Industrial robots

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Proseminar „Roboter und Aktivmedien“

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Part one >> Definitions

define: industrial robots / robotics

- *“[…] automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes.”* - ScienceDaily LLC, referenced on Wikipedia.org
- “It’s a branch of robotics concerned with industrial and manufacturing applications. Industrial robots usually take the form of a manipulator arm equipped with an end effector and various sensors. […]” - John Daintith. "industrial robotics." A Dictionary of Computing. (2004) via Encyclopedia.com (9 Nov. 2009)

comparison to known robot-definitions

Industrial robots	Robot-definiton by Ph.D. Zhang
automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes	A robot is an artificial, intelligent, autonomous system with a physical electro-mechanical platform. It is a combined device with enough perception, manipulation capability or mobility to implement typical tasks.

Are industrial robots just tools?

Yes, they are.	No, they aren't.
Mostly they repeat just pre-defined manipulations.	They often have sensors (e.g. cameras) to handle tasks (or parts of tasks) on their own. They work unattendedly. They remind of human behaviour (arm movement).

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Part two >> History

history

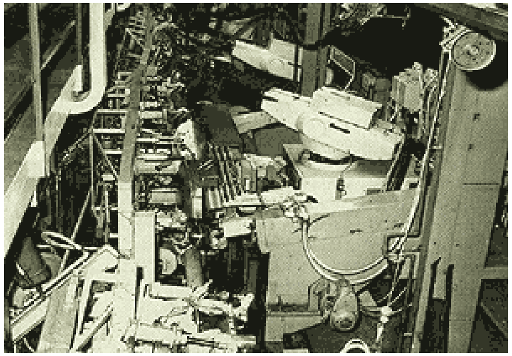
- First robotic patents in 1954 (granted in 1961) by George Devol

- Hydraulic actuators were used to move arms
- Movement was programmed in joint coordinates
- 1962 *Unimate* was the first industrial robot working, spot welding and extracting die castings at General Motors (GM)
- Victor Scheinman invented the Stanford arm in 1969 at Stanford University

history

- *Unimation* bought Scheinmans designs and developed in collaboration with GM a Programmable Universal Machine for Assembly (PUMA)

- 1971: Europe's first welding transfer line with robots
- 1973: KUKA Robotics built their first robot called FAMULUS



history

- 1974: Scheinman designed a robotic arm using feedback from touch and pressure sensors, which is controlled by a minicomputer
- 1977: ASEA (European robot company) introduced two robots that used microcomputer controller for programming and operation
- 1979: OTC Japan introduced the first generation of dedicated arc-welding robots
- 1981: Takeo Kanade invents the first robotic arm that has motors installed directly in the joints

history

- 1984: Height of the (industrial) robot boom
- 1988: *Motoman ERC* control system is able to control up to 12 axes
- 1994: *Motoman ERC* 21 axes, synchronize 2 robots
- 1998: *XRC controller 27* axes, synchronize 3 to 4 robots
- 1999: first internet remote diagnosis for robots developed by KUKA

history

- 2002: KUKA robot starring James Bond "Die Another Day"

- 2007: KUKA built “TITAN”: The World's Strongest Robot

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Part three >> Today's use

branches

- Typical applications of industrial robots include
  - *welding, painting,*
  - ironing, assembly,
  - pick and place,
  - **palletizing,**
  - product inspection and
  - testing,
- all accomplished with high endurance, speed, and precision.

KUKA

ABB Power and productivity for a better world™

MITSUBISHI ELECTRIC

adept

Picture: http://www.elettric80.it
Text: ScienceDaily online LLC (15.11.2009)

An important example: Car industry in Germany

- Development of robots within the car industry
- Advantages in the use of robots
- Social aspects

car manufacturing before robots

- Assembly line by Henry Ford
  - Optimized for one unit
  - Minor flexibility
  - Many manual activities
  - E.g. welding at fixed positions with manual spot-welding
  - Rising standards relating to human workplace and flexibility, quality and costs of cars
  - Assembly line should support
    - Labor
    - Various car types

1950-1990

- Standards were
  - 60kg payload
  - electromechanic actuator
- SCARA (Selective Compliance Assembly Robot Arm) used at subcontractor areas
- New tasks were plating, assembly-welding
- 1980: ca. 1200 industrial robots in Germany
- Forecast: about 33-50% of the workers will become unemployed because of robots
- \- Costs and technical feasibility
- \+ Automotive welding and assembly lines

1990-2000

- Mid 90s the controlling and programming was switched from hardware-programming to programming with an interface on a PC
- Increasing complexity caused by different robots working within the same station
- 2000: Half of installed robots in Germany are working at a car manufactory

advantages in the use of robots

- Cost minimizing
- Automated Production
- Quality
- Speed

social aspects

- Qualified workers are needed to supervise robots
- Dangerous work is done by robots → no humans get hurt
- More cars built
  - → New jobs for final inspection and testing
- Robots took jobs
  - → Risk of high unemployment

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Part four >> Types of robots

Overview: types of robots

Articulated robots

SCARA robots

Selective Compliant Articulated Robot Arm

Cartesian robots (Linear robots)

Pictures: http://vandorendesigns.com/projects.html | www.elettric80.it | http://www.instructables.com | http://www.mhu.de/

Video: articulated 6-axes robot

http://www.youtube.com/watch?v=TMqoNk9ShXw

Video: SCARA robot

http://www.youtube.com/watch?v=8E6aN4r_YIQ

Video: cartesian/linear robot

http://www.youtube.com/watch?v=MCsqlwyjxl4

Overview: types of end effectors

Welding robot

Painting robot

Grinding robot

Laser cutting robot

- Tools
  - Welding
  - Painting
  - Grinding
  - (Laser-) Cutting
- Grippers
  - Impactive
  - Ingressive
    - Intrusive
    - Non-Intrusive
  - Astrictive
    - Vacuum suction
    - Magneto adhesion
    - Electro adhesion
  - Contingutive
    - Thermal
    - Chemical

Pictures: H. Weihe, 2000, http://www.pandct.com/, KUKA Roboter GmbH © 2009, http://www.industrial-lasers.com/

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Video: KUKA Roboter GmbH © 2009

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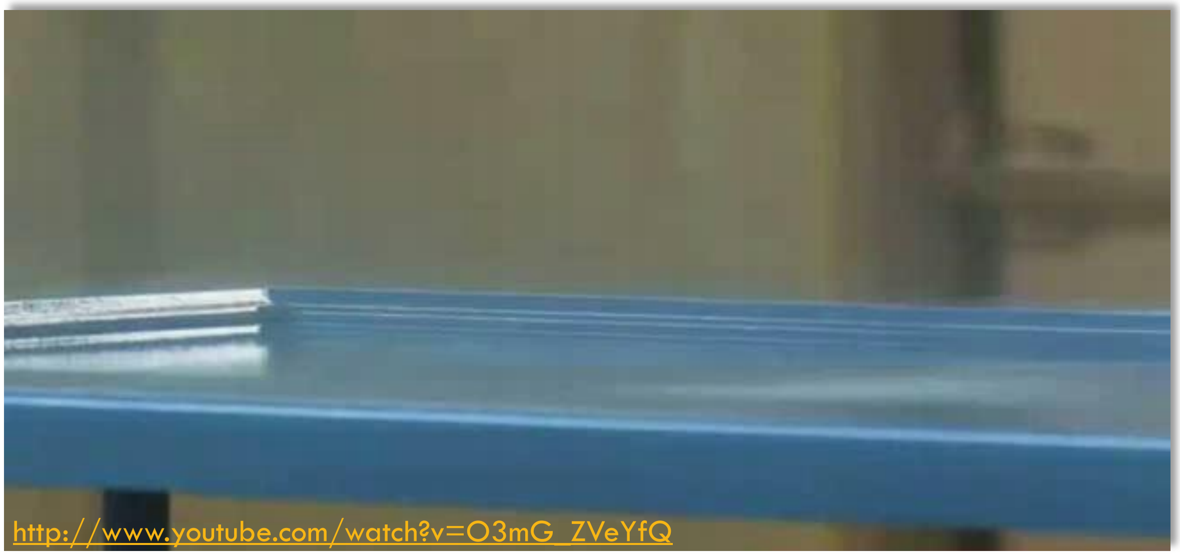

http://www.youtube.com/watch?v=O3mG_ZVeYfQ

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http://www.youtube.com/watch?v=6-qKZJxCWKY

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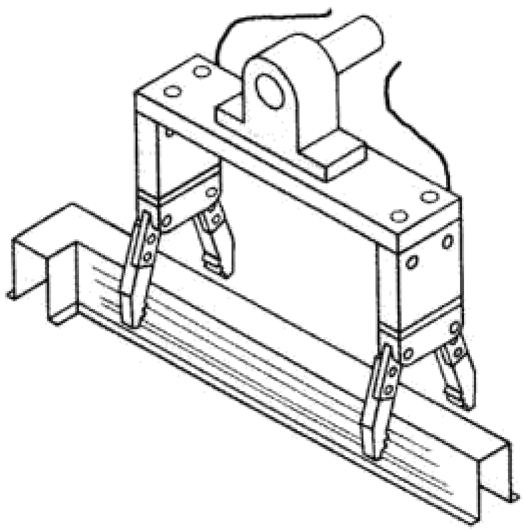
Overview: types of end effectors

Impactive prehension

… means gripping things with pressure

- most frequently used grippers
- normally between 2 and 4 fingers, moving simultaneously
- great variety of technical realizations



Typical examples	Typical manipulated material
tongs	rigid (inelastic), graspable objects
clamps	

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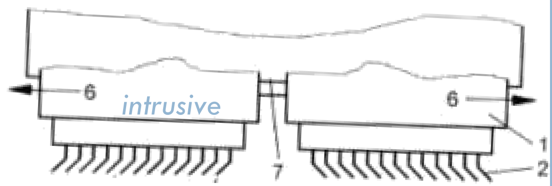
G.J. Monkman, S. Hesse, R. Steinmann, H. Schunk: *Robot Grippers* [Weinheim 2007]

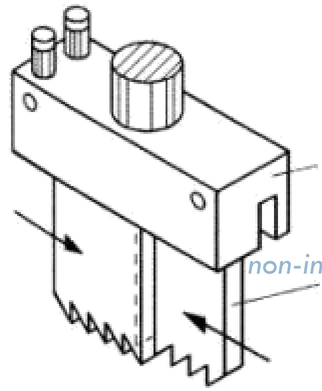
Overview: types of end effectors

Ingressive prehension

… means gripping things with mechanical stress



- Intrusive: prehension needs penetration through handled material
- Allows the object to be held without the need of maintain a n applied force.



Typical examples

- pins, needles and hackles (small and precise needles)
- hooks and loops

Typical manipulated material

- soft materials like foam or fibrous components
- textiles
- carbon and glass fiber

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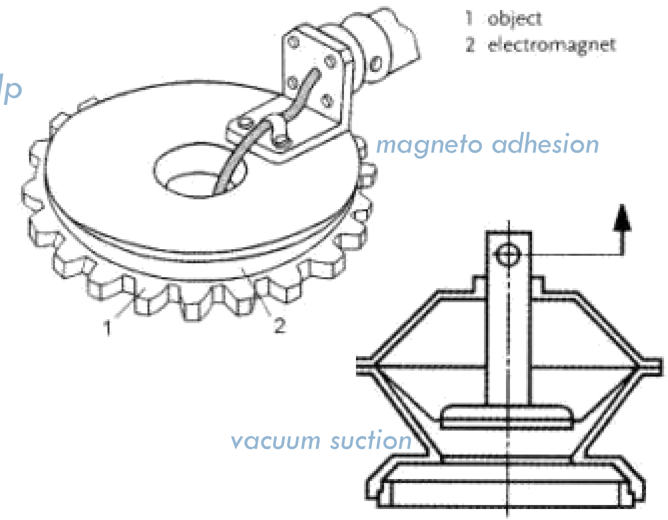
Overview: types of end effectors

Astrictive prehension

… means gripping things with physical help

- holding force without the application of pressure
- needs continuous energy supply



Typical examples

- vacuum suction cups
- electromagnet
- (electrostatic field)

Typical manipulated material

- non-porous, rigid material
- ferrous objects
- (microcomponents)

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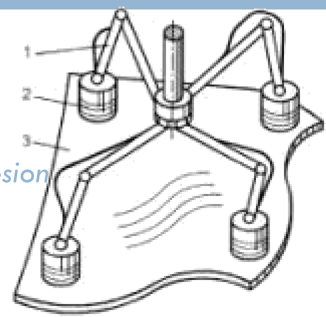
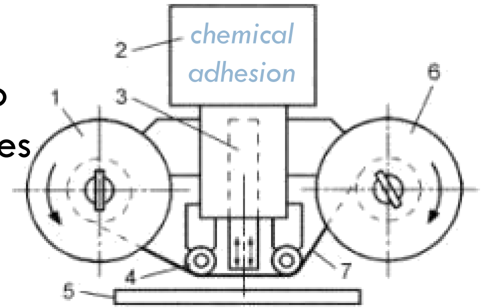
Overview: types of end effectors

Contingutive prehension

… means gripping things with chemical help



- thermal (ice-bridge): small droplets of water between gripping head and object get frozen by liquid carbon
- chemical (adhesive): objects stick to gripping head with the help of glues



Typical examples	Typical manipulated material
freezing, melting adhesives (glues)	textiles, carbon, glass fiber

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Part five >> Programming robots

programming robots

- Robots are typically programmed via
  - Laptop or desktop,
  - Internal network or Internet
- After installing the program, the PC is disconnected from the robot, that now runs on the installed program
- But most of the time a computer permanently “supervises” the robot and gives additional storage
- Modern robot control systems have a complex programming environment with integrated tools to adopt modules like external sensors (such as cameras or a turning moment measuring system)
- Programmable to adjust outside influences (like recognition of different objects)

two ways of programming robots

Online-Programming:

- Programming **at** or **with** the robot
- Methods:
  - Teach pendant
  - Playback
  - Manual programmed

Offline-Programming:

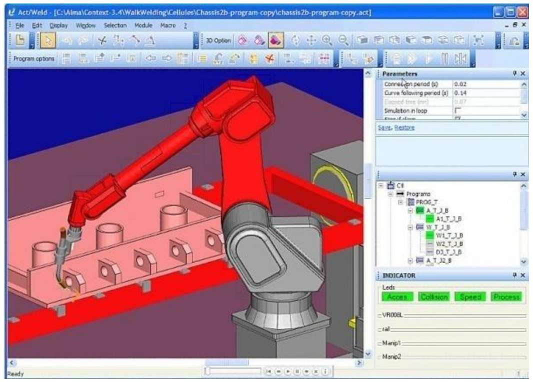
- Programming does not require the robot so that no working time gets lost
- Methods:
  - Textual programming
  - CAD programming
  - Macro programming
  - Acoustic programming

online-programming methods

- Teach pendant
  - handheld control and programming unit
    - P2P (Point-to-Point)
    - CP (Continuous Path)
- Playback or Lead-by-the-nose
  - Path given by human
- Manual programmed
  - Via button and switch (out of date)

offline-programming methods

- Textual programming - comparable to high programming languages
- CAD programming - based on engineering drawings and simulation
  - Verification possible:
    - Components attitude in space
    - Movement of components and tools
    - Are working points reachable?
    - Time needed for movement
    - Collision with environment?
    - Checking for alternatives



- Macro programming - shortened code of frequently recurring motions
- Acoustic programming - natural language used to program the robot

online-/offline-programming

Online

- Not abstract – working with the robot (teach it)
- Working with in the "real" environment
- Intuitive

Offline

- Abstract
- Not time-consuming
- Easy changeable
- Without the robot
- Look "inside" the robot

Final part >> Conclusion/Discussion

- Questions?
- Comments?