UNIVERSITY OF TWENTE.

MIRA

SEVENTH FRAMEWORK PROGRAMME

eHealth
Better Healthcare for Europe

SENSING DAILY-LIFE PHYSICAL INTERACTION WITH THE ENVIRONMENT AFTER STROKE

Peter H. Veltink

INTERACTION

UNIVERSITY OF TWENTE.

UNIVERSITÀ DI PISA

Roessingh Research and Development

University of Zurich

xsens

Smartex

CONTENT OF THIS PRESENTATION

Ambulatory sensing of human motor control – technological developments

EU **INTERACTION** project:

- Goals and concepts
- User requirements analysis
- Assessment of daily-life motor performance
- Sensing system
- Conclusions

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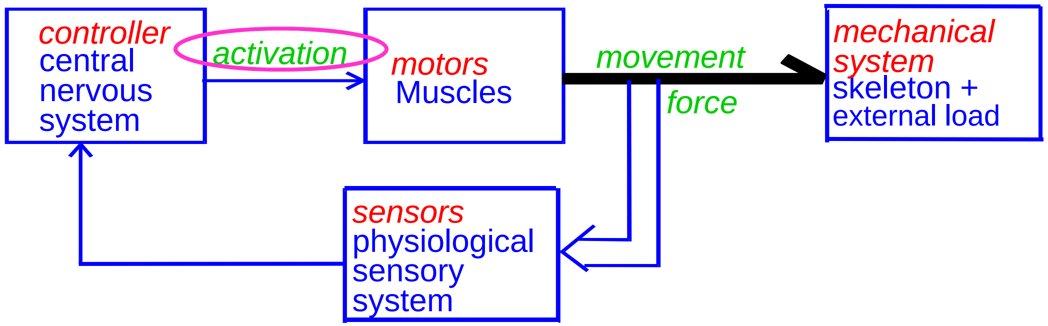
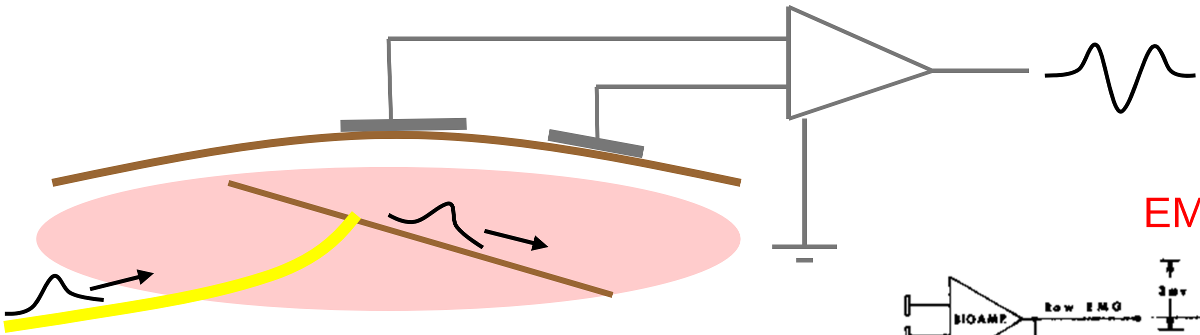
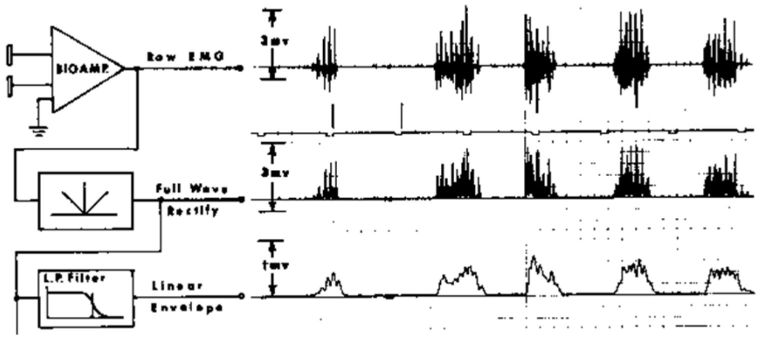
ARTIFICIAL SENSING

MUSCLE ACTIVATION / EMG



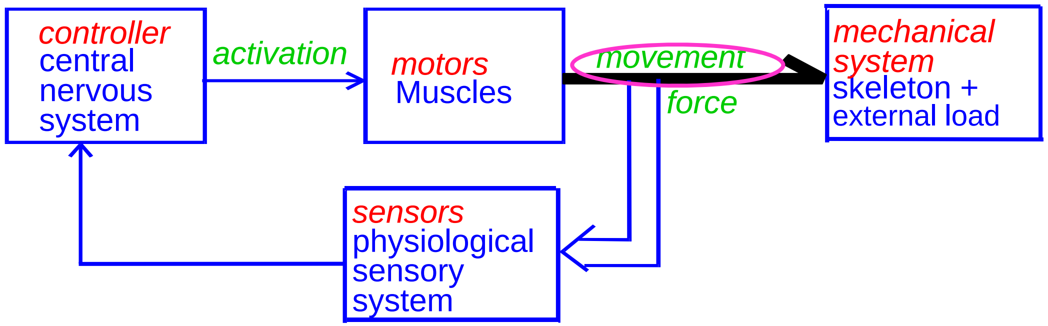


EMG processing



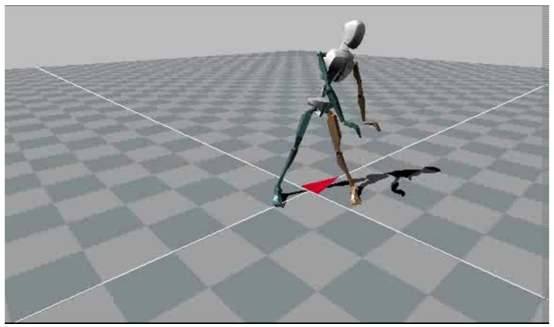
ARTIFICIAL SENSING

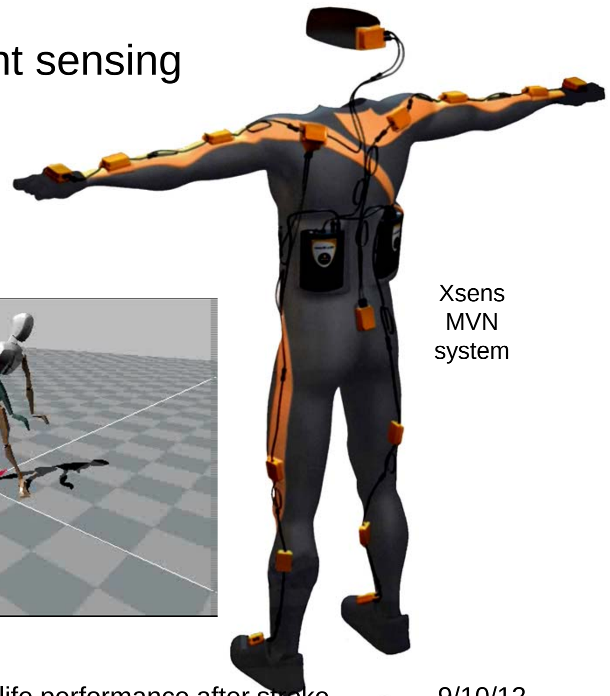
MOVEMENT



Textile sensing (Pisa)

Inertial movement sensing

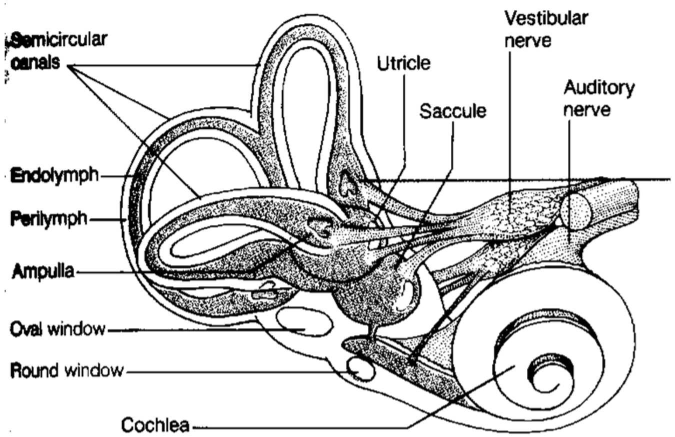




Xsens MVN system

INERTIAL SENSING
ARTIFICIAL SENSING - MOVEMENT

The human vestibular system
is an 3D inertial sensor system



Information concerning:

- acceleration
- orientation
- angular velocity

Artificial vestibular system

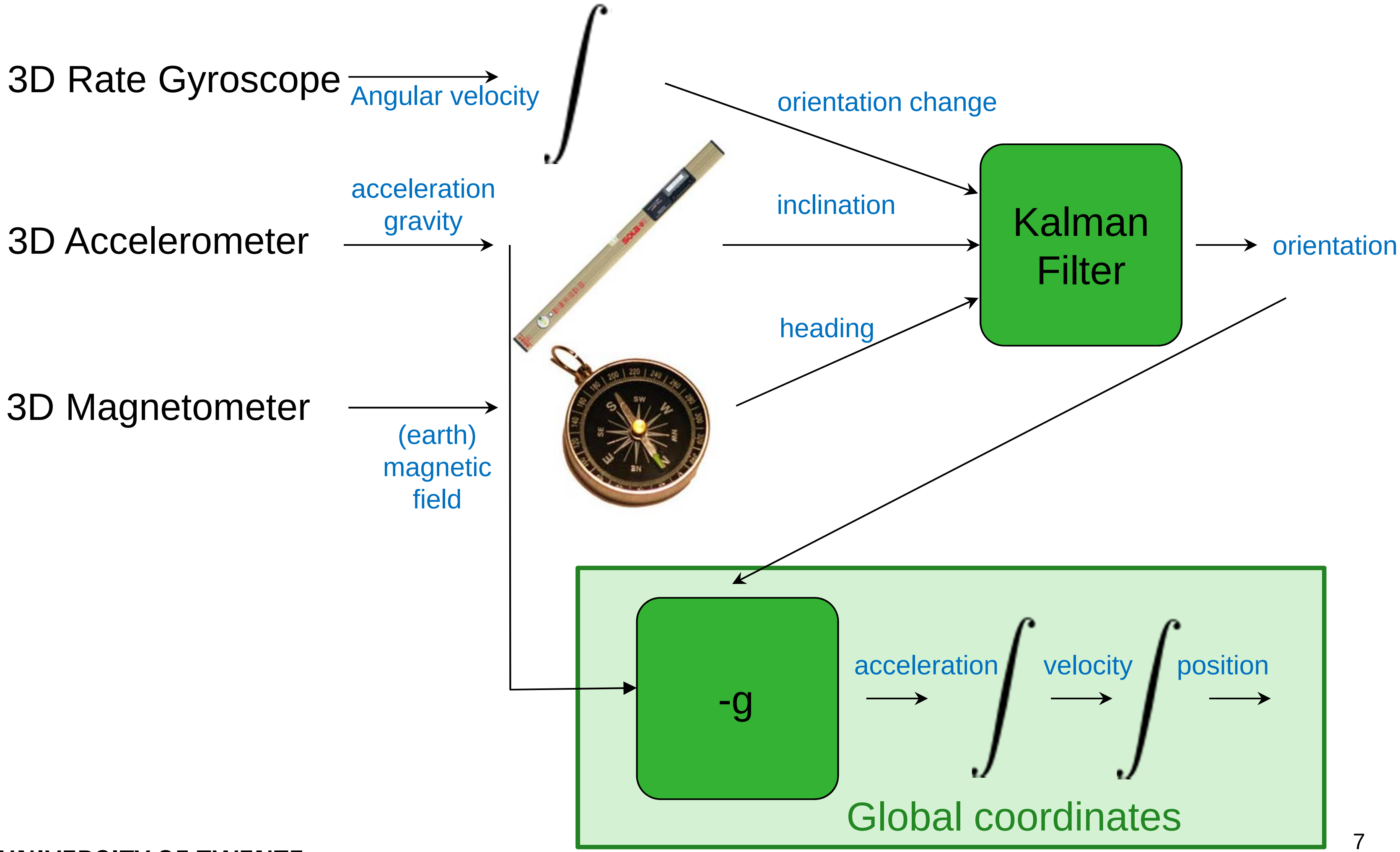
3D Accelerometer

- acceleration
- gravity → inclination

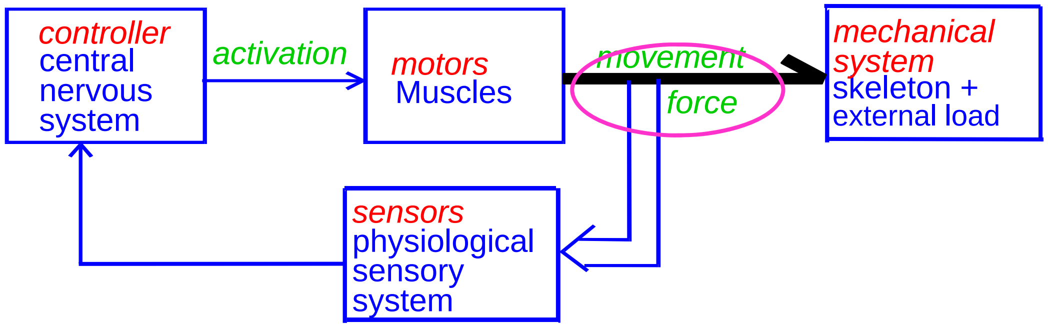
3D Rate gyroscope

Angular velocity → Orientation change

ESTIMATION OF ABSOLUTE KINEMATICS

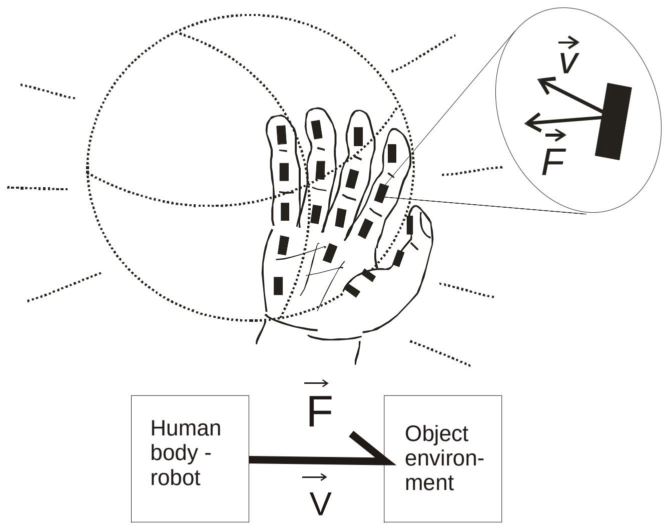


ARTIFICIAL SENSING
MOVEMENT AND FORCE



Instrumented shoes –
biomechanics of gait / balance

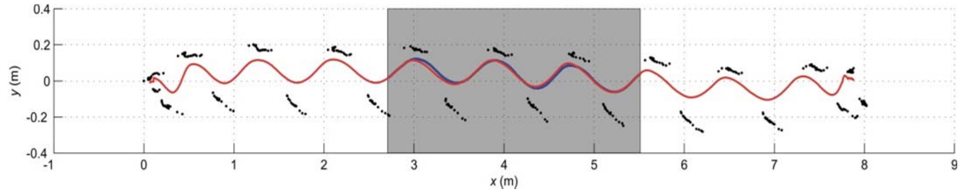
Instrumented gloves –
dynamic interaction / power transfer

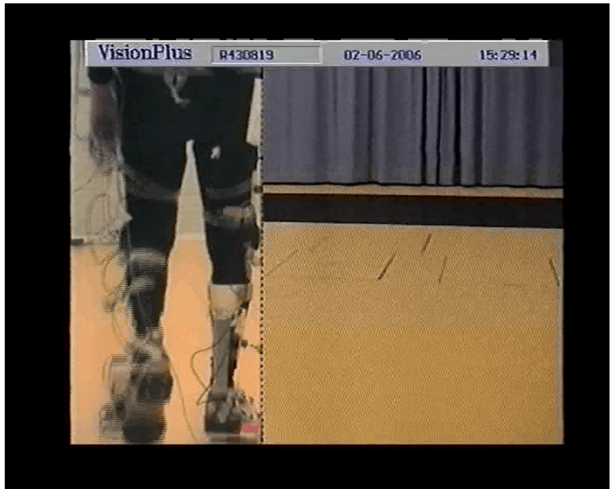


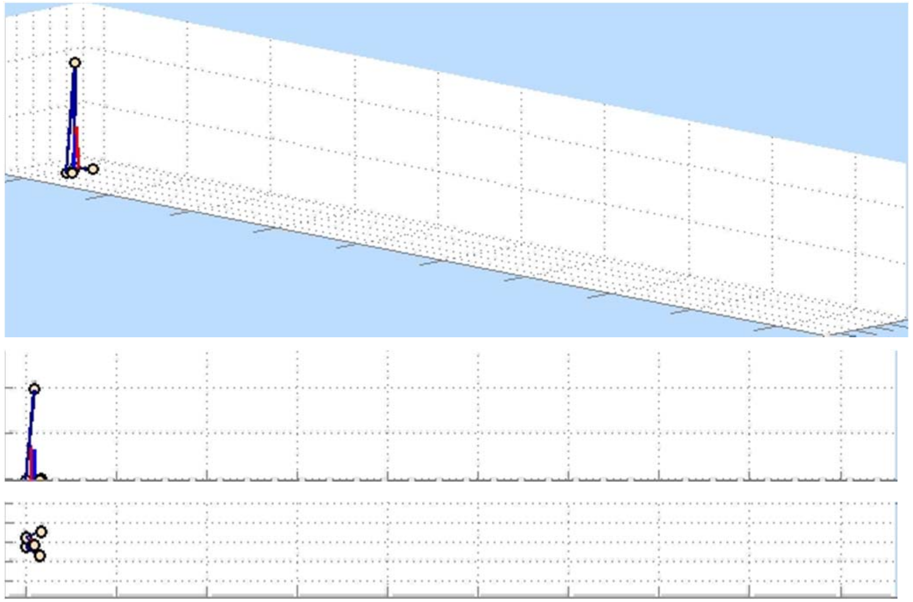
INSTRUMENTED SHOES – BALANCE

MOVEMENT AND FORCE SENSING

estimation Center of Mass movement

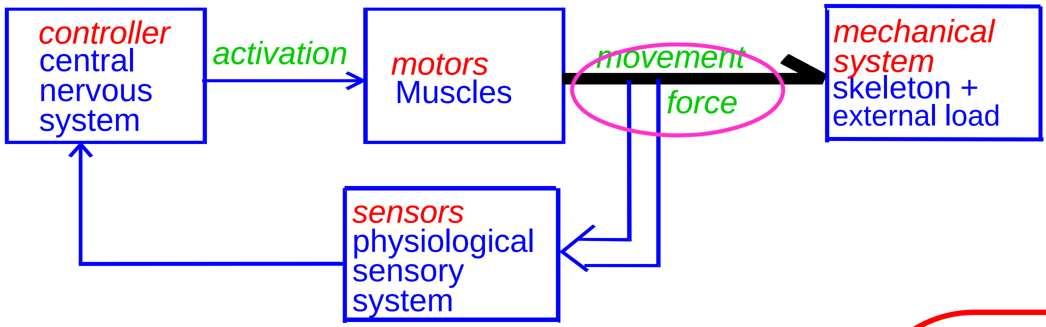






Schepers et al., IEEE BME, 2009

ARTIFICIAL SENSING
MOVEMENT AND FORCE



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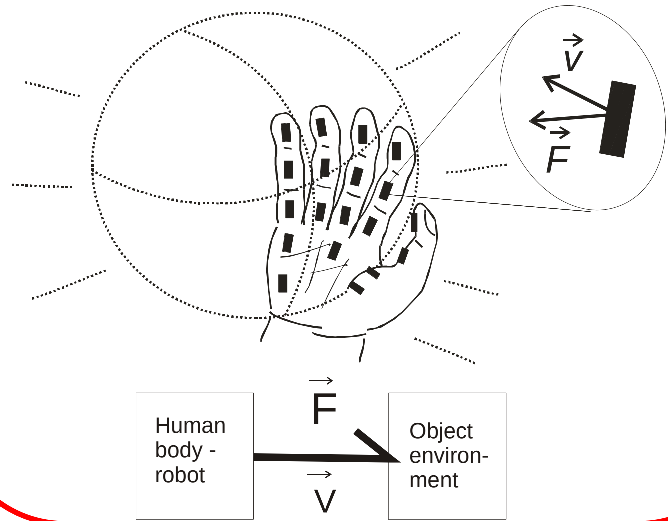
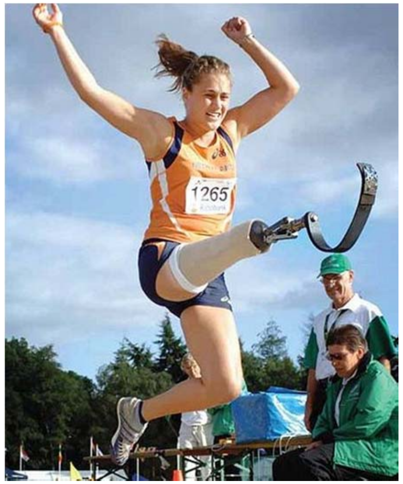
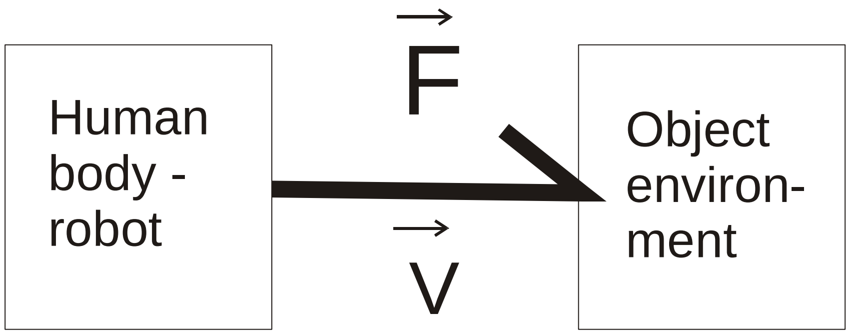


Ambulatory assessment of dynamic interaction with the environment – PowerSensor project

Physical labor

sports





power transfer

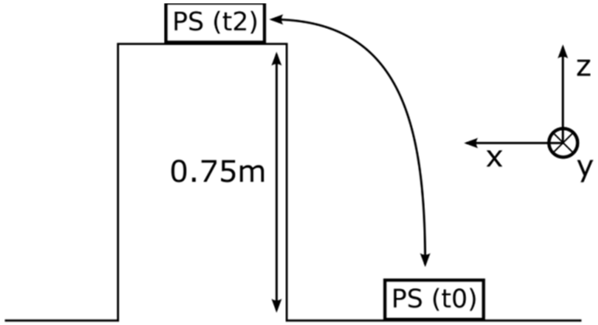
$$P = \vec{F} \cdot \vec{v}$$

Required sensing:

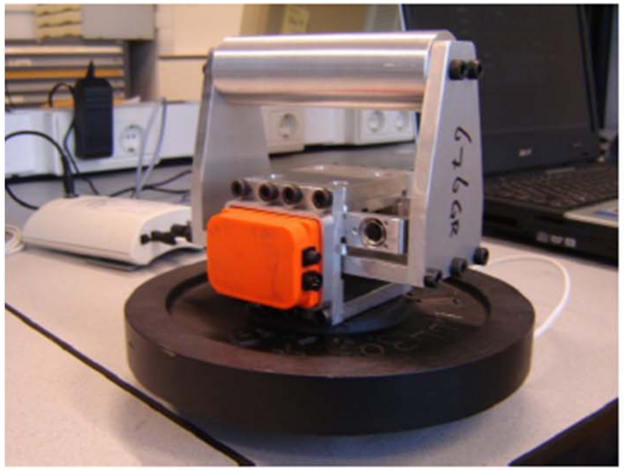
3D Inertial sensors

3D force/moment sensors

Power Sensing – Load Identification
Demonstration of concept
EXPERIMENTAL SETUP



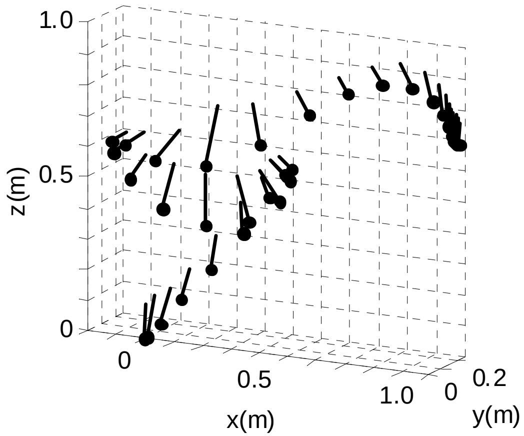
mass



spring

Power Sensing
Demonstration of concept

Load: mass



error estimated work:
2.2 ± 4.3 %

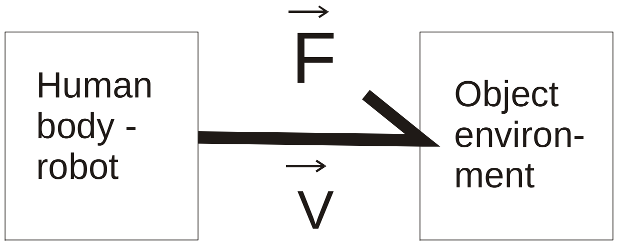
Veltink et al., IEEE BME, 2009

Power Sensing
Demonstration of concept

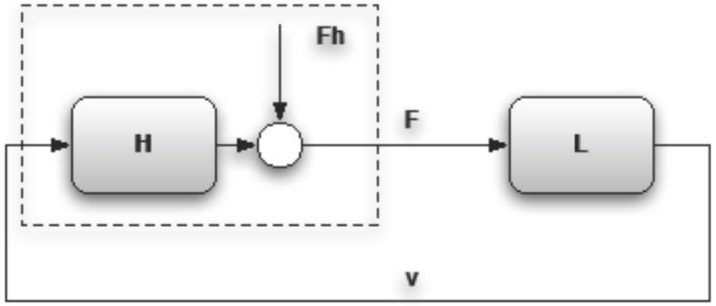
Conclusions:

- Estimation of power transfer and work performed from inertial and force sensing on the interface with the environment is possible
- Regular updates of kinematics from other sensors is required to avoid drift

Load identification - theory



If the human body is actively generating force on a passive load:



$v = L(F_h + F_p) \quad with\ F_p = Hv$

$if\ F_p \ll F_h : \ \frac{v}{F} = L$ Load admittance

Load identification – conclusion and discussion
Demonstration of concept

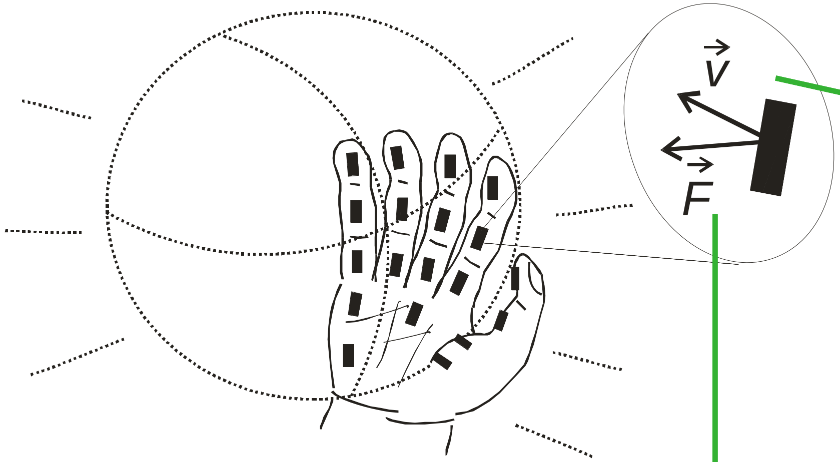
Conclusions

- Mass and spring loads can be identified
  from force and inertial movement sensing during object handling
- Variance Accounted For (VAF) was above 99%
- Masses were estimated within 5% error, spring stiffnesses within 3% error

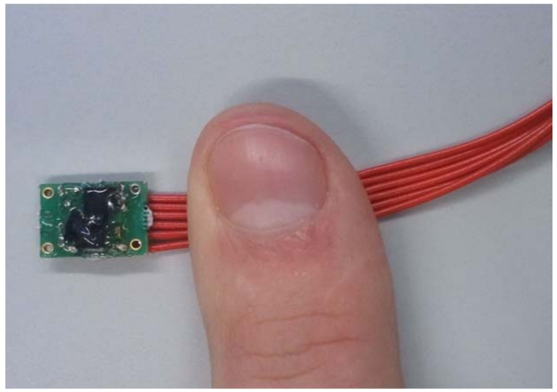
UPPER EXTREMITIES

SENSING DYNAMIC INTERACTION WITH THE ENVIRONMENT

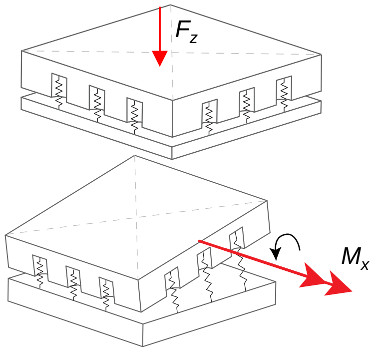
Powersensor project

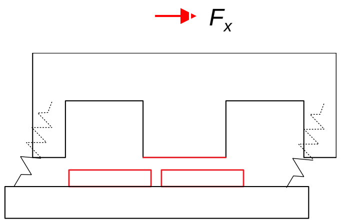


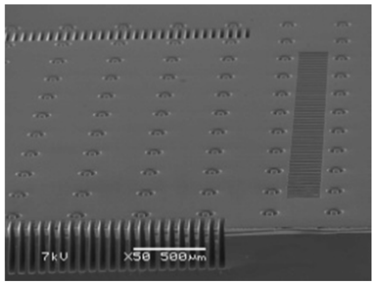
Inertial movement sensing (commercially available)

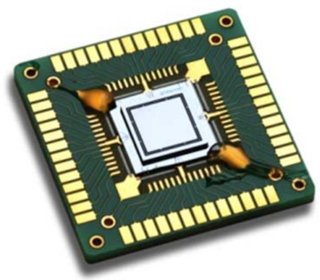


Silicon micromachined 6DoF force/moment sensor (under development: UT)







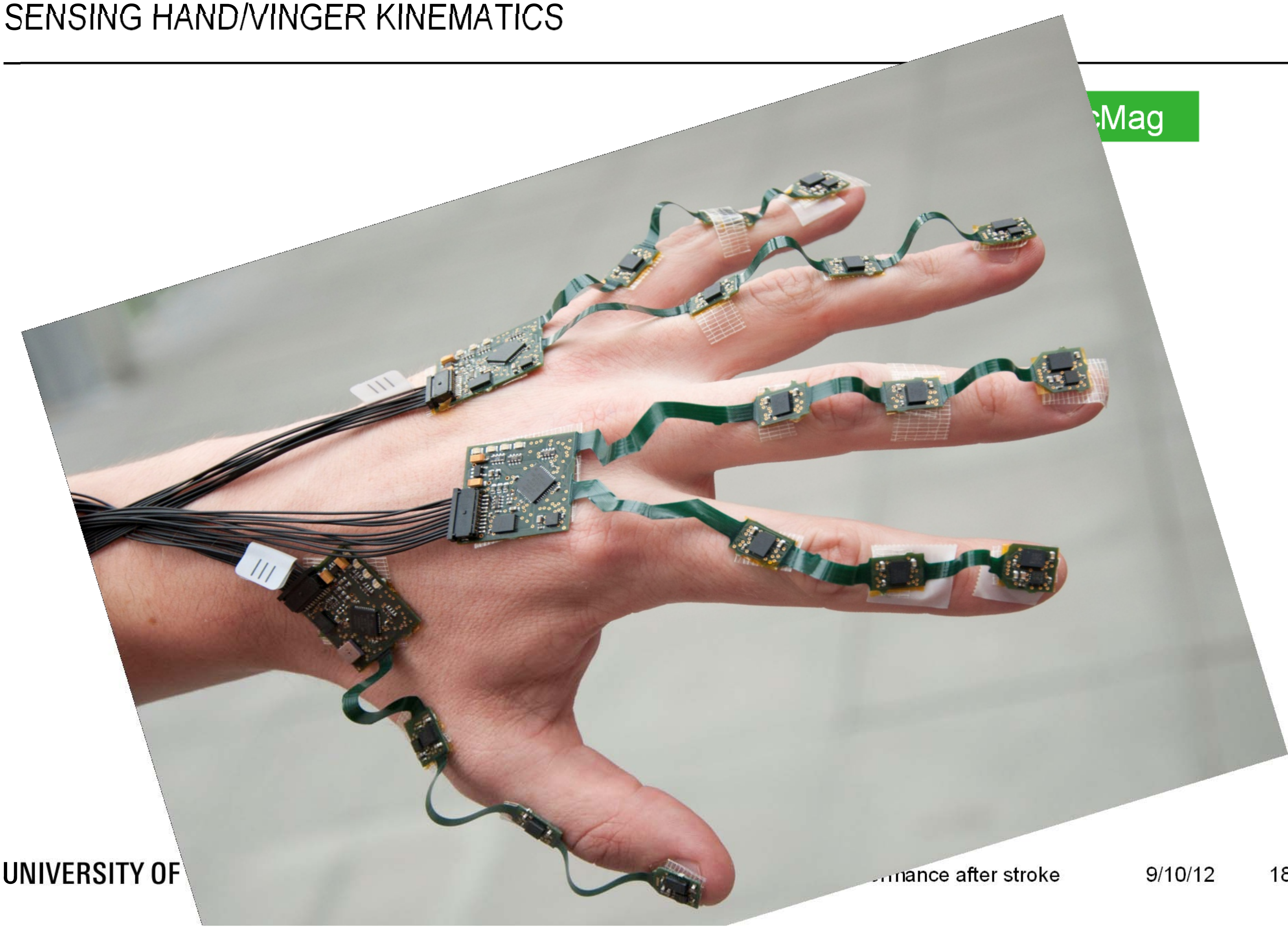


Robert Brookhuis, Remco Wiegerink (TST-MESA)

UPPER EXTREMITIES

SENSING HAND/VINGER KINEMATICS

:Mag



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REHABILITATION AFTER STROKE

INTERACTION

Clinical rehabilitation phase

training

therapeut

VR/robotics

capacity

Clinical tests

Daily-life

training

?

VR/robotics
at home

INTERACTION

performance

Daily-life Monitoring

?

OBJECTIVES
INTERACTION PROJECT

INTERACTION

Objective

Continuous daily-life monitoring of functional activities of stroke survivors during daily-life

Motivation

- Optimal daily-life performance is the objective of the post-stroke rehab program.
- No adequate information on daily-life performance is currently available
- Monitoring can help to guide therapy / training of the patients after their release from the hospital

Monitoring of *capacity* In the *rehab center* → Monitoring of *performance* during *daily-life*

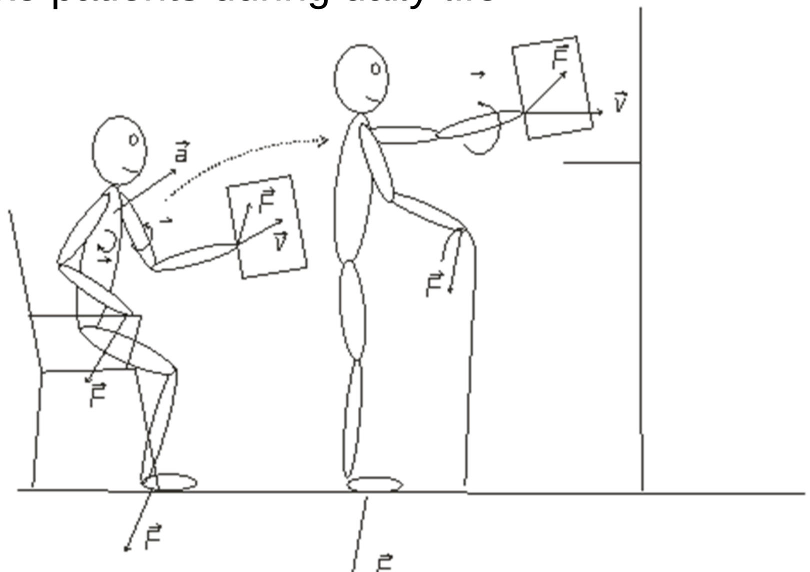
INTERACTION

Monitoring *movement quantity* → Monitoring *movement quality*

MONITORING OF DAILY-LIFE PHYSICAL INTERACTION WITH THE ENVIRONMENT AFTER STROKE

Specific objectives

- identification of specific movement tasks
  (reaching, grasping, gait, standing up / sitting down)
- Evaluation of upper and lower extremity task performance
  (temporal, kinematic, kinetic parameters;
  pathological synergies, spasms, smoothness of movements)
- Evaluating balance performance while interacting with the environment
- Telesupervision of stroke patients during daily-life



INTERACTION

SEVENTH FRAMEWORK PROGRAMME

eHealth
Better Healthcare for Europe

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TASKS TO BE MONITORED DURING DAILY-LIFE

USER REQUIREMENT ANALYSIS

INTERACTION

Lower extremities

- Standing (1)
- Sitting (1)
- Walking (1)
- Stair as/descending (2)
- Lying (3)

Quantitative: how much?
Qualitative: how good?

Upper extremities

- Reaching (1)
- Grasping (/ type) (1 / 2)
- Moving objects (3)
- Use of upper extremities to support body weight (3)

(1) Must - (2) Should - (3) Could - (4) Won't

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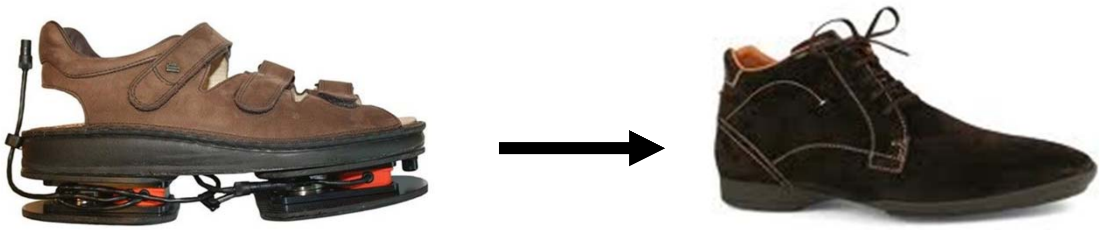
DAILY-LIFE SENSING SYSTEM

- Modular: shoes, trousers, shirt, partlial gloves
- Combination of textile stress sensing, inertial + force sensing , and, optionally, EMG
- Integrated in clothing

CHALLENGE

Unobtrusive sensing



This applies to all components of the modular sensing system:
Shoes, trousers, shirt, gloves

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CONCLUSIONS / DISCUSSION

MONITORING DAILY-LIFE PERFORMANCE AFTER STROKE

INTERACTION
SEVENTH FRAMEWORK PROGRAMME
eHealth Better Healthcare for Europe

- Optimal daily-life performance is the objective of the post-stroke rehabilitation program
- No adequate information on daily-life performance is currently available
- Daily-life monitoring of performance after stroke requires qualitative assessment of body movements and physical interactions with the environment
- Monitoring can help to guide therapy and training of the patients after their release from the hospital
- Daily-life provides a rich and variable functional perturbation environment, with high potential for training without generalization problems -> requires feedback