Robotics apetizer

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Outline of the talk:

- Robot, robotics, what is?
- Robotics and production.
- Fairy tales, toys and prototypes.

What is robotics?

In this lecture, robotics is understood as the discipline aiming at creating intelligent machines, i.e., integrating several scientific and technological areas.

Two historical milestones:

Golem a clay statue that was made alive by a special formula. The idea originates in a cabalistic legend from 12th century. It became known in conjunction with Prague rabbi Yehudah Löwe ben Bezela from the edge between 16th and 17th century.

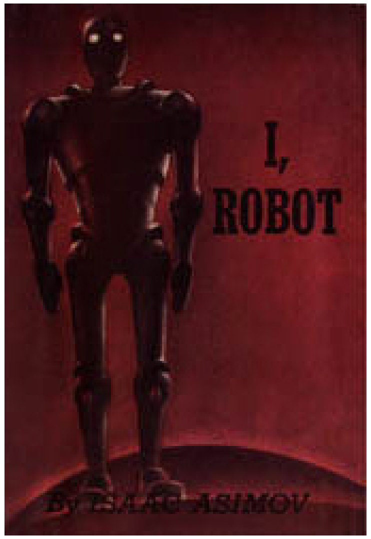
Robot Just young Rossum got an idea to make from it live and intelligent machines (Karel Čapek, R.U.R., prelude).

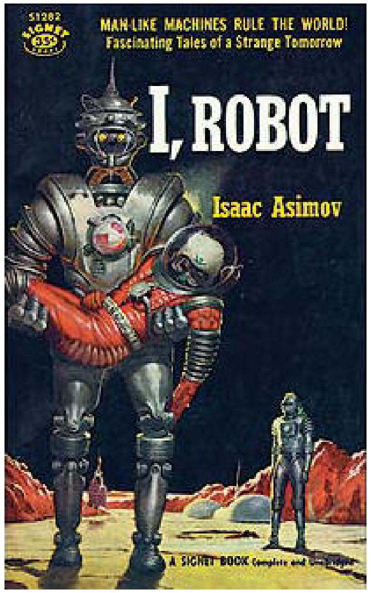
Staging R.U.R. in Paris 1924.

Three laws of robotics

(Isaac Asimov, I Robot, 1950.)

- A robot may not injure a human being or, through inaction, allow a human being to come to harm.
- A robot must obey the orders given to it by human beings, except where such orders would conflict with the First Law.
- A robot must protect its own existence, except where such protection would conflict with the First or Second Law.





Several definitions of the robot

Robot (McKerrow, 1986) The robot is a machine that can be programmed to perform different different tasks.

Robotics (Brady, 1985) is an intelligent connection between perception and action.

Robotics (McKerrow, 1986) comprises:

1. Design, production, control, and programming of robots.
2. Application of robots to tasks solving.
3. Analysis of control tasks, sensors, actuators, and algorithms in humans, animals and machines.
4. Application of the above to design and applications of robots.

Why are people interested in robots?

- We like to compare our abilities with the nature (symbolically). We intend to check how far do our creative abilities span and by means of repetition to penetrate into Laws of Nature.
- We intend to produce a perfect helper with abilities comparable to ours and who might be even more reliable than humans.

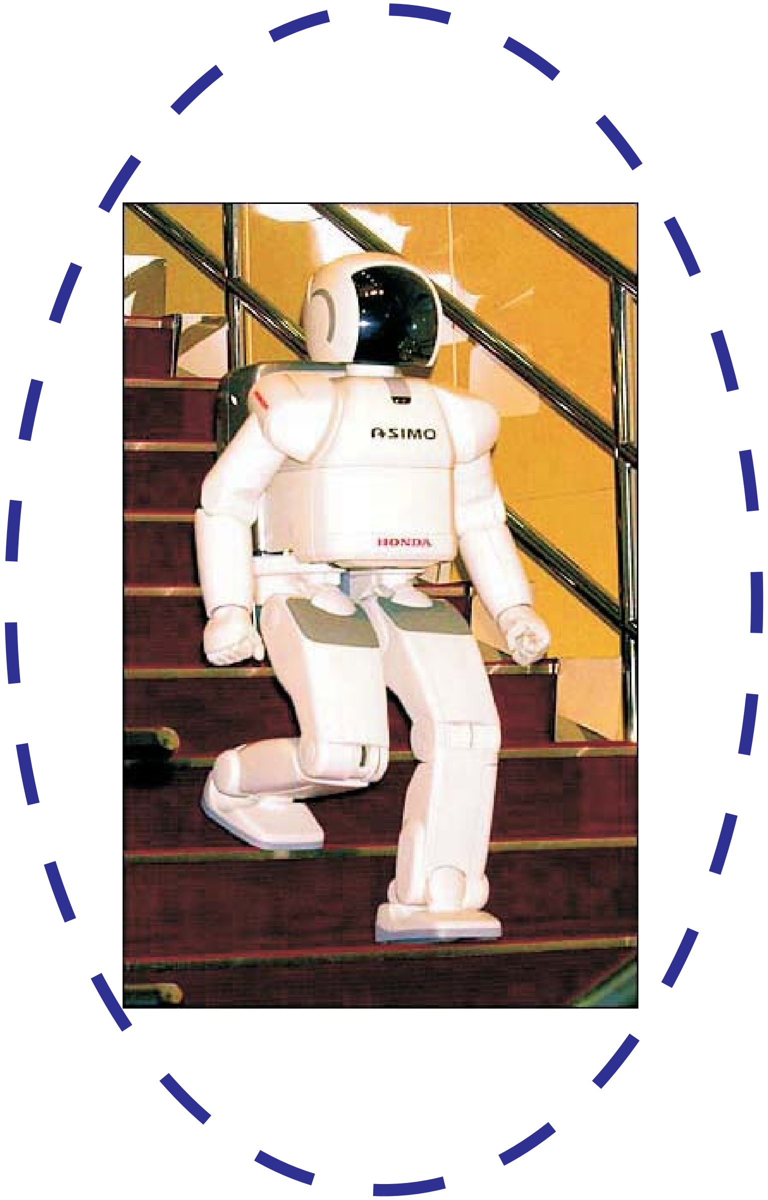
Robots and its subsystems

Subsystems:

- Mechanical.
- Electrical.
- Control.
- Power sources.

Towards cognitive robots:

- Sensors.
- Actuators.
- Cognitive (model of the world, perception, planning, . . .).



Various approaches to robotics

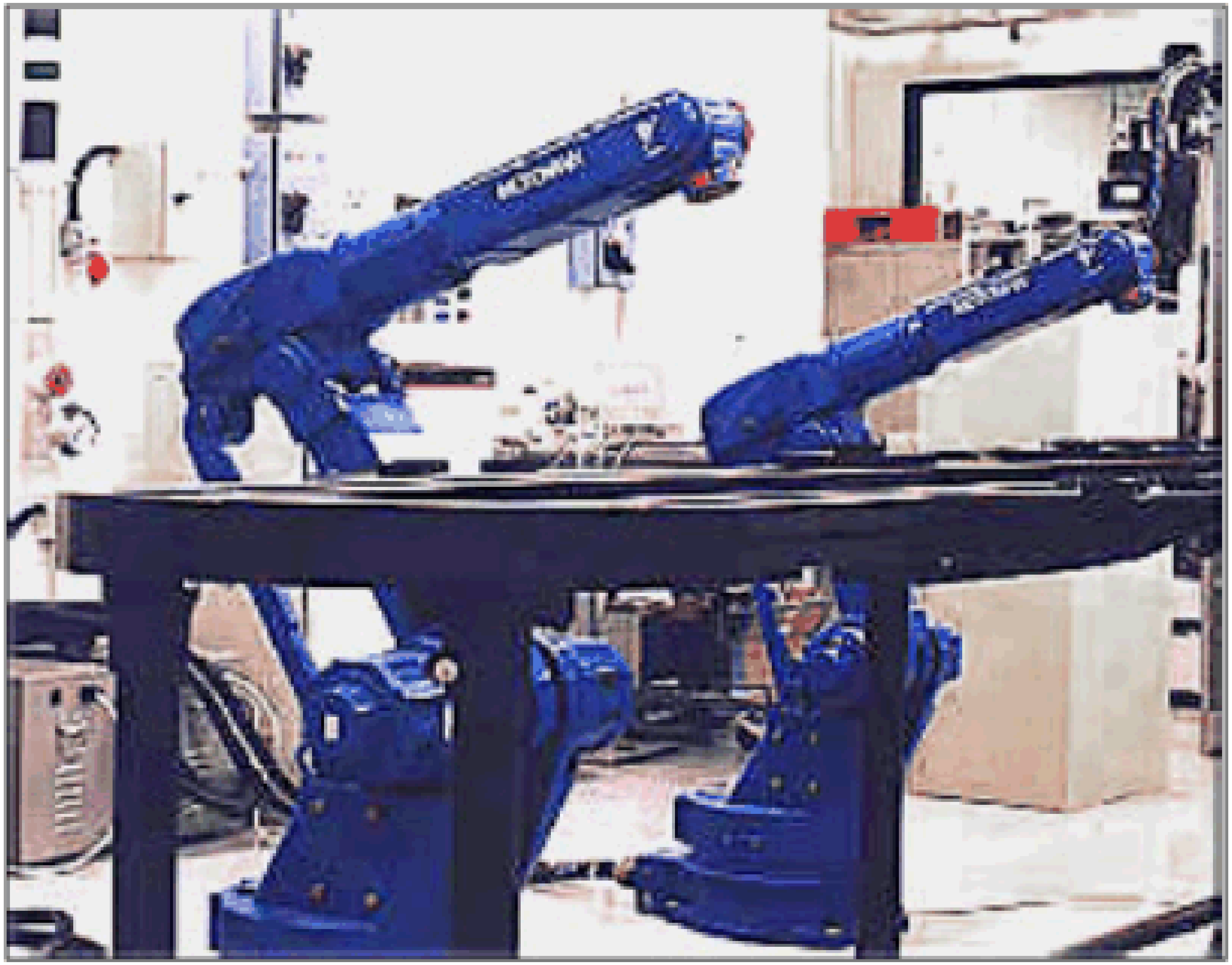
Theoretical robotics: searches for principles, potentials and constraints (biology, psychology, etology, mathematics, physics).

Experimental robotics: checks principles, builds toy devices (cybernetics, artificial intelligence, combination of engineering disciplines).

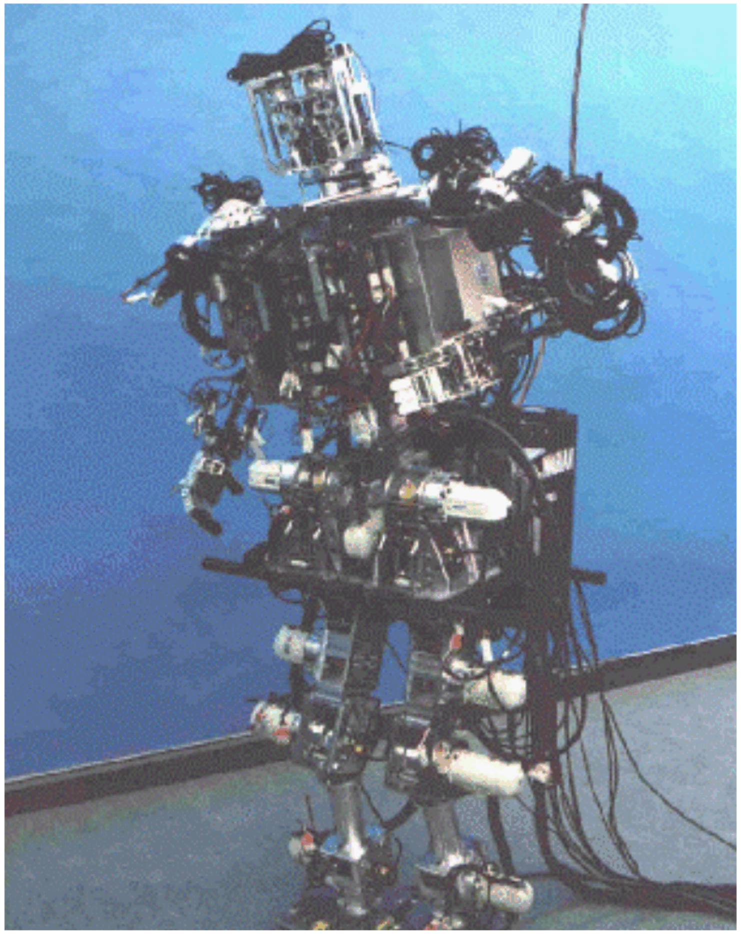
Experimental (industrial) robotics: Designs, builds and uses robots (control engineering theory and instrumentation, electronics, machine engineering, production automation).

Miscellaneous applied robotics: Designs various intelligent machines for industry and elsewhere. For instance, machines for quality check in production are often endowed by the ability to see, mobile robots are able to navigate autonomously, etc.

Robotics yesterday



Robotics today



Industrial robot

is and automatic device with the following abilities (in larger or smaller degree) [I.M. Havel 1980]

1. Manipulation abilities.
2. Automatic autonomous performance.
3. Its program can be modified easily.
4. Universality.
5. Feedbacks.
6. Concentrated in the space.

Deployment of industrial robots

Production and its automation

Proliferation of mechanization, automation and robots $\Longrightarrow$

- decrease of the human presence in production,
- shortening the production time (namely auxiliary one),
- increase of performance and productivity of labor.

Notes

- Technical, economic and social viewpoints.
- Automation decreases the influence of the human factor to the quality of production.
- The qualification structure of the work force is changed.
- The number of workers decreases which influences the unemployment.

Concepts related to industrial robotics

- Mechanization, automation.
- Machines with partial automation, semiautomatic machines, automata.
- Numerically controled (NC) machines.
- Automatic production line, automatized workcell, automatized workshop.
- Technological process is a collection of technological operations that leads from a semi-finished article to a product.
- Technologic operation, technologic position.
- Operational cycle

  periodic: clock rate, cf. synchronous automaton.

  flexible: flexible changes according to conditions, cf. asynchronous automaton.

Production types according to number of produced articles

Production	Automation
Single piece	Flexible automation means
Small series	
Mass	Hard automation

To which production type is the industrial robot usually deployed. Why?

Towards flexibility in automation

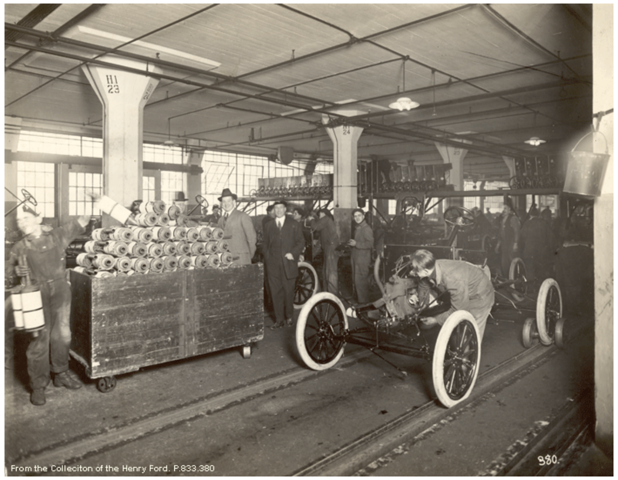
1860 Replaceable parts, standardization.

1913 Conveyer belt (Henry Ford) and machines in a fixed positions (the disadvantage: the failure of one machine stops the whole line).

1994 Interchangeable production lines, universal machines and flexible transport of articles.

- Structured $\sim$ effectiveness.
- Unstructured $\sim$ flexibility.

1913 Flywheel magnetos.



1915 Car bodies Model-T.

Charlie Chaplin, movie Modern Times 1936

Industrial appetizer 1 – the box assembly

Industrial appetizer 2 – sausages

Industrial appetizer 3 – the bakery

Robotics tomorrow

How does the engineer work?

- *"To the engineer falls the job of clothing the bare bones of science with life, comfort, and hope."* -– Herbert Hoover (*1874, died 1964, US president 1929—1933).
- *"Everything should be made as simple as possible, but not simpler."* -– Albert Einstein (1879–1955).
- *"Don't drag the engine like an ignoramus, but bring wood and water and flame, like an engineer."* — Maria Weston Chapman (1805-1885, US radical anti-slavery leader).
- *"Always listen to the experts. They'll tell you what can't be done and why. Then do it."* — Robert Heinlein (1907–1988, US science-fiction writer).

Cognitive systems

- **Artificial cognitive systems** $\equiv$ artificial systems that perceive, understand, learn and develop through individual or social interaction with their environment.
- **Societal needs** (which manifest themselves in financing of research):
  - to create and develop a scientific foundation for artificial cognitive systems.
  - . . . also by taking inspiration from the study of natural cognitive systems.
- Artificial cognitive systems research is expected to provide an enabling technology for all sorts of applications involving interaction with the real-world environment and its inhabitants.

Research in cognitive robotics today

DARPA Urban Challenge
November 2007

European humanoid robot
Aldebaran Robotics, France

Challenges

- **Ability to learn from experience** – allows the cognitive system to adapt to the outer conditions.
- **Robustness** – performance shouldn't degrade much with unexpected events and observations.
- **Effectiveness** – performance should improve because a cognitive system can predict or anticipate what might happen at some point in the future, near or far.
- **Naturalness** – performance should be tolerant to the ambiguity and uncertainty that is a consequence of dealing with humans and performance should improve with time.

Melting pot of different disciplines

- Artificial intelligence.
- Computer vision.
- Natural language processing.
- Robotics.
- Human-computer interaction.
- Mathematics.
- Psychology.
- Cognitive science.
- Computational neurosciences.
- Philosophy of mind.
- Various branches of engineering.
- Software development.

and **integration, embodiment . . .**

Dreaming and playing is useful

Fairy tales. A miraculous instrument is usually sought that would allow us to perform what has been impossible until now *(e.g., to develop a flying carpet and float in the air)*.

Toys. Various models are created which imitate dreams of the fairy tale stage although they are too far from any practical exploitation, *(e.g., a model glider which is already flying)*.

Prototypes fulfil practical requirements, a little at the beginning, and more and more later on, *(e.g., an airplane)*.

- Thinking in a fairy tale manner is an effort to perceive the result demanded.
- Toys clear up the principles and check whether it is possible to realize this or that dream.

Major economies support cognitive systems research

- European Commission: In FP5, FP6 and FP7.
- European national governments.
- United States of America:
  - NSF: program Robust Intelligence.
  - DARPA: many projects with substantial and dedicated funding; Supports challenges as Urban Challenge in Nov. 2007.
- Japan, China, Korea, Russia . . . .

- Industry
  - Automotive: autonomously driven car.
  - Defense: unmanned vehicles, combat robots.
  - Utensils: autonomous vacuum clearers, lawn mowers, . . .
- Space exploration: planetary rovers, robots for missions/repairs in the free space.

Fairy tales = proposals; Toys = demos

- In research projects proposals, fairy tales that can become real have a much higher chance to succeed.
- Making fairy tales real poses problems that may not be solvable through one or even several calls.
- In reality, there is a progress, of course, but the ‘components’ are not yet fully grasped.
- There should also be the space to slow down, go back, rethink and consolidate the components.
- The commission designers of funding programmes and proposers alike have the delicate task to balance between dreams and applicable outcomes.

- Demos are the vital tool not to loose the contact with the reality.

Fairy Tales and Reality

- The criticizer of the fairy tale metaphor could object that research in cognitive systems is not grounded in reality.
- The transition from fairy tale $\rightarrow$ toy $\rightarrow$ prototype is possible only because the research effort is deeply embedded in a rich back-drop of mathematical, scientific, and technological progress.
- The pursuit of this transition also motivates and drives these component areas forward.
- A very healthy (and necessary) symbiosis.

iCub robot, U of Genova

Courtesy Giorgio Metta

Grand challenges, positive influence

- Help to focus the efforts.
- Can be of lower cost and less bound to current technology than DARPA Urban Challenge.
- Examples of:
  - NSF Semantic Robot Vision Challenge: room with objects, simple mobile robot (embodied agent), gets list of objects, has to pick them up.
  - NoE PASCAL challenge: contest of machine learning algorithms.

Winner June 2008
Univ. of British Columbia

Example 1, industrially funded

Traffic signs recognition on the road

Courtesy J. Matas, CTU Prague

Example 2, industrially funded

Lamps inventorying in the British cities

Courtesy P. Doubek, J. Matas, CTU Prague

Example 3, funded by the European Commission

Pedestrian detection from omni-cameras

Courtesy project DIRAC, T. Pajdla, CTU Prague

Conclusions

- Robotics and cognitive systems research makes our way forward towards machines endowed with 'human'-like abilities.
- Many innovations appear as a side effect.
- Project selection is as good as the referees who decide about proposals.

- **Thank you for your attention.**

Poděkování: projekt RobotCub
José Santos-Victor, IST Lisbon