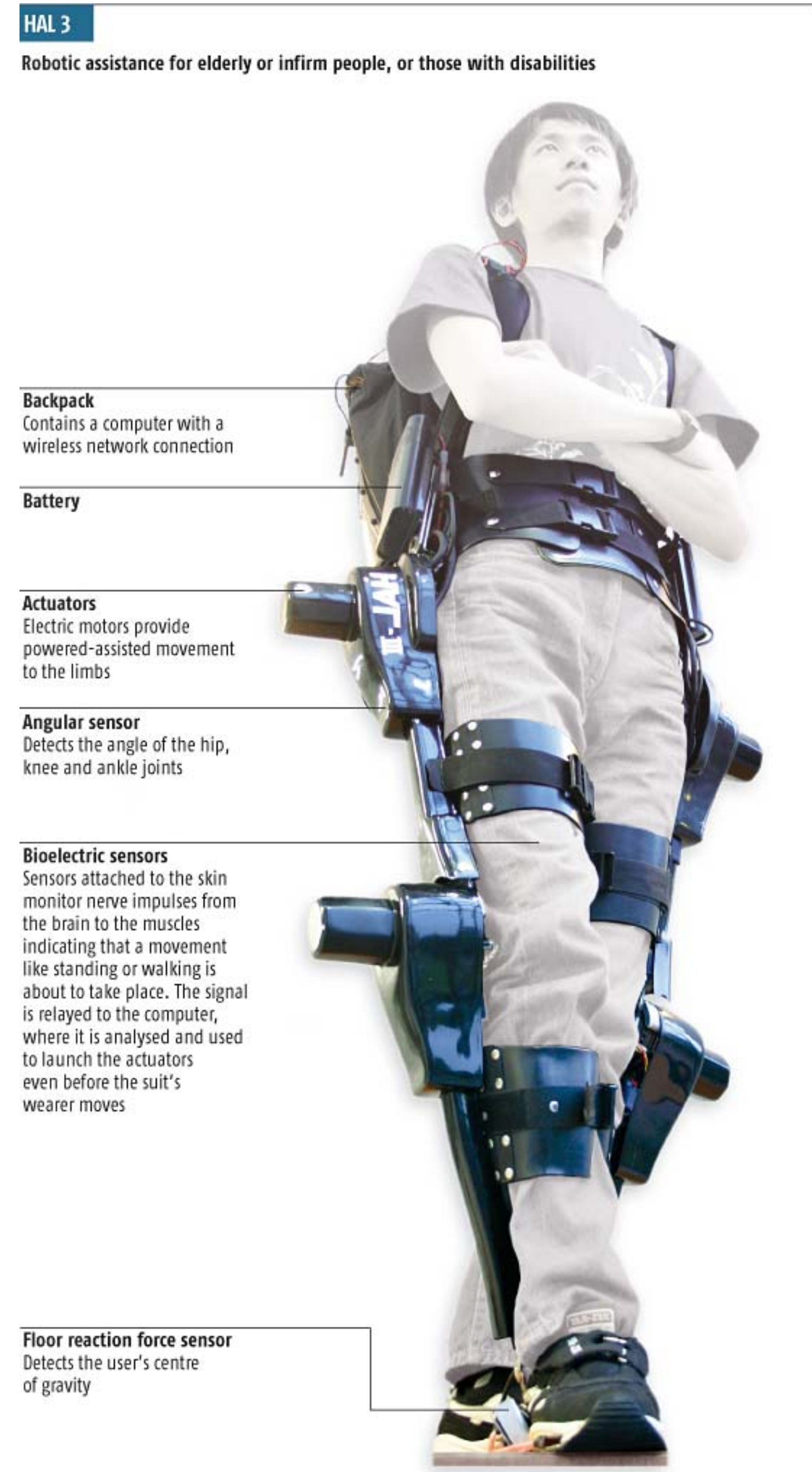
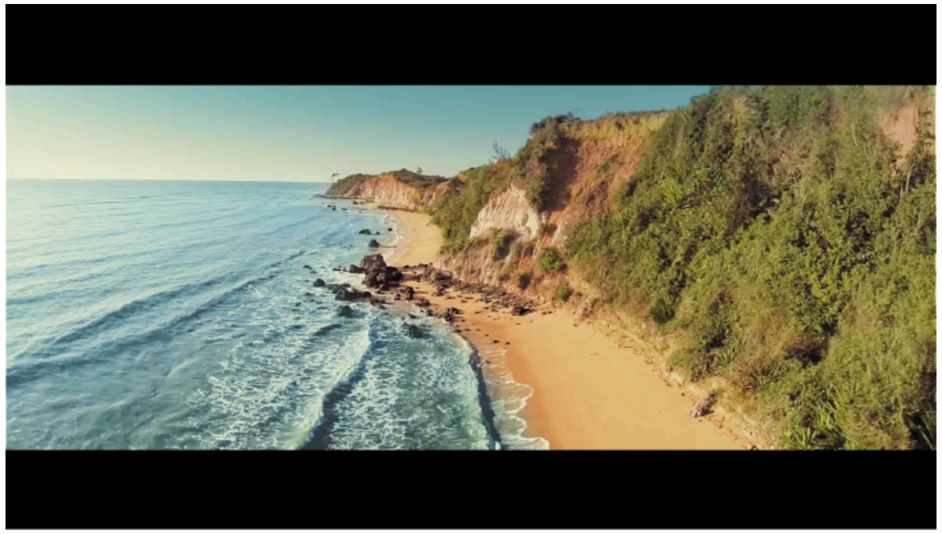
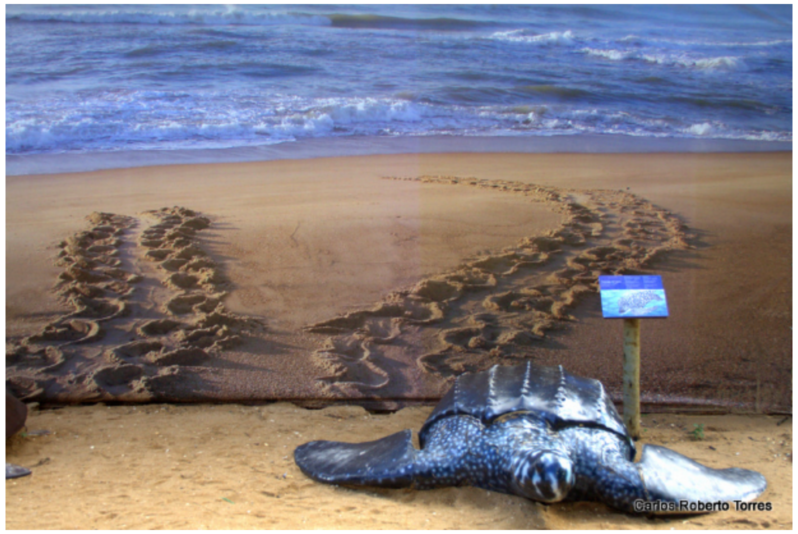
Wearable robot technologies

Prof. Dr. Anselmo Frizera
Electrical Engineering Department
Federal University of Espirito Santo




Vitória & Espírito Santo

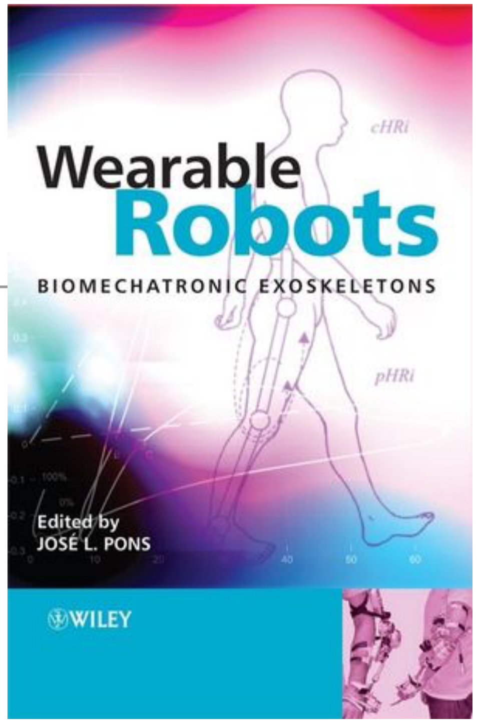

UNIVERSIDADE FEDERAL DO ESPÍRITO SANTO

UFES

- Fundada en 5 de mayo de 1954
- 101 cursos de grado
- 53 cursos de posgrado

- Personal:
  - 1.630 profesores
  - 2.200 administrativos
  - 19 mil estudiantes de grado
  - 2.680 estudiantes de posgrado

Technologies in WR



- **The limiting factor** in developing novel robots
  - Few examples of **fully portable** wearable robots
  - Lack of enabling technologies
- Ambulatory scenarios require:
  - Compact, miniaturized, energetically efficient technologies
  - Control, sensors, actuators

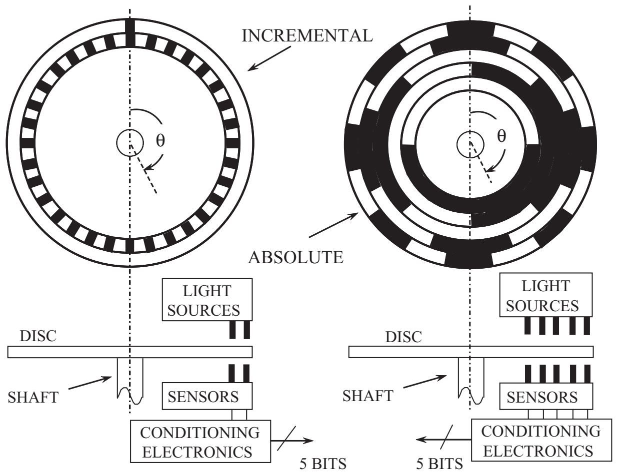
"Actuators and power sources are the ones that probably most limit wearability and portability at the present time."

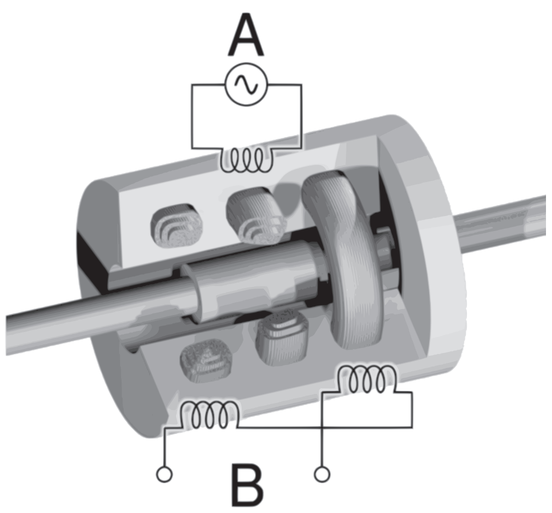
Sensor Technologies

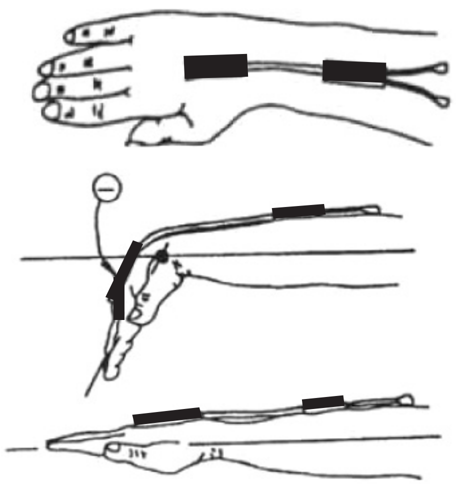
- Three types of sensors will be addressed:
  - Position and motion sensing: HR limb kinematic information
  - Bioelectrical activity sensors
  - HR interface force and pressure: human comfort and limb kinetic information

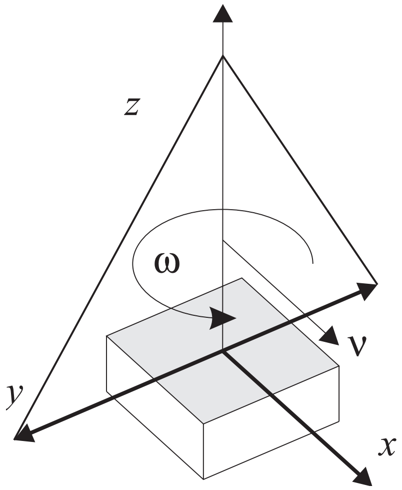
Sensor Technologies
Position and motion sensing: HR limb kinematic information

- Encoders
- Magnetic (Hall effect) sensors
- Potentiometers and LVDTs
- Electrogoniometers
- **MEMS inertial sensing technology**



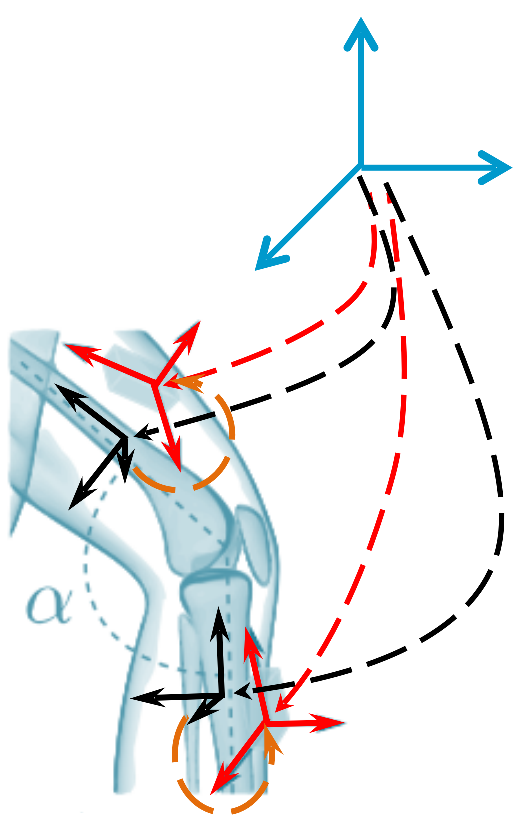


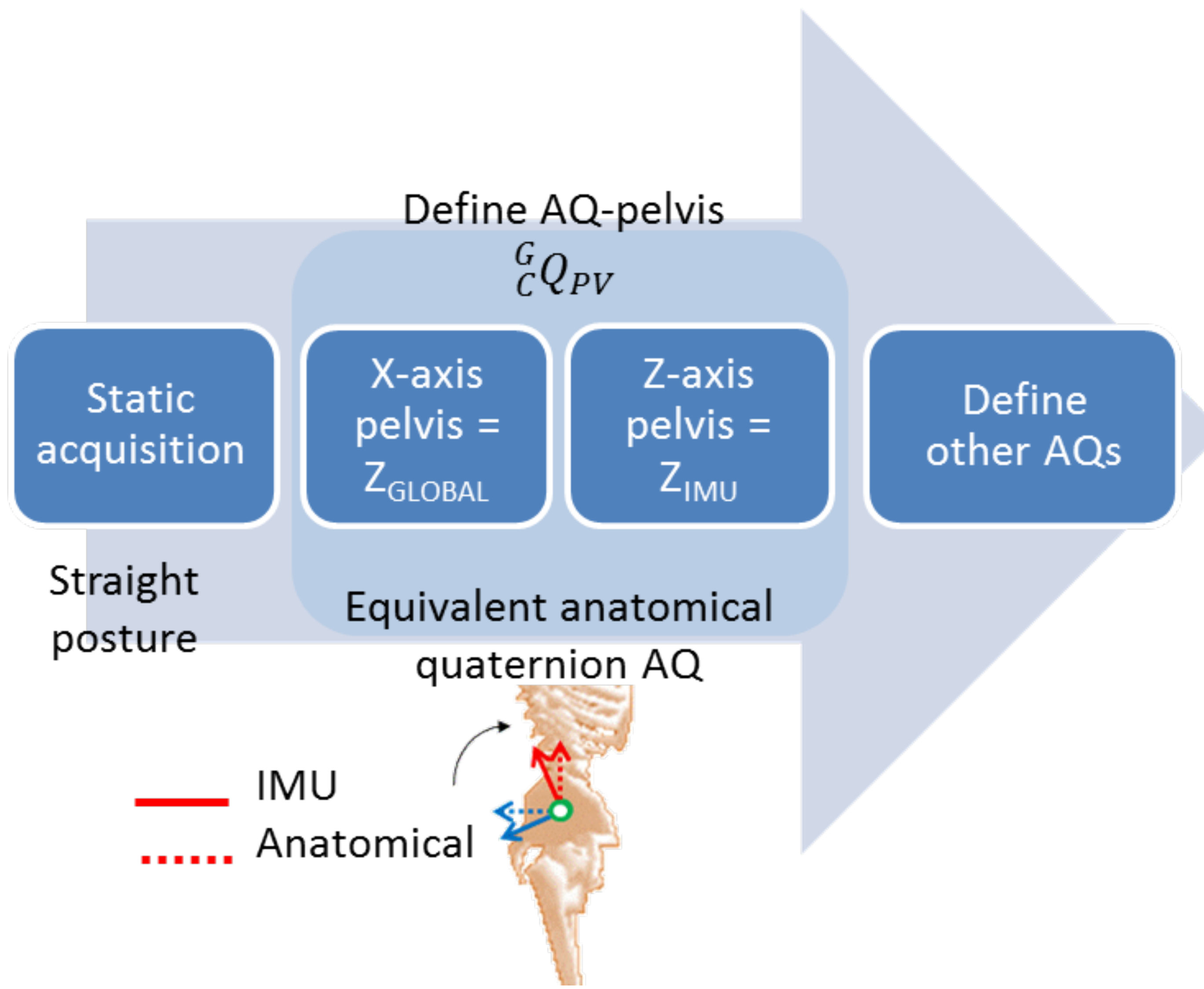




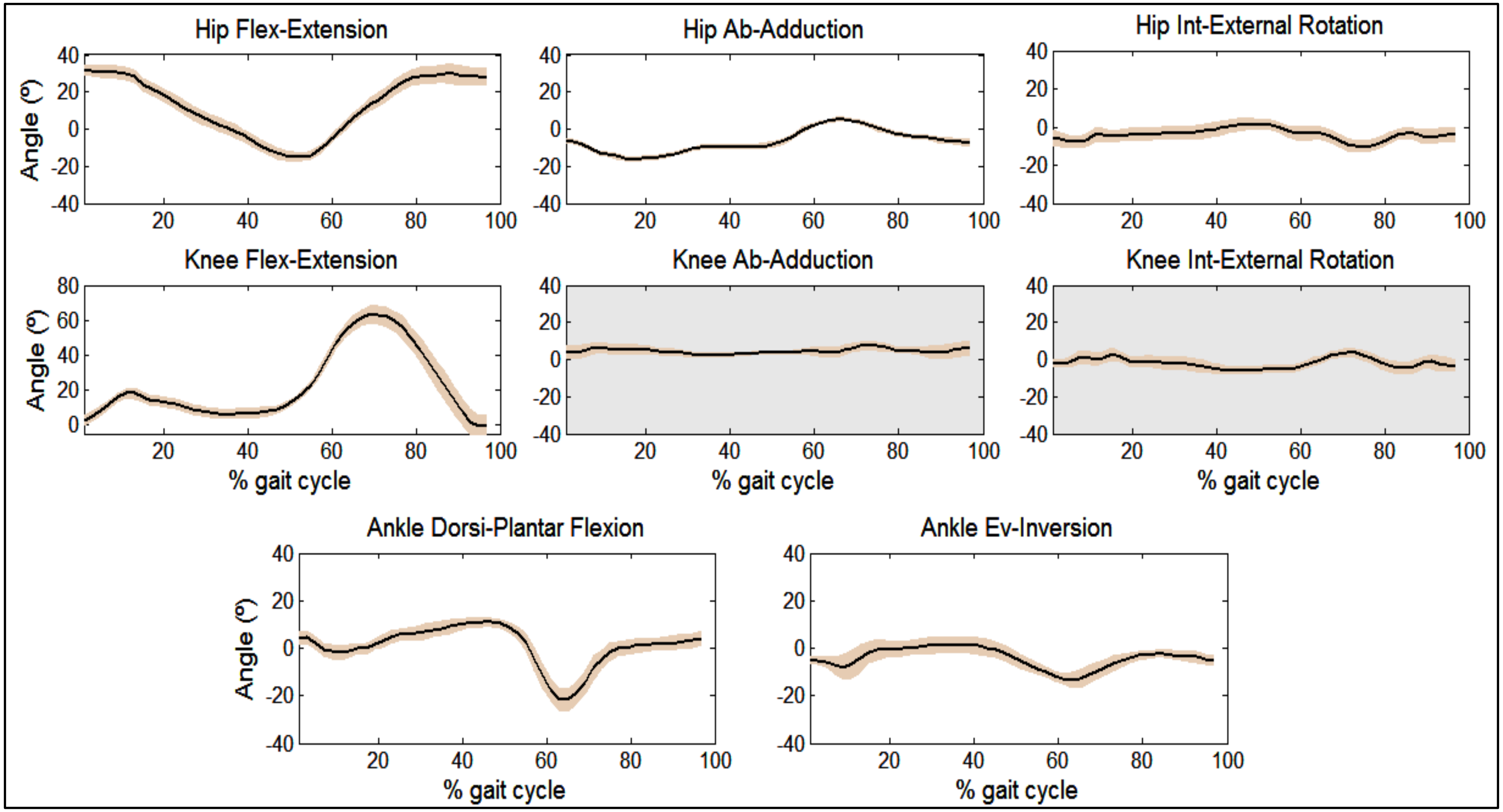
Gait Analysis Based on IMUs

- Aims of the study:
  - Investigate a calibration procedure to estimate sensor-to-body alignment
  - Estimate lower limb joint angles using inertial sensors



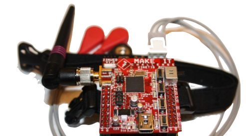


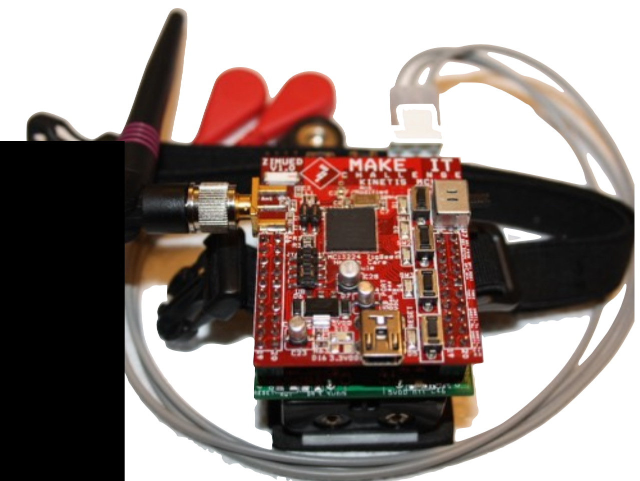
Gait Analysis Based on IMUs

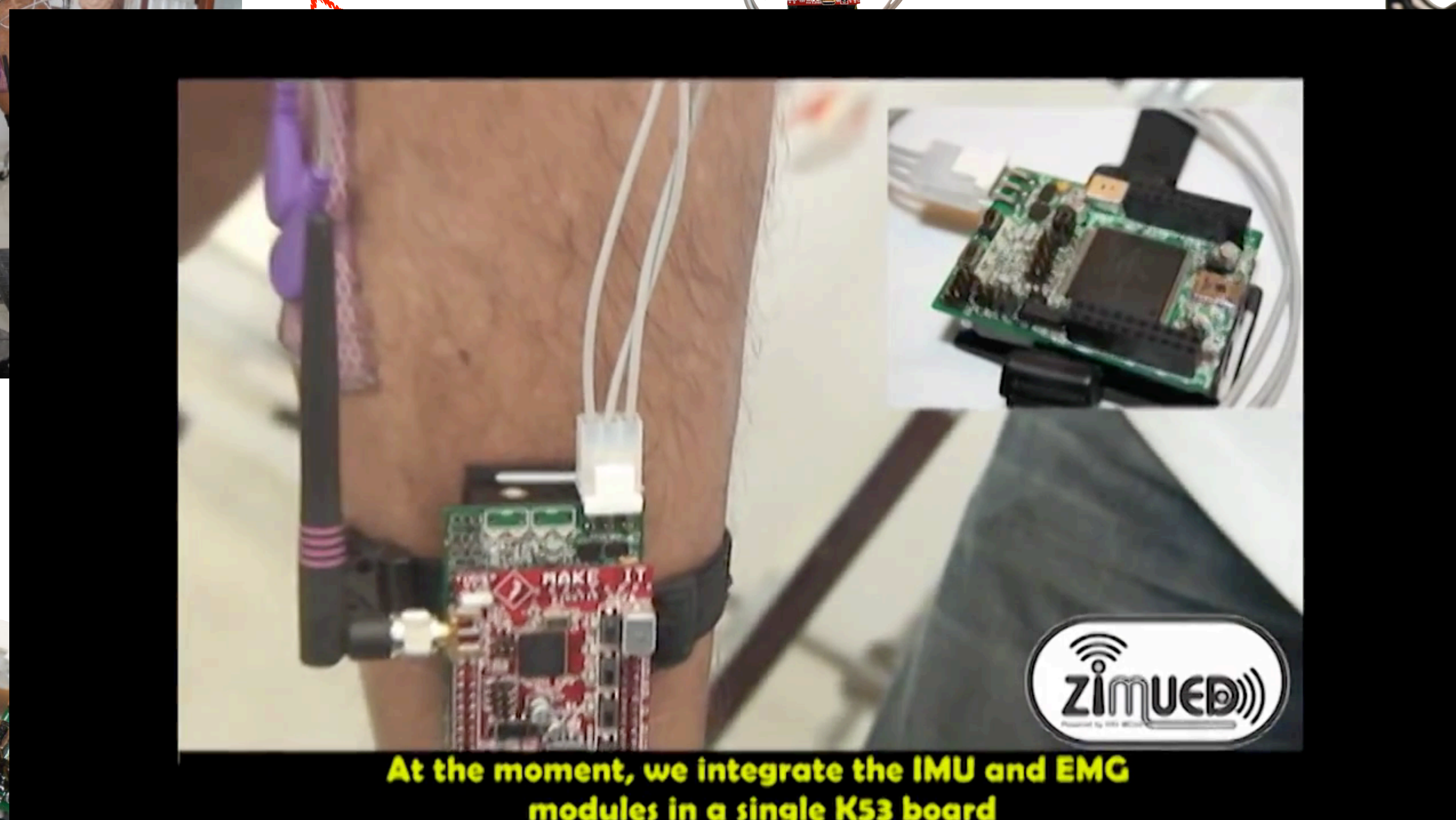


Development of Wireless Motion Capture System

Coordinator





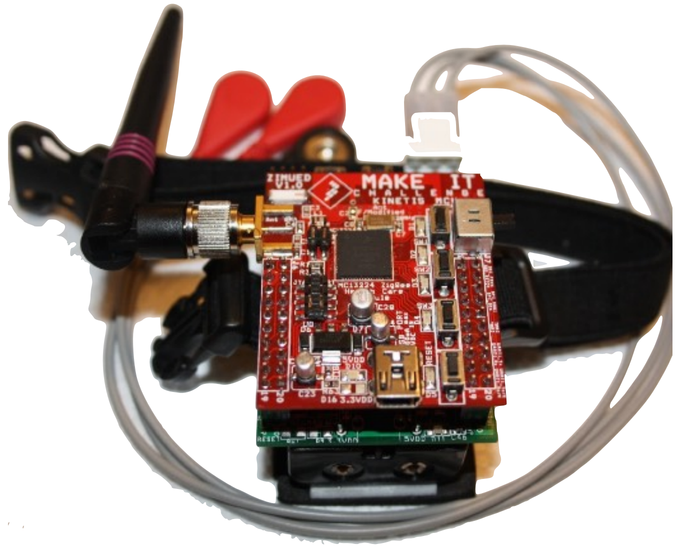


Analog and Digital integration uController (K53N512)

uController for handling the ZigBee Health Care Stack (MC13224)

Preliminary Experiments

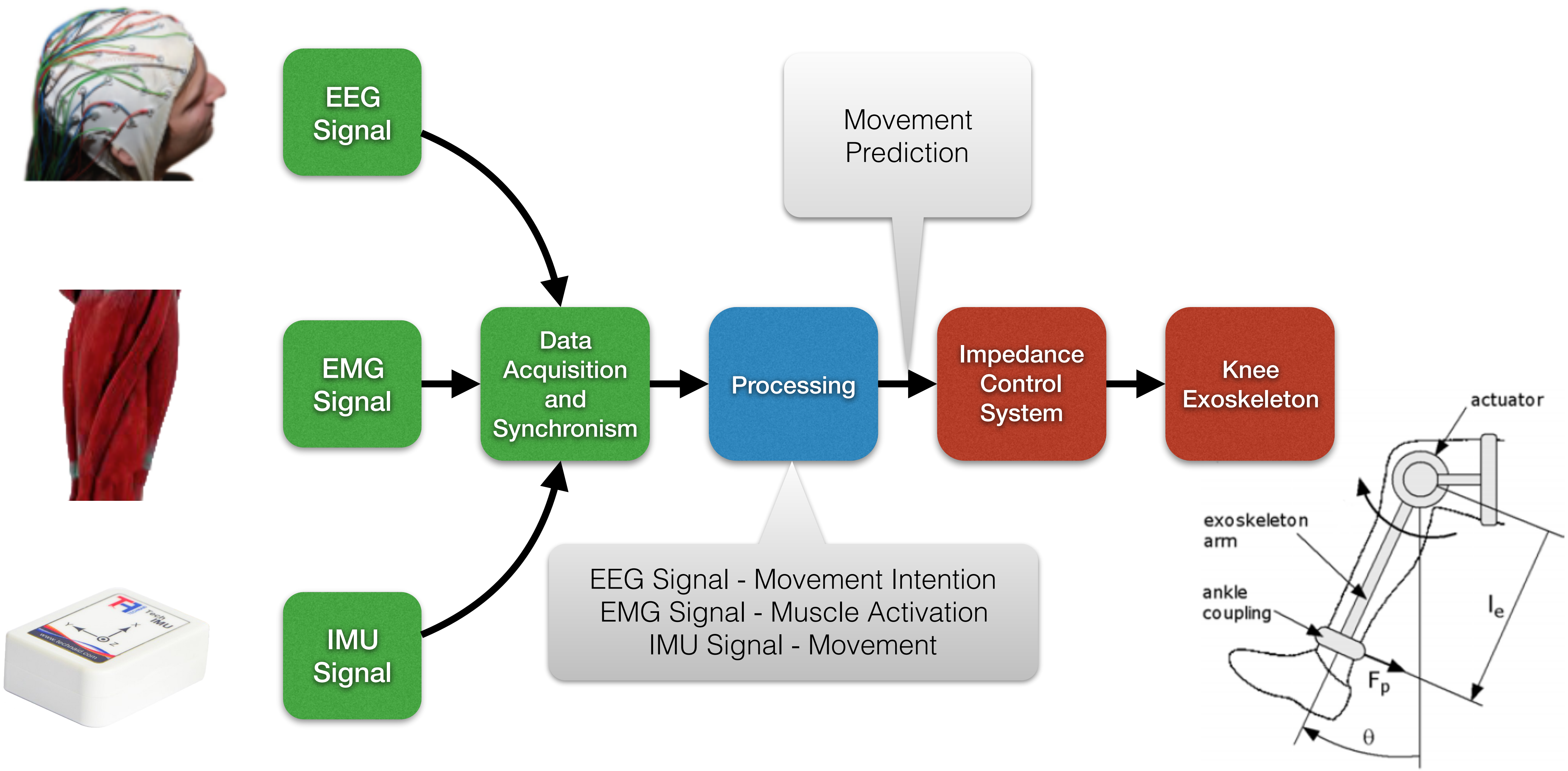
Ambulatory Assessment of Osteoarthrosis



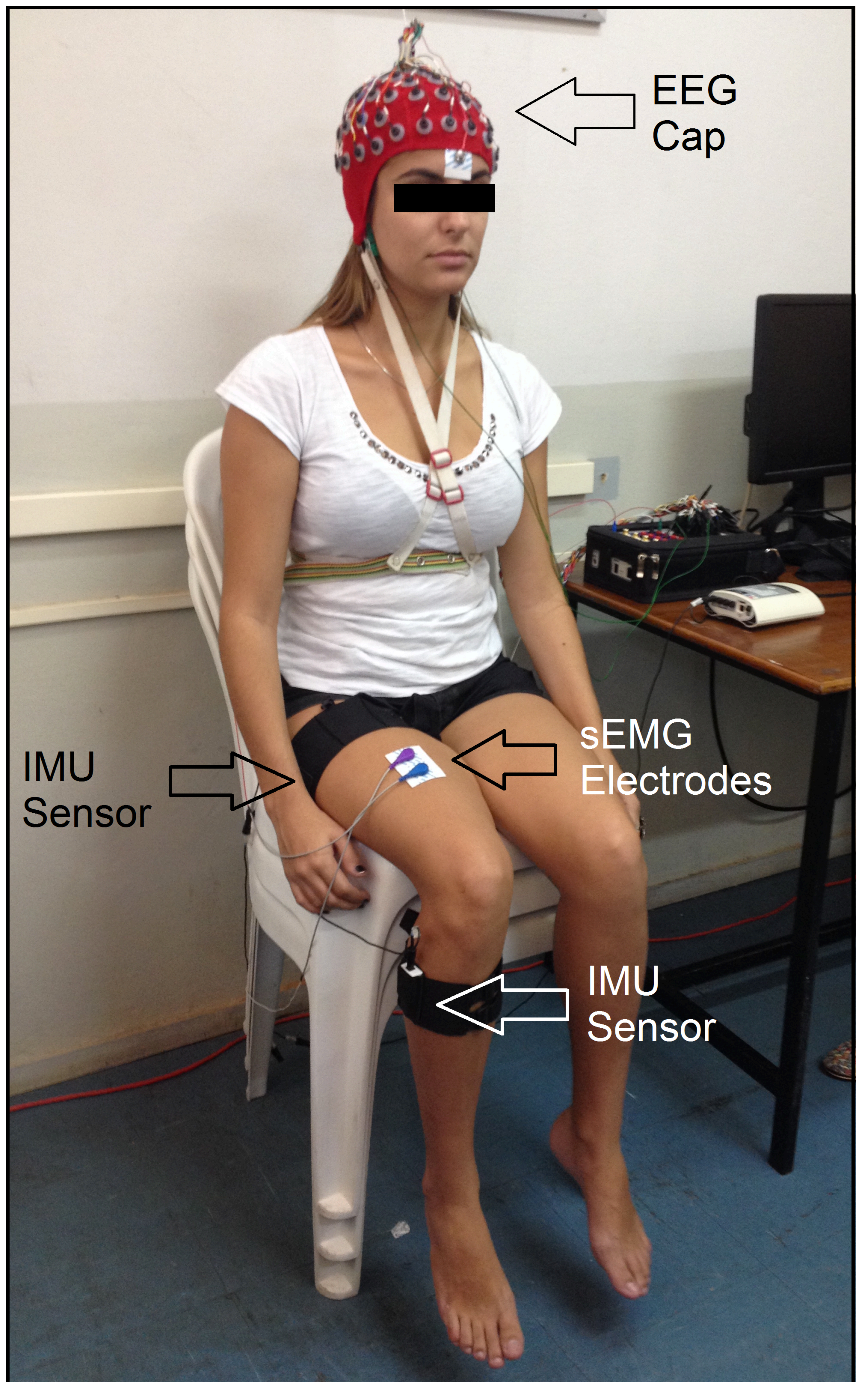
Sensor Technologies
Bioelectrical activity sensors

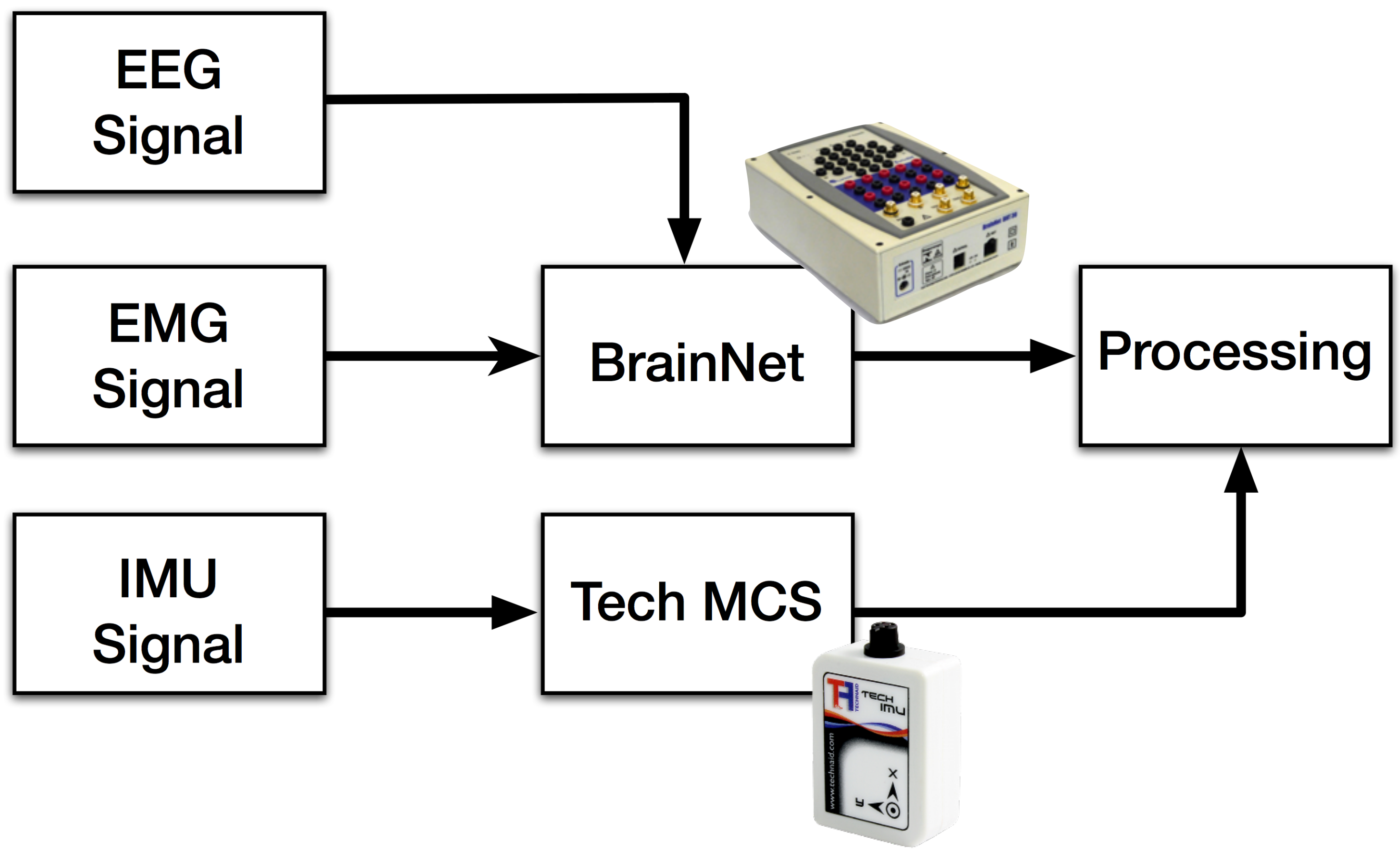
- Muscles
  - Depolarization of the motor unit causes depolarization of the muscle cell
  - Producing an electric impulse
- Brain:
  - Impulses produced by depolarization of the neuron cells in the brain tissue travel through the volume conductor and can be measured on the scalp

Multimodal Interface for Robotic Rehabilitation



Bioelectrical & Biomechanical Monitoring

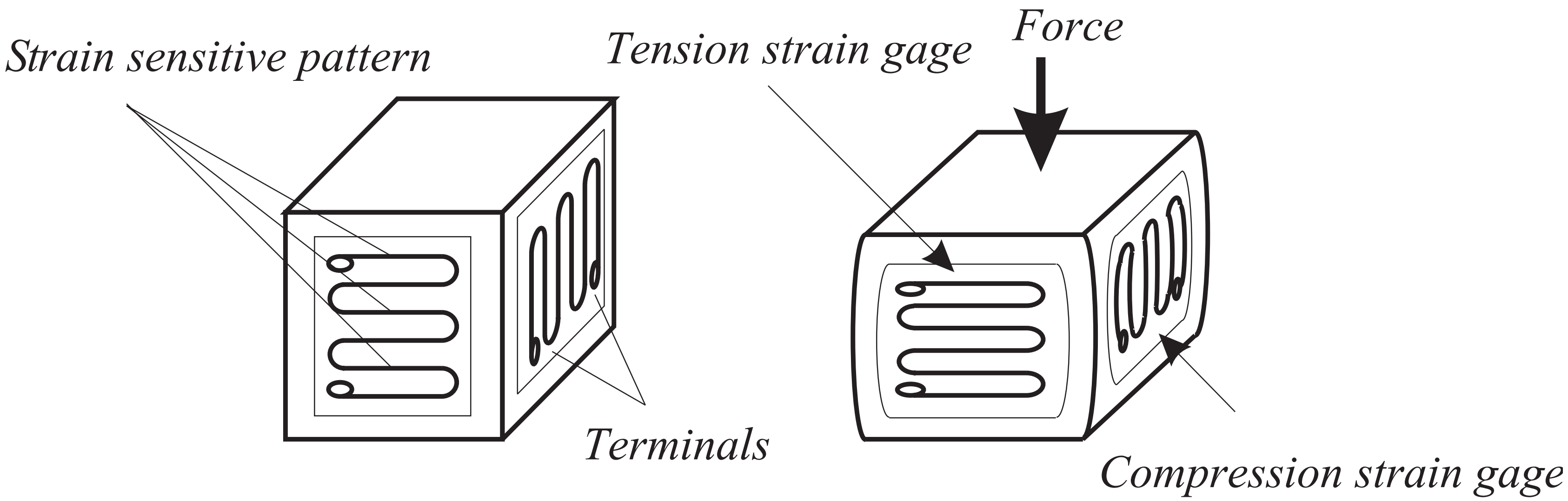




Sensor Technologies
HR interface force and pressure

- Piezoelectric sensors
- Capacitive force sensors
- Strain gauges
- Piezoresistive polymers
- Pressure sensing

Optical Fiber Sensors



Motivation

- **Existing solutions (electronic or imaging devices) :**

Drawbacks

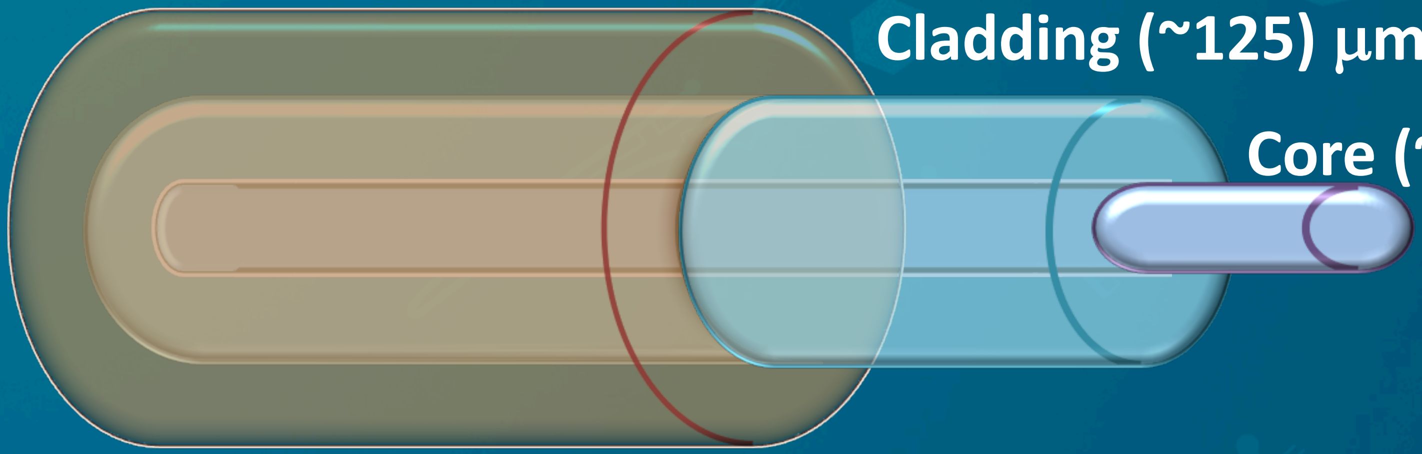
- High cost
- Fragility
- Instability
- Inconsistent feedback

- **New solution base on <u>optical fiber technology</u>:**

Advantages

- Robustness
- Flexibility
- Immunity to electromagnetic interference
- Ability to multiplex (sensing networks)

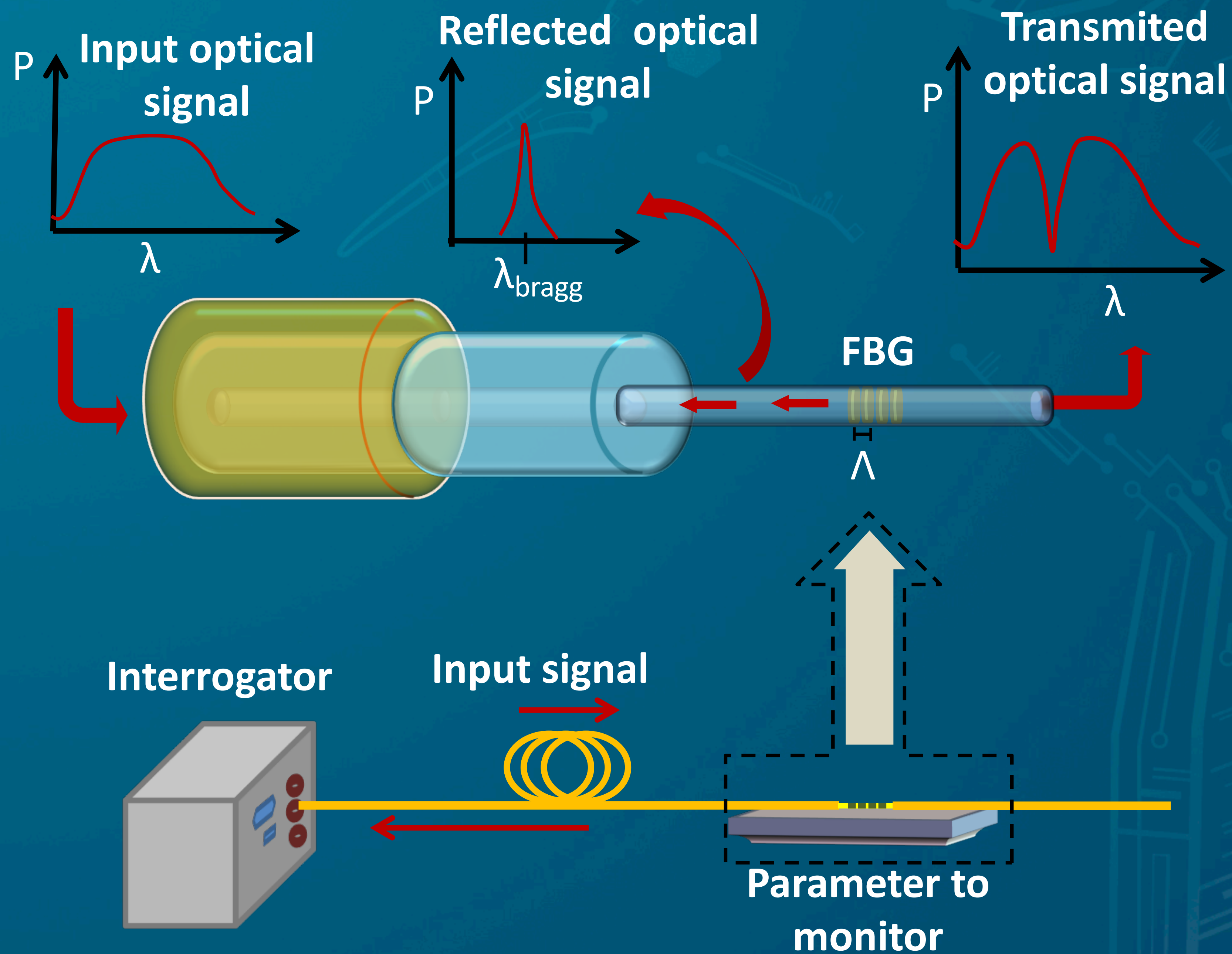
Optical Fiber Sensors



Optical fiber sensors advantages

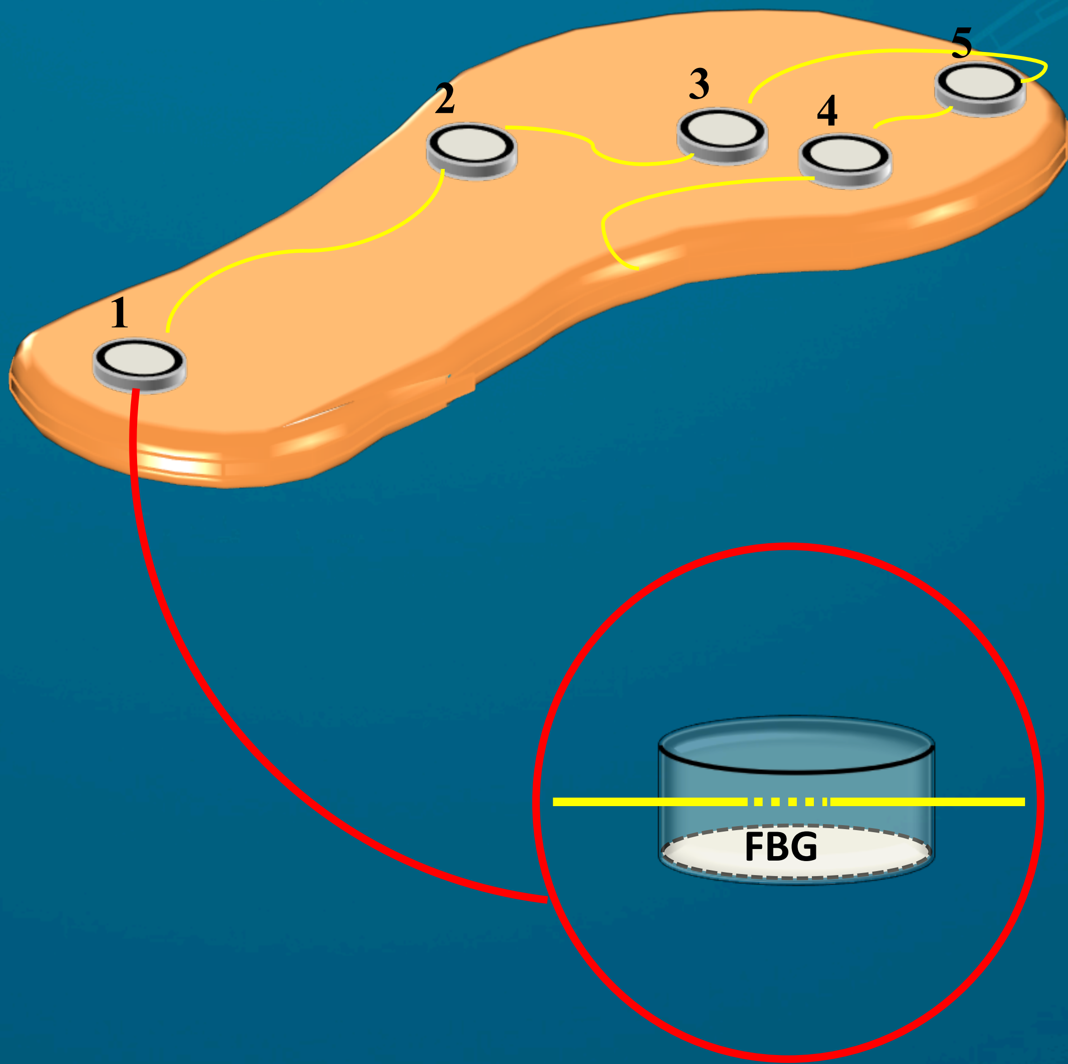
- Small size and weight
- Multiplexing capabilities
- Cost effective
- Low transmission loss
- Immunity to electromagnetic interferences

FBG Sensors



P
Input optical signal
λ
Reflected optical signal
P
λbragg
Transmited optical signal
P
λ
FBG
Λ
Interrogator
Input signal
Parameter to monitor

Insole Peparation

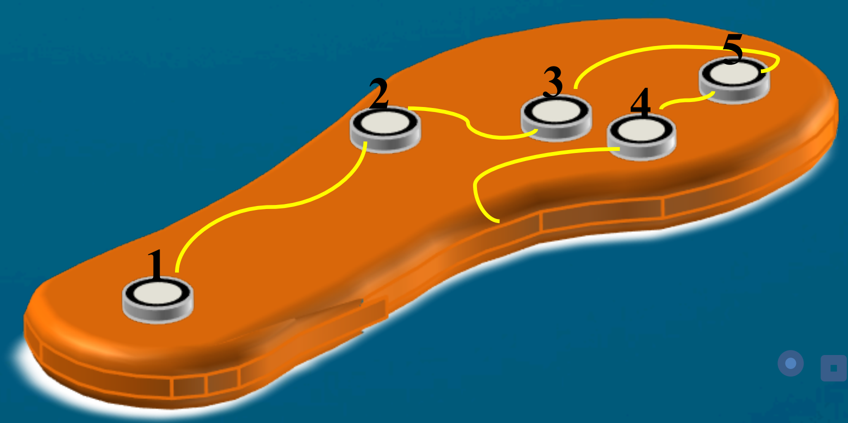


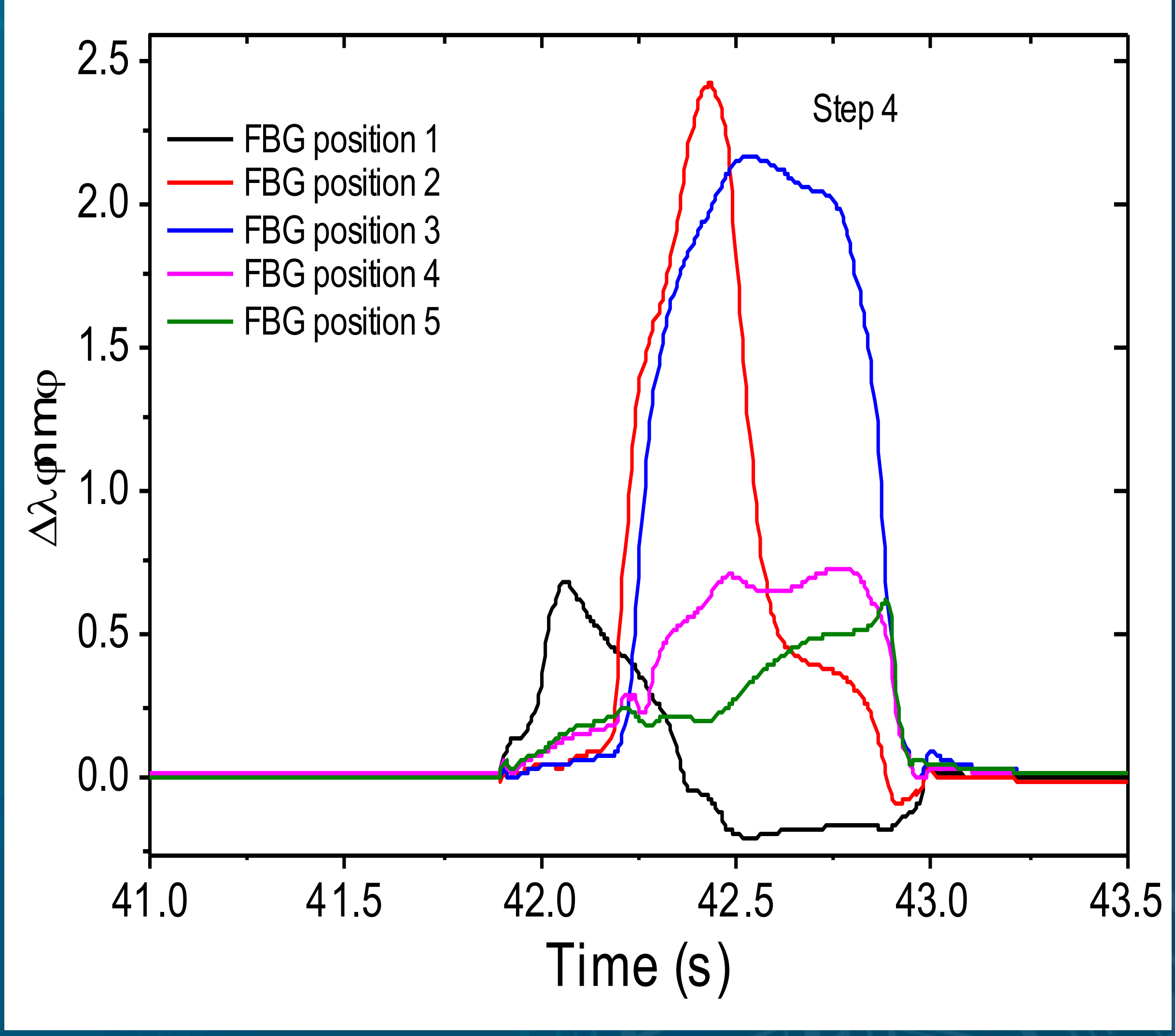
Epoxy resin cylindrical structures

- Developed optical platform:
  - Cork sole
  - 5 FBG sensors
- The encasement:
  - Cylindrical structures (1 cm)
  - Filled with epoxy resin

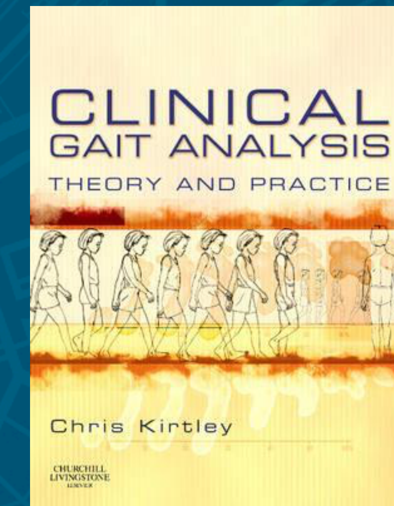
Results

- Sequenced events (activation) during gait
- Adequate sensibility and temporal response





Results



Adding the wavelength shift of the 5 sensors