CogSysI Lecture 1: Introduction

Intelligent Agents
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Organization

- Homepage of the course:
  [http://www.cogsys.wiai.uni-bamberg.de/teaching/](http://www.cogsys.wiai.uni-bamberg.de/teaching/)

- Programming Assignments in Prolog:
  Introduction to Prolog in the practice part of the course

- CogSysI gives an introduction to the basic topics of (cognitive oriented) AI

- Relation to the course “Semantic Information Processing” (Schlieder):
  - SIP Focus: Knowledge Representation, Deductive Inference, (Constraints, Games)
  - CS Focus: Problemsolving and Planning, Inductive Inference and Analogy, Multi-Agent-Systems
Studies in CogSys

- Prerequisites: Algorithms and Data Structures, Formal Basics of CS
- Helpful: Non-procedural Programming, Logic, Programming Skills
- CogSysI: Basic course in the field
- Specialisation: CogSysII (Learning Systems), CogSysIII (HCI)
- Getting skills in reading and presenting scientific literature: CogSys Seminar Course
- Learning how to do research in the field, preparation for thesis: CogSys Project
- Looking in other disciplines: Cognitive Psychology combines very well with CogSys
Course Objective

Introduce basic concepts, methods, and results of cognitive oriented AI research

- **Goal Oriented Behavior: Problem Solving and Planning:** Uninformed an heuristic search, production systems and human problem solving, planning

- **Inference and Learning:** Inference in first order logic, basic concepts of theorem proving, human reasoning, analogical/case-based reasoning, inductive learning

- **Multi-Agent-Systems:** Decision-making, communication, autonomous agents/robots
Textbooks


Textbooks cont.


*A detailed overview of topics of AI. Gives an overview of AI-research in Germany.*


*This is not a scientific text book but a most motivating, comprehensive book for a broad readership.*

... many others, see course web page
AI Organizations

- AAAI: American Association of AI
  Most important international conference: IJCAI
  Important journal: Artificial Intelligence

- ECCAI: European Coordinating Committee on AI

- Fachbereich 1, KI, der Gesellschaft für Informatik (GI)
  Annual conference: KI, interdisciplinary spring school: IK (Interdisziplinäres Kolleg)
Lecture 1: Introduction

- Goals, definitions, subject matter of AI
- Methods, topics of AI
- Relations to other research areas
- History
## Goals of AI

<table>
<thead>
<tr>
<th>Engineering</th>
<th>Methods for solving problems on a computer</th>
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<tbody>
<tr>
<td></td>
<td>algorithms/programs for inference, planning, learning, ...</td>
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<tr>
<td>Epistemology</td>
<td>Modeling of cognitive processes</td>
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<td></td>
<td>perception, reasoning, language understanding, ..</td>
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<tr>
<td>Formalisms</td>
<td>Development of formalisms for describing and</td>
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<td></td>
<td>evaluating problems and algorithms</td>
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<td>calculi of logic, graph theory, complexity theory, ...</td>
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↔ **AI is inherently an interdisciplinary area of research!**

(\text{Mathematics, Computer Science, Neurosciences, Cognitive Psychology, Linguistics, Philosophy of Mind})
Subject Matter of AI

Term “Artificial Intelligence” is problematic

- no satisfying definition of “intelligence”
  - Psychology: “Intelligence is what is measured by an intelligence test”
  - (Intelligence is the ability to acquire and apply knowledge.)
- “artificial”: problematic connotation, creation of machines which have human intelligence (“strong AI” in the 60ies)
- The more modern term “intelligent systems” is also not without problems.
Definitions of AI

A typical definition: *Artificial intelligence is the science of making machines do things that would require intelligence if done by men.* (Minsky, 1963, pp. 23)

Problems:

- term intelligence is used but not defined
- a lot of problems where we ascribe high intelligence, if a human can solve them, are relatively easy to solve by a computer program (solving mathematical equations, playing chess, some classes of mathematical proves ...)
- a lot of problems which can be solved by every child are very hard to realize with a computer program (object recognition, building a tower of blocks, language understanding, ...)
Example: Context Effects

(human intelligence makes heavily and easy use of context, Selfridge, 1955)
Example: Context Effects

(human intelligence makes heavily and easy use of context, Selfridge, 1955)
The extent to which we regard something as behaving in an intelligent manner is determined as much by our own state of mind and training as by the properties of the object under consideration. If we are able to explain and predict its behavior we have little temptation to imagine intelligence. With the same object, therefore, it is possible that one man would consider it as intelligent and another would not; the second man would have found out the rules of its behavior.

(Alan Turing, 1947)
Further Definitions of AI

There is no really satisfying definition of AI, two which I like are:

*AI researches how one could make a computer do what humans currently can do better.* (Elaine Rich)

*AI research is concerned with computer problems yet unsolved.* (Marvin Minsky)

→ For many concepts/ scientific fields (not only for AI) there is no single satisfying definition.

→ Pragmatic solution: Enumerate the topics, give examples (getting “concrete”)*
AI and Computer Science

AI is an integral part of computer science, the beginnings of computer science research are also the beginnings of AI research, but:

AI is that sub-discipline of computer science, which is concerned with analysis and formalization of thought processes which are not yet formally understood. In the case of success, that is if these processes got “de-mystified”, these areas become part of standard computer science and AI research is moving on to new problems. (Christian Freksa)

Examples:

- problem solving → efficient search algorithms
- automatic programming → compiler design
- reasoning → theorem proving
**Methods of AI**

- **Analytical, formal:** Analysis of problems, formalization, design and evaluation of algorithms (completeness, correctness, optimality; empirical evaluation of error rates and performance times)

  $\rightarrow$ *Precise description of problems and algorithms; formal, normative constraints for performance*

- **Empirical:** Recourse to biological and cognitive principles of organization and processing and their simulation

  $\rightarrow$ *Evidence for the existence of abilities and skills, their constraints and characteristics of performance*
Methods of AI cont.

- **Engineering:** (Efficient) implementations of algorithms, adaptation of algorithms to requirements of specific applications
  
  Application is one possibility to evaluate the scope, functionality and relevance of AI-algorithms

  As an AI researcher you should have knowledge of formal methods and of cognitive theories and empirical methods!
Two Perspectives

- AI as **engineering discipline**: make algorithms for solving AI problems
- AI as **cognitive modeling**: make algorithms which solve problems in a similar fashion as humans
  - AI as **theoretical psychology**

*Everything is vague to a degree you do not realise till you have tried to make it precise.* (Bertrand Russell)
Topics of AI

- **Problem solving and planning**
  - basic search techniques for many AI topics
  - Applications: Scheduling, configuration, manipulation of formula, games

- **Inference and theorem proving**
  - deduction of information which is given implicitly in knowledge bases
  - in contrast to other areas of AI: algorithms which are provably complete and correct
  - non-monotonic reasoning, fuzzy/probabilistic approaches
  - Applications: Program verification, knowledge based/expert systems
Topics of AI cont.

**Knowledge representation**
- can be crucial for performance of AI systems (easy retrieval of stored knowledge)
- logic, semantic nets, frames/schemes, graphs, ...

**Machine learning**
- Concept learning, classification learning
- strategy learning
- Applications: data mining, object recognition, process control
Areas of Application

- Natural language processing
- Computer vision (object recognition)
- Multi-Agent-Systems
- Robotics (action planning, navigation)
- ...

AI programming

- Declarative programming languages (5th generation languages): Prolog, Lisp; today there are no longer typical AI languages, modern planners and most machine learning algorithms are written in C.
Relations to Others Disciplines

**Philosophy:** Early AI made strong promises, philosophers started to ask whether human cognition has inherent aspects which cannot be transferred to a computer (Dreyfus, Searle). AI is an interesting area for philosophical studies of mind.

**Linguistics:** Chomsky had very strong influence to computer science (Chomsky hierarchy) and had a major impact on the beginning of cognitive psychology (Chomsky-Skinner debate). Interaction of AI and Linguistics: Computer Linguistic

**Psychology:** AI models influence psychological models (Minsky’s computer metaphor Mind/Brain, Software/Hardware).
While AI can give *formal constraints* for models of information processing, psychology and neurosciences can give *empirical constraints* and/or ideas for plausible heuristics for AI systems.
Kasparov vs. Deep Blue Match 1996: Kasparov suspected human intervention

Searle critique: Thought experiment “Chinese Room”

Cognitive Science approach: do not judge superficial performance; investigate process characteristics of the program (correspondence of number of rule applications to reaction times, similar errors etc.)
A Short History of AI

Prehistory

1943 McCulloch & Pitts “Logical Calculus of the Ideas Immanent in Nervous Activity” (Architecture for an intelligent system based on a neural net)

1948 Wiener “Cybernetics” (information theory)

1950 Turing: “Computing Machinery and Intelligence” (Turing-Test)

1955 Selfridge: Pattern-matching program
Early AI (1956 to mid 60ies)

- Dartmouth conference of 1956: Term AI comes into use (McCarthy)
- Focus on models of cognitive processes and general principles of intelligent behavior
  - Marvin Minsky (MIT): Perception
  - Problem Solving: GPS (1958)
- John McCarthy (Stanford): Lisp (1958)
... Early AI (1956 to mid 60ies)

- Games: Samuels (1959), Checkers
- Learning: Winston (1970), Learning by analogy
- Analogical reasoning: Evans (1959)
- Simon, 1965: “by 1985 machines will be capable of doing any work a man can do"
- Minsky (1968) “Semantic Information Processing” (an important collection of early work)
- Drawbacks, e.g. in machine translation $\rightarrow$ AI critique
Analogy Problems

Evans (1968), grammar inference method

A

B

C

1

2

3

4

5
A Short History of AI cont.

The middle years (70ies)

- no interest in interdisciplinarity and cognition
- focus on knowledge: representation and inferences
- Question-Answering systems, Expert systems
- SHRDLU, Winograd (1970): natural language system for manipulation and verification of statements in a blocksworld (procedural semantics)
- DENDRAL, Feigenbaum (since 1965): Analysis of molecular structures
- MACSYMA (1971): manipulation of formulas
- MYCIN, Shortliff (since 1974): medical diagnosis
... The middle years (70ies)

- PROLOG (1973) Colmerauer
- Development of languages for production systems (OPS, McDermott 1977) and shells for expert systems
- Planning: STRIPS (Fikes & Nilsson 1971), NOAH (Sacerdoti 1975)
- non-classic logic (Reiter, 1980), fuzzy logic (Zadeh, 1965)
- hierarchical nets, Quinlan (TLC, 1968); frames, Minsky (1975); Scripts, Schank & Abelson (1973)
A Short History of AI cont.

The 80ies

- Search for real world applications; intelligent tutor systems
- Language research: functional-logic programming
- Re-invention of backpropagation, new interest in neural/distributed information processing (Feldmann & Ballard 1982; Rumelhart & McClelland 1986)
- Big battles of symbolic vs. sub-symbolic AI
A Short History of AI cont.

The 90ies and now

- new interest in interdisciplinary research, birth of cognitive science

- AI-methods are used when helpful:
  “Some of the most successful applications of AI are those in which the artificial intelligence is spread like raisins in a loaf of raisin bread: the raisins do not occupy much space, but they often provide the principal source of nutrition.” (Esther Dyson, industrial analyst)

- Focus on learning

- Relation to robotics: embodied intelligence, situated action

- Multi-Agent Systems
The Running Gag of CogSysI

Question: How many AI people does it take to change a lightbulb?

Answer: At least 67.

First part of the solution: The Psychological Group (5)
- One to build an apparatus which will time lightbulb-changing performance
- One to gather and run subjects
- One to mathematically model the behavior
- One to call the expert systems group
- One to adjust the resulting system, so that it drops the right number of bulbs

(“Artificial Intelligence”, Rich & Knight)