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 Technical Aspects of Multimodal System
 Dept. Informatics, Faculty of Mathematics, Informatics and Natural Sciences
 University of Hamburg

LV 64.425

Intelligente Roboter

Lecturer
Houxiang Zhang
 TAMS, Department of Informatics
 University of Hamburg, Germany



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Lecture information

- **Class Schedule: Seminar LV64.425 Intelligente Roboter**
 - Tuesday, 8:30-10:00am;
 - Location: F334
- **Lecturer: Houxiang Zhang**
 - Office: F307
 - Phone: 2565
 - Office hours: Friday 11:00 or contact by email
- <http://tams-www.informatik.uni-hamburg.de/lectures/index.php>

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Content of this course

- Introduction to our lecture
- Review of robotic technology
 - What is robot? Review of research achievements
- Different robotic system introduction
 - Mobile robots;
 - Climbing robots;
 - Rescue robots;
 - Medical robots;
 - ...
- Other related research topics
 - Navigation; path planning algorithms
 - Application

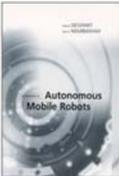
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Acknowledgments

- “Introduction to Autonomous Mobile Robots” by Roland Siegwart and Illah R. Nourbakhsh, and pertinent slides with this book are available on: <http://www.mobilerobots.org>



- Also thanks for online information from
 - [Dr. Alaa Khamis](#)
 - <http://guediggers.com/robodig/MobileRobotics/>

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Acknowledgments

- Other great work and related information on the internet



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Content of today' lecture

- Introduction to our lecture
 - Motivation, requirements, schedule, and other information;
- What is a robot?
 - Robot's definition; law of robots
- Review of robotic technology
 - History of robots; review of research achievements
- Robots' future

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Introduction to our lecture

- Motivation
- Requirements
- Our schedule
- Other useful information



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Introduction to our lecture

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Motivation

- We will look at different methods from the field of computer science that are used in robotics. The main focus is on the practical use of these methods which will be demonstrated with the help of relevant, up-to-date applications. Presentation subjects can be chosen from among the following areas:
 - Architectures: possibilities of behavior control
 - Mobile robotic technology: motivation- technology-various systems
 - Sensor perception and actuation
 - Man-machine-communication: multimodality, example systems
 - Service robots
 - User detection: gates and gestures
 - Manipulator and Multi-finger Hand

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Motivation (cont')

- According to schedule of "Vorlesung Intelligente Roboter", the main purpose of this seminar is to get to know some selected and very interesting topics within the areas of computer science and robotics.
- This seminar enables the participants to have an insight into some special applications and methods, which can be applied in the mobile robotics.
- There are also some other purposes of this seminar, such as enabling the participants to work independently in a scientific area, helping you to present the work in oral lecture and in writing documents.

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Introduction to our lecture

- Motivation
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- Our schedule
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What we require of you

- At the beginning, the lecturer will give some introduction of robotic technology. Then the overall problems are declared by the lecturer at the first lecture.
- It is supported by the discussion at each lecture, where the presenter can be asked. One topic can be handled by up to two participants.
- Each participant makes a presentation which should last more than 30 minutes. The presentation slides and the documents can be prepared with LaTeX (Style-File is available) or PowerPoint (Open Office is alternative).

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What we require of you (cont')

Other emphasis:

- You should attend the course regularly. Low attendance or absence will affect your grade.
- Three time reasonable absence is the limitation.
- German or English is available. English is encouraged
- Other possibility is still open.
 - Small Schein (only Presentation)
 - Big Schein (Presentation + Report)

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What we require of you (cont')

In order to get your Schein:

- *You should send your presentation in PDF to me two days before your oral.*
- *You should give your presentation on time.*
- *You should attend other students presentation regularly.*

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Introduction to our lecture

- Motivation
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Our schedule of the seminar part

- Introduction to the seminar
- Review on robotic technology and challenging issues of robotics
- Open topics for you
 - Mobile robots
 - Climbing robots
 - Rescue robots;
 - Medical robots;
 - Navigation and path planning
 - Famous robotic prototypes introduction
 - Introduction to some pre-selected papers on mobile technology

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Introduction to our lecture

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How to find information for your topics

- Our library: numerous journals and proceedings
- Internet
- Our Tams information </local/tams1.2/tams/proceedings/>
- [Other literature pre-selected by us](#)

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Other lecture material

- *Bioinspiration and Robotics: Walking and Climbing Robots*, Edited by: Maki K. Habib, ISBN 978-3-902613-15-8, Publisher: I-Tech Education and Publishing, Vienna, Austria, Sept. 2007.
- *Climbing and Walking Robots: Towards New Applications*, Edited by: Dr. Houxiang Zhang, ISBN 978-3-902613-16-5, Publisher: I-Tech Education and Publishing, Vienna, Austria, Oct. 2007.
- *Mobile Robotics Moving Intelligence*, Edited by: Jonas Buchli, ISBN 3-86611-284-X, Publisher: Pro Literatur Verlag, Germany / ARS, Austria, Dec. 2006.
- *Mobile Robots Toward New Applications*, Edited by: Aleksandar Lazinica, ISBN978-3-86611-314-5, Publisher: Pro Literatur Verlag, Germany / ARS, Austria, Dec. 2006.
- *Mobile Robots Perception & Navigation*, Edited by: Sascha Kolski, ISBN3-86611-283-1, Publisher: Pro Literatur Verlag, Germany / ARS, Austria, Feb. 2007. (Download)
- <http://tams-www.informatik.uni-hamburg.de/lectures/2008ss/seminar/jr/>

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Web links on robotics

- International Federation of Robots
 - <http://www.ifr.org/>
- IEEE Robotics and Automation Society(RAS)
 - <http://www.ncsu.edu/IEEE-RAS>
- European Robotics research Network (EURON)
 - <http://www.euron.org/>
- Robotics Trends, news and information
 - <http://www.roboticstrends.com/index.php>
- Robotics Online
 - <http://www.roboticonline.com/>

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Contact information:

Available time: 11:00 am on Friday.

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What is a robot?



- A robot is a mechanical or virtual, artificial agent. It is usually an electromechanical system, which, by its appearance or movements, conveys a sense that it has intent or agency of its own. The word robot can refer to both physical robots and virtual software agents, but the latter are usually referred to as bots to differentiate.[1]

[1] Telecom glossary "bot". Alliance for Telecommunications Solutions (2001-02-28). Retrieved on 2007-09-05.

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Where does "Robot" come from?

- In 1921 the Czech author Karel Čapek produced his best known work, the play Rossum's Universal Robots.
- "robot" was derived from the Czech word robota, meaning (forced) "work"




1890-1938

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Laws of robots from Isaac Asimov

- **Law 1:**
 - A robot may not injure a human being, or through inaction allow a human being to come to harm.
- **Law 2:**
 - A robot must obey the orders given it by human beings, except where such orders would conflict with the first law.
- **Law 3:**
 - A robot must protect its own existence as long as such protection does not conflict with the first or second law.
- **Zeroth Law:**
 - A robot may not injure humanity, or, through inaction, allow humanity to come to harm.



1920-1992

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Robot means what?




Webster Dictionary
An automatic apparatus or device that performs functions ordinarily ascribed to humans or operates with what appears to be almost human intelligence.
Robot Institute of America
A reprogrammable multifunctional manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks.
Japanese Industrial Robot Association (JIRA)
A device with degrees of freedom that can be controlled.
International Federation of Robotics (IFR)
An automatically controlled, reprogrammable multipurpose manipulator programmable in three or more axes.

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Other definitions

- Any device which replaces human labor (Sosoka, Japan, 1985)
- A programmable multifunction manipulator designed to move material, parts, or specialized devices through variable programmed motions for performance of a variety of tasks (Robotics Institute of America, Schlüssel, 1985).
- A robot is a machine which can be programmed to do a variety of tasks, in the same way that a computer is an electronic circuit which can be programmed to do a variety of tasks (McKerrow, 1986).
- Robotics is the intelligent connection of perception to action (Mike Brady, Oxford, 1985).

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Difference between a machine and a robot

- Two Volkswagen Touareg



Original Volkswagen Touareg



Stanley, Stanford Racing Team
The winner of the 2005 DARPA Grand Challenge

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My definition of “robot”

- 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.
- Its purpose is to release human beings of laborious tasks, and of working in a critical environment, or to provide services to improve the our living standard.






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Scientific fictions and movies on robots

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History of robots

- Mechanical dolls and other devices
 - Al Jazari (1206AD)

Diagram of a water-raising machine from The Book of Knowledge of Ingenious Mechanical Devices by al-Jazari.
 The double-action reciprocating suction piston pump water-raising machine with a crankshaft connecting rod mechanism invented by al-Jazari.
 The elephant clock from al-Jazari's manuscript.
 One of al-Jazari's candle clocks.
 A model of the automaton designed by al-Jazari.
 A table device automaton designed by al-Jazari.
 A hand-washing device designed by al-Jazari.
 Al-Jazari's water-powered scribe chain pump device.

<http://en.wikipedia.org/wiki/Al-Jazari>

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History of robots

- Mechanical dolls and other devices
 - Automaton in the Swiss Museum CIMA
 - Tea-serving Japanese automaton, "karakuri", with mechanism (right), 19th century

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History of robots

- Mechanical automata
 - The “ wooden galloper with swing cargo box” (231-234) was created by Zhuge Liang while he served Shu-Han. It was a mechanical, walking replica of an ox whose main purpose was to carry supplies such as grain to an army that was running low on supplies.
 - Duck of Vaucanson (1739), an early automaton was created in 1738 by Jacques de Vaucanson, who created a mechanical duck that was able to eat and digest grain, flap its wings, and excrete.




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History of robots

- Mechanical automata
 - Tanaka Hisashige’s 1851 perpetual clock, in the National Science Museum
 - Japan's first steam engine, manufactured in 1853.





Tanaka Hisashige
 (1799-1881)

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Early research achievements

- In 1926, by Westinghouse Electric Corporation, “Televox” the first robot put to useful work.
- In the 1930s, a humanoid robot “Elektro” for exhibition purposes, including for 1939 and 1940 World's Fairs.




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Early research achievements

- In 1928, by Makoto Nishimura, “Gakutensoku” Japan's first robot.
- In 1949, by William Grey Walter, “Elmer and Elsie”, the first electronic autonomous robots These robots could sense light and contact with external objects, and use these stimulus to navigate.



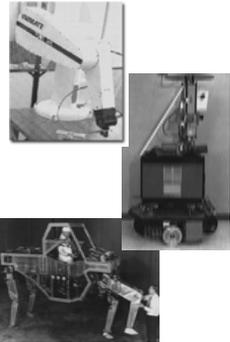

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Early research achievements

- In 1961, by George C. Devol “Unimate”, first industrial robot.
- In 1967, by SRI, Palo Alto, CA. “Shakey”, a small unstable box on wheels to solve problems and navigate in its environment.
- 1960s , by Ralph Moser at General Electric Corp, “General Electric Walking Truck”, a large (3,000 pounds) four legged robot that could walk up to four miles per hour. The walking truck was the first legged vehicle with a computer-brain, developed.



<http://www.wikimedia.org/wiki/Unimate>

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From 1970s to now...

- Robots have been changing our life from all aspects...



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Review of robotic technology

- **What is robotics?**
- **Why should you know something on robots?**
 - Robotics is the science and technology of robots, their design, manufacture, and application. Robotics requires a working knowledge of electronics, mechanics and software, and is usually accompanied by a large working knowledge of many subjects.
- Robotics is the intelligent connection of perception to action.

<http://en.wikipedia.org/wiki/Robotics>

M.Brady, Artificial intelligence and Robotics Artificial Intelligence, 26, pp.79-121,1985

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Robotics discipline

- Robotics involves:
 - Methodology: how to implement or design the robots from the system view point
 - System integration: system design
 - Mechanical system and design: realize a physical prototype
 - Kinematics and dynamics
 - Control system design and electrical realization
 - Software integration
 - Control algorithms
 - On-site testing, evaluation, and improvement

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An example

Labels on the right side of the slide:

- Omnidirectional vision system
- Stereo camera head with PTU
- Screen mounting
- Controller for BarrettHand
- Controller for PA10
- Power electronics for PA10, controller for hand camera and PTU

Labels on the left side of the slide:

- BarrettHand and hand camera
- Mitsubishi PA10-6C
- preparation for second manipulator

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Another example-Ugobe Pleo

Pleo is UGOBE's first "designer life form"; based on the Camarasaurus dinosaur and made up of an amazing array of sensors, motors (14), and distributed computing with an ARM-7 processor commanding it all.

<http://www.ugobe.com/>

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Robot Taxonomy

- There are only two kinds of robots primarily according to their mobility:
 - Manipulator robots (Industrial arms)
 - Mobile robots

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Mobile robot classification

- According to the environment in which they travel:
 - Land or home robots; aerial robots and underwater robots
- Kinematics
 - Sliding frame robot, legged robot (humanoid robot and multi-leg robot); wheeled robot and chain-tracks

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Mobile robot classification

- According to the autonomous levels:
 - Autonomous or semi-autonomous modes
- According to applications
 - Service robots; edutainment robots; pure research prototypes; space robots; and civil or military robots



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Review of robotic technology

- What is robotics?
- Why should you know something on robots?
 - Robotics will connect the research, technology with industry and normal life.
 - Robotics will change our life in the following 30 years, it is not only a future technology.
 - Robotics will be more and more popular and absolutely necessarily for human society.
 - For you, robotics means a big chance for good future.

@hzhang

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Markets & Challenges



1. Robotics for Industry



2. Service Robotics



3. Security & Space Robotics



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Why should you know something on robots?

- Microsoft Chairman Bill Gates lays out the robotic future in the cover story of January's Scientific American Magazine.
 - In the story, Gates argues that the robot industry is akin to the PC industry 30 years ago.
 - Robots will be everywhere in our life.



1955-present

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Robots in our life

- Climbing robots
- Multi-legged walking robots
- Robots for Education and entertainment
- Modular robots
- Snake-like robots
- Rescue robots
- Medical system & Surgery robots
- Underwater robots
- Humanoid robots
- Service robots for special tasks
- Industrial robots-robotic arms
- Open topics ...

<http://www.esom.org/resources/robotgallery.htm>

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Transportation and service

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Personal assistant

Nursebot

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Personal assistant – Humanoid Robots

TAMS Humanoid Robots

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Medical system & Surgery robots



Cleaning and maintenance



Research prototypes



Education and entertainment robots

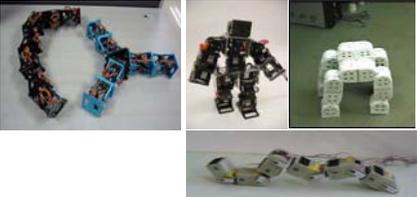


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Edutainment robots – Modular robot

- Main idea: Building robots composed of **modules**
- The design is focused on the module, not on a particular robot
- The different combinations of modules are called **configurations**

- Some advantages:
 - Versatility
 - Fast prototyping
 - Testing new ideas



Other example 1 Other example 2

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Space exploration robots

The NASA Space Telerobotics Program was shut down in 1997, and the research and technology development tasks supported by the program were transferred to other efforts.

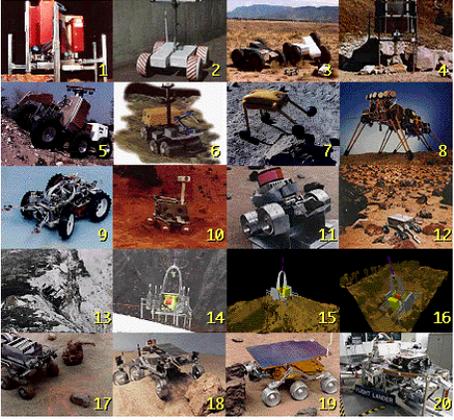



http://ronier.oact.hq.nasa.gov/telerobotics_page/telerobotics.shm

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Demining robots



(a) Armtrac 25. (Armtrac Ltd., United Kingdom)
(b) Bozena 4 (WAY Industry J.S. Co. Slovak Republic)
(c) Mini-flail. (US Department of Defense)
(d) Diana 44T (Hontstav S.R.O., Slovak Republic)
(e) Minecat 140. (Norwegian Demining Consortium)
(f) The MV-4. (DOK-ING d.o.o., Croatia)

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Agricultural robots



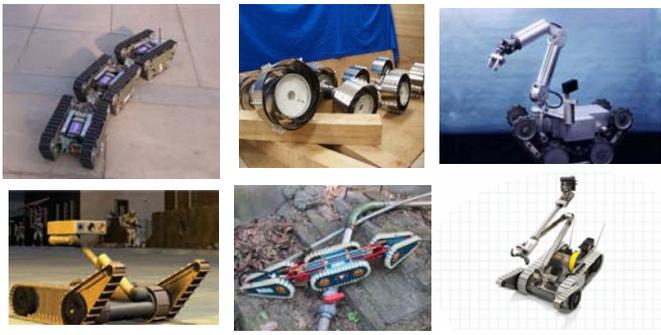
Ag-robots Farm Robots
Illinois University

Demeter
National Robotics Engineering Consortium
<http://www.rec.ri.cmu.edu/projects/demeter/demeter.shtml>

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Urban search and rescue & military



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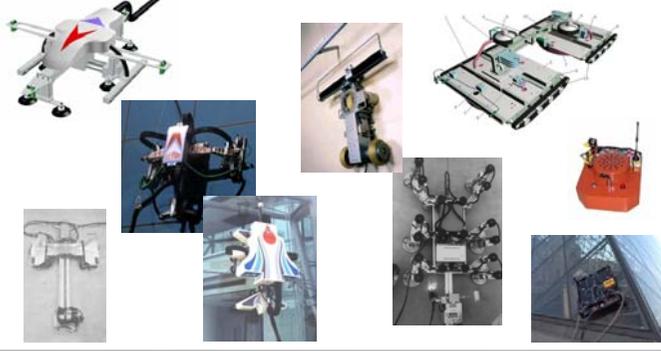
Fire fighting robots



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Construction and building maintenance



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Inspection robots

- According to the environment in which they travel:
 - Open natural environment
 -
 - Man-made environment
 -

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Underwater robots

Other examples

„Manta ray“

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Unmanned aerial vehicle (UAV)

Sub-mini helicopters

MAV/D-25

SUAV/MD-100 SUAV/MD-120 SUAV/MD-180 SUAV/MD-200

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Many interesting robotic prototypes

- Legged robots
- Wheeled robots
- Chain-tracked robots
- Sliding frame robots and snake-like robots

<http://www.euron.org/resources/robotgallery.html>

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Legged robots

- One leg
- Two-legged-Biped
- Four-legged-Quadruped
- Six-legged-Hexapod
- Eight-legged-Octopod

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Legged robots

- One leg
- Two-legged-Biped
- Four-legged-Quadruped
- Six-legged-Hexapod
- Eight-legged-Octopod

Other example

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Legged robots

- One leg
- Two-legged-Biped
- Four-legged-Quadruped
- Six-legged-Hexapod
- Eight-legged-Octopod

Other example

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Six-legged mobile robots

- One leg
- Two-legged-Biped
- Four-legged-Quadruped
- Six-legged-Hexapod
- Eight-legged-Octopod

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Legged robots

- One leg
- Two-legged-Biped
- Four-legged-Quadruped
- Six-legged-Hexapod
- **Eight-legged-Octopod**

<http://www.fusionmotion.net/viewtopic.php?r=3243&id=944e52ee3752908cad162a399e1933f>

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Wheeled robots

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Chain-tracked robots

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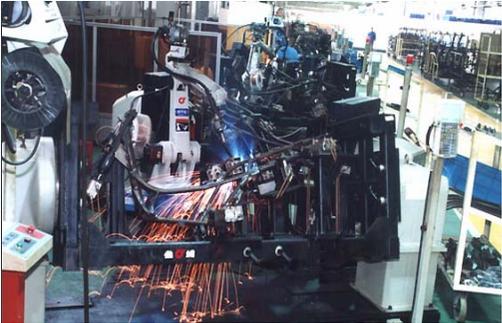
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Snake-like robots

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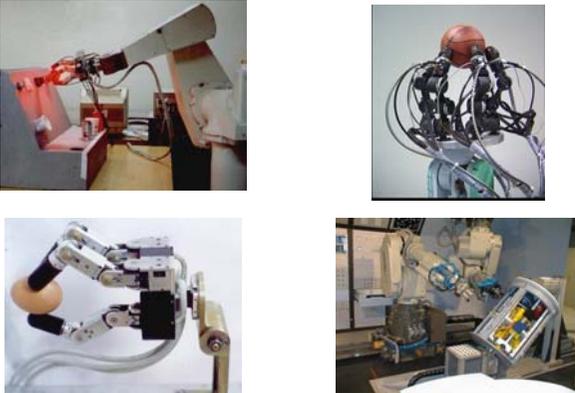
Industrial robots & Robotic arms



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Arm cooperation



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Content of today' lecture

- Introduction to our lecture
 - Motivation, requirements, schedule, and other information;
- What is a robot?
 - Robot's definition; law of robots
- Review of robotic technology
 - History of robots; review of research achievements
- Robots' future

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Robotics' future

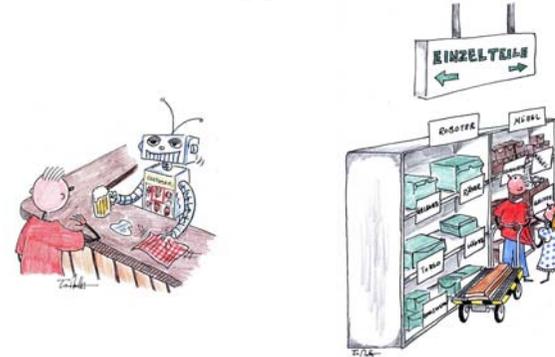
- Standardize robots
 - Robotics companies have no standard operating software that could allow popular application programs to run in a variety of devices. The standardization of robotic processors and other hardware is limited, and very little of the programming code used in one machine can be applied to another.

- Hardware costs are falling for robots
 - Another barrier to the development of robots has been the high cost of hardware, such as sensors and actuators.

- Software applications need a conductor
 - Control methods, cognition...



One day it will happen...



Thanks for your attention!

Any questions?