Human-machine interaction

ScuDo
Scuola di Dottorato – Doctoral School
WHAT YOU ARE, TAKES YOU FAR
XXXII Cycle

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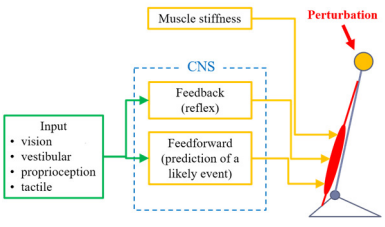
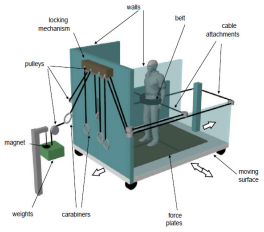
POLITECNICO DI TORINO

Automatic system for the clinical assessment of postural control

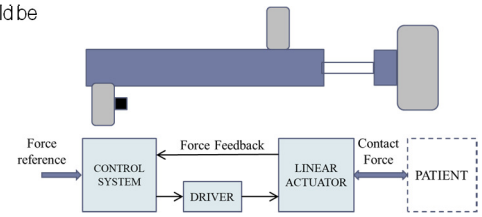
Research context

- **Postural control**, managed by the central nervous system, can be evaluated observing the response to an external perturbation (**NO** standard procedures)

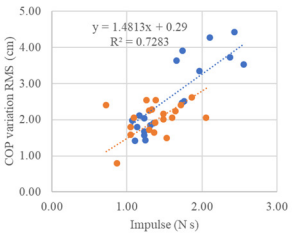


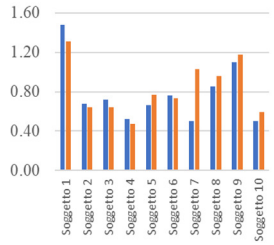


- **Aim of the study:** to develop an automatic system able to exert a controlled mechanical perturbation to the body of the patient and to analyze his/her response
- The **perturbation** should be
  - repeatable
  - scalable
  - flexible
  - accurate



A preliminary study

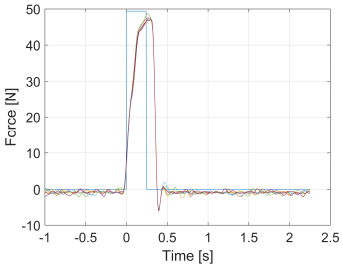


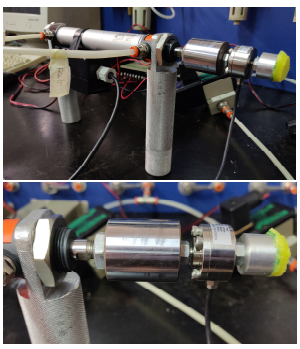


- Experimental trials performed on healthy subjects with an instrumented manual perturbator → correlation between the **impulse** and the body **response** (COP displacement)

The first automatic prototype

- Automatic **hand-held** perturbator with pneumatic actuation, low cost components
- Can be incorporated in a robotized system (**PGAS**, patent pending) for positioning
- Currently under test in laboratory





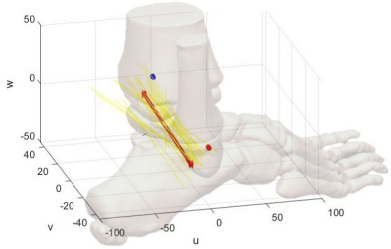
Future steps

- Improvements in the architecture and control, testing of different types of **actuation**
- Identification of algorithms to **interpret** the response of the patient
- Integration of the hand-held perturbator in the **overall automatic system**

In-vivo kinematic analysis of ankle joint for the development of hinged AFO

Context and issues addressed

- The **arbitrary placement** of the joint in hinged AFO reduces the effectiveness of such devices
- The hinge should take into account the **floating** of ankle joint rotation axis
- **Aim of the study:** to define new methodologies for the in-vivo kinematic analysis of ankle joint, oriented towards the design of subject-specific hAFO

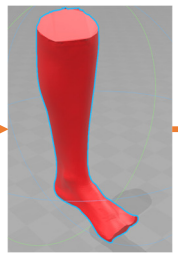


Critical aspects

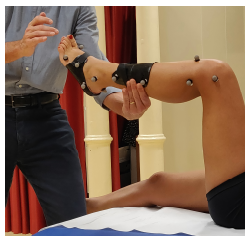
- High **compatibility** between the anatomical surfaces and the shells of the orthosis
- In-vivo motion analysis affected by instrumental errors and by **soft tissue artifact**
- Minimal amount of space available to the hinge, **wearable** inside the shoe

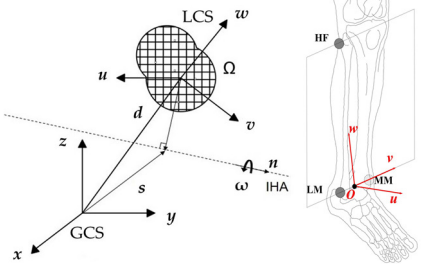
Methodology

1. **3D scan** of the lower limb with a commercial optical scanner
2. **Modelling** of the brace shells (3D cad), **meshing**
3. **Fabrication** by additive manufacturing, PLA or ABS
4. **Motion analysis** (Istituto Ortopedico Rizzoli, Bologna) of several motor tasks



5. **Kinematic analysis**:
   - ankle joint rotations (ML, AP, PD)
   - **I**nstantaneous (and **M**ean) **H**elical **A**xes





6. **Final** step: hinge joint **features** definition (placement, range of movement)

Future work

- Identification of the **significant motor tasks** for joint kinematics evaluation
- Design of the **floating axis hinge**, 3D printing fabrication and shell **integration**
- **Experimental** testing and FEA **simulations** of the brace prototypes

Published works

- De Benedictis, Carlo; Franco Walter; Maffiodo Daniela; Ferraresi Carlo (2019) Hand Rehabilitation Device Actuated by a Pneumatic Muscle, In: MECHANISMS AND MACHINE SCIENCE (67), pagine 102-111, DOI 10.1007/978-3-030-00232-9_11
- Ferraresi, Carlo; De Benedictis Carlo; Maffiodo Daniela; Franco Walter; Messere Alessandro; Pertusio Raffaele; Roatta Silvestro (2019) A Novel Pneutronic Device for the Investigation of Compression-Induced Physiological Phenomena: Modeling and Experimental Testing, In: MECHANISMS AND MACHINE SCIENCE (65), pagine 207-215, DOI 10.1007/978-3-030-00329-6_24
- Franco, Walter; Maffiodo, Daniela; De Benedictis, Carlo; Ferraresi, Carlo (2019) Dynamic Modeling and Experimental Validation of a Haptic Finger Based on a McKibben Muscle, In: MECHANISMS AND MACHINE SCIENCE (66), pagine 251-259, ISBN: 978-3-030-00364-7
- Ferraresi, C.; Leardini, A.; De Benedictis, C.; Franco, W.; Maffiodo, D. (2017) Design and test of a Hinged Ankle-Foot Orthosis based on natural joint kinematics, In: GAIT & POSTURE, pagine 35-36, ISSN: 0966-6362

List of attended classes

Trasmissioni automobilistiche. manuali, non manuali e ibride (20 hours)
Public speaking (5 hours)
Sviluppo dei comandi di volo fly-by-wire (20 hours)
Programmazione scientifica avanzata in matlab (20 hours)
LabVIEW Core 1 (24 hours)
LabVIEW Core 2 (16 hours)
Data Acquisition Using NI-DAQ and LabVIEW (16 hours)

Didactic assignments

- 02IKKMV Meccanica applicata ai sistemi biomedici (AA-ZZ)
- 07BOTMN Meccanica applicata alle macchine (AA-CAO)