

58066-7 Artificial Intelligence (AI) Fall 2007

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1.1 What is intelligence?

- Property of mind consisting of capacities to
 - reason
 - plan
 - solve problems
 - think abstractly
 - use language
 - learn
 - be creative
- Emergent property of brain

1.2 What is artificial intelligence?

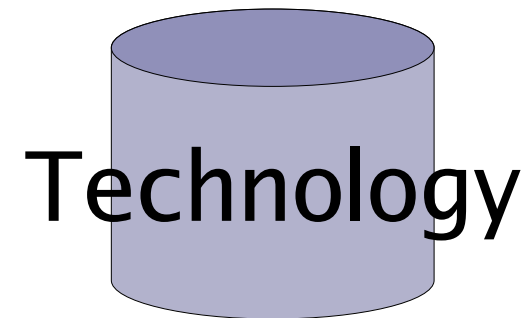
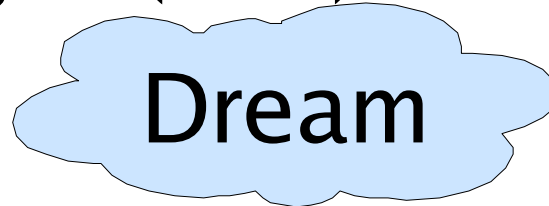
- As Marvin Minsky put it:

“AI is the science of making machines do things that would require intelligence if done by men.”

- and John McCarthy:

“the science and engineering of making intelligence machines.”

- Terry Winograd (1985):



- **Goals:**

- To replicate human mind in its entirety
- To come up with a theory of general intelligence
- Psychology, philosophy, Cog Sci

- To design systems
- To develop successful task-specific applications
- Computer science and engineering

1.3 Initiation

- Proposal for the Dartmouth College Summer research project on artificial intelligence in 1956.
- Proposers: John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon

“We propose that 2 month, 10 man study of artificial intelligence be carried out during summer 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it.”

- **Problems addressed in the proposal**

(AI magazine, Winter 2006):

- **Automatic computers**

- Incapability of taking advantage of current computational power

- **Computer use of language**

- Thinking == manipulation of words according to rules

- **Neuron nets that form concepts**

- **Theory of complexity of calculation**

- **Self-improvement**

- **Abstraction from sensory data**

- **Randomness and creativity**

- Project fell short of expectations; not much collaboration
 - attendees arrive at various times, and
 - most kept their own research agendas.
- No agreement on general theory, especially on learning, or common methodology or choice of problems.
- Shared vision that machines can be made to perform intelligent tasks.

1.4 The 25th Anniversary

- Concept of intelligence reduced to *symbol manipulation*.
 - Physical Symbol System (PSS) Hypothesis (Simon & Newell, 1963):
“physical symbol system has necessary and sufficient means on general intelligent action.”
 - A PSS “consists of a set of entities, called symbols, which are *physical patterns* that can occur as components of another type of entity called an expression (or symbol structure). “
- Controversy about the name
 - *intelligence* is reserved for humans
 - *artificial* connotes something inferior
 - Alternatives: heuristic methods, complex information processing, automata studies, or even advanced programming languages, information processing psychology, advanced symbolic manipulation, or automatic programming.

1.5 The 30th Anniversary

- Scientists in the field disagree on (Bobrow & Hayes, 1985):
 - Coherence of the discipline.
 - “Curious mixture” or no discipline at all
 - Methodological question — not interesting
 - AI's rapid progress in the past decade(s).
 - AI has grown not progressed
 - “Steady progress” in neighboring fields
 - The most important advances so far, and future breakthroughs
 - Expert systems, connectionism, learning
 - Language processing
 - Advanced computer technology's impact on future of AI.
- “Many people want to believe that AI must fail.” (Sloman, 1992)

1.6 The 50th Anniversary

- These days even more clear that the discipline lacks general principles, architectures or concepts (Mackworth; Brachman, AI magazine, Winter 2006)
- Specialized subfields that
 - do have their well-defined paradigms
 - develop sophisticated designs that are tailored for specific tasks → make wonderful scientific breakthroughs but do not lead to AI.
 - have their own presentations forums and publications.
- No communication between specialty areas.
- Divide also between
 - Cognitive science and Computer science
 - USA/Europe and Asia

- Human intelligence is multifaceted thing; cannot be achieved by focusing on a single issue, say learning or natural language understanding.
- So far more technological advances than theoretical
 - No general theory of intelligence
 - Machine intelligence impossible to prove → need demonstrations
- Progress (Brachman (Yahoo!), AI magazine, Winter 2006):



1.7 DARPA Grand Challenge

- The Defense Advanced Research Projects Agency (DARPA) is the central research and development unit for Department of Defense.
- To advance research and development of autonomous robotic ground vehicles.
 - In the US about 42,000 people die in traffic accidents yearly (1 million worldwide), mostly because of human error.
 - Commuting takes time.
 - Enables people with disabilities or too young or old to drive to move around.
 - Make traffic more efficient.
 - Can drive itself to anyone with transportation needs.
 - Unmanned combat vehicles.

- 2004 Grand Challenge

- 142-mile on- and off-road route between Las Vegas and Los Angeles.
- \$1 million cash award.
- No finishers. The best team, Carnegie Mellon, made 7.4 miles from the start.

- 2005 Grand Challenge

- 132-miles route in Mojave desert.
- \$2 million cash award.
- Five vehicles finished, the winner –Stanford– just in little less than 7 hours, the fifth in 12 hours.

- 2007 Urban Challenge

- To finish 60-mile urban route in 6 hours.
- Includes:
 - Negotiation with traffic and obstacles
 - Obeying traffic regulations
 - Merging



1.8 What lies in AI's future?

(Intelligent Systems, May/June 2006; AI magazine, Winter 2006)

- Robotics and intelligent systems
 - Disaster rescue
 - Personal robots: household aid, special need aid, elder care
 - Tutoring, language processing (closed captioning, automatic translation)
 - Autonomous ground vehicles
- Ubiquitous/pervasive computing
 - Shopping assistant
 - User modeling
- Multi-agent applications

1.9 Challenges

- Skeptics on three forms of AI (Skeptic Vol. 12, No. 2, 2006)
 1. Connectionism
 - The brain: neuroscience's antiprogress: as more information is gained, less is known.
 2. Symbolic AI
 - **Natural** language comprehension
 - Expertise
 - Common sense knowledge, similarity, analogy
 3. Robotics
 - “Even if it is true that current robots had attained insect-level intelligence, this wouldn't indicate that human-level artificial intelligence is attainable. The number of neurons in an insect brain is about 10,000 and in a human cerebrum about 30,000,000,000. But if you put together 3,000,000 cockroaches (this seems to be the idea behind “swarms ”), you get a large cockroach colony, not human-level intelligence.”

1.10 Tentative topics

1. Problem solving and search

- Constraint satisfaction
- Combinatorial optimization
- Games

2. Learning

- Unsupervised, supervised, reinforcement, CBR

3. Knowledge representation

- Production systems, semantic nets, frames, concept maps

4. Logic and reasoning

5. Planning

6. Natural language processing

- Comprehension, generation, speech processing

7. Perception

8. Information retrieval

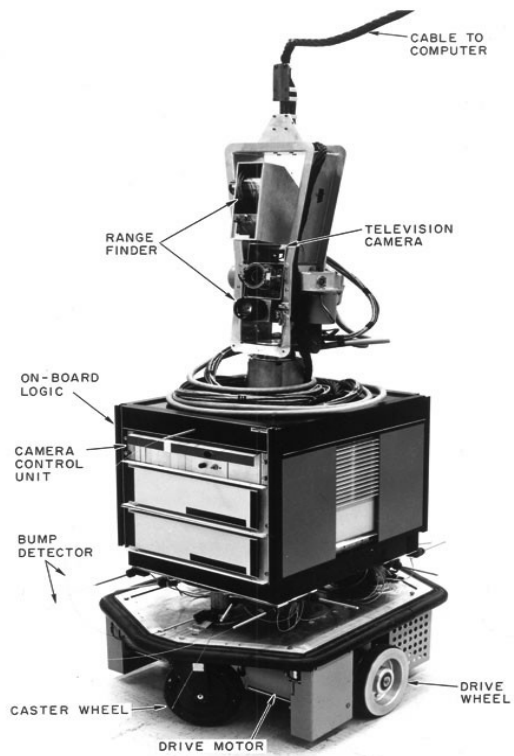
9. Multi-agent systems

10. Artificial life

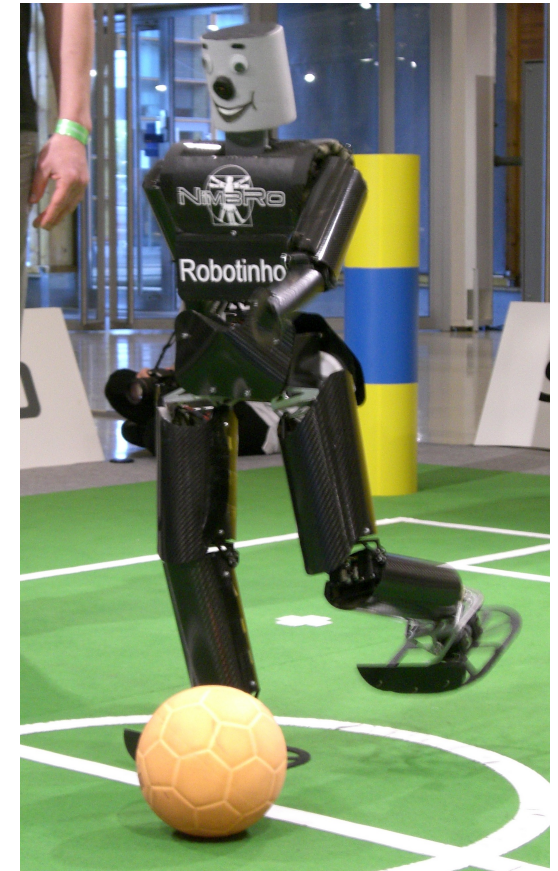
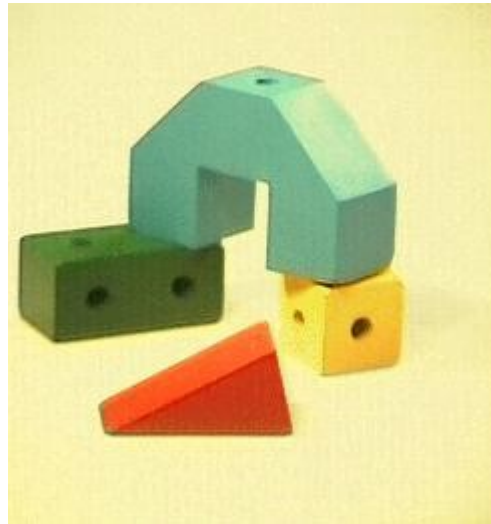
11. Philosophy of AI

12. Robotics

1.11 True challenges



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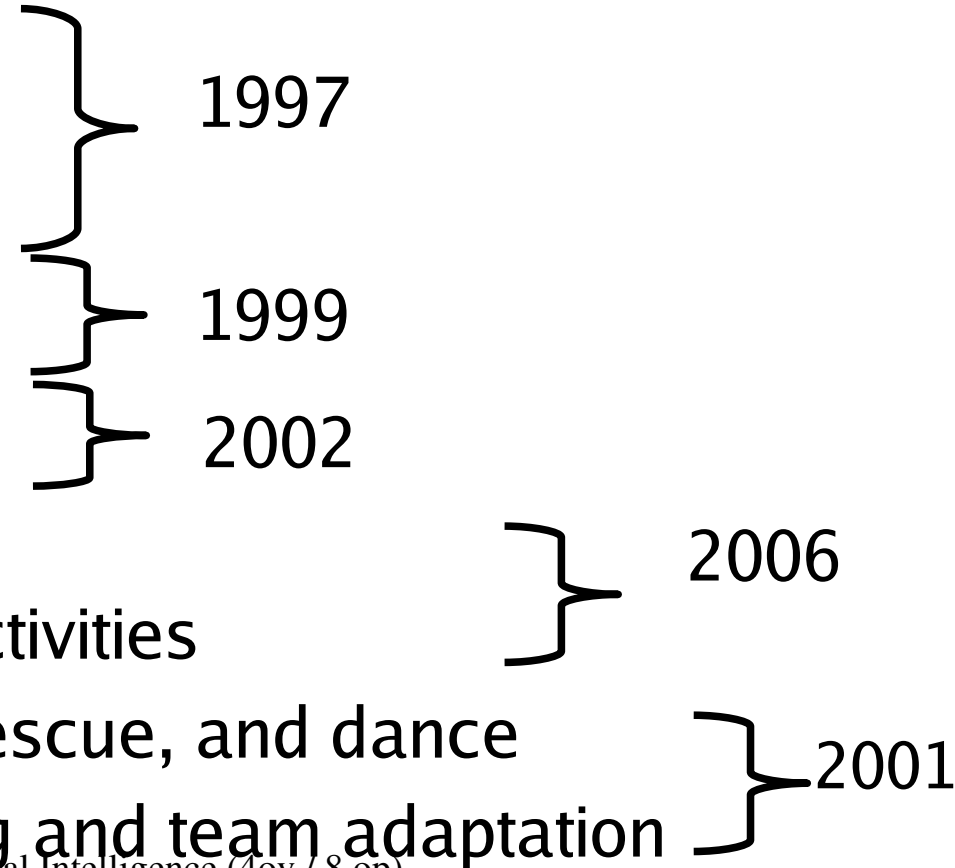


1.12 RoboCup

- International joint project to promote AI and intelligent robotics research.
- The goal:
 - “by 2050, develop a team of fully autonomous humanoid robots that can win against the human world champion team in soccer.”
- Research questions to be tackled:
 - Perception, decision making, action selection, hardware design, materials, energy, etc.
- Restrictions in material, speed, size, and weight.
- Quite different from chess!

1.13 RoboCup history

- 42 teams in 1997 → 450 teams in 2006
- Five soccer leagues and three others:

- Middle-Size league
 - Small-Size league
 - Simulation league
 - Four-legged league
 - Humanoid league
 - RoboCupRescue league
 - [RoboCup@Home](#) - daily activities
 - RoboCupJunior - soccer, rescue, and dance
 - Coach - opponent modeling and team adaptation
- 
- 1997
- 1999
- 2002
- 2006
- 2001

1.14 Leagues

- Middle-Size League
 - Diam < 50cm, height < 80cm, weight < 50kg
 - Individual sensors and control program, communication via WLAN.
 - No barriers around the field → localization by vision
 - Kicking devices
 - Variable lighting conditions
 - Plan was to play on the outdoor field in 2007

- **Small-Size League**
 - Diameter < 15cm
 - Central computer determining the actions of players; communication via radio
 - Bird-eye view of the field from two cameras
 - 4-time increase in the field size and removal of barriers in 2004
 - Kicking mechanism
 - Velocities up to 2.5 meters per second
 - Tactical game play, fast cooperative play and estimation of opponent strategies by most teams

- **Simulation League**

- Virtual playing ground with original soccer field and 11 players.
- Server simulates physical world and player bodies
- Multi-agent system
 - Each player is controlled by an individual program.
 - Restricted view of the environment → player program generates an internal view of the situation → program decides on the next action.
 - Coordination and cooperation, distributes planning, learning at various levels (individual skills vs. team behavior), and opponent modeling.
- Started with 2-dimensional simulation, moving to 3-dimensional.
- Real soccer-like behavior

- Coach competition
 - In 2-D simulation league each team is allowed to use coach program.
 - Original goal: team adaptation and opponent modeling
 - Competition begins by the analysis of log files from previous games.
 - Analyze the game using a global view.
 - Advices the team during breaks, decides about substitutions
 - Performance measure as score difference

- **Four-Legged League**

- Every team has the same platform, Sony's AIBO robot
 - wireless LAN
 - 20 degrees of freedom
 - camera at the front of the head
 - moves 50cm per second
- Focus on perception and hardware control methods
- Motion detection and motion modeling
- Localization without colored landmarks
- Demonstration game with 11 players and larger field

- Humanoid League

- Autonomous robots with humanlike proportions and appearance:
 - one head, one body, two arms and legs
 - Child-size < 60cm, teen-size < 120cm
 - Maximum foot size, arm length and minimum height of the center of mass.
- Until 2005 penalty shootout, thereafter 2 vs. 2 games
- Must be able to get up if fallen
- Able to kick without losing balance
- Adapt to variable lighting conditions

1.15 RoboCup Competition

- Form of evaluation
- Successes and great technological advances in last 10 years prove the concept relevant and effective
- Engages mainly young researchers
- Expensive — use ordinary environments
- Exchange of ideas and methods disadvantage of revealing secrets outweighed by the number of citations and references.

1.16 RoboCup Techniques

- Integration of sensory information
- Strictly defined lighting conditions and colored landmarks only in 4LL league ← camera quality
- Removal of walls had a major impact.
- Until 2005 ball was played flat.
- Three years ago, walking without falling was considered success → keeping balance still an issue.
- Cooperation between robots
 - Only works in simulation league → classical planning does not work in real time or dynamical environments
 - Gets harder with the number of players and the field size
- Scientific questions and technical challenges remaining
- Lesson learned so far: no single approach can solve all open issues.