Vorlesung
Grundlagen der Künstlichen Intelligenz

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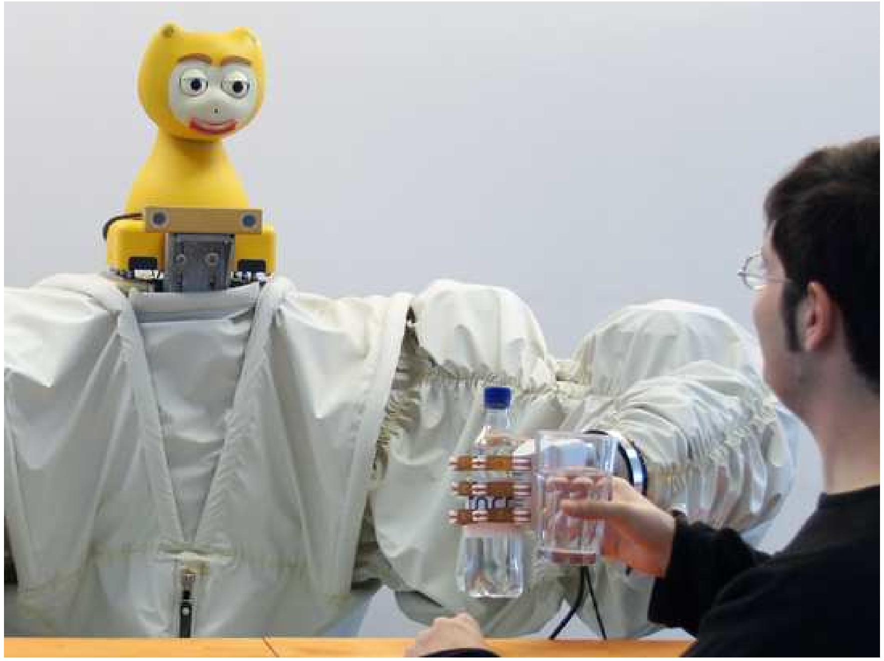


Wintersemester 2012/13 22.10.2012

Organisational remarks

- Lecture: Mo, 12:15-13:45, Interims-Hörsaal 2
- Lecture /Exercise: Fr., 12:15-13:45

- Book: Russel/Norvig: Artificial Intelligence: A Modern Approach, 3. ed. (dt. und engl. Ausgaben erhältlich)

- Also based on the lecture by Prof. Michael Beetz, WS2011/12

Chapter 1

Introduction

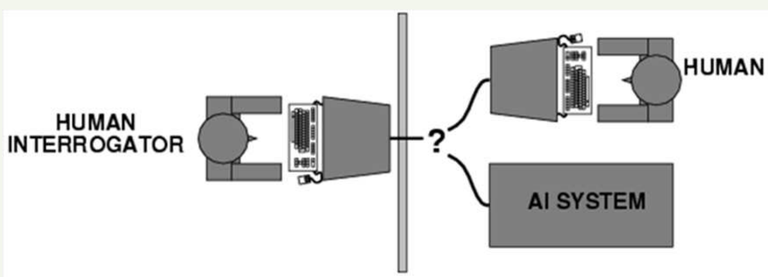
What is Artificial Intelligence?

- The construction of intelligent systems (computers, smartphones, cars, robots, …)
- Formalization and representation of knowledge and reasoning based on that knowledge
- Development and use of computational models to understand humans and artificial agents
- Build the bases for natural human-system interaction on each level (common sense to expert use)

What is Artificial Intelligence?

	Human-like	Rational
Thinking	"The exciting new effort to make computers think ... machines with minds, in the full and literal sense" (Haugeland, 1985) "The automation of activities that we associate with human thinking, activities such as decision-making, problem solving, learning ..." (Bellman, 1978)	"The study of mental faculties through the use of computational models" (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act" (Winston, 1992)
Acting	"The art of creating machines that perform functions that require intelligence when performed by people" (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better" (Rich and Knight, 1991)	"A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes" (Schalkoff, 1990) "The branch of computer science that is concerned with the automation of intelligent behavior" (Luger and Stubblefield, 1993)

What is Artificial Intelligence?

	Human-like	**Rational**
Thinking	Cognitive Sciences, Neurosciences	Logic-based reasoning
Acting	Turing-Test  	Rational agents maximize goal achievement, given the available information ⇒ Doing the “right” thing

Systems that think like humans

- Top-down approach: Cognitive sciences
  - Theories about internal activities in the human brain
  - What level(s) of abstraction are appropriate?
- Bottom-up approach: Neurosciences
  - Understanding of natural neural networks still a challenge
  - Sensing of brain activity improving (skin, fMRI, implanted neural interfaces)

Image source: DLR
http://www.dlr.de/dlr/presse/desktopdefault.aspx/tabid-10172/213_read-5268/

Systems that act like humans

- Turing-test (Turing, 1950): Imitation game using a screen/keyboard interface to communicate with the other agent
  - Goal: identify whether the communicatin partner is human or a machine
- Contains many key aspects of AI:
  - Natural language processing
  - Knowledge representation
  - (Logical) inference
  - Learning
- The “total Turing test” also includes
  - Computer vision
  - Robotics

Systems that think rationally

- Logic-based reasoning: Facts and deduction rules
- Origin in philosophy (Aristotele)
- Problems:
  - Intelligent behaviour is not only based on logical considerations
  - Complexity! Both, in representing parts of the real world and in the reasoning about it

- Direct line through mathematics and philosophy to modern AI

Systems that act rationally

- Rational agents:
  - An agent is an entity that perceives and acts
  - Abstractly, an agent is a function from percept histories to actions: [f: $P^* \rightarrow A$]

- For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance
  - Caveat: computational limitations make perfect rationality unachievable

- Design best program for given machine resources

A brief history of AI

taken from http://aitopics.net/BriefHistory

Year	Event
1956	John McCarthy coined the term "artificial intelligence" as the topic of the Dartmouth Conference, the first conference devoted to the subject.
	Demonstration of the first running AI program, the Logic Theorist (LT) written by Allen Newell, J.C. Shaw and Herbert Simon
1957	The General Problem Solver (GPS) demonstrated by Newell, Shaw & Simon.
1958	John McCarthy (MIT) invented the Lisp language.
1961	James Slagle (PhD dissertation, MIT) wrote (in Lisp) the first symbolic integration program, SAINT, which solved calculus problems at the college freshman level.
1962	First industrial robot company, Unimation, founded.
1964	Danny Bobrow's dissertation at MIT (tech.report #1 from MIT's AI group, Project MAC), shows that computers can understand natural language well enough to solve algebra word problems correctly.

A brief history of AI

taken from http://aitopics.net/BriefHistory

Year	Event
1965	J. Alan Robinson invented a mechanical proof procedure, the Resolution Method, which allowed programs to work efficiently with formal logic as a representation language.
	Joseph Weizenbaum (MIT) built ELIZA, "simulating" the dialogue of a psychotherapist
1967	Dendral program (Feigenbaum, Lederberg, Buchanan, Sutherland) to interpret mass spectra on organic chemical compounds. First successful knowledge-based program for scientific reasoning.
	Joel Moses (PhD work at MIT) demonstrated the power of symbolic reasoning for integration problems in the Macsyma program. First successful knowledge-based program in mathematics.
	Richard Greenblatt at MIT built a knowledge-based chess-playing program, MacHack, that was good enough to achieve a class-C rating in tournament play.

A brief history of AI

taken from http://aitopics.net/BriefHistory

Year	Event
1968	Marvin Minsky & Seymour Papert publish Perceptrons, demonstrating limits of simple neural nets.
1969	SRI robot, Shakey, demonstrated combining locomotion, perception and problem solving.
	First International Joint Conference on Artificial Intelligence (IJCAI)
1970	Patrick Winston's PhD program, ARCH, at MIT learned concepts from examples in the world of children's blocks.
1971	Terry Winograd's SHRDLU demonstrated the ability of computers to understand English sentences in a restricted world of children's blocks.
1972	Prolog developed by Alain Colmerauer.
1974	Ted Shortliffe's MYCIN (Stanford) demonstrated the power of rule-based systems for knowledge representation and inference for medical diagnosis and therapy. Sometimes called the first expert system.

A brief history of AI

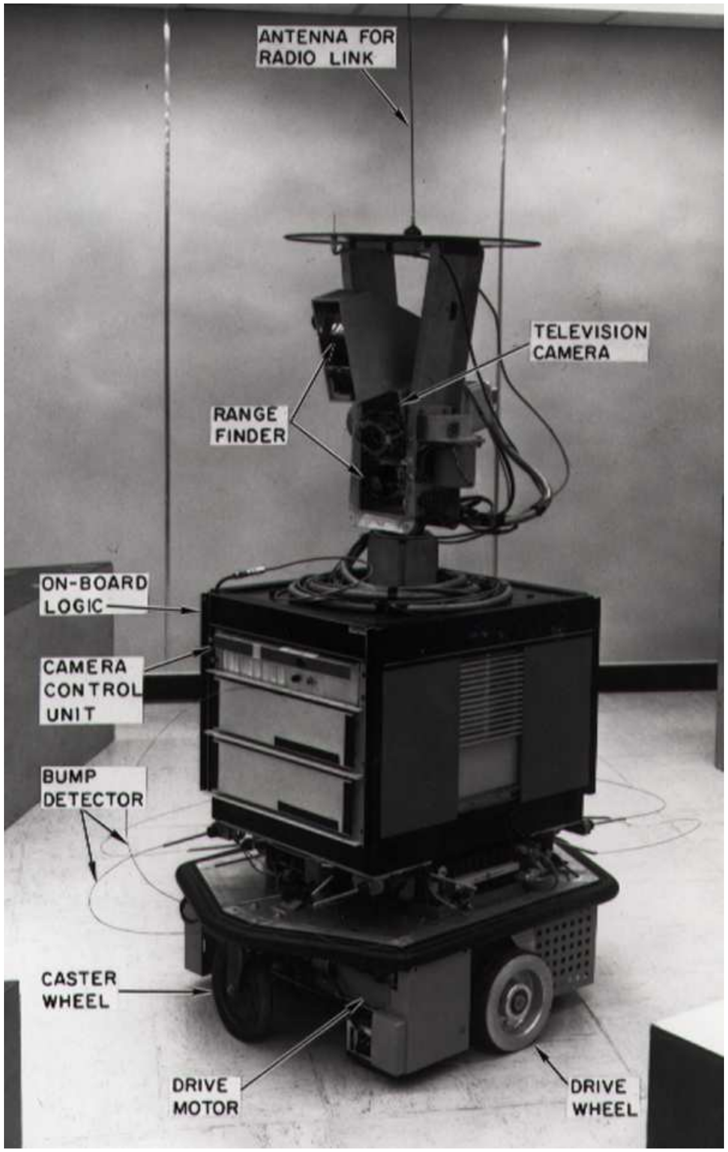
taken from http://aitopics.net/BriefHistory

Year	Event
1975	Marvin Minsky published his widely-read and influential article on Frames as a representation of knowledge, in which many ideas about schemas and semantic links are brought together.
	The Meta-Dendral learning program produced new results in chemistry (some rules of mass spectrometry) the first scientific discoveries by a computer to be published in a refereed journal.
1976	Doug Lenat's AM program (Stanford PhD dissertation) demonstrated the discovery model (discovery of number theory)
1983	John Laird & Paul Rosenbloom, cogntive architecture SOAR
1989	Dean Pomerleau at CMU creates ALVINN (An Autonomous Land Vehicle in a Neural Network), autonomous coast-to-coast drive
1997	Deep Blue beats the current world chess champion, Garry Kasparov,
	NASA’s pathfinder mission: first autonomous robotics system, Sojourner
	First official Robo-Cup soccer match

… and today?

- The situation has changed:
  - Computational power, embedded computing devices
  - Cheap sensors and multi-media devices
  - Computer networks, WWW, augmented reality, computer games, robotics
- But: still need for „intelligent“ systems
  - Semantic information retrieval
  - Logistics
  - Domestic service robots
  - Smart devices and ambient intelligence
- Many methods available:
  - Learning, reasoning, probabilistic state estimation and prediction,…

Examples of “recent“ AI systems



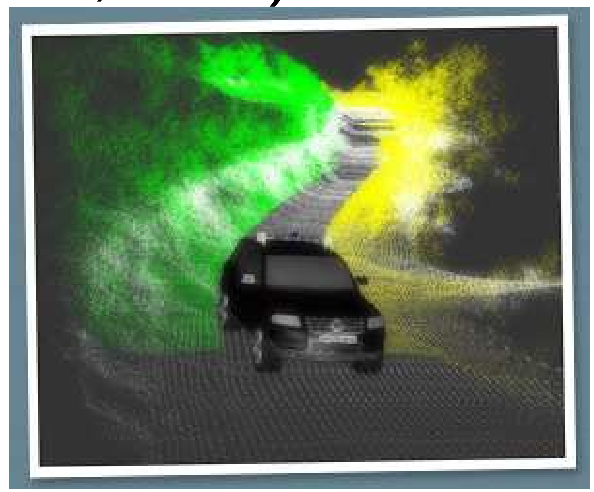
http://archive.computerhistory.org/resources/still-image/Robots/shakey.102635321.lg.jpg

- SRI‘s Shakey
  - Knowledge representation
  - (Logical) inference
  - Learning
  - Computer vision
  - Planning

Examples of recent AI systems

- DARPA grand challenges (2004, 2005)

http://cs.stanford.edu/group/roadrunner//old/presskit/high_res_pics/Stanley_Image3.jpg



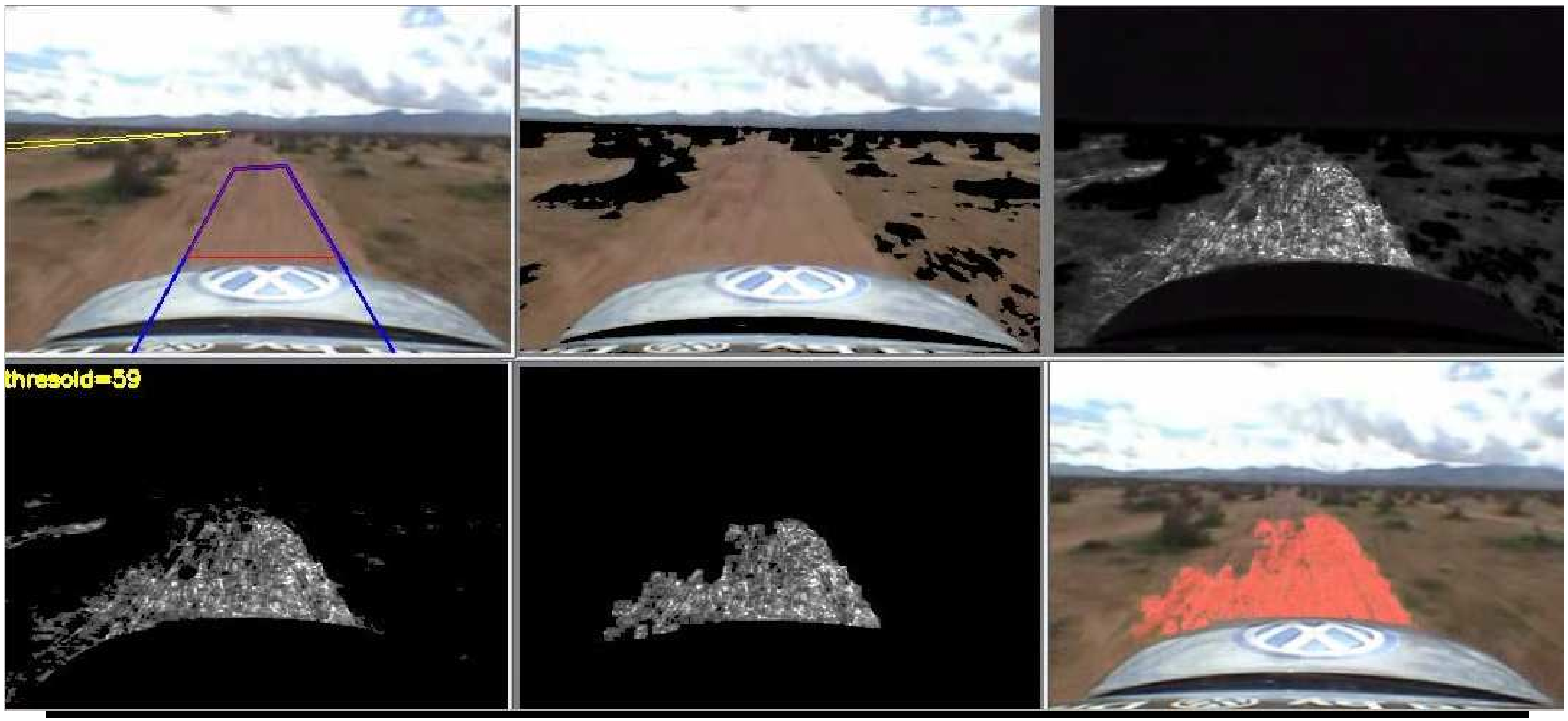
http://cs.stanford.edu/group/roadrunner//old/technology.html

- DARPA Urban challenge (2007)

http://archive.darpa.mil/grandchallenge/images/photos/high_res/IMG_6737.JPG

Examples of recent AI systems

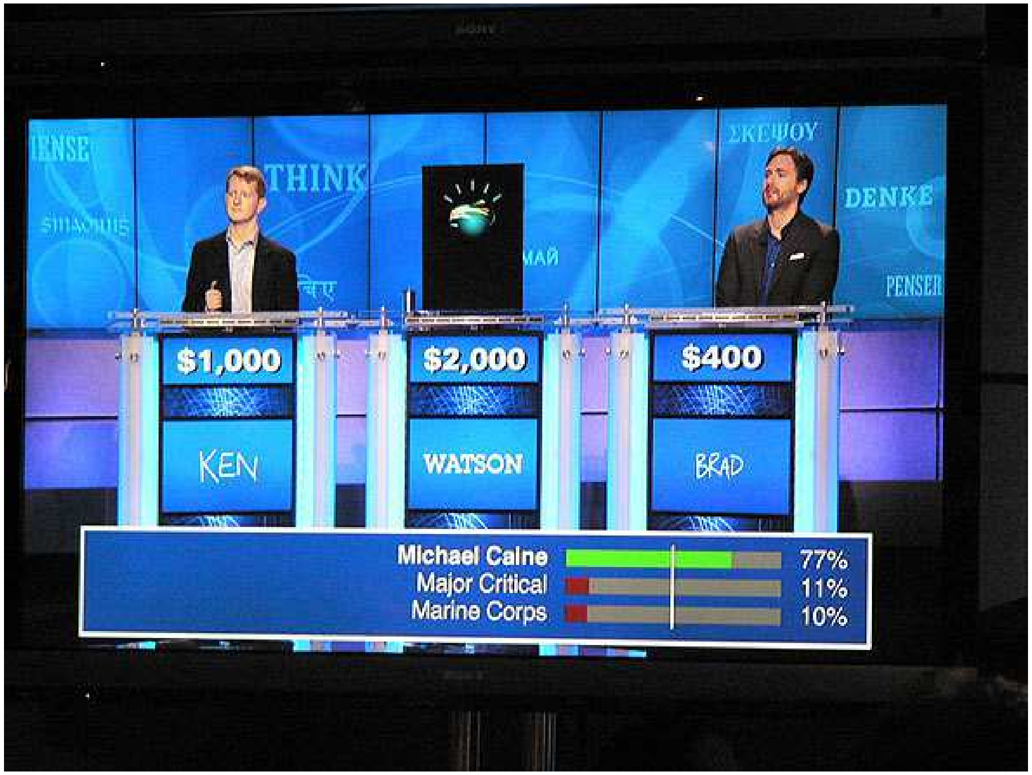
- DARPA grand challenge 2005



http://robots.stanford.edu/talks/stanley/processing.avi

Examples of recent AI systems

- 2011: IBM‘s Watson playing Jeopardy!



http://www.informationweek.com/software/business-intelligence/inside-watson-ibms-jeopardy-computer/229100143

Examples of recent AI systems

- 2011: Apple's SIRI
  - Personal assistant
  - Speech recognition

http://images.apple.com/ios/images/overview_hero.png

The future

- Complex interacting (robotic) systems
- Natural everyday activities
- “AI completeness“

EU project JAMES:
Joint Action for
Multimodal Embodied
Social Systems

http://www.fortiss.org/forschung/projekte/james/

Upcoming DARPA challenge (2012)

- Goal: “develop ground robotic capabilities to execute complex tasks in dangerous, degraded, human-engineered environments.”
- Key robotic technologies include “supervised autonomy, mounted mobility, dismounted mobility, dexterity, strength, and platform endurance.”

http://www.darpa.mil/uploadedImages/Content/NewsEvents/Releases/2012/Robotics.jpg

Some thoughts about humans and machines

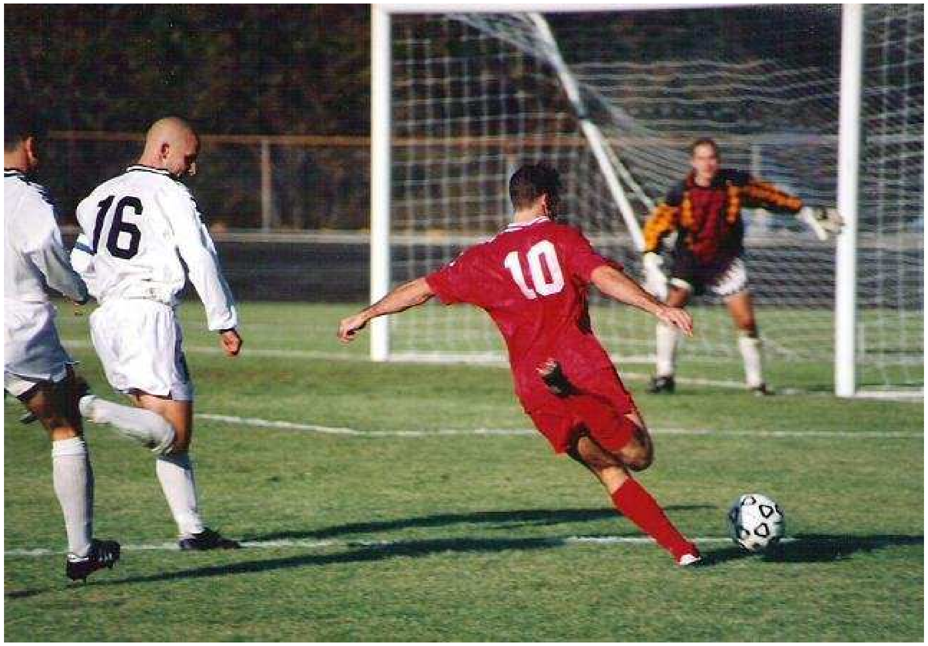
Technical Systems	Humans
High speed	Slower
High accuracy	Less accurate
High forces	Less powerful
Fast feedback	Slower feedback

But …

Technical Systems	Humans
Less adaptive	Highly adaptive to unforseen situations
Typically specific power and sensitivity	Large range: power vs. sensitivity
Typically for specific purpose	“Universal“ capabilities

Which problem is harder?

http://de.wikipedia.org/w/index.php?title=Datei:VishyAnand12.jpg&filetimestamp=20120319084237



http://de.wikipedia.org/w/index.php?title=Datei:Football_iu_1996.jpg&filetimestamp=20100417155933

Chess vs. soccer

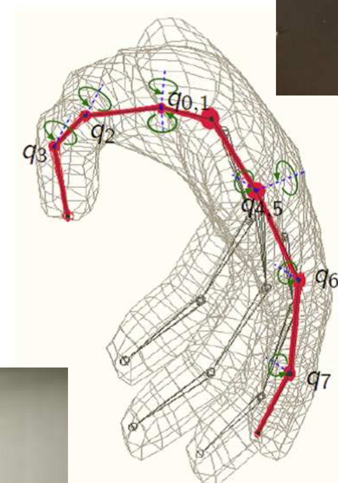
	Chess	Soccer
Environment	Static	Dynamic
State changes	Turn taking	Real time
Information accessibility	Complete	Incomplete
Sensor readings	Symbolic	Non-symbolic, noisy
Control	Central	Distributed

Robot games (soccer, table tennis, …) require

- Acting in higly dynamic environments
- Acting under uncertainty
- Prediction-based motion control

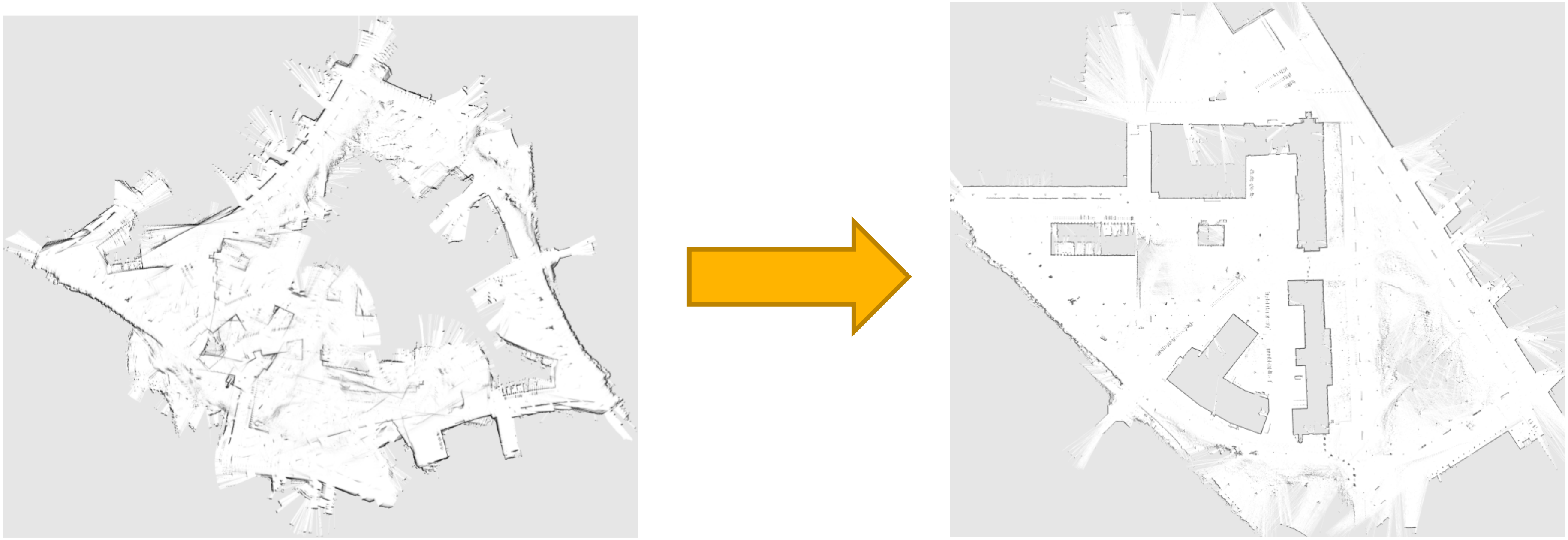
Why is it so hard?

- Context-based decisions
  – Where to drive/stand
  – Which arm/manipulator to use?
  – How to reach?
  – Which grasp pose?
  – How much force?
  – How to hold/move?



AI for robots – mapping and navigation

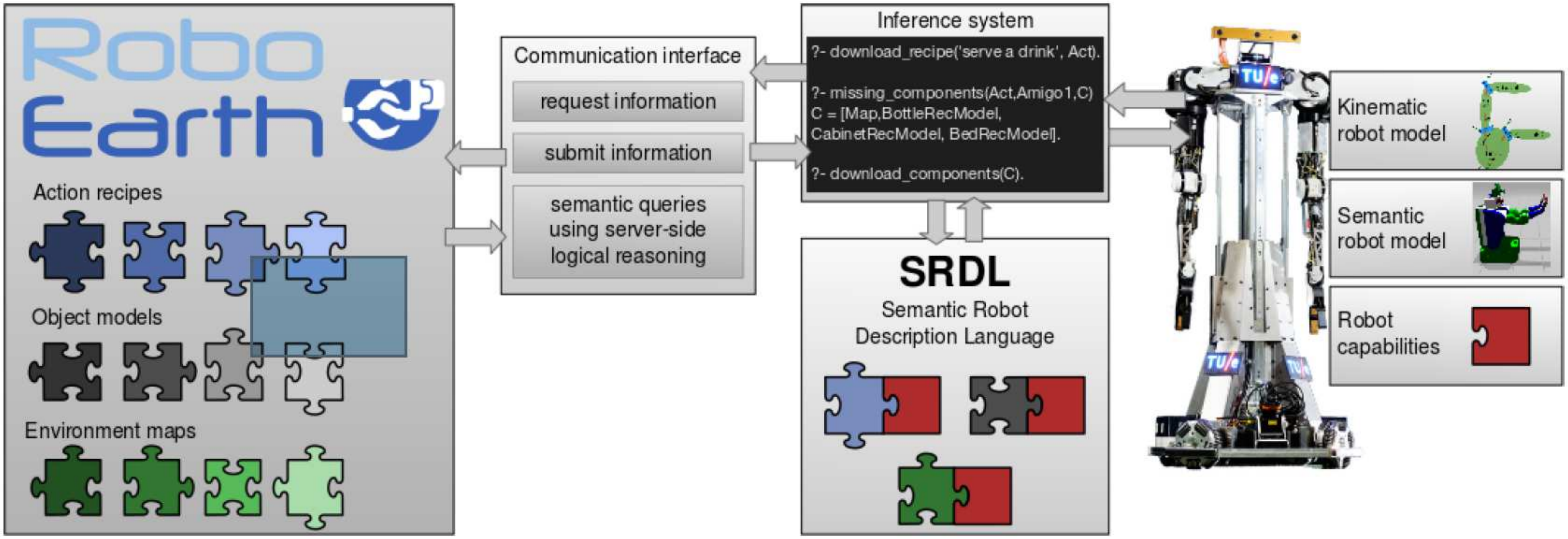
- Find a model of the environment based on sensor data



Courtsey of Cyrill Stachniss and Giorgio Grisetti.

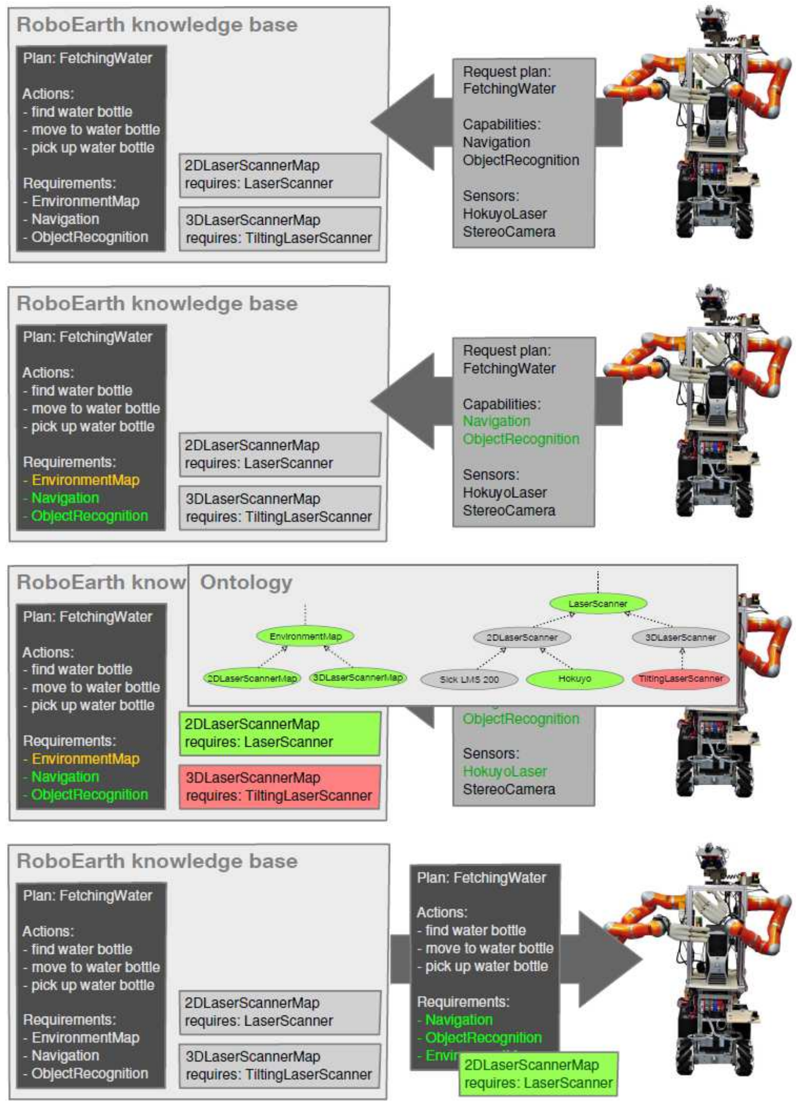
- Where am I?
- Where is my goal?
- How to get there?

AI for robots – example RoboEarth project

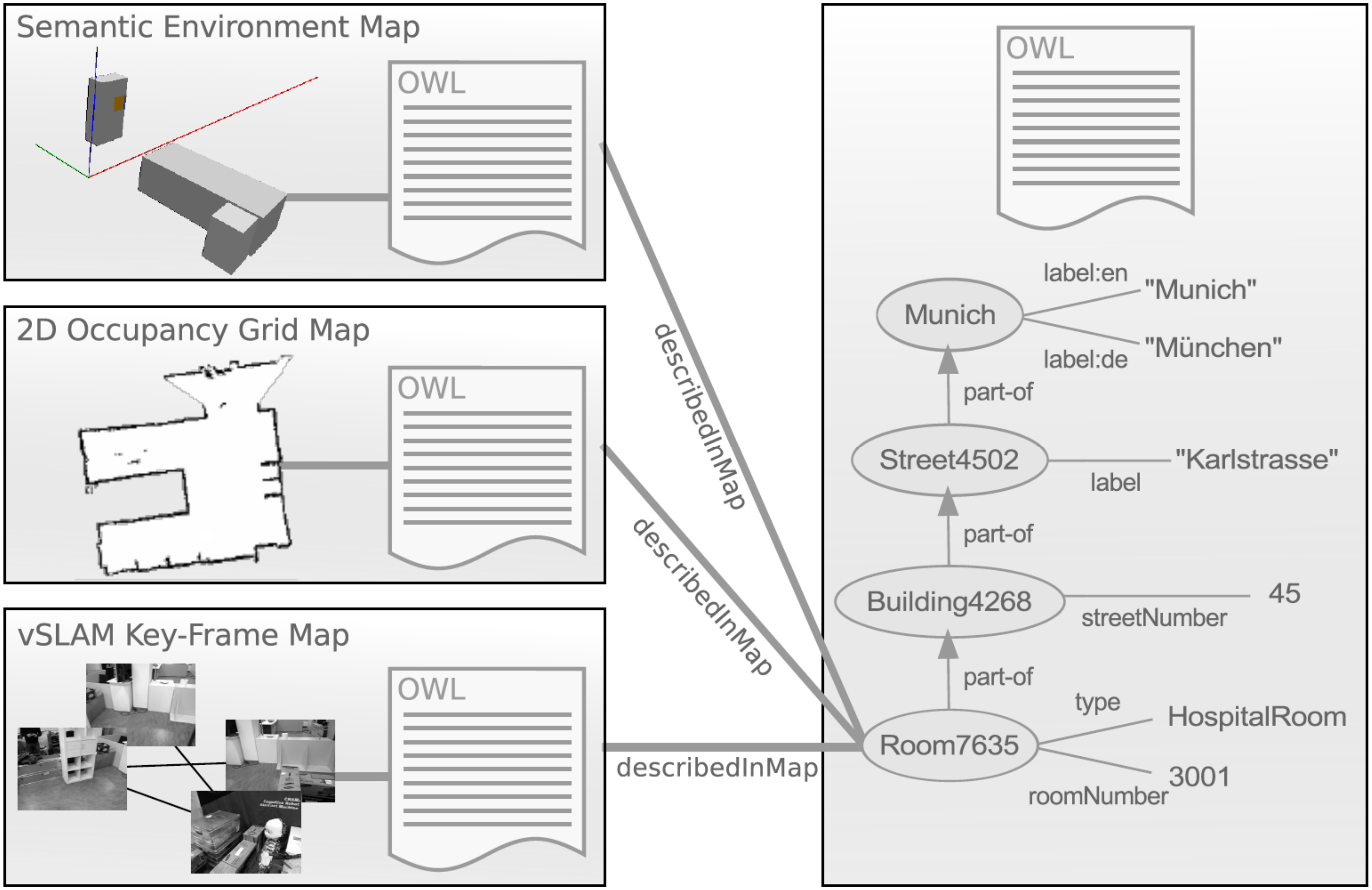


[Moritz Tenorth, Alexander Perzylo, Reinhard Lafrenz, and Michael Beetz. The RoboEarth language: Representing and Exchanging Knowledge about Actions, Objects and Environments. In IEEE International Conference on Robotics and Automation (ICRA), St. Paul, MN, USA, May 14-18 2012]

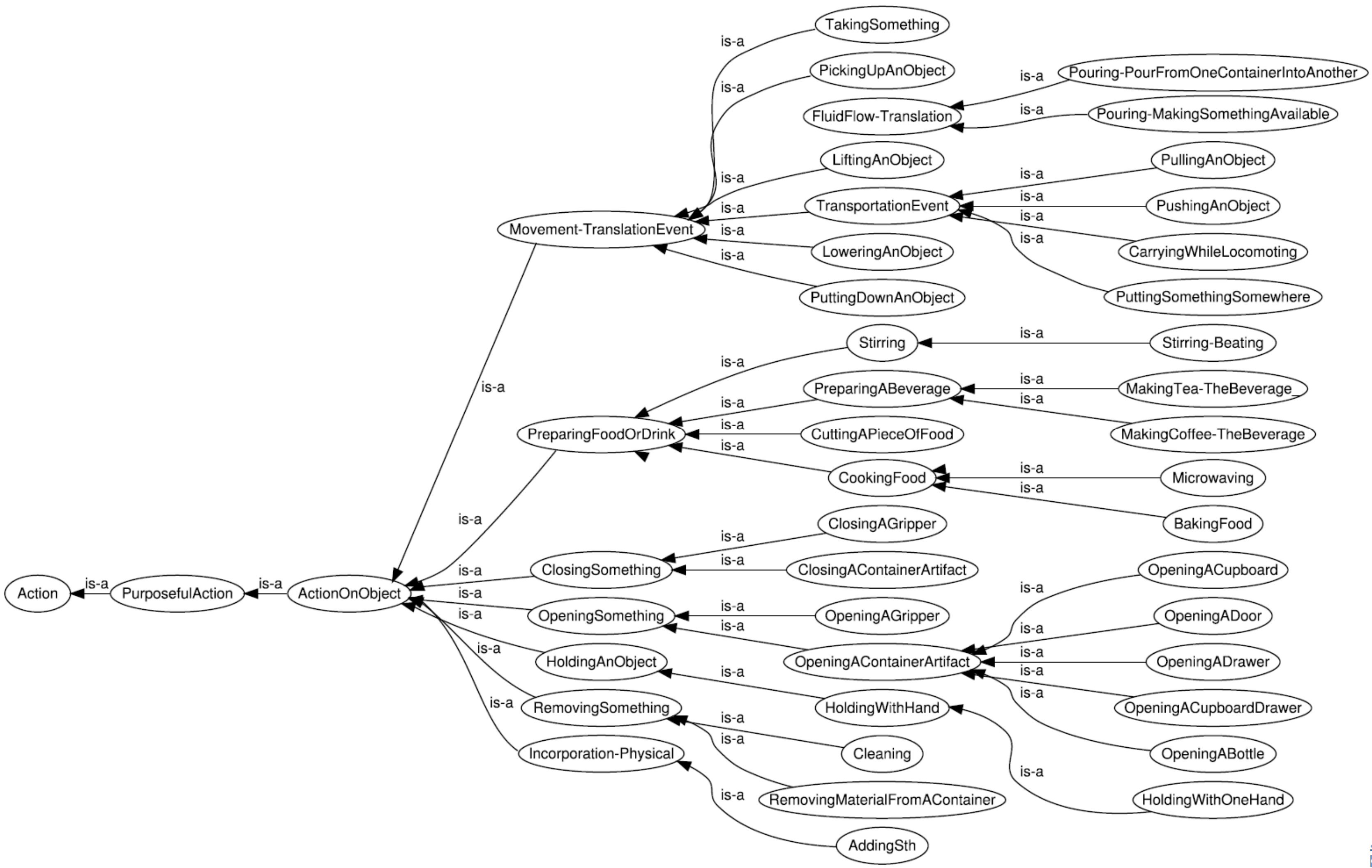
AI for robots – example RoboEarth project



AI for robots – example RoboEarth project

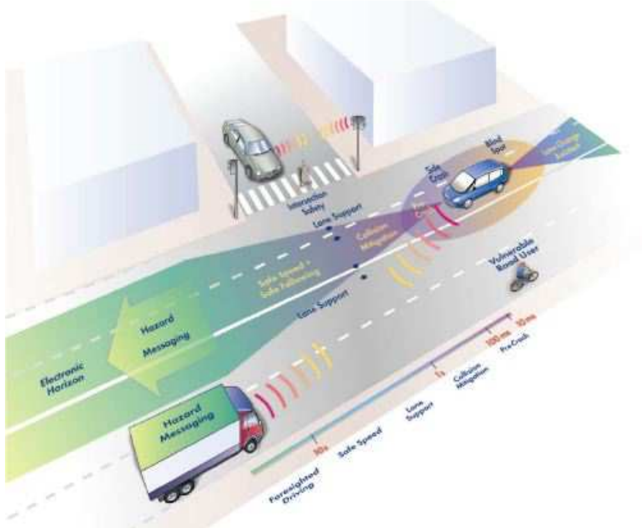


AI for robots – example RoboEarth project

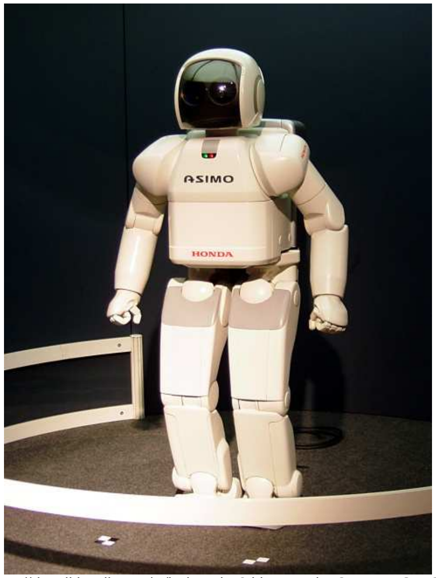


Conclusion

- Different worlds converge:
  - Logics and reasoning
  - Sensors/actuators
  - Embedded systems
  - Real-time systems
  - Human-machine interaction
  - Semantic/smart web



http://www.forwiss.uni-passau.de/de/projectsingle/52/main.html



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http://so.wikipedia.org/wiki/File:Group_of_smartphones.jpg

Lecture outline (to be detailed)

- Introduction (this lecture)
- Intelligent agents
- Problem solving by search
  - Uninformed search
  - Heuristic search
  - Constraint-based search
- Logical agents
- Planning agents
- Knowledge representation
- Acting under uncertainty
- Learning Agents