eurecat

# Rapid Skill Learning with Hand-Held Grippers

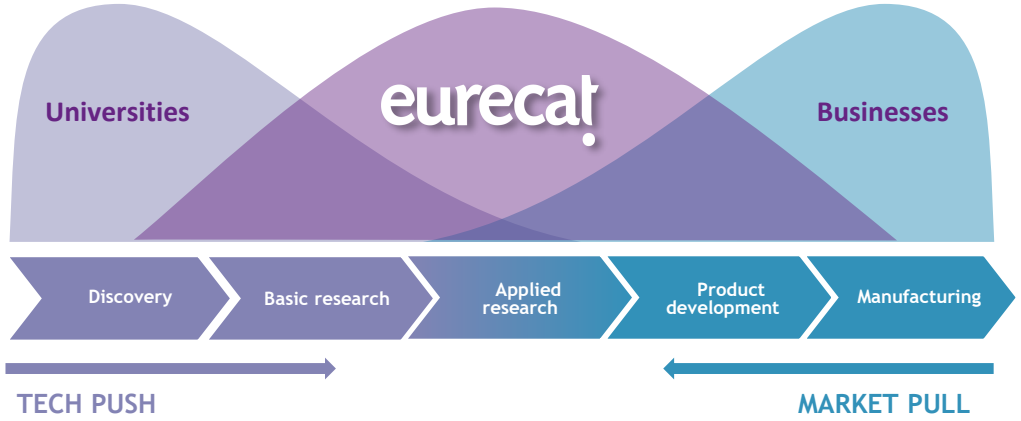
**Néstor García**

WS#42 Advancing AI-Powered Robotic Cognition, Deliberation and Learning for Real-World Applications

**European Robotics Forum**
Stuttgart - March 24th-27th, 2025

*"innovating with businesses"*

# Who are we?




**R+D+I with market impact**

**+400** private contracts

**+200** research projects

**62M€** income in 2023

**+780** employees

## Robotics and Automation Unit

+40 researchers

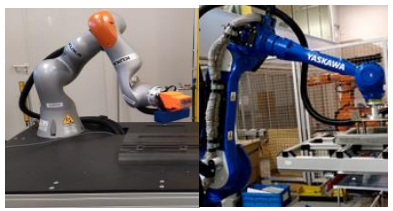
6 PhDs ongoing

8 MSc Thesis yearly


### Cognitive Robotics

### Mobile Robotics

### Collab. & Manipulation




ERF2025 STUTTGART | GERMANY 25–27 MARCH

# Challenge

Can you tell me what steps I must follow to set a table for one person?

LLMs provide **which** sequence of steps could be followed in a task

Here's a simple step-by-step guide:

- **Choose Your Tableware**: Pick a plate, utensils, glassware, and napkin. If you have multiple types (e.g., different sizes of plates or glasses), select those that suit your meal.
- **Place the Plate:** Set the main plate in the center of your place setting. If you have a charger plate (a decorative base plate), place it underneath.
- **Position the Utensils**:
  - **Fork**: Place it to the left of the plate.
  - **Knife**: Set it to the right of the plate, with the blade facing the plate.
  - **Spoon**: If needed, place it to the right of the knife.
  - **Dessert Spoon/Fork** (optional): Position it horizontally above the plate if you're having dessert.

But **how** these steps have to be performed by a **robot**?

# Challenge

Can you describe how can I reproduce these each of these steps with a robot?

Certainly! Here's how a robot could execute each step to assemble a two-pulley system:

**1. Gather Required Materials and Tools:** Use robotic arms to pick up two pulleys, a rope, bolts, and a wrench, load materials from a storage area onto the workspace, ensure the robot's gripper is adapted for different object shapes.

**2. Mount the Fixed Pulley:** Position the pulley on a predetermined support location. Use the robot arm to insert bolts or hooks and secure them with a wrench. Verify pulley rotation to ensure it moves freely.

**3. Mount the Second Pulley:** Move the second pulley to the load or another stationary support. Attach the pulley in alignment with the first using bolts or hooks. Check that it's securely fastened and can rotate.

**4. Thread the Rope or Belt:** Use a robotic end-effector to grip and guide the rope through both pulleys. Anchor one end of the rope to a fixed point if necessary. Ensure the rope is properly tensioned and free of tangles.

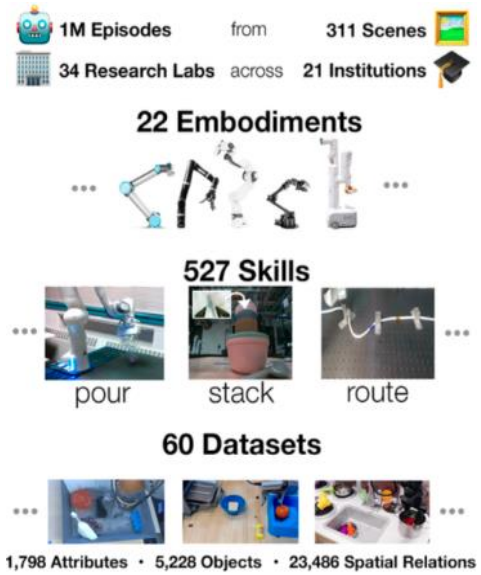
**Embodiment**
What robot with which sensors/tools do we use?

**Action heterogeneity**
What actions to consider?

**Generalization**
How this compares to what the robot already knows?

# State-of-art

## Generalist robot policy

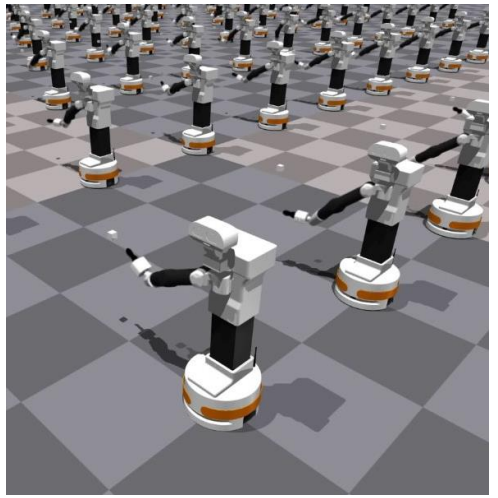



Off-site demonstrations on diversity of settings and tasks

Uncertain results on new/unknown environments

**Open X-Embodiment: Robotic Learning Datasets and RT-X Models -** O'Neill, 2023

## Virtual environments and Reinforcement Learning



Speed up learning process

Sim2Real gap

Definition of reward function

**Sim-to-real gap in RL: Use Case with TIAGo and Isaac Sim/Gym -** Albardaner, ERF 2024

# Envisioned Approach

1. Trained on-site with handful demos from non-expert users
2. Minimize embodiment problem without increasing learning burden
3. Skill-specific manipulation models
4. Embedding recovery mechanisms

≤ 200 task demos

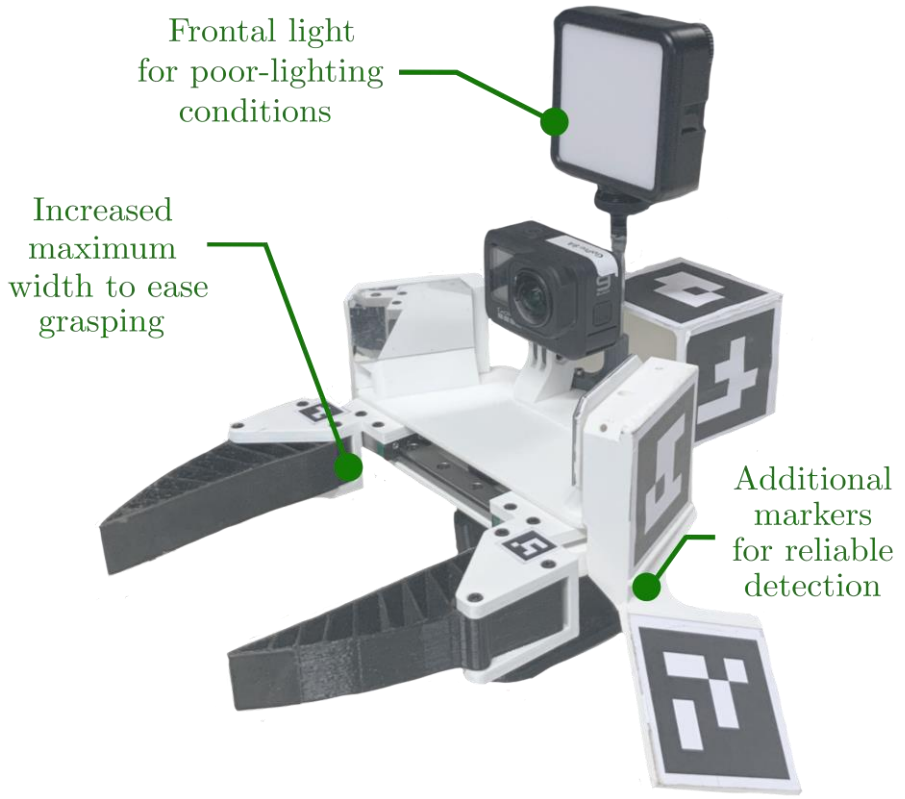
**Universal Manipulation Interface (UMI):**
**In-The-Wild Robot Teaching Without In-The-Wild**
Robotss – Chi, RSS 2024

# Envisioned Approach

## Improved demo acquisition

Scene & task biases ▶ Lightning control & finger adaptation

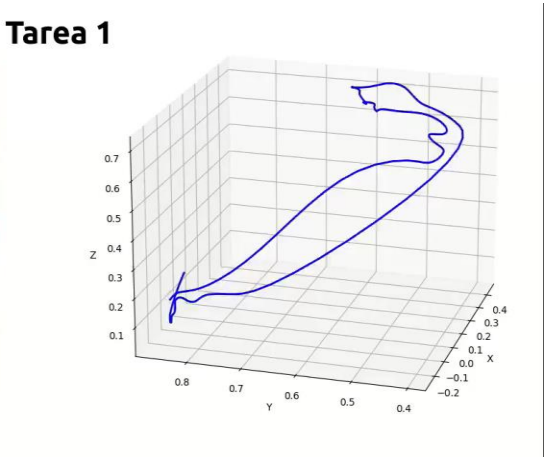
ORBSLAM3 fails to deliver demo traj. in visually-challenging environments ▶ EKF-based localization from marker detection and inertial measures

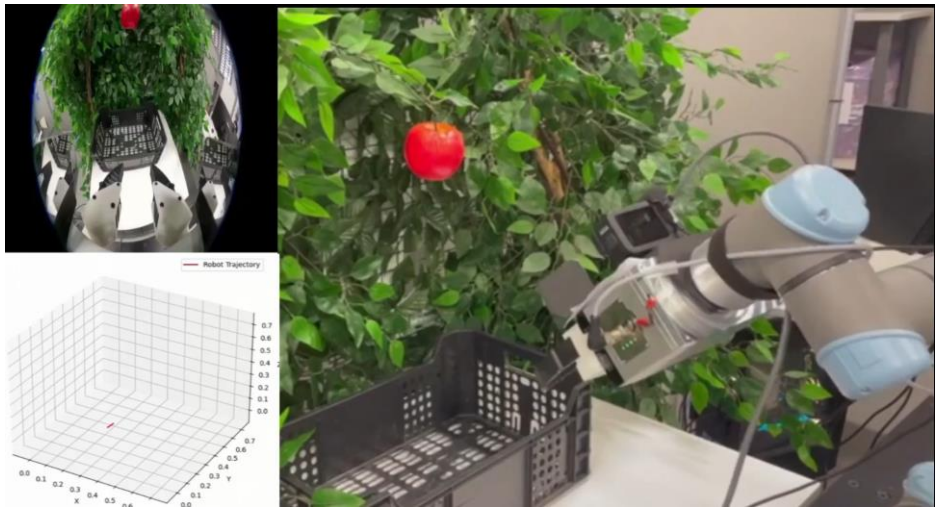



**Advances on Affordable Hardware Platforms for Human Demonstration Acquisition in Agricultural Applications**
– San Miguel, ERF 2025, Nominated **Best Paper Award!**

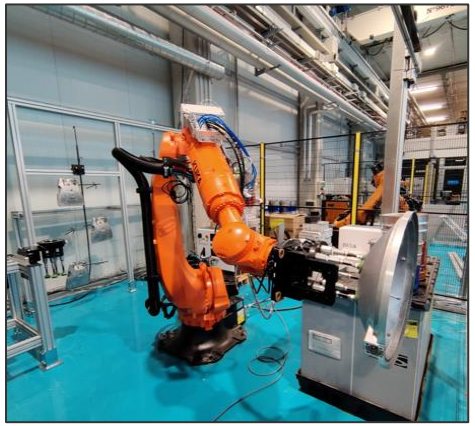
# Initial Application Results

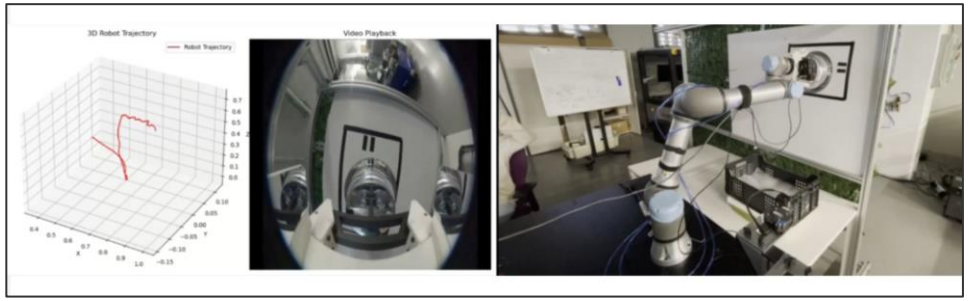
## Agricultural settings



## Paintshop settings



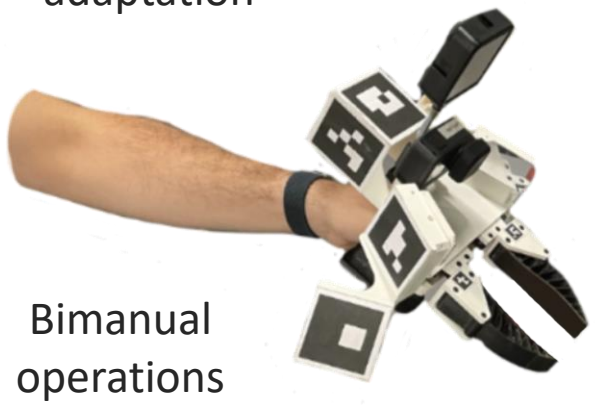


# IntelliMan Project Use Cases

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

Force adaptation

Object Grasping

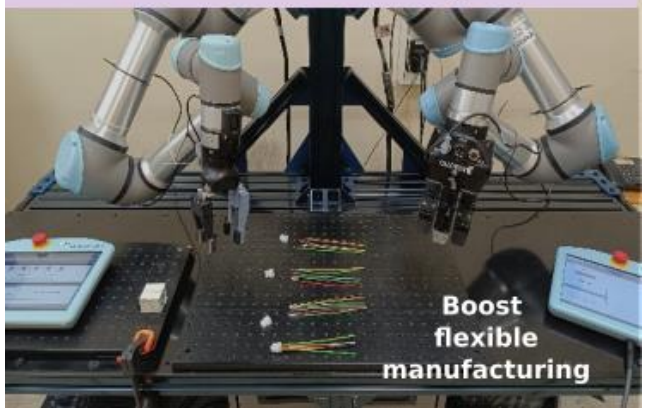


Bimanual operations

Tool-handling

**Use Case 1:** Increase user trustworthiness in upper limb prostheses


**Use Case 3:** Robotic assembly of products with deformable linear objects





**Use Case 2:** Reliable robot manipulation in Human Environments

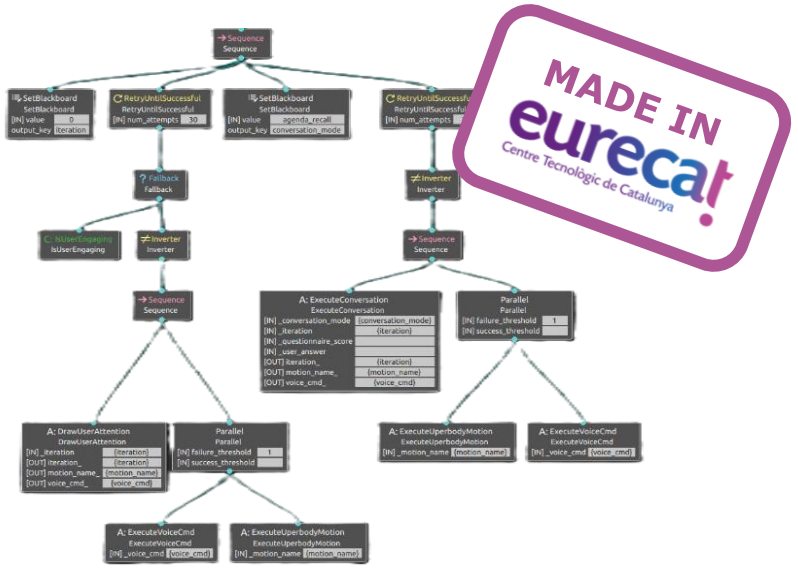

**Use Case 4:** Robotic manipulation of fresh food items

ERF2025 STUTTGART | GERMANY 25–27 MARCH

# Limitations, Challenges and Outlook

- Input limited to self-contained hardware solutions
- User-friendly gripper adaptation from description and constraints
- Increasing number of samples for higher long-horizon tasks
- Supervision of LLMs for real-scenario deployments

**Task Orchestration with Behaviour Trees & LLM-enhanced planning**




**Boosting robot behavior generation with large language models and genetic programming** - Verdaguer, ICRA 2024

# Questions?

**Néstor García Hidalgo**

Head of Robotic Manipulation

eurecat

Centre Tecnològic de Catalunya