ISTITUTO ITALIANO
DI TECNOLOGIA

Humanoid robots that learn: challenges and applications

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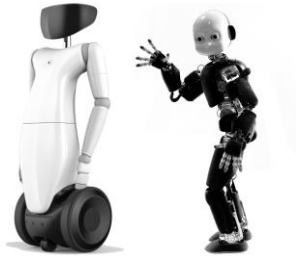
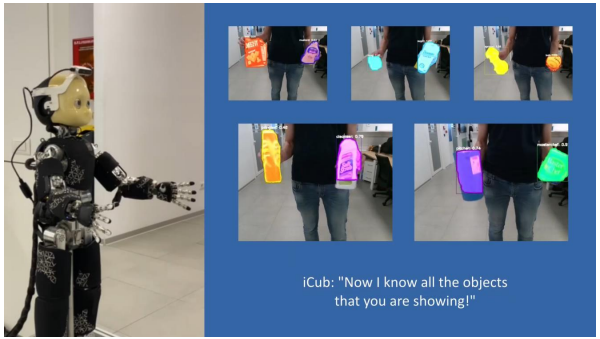
Workshop on Humanoid Robotics Go Ubiquitous! Industries and Researchers as the Key Enablers

19 September 2024, Lecco

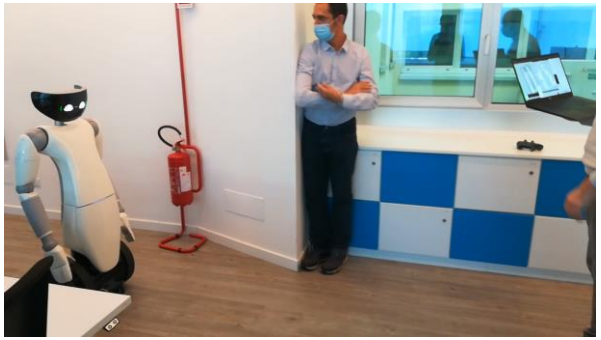
Humanoid Sensing and Perception



platforms (sw)



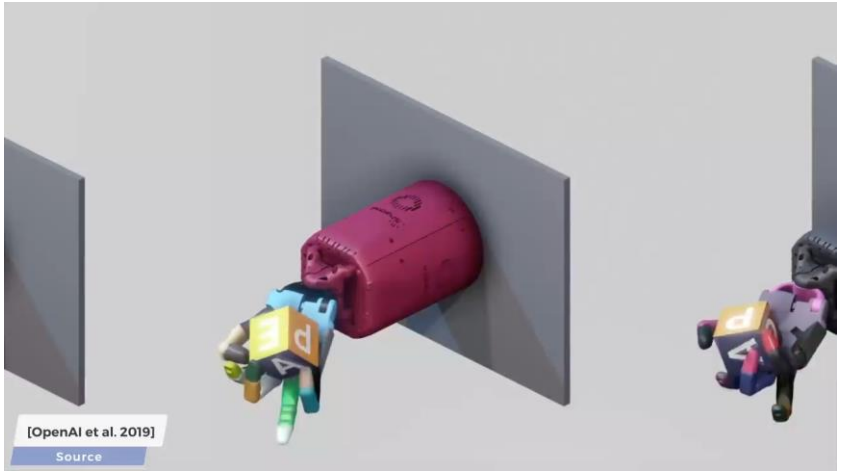
perception



behavior orchestration

interaction

AI & Robotics

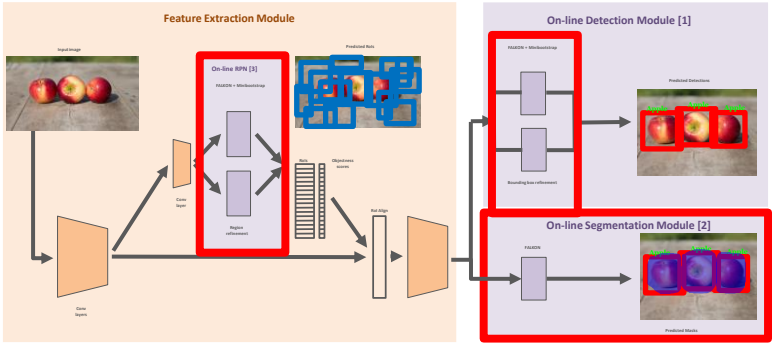


- ✗ Huge amount of data real or synthetic
- ✗ Computation is free
- ✗ Supervision is free
- ✗ Learning is off-line

- ✓ How do we get sufficient amount of data?
- ✓ Where do we get supervision?
- ✓ How to explore safely?
- ✓ Need to adapt/learn online

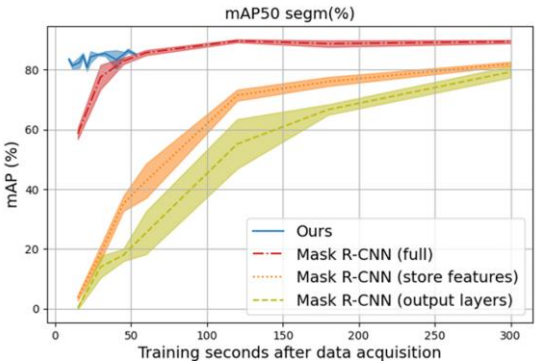
Source: OpenAI Learning Dexterity

Fast (transfer) learning of object segmentation



FEATURE-TASK

TARGET-TASK



Ceola, Maiettini, Pasquale, Meanti, Rosasco, Natale, Segment Well Segment Fast, IEEE Transactions of Robotics, 2022
Ceola, Maiettini, Pasquale, Rosasco, Natale, Fast Object Segmentation Learning with Kernel-based Methods for Robotics, ICRA 2021

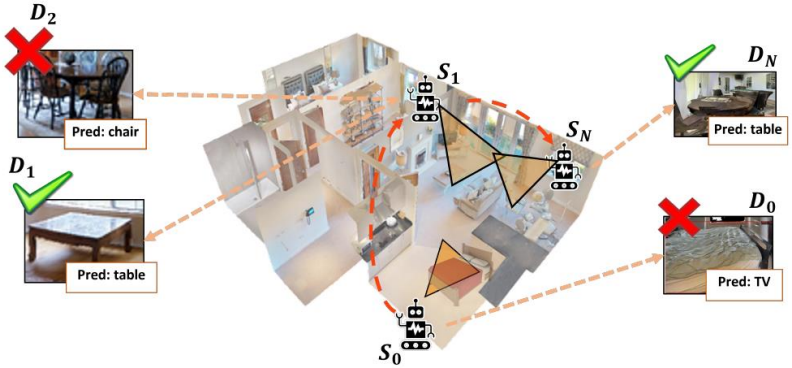
On-the-fly learning

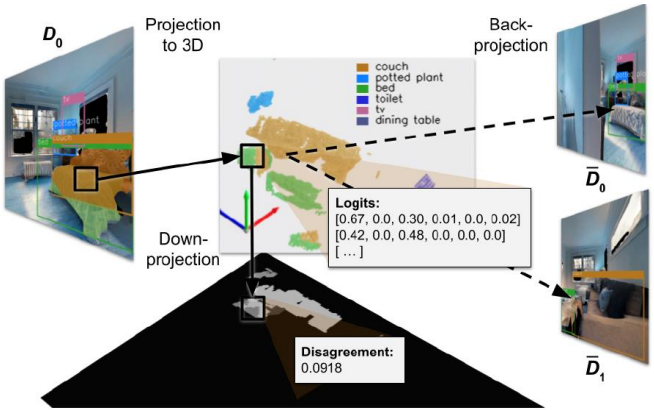
H: this is the masterchef
iCub: ok, show me the masterchef
…

https://youtu.be/MHC7033C6PQ

Ceola, F., et al. Learn Fast, Segment Well: Fast Object Segmentation Learning on the iCub Robot., IEEE T-RO, 2022

Look around and learn





Explore the environment and **collect detections**
Resolve disagreement and build **disagreement map**
Train policy to **maximize disagreement** while exploring
Collect dataset with the policy and **fine-tune detector**

Scarpellini, Rosa, Morerio, Natale, Del Bue, Look around and learn: self-improving object detection by exploration, ECCV 2024

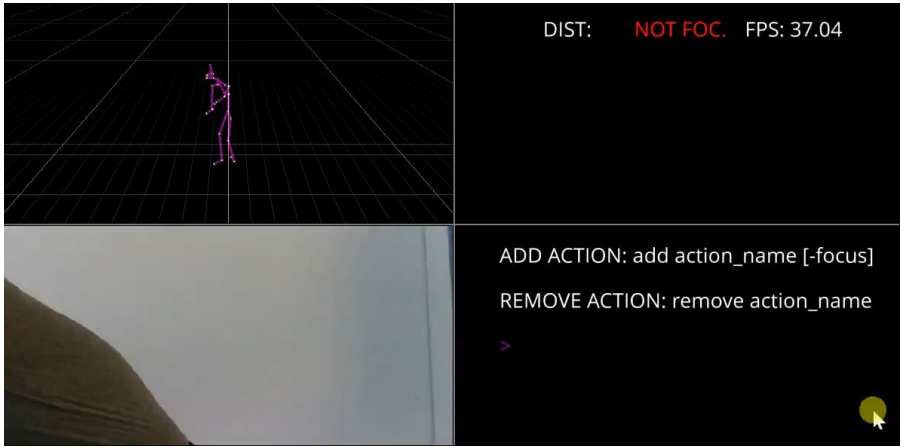
Look around and learn

Policy	Self-training [41]	SEAL perc. [9]	***Disag. reconc.***	*GT*
Random	39.67	41.19	41.88	*47.20*
Frontier [42]	40.18	41.98	43.09	*45.06*
Neural [6]	39.98	39.56	40.32	*44.86*
SemCur [8]	40.23	41.06	41.37	44.67
SEAL [9]	39.33	43.01	42.38	*44.57*
Inform [18]	**40.25**	44.15	43.70	45.49
Look Around	38.66	**45.90**	**46.60**	***48.01***

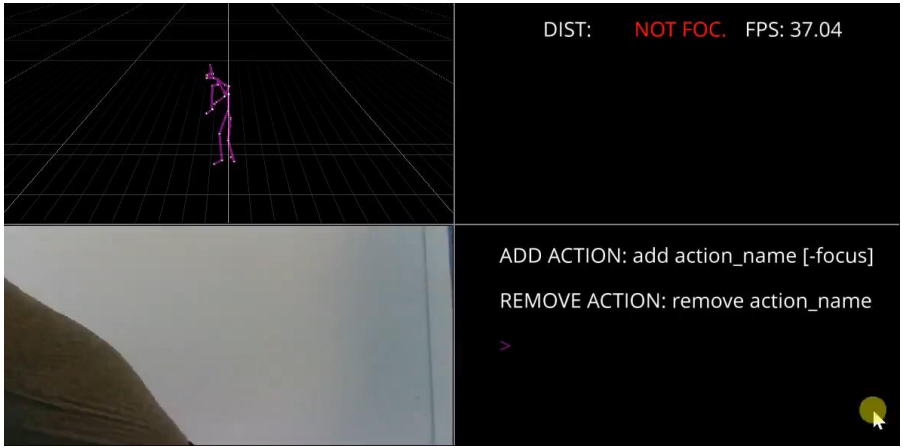
Off the shelf: **~40 mAP**

Scarpellini, Rosa, Morerio, Natale, Del Bue, Look around and learn: self-improving object detection by exploration, ECCV 2024

Few shot action recognition



Training



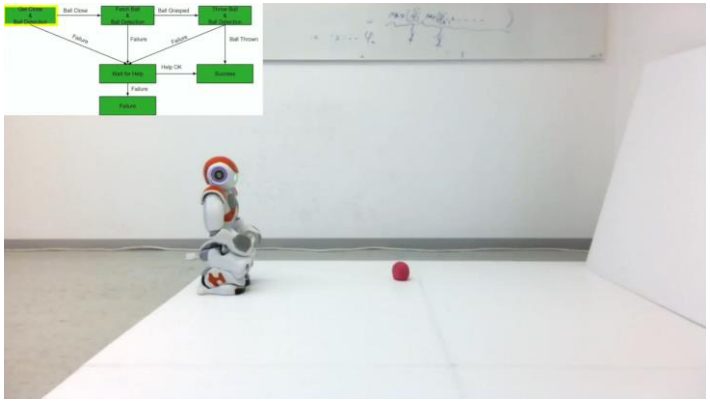
Inference

- Few shot learning of **new actions**
- **Open set**: determine whether an action is within the set that the robot can recognize

Berti, S., Rosasco, A., Colledanchise, M., and Natale, L., One-Shot Open-Set Skeleton-Based Action Recognition, Humanoids 2022

…it’s not just about AI

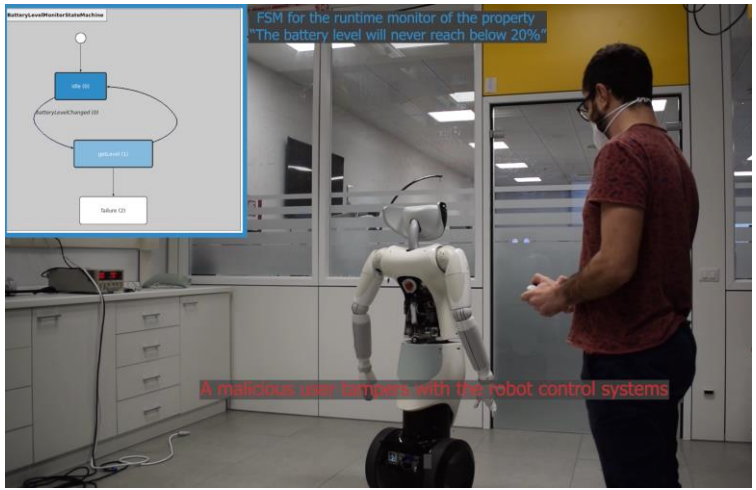
source: http://drc.mit.edu/

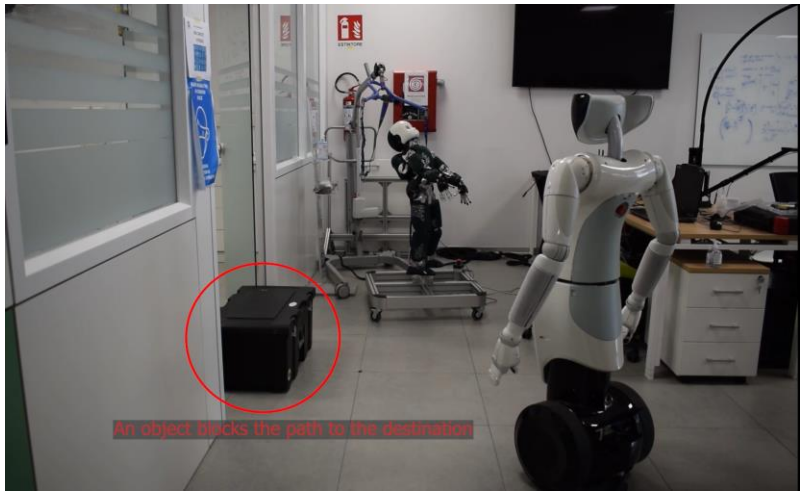


Credits: Michele Colledanchise

CONVINCE: Increasing robot autonomy

In dynamic environments robots are unable to deal with unexpected situations and fail to remain operational without human intervention





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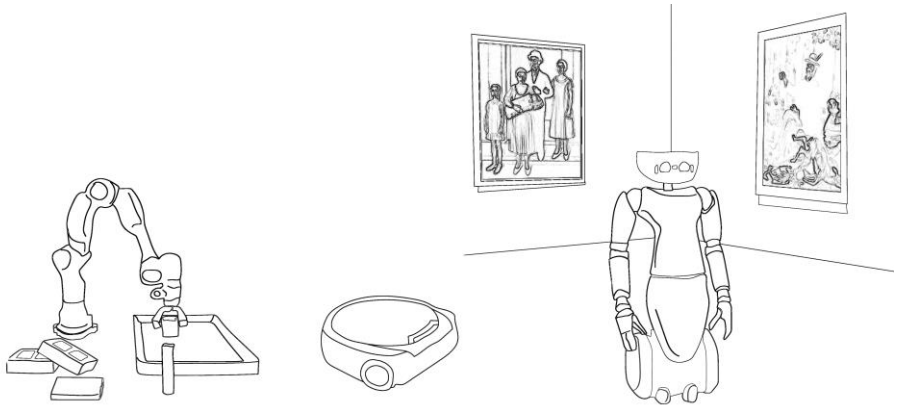
CONVINCE

CONVINCE: Increasing robot autonomy

- Focus on the deliberation system, preventing and recovering from failures, at design and runtime
- Formal methods to increase confidence of correct execution (off-line and run-time)
- To integrate such capabilities in a software toolchain



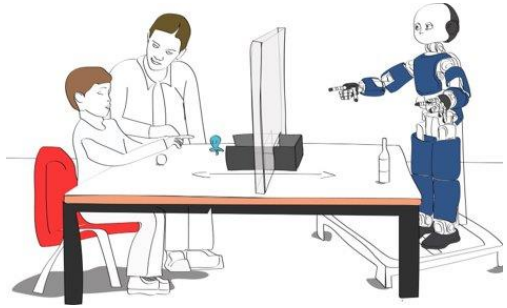
https://convince-project.eu/

CONVINCE

Funded by the European Union

HORIZON-CL4-2021-DIGITAL-EMERGING-01, GA 101070227

Applications



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CONVINCE

INAIL
Istituto Nazionale per l'Assicurazione contro gli Infortuni sul Lavoro

ergoCub

FIT4MEDROB
Fit for Medical Robotics

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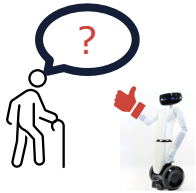
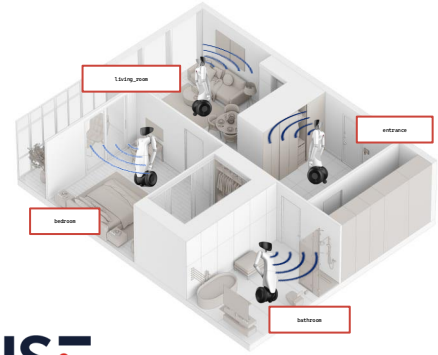
NextGenerationEU





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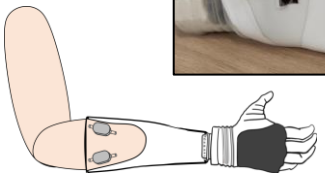
RAISE



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TrialsNet

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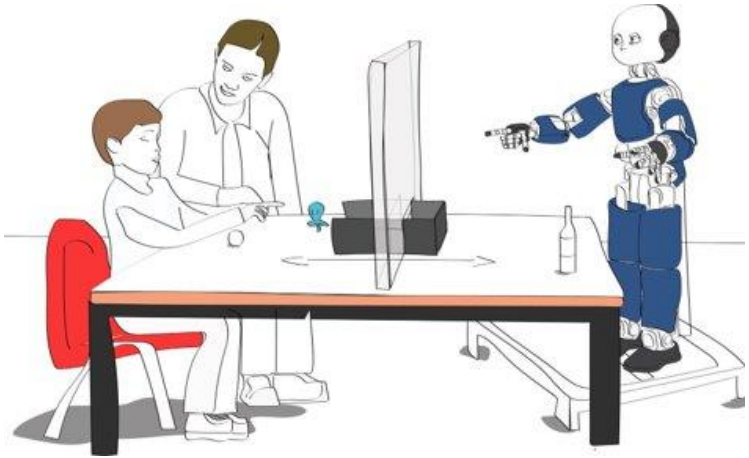
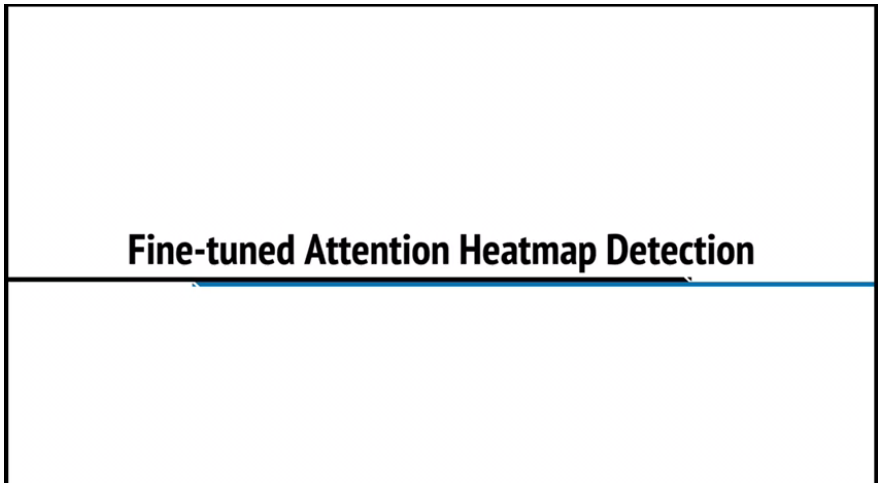
RAISE

Shared attention in human-robot joint tasks

- Robot assisted therapy and cognitive rehabilitation
- Shared attention mediated by objects and tools
- Social cues detection for human-robot interaction and object learning





FIT4 MED ROB Fit for Medical Robotics
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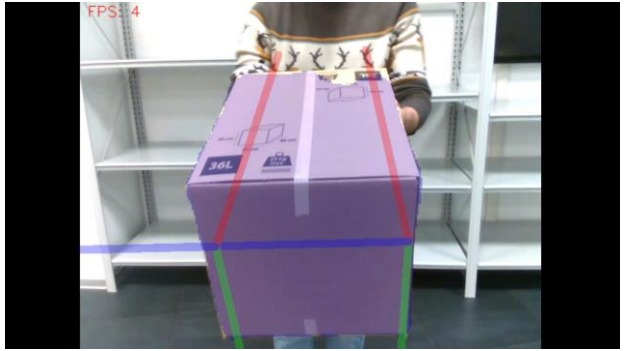
NextGenerationEU
iit S4HRI
iit HSP

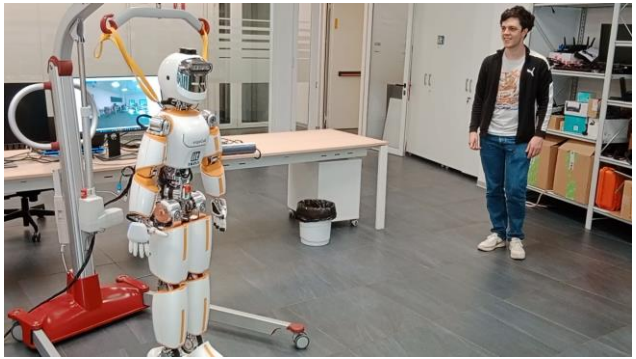
AI for human-robot collaboration

Vision Based Action Recognition

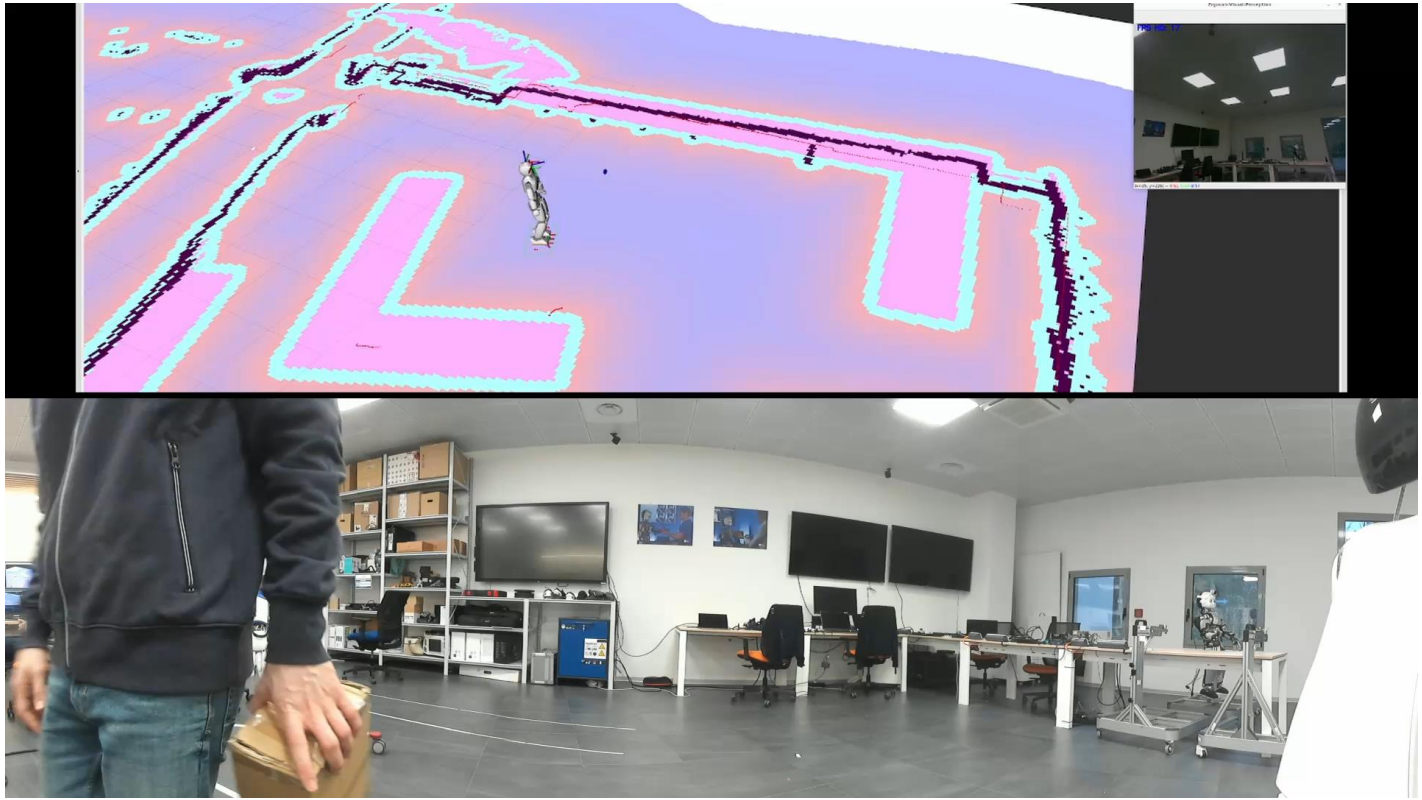
Object Detection and Grasp Pose Estimation



Bi-manual grasping



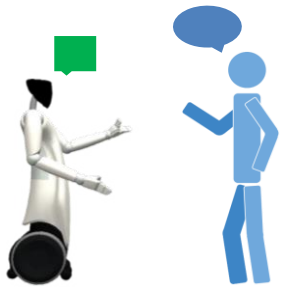
AI for human-robot collaboration

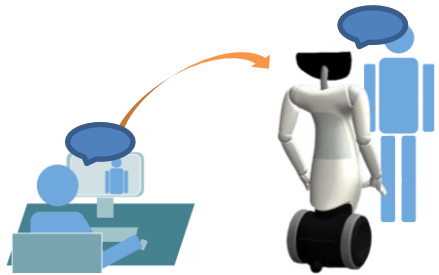


Robotic assistant in a smart environment

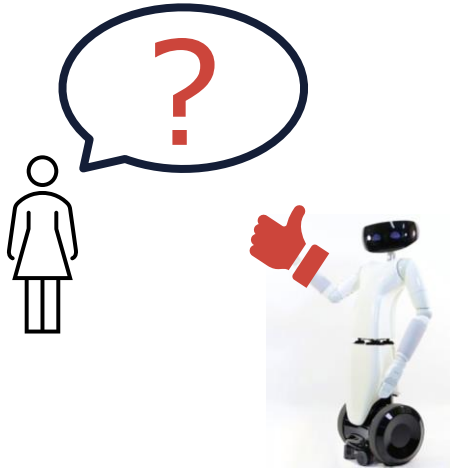
A smart environment with a sensor network and a robotic platform to support humans

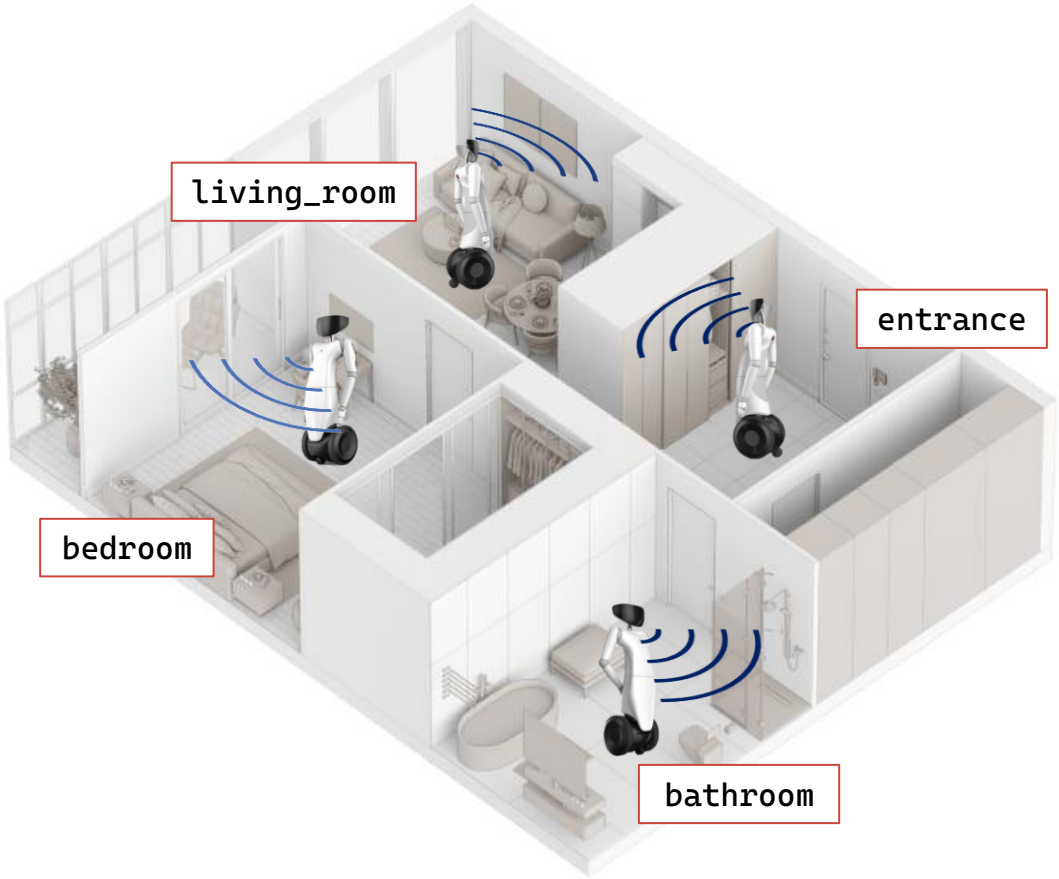
- Perform tasks, welcome or guide humans inside an hospital, cognitive rehabilitation
- Remote assistance
- Mediate interaction between the humans and the smart environment

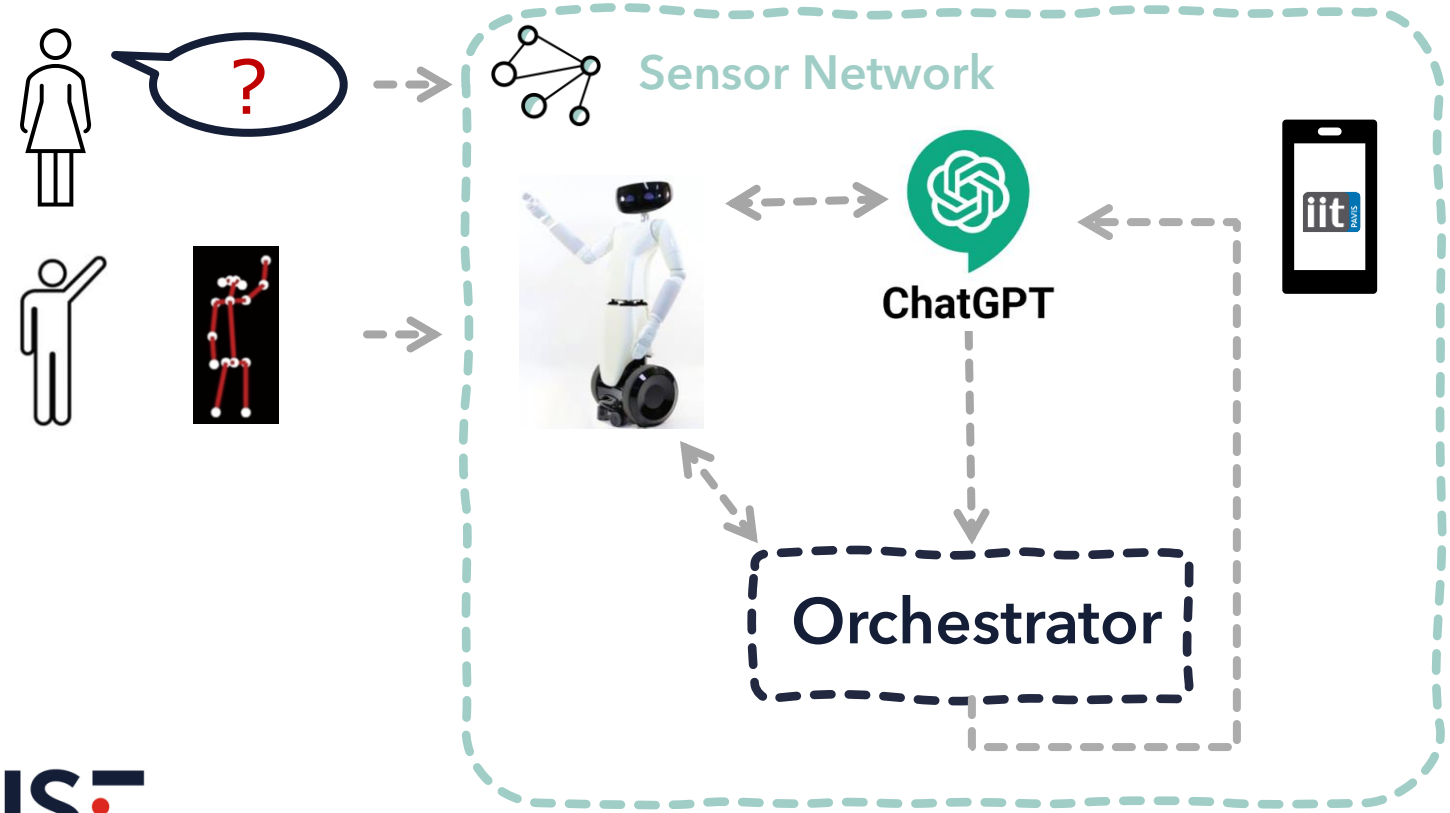


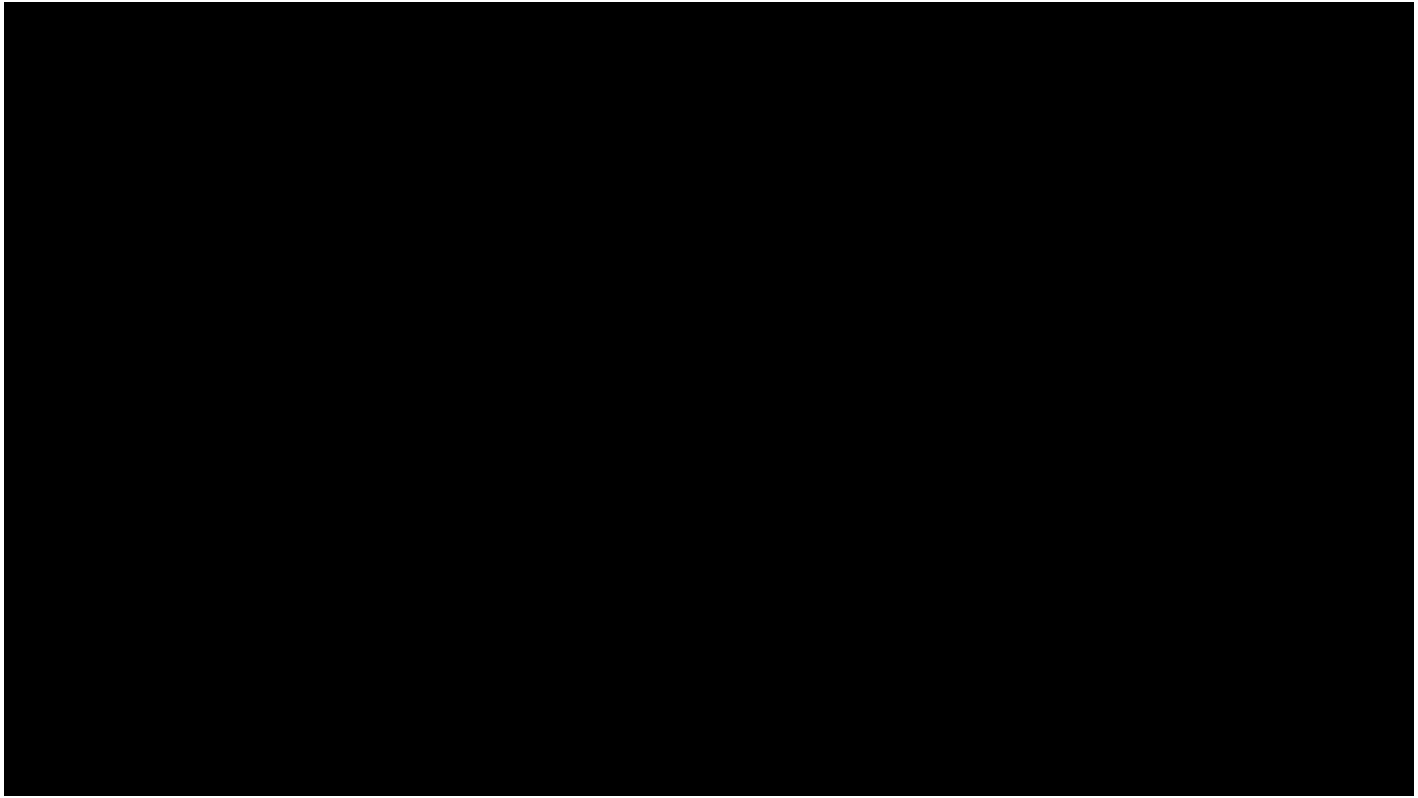


Object retrieval






?
Sensor Network
ChatGPT
Orchestrator

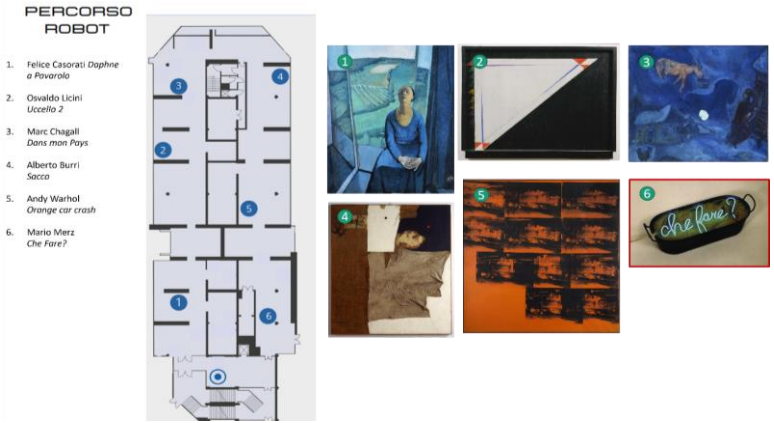


A robotic museum guide

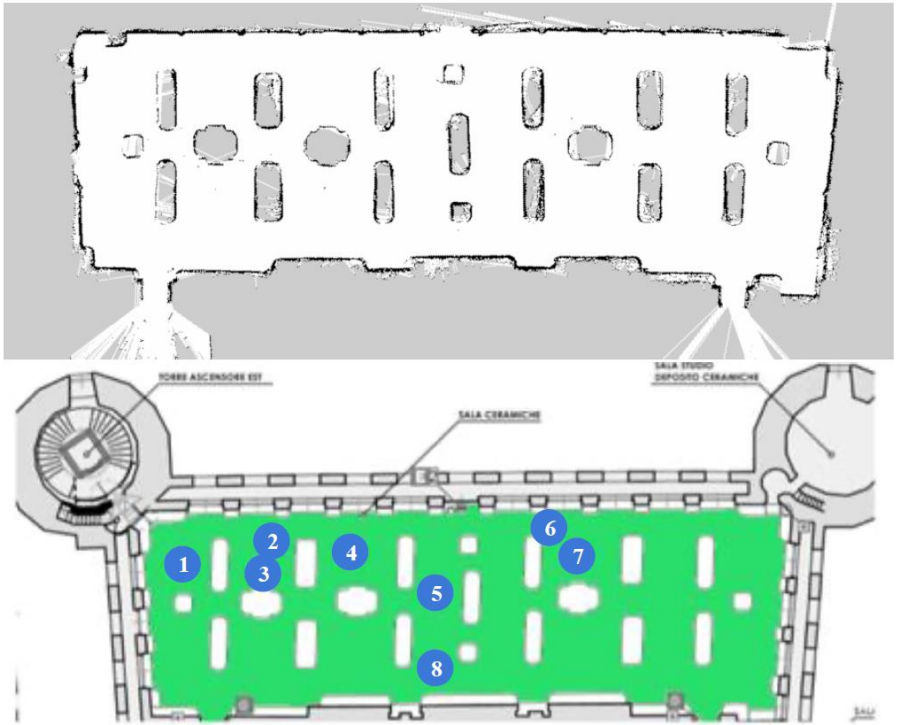
Funded by the European Union

CONVINCE

- Dialog management
- Human-detection
- Self-localization
- Navigation
- 5G connectivity to off-load computation

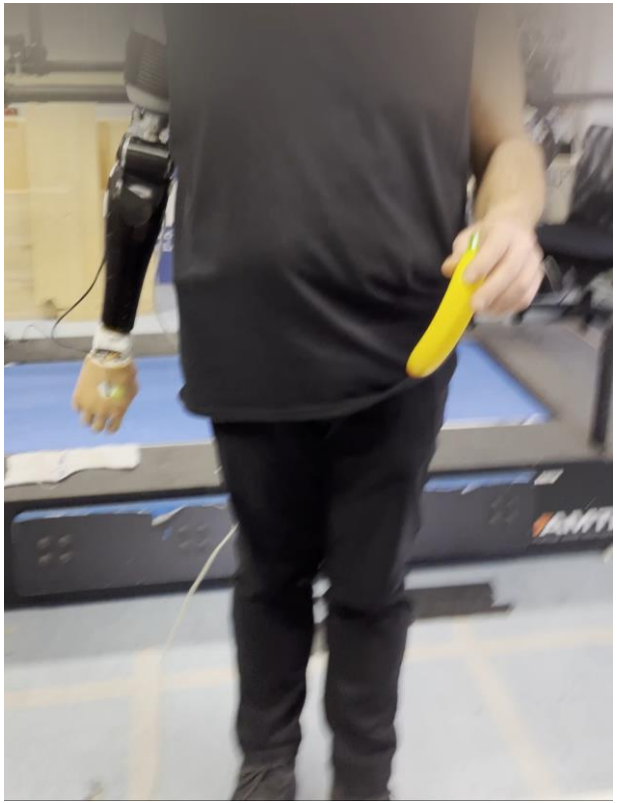


Galleria Arte Moderna, Turin, Italy



Palazzo Madama, Turin, Italy

Test of the Vision-based Wrist Control System on the Patient



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Acknowledgments

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Gianluca Correnti


Ettore Landini


Marco Randazzo


Stefano Rosa


Sofia Faraci


Francesco Donato

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Ethical Technology Adoption in Public Administration Services

FAIR
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RAISE

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Fit for Medical Robotics

TrialsNet

CONVINCE

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DANIELI

ellis unit GENOA