Italian Robotics in 2024: Projects Supported by the National Recovery and Resilience Plan

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Giovanni Boschetti[1], Giuseppe Carbone[2], Marco Ceccarelli[3], Alessandro Gasparetto[4], Lorenzo Scalera[4], and Renato Vidoni[5]

[1] University of Padua, 35122 Padua, Italy
giovanni.boschetti@unipd.it
[2] University of Calabria, 87036 Rende, Italy
giuseppe.carbone@unical.it
[3] University of Rome Tor Vergata, 00133 Rome, Italy
marco.ceccarelli@uniroma2.it
[4] University of Udine, 33100, Udine, Italy
{lorenzo.scalera, alessandro.gasparetto}@uniud.it
[5] Free University of Bozen-Bolzano, 39100 Bolzano, Italy
renato.vidoni@unibz.it

Abstract. This paper provides a synthetic description of a selection of PNRR-funded research projects led by roboticists of several Italian Universities. The Italian PNRR is a part of the Next Generation plan launched by the European Union after the COVID-19 pandemic with strategic investments in digitalization and innovation, ecological transition, and social inclusion. In this context, we present the ASSIST PRIN project developed by the Universiy of Padua and Rome Tor Vergata, the activities on PNRR projects at University of Calabria, the Agritech National Center and the Interconnected Nord-Est Innovation Ecosystem, in which the University of Udine and the Free University of Bozen-Bolzano are involved.

Keywords: Next Generation EU, robotics, assistive robotics, collaborative robotics, robotics for agriculture

1 Introduction

The Italian scientific community has always been active in the field of robotics. High-level research in the robotic domain has been and is still carried out in many Italian universities and research centers. Historically, the Italian scientific community has been characterized by the creativity of its members, which allows to find a propose innovative and non-standard solutions to complex problems, such as the design of mechanical, mechatronic and robotic systems [1,2].

The interaction between academy and private sector has been fostered by the starting of the Italian National Recovery and Resilience Plan ("Piano Nazionale di Ripresa e Resilienza – PNRR"), that has been launched in 2022 [3]. The Italian PNRR is a part of the global plan ("Next Generation EU") launched

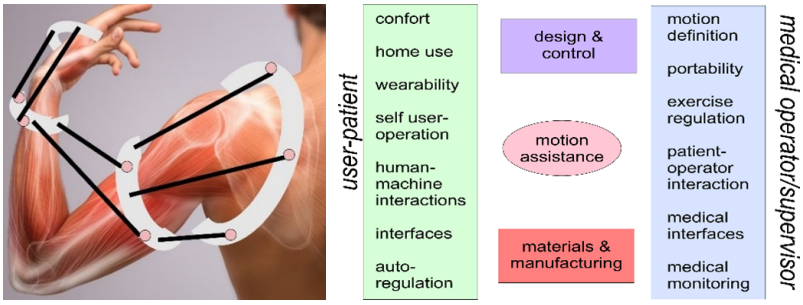
by the European Union after the COVID-19 pandemic, in order to allow the public and the private sector of the Member States to recover faster from the recession caused by the lockdown and the restrictions due to the pandemic. The total value of the Italian PNRR is 194.4 billion Euro [3]. A portion of the plan has been allocated to large consortia where both universities (as well other public institutions) and private companies run research projects in several domains. Moreover, the Ministry of University and Research used the funds of PNRR to finance many scientific projects. Many researchers belonging to the Italian robotic community are members of the above mentioned consortia, or participate in projects funded by the plan.

This paper provides a synthetic description of a selection of PNRR-funded research projects led by roboticists of several Italian Universities. The paper is organized as follows. Section 2 presents the ASSIST PRIN project, in which the University of Padua and University of Rome Tor Vergata are involved. In Sect. 3, the activities on PNRR projects at University of Calabria are illustrated. Furthermore, the Agritech National Center and the Interconnected Nord-Est Innovation Ecosystem, in which the University of Udine and Free University of Bozen-Bolzano participate, are described in Sect. 4 and 5, respectively.

2 The ASSIST PRIN project

The teams of Padua with prof. Giovanni Boschetti as team leader and Rome Tor Vergata with prof. Marco Ceccarelli as team leader have joined forces for the development of the project "Development of modular cable-actuated system for motion assistance of limbs" (ASSIST) [4,5], with the aim of advancing experiences and results in previous collaborations on motion assisting devices [6,7]. The ASSIST project is aimed at the development of ASSIST exoskeleton, a modular and portable cable-driven system for easy wearing on arms and legs in limb motion assistance. The ASSIST exoskeleton is based on an idea that is clearly presented at a conceptual level in an Italian patent application [5] and will be further elaborated in the activities of this project in an efficient solution to be designed with user-oriented features for practical implementation of a market product in a near future. Specific attention will be addressed to solutions for elderly people in exercising and rehabilitation activities.

The proposed device for motion assistance of limbs is conceived as made up of three modules (Fig. 1a), each composed of a lower platform ring, an upper plat-form ring, four cables connecting the two platforms, four servomotors, a unit control, sensors for device motion and limb conditions, a data processing and transmission unit, and a battery unit. The mechanical design is characterized by a structure that is based on a parallel-architecture mechanism to assist or guide relative movement of the assisted joint of a human limb. In each module the cables are installed in pairs with the characteristic of forming an antagonistic cable structure for the pulling action of one in correspondence with the release of the other while performing the flexion and extension of the assisted joint.



(a) (b)

Fig. 1: Schemes and plans for ASSIST 2024 PRIN project: (a) conceptual design [5]; (b) requirements and goals [4].

The project will include multidisciplinary activity with contributions from medical frames when considering an integration of technical and medical aspects for expected results in design solutions and advances in biomechanical expertise, as summarized in Fig. 1b. Activity is planned within four Work Packages in a work plan with phases from December 2023 to November 2025. Phase 1 is focused on analysis of state of the art and requirement definition from existing literature and from the experience of both partner units and external contacts of the research units, such as doctors and therapists. Phase 2 is planned on design and testing of biomechanical aspects for which conceptual and mathematical models will be conceived and designed in details for design solutions. Finally, Phase 3 is dedicated to prototyping solutions and testing them for validation and characterization of the proposed solutions and the built prototypes.

3 Activities on PNRR projects at University of Calabria

The team led by Giuseppe Carbone at the University of Calabria is actively engaged in four projects: Age-IT, FAIR, TECH4YOU Task 3.3.1 and Task 4.4.1.

PNRR Age-It project (Aging Well in an Aging Society): Age-It seeks to overcome the fragmentation of various research perspectives on aging. The University of Calabria's involvement is within the Spoke 9 "Advanced technologies for active and healthy aging". Specifically, the Task 9.3.4 focuses on developing an upper-limb exoskeleton and establishing standard testing procedures for assessing their performance. The first year of activities has led to several ongoing activities. Some first results have been published in [8,9]. Figure 2a shows an example of passive exoskeleton that has been developed within this project.

PNRR FAIR Project (Future AI Research): Task 9.5.4 within the FAIR project focuses on "Green-aware robot design and operation strategies". The green dimension is interpreted at large: supporting harmless artifact interaction with the

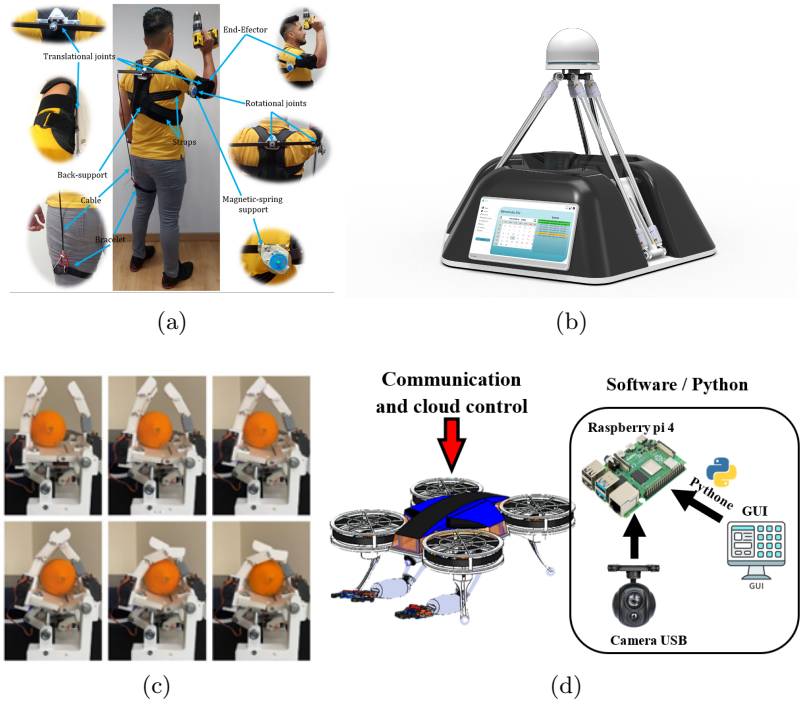


Fig. 2: Examples of activities at University of Calabria: (a) a passive exoskeleton; (b) the ADIUTOR assistive device; (c) frame sequence of a grasping tests with an orange; (d) a scheme of the proposed hybrid drone.

natural environment and with human well-being at both psychological, social and physical levels. The primary objective is to develop eco-sustainable methodologies and procedures for designing innovative robotic devices. Key challenges and innovative aspects involve identifying sustainable materials for soft robotics applications, developing lightweight solutions to reduce energy requirements, and utilizing sustainable, cost-effective, and lightweight materials with reduced processing energy. Figure 2b shows an example of ADIUTOR, a robotic device for upper-limb rehabilitation that will be re-engineered within the FAIR project. Some milestones of this project have been published in [10,11].

PNRR Project TECH4YOU (Technologies for Climate Change Adaptation and Quality of Life Improvement): TECH4YOU is the Calabria and Basilicata innovation ecosystem project. One of the main goals of TECH4YOU is to support processes for the enhancement of scientific research results by facilitating technology transfer to support digital transformation, increase the diffusion of technologies with low environmental impact and improve the resilience of the territory. Specifically, we lead Task 3.3.1 that involves developing an innovative robotic solution for soft robotic harvesting of horticulture products. Figure 2c shows an example of a robotic hand that is one of the concepts under investiga-

(a) (b)

Fig. 3: Scout 2.0 mobile robot (a); 3D reconstruction of the vineyard (b).

tion within this project for tomato and orange harvesting. Some milestones of this project have been published in [12].

PNRR Project TECH4YOU also includes our research leadership within the Task 4.4.1 that aims to design a hybrid drone for harsh environments. The main goal will be the development of a flying and walking drone being able to inspect coastal areas and remotely interact with marine drones. Figure 2d shows an example of the proposed hybrid drone concept. The activities of this drone consists of inspection tasks of cultural heritage sites in coastal areas. The proposed drone will be also able to interconnect remotely with nearby underwater drones as well as it can provide video recordings or interactive communications for interactive and immersive user perspectives.

4 The Agritech National Center

The National Center for the Development of New Agricultural Technologies (Agritech) is based on the use of enabling technologies for the sustainable development of agri-food productions, with the aim of promoting adaptation to climate change, reducing environmental impact in the agri-food sector, developing marginal areas, and ensuring safety, traceability, and security of supply chains [13]. The project is worth approximately 350 million euros, with 320 million funded by the PNRR, and involves 28 universities, 5 research centers, and 18 companies. The project duration is 36 months from 01/09/2022 to 31/08/2025.

The robotics research groups of the University of Udine (UniUD) and Free University of Bozen-Bolzano (UniBZ) are involved in the work package 4.2 titled "Smart-climate and resilient agriculture and forestry: from sustainable products to the bioeconomy". The task research activity are focused on the development and implementation of advanced monitoring techniques and novel management practices for saving soil and water, optimizing carbon balance, and maximizing the efficiency of used resources and mitigating impacts.

In the context of agriculture, ground mobile robots can play an important role for monitoring and mapping. Robotic solutions can acquire data from crops and

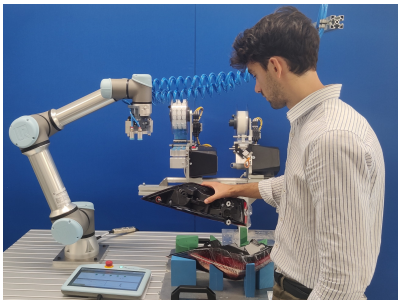


Fig. 4: Example of human-robot collaboration for an assembly task.

plants at a close range and from different viewpoints, are less weather dependent than airborne platforms, are not subjected to strict legislative regulations, and have a higher payload with respect to unmanned aerial vehicles (UAVs) [14].

For this reason, the role of the UniUD and UniBZ units, in particular with the FiRST-Field Robotics Lab [15] and the Mechatronics and Robotics Lab [16], is the development of an mobile autonomous robotic system with embedded self- and ambient-awareness for 3D canopy monitoring, and vegetative indices computation. The robotic platform is based on a Scout 2.0 mobile robot by AgileX Robotics provided with four electric motors and equipped with an NVIDIA Jetson Xavier onboard computer, an Intel RealSense D435 camera, and a Velodyne VLP-16 LiDAR sensor (Fig. 3a). The robot has been used to perform an analysis of the effects of water regime on grapevine canopy status. Data from the ground robot are combined with those obtained with a UAV to obtain multispectral images for vegetation indexes estimation, and the 3D reconstruction of the canopy (Fig. 3b), respectively [17]. UniBZ is also involved in the work package 4.1 titled "Next-generation technologies for resilient traits of crop varieties and tree species" with a research focus on technical solutions for high-quality wood and wood-supply chain. In particular, the group looks at automating and robotizing processes and operational monitoring tasks for forestry-related activities.

5 The Interconnected Nord-Est Innovation Ecosystem

The Interconnected Nord-Est Innovation Ecosystem (iNEST) project is funded by the Ministry of University and Research within the framework of investments outlined in the PNRR [18]. The research and innovation program of iNEST is organized according to a structure consisting of 1 hub and 9 spokes, involving 24 partners including all universities of North-East of Italy as well as the main research and technology transfer organizations active in the territory. From 2022 to the end of 2025, the iNEST working plan manages a budget of about 110 million euros. The robotics research groups of UniUD and UNIBZ, in particular with the Smart-Mini-Factory Lab [19], are involved in the research topic 2 "Smart Manufacturing, Mechatronics and Robotics" of the Spoke 3 "Green and Digital Transition for Advanced Manufacturing Technology". The research activities

are focused on dynamic modelling and trajectory planning for mechatronic and robotic systems also towards Digital Twin solutions, for energy efficiency and collaborative robotics applications.

Energy efficiency is indeed a critical aspect of robotic systems, as it directly impacts their environmental footprint and operational costs. The evaluation of energy efficiency strategies involves assessing their effectiveness and quantifying their impact on robotic systems. Collaborative robotics involves the interaction between humans and robots in shared workspaces, scenarios where ensuring the safety of human workers is paramount (Fig. 4). Safe interaction strategies involve the integration of sensing, perception, and control algorithms to enable robots to detect and respond to human presence and movements in real-time [20,21]. The study and evaluation of strategies for energy efficiency in robotic systems and the development of trajectory planning approaches for safe human-robot interaction are essential for sustainable and safe robotic operations.

6 Conclusions

In this paper, we presented a synthetic description of a selection of PNRR-funded research projects led by roboticists of several Italian Universities. In particular, we presented the ASSIST PRIN project developed by the Universiy of Padua and Rome Tor Vergata, the activities on PNRR projects at University of Calabria, the Agritech National Center and the Interconnected Nord-Est Innovation Ecosystem, in which the University of Udine and the Free University of Bozen-Bolzano are involved. These projects testify the activity of the Italian scientific community in the field of robotics, with specific competencies on assistive robotics, collaborative robotics, mobile robotics and robotics for agriculture.

Acknowledgments

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