

INTELLIMAN

AI-powered manipulation system for advanced robotic service, manufacturing and prosthetics



From grasping a cable to picking a strawberry—IntelliMan brings intelligence into prostheses and robots, with the human always at the centre

IntelliMan's focus is on how a robot can learn efficiently to perform manipulation tasks in a targeted, high-performance and safe matter.

- **IntelliMan enables robots to adapt to real-world uncertainty**, allowing manipulation of deformable and unpredictable objects in dynamic environments
- **IntelliMan integrates multi-modal perception, task-level reasoning, and human-in-the-loop learning**, bridging the gap between manual labor and full automation
- **IntelliMan delivers intuitive control through wearable neuromuscular interfaces (sEMG)**, empowering users to guide and teach robots effortlessly
- **IntelliMan develops open and modular robotic platforms**, accelerating innovation and technology adoption, especially for SMEs
- **IntelliMan promotes human-centered, responsible automation** in line with **Industry 5.0** and **EU strategies** for digital and social sustainability

Use Cases – purpose and demonstration objectives

Application scenarios on gripping and placing with flexible objects: support development of various solutions for the manipulation problem.



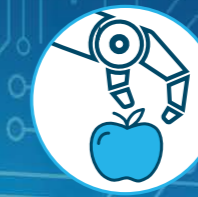
Upper-limb prosthetics:
increase user trustworthiness and enhance embodiment



Robotic assembly of products:
robust handling of deformable linear objects

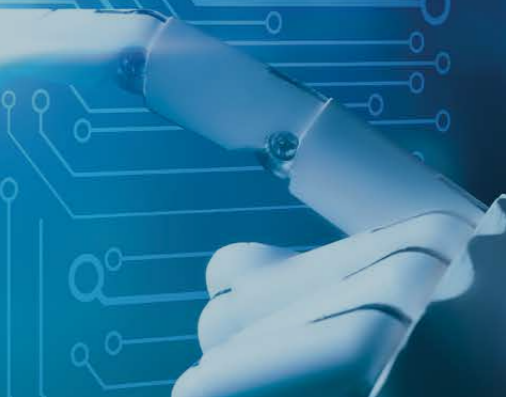


Daily life kitchen activities:
reliable robotic manipulation of everyday objects

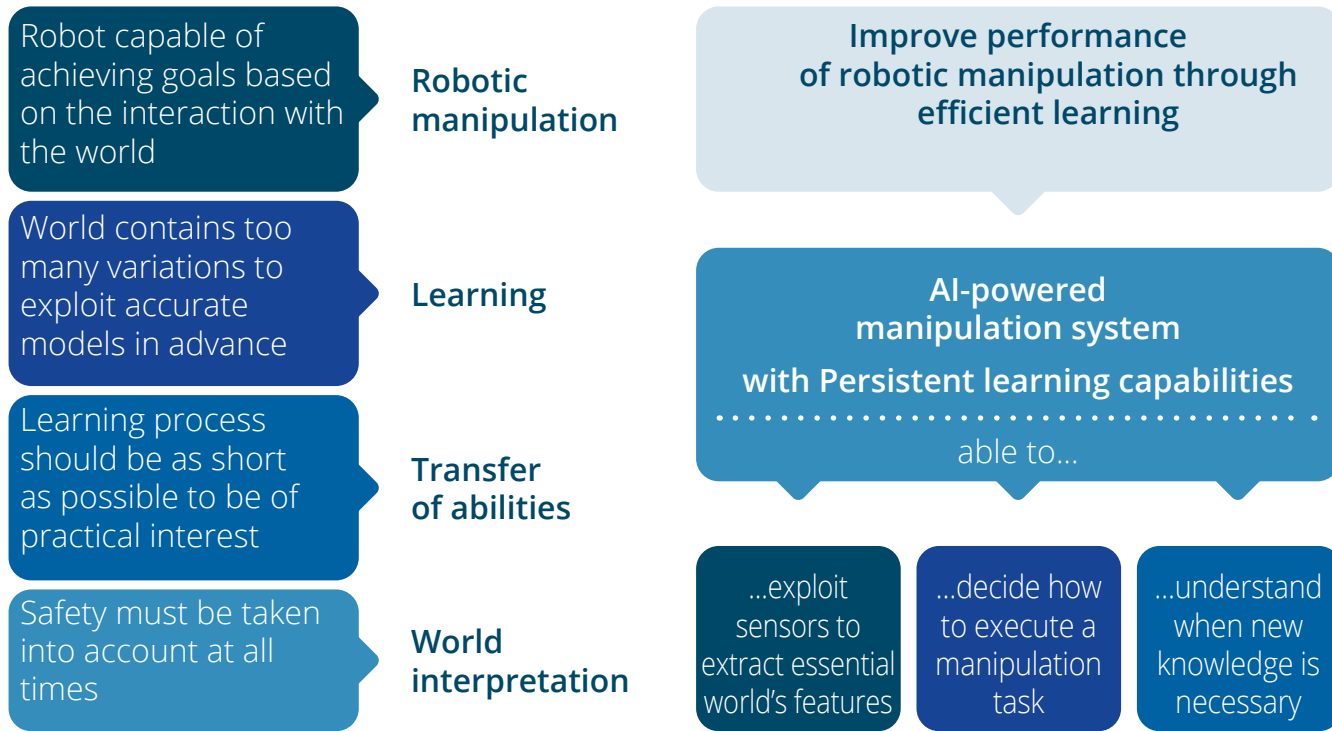


Robotic fresh food handling for logistic applications:
sensing-based multi-finger grasping

AI



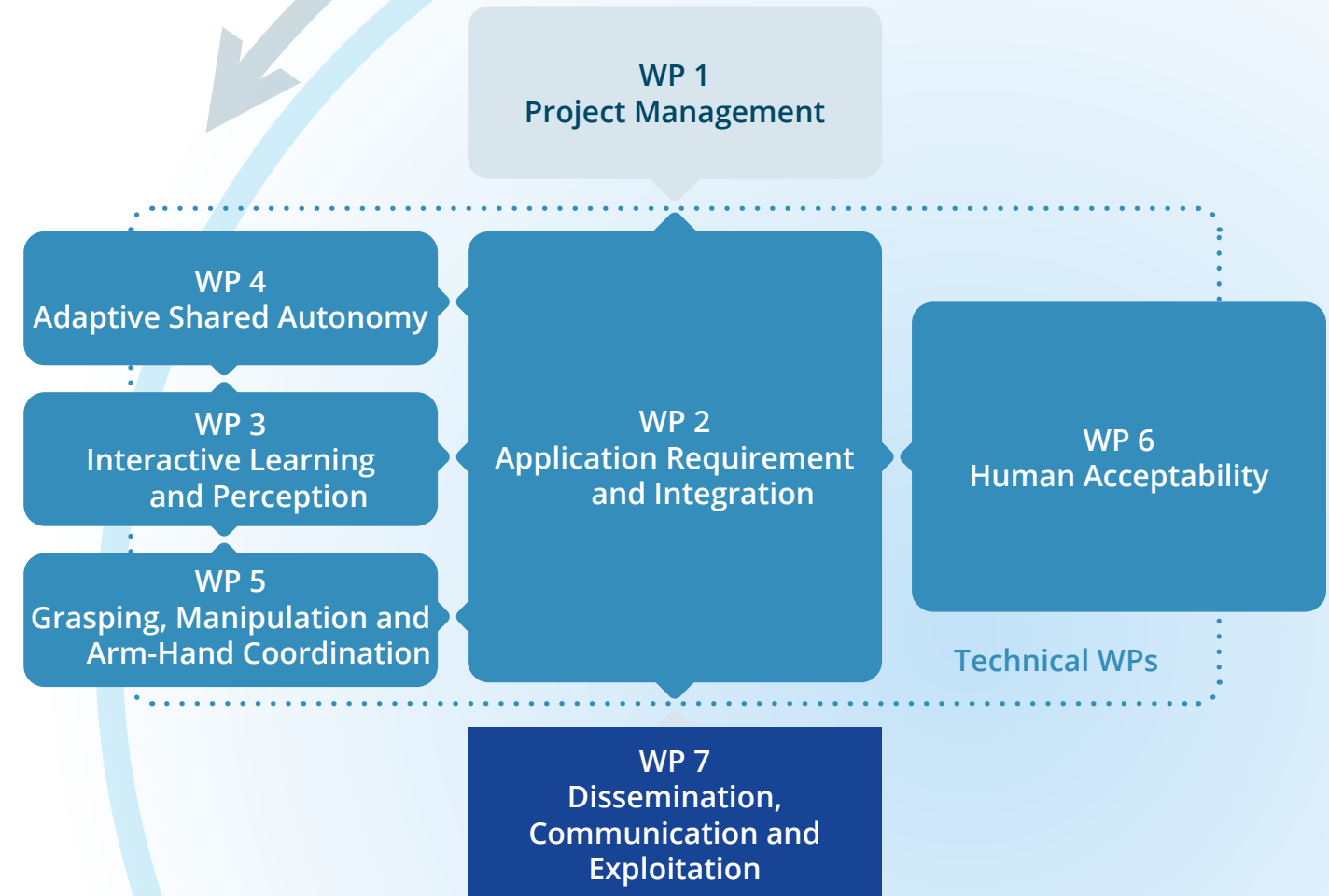
Challenge and Methodology



Developed **AI-based manipulation solutions** can be **transferred across different** robotic systems and applications **scenarios**:

- **Learn** general manipulation **task structures** and **hierarchies** from **interaction** with **environment and/or humans**
- **Exploit** the same **shared autonomy** methodologies in different robotic systems to **interact efficiently with humans**
- **Reduce** the number of the **training samples** combining **model-free** and **model-based** approaches
- **Guarantee performance, safety** and **failure detection** of the AI-based manipulation solutions

Project Structure



WP3: Highest level of abstraction
WP4 and WP5: "Engine and bridge" of use-case-oriented solutions
WP6: Human-centered evaluation of the results

Ambition/Objectives

AI-based Manipulation

Object and Environment Interaction



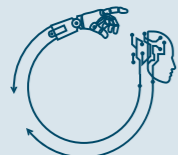
Hand-Arm-System



Shared Autonomie



Human Interaction



Model-Based Features

Desired Grasp, Manipulation Task



Mass, COM, Inertia matrix



Shape



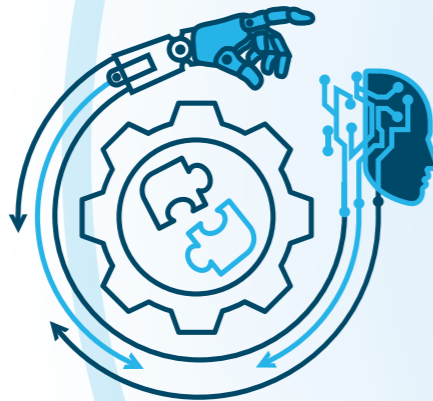
Surface Friction



Stiffness, Damping



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Upper-limb prosthetics

- Adaptive shared autonomy control framework for grip force regulation of robotic hand grasping
- Combined user intent estimation, tactile feedback and adaptive assistance
- Persistent learning through an incremental learning-based algorithm, improving robustness and usability for a prolonged operation
- Validated with able-bodied participants and upper-limb amputee in grasping and manipulation tasks

INAIL
CENTRO PROTESI



Manipulation in kitchen activities

- Manipulation of household items in wide-scenario tasks with a mobile platform, through the generation of ontology-based plans executed by object-centric flavour-based adaptive Behaviour Trees Mobile robot for scenario-wide tasks
- The supervised pipeline relies on artificial vision model using deep neural networks for object detection, able to generalise for shape and size variations.
- Object grasping is ensured through physics-informed grasp generation and flexible sensors mounted on the gripper that provide measures to control over the grasp and detect slippages

eureka!



Fresh food handling

- Robotic fresh-food handling solution based on parallel and multi-fingered grasping, integrating closed-loop force feedback and machine-learning-based manipulation strategies for delicate handling
- Intelligent manipulation in cluttered environments, generalisable grasping for picking from dense environments
- Manipulation capabilities of multiple items, especially delicate fruits and vegetables
- Human-like haptic interaction

ocado
TECHNOLOGY



Flexible manufacturing

- Deformable objects manipulation for the assembly process of connector and wires
- Visuo-tactile insertion check through stereo-vision system for pose estimation and active monitored insertion phase via tactile feedback
- Learn kinematic relationship
- Learn manipulation features

ELVEZ



Use Cases Outcomes

- Reduce the abandonment rate of prosthesis by 20%
- Reliable robot manipulation in daily-life kitchen activities
- A 90% success rate in the robotic manufacturing of connectors in lab environment
- A robotic solution for fresh food handling based on parallel or multi-fingered grasping

Key Exploitable Results

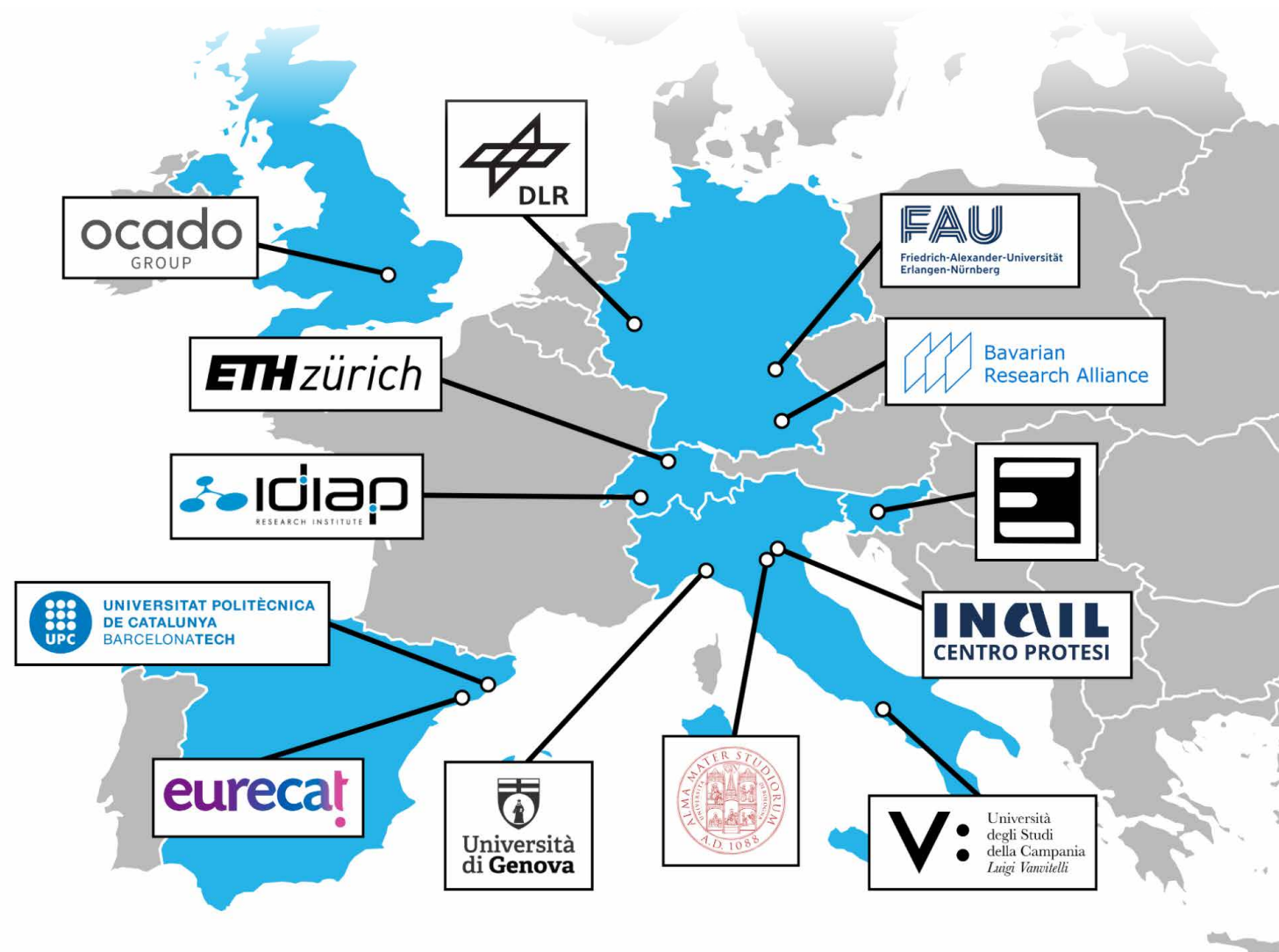
- ▶ **Increased user trustworthiness and enhanced embodiment in upper-limb prostheses**
- ▶ **Enable safe and reliable manipulation in household scenario**
- ▶ **Robotic assembly of products involving deformable linear objects manipulation**
- ▶ **Robotic handling of fresh foods for logistic applications**

Key Exploitable Results & Outcomes

- **IntelliMan enables robots to adapt to real-world uncertainty**, allowing manipulation of deformable and unpredictable objects in dynamic environments.
- The project integrates **multi-modal perception, task-level reasoning, and human-in-the-loop learning**, bridging the gap between manual labor and full automation.
- It delivers **intuitive control through wearable neuromuscular interfaces (sEMG)**, empowering users to guide and teach robots effortlessly.
- IntelliMan developed **open and modular robotic platforms**, accelerating innovation and technology adoption, especially for SMEs.
- The project promotes **human-centered, responsible automation** in line with **Industry 5.0** and **EU strategies** for digital and social sustainability.

- An **AI-based manipulation system** that can be **seamlessly used** across different robotic platforms and over different application scenarios
- A **task structure interpreter** and a set of manipulation skills that can be exploited in real application scenarios to compose new manipulation tasks
- A **reduction of training samples by 50%** wrt SoA preserving same the success rate or improving it
- An **AI-based manipulation system** able to guarantee a **90% success rate** in real applications

Project partners



Coordination:
Università di Bologna, Italy

Project partners:

- Alma Mater Studiorum – Università di Bologna, Italy
- Deutsches Zentrum für Luft- und Raumfahrt eV, Germany
- Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany
- Universitat Politècnica de Catalunya, Spain
- Università Degli Studi di Genova, Italy
- Università Degli Studi Della Campania Luigi Vanvitelli, Italy
- Fundacio Eurecat, Spain
- Istituto Nazionale Assicurazione Infortuni Sul Lavoro Inail, Italy
- Elvez, Proizvodnja Kableske Konfekcije in Predelava Plasticnih Mas Do, Slovenia
- Ocado Group, UK
- Bavarian Research Alliance GmbH, Germany
- Idiap Research Institute, Switzerland
- Eidgenössische Technische Hochschule Zürich, Switzerland
- Universität Zurich, Switzerland (Former Partner)

Project profile

Project name: IntelliMan (grant agreement no. 101070136) – AI-Powered Manipulation System for Advanced Robotic Service, Manufacturing and Prosthetics
Duration: 09/2022-03/2026
Programme: Horizon Europe
EU funding: 4.5 million (total project amount: EUR 6 million)

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www.intelliman-project.eu