Control of industrial robots

Industrial robotics

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What is a robot?

A repro programmable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks.

(Robot Institute of America, 1980)

The robot is not just a mechanical device...
A robot and its control unit

Mechanics

Intelligence
Why six joints?
The mechanical system

The manipulator consists of a series of rigid bodies (links) connected by joints.

One end of this chain makes the BASE, usually fixed to the floor.

At the other end we have the END EFFECTOR where the gripper or tool is mounted.

Usually manipulators have six links:
- the first three make the positioning
- the last three (WRIST) make the orientation
Rigid automation
- The sequence of operations is fixed
- Production process composed of a sequence of simple operations
- Large production with very small variations

Programmable automation
- The sequence of operations can be changed
- Medium-low production batches
- Between batches the production plant has to be reconfigured

Flexible automation
- Production can be varied without idle times for conversion
- Machine characterized by high flexibility and configurability
  (FMS: Flexible Manufacturing Systems)
Typical operations performed by robots

Link to the video: https://www.youtube.com/watch?v=EbBwxDtDjPw
A robotized car factory

Link to the video: https://www.youtube.com/watch?v=VpwkT2zV9H0
An excellent source of information...
Continued record sale since 2013

Estimated annual worldwide supply of industrial robots
2009-2017 and 2018*-2021*

*forecast

Source: IFR World Robotics 2018
Emerging region: Asia

Estimated worldwide annual supply of industrial robots 2016-2017 and forecast for 2018*-2021*

*000 of units

<table>
<thead>
<tr>
<th>Year</th>
<th>Asia/Australia</th>
<th>Europe</th>
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<td>191</td>
<td>56</td>
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<td>2017</td>
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<tr>
<td>2021*</td>
<td>463</td>
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*forecast

Source: IFR World Robotics 2018
China has significantly expanded its leadership in the industrial robotics market. The bar chart shows the estimated worldwide annual supply of industrial robots in 15 largest markets for 2017. China leads with 137,900 units, followed by Japan with 45,500 units, and the Rep. of Korea with 39,700 units. The United States ranks fourth with 33,200 units. Other significant markets include Germany with 21,400 units, Taiwan with 10,900 units, Vietnam with 8,300 units, Italy with 7,700 units, and Mexico with 6,300 units. The chart also includes data for France, Singapore, Spain, Canada, India, and Thailand.

Source: IFR World Robotics 2018
2021: 3.8 million industrial robots in operation

Estimated worldwide operational stock of industrial robots 2016-2017 and forecast for 2018*-2021*
Main drivers: automotive, electronics, metal

Estimated annual supply of industrial robots at year-end by industries worldwide 2015-2017

- Automotive: 2017 - 126, 2016 - 103, 2015 - 98 (+22%)
- Electrical/electronics: 2017 - 121, 2016 - 91, 2015 - 65 (+33%)
- Metal: 2017 - 45, 2016 - 29, 2015 - 29 (+55%)
- Plastic and chemical products: 2017 - 21, 2016 - 20, 2015 - 20 (+9%)
- Food and beverages: 2017 - 10, 2016 - 8, 2015 - 7 (+19%)

Source: IFR World Robotics 2018
Why so many robots?

- Shift to high mix/low volume production
- Customization: increasing mix requires more flexible production
- Higher quality demands on manufacturing process
- Global competitiveness
- Short life cycles of electronic products

Source: IFR
New markets for robots

- **Metal industries** – more flexibility and cost efficiency
- **Rubber and plastics industry** – more integrated manufacturing concepts
- **Food and beverage industry** – shift to even shorter production runs
- **Pharmaceutical industry** – improving productivity without sacrificing quality

Source: IFR
Common robot configurations (1/2)

**Anthropomorphic**

- The typical structure of the robot manipulator
- Dexterous structure
- Mechanical stiffness is a function of configuration

**SCARA**

- All joints with vertical axes
- Very rigid to vertical loads, compliant to horizontal loads
Common robot configurations (2/2)

Delta

- Parallel kinematic structure
- Very fast and accurate
- Limited workspace

Cartesian

- All joints give linear motion
- Very rigid mechanically
Advanced motion programming

https://www.youtube.com/watch?v=PSKdHsgtok0

ABB True Move & Quick Move
(commercial video)
Parallel kinematic machines (very fast)

https://www.youtube.com/watch?v=ipuhpzELGs4
New robots: redundant arms (seven joints)

https://www.youtube.com/watch?v=sZYBC8Lrmdo
New robots: dual arm robots

ABB YuMi

EPSON dual-arm

KAWADA HIRO

KAWASAKI DUARO
New robots: dual arm robots

YuMi® - Papercrafting
Collaborative robotics

- A new scenario where humans and robots collaborate at the same task.
- It is expected to have a breakthrough in the coming years, particularly in SMEs.
Collaborative robotics
Collaborative intelligent robotics

https://www.youtube.com/watch?v=P1p1-hejjaQ
Industry 4.0

- Robots are key components in the manufacturing of Industry 4.0.
- Physical and digital systems are today integrated in Cyber-Physical systems.
- Robots allow flexibility, cost effectiveness and productivity in smart factories.

Source: Bosch
Industry 4.0

Self-optimizing production

Robots doing the same task connect across all global locations so performance can be compared and improved at the click of a button.

Self-programming robots

Robots automatically download what they need to get started from a cloud library and then start to optimize through “self-learning”.

Source: IFR
Predictive maintenance

Robots are connected to the cloud and diagnostics information, alarm information, maintenance information, can be collected and used for predictive maintenance.

Source: FANUC
Predictive maintenance

Source: FANUC

https://www.youtube.com/watch?v=DDDWjaX0oC8