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3D inertial and magnetic sensing of human motion
– promising applications

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Biomedical Signals and Systems

BMTI

applications

A. Detection of movement conditions
1. Activity monitoring
2. Timing control of FES supported gait using real-time state detection

B. Estimation of human movements
1. 3D movement analysis in movement disorders
2. Assessment of balance control performance
3. Quantitative control of FES-supported movement – foot movement control for two-channel drop-foot stimulation
4. Ambulatory VR training

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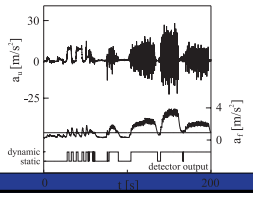
Activity monitoring

Detection of postures and movements using uni-axial accelerometers

posture – movement detector

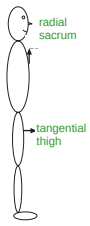
Example result: detection posture - movement

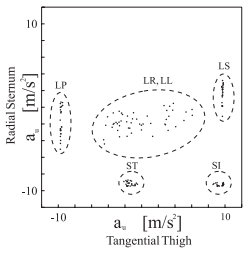


(Veltink et al., 1996)

Actvity monitoring

Distinguish postures by analyzing inclinations of body segments

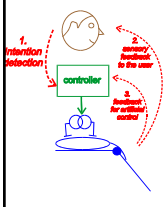


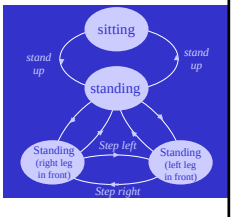


Activity monitoring

Intention detection for FES control

Sensing for assistive human motor control





Activity monitoring

Applications of activity monitoring:

- evaluate impact of rehabilitation treatment on daily-life activity pattern
- assess relation between heart conditions and movement activities
- evaluate labour activities (ergonomic studies)
- intention detection for FES supported mobility

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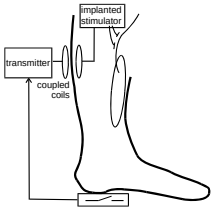
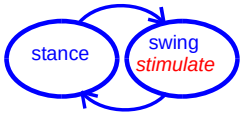
Timing control of FES supported gait using real-time state dectection

drop foot stimulator
timing control





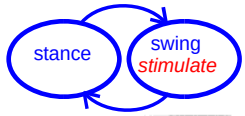
Finite state control

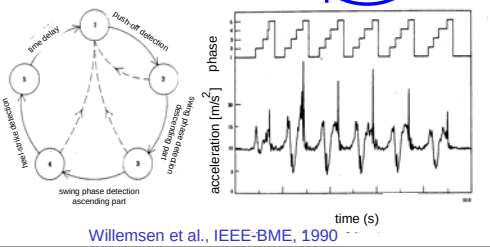
Sensing:
heel switch
accelerometer

drop foot stimulator
timing control

Finite state control

Sensing gait phases
with accelerometer on shank





Willemsen et al., IEEE-BME, 1990

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Ambulatory 3D movement analysis in movement disorders

Stroke gait

Stairs (healthy test trial)

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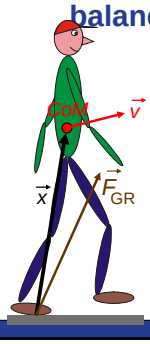
3D Assessment of balance control performance



- CoM position
- velocity CoM
- relative position CoM – CoP
- Ground reaction force
- segment orientations and angular velocities
- foot placement

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Quantative control of FES-supported movement –

foot movement control for two-channel drop-foot stimulation

channel 1: deep peroneal nerve: dorsiflexion + inversion

channel 2: superficial peroneal nerve: eversion

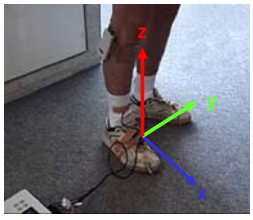
2-channel drop foot stimulator (RRD, UT, MST, Finetech)

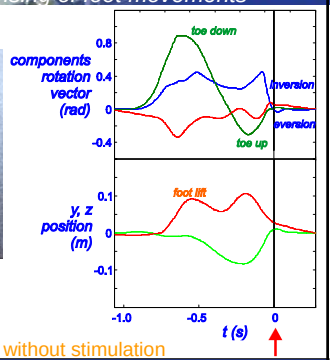
The problem

Automatic tuning of both channels for balanced dorsiflexion

Requirements:
1. Adequate Sensing of foot movements
2. Characterise influence of Stimulation on foot movements
3. Adequate control strategy

Automatic balancing 1 - 3D inertial sensing of foot movements





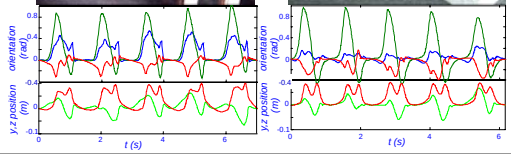
(Veltink et al., 2003)

step without stimulation

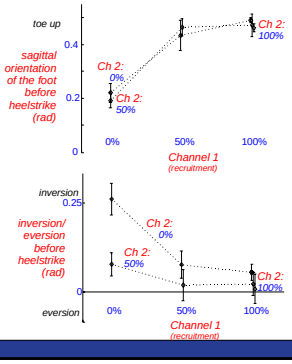
Automatic balancing 2 - Influence of stimulation levels on foot movements

threshold stimulation on both channels

maximum recruitment on both channels



Automatic balancing 3 - Influence of stimulation levels on foot movements



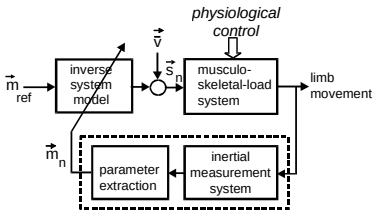
Sagittal orientation of the foot before heelstrike is mainly controlled by channel 1 (deep peroneal nerve)

⇨ System model for feed forward control

A well balanced stimulation of both channels prevents inversion at foot contact

Automatic balancing 4 - Adequate control of balanced dorsiflexion

Proposed Control scheme



Control scheme:

Adaptive feedforward

Cycle-to-cycle

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Ambulatory VR training

Training of grasping (target application: e.g. stroke)

Head mounted device
+
Inertial and magnetic sensing on the arms

Create virtual training environment outside lab

M. Aznar

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