Human-robotic cooperation

In the light of Industry 4.0

Central European cooperation for Industry 4.0 workshop

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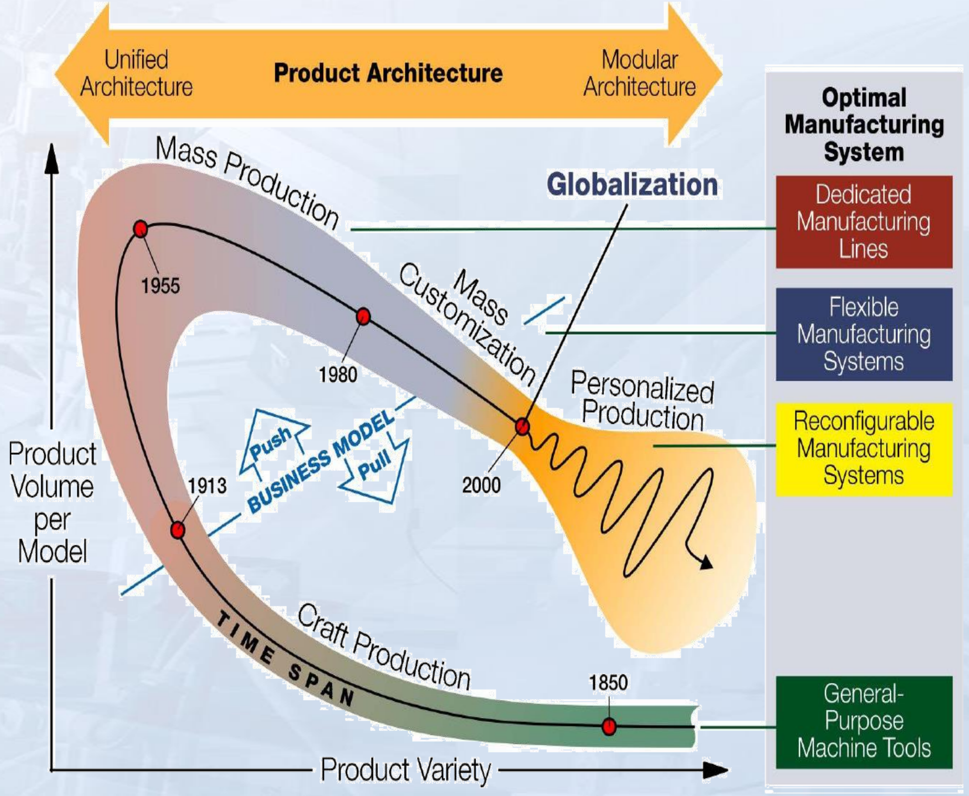
Motivation

- Key challenges
  - Dynamically changing, highly uncertain environment
  - Real-time reaction required
  - Increasing complexity

- New opportunities by I4.0
  - Digitization: data volumes, computational power, connectivity
  - Sensor and data processing technologies
  - Novel technologies in manufacturing and assembly



[Koren]

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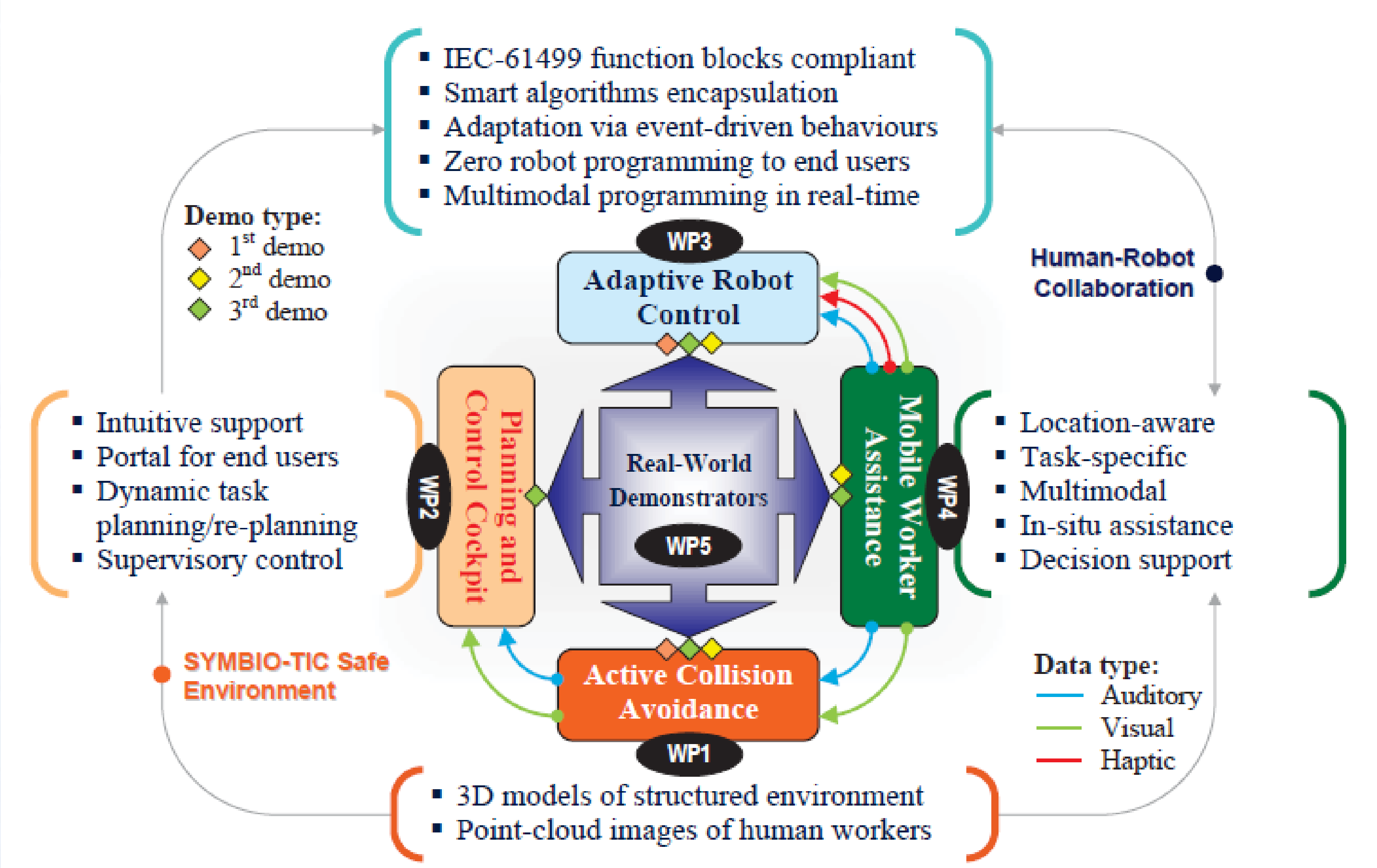
Human-Robot collaboration - SYMBIOTIC Project

Project Objectives

- To develop an active collision avoidance subsystem to safeguard human workers
- To generate adaptive task plans appropriate to both robots and human workers
- To adapt to dynamic changes with intuitive and multimodal programming
- To provide human workers with in-situ assistance on what-to-do and how-to-do



[Symbiotic Human-Robot Collaborativ Assembly – No. 637107]

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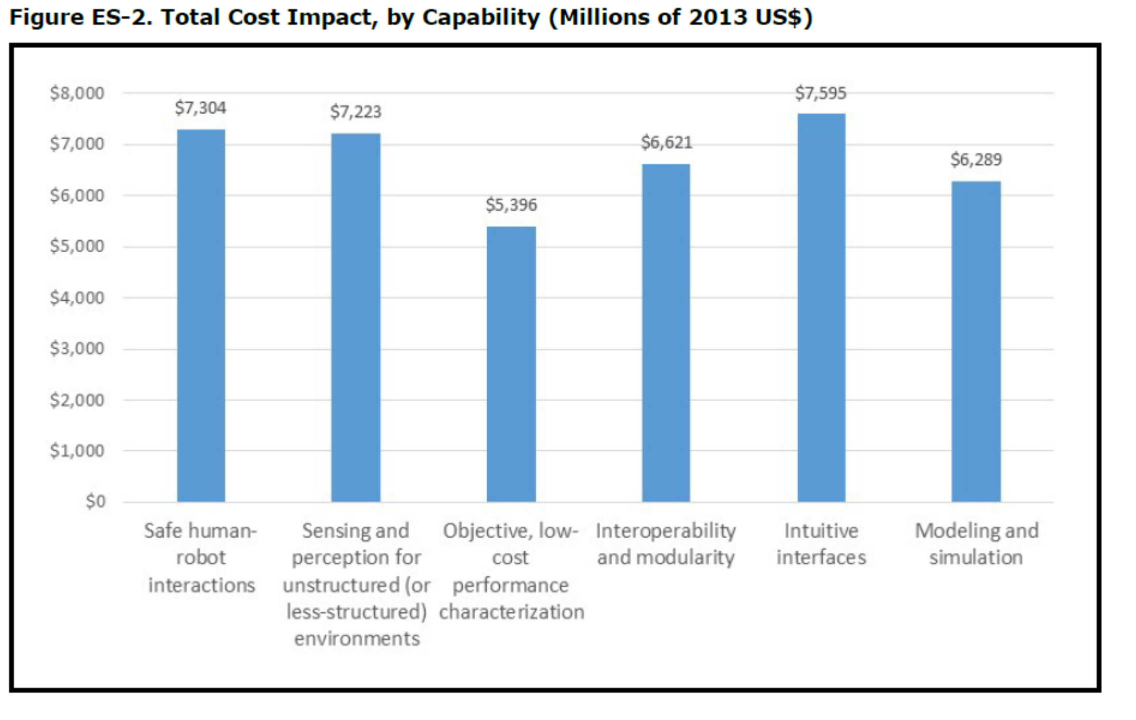
Promise of advanced robotics in manufacturing

- Advanced robotics and automation have been discussed as potential game-changing technologies for strengthening the U.S. manufacturing sector, particularly for small and medium-sized manufacturers (SMEs).
- Advanced robotics can help to decrease production costs as well as offer greater flexibility to manufacturers to respond to changing market conditions and consumer preferences.
- Next-generation robots could be mobile and autonomous in their environment, with the ability to operate in unstructured environments free from the physical cages that have surrounded traditional industrial robots for decades and to collaborate safely with humans while doing so

Link,A.N.; Zachary T.; Alan O. ;O'Connor C.: *Economic Analysis of Technology Infrastructure Needs for Advanced Manufacturing: Advanced Robotics and Automation*
NIST GCR 16-005, August 2016

What capabilities that are still missing

- Safe human-robot interaction (HRI)
- Sensing and perception for unstructured (or less-structured) environments
- Objective, low-cost performance characterization
- Interoperability and modularity
- Intuitive interfaces
- Modeling and simulation



[NIST GCR 16-005]

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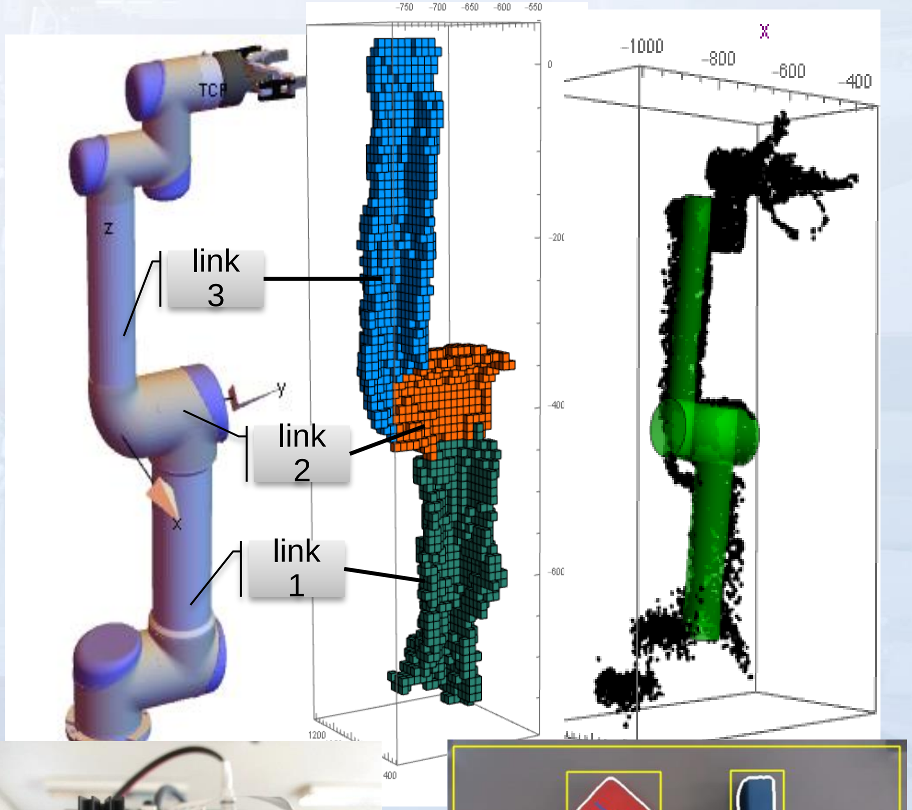
Safe Human robot interface

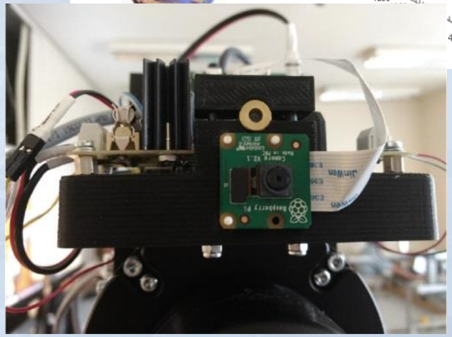
- Universal standards for developers of robotics technologies and the application of these technologies in manufacturing settings with robots working in close proximity to people
- Test protocols, objective scientific and engineering data, reference databases, and other technical inputs into standards for safe HRI (power/force-limiting, speed/separation monitoring, hand-guided operation, safety-rated monitored stop)

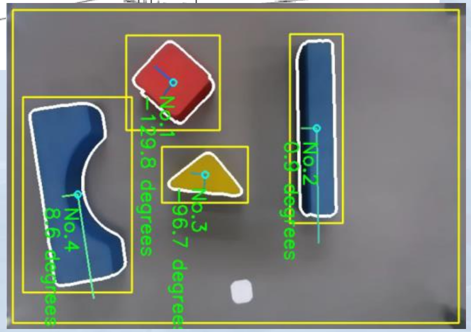
Intuitive human-robot interfaces

Sensing and perception for unstructured environments

- Improved perception (and the ability to plan and re-plan the robot's actions based on what it "sees" and "knows") gives a robot greater autonomy, lessening its demand that its work environment meet stringent tolerances
- Sensor registration and calibration
- Proof-of-concept robotics applications of knowledge representation and reasoning







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Point cloud based robot cell calibration

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Objective, low-cost performance characterization

- Making it easier for robotics users to know what they are buying and for developers and suppliers to show what their systems do.
- Common performance metrics, objective data, testbeds, test methods, and benchmarks to characterize the performance attributes of advanced systems, subsystems, and components.

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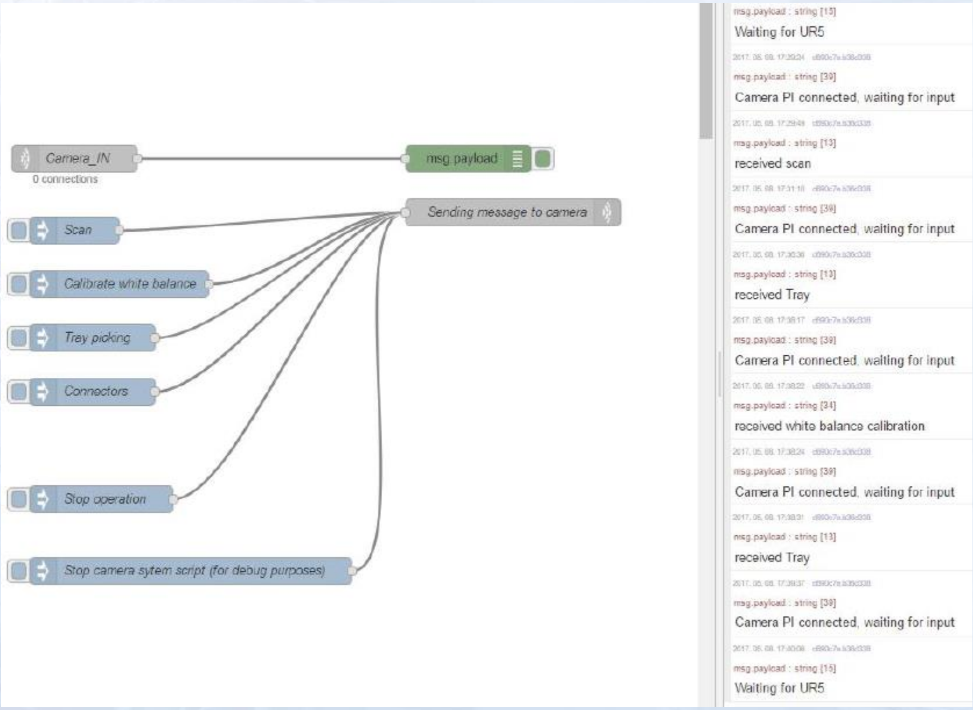
Interoperability and modularity

- Plug-and-play for system components, enabled by standards for physical and electronic interfaces and software interfaces or translators
- Plug-and-play functionality
- Reduced integration costs (physical and software interfaces)
- Modular development of systems
- Increased adaptability of robotic systems
- Scalable, reconfigurable, and reusable robotic systems
- Reduced retooling costs
- Increased adoption in industries with small production runs

Intuitive interfaces

- The time and cost of setting up an automated line could be reduced significantly if robots could be programmed more intuitively, without the need to write many lines of code.
- Enabling rapid programming and training without specialized skills
- Protocols to simplify the programming, training, and rapid re-tasking of robots
- Standard programming language for industrial robotics analogous to SQL or HTML



ROS Robots

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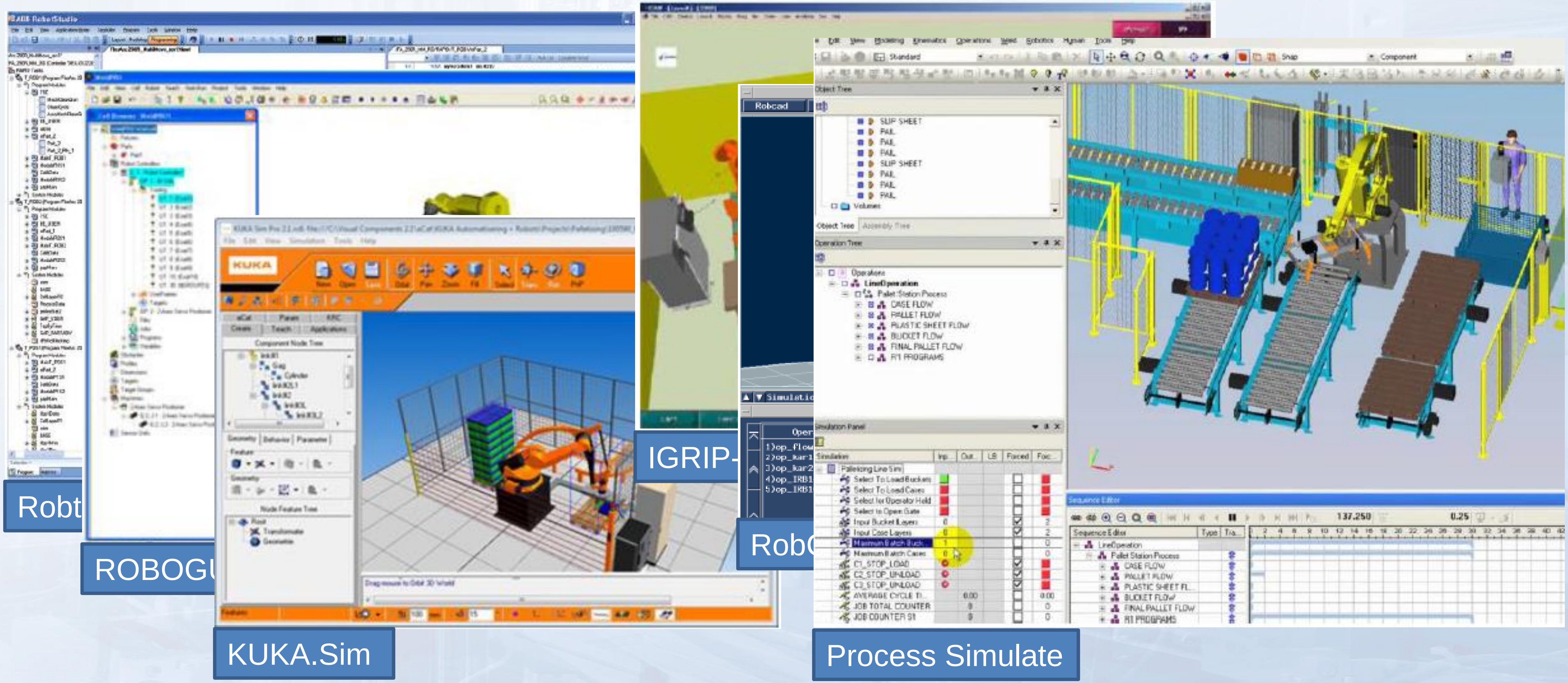
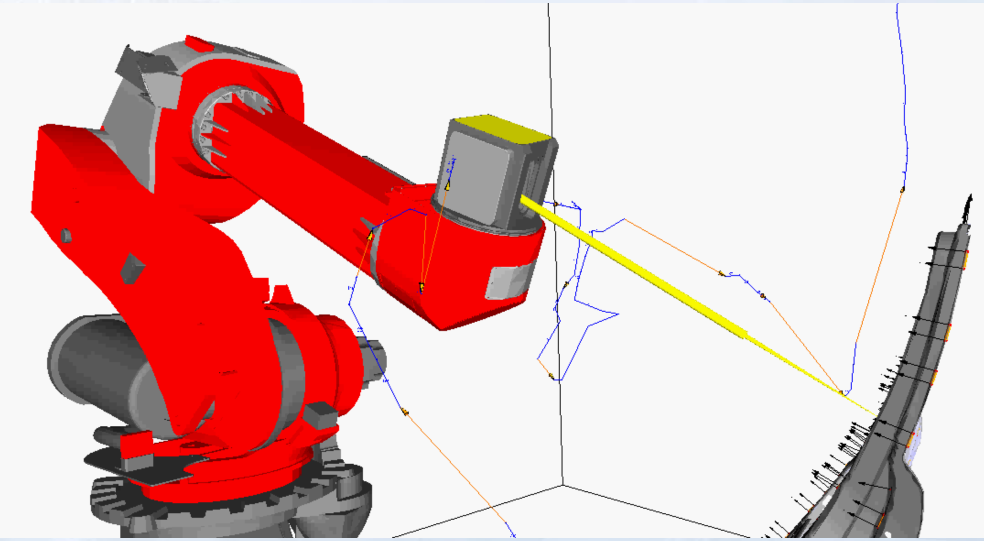
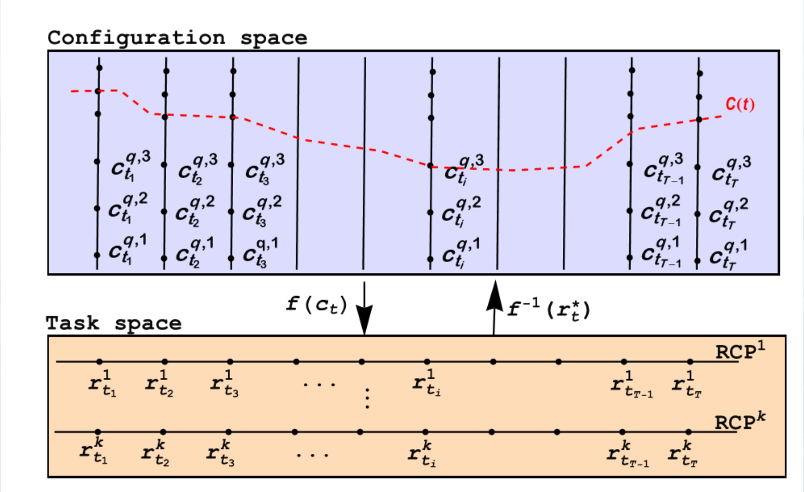
Modeling Simulation systems



Modeling and simulation – Digital TWIN

- Virtual factory floor allowing modeling and simulation, calibrated based on real-time data feed from robots, machine tools, sensors, and control systems on the floor
- Robust, open, real-time operating system on the factory floor
- Reference models, modeling frameworks to fully integrate robots into models of the manufacturing environment and enable robust simulation/prediction





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Advanced process planning in a Digital Twin

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Thank you for your attention!

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