SAM : COBOTIC SYSTEM

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Outline

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3. Transition to cobotic system
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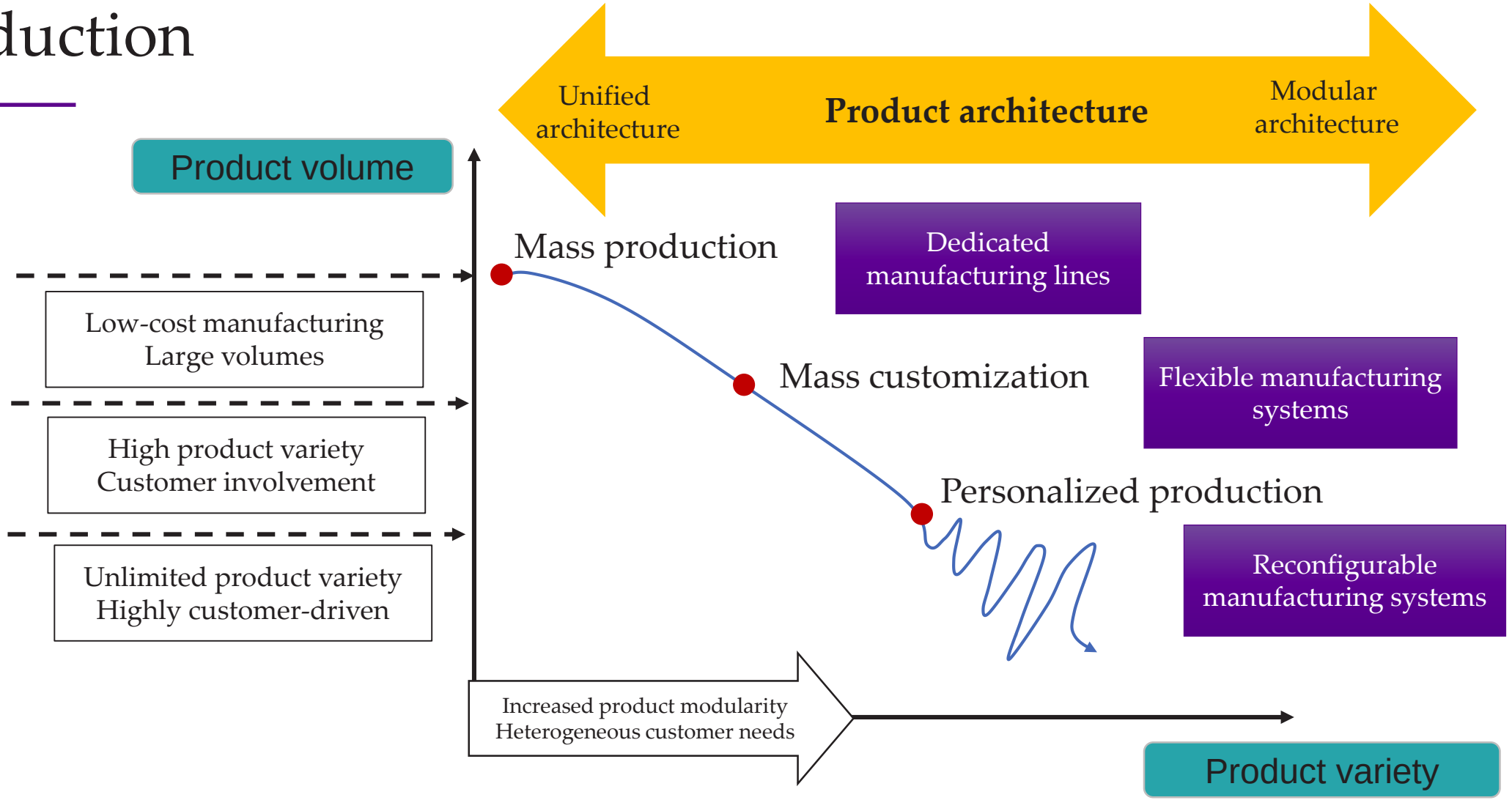
Introduction

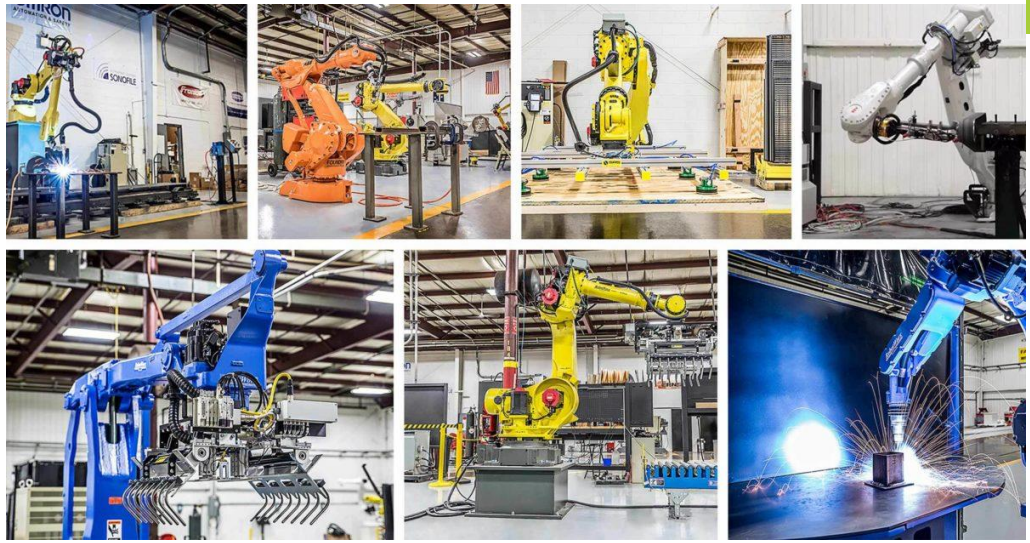


Timeline of manufacturing system (adapted from Koren2010, Mourtzis2012)

Introduction

Industrial robots are increasingly used in a variety of applications in order to help humans, they are :

- Used to perform repetitive, tedious and hazardous manufacturing tasks,
- Provides high precision and speed, but only on a large scale,
- Installed in physically separated and Workspaces away from humans.



But,

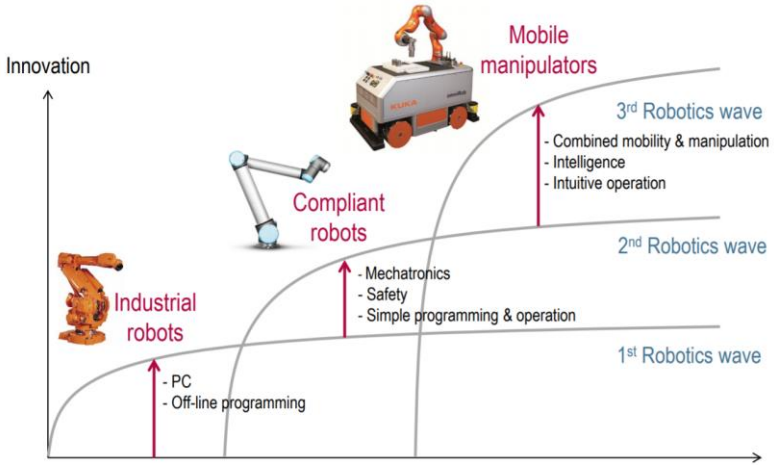
- The used solutions are often too standardized and not generic,
- Safety as design feature is rarely available,
- Lack of trust from end users.

Also some tasks may be:

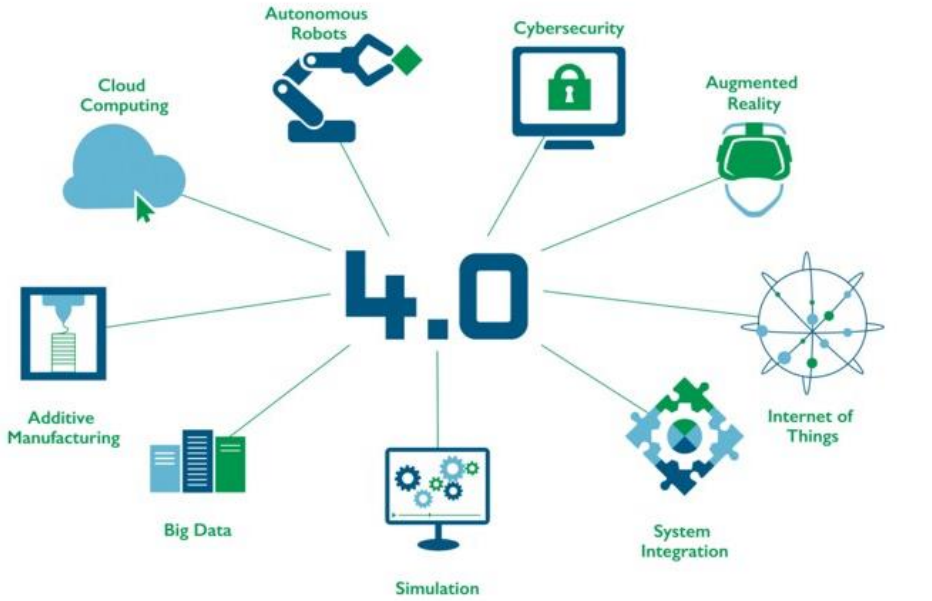
- Too complex to be fully achieved by robots,
- Too expensive to be fully automated.

Introduction

- **Key challenges**
- Increasing complexity,
- Highly uncertain and dynamic environment,
- Lack of adaptability and flexibility,
- Need of operational efficiency,



https://www.b2match.eu/system/reineu2016/files/Siciliano_Industrial_robotics_in_Europe.pdf?1464768420



- **New opportunities by Industry 4.0**
- Digitization: data volumes, computational power, connectivity
- Sensor and data processing technologies
- New generation of robots,

Manipulator robot

- **What is a robot ?**
- A robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmable motions for the performance of a variety of tasks. [Robot Institute of America]
- To qualify as a robot, a machine must be able to:
  - **Sensing and perception**: get information from its surroundings
  - **Carry out different tasks**: Locomotion or manipulation, do something physical–such as move or manipulate objects
  - **Re-programmable**: can do different things
  - **Function autonomously and/or interact with human beings**



Manipulator robot

Perform 4A tasks in 4D environments

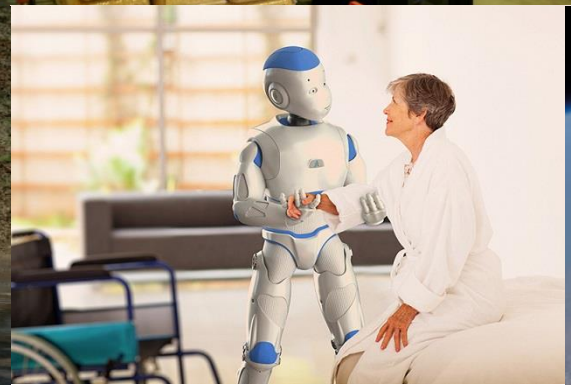
Automation, Augmentation, Assistance, Autonomous

Dangerous Dirty, Dull, Difficult

- **Why use robots?**








Manipulator robot

- **Mechanical Structure**
- It is an assembly of pairs of rigid bodies that can move respect to one another via a mechanical constraint
- It consists of a series of rigid bodies (links) interconnected by means of articulations (joints).

Joint : connection between two links (revolute or prismatic)

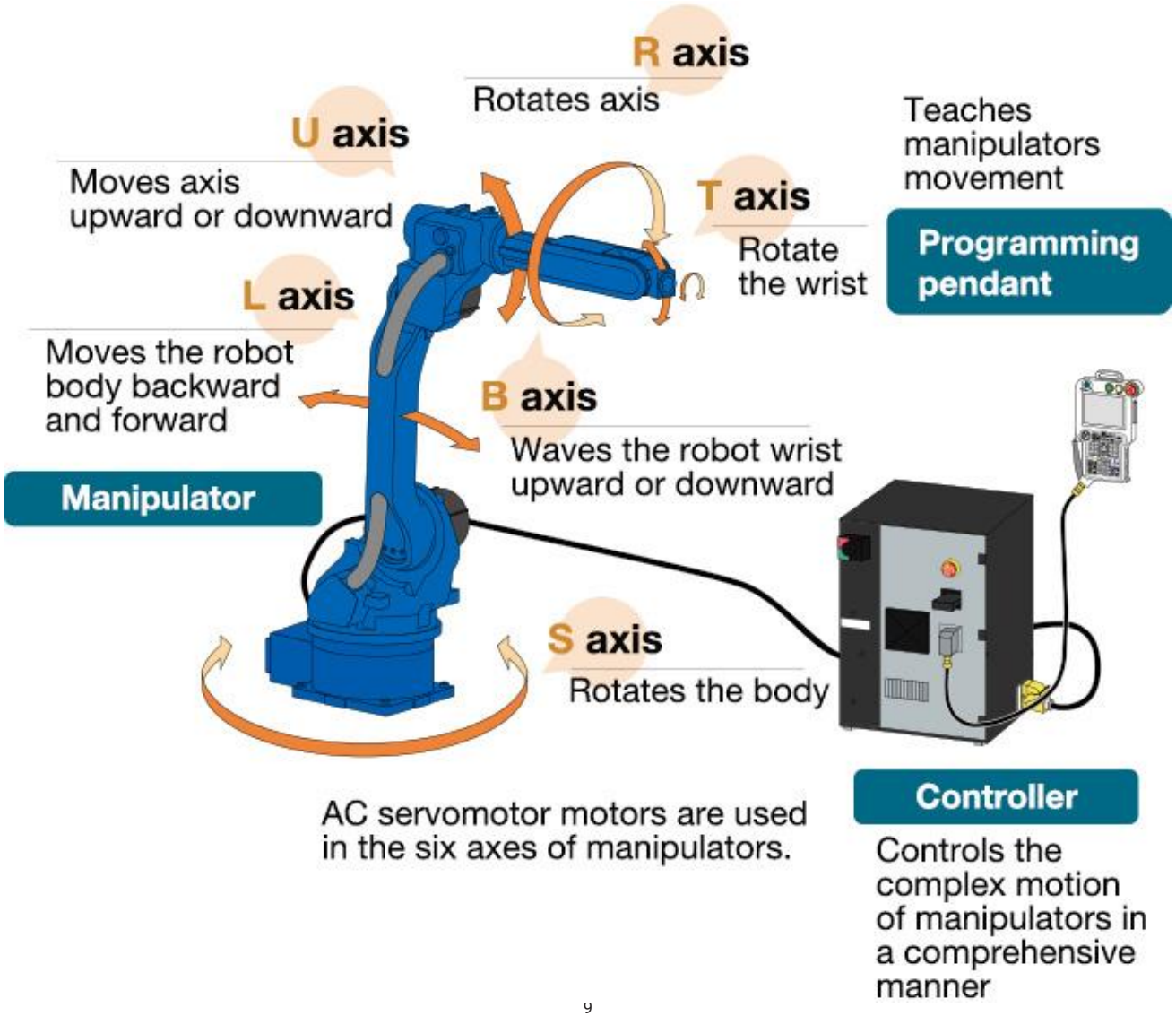
End-Effector : interacts with the environment

Base : connected to ground

Link : rigid body

Manipulator robot

- **Robot's components**



Manipulator robot

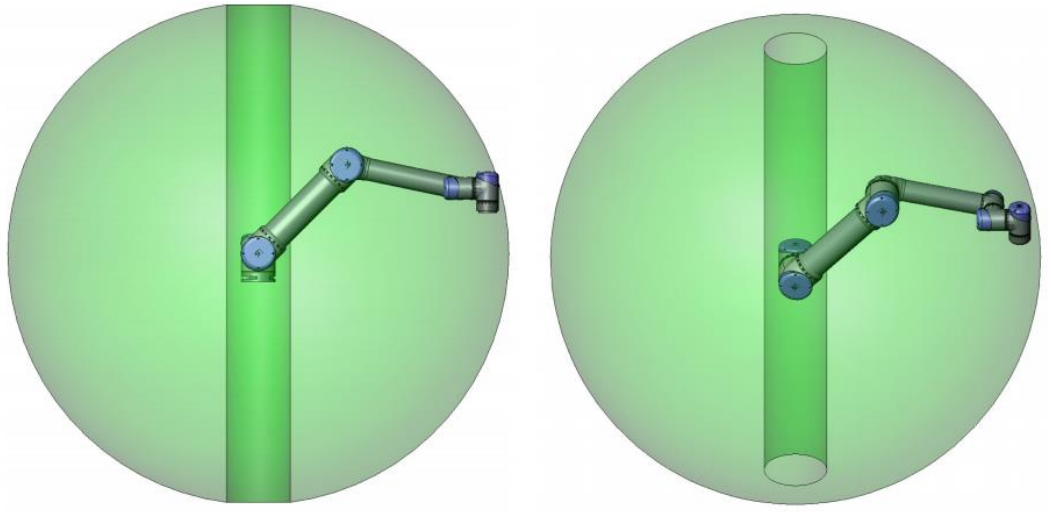
- **Robot Specifications**
- **Degree of Freedom (DOF):** The degrees of freedom of a robot is defined as the number of independent movements it has.
- **Payload (load capacity):** is the weight a robot can carry and still remain within its other specification.
- **Precision:** is defined as how accurately a specified point can be reached.
- **Repeatability:** is how accurately the same position can be reached if the motion is repeated many times.

Kuka LWR with 7 axes

Manipulator robot

❑ Robot Specifications

❑ Workspace: The workspace of a robot arm is the set of all positions that it can reach. This depends on a number of factors including the dimensions of the arm.

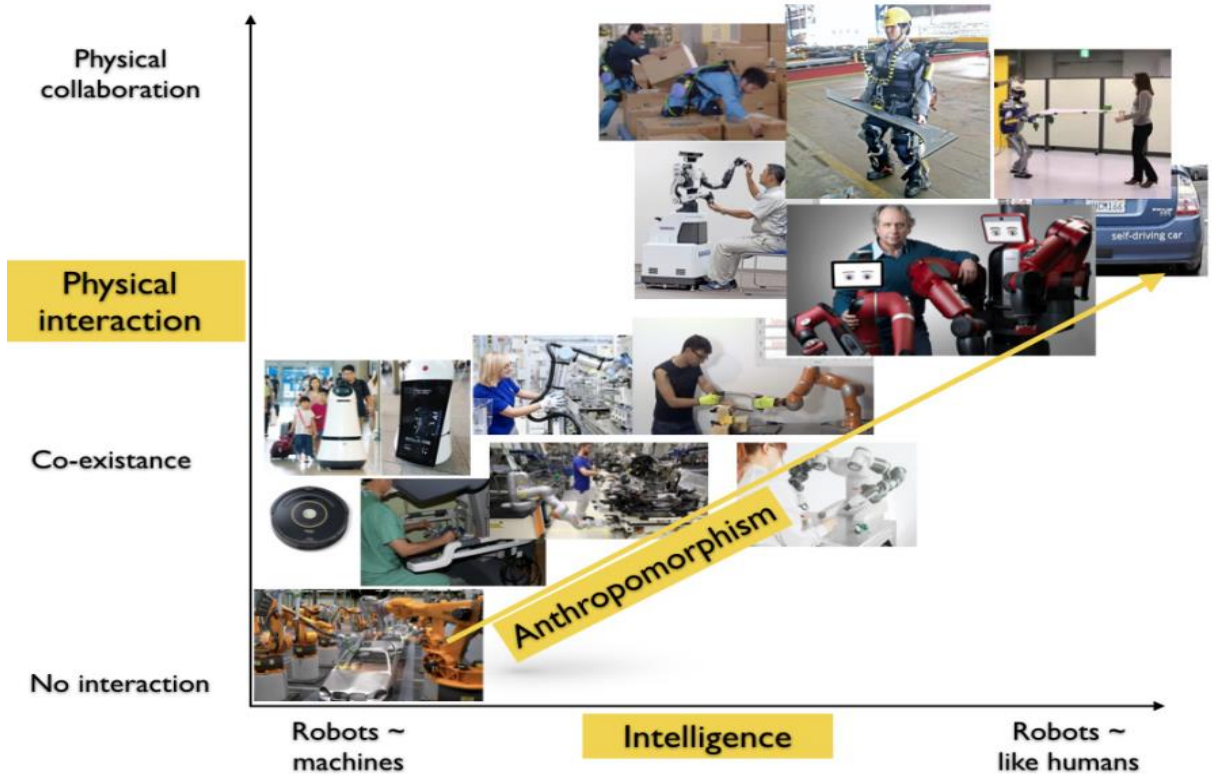


Front Tilted

Transition to cobotic system

- Robot are no longer confined to cages, easily interconnected with other robots and employees
- Human worker assisting and sharing the execution of tasks with robots (more flexible and affordable solution).
- Humans are sharing the same workspace with robots, considering them as useful collaborators.

Cobotic system

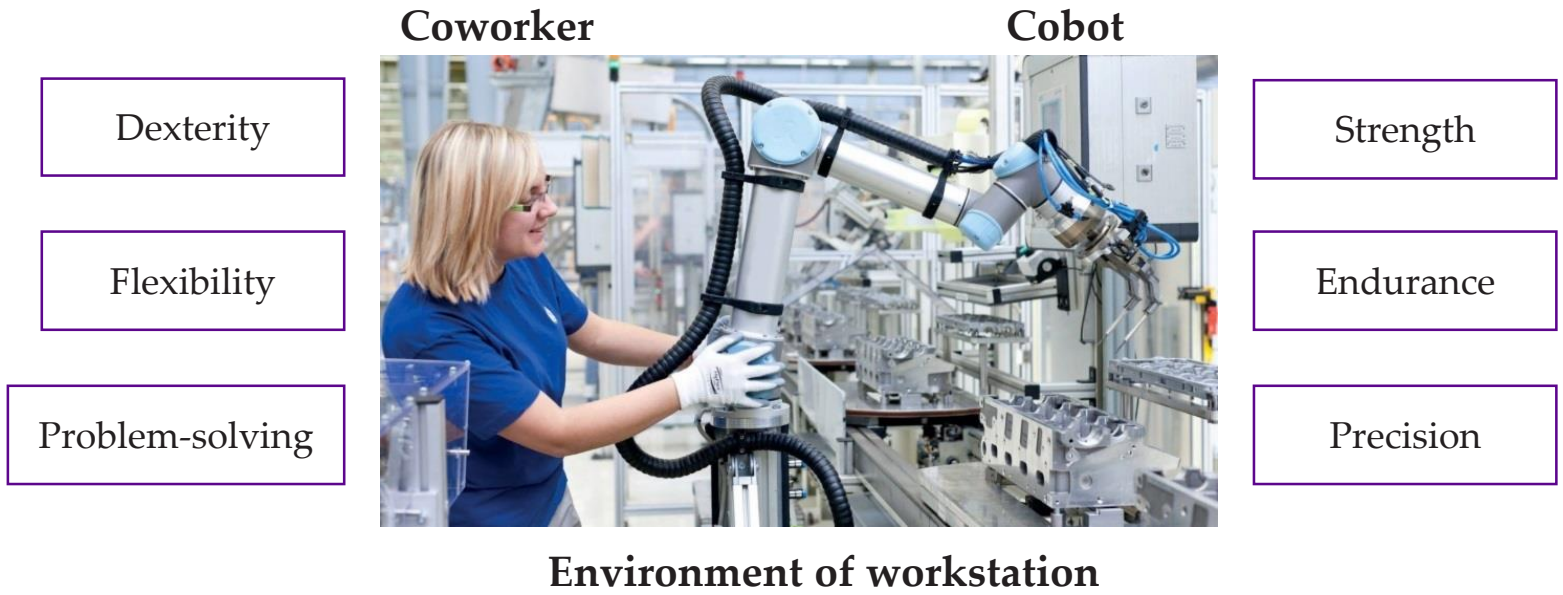


Transition from industrial robots working separately from humans, to cobots able to coexist and safely interact with operators [Ivaldi2018].

Transition to cobotic system: What is a cobotic system ?

Cobotics is a neologism formed by the terms “colloborative” and “robotics” proposed first by Peshkin and Colgate to conceptualize the direct interaction between a robot and a human on a dedicated workstation [Peshkin1999] .

A cobotic system is a flexible system where a human (coworker) and a cobot can safely interact and collaborate to achieve assigned tasks.



Transition to cobotic system : Cobot Vs. Robot

- Unaware of surroundings
- Potential danger to human safety
- High precision and repeatability
- Definite operations for task completion are required
- Need expert programmers
- Integration is costly and expensive

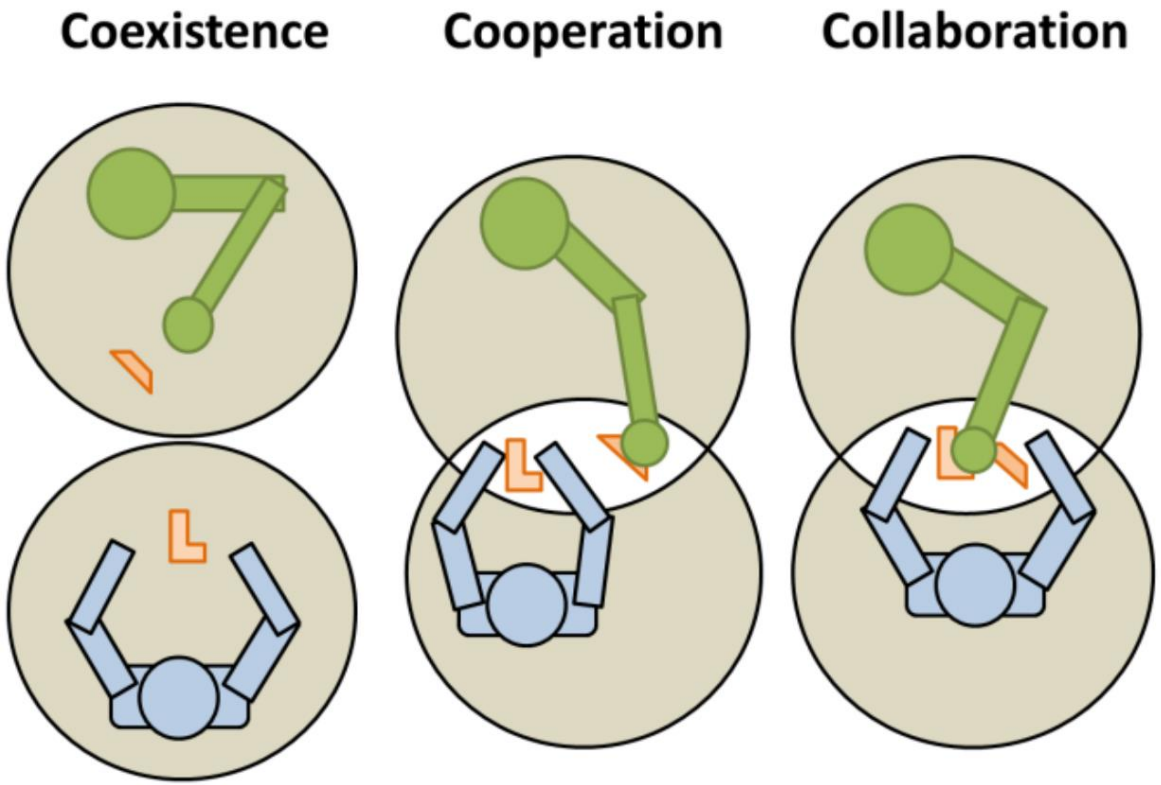
- Understands people and environment
- Safer compared to robots
- Flexible and easy to use
- Tasks are performed similar to human way
- Can be trained by demonstration
- No/minimum integration required
- Affordable

Categories of Human-Robot Interaction

- **Coexistence:** a case in which both are close to each other and act simultaneously, but without common workspace. They may have different aims as they can operate on dissimilar tasks. The robot has its own dedicated space distinct from the human one.

- **Cooperation:** the two "partners" work on their own tasks and can share a common space but not on the same product nor same part. They fulfil the requirements of time and space, simultaneously.

- **Collaboration:** an organization with common and simultaneous work on the same product or part. A direct contact (haptic, auditory, etc.) occur between human and robot. Typically the robot handles, presents and holds a part while the operator works on it.



Realization possibilities of human-robot workstations (according to Bauer2016)

Types of Cobot

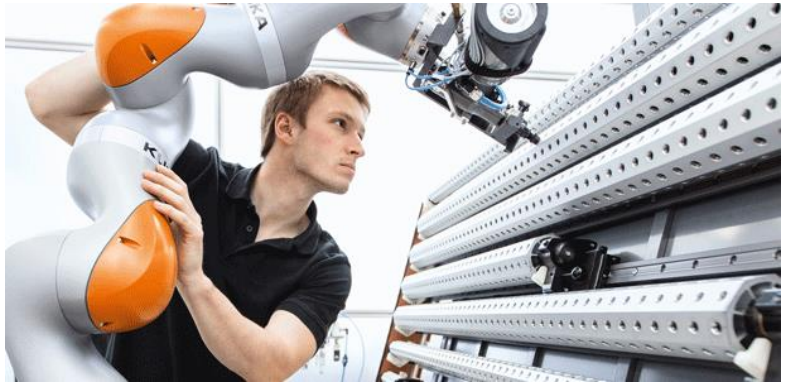
	Cobot – co manipulation	Exoskeletons	Teleoperation
			
✚	- provide assistance to human - provide strength and endurance - freeing human from repetitive and dangerous tasks	- provide physical assistance and reduce the risk of work-related musculo-skeletal diseases.	- task control can rely on human perception, judgement, decision, dexterity, experience and training.
⛔	- needs to be able to interact safely with the human - needs to be able to perceive human posture and efforts (several occlusions) - acceptance and trust	- needs to be able to detect current and future human activity - acceptance of this kind of technology (privacy, effects on the human body, ergonomic)	- operator must cope with a sense of remoteness, - coordination of many information and control variables

Interaction mechanisms with cobotic systems

- **Physically**: button, joystick, mouse, handling a robot or end effector replica.
- **Visually** (information for visual feedback): screen, glasses (virtual or augmented reality), by distance measurements.
- **Motion capture**: a camera is used to acquire the information of the working environment and the worker (eye-tracking, finger-tracking, arm motion tracking, or full body motion tracking.). The camera is placed pointing towards the working area of the robot in the region above the human operator.
- **Soundly**: From a given voice request (oral communication), this model extracts the key elements on the text and translates them into a robot-understandable representation [Hannun2014].
- **Brain Computer Interface**

Applications

- Pick and place
- Machine tending
- Intralogistics
- Dispensing, gluing and welding
- Assembly
- Quality inspection
- Support and guidance



Issues and crux of a cobotic system

- **Economic issues**
- Evolution of the manufacturing production from mass to small production
- Increasing the personalization of manufacturing products
- Flexibility of manufacturing production
- **Social issues**
- Reduce the drudgery of work
- Reduce the physical constraints related to the work

Ex: Handling heavy loads, strain physical postures,

- Reduce the exposure to dangerous environments

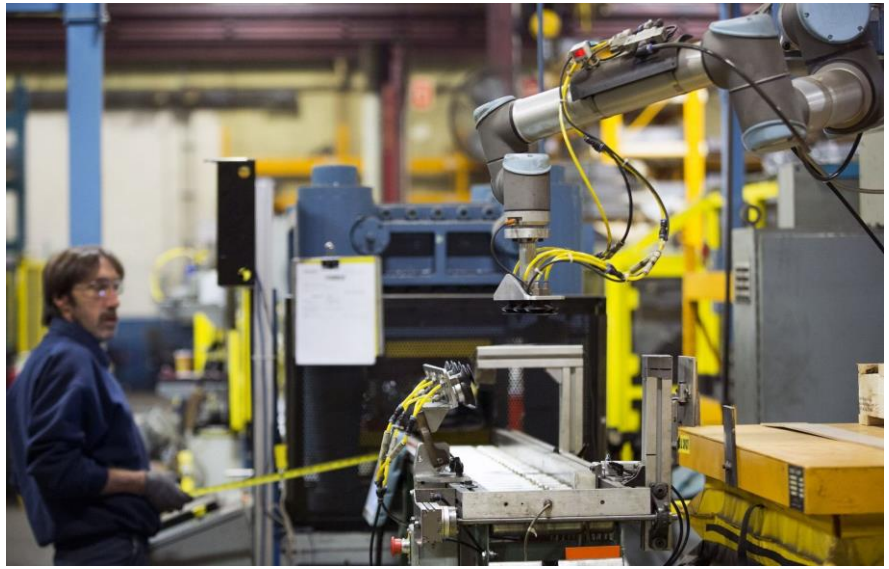
Ex: Chemical agent, excessively variable temperatures, noise

- Certain paces of work

Ex: Night work, work in shifts, repetitive work

Issues and crux of a cobotic system

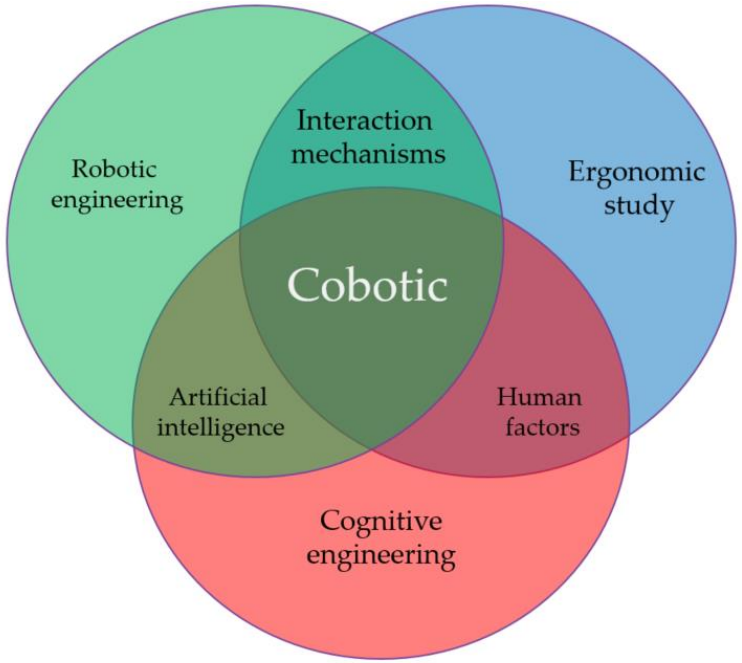
- Safety requirements impose reduced speed, forces, etc.
- Cost of additional safety-enabled components and additional engineering and certification effort
- Slower
- Less powerful
- Payload
- High precision



Challenges and open issues of cobotic system

In order to integrate and adopt cobotic system into industrial manufacturing, several challenges and open issues still need to be addressed:

- Security and safety (Control of contacts and physical interaction),
- Role estimation and adaptive role allocation during collaboration,
- Synchronization and coordination,
- Learning by demonstrations,
- Ergonomic reasons,
- Cobot acceptance,
- Performance of collaboration productivity.

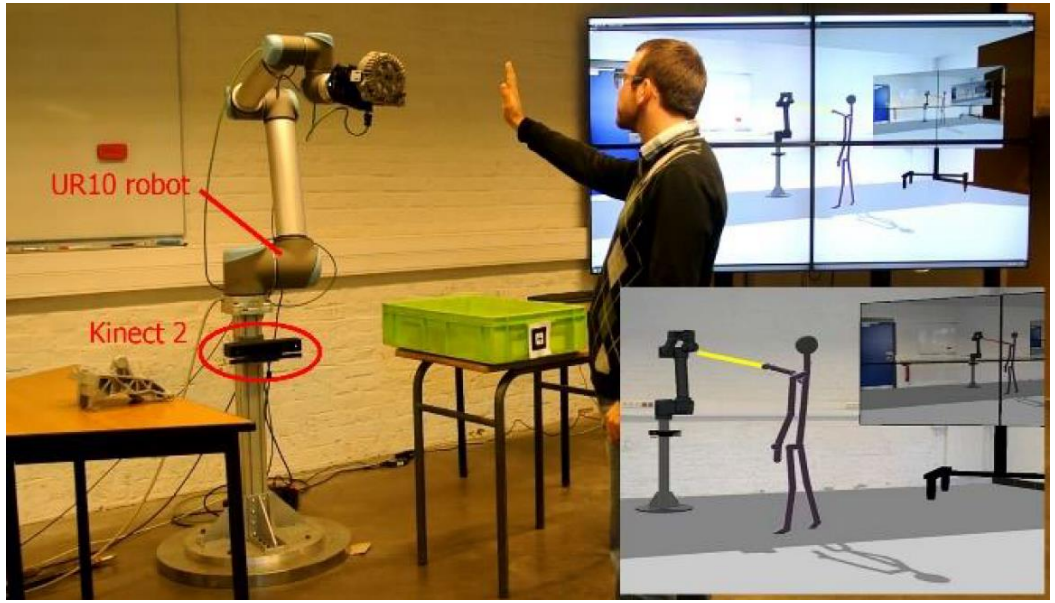


Challenges and open issues of cobotic system

Security and safety

- Safety protects humans from the systems. It is assured by limiting the maximum transmittable energy during impact, due to the robot structure.

- Security essentially protects the systems from humans as attackers.
  - Should be introduced while developing control architectures.
  - So as not to injure human collaborators while performing tasks.



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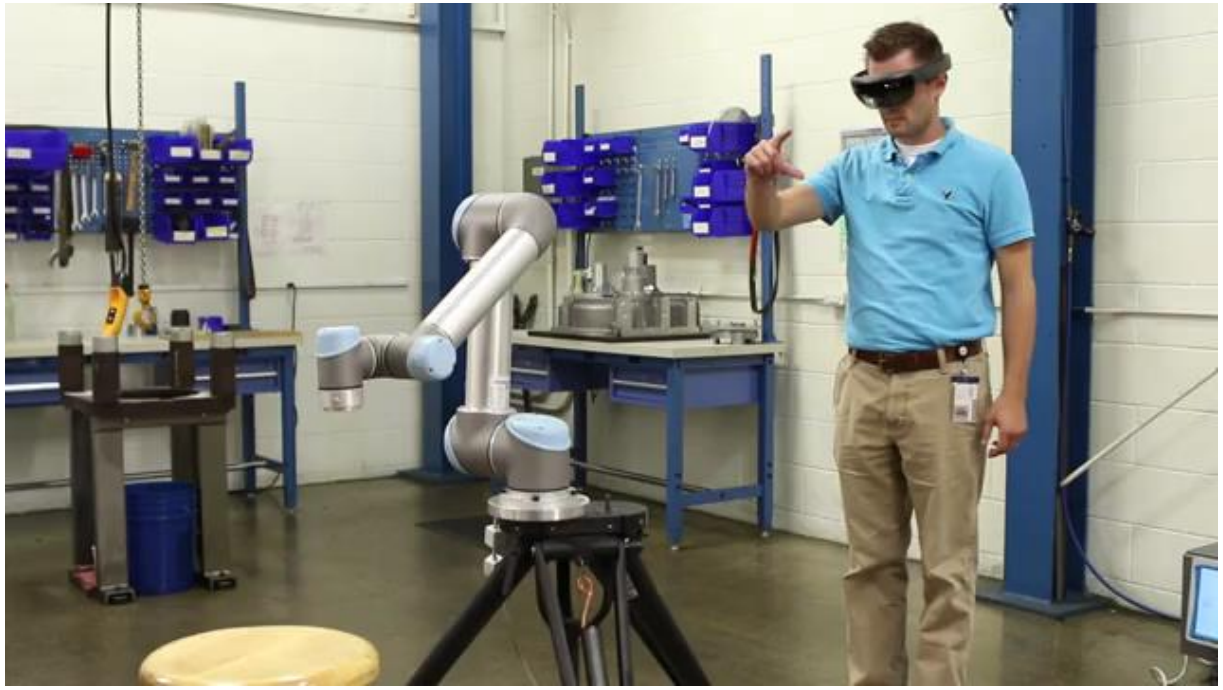
Challenges and open issues of cobotic system

- **Virtual & augmented reality**

- Through VR/AR technology, humans will be able to obtain virtual objects, graphics instructions and information on the robot motion.

- The robot will receive control commands from the human to help transferring virtual objects...



The next wave of automation

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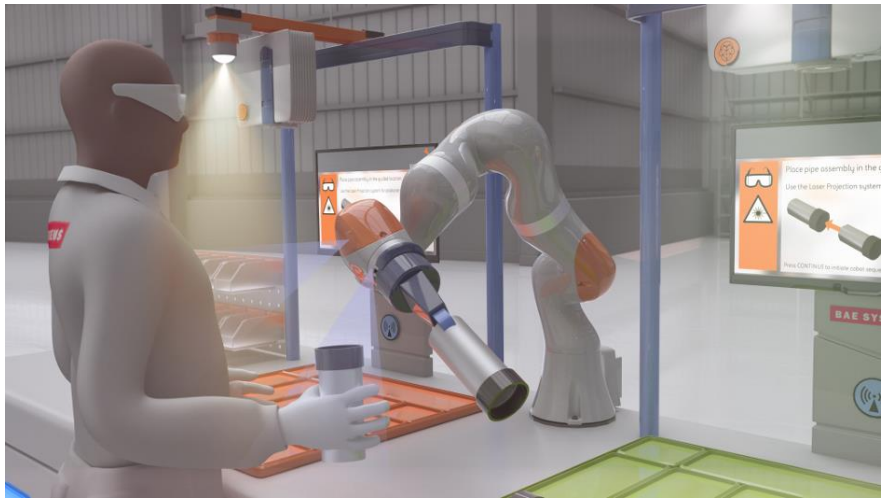
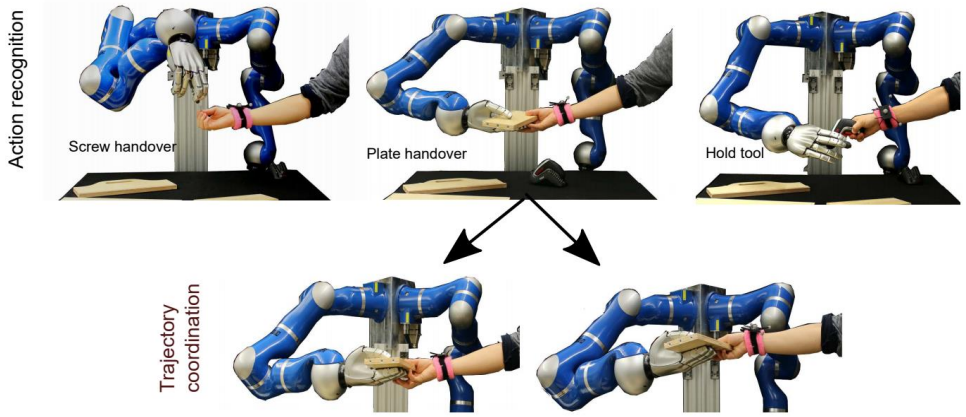
https://blog.universal-robots.com/how-augmented-reality-and-cobots-drive-the-next-wave-of-automation

Challenges and open issues of cobotic system

- **Perception and interpretation of human behaviors**
- Detect human presence, identify and determine requests based on body language, hand gestures, activities, etc.
- Examine markerless recognition.





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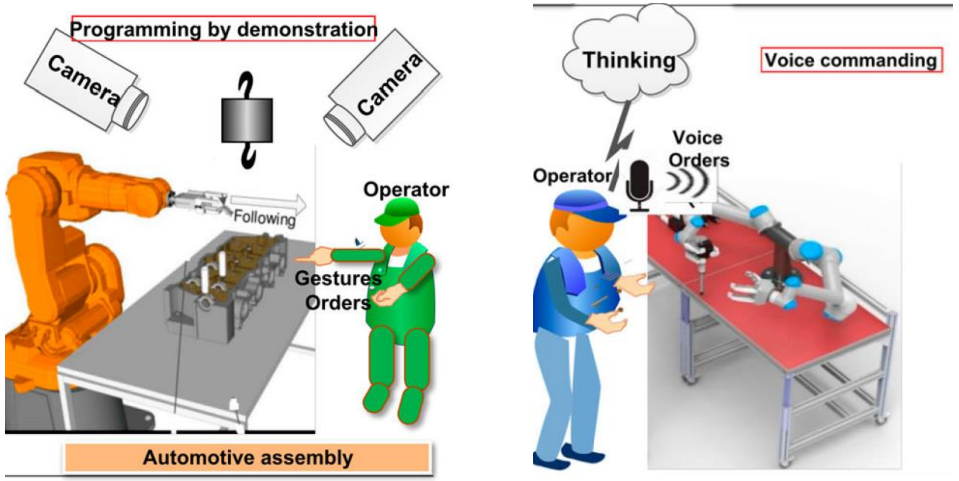
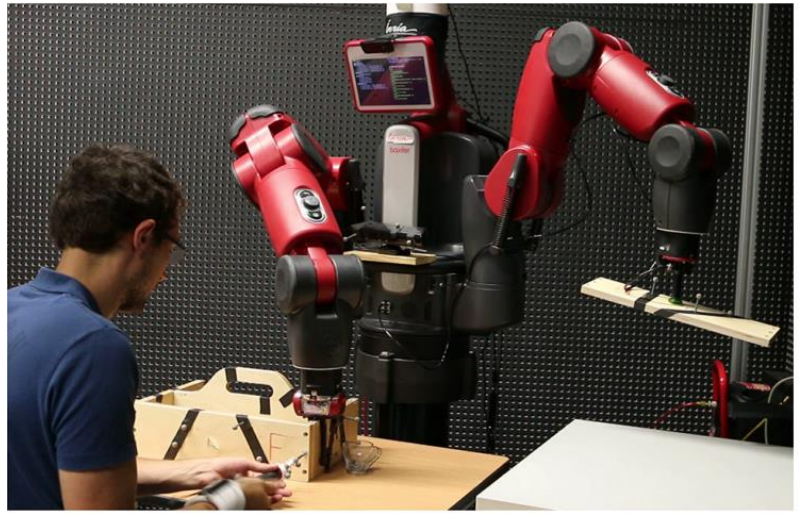
Maeda, G., Ewerton, M., Neumann, G., Lioutikov, R., & Peters, J. (2017). Phase estimation for fast action recognition and trajectory generation in human–robot collaboration. *The International Journal of Robotics Research*, *36*(13-14), 1579-1594.

Challenges and open issues of cobotic system

- **Multi-modal high-level interaction**
- HRI in cobotic systems must incorporate several methods with a high-level interface to guide human accomplishing operations.
- Combining audio commands with gestures simultaneously
- Adding virtual objects on the real-world scene.





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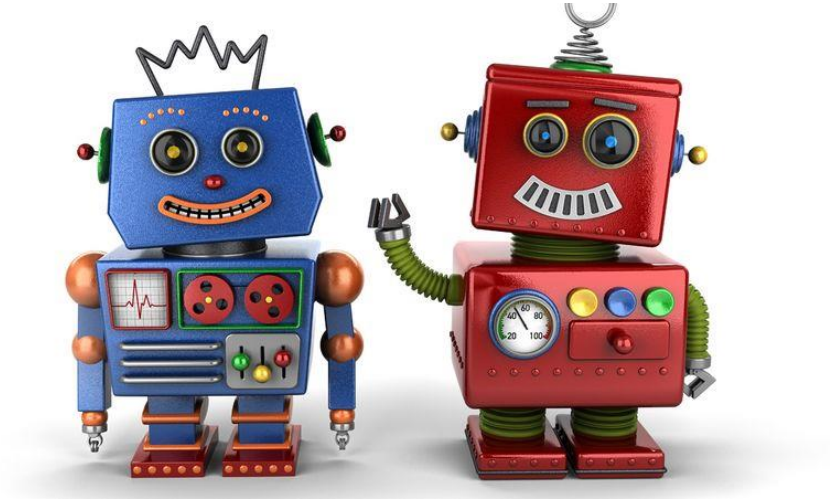
Conclusion

- Cobotic received much attention from academia.
- Trend in industrial cobotics is to obtain flexible systems where humans and robots can safely interact and collaborate to achieve assigned tasks.
- When humans need to physically interact with a robot, the standard of normal and effective performance is their experiences of daily interactions with other humans.



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