Collaborative robotics in manufacturing: an accessible and flexible solution

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What's my expertise in collaborative robotics?

- Cobot black belt, everyday usage ☐
- Made some experiments ☐
- Got some information from media coverage ☐
- No knowledge at all ☐

Collaborative robotics in manufacturing

→ Agenda

Welcome Mr. Cobot

→ From technology to innovation

Edwin Mansfield, a professor at the University of Pennsylvania, calculated in 1989 that it had taken 12 years for half of the population of potential robot users to be persuaded to use industrial robots even though they admitted their considerable advantages

Welcome Mr. Cobot

→ A definition

"The objective of collaborative robots is to combine the repetitive performance of robots with the individual skills and ability of people. People have an excellent capability for solving imprecise exercises; robots exhibit precision, power and endurance."

[ISO150066]

Welcome Mr. Cobot

→ Brief history

1920
The term «robot» is coined by the science fiction writer Karel Čapek

1954-59
George Devel invents the first industrial robot, collaborates with Joseph Engelberger and launches «Ultimate» which is initially deployed at General Motors

1960-00
Industrial robots in cages spread in automotive and other industrial sectors

2001-05
At University of Southern Denmark a new type of robot is invented to match the evolving market needs

2005
Universal Robots is founded by researchers Esben Østergaard, Kristian Kassow and Kasper Støy

2008
Universal Robots launches UR5, the first collaborative robot to enjoy commercail success

2012
Universal Robots launches UR10 with increased reach and enhanced payload

2012-16
Maturity of collaborative robots makes new producers (KUKA, ABB, Fanuc, …) and startups (Rethink Robotics) join the segment

2015
Universal Robots launches UR3, the first table-top collaborative robot

2016
ISO eventually publishes the ISO/TS 15066 standard, defining guidelines for workers' safety in collaborative robotics environments

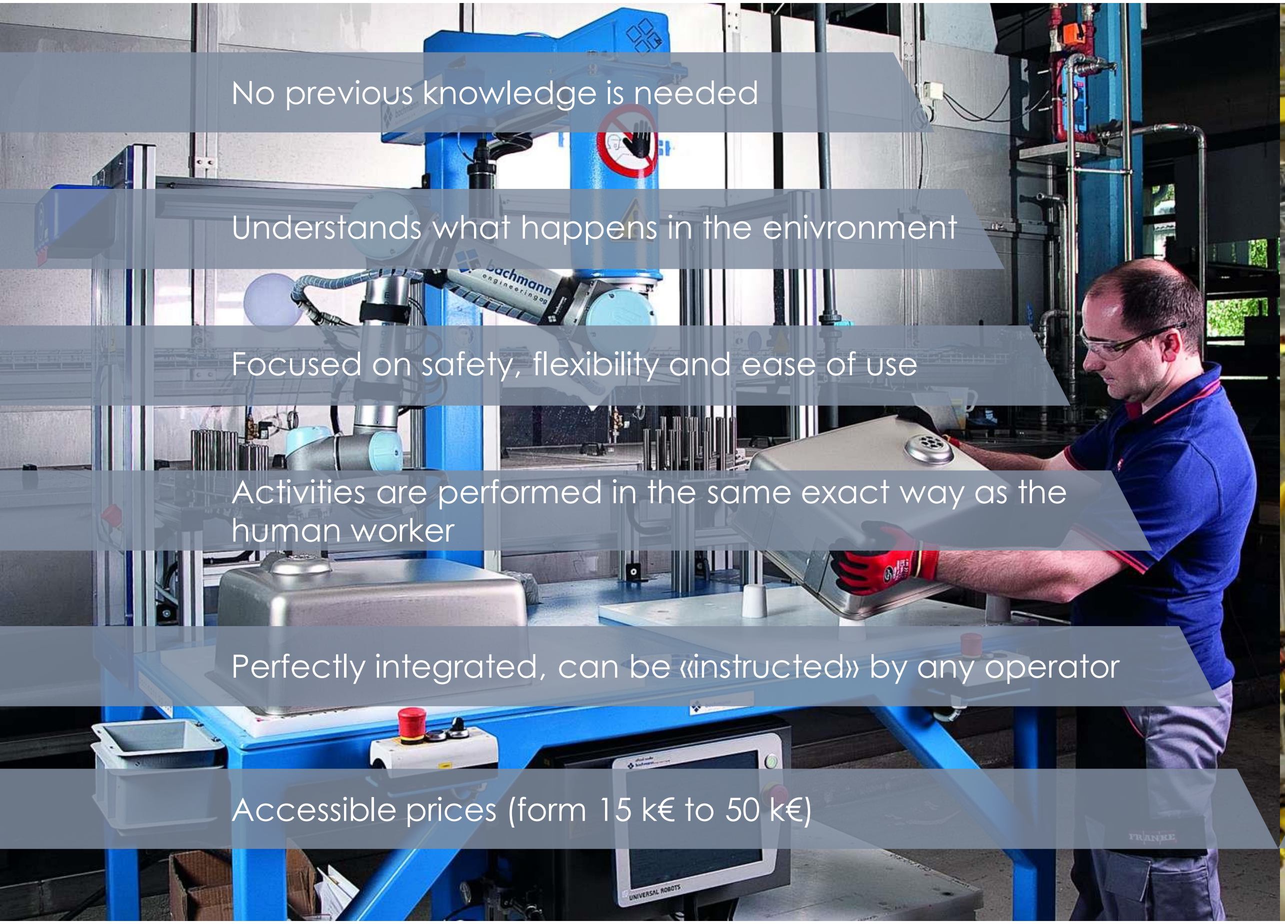
2018
The global market of collaborative robots reaches a value of 500 million dollars

Source: Universal Robots

Welcome Mr. Cobot

→ Collaborative robots vs. traditional robots

Collaborative robots



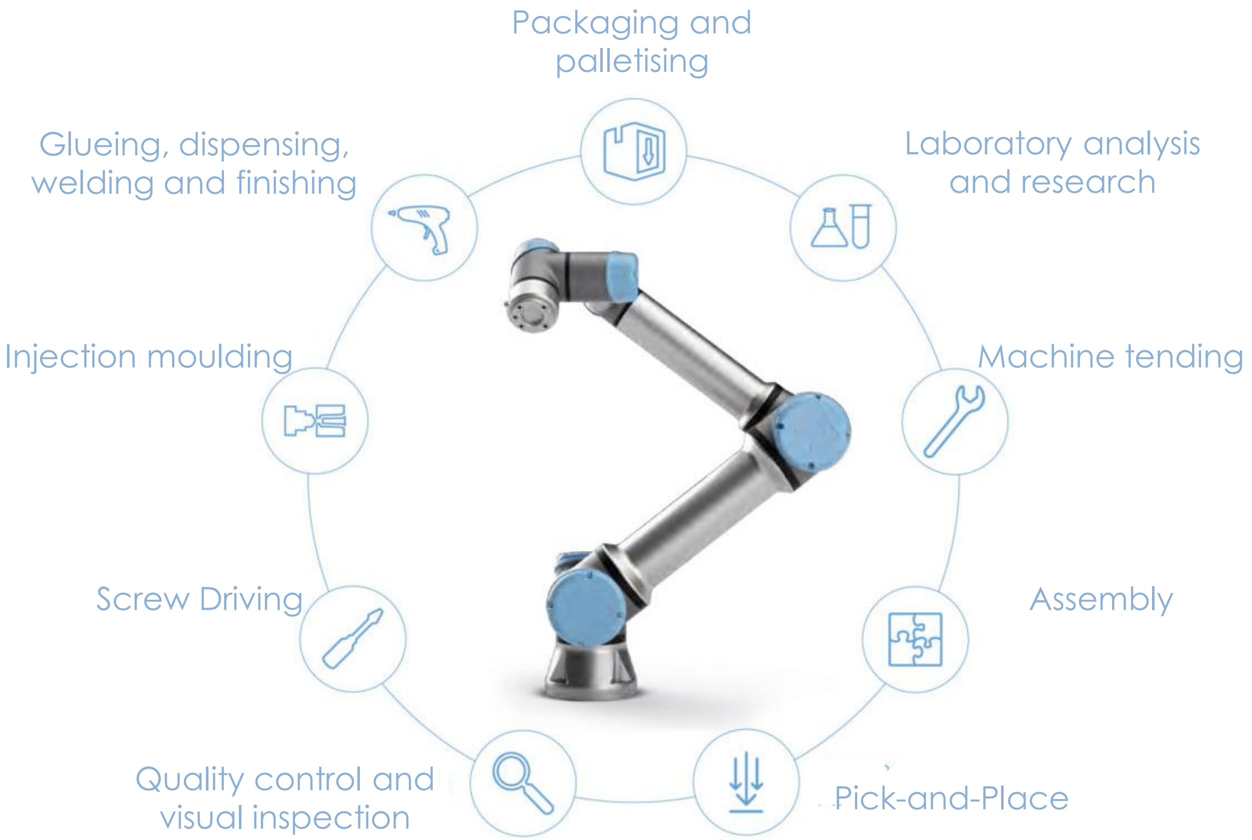
- No previous knowledge is needed
- Understands what happens in the enivronment
- Focused on safety, flexibility and ease of use
- Activities are performed in the same exact way as the human worker
- Perfectly integrated, can be «instructed» by any operator
- Accessible prices (form 15 k€ to 50 k€)

- Require programming, robotics and automation experience
- Blind and unaware of the surrounding environment
- Focused on performance, precision and repeatability
- Programmed for a specific task
- Require integration and dedicated tooling
- Expensive (>100 k€)

Traditional robots

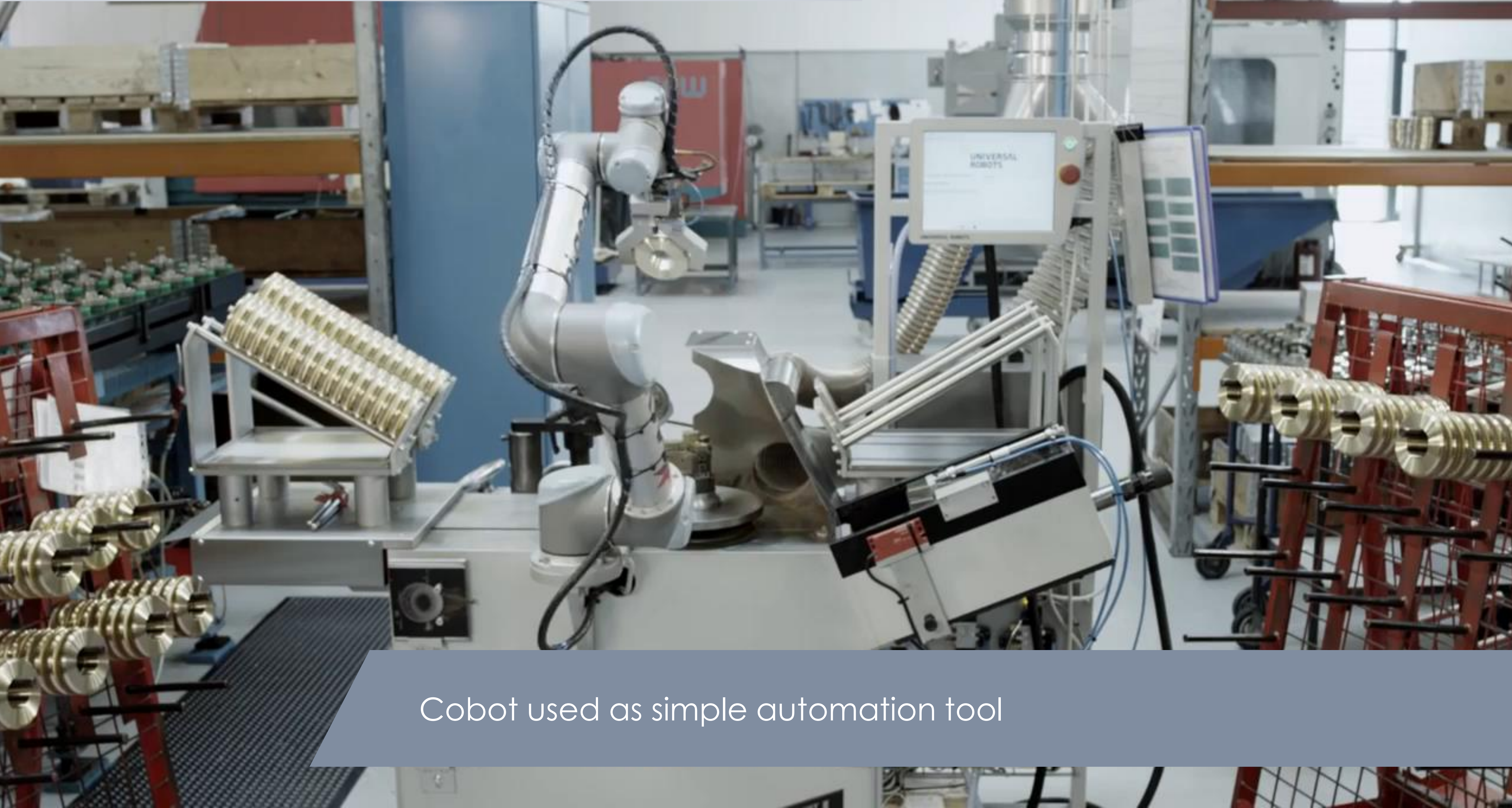
Welcome Mr. Cobot

→ Typical applications



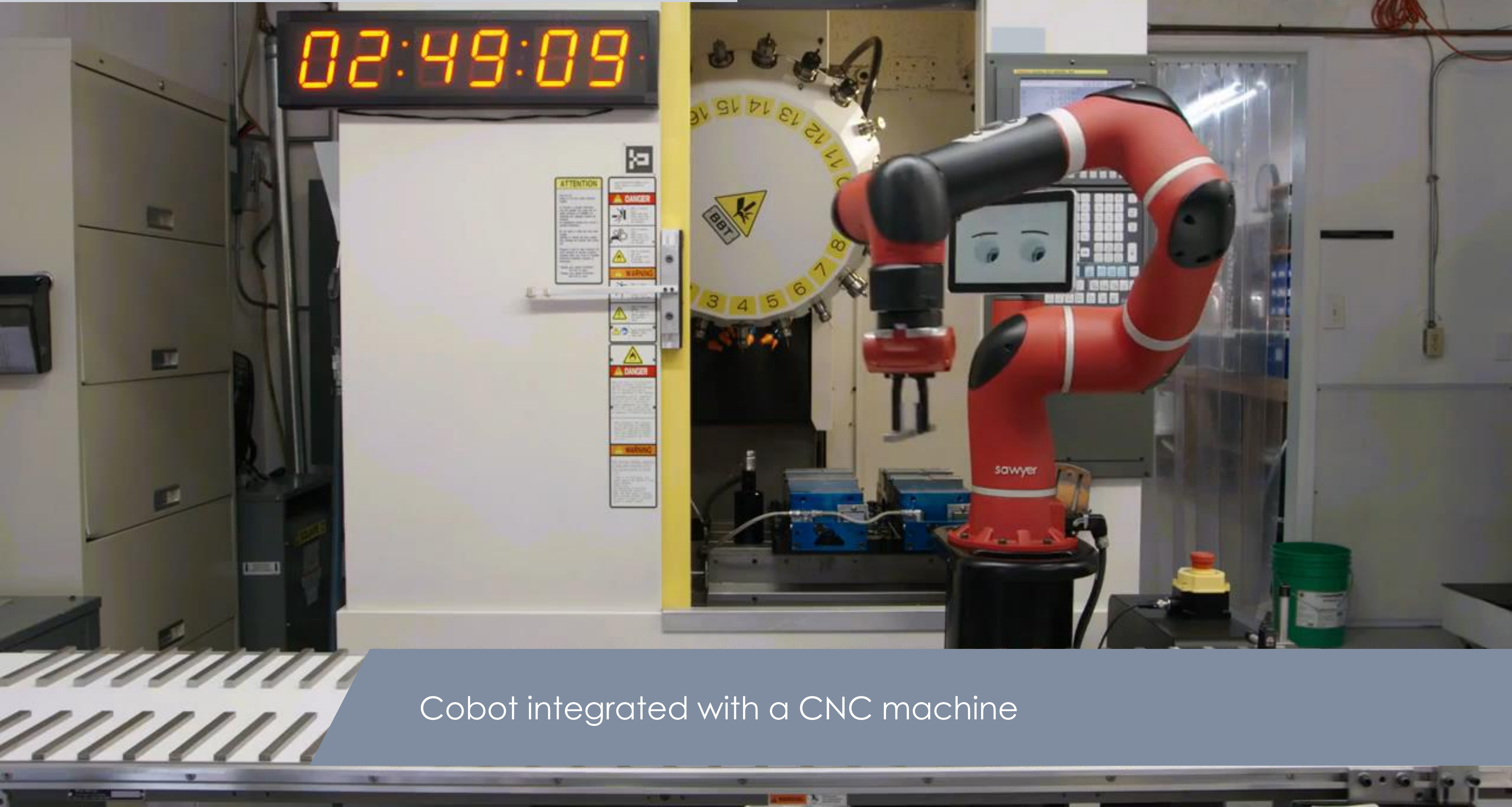
Source: Universal Robots

https://www.youtube.com/watch?v=plcxOGo7ieU time 2:22



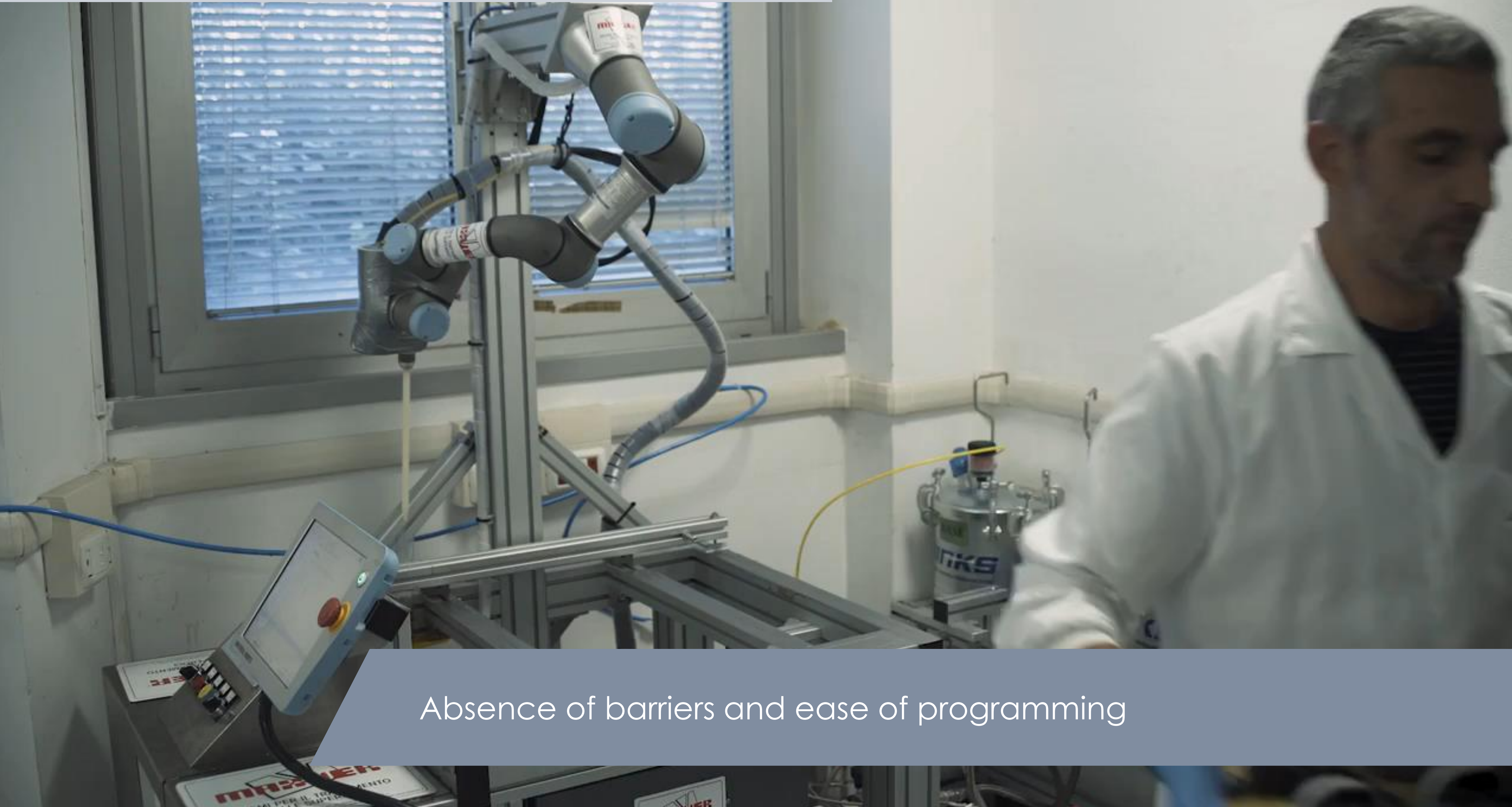
Cobot used as simple automation tool

https://www.youtube.com/watch?v=fCrYsSKNgiA



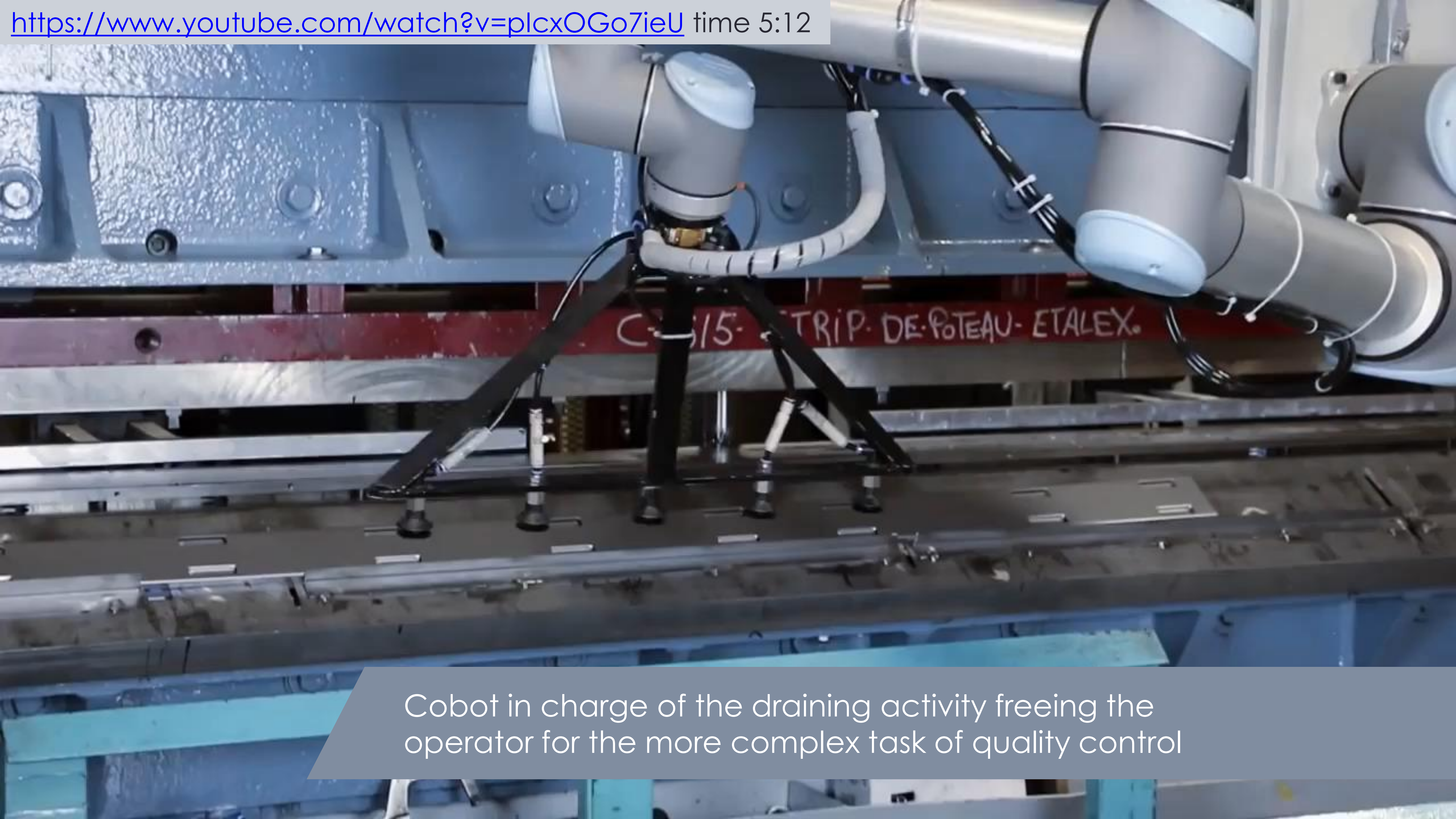
Cobot integrated with a CNC machine

https://www.youtube.com/watch?v=bVJNjm2SeTQ&t=11s



Absence of barriers and ease of programming https://www.youtube.com/watch?v=nFzBXGnI8-0 time 3:40

Safety devices added to enhance collaboration https://www.youtube.com/watch?v=pIcxOGo7ieU time 5:12

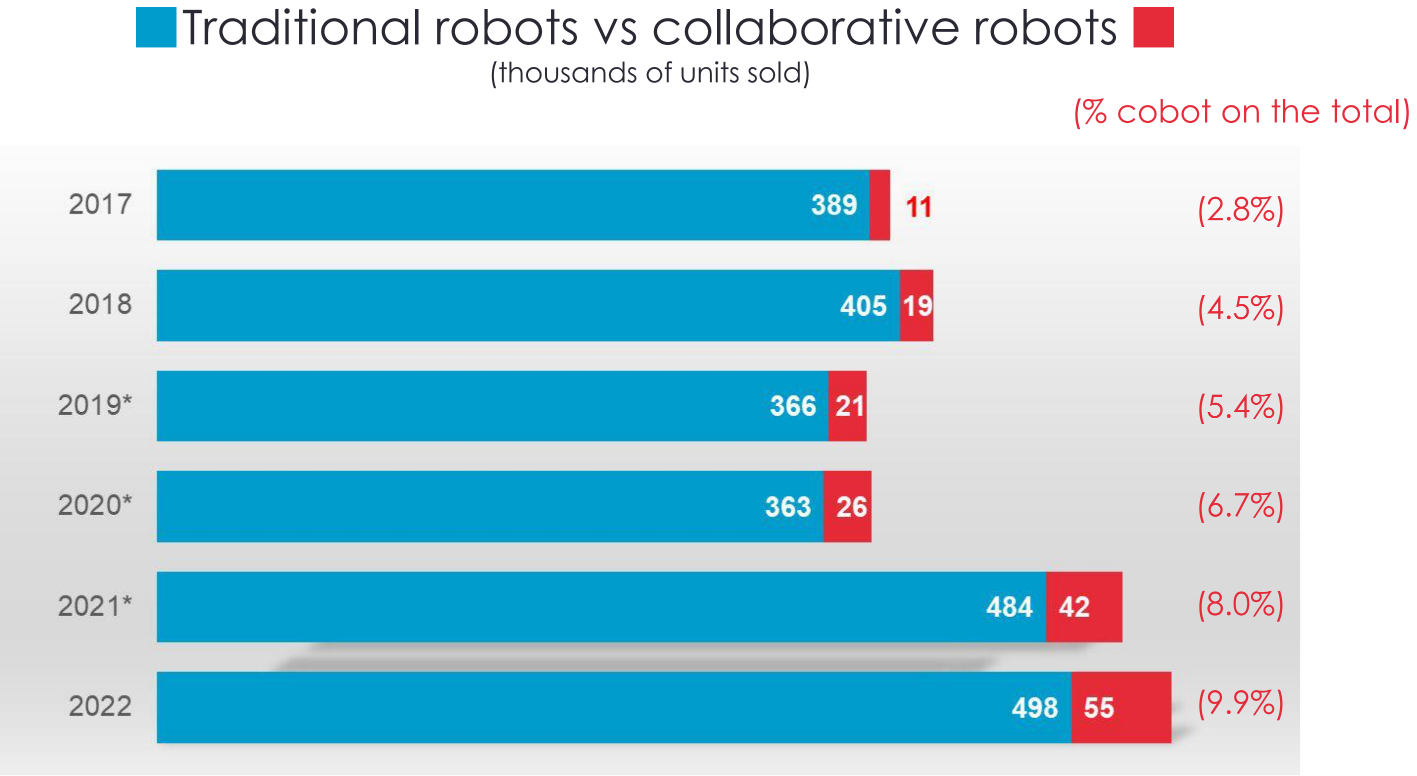


Cobot in charge of the draining activity freeing the operator for the more complex task of quality control https://www.youtube.com/watch?v=plcxOGo7ieU time 7:32

Cobot collaborating with workers to carry out tasks requiring the highest accuracy

Market trends and application sectors

→ Units sold



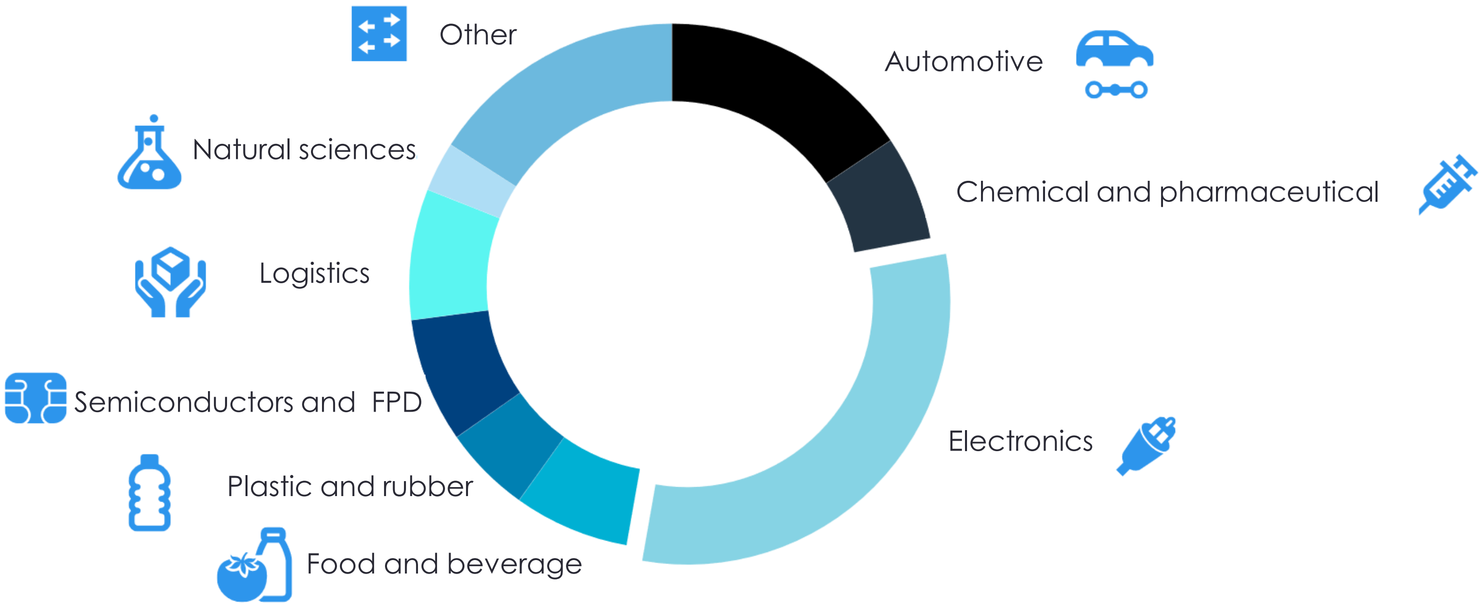
Source: World Robotics, 2023

There are on average 74 robots in the work every 10’000 workers

[International Federation of Robotics]

Market trends and application sectors

→ Application sectors

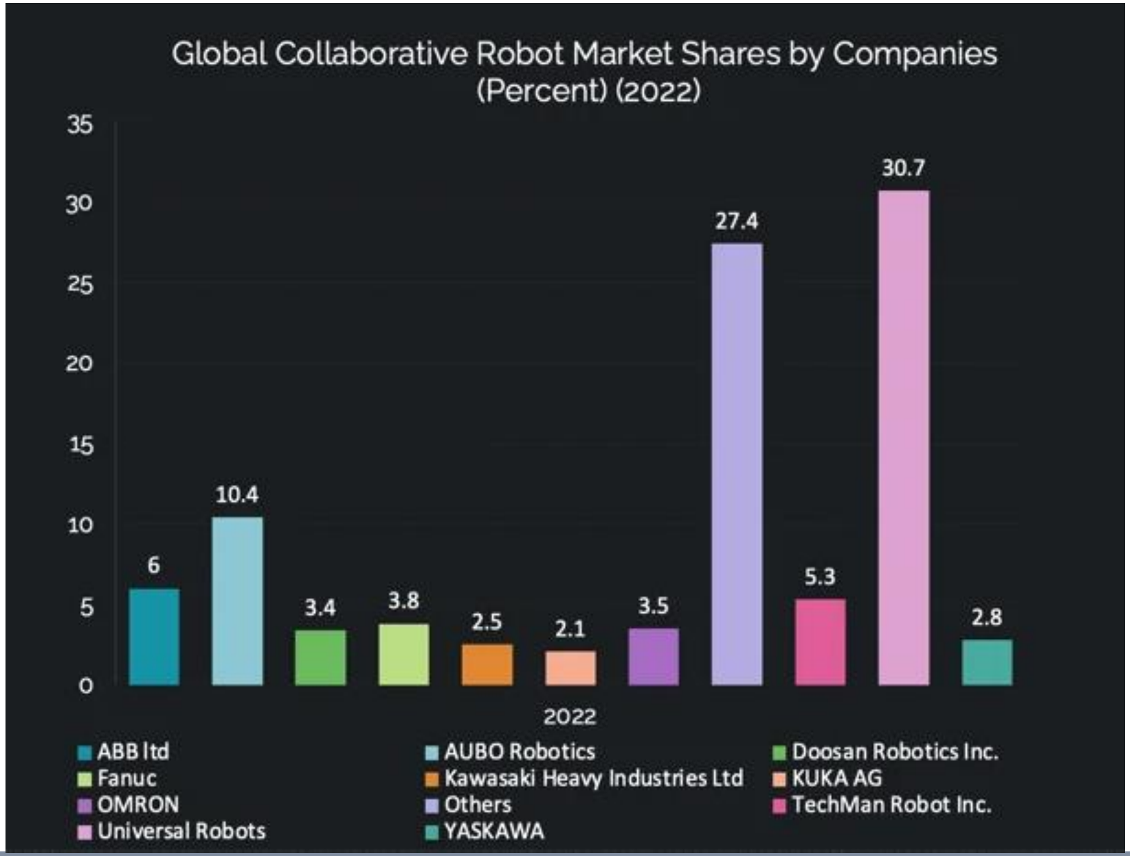


The sectors with the highest amount of deployed cobots are electronics, automative and logistics

[Interact Analysis]

Market trends and application sectors

→ Market shares



Universal Robots still holds the biggest market share with 30% of the sector revenues

[Statzon/ Market Research Future]

Market trends and application sectors

→ From the smallest to the biggest one

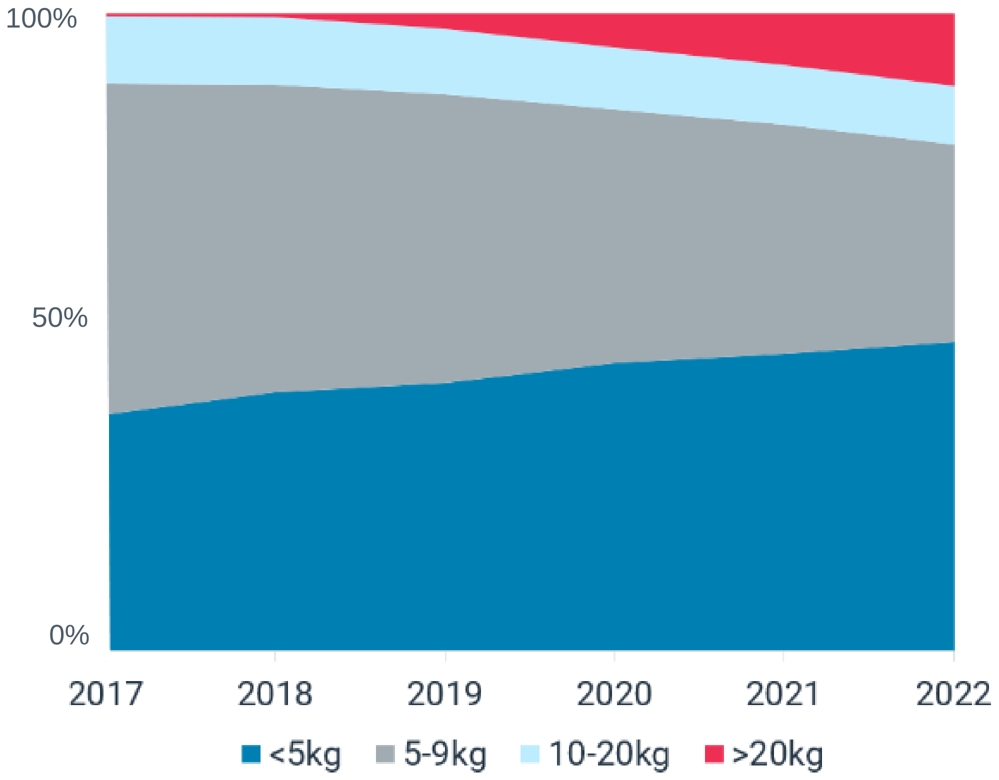
ABB YuMi – IRB 14000
Degrees of freedom: 7+7
Payload: 0.5 kg
Reach: 559 mm
Repeatability: ± 0.02 mm
Weight : 38 kg
Speed: 1500 mm/s
Safety: Intrinsic

Universal Robot UR5
Degrees of freedom: 6
Payload: 5 kg
Reach: 850 mm
Repeatability: ± 0.1 mm
Weight: 18.4 kg
Speed: 1000 mm/s
Safety: Joint sensors

FANUC CR-35iA
Degrees of freedom: 6
Payload: 35 kg
Reach: 1’813 mm
Repeatability: ± 0.04 mm
Weight: 990 kg
Speed: 750 mm/s
Safety: Force sensor

Market trends and application sectors

→ Is bigger better?



Small size cobots are the most requested

[Interact Analysis]

What is the ideal application to begin the cobot journey

- Productivity
- Task complexity
- Variability of workpieces
- Collaboration level
- Connectivity and integration
- Work environment

6 Key dimensions

Source: Universal Robots

Where to start from

- **Productivity**
- Task complexity
- Variety of workpieces
- Collaboration level
- Connectivity and integration
- Work environment

Productivity similar to the operator's

→ improves **ergonomics** and **quality**
→ the process can continue **without stops**
→ the cobot is in charge of **low added value** and **unsatisfactory** activities

Source: Universal Robots

Where to start from

- Productivity
- **Task complexity**
- Variety of workpieces
- Collaboration level
- Connectivity and integration
- Work environment

Simple and constant tasks

→ cobot peroms its work with a **simple** and **minimal feedback** from sensors or external controllers

Source: Universal Robots

Where to start from

- Productivity
- Task complexity
- **Variety of workpieces**
- Collaboration level
- Connectivity and integration
- Work environment

Constant format, same sorting, easy to pick

→ the workpiece is always presented in the **same position** on a table or tray, so that the cobot repeats its process many times

→ **a single end effector** is enough for multiple processes

Source: Universal Robots

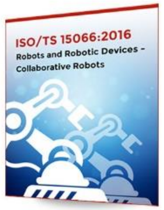
Where to start from

- Productivity
- Task complexity
- Variety of workpieces
- **Collaboration level**
- Connectivity and integration
- Work environment

Specific work and interaction spaces for operators and cobot

→ the cobot executes the **repetitive phases**, and eventually **dangerous** handling of work pieces and interaction with other machines while operators perform **specialised tasks**

→ **risk analysis** helps to define the human-cobot interaction in a proper way



ISO15066 specifies the safety requirements for a collaborative system

Source: Universal Robots

Where to start from

- Productivity
- Task complexity
- Variety of workpieces
- Collaboration level
- **Connectivity and integration**
- Work environment

Cobot mimicking the human interaction with other machines

→ the cobot simply **takes** over a human interaction, such as opening a door, loading or unloading workpieces or even more complex tasks

Source: Universal Robots

Where to start from

- Productivity
- Task complexity
- Variety of workpieces
- Collaboration level
- Connectivity and integration
- **Work environment**

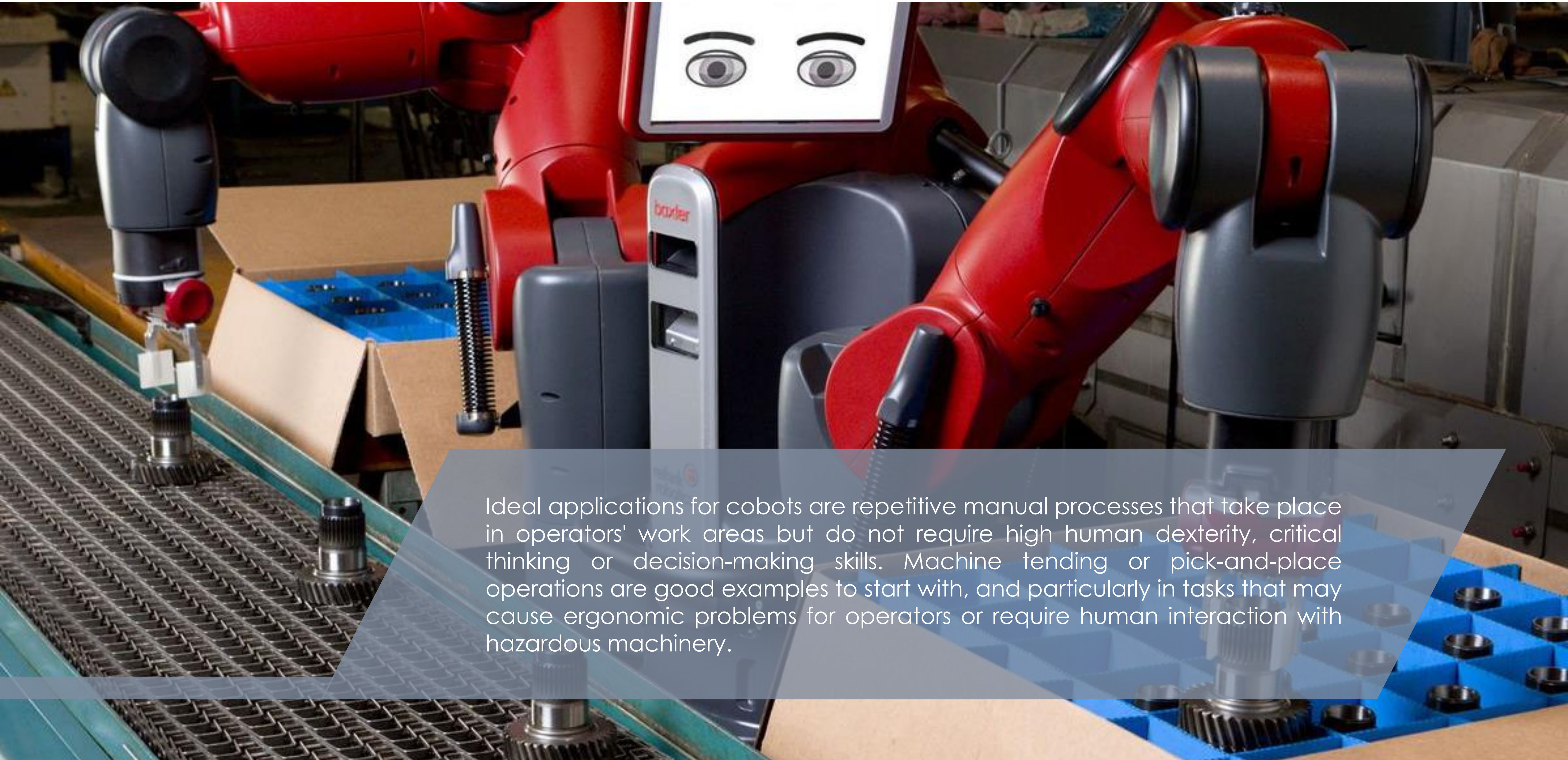
Standard operators' work environment

→ cobots can operate in almost any environment in which human beings typically work **independently from temperature, noise or dirt**

Source: Universal Robots

Where to start from

→ The ideal application



Ideal applications for cobots are repetitive manual processes that take place in operators' work areas but do not require high human dexterity, critical thinking or decision-making skills. Machine tending or pick-and-place operations are good examples to start with, and particularly in tasks that may cause ergonomic problems for operators or require human interaction with hazardous machinery.

Our research in collaborative robotics

→ Our survey on collaborative robotics adoption

- 39 interviews
- 19 manufacturing companies
- 20 system integrators
- 17 European countries

Our research in collaborative robotics

→ Our survey on collaborative robotics adoption

41%

of interviewed companies not owning a cobot is willing to buy one in the next 3 years

45%

of system integrators already worked on a cobot deployment

47%

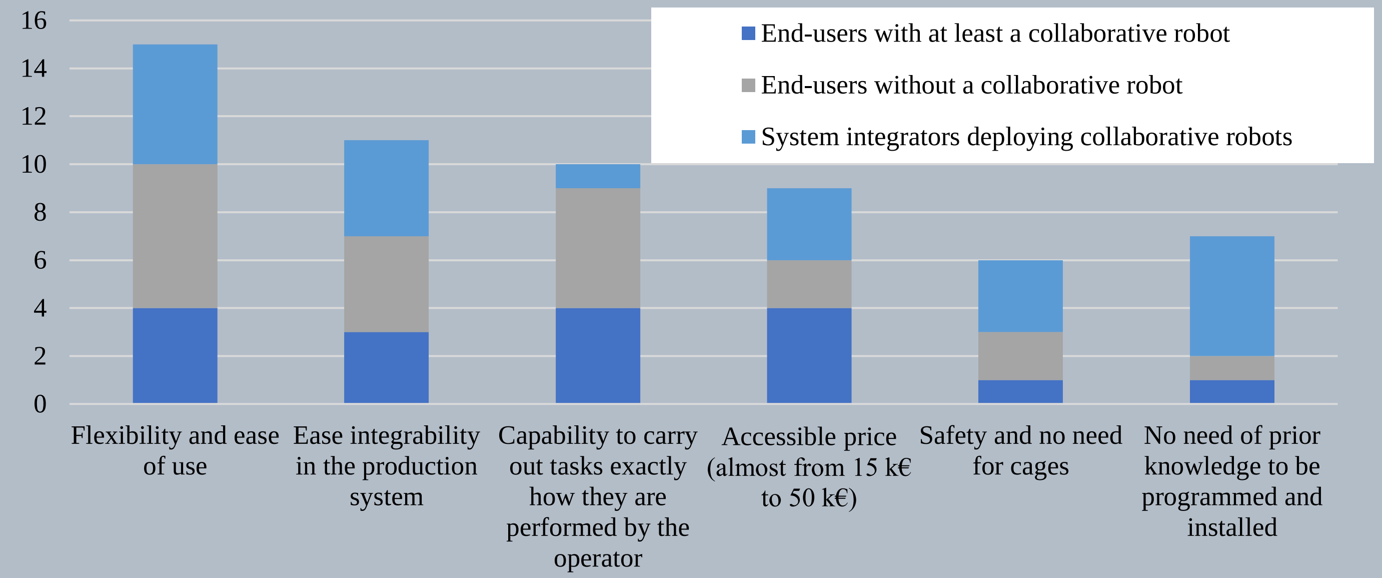
of users have a cobot in production

Lack of resources and high initial investment

are considered main barriers to the introduction of collaborative robotics

Montini, E., Daniele, F., Agbomemewa, L., Confalonieri, M., Cutrona, V., Bettoni, A., ... & Ferrario, A. (2024). Collaborative Robotics: A Survey From Literature and Practitioners Perspectives. *Journal of Intelligent & Robotic Systems, 110*(3), 117.

Features driving the choice of collaborative robots



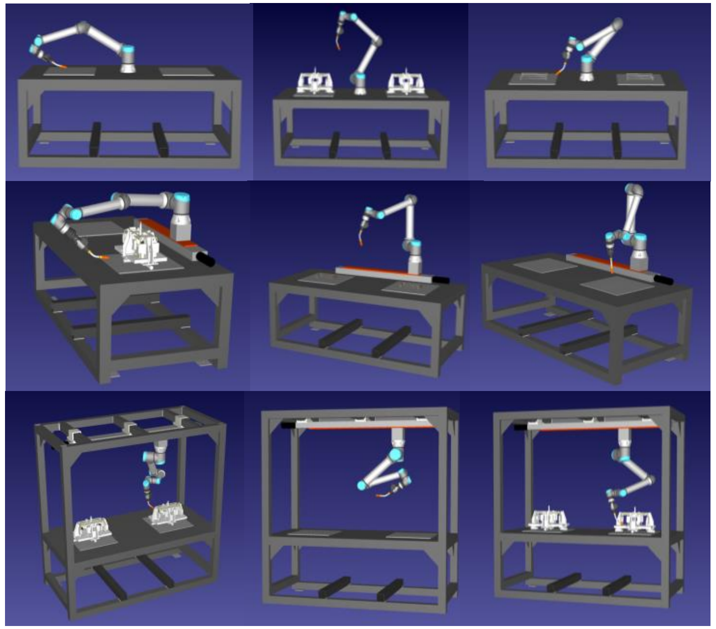
Our research in collaborative robotics

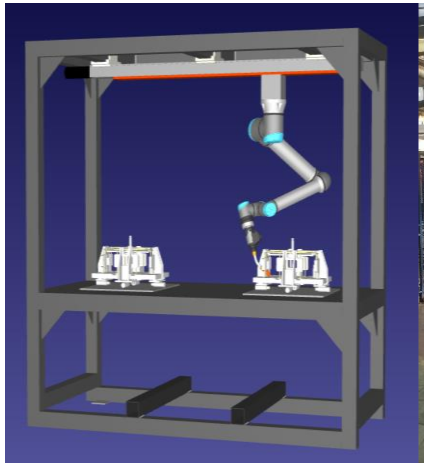
→ Thesis: cobot in steel wire processing

Maximizing the productivity and well-being of workers in metal processing: a study on the implementation of collaborative robots

[Giovanni Fontana]

- → Identification of **processes** and operations with the greatest potential in the production system
- → Quantitative and qualitative analysis of the technological and production **requirements** of the considered processes
- → Evaluation of the **benefits** and challenges associated with the implementation of cobots in the identified processes and operations
- → Drafting of **recommendations** for the successful implementation of collaborative robots in the company
- → Supporting the development of a **work cell** equipped with a collaborative robot for the identified process

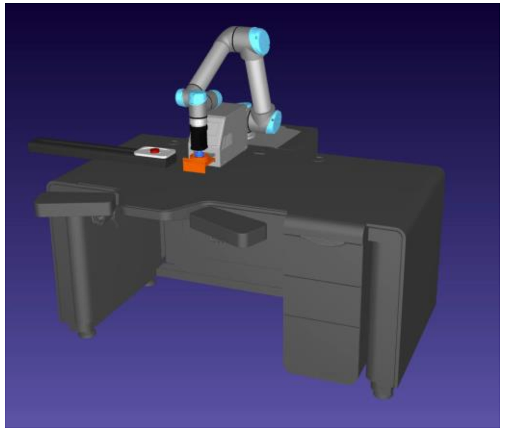




Our research in collaborative robotics

→ Thesis: cobot in the watch industry

SWATCH GROUP



Exploring the Productivity Effects of Collaborative Robotics in Watchmaking Component Assembly Workstations: the TSGA case

[Davide Matteri]

- → Definition of the **process** to be "cobotized"
- → Analysis of the work cell and line **balancing**
- → Design of the new **work cell**
- → Simulation of **comparison** between AS-IS and TO-BE condition
- → Definition of two "what-if" **scenarios**
- → Simulazione di **confronto** tra stato AS-IS e TO-BE

[Mini-Factory] Implementation of the new YuMi work cell

- → Improvement of the work cell design
- → First demonstration of operation

Brilliant: our experience

→ The project goal

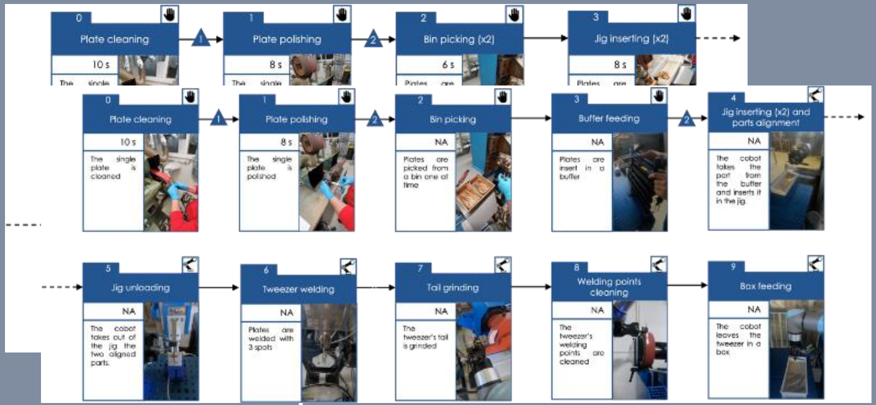
The BRILLIANT project combines the flexibility and dexterity of human beings with the repeatability of cobots to achieve artisanal manufacturing 4.0 by developing a collaborative, smart, orchestrated and reconfigurable work cell

Scuola universitaria professionale della Svizzera italiana
SUPSI

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement N° **863874**

Brilliant: our experience

→ Design, development, programming and deployng of a cobotic work cell



Analysis of the AS-IS scenario

Concept for the TO-BE scenario

Start of the project

Decision

Brilliant: our experience

→ Design, development, programming and deployng of a cobotic work cell

Feasibility analysis for polishing phase

Picking and alignment test

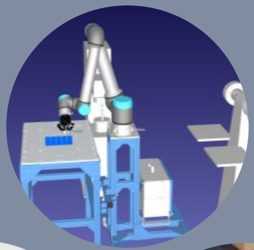
Decision

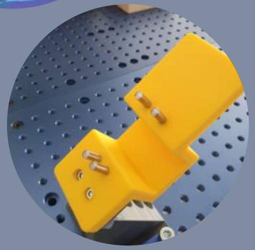
Start of the project

Start of 1st round of laboratory tests

Brilliant: our experience

→ Design, development, programming and deployng of a cobotic work cell





- Programming of elementary operations
- Prototyping
- Simulation and work cell design
- Technology selection

Decision

Start of the project

Start of 1st round of laboratory tests

Start of 2nd round of laboratory tests

Brilliant: our experience

→ Design, development, programming and deployng of a cobotic work cell

Programming to orchestrate cobot and work cell

Part program parametrisation

Start of 1^{st} round of laboratory tests

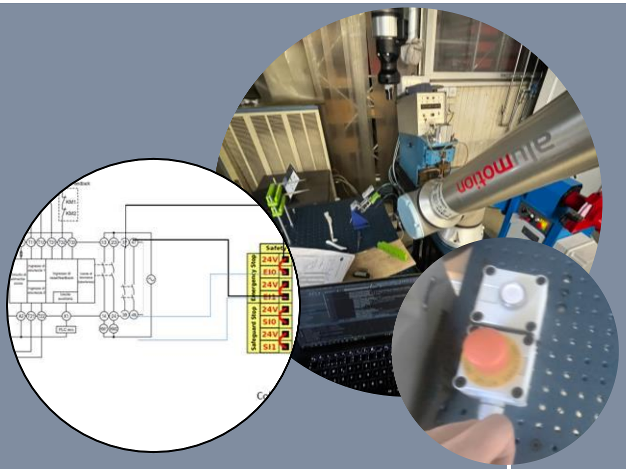
Start of 2^{nd} round of laboratory tests

Start of the project

Decision

Brilliant: our experience

→ Design, development, programming and deployng of a cobotic work cell



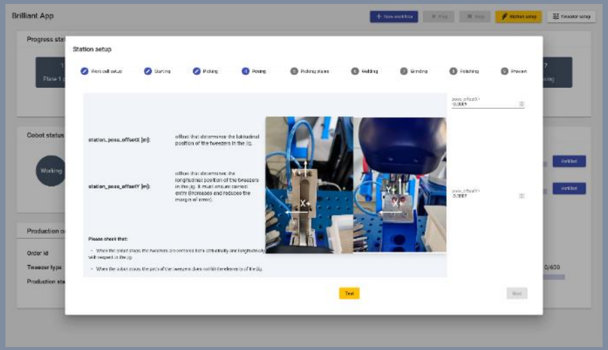
Setup of the work cell

Deployment and integration of machineryi

- Decision
- Start of the project
- Start of 1st round of laboratory tests
- Start of 2nd round of laboratory tests
- Deployment

Brilliant: our experience

→ Design, development, programming and deployng of a cobotic work cell



Support to the GUI development and refinement

Decision

Start of the project

Start of 1^{st} round of laboratory tests

Start of 2^{nd} round of laboratory tests

Deployment

Test and continuous improvement

Brilliant: our experience

→ Design, development, programming and deployng of a cobotic work cell

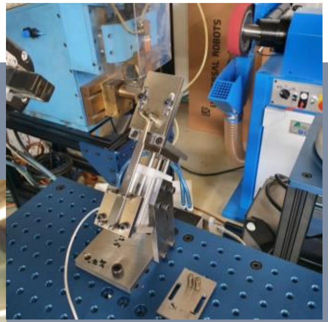
Optimisation of cycle time

Testing

- Decision
- Start of the project
- Start of 1st round of laboratory tests
- Start of 2nd round of laboratory tests
- Deployment
- Test and continuous improvement

Brilliant: our experience

→ Design, development, programming and deployng of a cobotic work cell



Continuous improvement

Scouting of new opportunities

Decision

Start of the project

Start of 1st round of laboratory tests

Start of 2nd round of laboratory tests

Deployment

Test and continuous improvement

End of the project

Brilliant: our experience

→ The achieved result

https://youtu.be/i9XwLzSgDUc

Montini, E., et. Al. (2023, September). A Smart Work Cell to Reduce Adoption Barriers of Collaborative Robotics. In *IFIP International Conference on Advances in Production Management Systems* https://www.youtube.com/watch?v=6E8l6aJ0c3k

KITT4SME

Platform-enabled kits of Artificial Intelligence for an easy uptake by SMEs

AI applied to the collaborative screwdriving process of the automotive parts

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 952119

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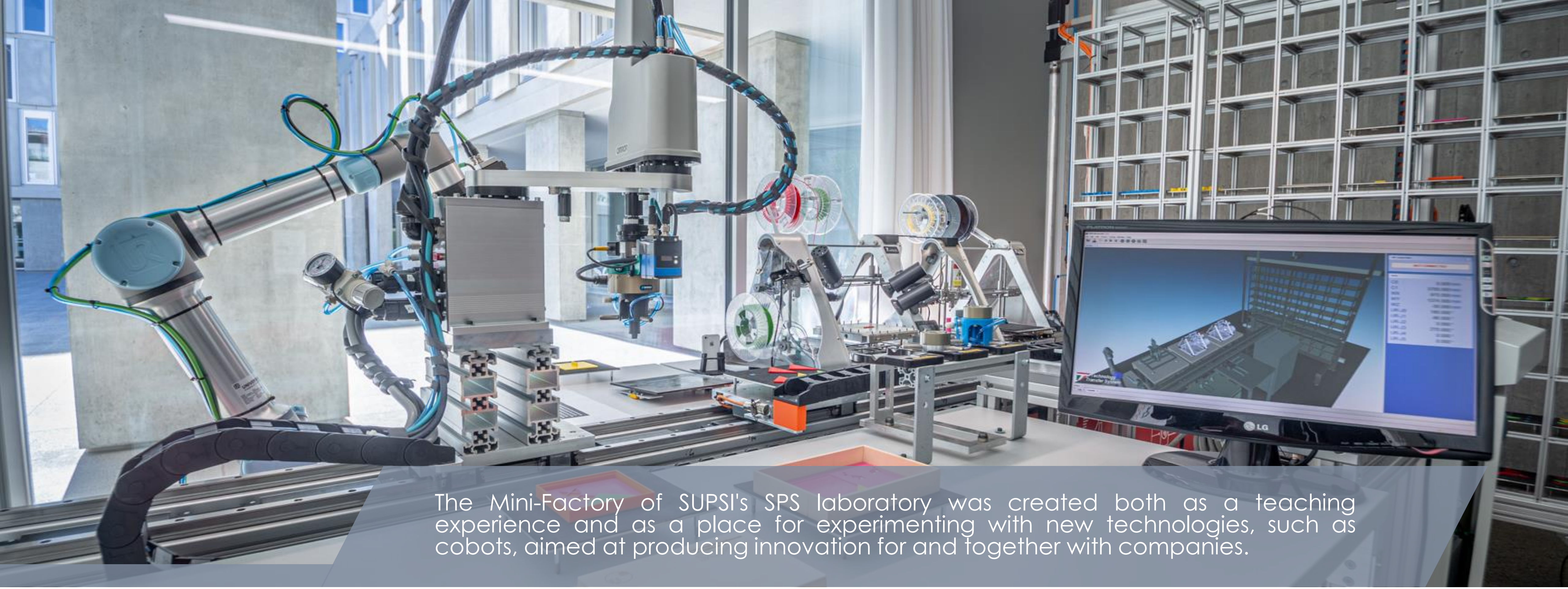

The Mini-Factory of SUPSI's SPS laboratory was created both as a teaching experience and as a place for experimenting with new technologies, such as cobots, aimed at producing innovation for and together with companies.

Thank you for the attention!

Q&A

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More Artificial Intelligence videos from KITT4SME
More Human Robot Collaboration videos from SPS-Lab