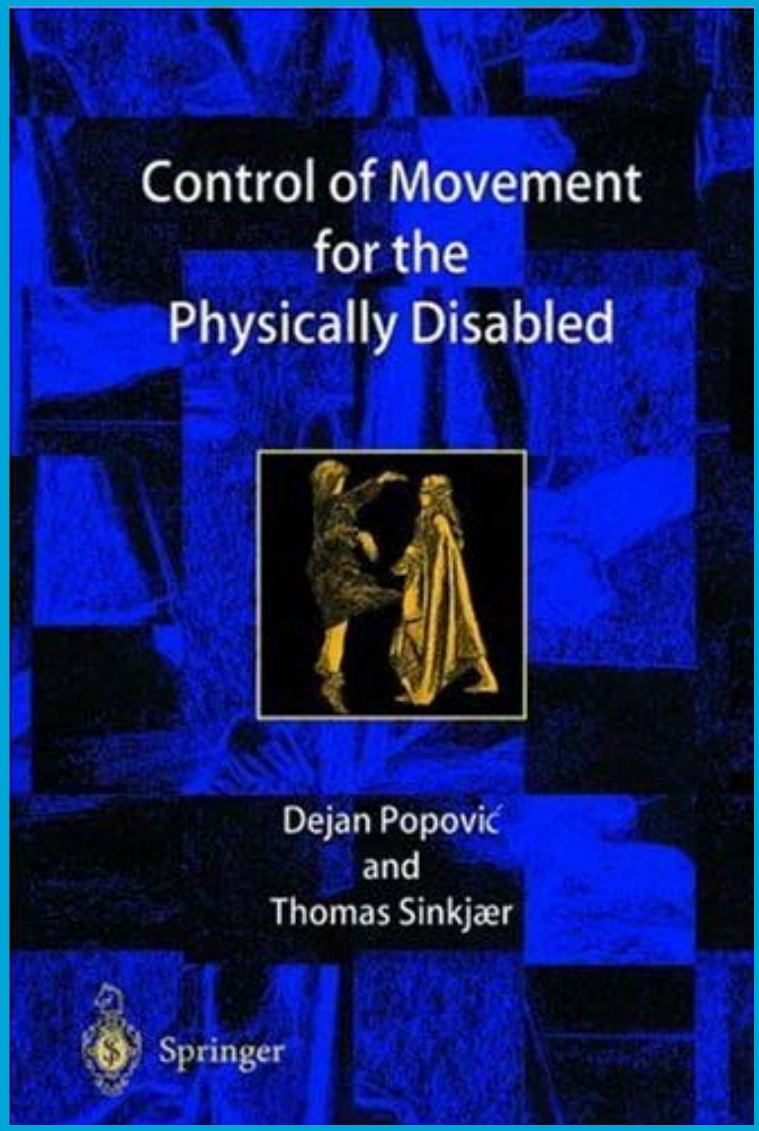
February 7 – June 6, 2007

15 lectures, 1 practical assignment: 4 EC

Pre-requisites: Human Motion Control (wb 2407)

Course info

- Blackboard:
  - Announcements
  - Lecture Notes
  - Assignments
  - Chapters Reader
- Course Manual: What should be learned
- Examination: Written examination: June 20, 2007
- Grades: 25% oral presentation assignment,
  25% assignment report
  50% written examination
- Books (optional)



Publisher: Springer [2000]

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± Euro 150.00

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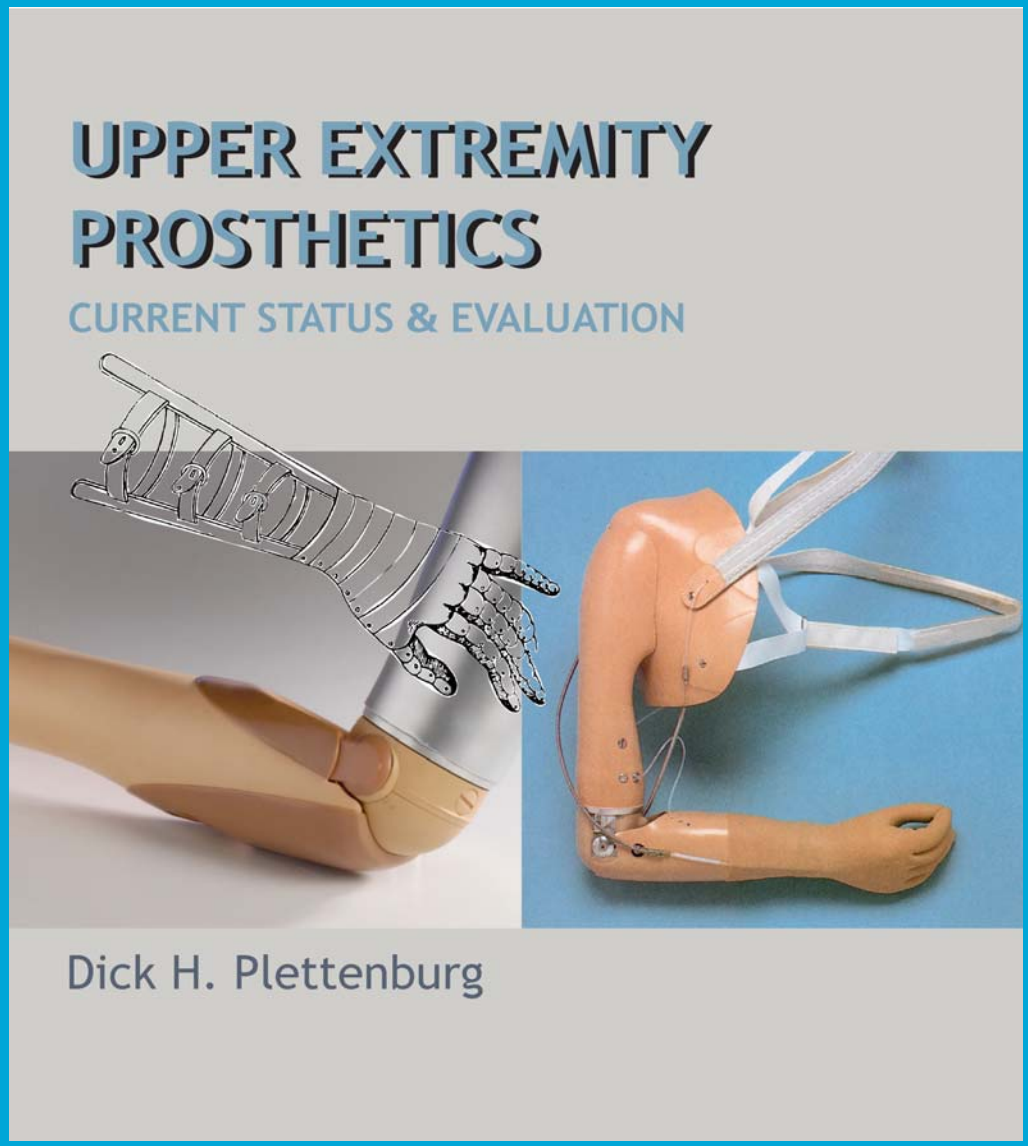

Publisher: VSSD – Delft [2006]

www.vssd.nl/hlf/m011.htm

ISBN-13: 978-90-71301-75-3

Euro 27.50

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Lecture schedule

2007-02-07	Introduction	Dick Plettenburg
2007-02-14	Human motion control	Erwin de Vlugt
2007-02-21	Artificial mechanical systems for the lower extremities (prostheses and orthoses)	Bart Koopman (UT)
2007-02-28	Rehabilitation of patients with motion disorders	Carel Meskers (LUMC)
2007-03-07	Artificial mechanical systems for the upper extremities (prostheses and orthoses)	Dick Plettenburg
2007-03-14	Actuators for mechanical devices	Dick Plettenburg
2007-03-21	Control interfaces for mechanical devices	Dick Plettenburg

Lecture schedule (cont.)

2007-04-11	Exo-skeletons	Just Herder
2007-04-18	Gait analysis	Jaap Harlaar (VU)
2007-04-25	Motion control in patients with neurological disorders	Bob van Hilten (LUMC)
2007-05-09	Artificial motor control	Frans van der Helm
2007-05-16	Artificial sensoric interfaces	Frans van der Helm
2007-05-23	Functional electro-stimulation	DirkJan Veeger
2007-05-30	Training devices in rehabilitation	Dick Plettenburg
2007-06-06	Presentation student assignments	you