AI and robotics for agile manufacturing

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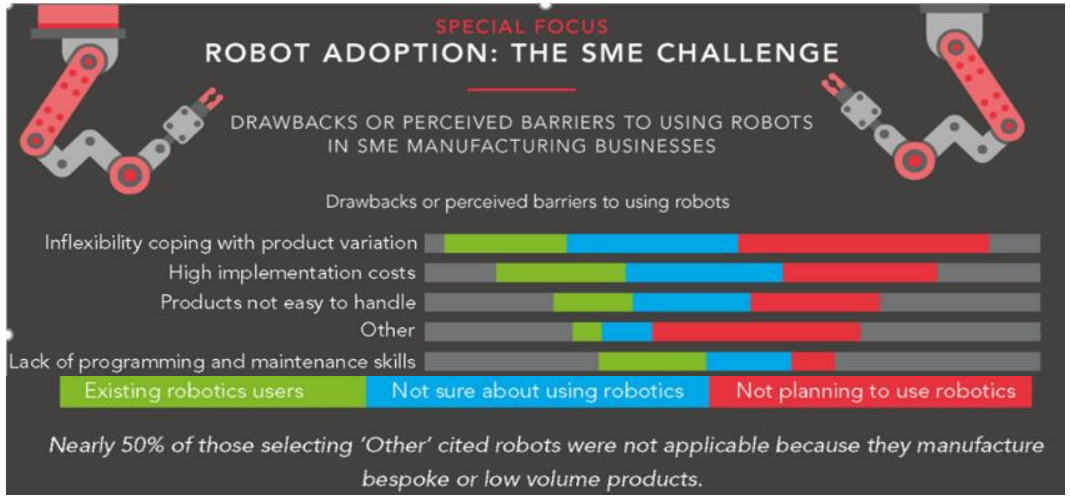
Challenges and purpose of intelligent industrial robot

❑ Easy to use, agile and resilient robotics

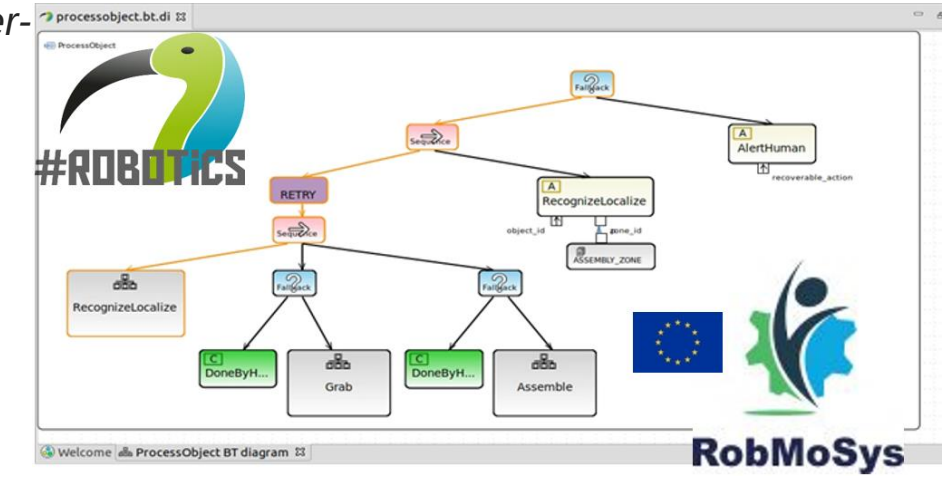
- ➢ *Easy to use*
  - ➢ *Technology accessible for non expert users*
  - ➢ *Integration costs reduced*
  - ➢ *Compatibility with small production size*
- ➢ *Agility*
  - ➢ *Adaptation to unknown and cluttered environment*
  - ➢ *Realization of complex tasks in autonomy*



Ref : https://www.themanufacturer.com/articles/robot-adoption-the-sme-challenge

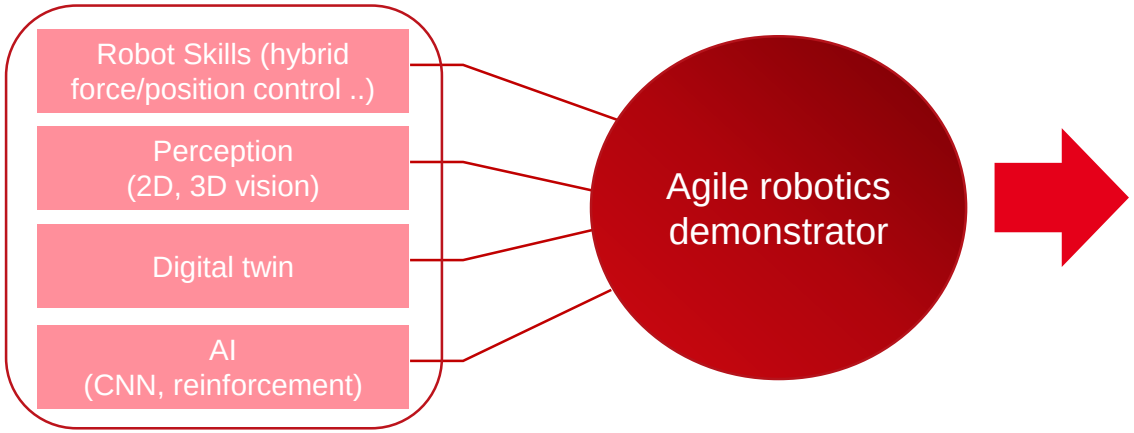
❑ Principle

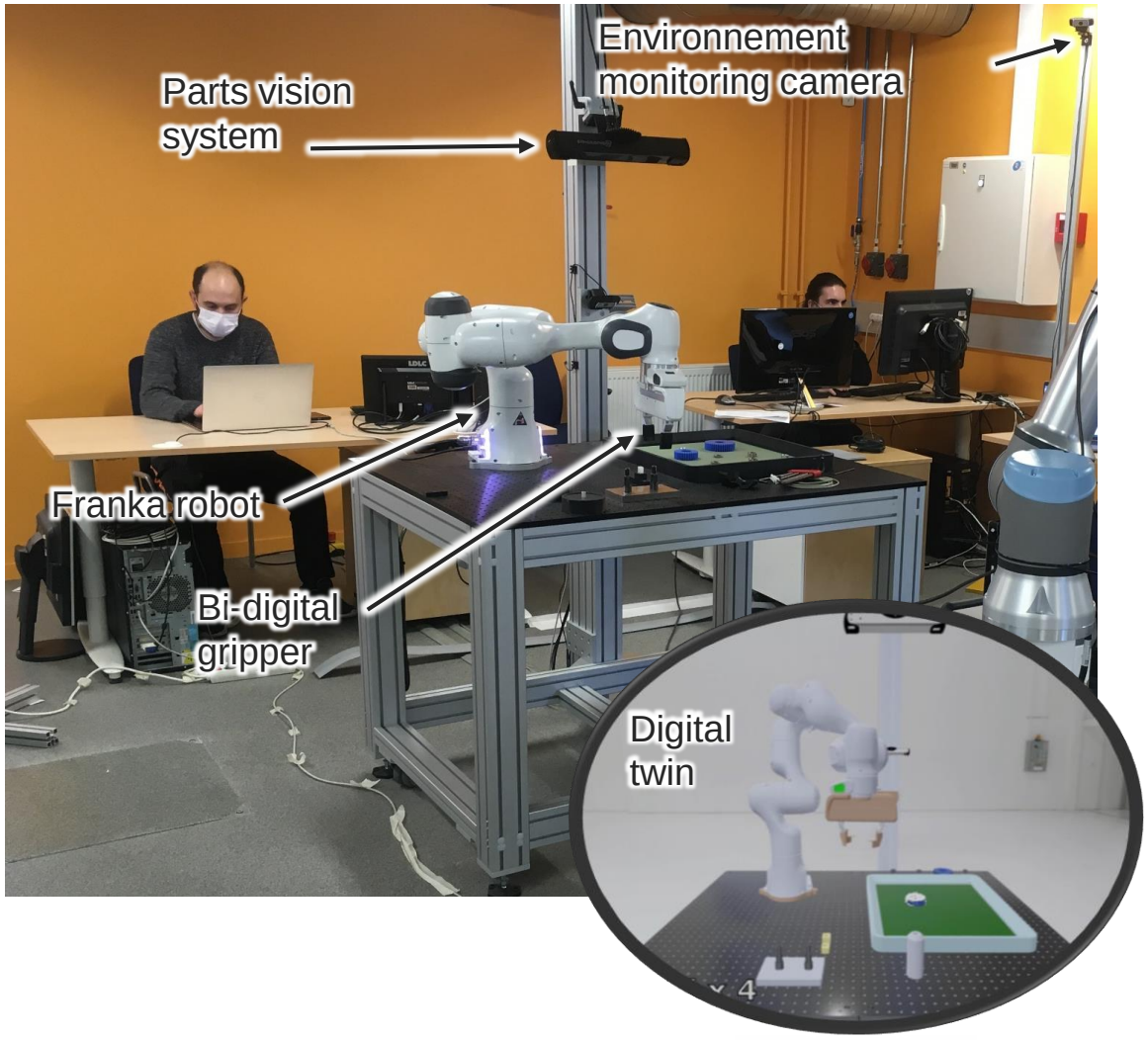
- ➢ *No code programming*
  - ➢ *Task explained by the operator without complex programming (NLP, user-friendly HMI, demonstration …)*
  - ➢ *Behavior tree construction*
  - ➢ *Visualization and validation on digital twin*
- ➢ *Intelligent execution*
  - ➢ *Environment perception and situation awareness*
  - ➢ *Execution monitoring and dynamical orchestration*



Intelligent interactive robotic platform

Combining SoA CEA List technological bricks in a common robotic platform





Applications

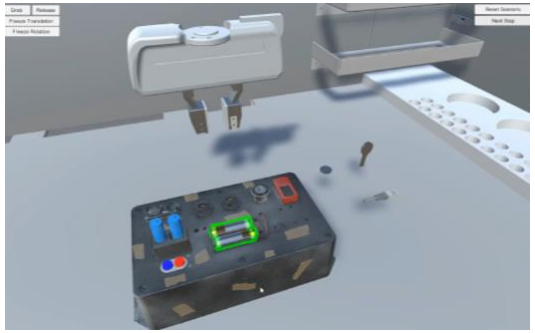
Application to assembly tasks :

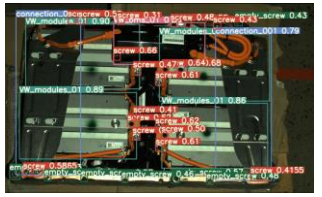
- Common to various application domains
- Still often manual (easy for humans but difficult for robots)

First demonstrator: inspired from the Gear Unit Assembly challenge

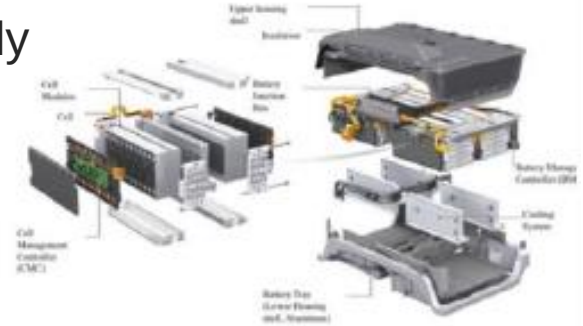
NIST / WRS
Gear Unit Assembly

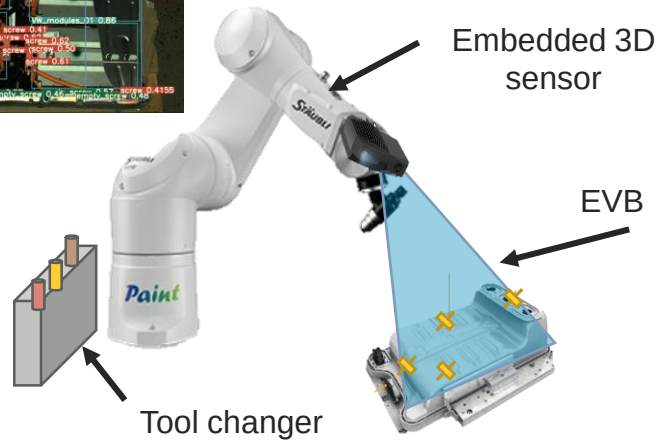
Second demonstrator: Robothon challenge





‘Moonshot’ project demonstrator: EBV disassembly





Assembly task (known parts)

NIST / WRS
Gear Unit
Assembly

The base of the assembly is fixed and all other parts are thrown on the table (all parts are visible and accessible).

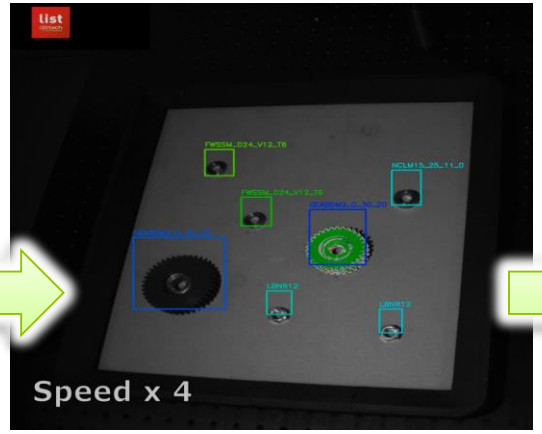
The robot:

- **flashes** the scene, **recognizes and localizes** the parts,
- **grasps** the first part (with an **adapted strategy** taking into account grasping, movement and assembly constraints),
- **plans** the movement and **moves** the part towards the (partially assembled) system,
- **assembles** the part using **robot's assembly skills** with force control (e.g. insertion, screwing, …),
- makes a visual acquisition to **validate the assembly**,
- repeats this procedure until the system is fully assembled.

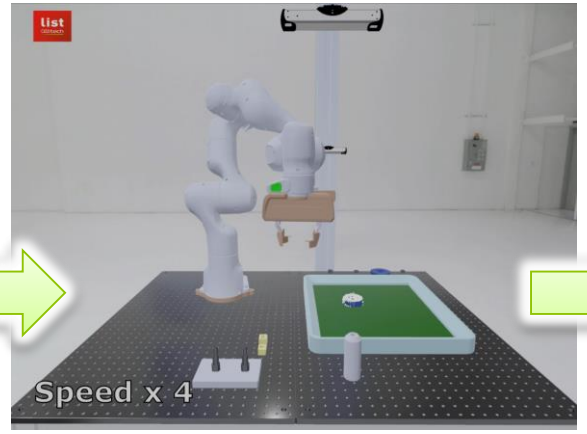
If an error occurs (e.g. one part misses or an unknown part is detected), the robot moves back in safety position and asks help (e.g. visual or audio message). An operator brings (and potentially assembles) the missing part and the system starts again (at the right step).

Principle of operation (autonomous mode)

2D and 3D images acquisition



DNN 2D object recognition and framing / Rapid 3D localization using local point cloud



Update of the Digital Twin / Generation of collision free grasps and access paths

Real time control along the target trajectory (DT runs in parallel)

Return to initial configuration and launch of the next step

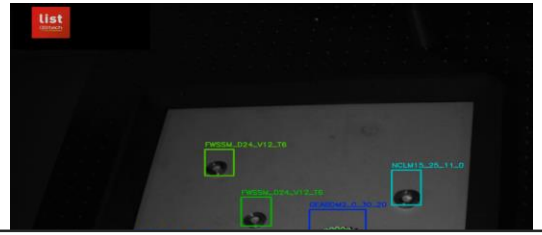
Object assembly using a dedicated skill

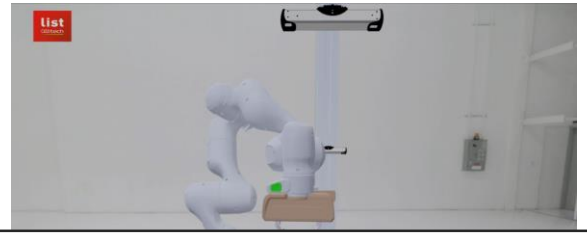
Generation and execution of a collision free trajectory to reach the assembly configuration

Object grasp using a dedicated skill

Principle of operation (autonomous mode)

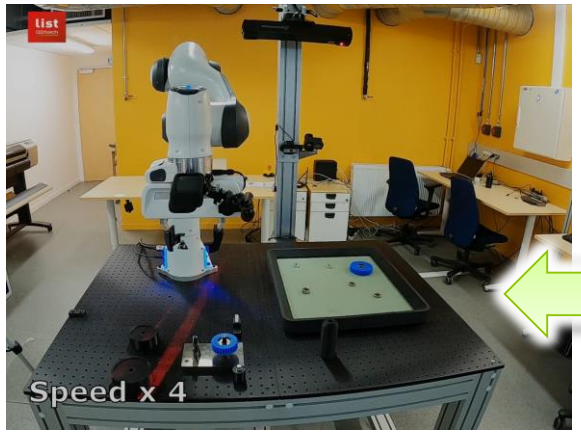
2D and 3D images acquisition



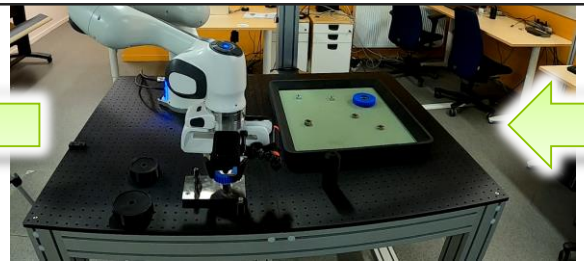


HMI for task progress monitoring

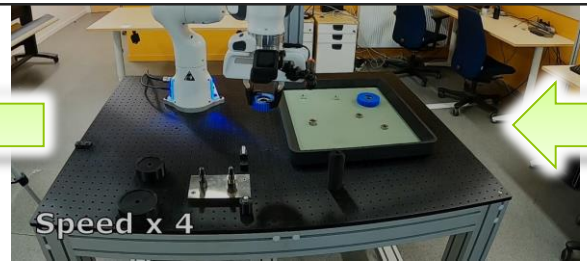
Real time control along the target trajectory (DT runs in parallel)



Return to initial configuration and launch of the next step



Object assembly using a dedicated skill



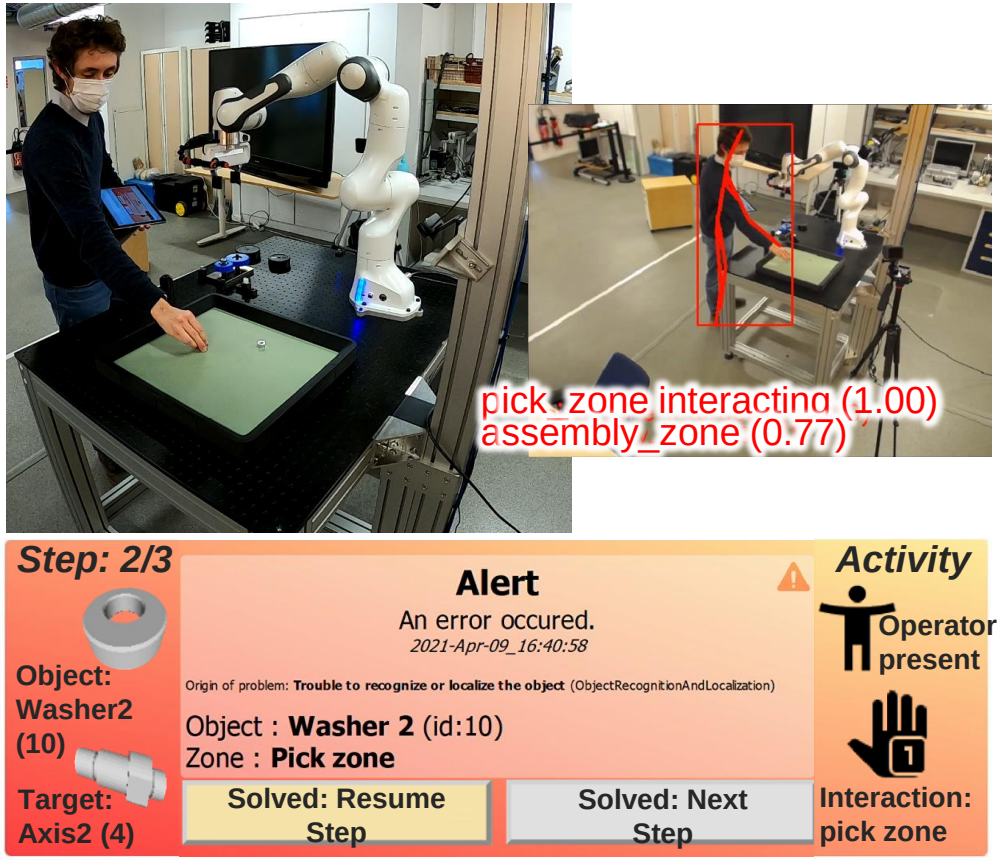
Generation and execution of a collision free trajectory to reach the assembly configuration

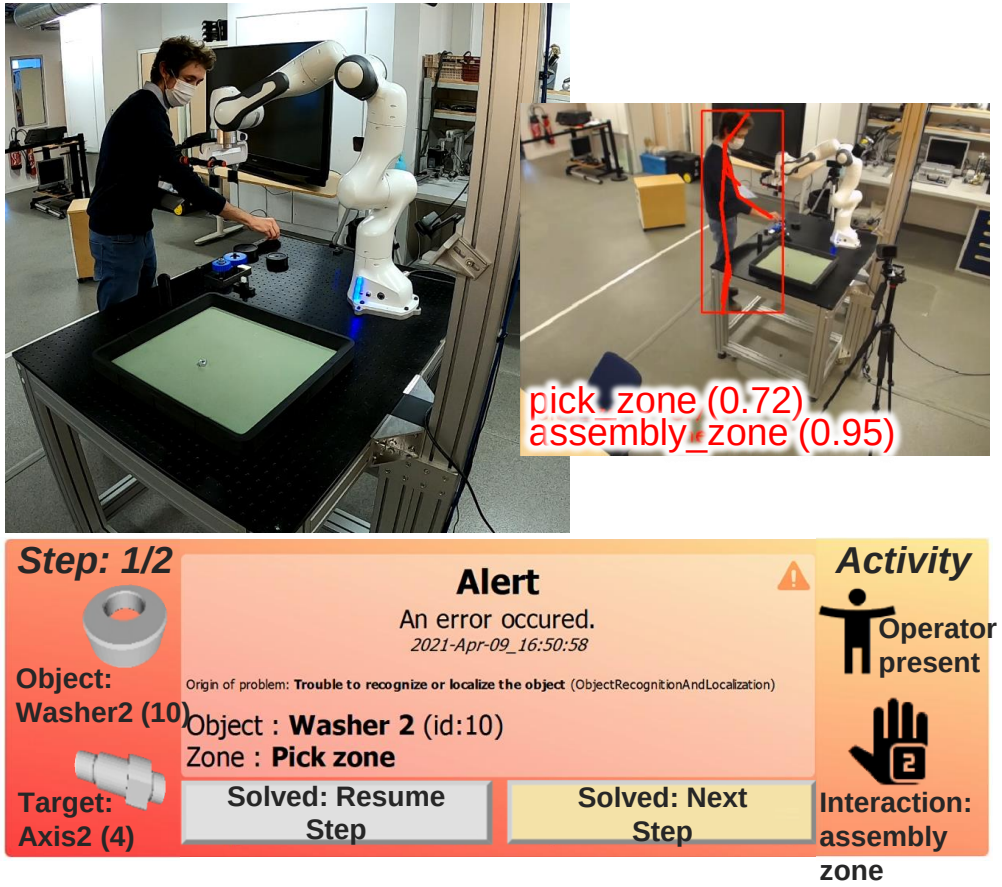
Object grasp using a dedicated skill

Principle of operation (interactive mode)

Warning displayed in case of error :

- Operator can either replace the missing part or assemble the part
- Environment monitoring camera used to analyze operator actions





Interactive intelligent robotic platform @CEA List

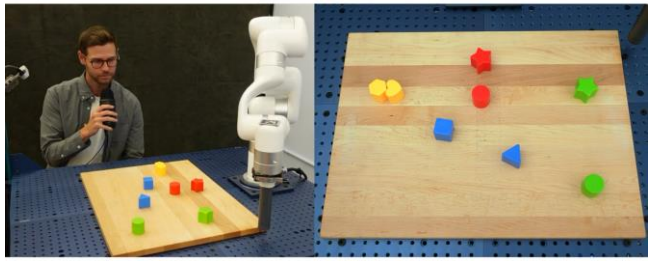
Combining robotics, AI, digital twin and visual perception for agile robotics

Additional ongoing work :

- User-friendly HMI based on scene understanding
- Situational awareness and dynamic orchestration
- Reinforcement learning of new tasks and skills

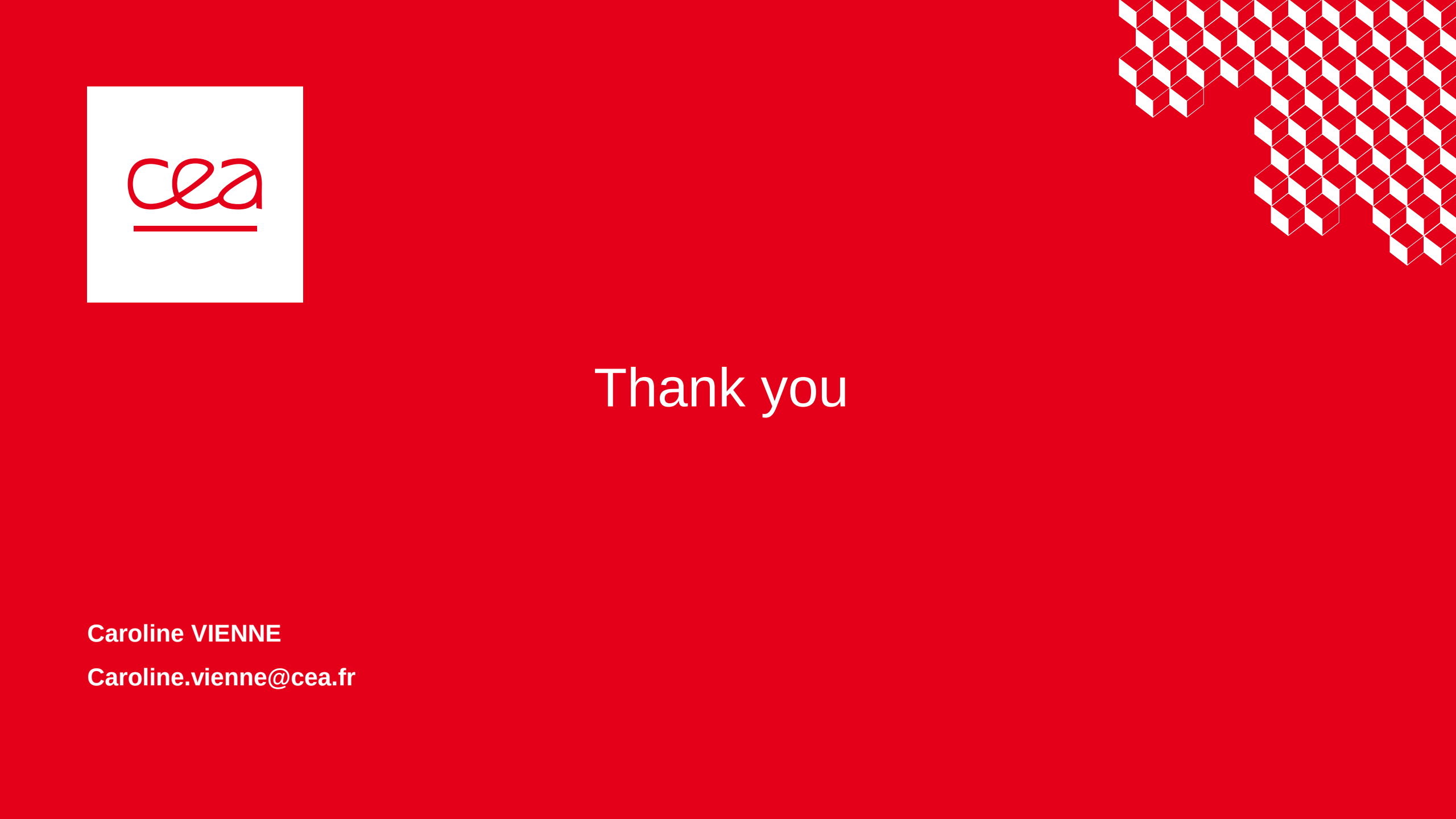
Perspectives :

- LLM : generative AI for robot control



"push the green star between the red blocks" (1x speed)

Interactive Language: Talking to Robots in Real Time (2022)
https://interactive-language.github.io



Thank you

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