Control of industrial robots

Industrial robotics

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What is a robot?

A reprogrammable, 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…

COMAU SMART NH3
A robot and its control unit

Mechanics

Intelligence

1

2

3

4

5

6
Why six joints?

Source: Comau Robotics
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
Automation in industry

**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...
Supply of industrial robots by year

Estimated annual worldwide supply of industrial robots
2008-2016 and 2017*-2020*

- 2008: 113
- 2009: 60
- 2010: 121
- 2011: 166
- 2012: 159
- 2013: 178
- 2014: 221
- 2015: 254
- 2016: 294
- 2017*: 346
- 2018*: 378
- 2019*: 433
- 2020*: 521

+15% on average per year

Source: IFR World Robotics 2017
Supply of industrial robots by industry

Estimated annual supply of industrial robots at year-end by industries worldwide 2014-2016

  +6%
  +41%
- Metal: 2016 - 29, 2015 - 21, 2014 - 29
  -3%
- Chemical, rubber and plastics: 2016 - 20, 2015 - 20, 2014 - 17
  -4%
- Food: 2016 - 7, 2015 - 7
  +20%

Source: IFR World Robotics 2017
Supply of industrial robots by region

Estimated worldwide annual supply of industrial robots 2015-2016 and forecast for 2017*-2020*

- **2015**: Asia/Australia 161, Europe 50, America 38
- **2016**: Asia/Australia 191, Europe 56, America 41
- **2017** (forecast): Asia/Australia 230, Europe 61, America 48
- **2018** (forecast): Asia/Australia 257, Europe 64, America 51
- **2019** (forecast): Asia/Australia 296, Europe 71, America 58
- **2020** (forecast): Asia/Australia 354, Europe 83, America 73

*forecast

Source: IFR World Robotics 2017
Supply of industrial robots by country

Estimated worldwide annual supply of industrial robots
15 largest markets 2016

- China: 87,0
- Republic of Korea: 41,4
- Japan: 38,6
- United States: 31,4
- Germany: 20,0
- Taiwan: 7,6
- Italy: 6,5
- Mexico: 5,9
- France: 4,2
- Spain: 3,9
- Thailand: 2,6
- India: 2,6
- Singapore: 2,6
- Canada: 2,3
- Czech Republic: 2,0

Source: IFR World Robotics 2017
Operational stock of industrial robots

Estimated worldwide operational stock of industrial robots 2015-2016 and forecast for 2017*-2020*

Source: IFR World Robotics 2017
Global market of industrial robots

- Value of the global market of industrial robots: US$ 13.1 billion
- Value of the global market of robotic systems: US$ 40 billion
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
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

- EPSON dual-arm
- ABB YuMi
- KAWASADA HIRO
- KAWASAKI DUARO
Robot programming

Control unit:
- MMI
- Power electronics
- Motion planning
- Control
- Supervision

Teach pendant (or flex pendant):
- Robot programming interface
- Also wireless
Programming environments

ABB Robot Studio
Advanced motion programming

https://www.youtube.com/watch?v=PSKdHsqtok0

ABB True Move & Quick Move
(commercial video)
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 intelligent robotics

Link to the video: 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
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.
Predictive maintenance

Source: FANUC

Link to the video: https://www.youtube.com/watch?v=DDDWjaX0oC8