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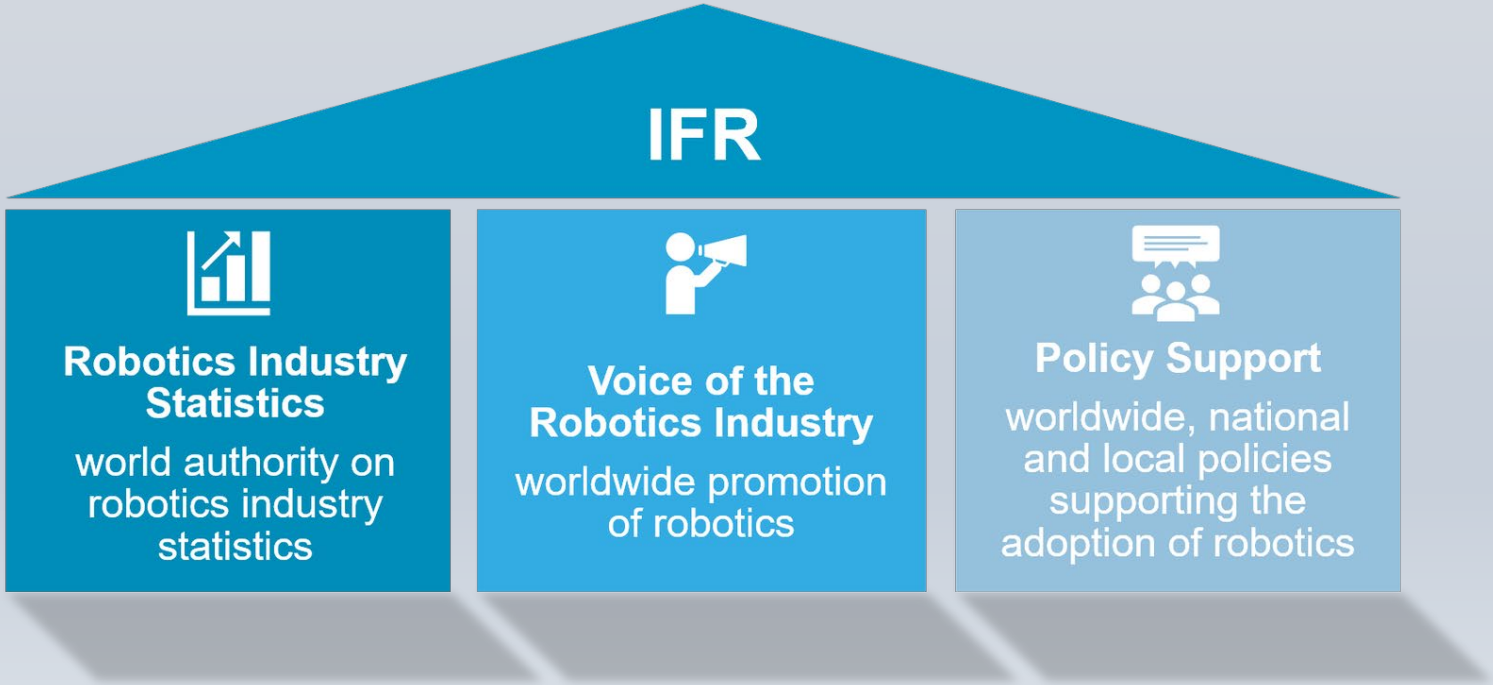
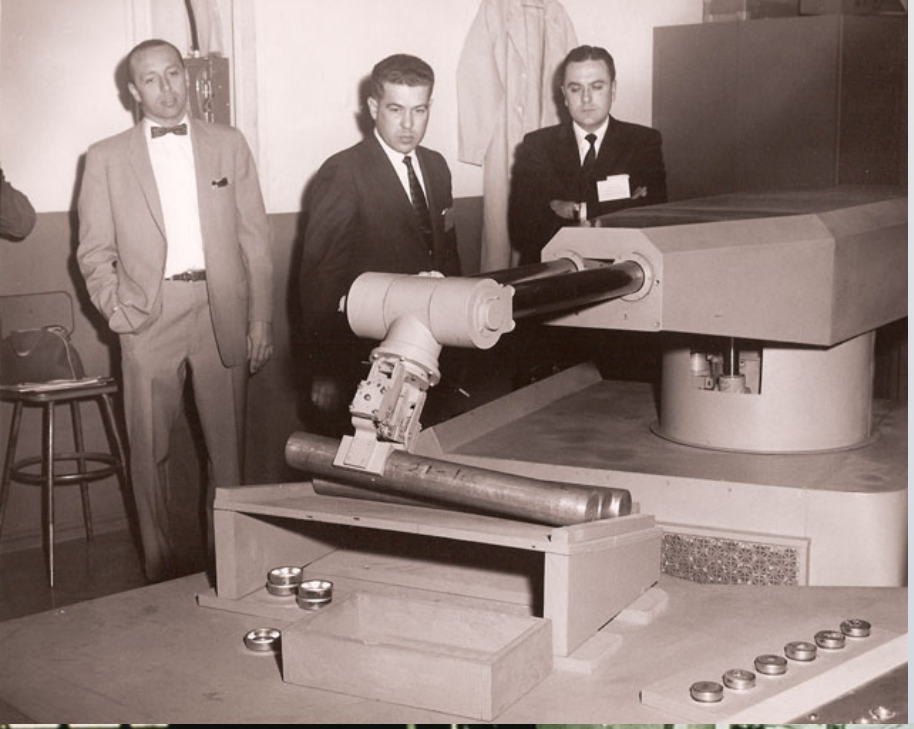
Wie Roboter unsere Fabriken verändern

International Federation of Robotics

- **Non-profit organization since 1987**
- **Connecting the world of robotics around the globe**
- **65 members from over 20 countries**

- **Annual global robotics turnover $50 billion** (robot systems including software & peripherals)





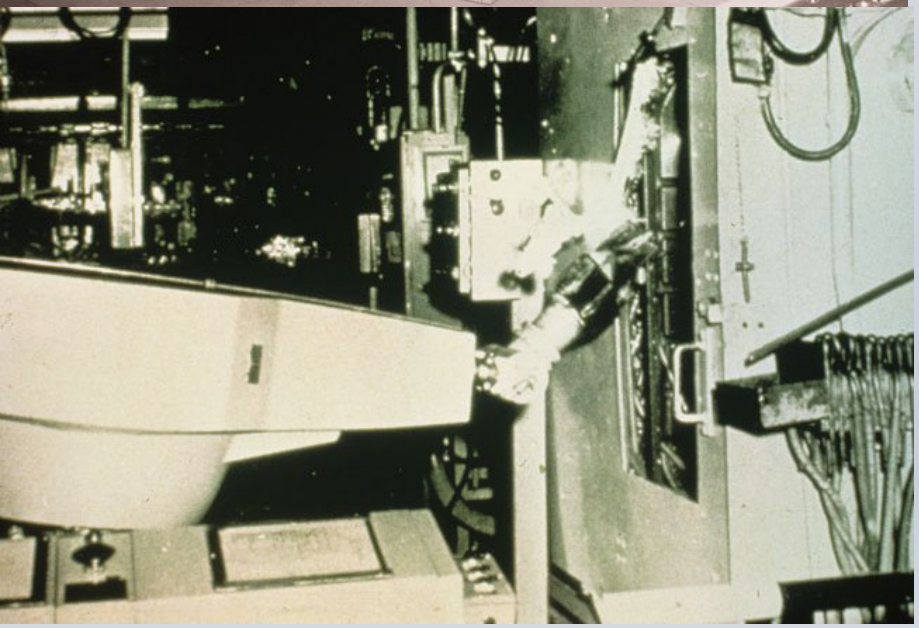


Image: Kuka

Robot History (1)

- **1920:** Czech Science Fiction autor Karel Čapek creates **the word "robot"**
  - Czech "robota" = forced labor, drudgery
- **1956:** George Devol and Joseph Engelberger found "Unimation", **the world's first robotics company**
  - in the 1980ies dissolved into Stäubli
- **1959:** Unimation presents the **prototype** of the first industrial robot
- **1961: First industrial robot deployed** at GM plant in New Jersey
  - production of automotive interior components
  - handling of hot diecast metal pieces

Robot History (2)

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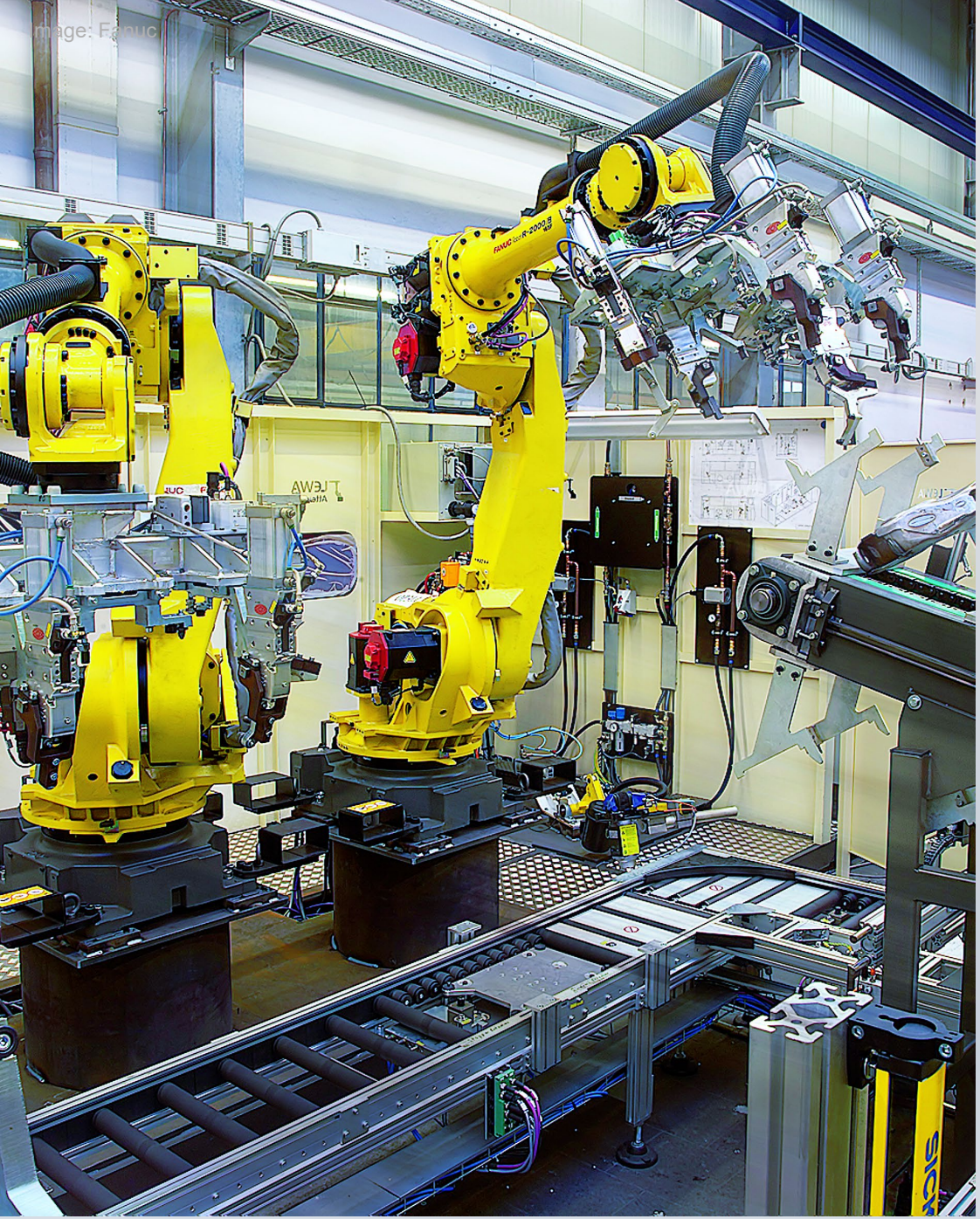
- **1970ies: Technological progress**
  - Substitution of hydraulic parts by electric ones
  - Substitution of magnetic drums by microprocessors
- **1970ies and 1980ies: Competition rises**
  - Market entry of hundreds of European and Japanese companies (start-ups and industry giants expanding into robotics)
- **1990: Shakeout** and market consolidation
- **since the 2000s: Cobots and service robotics** are seeing huge market entry
- **today:** Robots relieve humans from **4d tasks** ("dirty", "dull", "dangerous", "delicate")



Why industrial robots?

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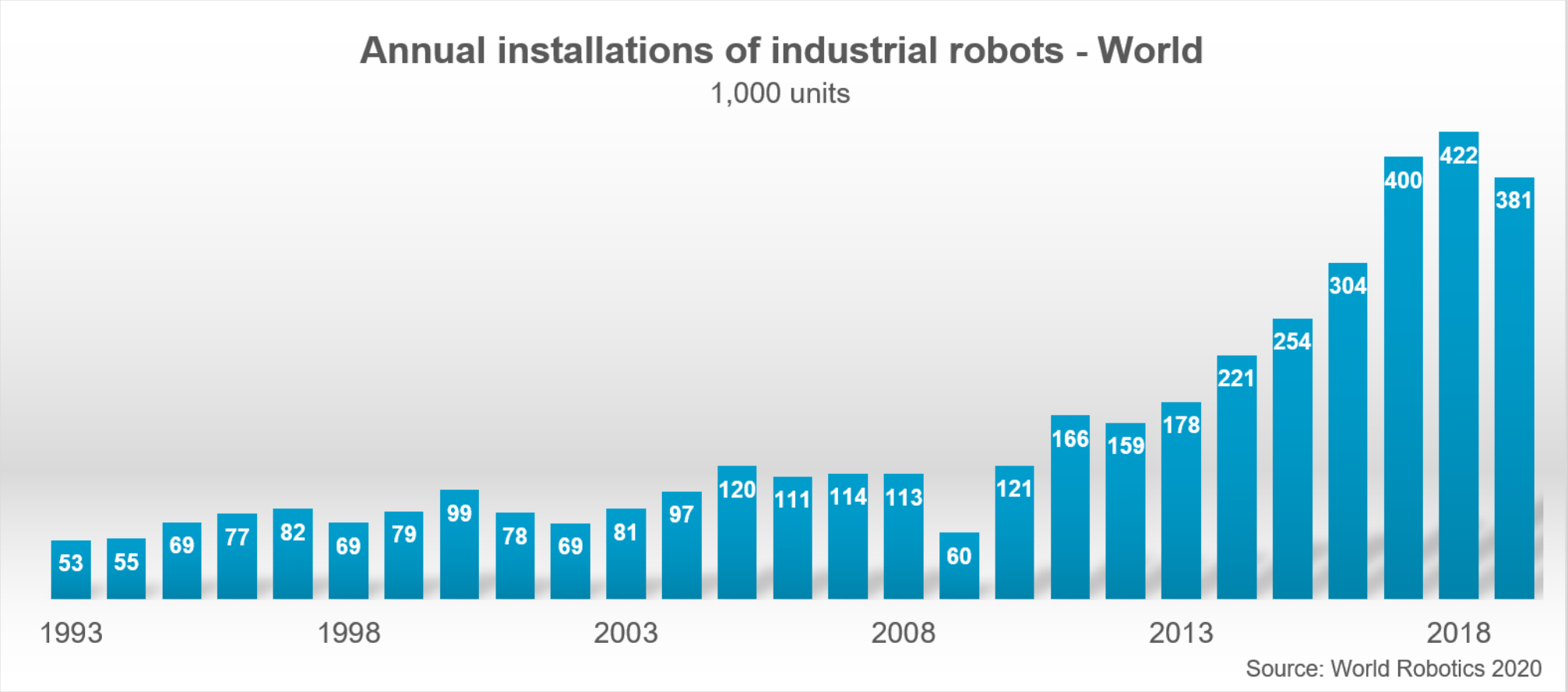
There is a lot of other special purpose automation machinery available, but...

- industrial robots are **flexible multipurpose tools:**
  - They can reach and hold every position in their range
  - They can run different programs for different tasks.
  - They can use different end effectors to do something totally different.
  - They can be programmed to "decide" about their action depending on their sensor input.

Weltweiter Absatz von Industrierobotern



Global statistics on robot diffusion

Image: Stäubli

Image: Omron

Two separate reports

- **industrial robots**
  - automatically controlled, programmable, multipurpose, 3+ axes, for use in industrial automation applications (ISO 8373:2012)
  - typically based on 5 different kinematic types that are equipped with applications-specific end-effectors

- **service robots:**
  - performs tasks excluding industrial automation (ISO 8373:2012)
  - usually application-specific design, often just 2 axes
  - sometimes not fully autonomous but remote-controlled

➢ **different customers, pricing, machinery, distribution channels, suppliers**

Image: KUKA

Image: KUKA

The blurring lines between industrial and service robots

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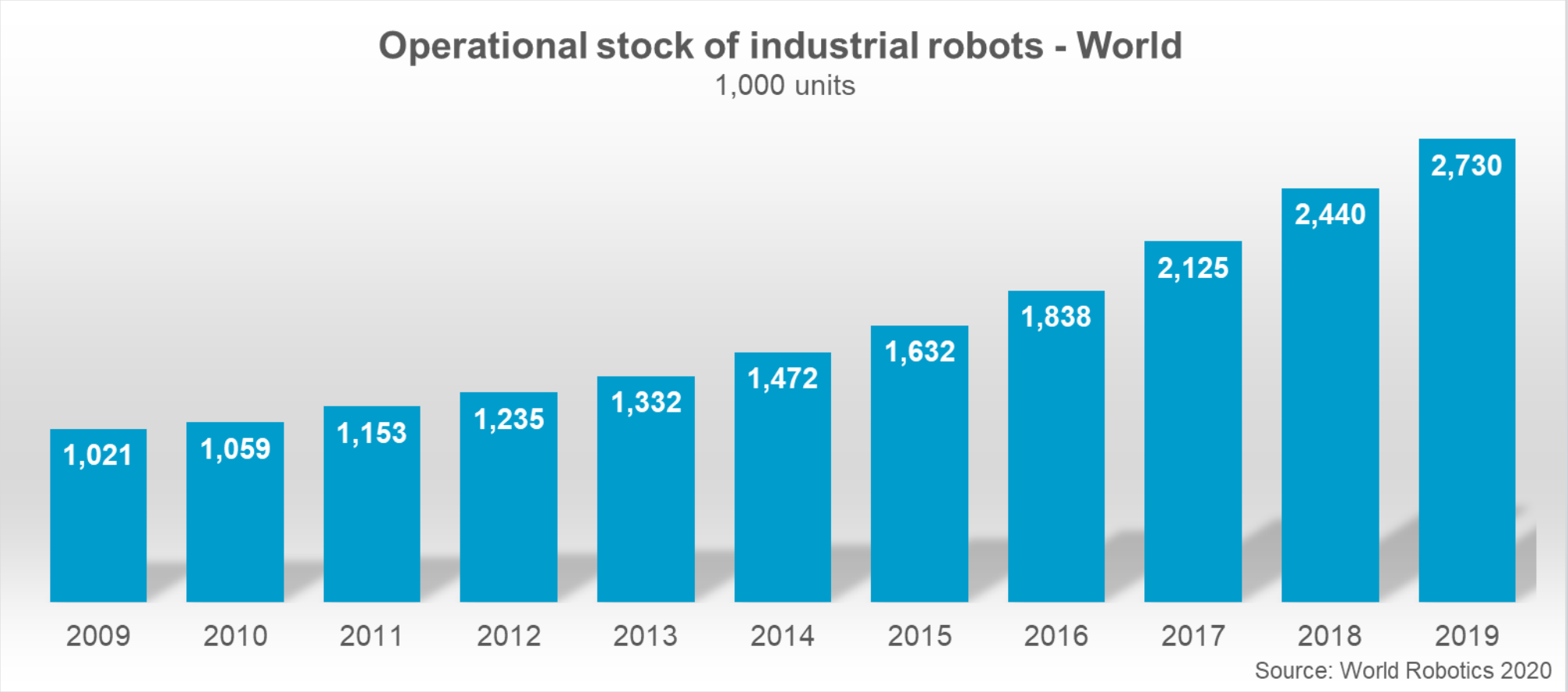
Depending on its **application**, the same unit can be a service robot or an industrial robot.

Usage concepts change – new applications emerge.

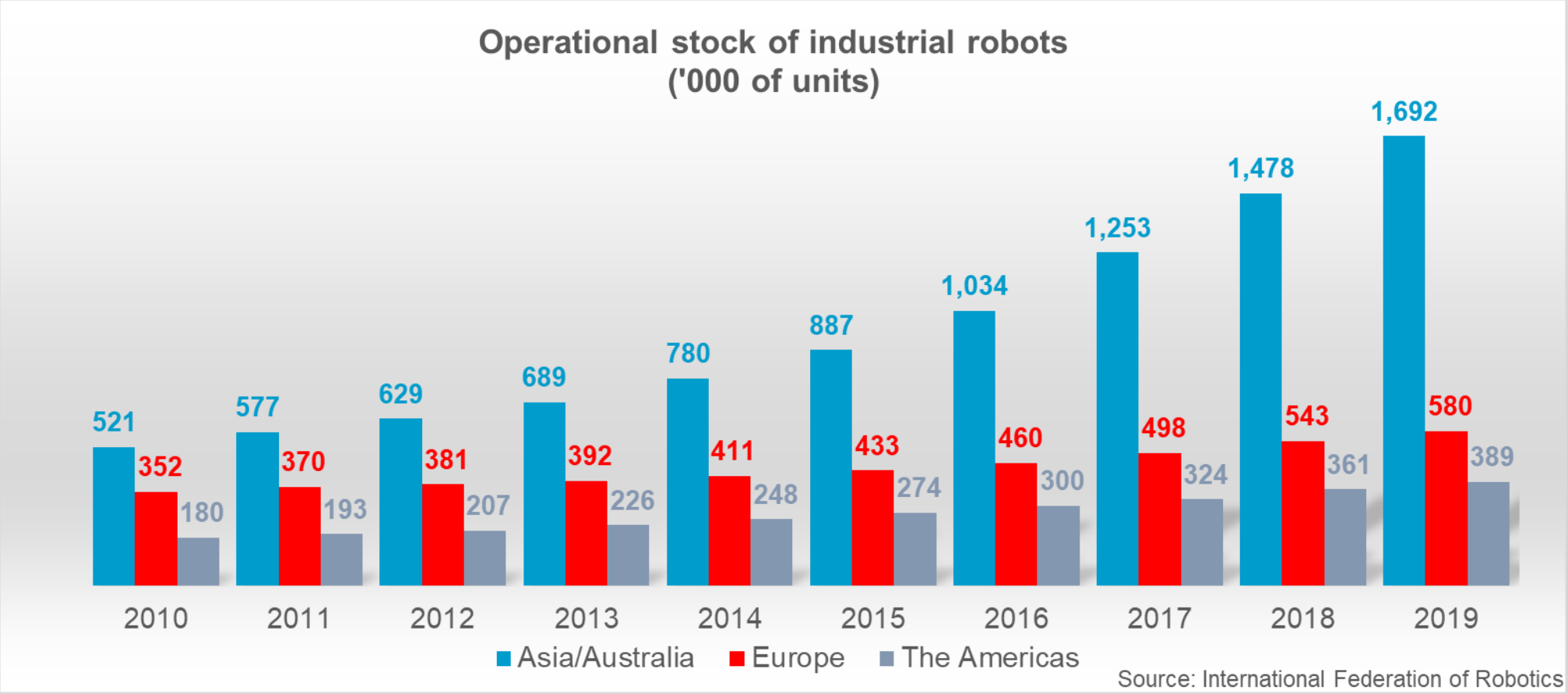
AI and machine learning technologies enable robots to **sense and respond** to their environment.

Robots are increasingly supporting humans both at **work** and in their **private lives**.

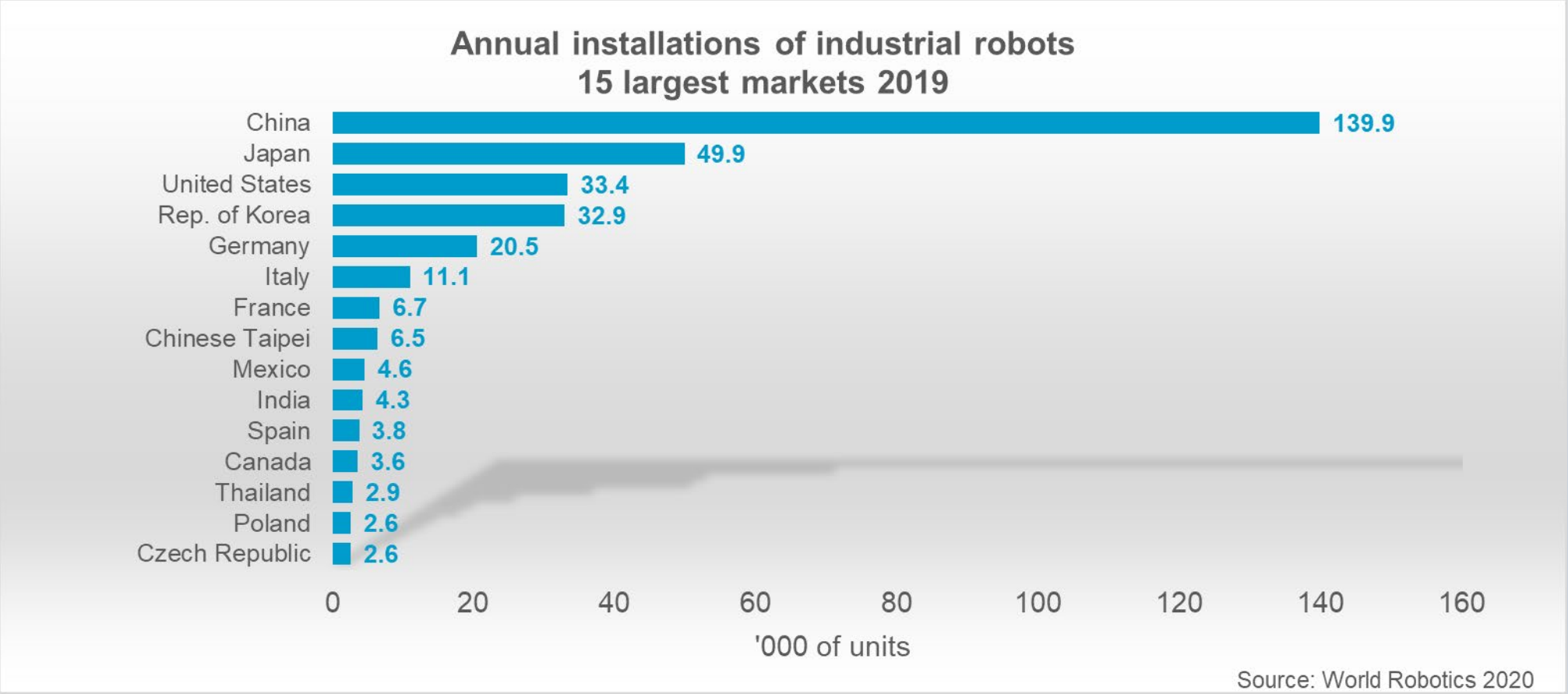
Weltweiter Einsatz von Industrierobotern



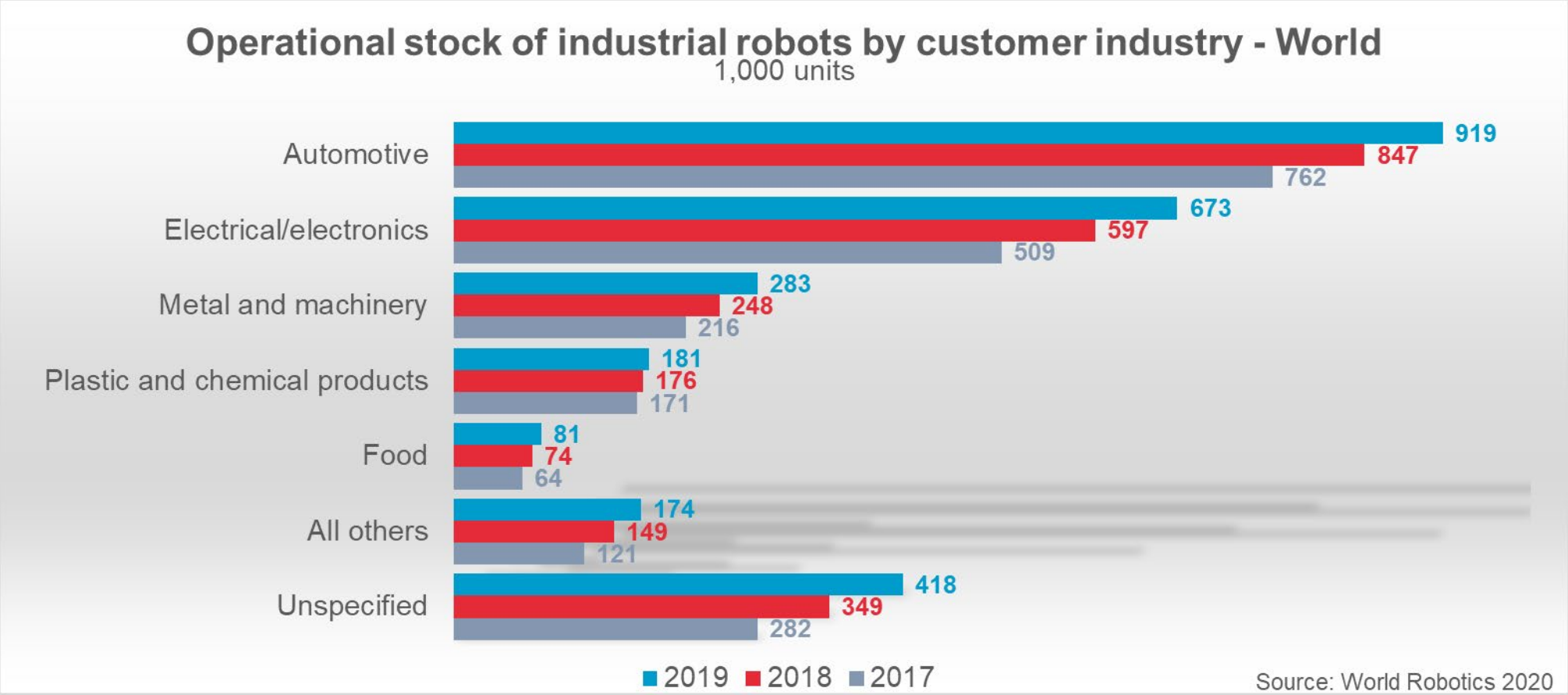
Asien Spitzenreiter



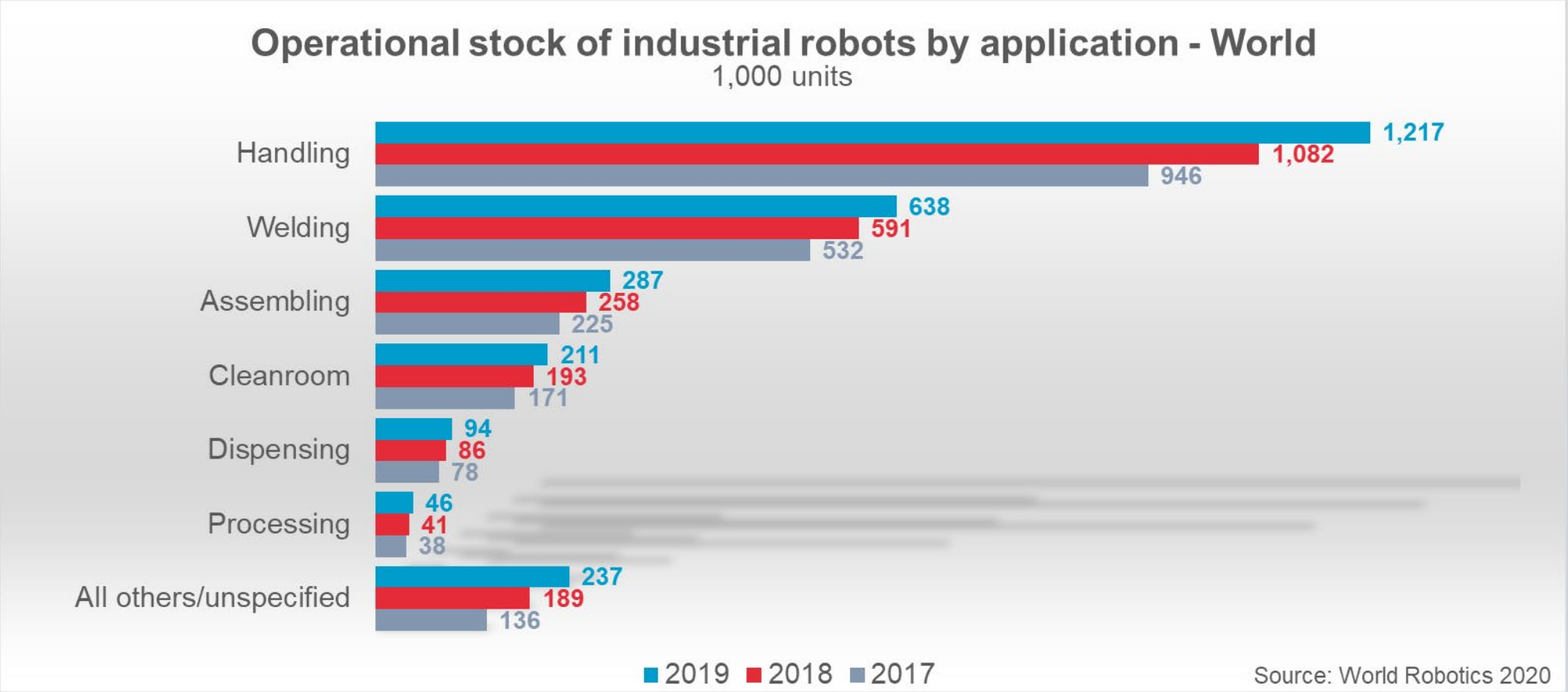
China remains the main end user of industrial robots



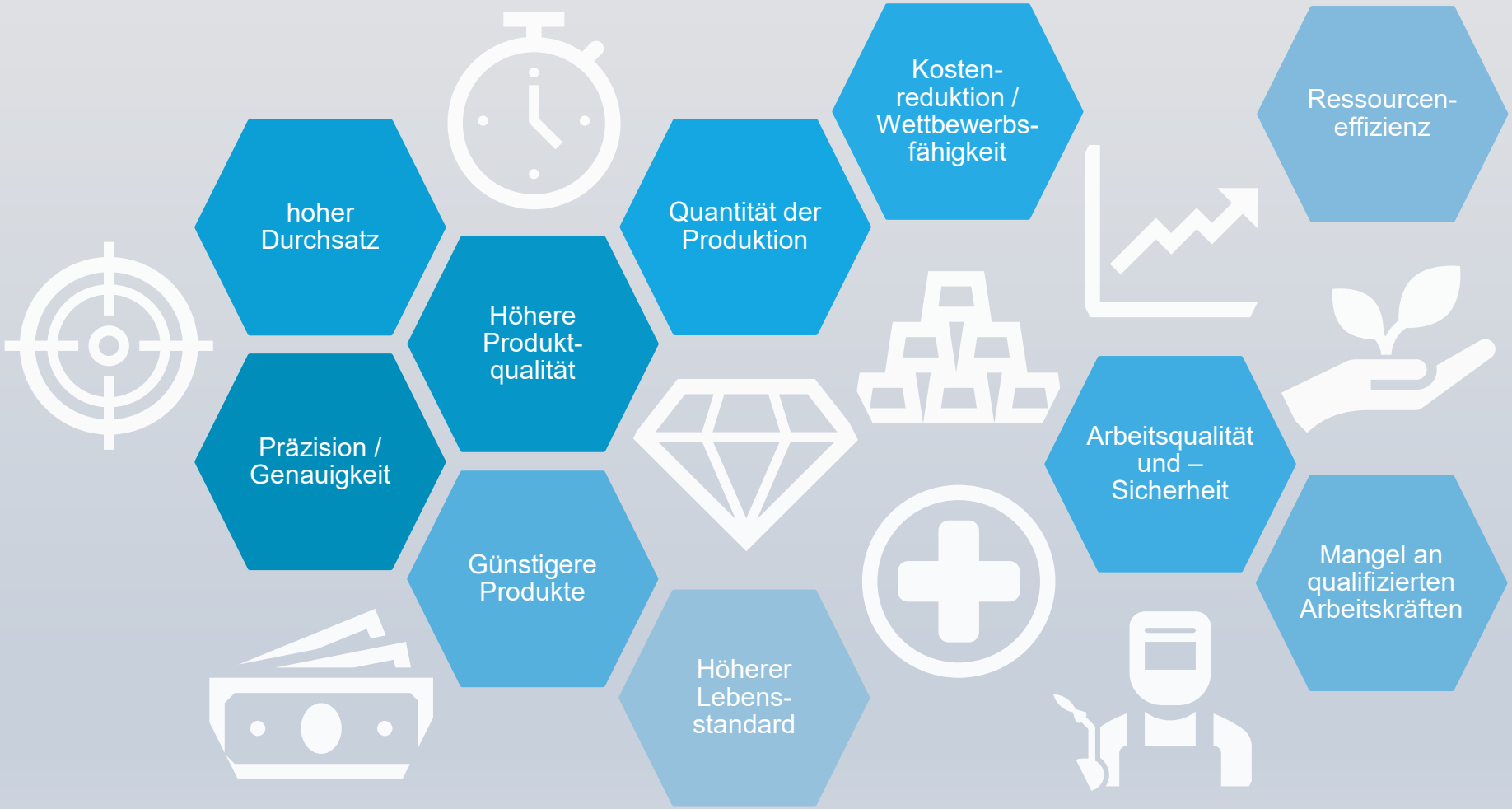
Kundenbranchen: Automobil und Elektronik



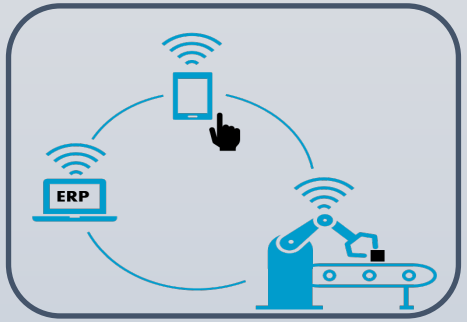
Operational stock by application



Warum sind Roboter so erfolgreich?

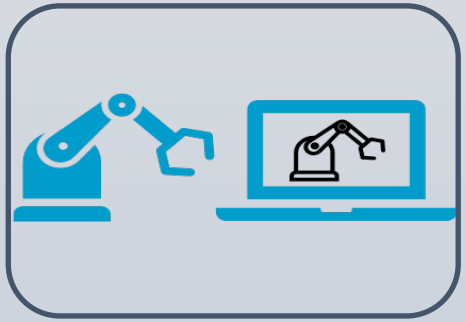


FIVE SCENARIOS FOR CONNECTED ROBOTS IN MANUFACTURING

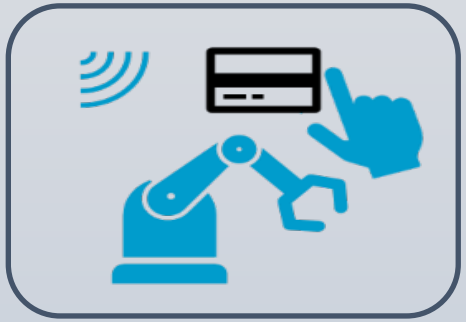


AUTOMATED PRODUCTION

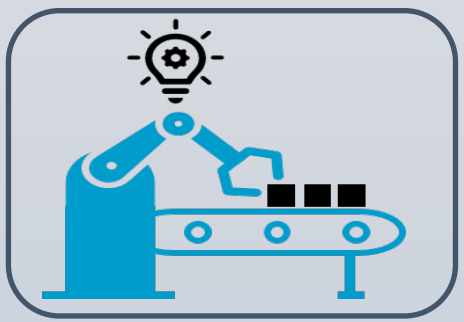
OPTIMIZING PERFORMANCE



DIGITAL TWIN



ROBOT AS A SERVICE



SENSE AND RESPOND

Image: MIR

Automated Production

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Digitization of the entire process

- from customer order to shipment
- each stage automatically triggering downstream processes
- enabling to remotely monitor progress and resolve conflicts
- manufacturers can immediately understand the resource implications of a new product
- optimization of production organization

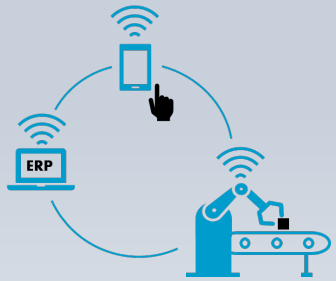

Image: ABB

Optimizing performance

- **Connecting robots and other machines to a central server**
  - to extract and aggregate data
  - to optimize machine performance – in real-time or retrospectively
- **Cloud-based services**
  - can aggregate anonymous data of similar machines
  - increase benefits for the user

Image: FANUC

Virtual Simulation and Digital Twin

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Virtual representations of robots

- enable to simulate operations and changes to parameters before implementation

Digital twin

- linking physical machines in real time to a virtual representation of the same machine
- forecast the impact of a continuation of ongoing processes
- investigate causes of performance issues or machine malfunctions.

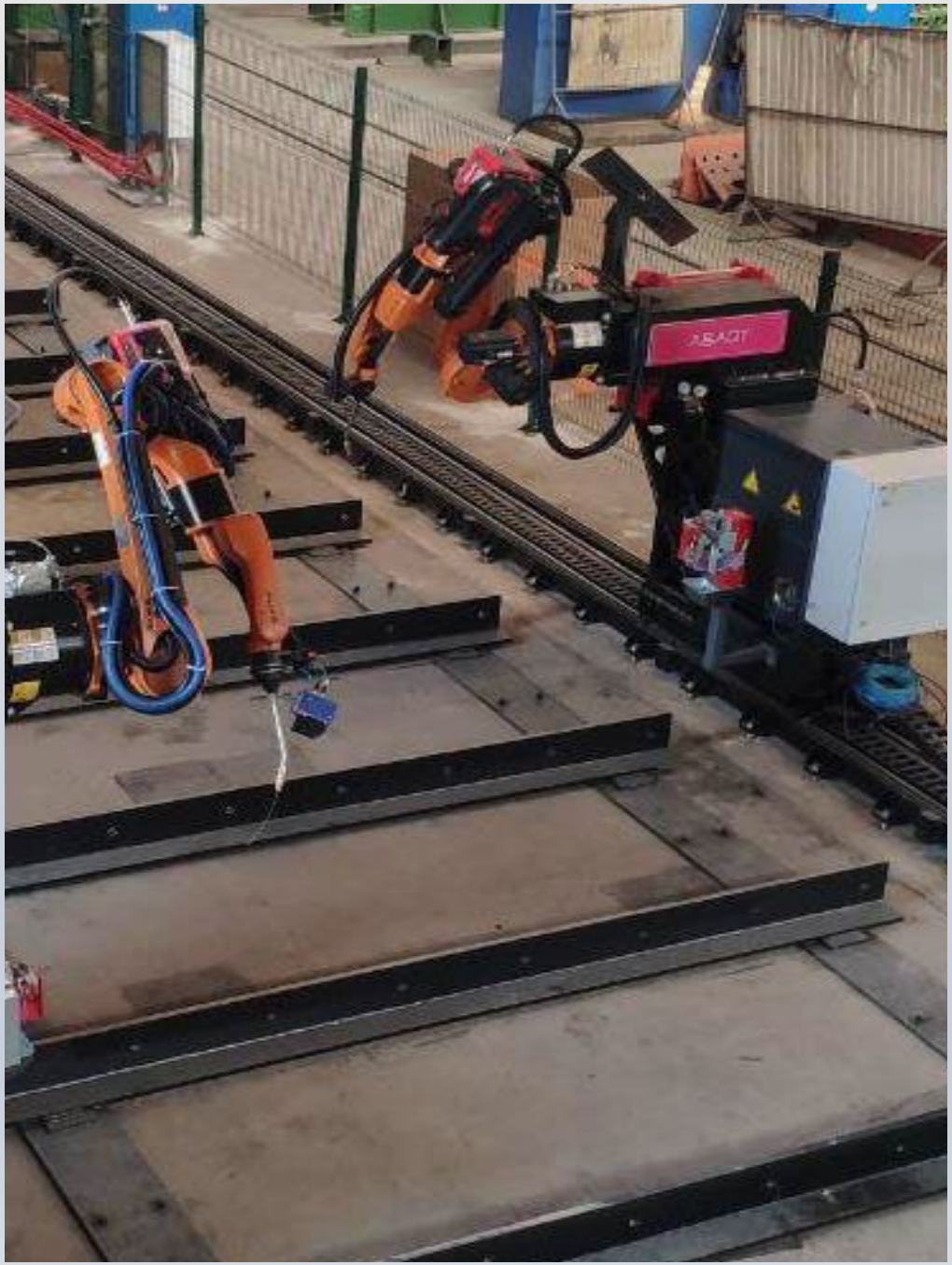

Image: Abagy

Robots as a Service

- **Connecting physical equipment to the internet**
  - allows to offer machines as a rental service and charge for actual usage
  - rapidly scale production to cope with sudden peaks in demand
- **Predictability of operating expenditure:**
  - Customers spare front capital investment and unplanned maintenance costs
  - Esp. for SMEs during early phase of robot adoption
  - Shift risk from robot user to supplier

Image: Stäubli

Sense and respond

- Sensors and vision enable robots to respond to external environment
- Pick-and-place applications: highly complex applications running in real-time
- Autonomous navigation in factories and warehouses next to humans

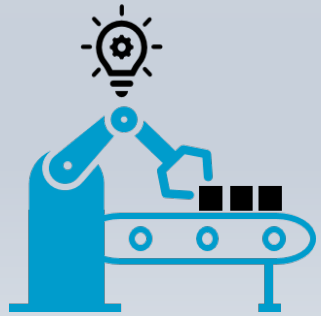

Image: Pixabay

Future Trends

Going forward, manufacturers can expect advances in four key areas:

- **Connected hardware**
- **Software development**
- **Communication frameworks**
- **Organization of production**

Image: Schunk

Connected hardware

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Technological advancements expand the range of possible tasks:

- **Machine Vision systems and machine learning algorithms**
- **Built-in sensors and sensor skins for collaborative robots**
- **Tactile and soft grippers**
- **Self-optimizing robots**

Image: KUKA

Software development

- More intuitive programming interfaces
- Programming by demonstration
- ‘Out-of-the-box’ robot systems for standard applications
- Machine learning algorithms improving robot performance
- Cloud solutions providing access to program libraries and real-time solutions
- Machine learning and predictive algorithms reducing implementation and training time

Image: Pixabay

COMMUNICATIONS FRAMEWORKS

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Reducing integration costs and installation time through:

- **Seamless, vendor-neutral communication between robots and other machinery**
- **Holistic view of the performance of all machines in the production cycle**
- **Standard interfaces and controllers**
- **Increasing abstraction in programming into semantic layers (e.g. OPC-UA)**

Image: KUKA

Organization of Production

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Trend towards customization drives adoption of ‘flexible manufacturing’ strategies

- **production cells with discrete processes running in parallel**
- **mobile robots move materials and finished components between cells**
- **quick reconfiguration of cells to accommodate changes in orders**
- **Robots automatically moved between cells and re-tasked.**

Image: Pixabay

Implications for manufacturers and policy makers

Focus on:

1. **Closer collaboration between automation technology suppliers and customers in manufacturing**

2. **Policies to encourage adoption of automation technologies, especially for SMEs**

3. **Skills development and planning**

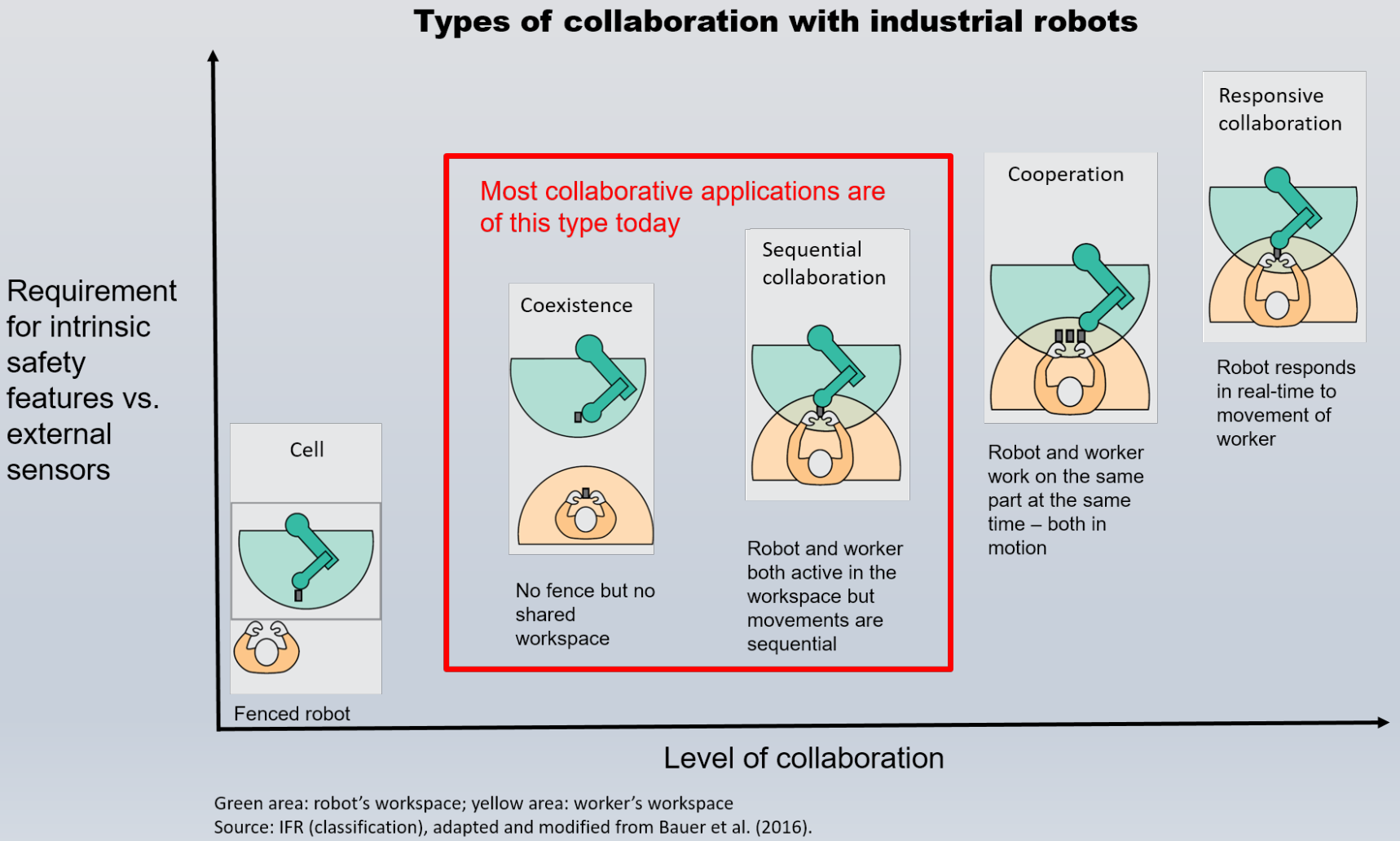
4. **Promoting careers in manufacturing**

Image: ABB

Human-robot collaboration: vision and reality

- A new chapter in robotics, with high potential
- Combining typically human and typically “machine” strengths
- Concern: Human subjected to the robot’s instructions
- Promise: more ergonomic work
- So far more “coexistential” than “collaborative”
- Will find more widespread adoption in the coming years

Types of human-industrial robot collaboration



Green area: robot's workspace; yellow area: worker's workspace
Source: IFR (classification), adapted and modified from Bauer et al. (2016).

Collaborative robots: sales volume growing

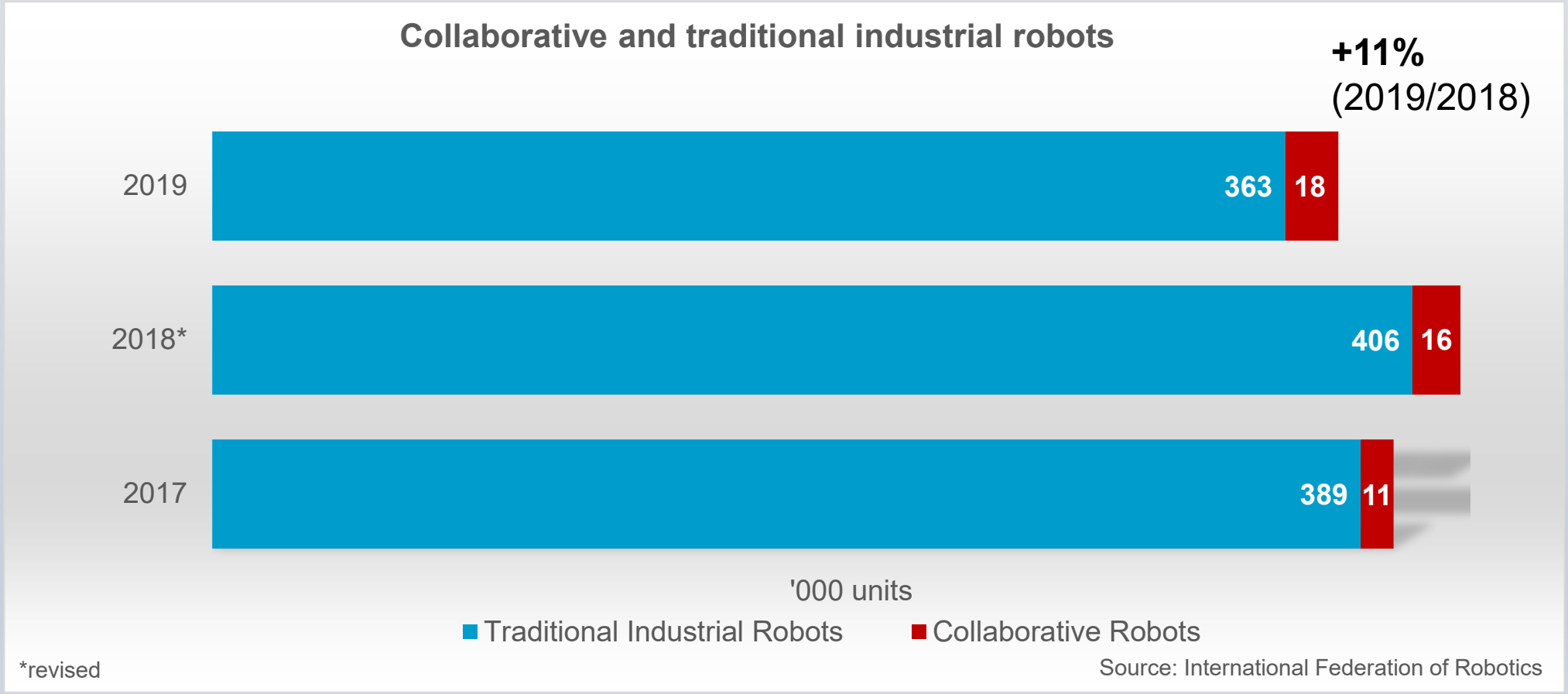


Image: OnRobot

Benefits of collaborative robots

- Economically-viable entry-point to automation
- Support workers in tedious tasks
- Ease of programming & use
- Easier re-deployment (re-useability)
- Suitable for short production runs („high mix – low volume production“)
- Take up less factory floor space
- Better mobility within the factory
- **Reimagine business processes** to make optimal use of collaborative robots.

Image: KUKA AG

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"To understand machine capabilities, one must understand human capabilities"

Image: shutterstock

Polanyi's Paradox*

Our tacit knowledge of how the world works often exceeds our explicit understanding

"We can know more than we can tell"

** term coined by David Autor (MIT), referring to the work of Hungarian-British polymath Michael Polanyi*

Image: shutterstock

Moravec's Paradox*

What is simple even for children (e.g. sensorimotor and perception skills) is difficult for machines.
And vice versa.

** after roboticist, AI researcher and futurist Hans Moravec*

Image: Fraunhofer IPA

A concrete example: warehouse automation

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What does the simple task of picking and stowing items on shelves involve?

- Object recognition
- Pose recognition
- Selection of gripping points
- Grasp planning
- Compliant manipulation
- Motion planning
- Task execution
- …

Polanyi's and Moravec's Paradox at work!

Intelligent automation (IA):
Humans complementing machines

"The highest form of technology is not full automation or full autonomy, but it is automation and autonomy that are very beautifully, gracefully linked to the human operator."

David A. Mindell, autonomous robotics pioneer
Massachusetts Institute of Technology (MIT), USA

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Information Paper

How Connected Robots are Transforming Manufacturing

published by
International Federation of Robotics
Frankfurt, Germany

October 2020

IFR International Federation of Robotics

IFR Positioning Papers

https://ifr.org/papers

- **How Connected Robots are Transforming Manufacturing**
- Demystifying Collaborative Industrial Robots
- Artificial Intelligence in Robotics
- Robots and the Workplace of the Future
- The Impact of Robots on Productivity, Employment and Jobs
- Next Generation Skills – Enabling today's and tomorrow's workforce to benefit from automation

Shaping Good Work of the Future

IFR International Federation of Robotics

Recently published:

- ✓ The European Robotics Industry's perspective of the future of work
- ✓ Defines 10 focus areas to actively shape the development

www.eu-nited.net/robotics

Thank you!

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