Industrial automation and robotics

Introduction to the industrial robotics

Prof. Paolo Rocco (paolo.rocco@polimi.it)
Politecnico di Milano, Dipartimento di Elettronica, Informazione e Bioingegneria
What is a robot?

An automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications

(ISO 8373:2012)

The robot is not just a mechanical device...
So, a robot moves…

Then, is this a robot?

Well, it moves, but it has no axis and cannot manipulate the environment moving parts. So it is not a robot by our definition.

And a generic artificial intelligence product (a chatbot for example)? No, it is not a robot.
A robot and its control unit

Mechanics

Intelligence

Source: Comau
Why six joints?

Source: Comau
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

Source: Comau
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

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

https://www.youtube.com/watch?v=VpwkT2zV9H0
An excellent source of information...

Source: International Federation of Robotics website
Annual installations of robots in the world

Source: International Federation of Robotics website

Source: World Robotics 2021
Annual installations of robots in the world: forecast

Source: International Federation of Robotics website
China has significantly expanded its leadership

Source: International Federation of Robotics website
Robot density (number or installed robots per 10,000 employees)

Source: International Federation of Robotics website
Key sectors

Annual installations of industrial robots by customer industry - World

1,000 units

- All others: 30 (2020), 36 (2019)

Source: International Federation of Robotics website
Operational stock of robots

Source: International Federation of Robotics website

Source: World Robotics 2021
Global market of industrial robots

- Value of the global market of industrial robots: **US$ 16.2 billion**
- Value of the global market of robotic systems: **US$ 48 billion**
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: International Federation of Robotics
The typical structure of the robot manipulator
- Dexterous structure
- Mechanical stiffness is a function of configuration
Common robot configurations (2/4)

- All joints with vertical axes
- Very rigid to vertical loads, compliant to horizontal loads

Source: International Federation of Robotics
Common robot configurations (3/4)

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

Parallel/Delta Robot

Source: International Federation of Robotics
Common robot configurations (4/4)

- All joints give linear motion
- Very rigid mechanically

Source: International Federation of Robotics
Advanced motion programming

Superior Motion Performance by ABB Robotics

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

Source: Adept
Parallel kinematic machines (very fast)

https://www.youtube.com/watch?v=ipuhpzElGs4

Source: Adept
Trends: redundant robots (seven joints)

Source: KUKA

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

- EPSON dual-arm
- ABB YuMi
- KAWADA HIRO
- KAWASAKI DUARO
Trends: dual arm robots

YuMi® - Papercrafting

Source: ABB Robotics
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.
The fourth industrial revolution

Fine 18 secolo → Inizio 20 secolo → Dai primi anni ’70 → Industry 4.0

1° Meccanica e potenza vapore
2° Elettricità e produzione di massa
3° Elettronica, IT e Automazione industriale
4° Utilizzo di macchine intelligenti collegate ad internet

Source: SIEMENS
Robots in the era of the IOT

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: International Federation of Robotics
A digital twin of the robot

A digital representation of the robot is then used to monitor the robot: a digital twin of the robot.

Cloud-based analytics and intelligence platform provide users access to robot data at any time.

Source: KUKA
Robots in the era of the IOT

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
Robots in the era of the IOT

Source: FANUC

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