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# Alessandro Mazzarini

## WORK EXPERIENCE

30/09/2021 – CURRENT Pontedera, Italy
**PHD STUDENT** SCUOLA SUPERIORE SANT'ANNA

PhD student in Biorobotics. I'm working on the design, development and validation on amputee subjects of robotic lower limb prostheses inside the project MOTU++ funded by INAIL. In particular, the main tasks I'm carrying out are:

- Design of the controller of a robotic transtibial prosthesis
- Certification of the prosthesis as a class IIa medical device
- Definition of the clinical study and experiments with amputee subjects
- Project management

14/12/2020 – 30/09/2021 Pontedera, Italy
**RESEARCH FELLOW** SCUOLA SUPERIORE SANT'ANNA

Validation and benchmarking of control algorithms on robotic devices, in particular sensor fusion algorithms for the estimation of Euler angles and segmentation algorithms with wearable sensory apparatus.
Clinical trials both with healthy and amputee subjects.

31/07/2019 – 29/09/2019 Mainz, Germany
**TRAINEESHIP** FRAUNHOFER IMM - INSTITUT FÜR MIKROTECHNOLOGIE UND MIKROSYSTEME

Summer traineeship within the EU project NeuHeart, funded by Erasmus+
Student Mobility Programme 2019/20. During this period, I have developed a model for the left ventricle of the heart and took part in the design and simulation of a MEMS based sensor.

30/04/2014 – 30/07/2014 Jesi, Italy
**COMBINED STUDY/WORK EXPERIENCE** MAIP PIERALISI

## EDUCATION AND TRAINING

25/09/2018 – 03/12/2020 Pisa, Italy
**M. SC. IN BIONICS ENGINEERING** Scuola Superiore Sant'Anna and University of Pisa

The aim of the thesis was to analyse the mechanical model and verify gait segmentation algorithms in a semi-active transtibial prosthesis.
Its main objectives were

- The analysis, implementation (both offline and online) and verification of the kinematic model of the prosthesis providing a real-time estimation of the prosthetic ankle angle.
- The evaluation of the kinetic model capable of predicting the power of the prosthesis and energy injected by the prosthesis actuator.
- The development of a gait segmentation algorithm based on an onboard load cell and the assessment of its performance relative to the two algorithms based on (i) a foot IMU and (ii) a matrix of foot pressure sensors. The evaluation had the objective of identifying the most reliable approach for the prosthesis control and of investigating whether a sensory fusion approach might improve the individual performance of each algorithm.

Average exam score = 29,8/30

**Address** 56125, Pisa, Italy | **Final grade** 110/110 cum laude | **Level in EQF** EQF level 7 |

**Thesis** Analysis of the mechanical model and of gait segmentation algorithms of a semi-active TT prosthesis

13/09/2015 – 28/10/2018 Ancona, Italy

### **BACHELOR DEGREE IN BIOMEDICAL ENGINEERING** UNIVPM - Università Politecnica delle Marche

The aim of the thesis was to analyse muscular co-contraction at the level of the ankle joint by the use of the wavelet transform in hemiplegic children. The work analysed EMG data coming from 5 healthy and 5 hemiplegic children, and it aimed to confirm time-frequency analysis as a valid method for the recognition of the co-contraction in healthy subjects, as well as the possibility to apply the same method to subjects affected by cerebral palsy.

Average exam score = 29/30.

**Address** via Brecce Bianche 12, 60131, Ancona, Italy | **Final grade** 110/110 cum laude | **Level in EQF** EQF level 6 |

**Thesis** Assessment of muscle co-contraction in hemiplegic children through Wavelet transform analysis

13/09/2010 – 03/07/2015 Jesi, Italy

### **MATURITÀ SCIENTIFICA** Liceo Scientifico Leonardo Da Vinci

**Address** viale Giuseppe Verdi, 23, 60035, Jesi, Italy | **Final grade** 98/100

## LANGUAGE SKILLS

Mother tongue(s): **ITALIAN**

Other language(s):

| | UNDERSTANDING | | SPEAKING | | WRITING |
|---|---|---|---|---|---|
| | Listening | Reading | Spoken production | Spoken interaction | |
| **ENGLISH** | C1 | C1 | C1 | C1 | C1 |
| **SPANISH** | A2 | A2 | A2 | A2 | A2 |

*Levels: A1 and A2: Basic user; B1 and B2: Independent user; C1 and C2: Proficient user*

## DIGITAL SKILLS

Office Suite - Microsoft Office | NI LABVIEW | Basic user of Autodesk Fusion 360 | Latex Software | MATLABSimulink | Arduino IDE | MPLAB X IDE | Vector Illustration | Python | C++

**Certifications**

First Certificate in English (FCE - Level B2) University of Cambridge ESOL Examinations | European Computer Driving Licence ECDL

## ADDITIONAL INFORMATION

### PUBLICATIONS

**A low-power ankle-foot prosthesis for push-off enhancement** – 2023

Passive ankle-foot prostheses are light-weighted and reliable, but they cannot generate net positive power, which is essential in restoring the natural gait pattern of amputees. Recent robotic prostheses addressed the problem by actively controlling the storage and release of energy generated during the stance phase through the mechanical deformation of elastic elements housed in the device. This study proposes an innovative low-power active prosthetic module that fits on off-the-shelf passive ankle-foot ESAR (Energy-Storage-And-Release) prostheses. The module is placed parallel to the ESAR foot, actively augmenting the energy stored in the foot and controlling the energy return for an enhanced push-off. The parallel elastic actuation takes advantage of the amputee's natural loading action on the foot's elastic structure, retaining

its deformation. The actuation unit is designed to additionally deform the foot and command the return of the total stored energy. The control strategy of the prosthesis adapts to changes in the user's cadence and loading conditions to return the energy at a desired stride phase. An early verification on two transtibial amputees during treadmill walking showed that the proposed mechanism could increase the subjects' dorsiflexion peak of 15.2% and 41.6% for subjects 1 and 2, respectively, and the cadence of about 2%. Moreover, an increase of 26% and 45% was observed in the energy return for subjects 1 and 2, respectively.

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**A Model-Based Framework for the Selection of Mechatronic Components of Wearable Robots: Preliminary Design of an Active Ankle-Foot Prosthesis**

– 2022
This paper presents a dynamic modelling approach to aid the selection process of actuation components during the design of wearable robots. As a case study, an application of the model to the preliminary design of a fully active ankle prosthesis is presented.

Mazzarini, Alessandro, et al. "A Model-Based Framework for the Selection of Mechatronic Components of Wearable Robots: Preliminary Design of an Active Ankle-Foot Prosthesis." *Computers Helping People with Special Needs: 18th International Conference, ICCHP-AAATE 2022, Lecco, Italy, July 11–15, 2022, Proceedings, Part II*. Cham: Springer International Publishing, 2022.

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**A Multimodal Sensory Apparatus for Robotic Prosthetic Feet Combining Optoelectronic Pressure Transducers and IMU**

– 2022
Timely and reliable identification of control phases is functional to the control of a powered robotic lower-limb prosthesis. This study presents a commercial energy-store-and-release foot prosthesis instrumented with a multimodal sensory system comprising optoelectronic pressure sensors (PS) and IMU. The performance was verified with eight healthy participants, comparing signals processed by two different algorithms, based on PS and IMU, respectively, for real-time detection of heel strike (HS) and toe-off (TO) events and an estimate of relevant biomechanical variables such as vertical ground reaction force (vGRF) and center of pressure along the sagittal axis (CoPy). The performance of both algorithms was benchmarked against a force platform and a marker-based stereophotogrammetric motion capture system. HS and TO were estimated with a time error lower than 0.100 s for both the algorithms, sufficient for the control of a lower-limb robotic prosthesis. Finally, the CoPy computed from the PS showed a Pearson correlation coefficient of 0.97 (0.02) with the same variable computed through the force platform.

Fiumalbi, Tommaso, et al. "A Multimodal Sensory Apparatus for Robotic Prosthetic Feet Combining Optoelectronic Pressure Transducers and IMU." *Sensors* 22.5 (2022): 1731.

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## DRIVING LICENCE

**Driving Licence:** B

## CONFERENCES AND SEMINARS

14/02/2023 – 15/02/2023 – Groningen, the Netherlands
**MyLeg Winter School** Participation to the MyLeg Winter School and poster presentation

10/10/2022 – 10/10/2022 – Milano, Italy
**Seminar Lower-Limb Prostheses** Seminar lesson about lower-limb prosthetic devices developed at the Wearable Robotics Laboratory in the framework of the first level Master in Advanced Technologies in Rehabilitation of Humanitas University

11/07/2022 – 15/07/2022 – Lecco, Italy
**Joint International Conference on Digital Inclusion, Assistive Technology & Accessibility - ICCHP-AAATE 2022** Presented the conference paper: "A Model-Based Framework for the Selection of Mechatronic Components of Wearable Robots: Preliminary Design of an Active Ankle-Foot Prosthesis"

## PROJECTS

01/02/2022 – 01/05/2022
**High-Tech Entrepreneurship project** Development of a business model for a high-tech start-up. Analysis of the market competitors and development of the strategic roadmap for the start-up

**Three state amplitude control (current) of one DoF robotic hand** Three state amplitude control is a technique for granting grasping capabilities to an amputee patient through the use of a one degree of freedom (DoF) commercial hand prosthesis. A firmware programmed in C was developed, by implementing

a Finite State Machine (FSM) and a PID current controller to modulate the hand opening and close by reading an electromyographic (EMG) sensor placed in the forearm.

**Neural Networks for Emotion Recognition** Emotion recognition is an interesting problem to solve through the development of intelligent systems that can measure the affective state given physiological information recorded by specific sensors. In this project an approach to this problem was developed through the design of Multi Layer Perceptron (MLP) and Radial Basis Function (RBF).
A database containing 40 physiological signals in response to 40 videos for each of the 32 subjects was used. Firstly the data have been processed and then a total amount of 630 features were extracted from the signals and selected.
Using the selected features the best hyperparametrization for the two networks has been found minimizing the Mean Square Error (MSE): MLP network with 1 or 2 hidden layers and with logistic or hyperbolic tangent functions, and RBF network.

**Experimental design for haptic feedback on lower limb** A haptic stimulation feedback system has been developed to allow lower leg amputees improve walking performance and control of the prosthesis. The intention was to remap along the waist the location of the foot-ground center of pressure by the mean of three piezo-electric vibro-tactile actuators. The project aimed to design an experimental protocol to assess the effectiveness of the system to create the aforementioned illusion over a larger population sample. The experimental setup included 3 vibro-tactile piezo-electric actuator units positioned along a belt, each at a known relative distance. Their activations were driven by a LabVIEW routine running on a National Instruments (NI) sbRIO controller board with FPGA module. Moreover, a parallel LabVIEW virtual instrument (VI) run on another laptop with a Graphical User Interface (GUI) where the subject under test could give real-time quantitative evaluations of the perceived stimulus.

30/09/2019 – 29/03/2020
**Apprenticeship** Development of a soft sensorized lung for a high fidelity surgical simulator.
Extraction of the 3D model of the lung from a CT scan, design and3D printing of the mold, production of 5 polymeric lungs using different polymers, integration of a sensor interfaced through Arduino and LabVIEW to evaluate the intensity and position of the stress applied to the lung.

## HONOURS AND AWARDS

30/09/2021
**Winner of a PhD scholarship in Biorobotics – The BioRobotics Institute**

13/12/2020
**Winner of a research scholarship "Support to the development and the validation of wearable robotic systems for rehabilitation, assistance and enhancement of motor capabilities" – The Biorobotics Institute**

2021
**Qualification - Industrial Engineer – Università di Pisa**

## MANAGEMENT AND LEADERSHIP SKILLS

**Project handling** Throughout my whole experience inside the university, I learned to communicate, adapt to different situations, to make decisions and to manage efficiently my time.
In particular, during the Ph.D., I have been involved in the following tasks:

- Preparation of presentation for project consortium meetings.
- Coordination of project consortium.
- Drafting of documents for project deliverables, minutes of meetings, clinical studies submissions and medical device certifications.

## COMMUNICATION AND INTERPERSONAL SKILLS

**Teamwork and collaboration** Collaboration and mediation gained thanks to numerous project done during the M.Sc. in Bionics Engineering.
Communication team on weekly/monthly recaps.

Teamwork skills gained thanks to the volunteering activity in ACI (Azione Cattolica Italiana)