Dipartimento Meccanica Matematica Management

MUR
Dipartimento
di Eccellenza
2018-2022
2023-2027

CALL FOR EXPRESSION OF INTEREST FOR MSCA POSTDOCTORAL FELLOWSHIPS AT POLITECNICO DI BARI

Research project

Nome and Surname: Gianluca Percoco

Title: Bio-Inspired Interlocking Soft–Stiff Musculoskeletal Systems via 3D Printing for on-demand prosthetics

Description:

Project Summary

Human musculoskeletal systems derive their exceptional functionality from the seamless integration of soft and stiff tissues, distributed sensing, and active force generation. While recent advances in additive manufacturing have enabled the fabrication of anatomically inspired robotic and prosthetic structures, current 3D-printed systems largely remain structural replicas, lacking the functional integration required for human-like performance. In particular, the fabrication of robust soft–stiff interfaces, embedded sensing, and artificial muscles remains a major challenge, often addressed through manual assembly and expensive manufacturing platforms.

This postdoctoral project aims to establish a hybrid 3D-printing framework for the one-shot fabrication of functional musculoskeletal systems, enabling the direct integration of soft tissues, rigid reinforcements, sensing elements, and actuation within a single manufacturing process. By combining patient-specific anatomical data with multi-material additive manufacturing, the project targets the development of smart, customizable prosthetic systems that more closely replicate the biomechanics and sensing capabilities of human limbs.

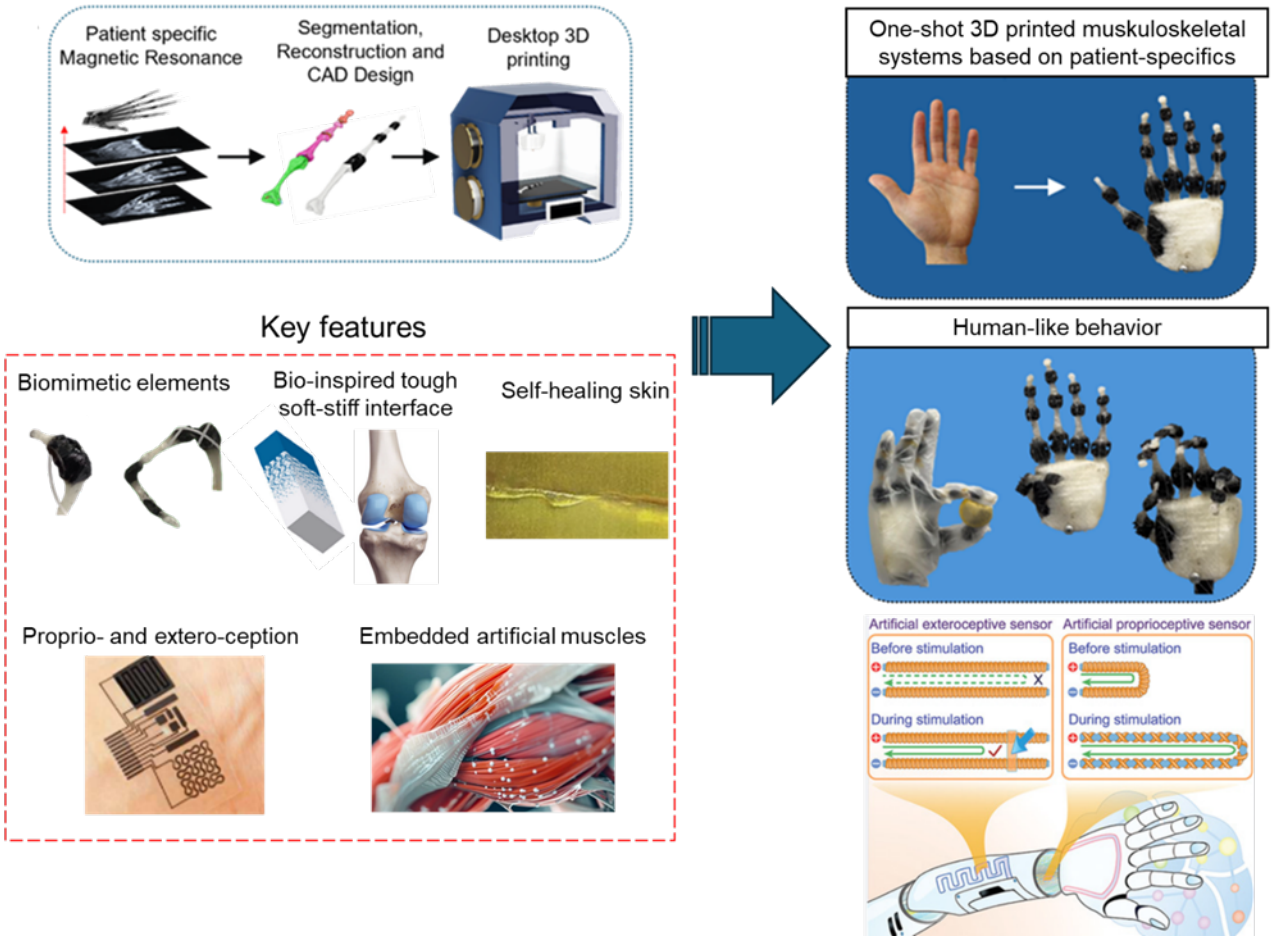

Figure 1- Graphical abstract

Research Objectives

The central objective of this research is to redefine how musculoskeletal robotic and prosthetic systems are manufactured, shifting from assembly-based fabrication toward monolithic, multifunctional 3D printing. Specifically, the project seeks to:

- Develop a hybrid multi-material 3D-printing platform capable of processing soft elastomers, rigid fiber-reinforced polymers, and functional inks within a unified workflow.
- Engineer bio-inspired soft–stiff interfaces that transform traditional failure-prone junctions into mechanically robust, load-bearing regions, analogous to ligaments, tendons, and joint capsules in human anatomy.
- Embed proprioceptive and exteroceptive sensing networks directly into musculoskeletal structures using stretchable conductive inks and soft electronics.
- Enable the integration of bio-inspired artificial muscles and protective, self-healing skin layers during fabrication, reducing post-processing and extending system durability.

Scientific Approach

The project will leverage medical imaging data (e.g., MRI) to guide the generation of anatomically accurate CAD models of musculoskeletal structures such as hands or lower limbs. These models will explicitly

encode soft joints, ligaments, tendons, and rigid skeletal segments, allowing function-driven material placement rather than purely geometric replication.

A custom hybrid 3D-printing architecture will be developed by combining filament-based extrusion for rigid and fiber-reinforced components with direct ink writing for soft polymers, conductive inks, and functional materials. This approach will enable monolithic printing of structures composed of elastomers, hydrogels, rigid composites, and self-healing polymers, while preserving precise spatial control over material transitions.

A key scientific focus will be the design of graded and interlocking soft–stiff interfaces, inspired by natural entheses, to enhance mechanical strength and fatigue resistance under cyclic loading. Embedded conductive pathways will form distributed sensing networks capable of measuring deformation, contact, and joint motion, providing real-time proprioceptive and exteroceptive feedback. Where required, automated integration of artificial muscles will be performed during printing to achieve compact, biologically inspired actuation.

Expected Outcomes and Impact

The project is expected to deliver a new hybrid additive manufacturing paradigm for musculoskeletal robotics and prosthetics, along with demonstrator systems showcasing integrated structure, sensing, and actuation without manual assembly. The resulting platforms will enable the rapid fabrication of patient-specific prosthetic devices with enhanced functionality, durability, and biomimicry.

Beyond prosthetics, the proposed approach will impact soft robotics, rehabilitation devices, and human–machine interfaces, contributing to a future in which digitally derived anatomical models can be directly transformed into functional physical systems. By unifying anatomy, materials, and manufacturing, this research will advance the state of the art toward truly human-like artificial musculoskeletal systems.

Candidates should provide detailed CV

Candidates must be eligible according to the criteria established by the 2026 MSCA Postdoctoral fellowship call:

- to have a PhD by the call deadline.
- to have up to 8 years of research experience after PhD.
- to be citizens of an EU State or of an Associated Country.
- not to have resided or carried out their main activity in Italy for more than 12 months in the 36 months before the call deadline.

Contacts

Gianluca Percoco: gianluca.percoco@poliba.it