

Empowering Flexible Manufacturing: Cost-Effective Hand-Held Grippers for Rapid Robotic Skill Acquisition

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Robotics and Automation - Collaborative Robotics



Who are we?



+40 researchers

6 PhDs ongoing

8 MSc Thesis yearly



Applied Research

R+D+I with market impact

+400 private contracts

+200 research projects

62M€ income in 2023

+780 employees

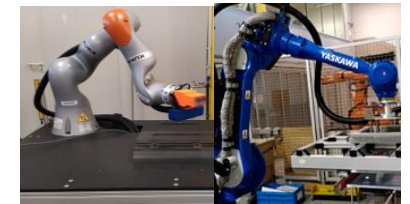
Cognitive Robotics



Mobile Robotics



Collab. & Manipulation



Challenge

Can you tell me what steps I can follow assemble a two-pulley system?

LLMs allow robots to know **what** sequence of steps could be followed in a task

To assemble a two-pulley system, follow these steps:

- 1. Gather Required Materials and Tools:** two pulleys (same or different sizes, depending on the desired mechanical advantage), a rope or belt (suitable for the pulley grooves), a fixed structure or support to mount the pulleys, bolts or hooks (for attaching pulleys to the support), wrench or screwdriver (if bolts are used)
- 2. Mount the Fixed Pulley:** Secure one pulley to a stationary support structure using bolts or hooks. Ensure that the pulley can rotate freely and that it is positioned so the rope or belt can move through it without obstruction.
- 3. Mount the Second Pulley:** If using a movable pulley, attach it to the load you intend to lift. If using a fixed configuration, mount the second pulley to a different stationary support in a position aligned with the first pulley.
- 4. Thread the Rope or Belt:** Pass the rope or belt through both pulleys. If using a fixed-and-movable setup, one end of the rope should be anchored to a support structure or the fixed pulley.

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.

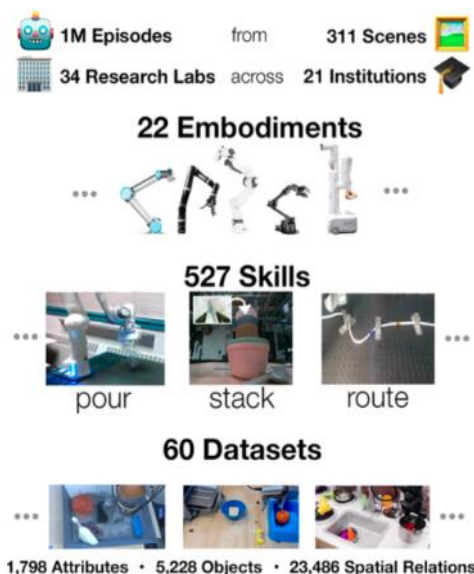
Embodiment - What robot with which sensors/tools do we use?

Action heterogeneity - What actions to consider?

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

Current approaches

Generalist robot policy

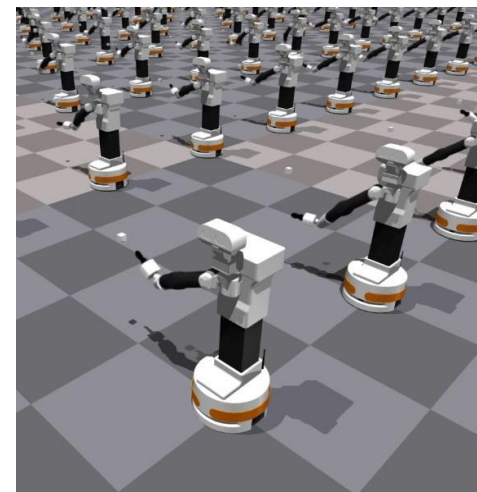


Off-site demonstrations
on diversity of settings
and tasks

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

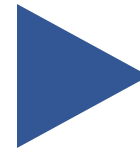
Sim2Real gap

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



Hand-held grippers with visual feedback for diffusion policies



≤ 200 task demos

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

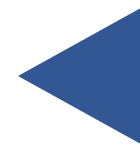
Envisioned approach

Improved demo acquisition

Scene & task biases



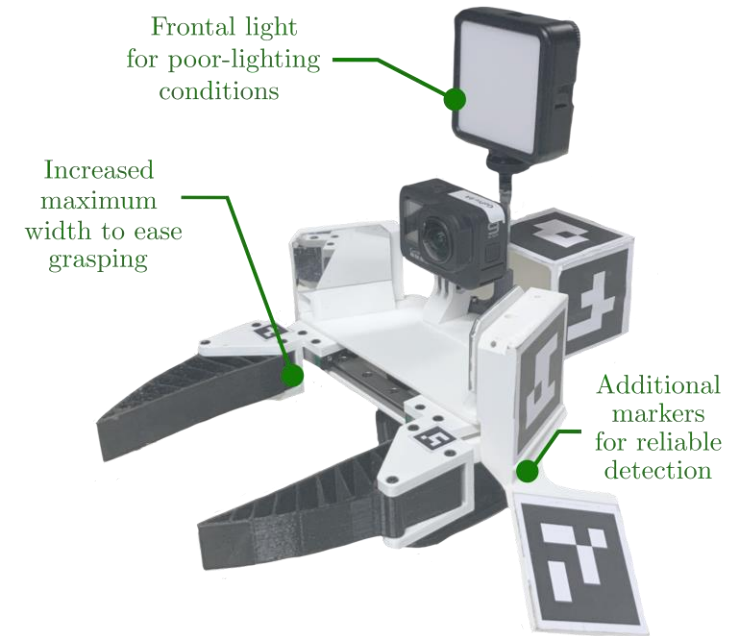
Lighting control & finger adaptation



ORB_SLAM3 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 (Under Review)

Envisioned approach

Dexterous dismantling for recycling operations



FREE4LIB

BATEC REVERSE

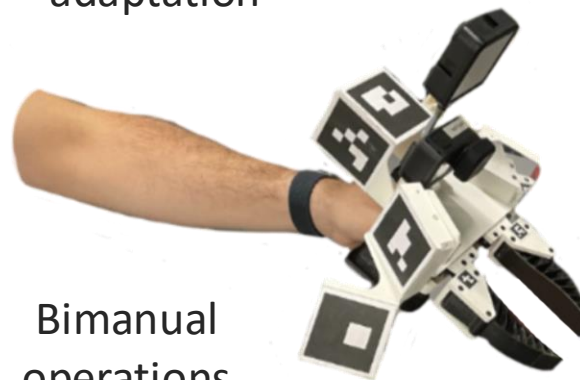
SADAKO TECHNOLOGIES

PIooto



Force adaptation

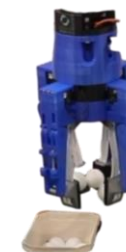
Object Grasping



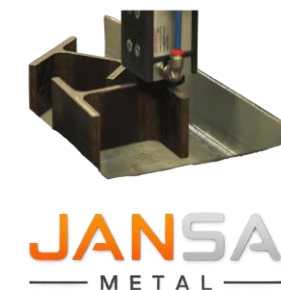
Bimanual operations

Tool-handling

Manipulation of complex objects



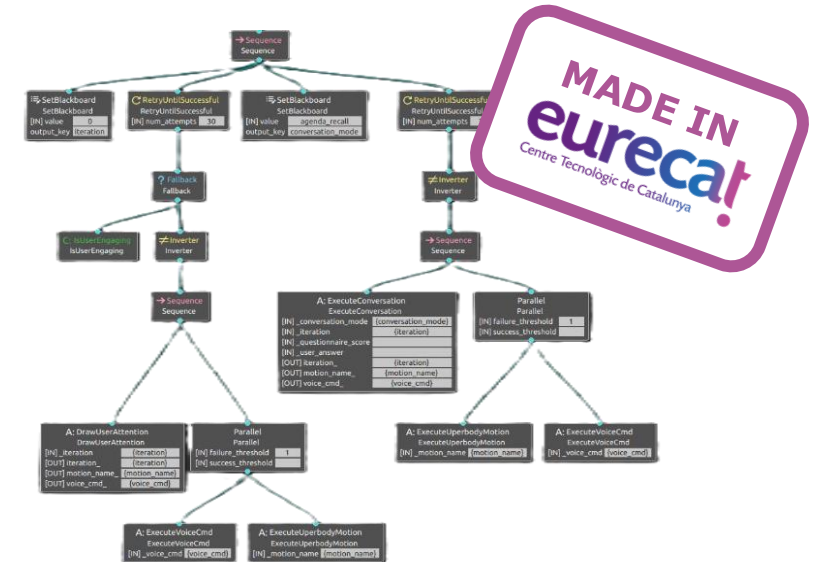
Precise assembly operations



Limitations, Challenges & 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 - Verdagner, ICRA 2024

PlanCollabNL: Leveraging Large Language Models for Adaptive Plan Generation in Human-Robot Collaboration - Izquierdo, ICRA 2024



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