

# NRI: INT: COLLAB: Manufacturing USA: Intelligent Human-Robot Collaboration for Smart Factory

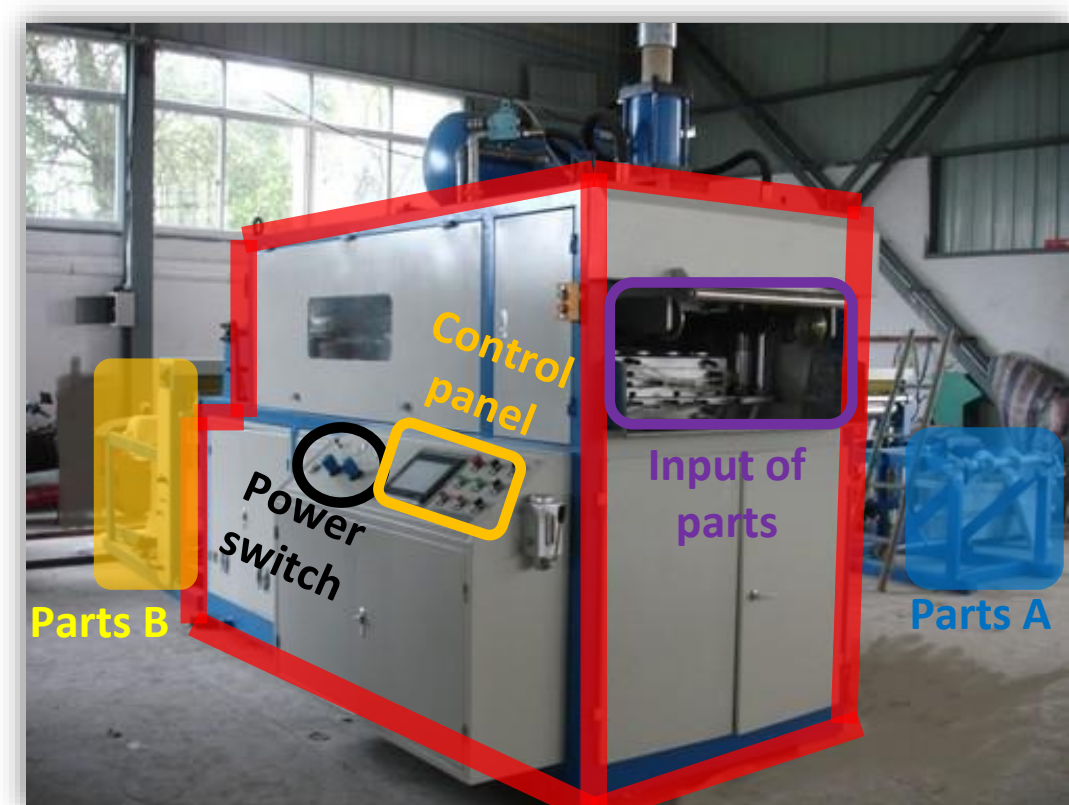
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**Fundamental challenges** in human-robot collaboration in the manufacturing environment:

- Limitation of one-to-one sensing between humans and robots
- Lack of adaptive and stochastic modeling methods for reliable recognition and prediction of human actions and motions in different manufacturing scenarios
- Multi-scale human-robot coordination

**Research Goal:** This project aims to design, develop, and systematically evaluate in a realistic manufacturing setting an intelligent human-robot collaboration system enabled by ubiquitous sensing, customized cognition, real-time prediction, and intelligent control methods, which ensure operation safety and production efficiency, for deployment on the factory floor.

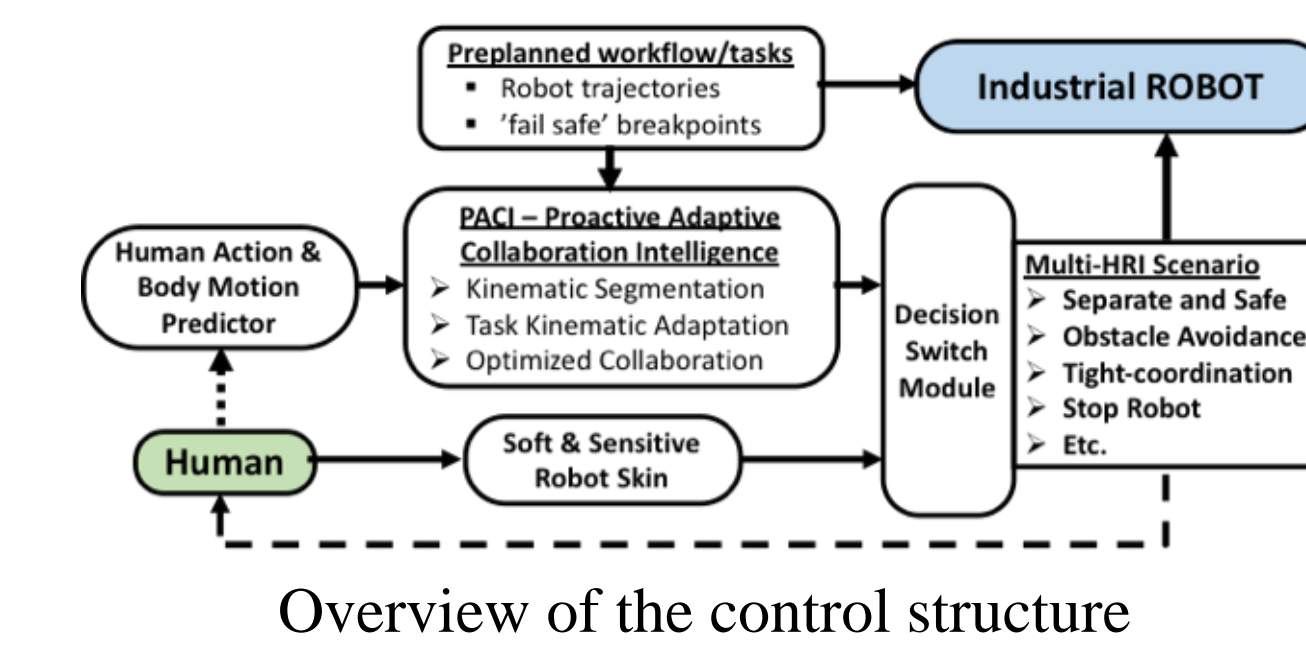
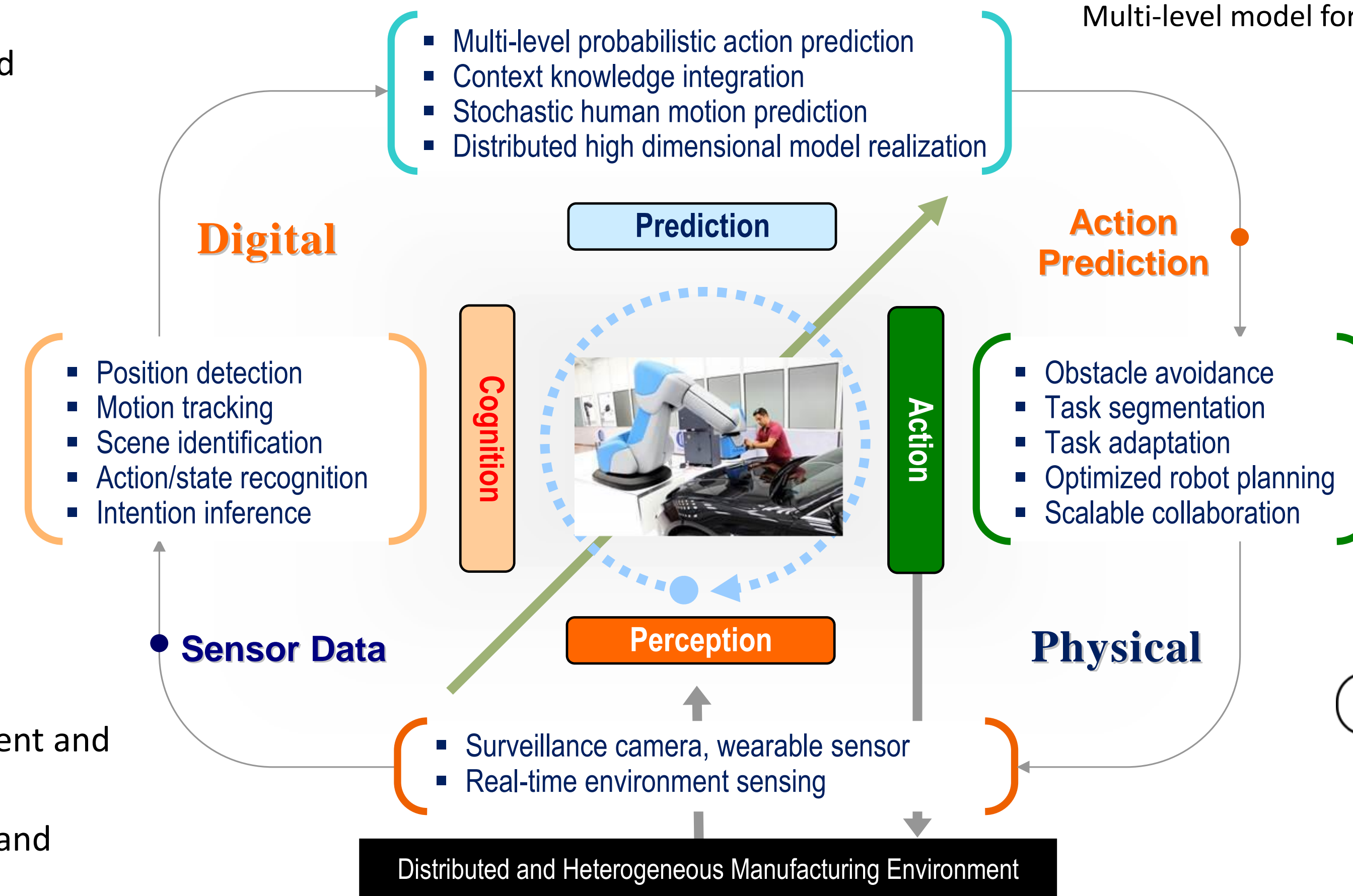
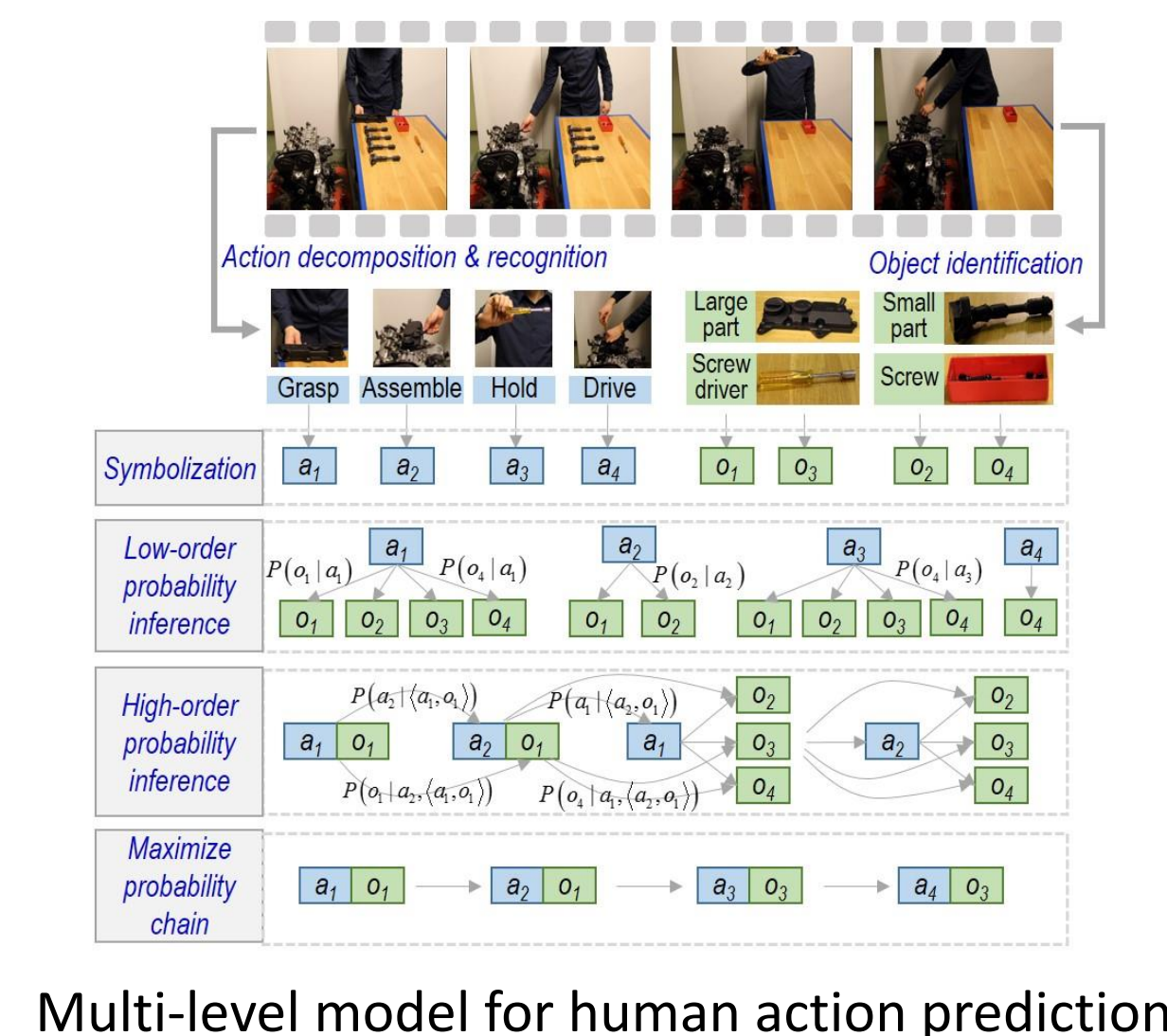
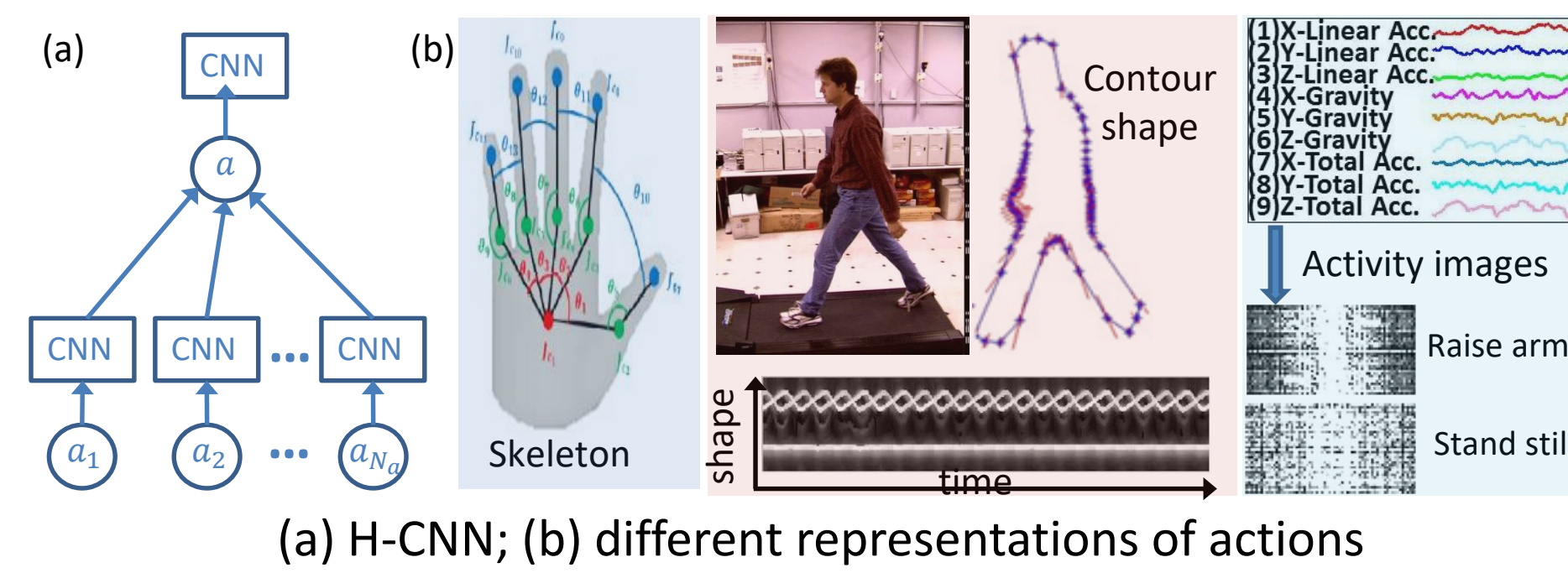


View registration & object recognition

**Technical Approach:** Specific tasks include algorithms development and deployment on lab-scale and real-world testbeds, to

1. sense and cognize where objects (i.e., robots, humans, parts and tools) are located and what each worker is doing;
2. predict what the next human action will be; and
3. plan and control safe and optimal robot trajectories for individualized on-the-job assistance for humans, avoiding worker injury proactively.
4. Evaluation of human robot collaboration (HRC) using key performance indicators: human safety level and productivity/task performance efficiency (*ISO 10218-2 standard, called SAFER-HRC; ISO/TC 299 Robotics: ISO 10218-2 and ISO/TS 15066 [ISO/TC299]*).

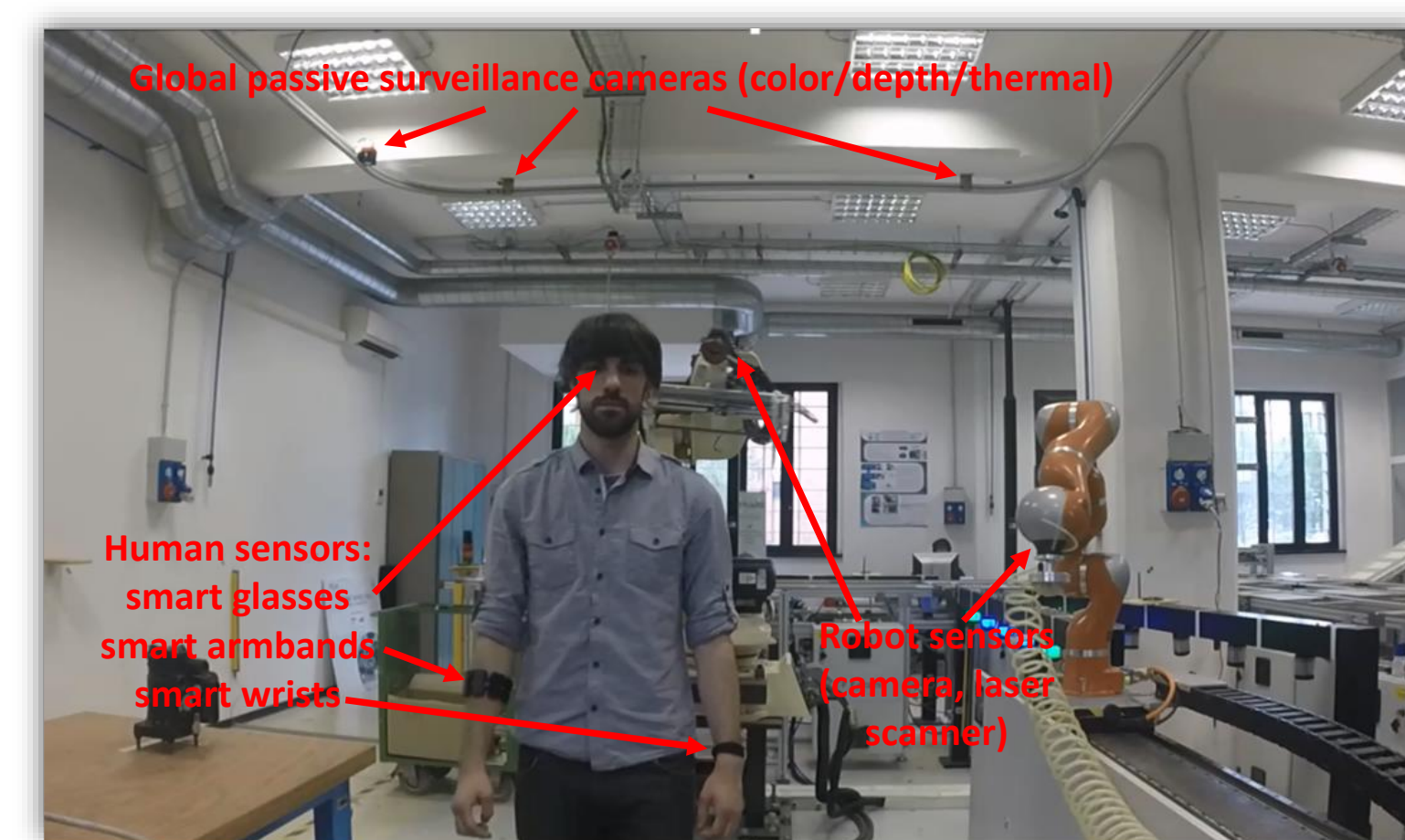
The outcome from the project will be evaluated on the shop-floor at the collaborating company COsorizio MACchine Uensili (COMAU), and in the test beds of the Institute of Intelligent Industrial Technologies and Systems for Advanced Manufacturing of the National Research Council of Italy (STIIMA-CNR).



Comau – Aura Collaborative Robot



Partner Facilities: Comau and STIIMA-CNR



**Intellectual Merits/Scientific Impact**

- **Sensing:** A suite of ubiquitous sensors to gather real-time in-situ sensor data about individual objects in the working environment – object detection, tracking and recognition by many-to-one collaborative sensing, passive plus active sensing, and local plus global sensing
- **Cognition:** A theoretic guidance to find the most informative data samples for human annotation and label propagation – an adaptation architecture to customize initial cognition models to understand human actions within different manufacturing cells
- **Prediction:** Variable-order Markov models to decompose constituent human actions and define interactions between actions and the environmental contexts, for future action prediction – integrated distributed particle filters with human motion models to track and predict human motion trajectory with probabilistic uncertainty evaluation
- **Action:** Multilayer and modular control structures that allow stable mode switching for flexibility in defining the ‘optimized’ robot response, safely adapting to human worker planned and unplanned interactions, and maintaining production efficiency.

To **broaden the impact** of this project, a partnership with Manufacturing USA Institute(s) and professional societies will be established to develop and incorporate human-robot collaboration learning modules into robotics and smart manufacturing-related curricula.

- Raise public awareness (including STEM events & workshops) and dissemination of research results
- Synergetic education, training and career opportunities
- Accelerating adoption of smart factory-enabling technologies