DIGITAL TWIN ENABLED FRAMEWORK FOR INDUSTRIAL HUMAN-ROBOT COLLABORATION

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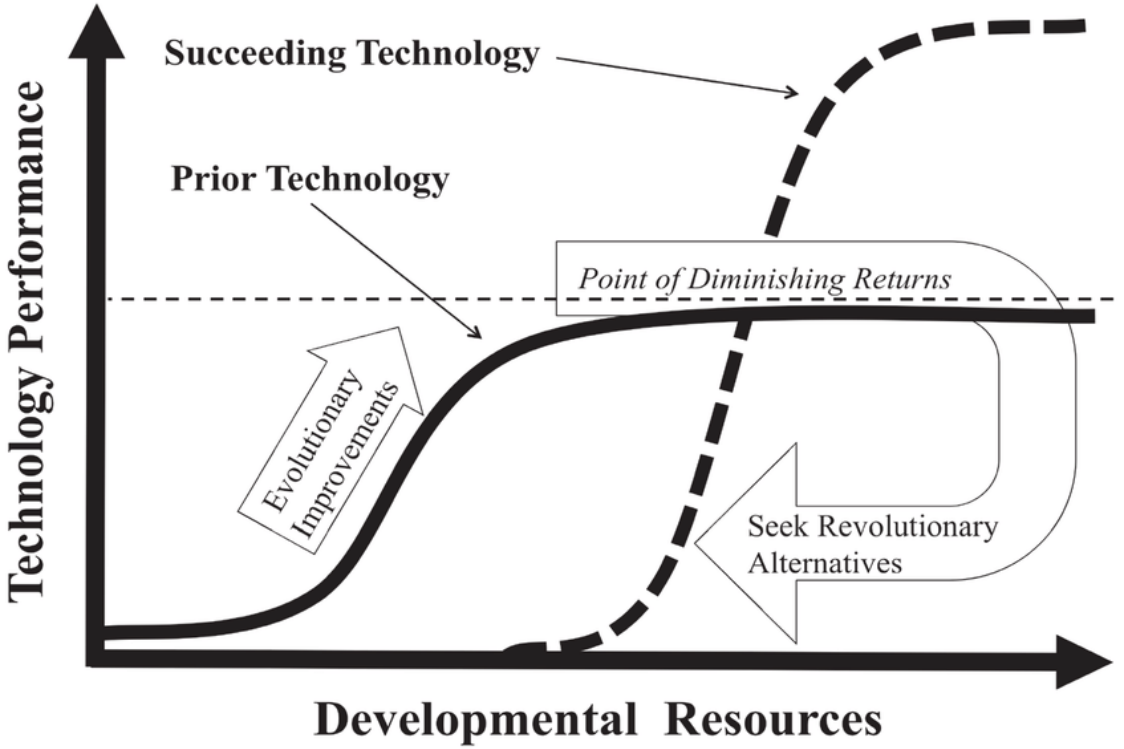
Introduction

- Robots have been widely applied to relieve humans from tedious, repetitive, and risky tasks. However:
  - The technological progress is only partially reflected by the increase of automation;
  - For many applications, robots are still not advanced enough;
  - Human assistance is needed to tackle the changes in tasks and environmental factors;
  - It is necessary to seek revolutionary alternatives to overcome the plateau.



Source: Marc G. Millis

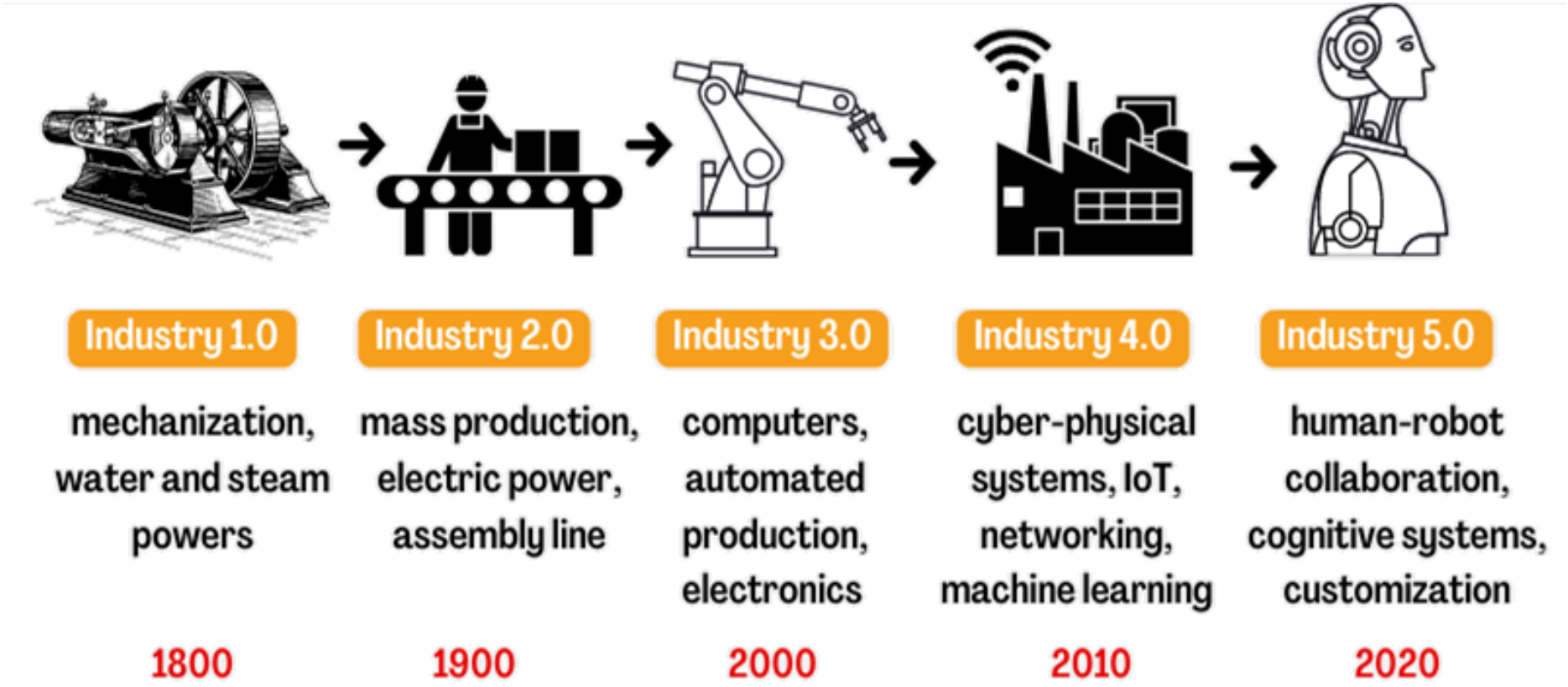
Introduction - Collaborative robotics

- Humans have advantages over machines regarding intuitive decisions, responsiveness, agility, and adaptability;
- A new generation of collaborative robots (cobots) has been developed to enable humans to work with robots;
- Cobots are industrial robots outfitted with several sensors;
- Cobots are meant to put humans at the centre of a manufacturing task and free workers from various tasks without difficulty, danger, or dullness;
- Cobots are potentially attractive for SMEs;
- The cobot sector is expected to proliferate in the upcoming years.

Source: KUKA

Introduction - Industry 4 → Industry 5

Whereas the main aim of the fourth industrial revolution (Industry 4.0) is about adding autonomous behaviours to machines, the fifth industrial revolution (Industry 5.0) aims to enable synergy between people and autonomous machines.

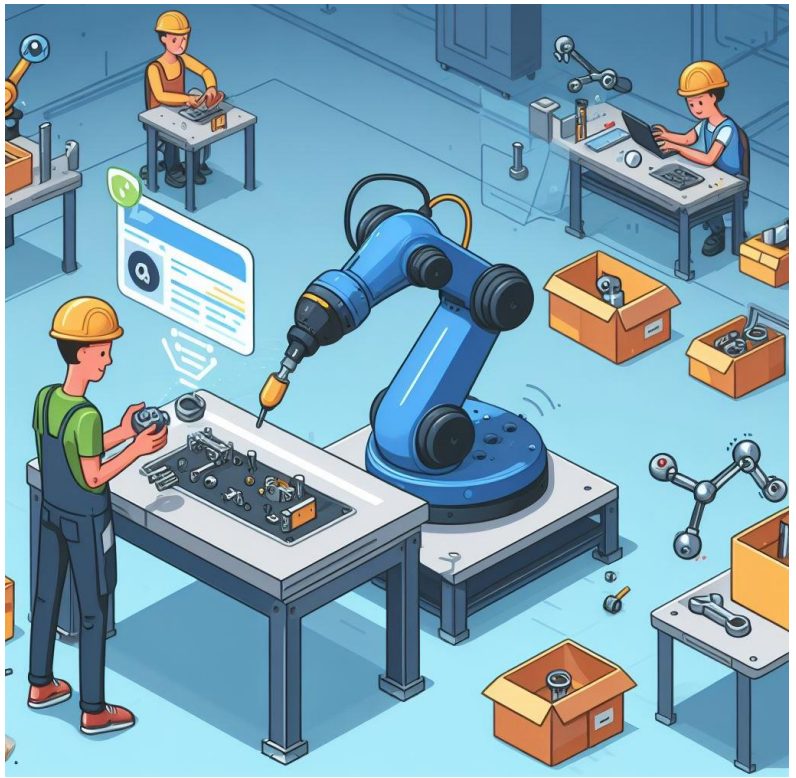


Possible future scenario and research challenge

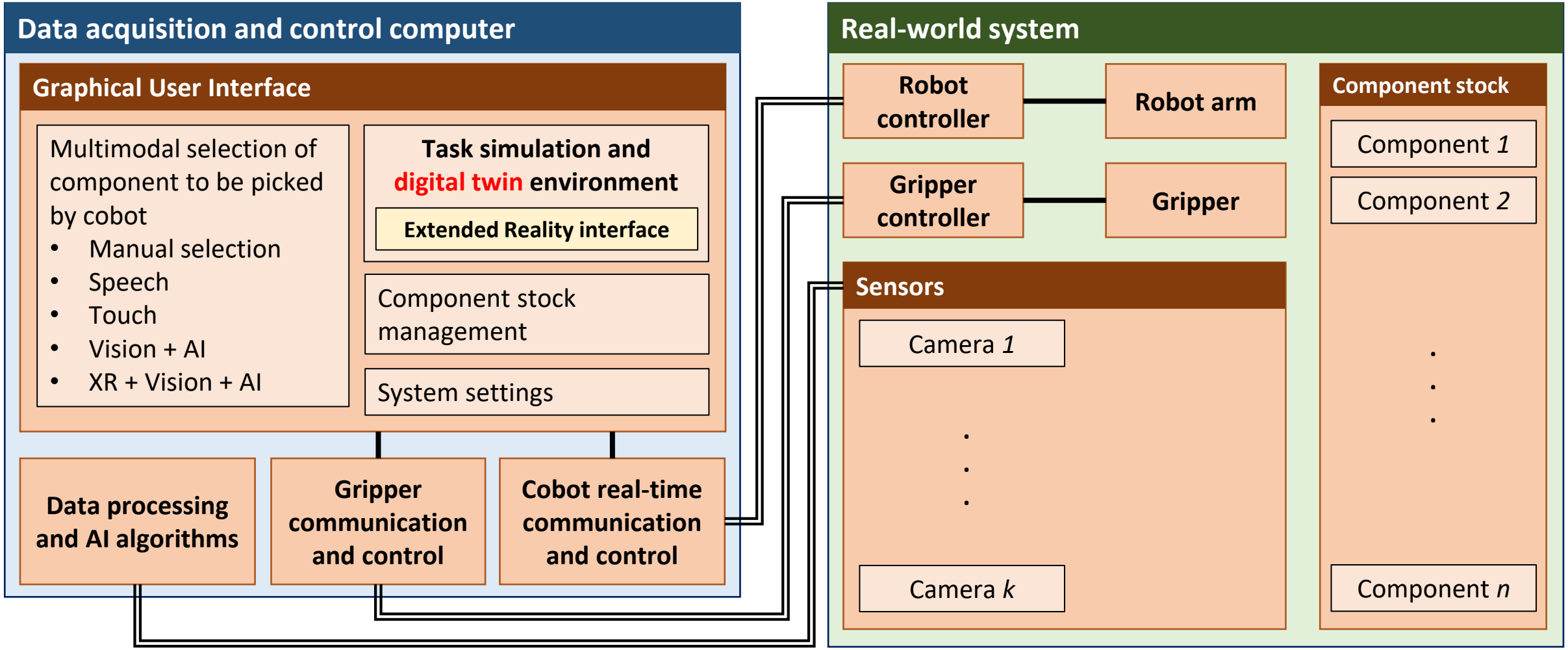
- Assembly tasks that require human intervention are common in industrial manufacturing.

- **A typical future scenario** could consist of:
  1. a person working alongside one or more cobots on assembling a specific industrial product made of several parts
  2. a data acquisition and control unit, with vision sensors, simultaneously monitoring the person and the environment and inferring what assembly phase the operator is performing at any time, using an analysis of human intentions based on AI software.

- **The current research challenge** consists in making this future scenario a reality and creating non-invasive work companions so that human workers can focus on their tasks, feeling helped safely.



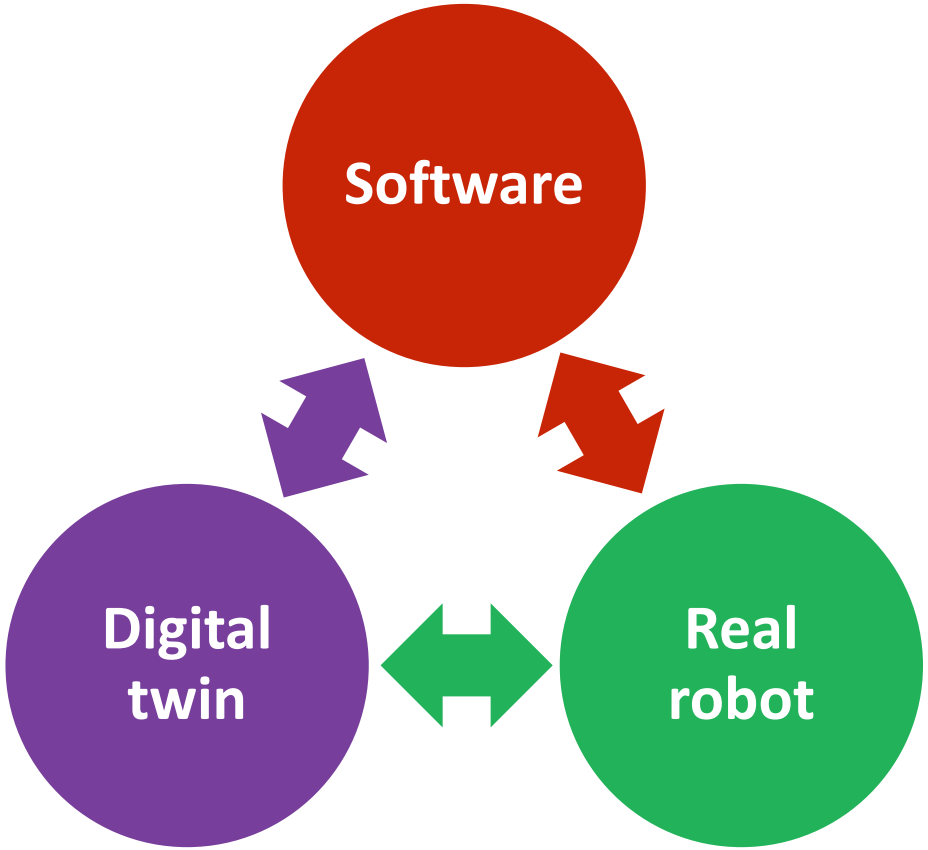
Proposed Digital-twin-enabled Framework for Industry 5



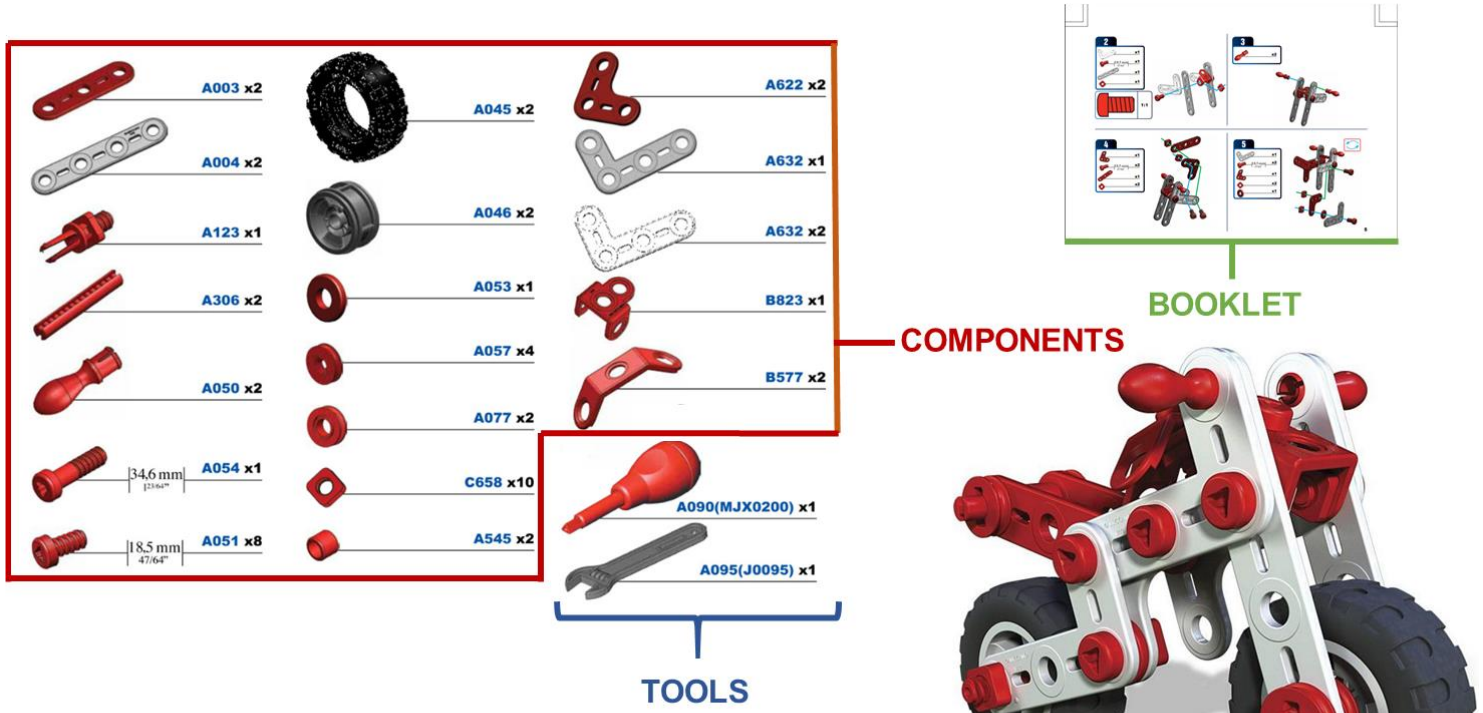
Proposed Digital-twin-enabled Framework for Industry 5

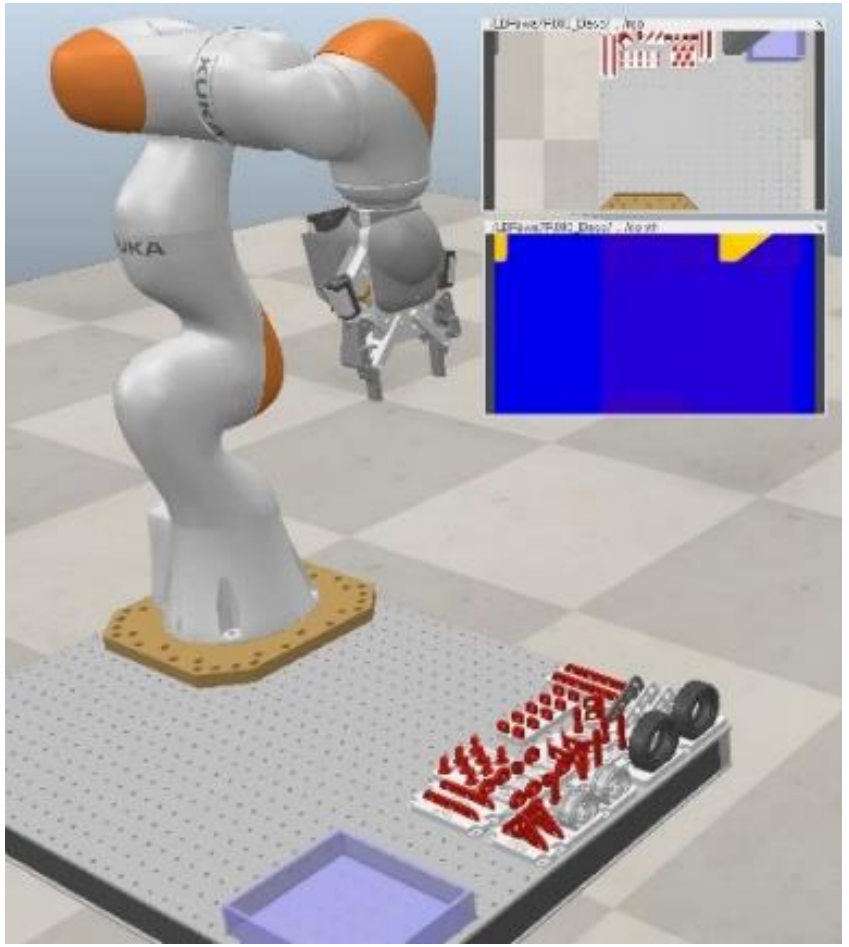
The digital-twin offers a range of benefits:

- **Virtual representation of the robot**;
- **Behaviour modelling**;
- **Simulation and validation**;
- **Monitoring and maintenance**;
- **Continuous updates and improvements**.



Ongoing development





Francesco Ragusa, Antonino Furnari, and Giovanni Maria Farinella. "Meccano: A Multimodal Egocentric Dataset for Humans Behavior Understanding in the Industrial-Like Domain", Computer Vision and Image Understanding (2023): 103764.

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Conclusions

The proposed framework can improve collaboration between cobots and humans in assembly tasks;

- **Object handling assistance;**
- **Intuitive control;**
- **Operator safety;**
- **Quality control and inspection:** A cobot can be equipped with vision sensors and other advanced sensors to perform quality checks during assembly. The cobot can verify the correct position, alignment, or the presence of defects on assembled parts. In case of detecting anomalies, it can alert the human operator or initiate corrective actions.
- The proposed framework allows designers to experiment in real and simulated scenarios with complex human-robot interactions, considering human factors such as expectation and satisfaction in the future manufacturing processes.

Thanks for your attention

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