Introduction to Artificial Intelligence

G. Lakemeyer

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Introduction to Artificial Intelligence

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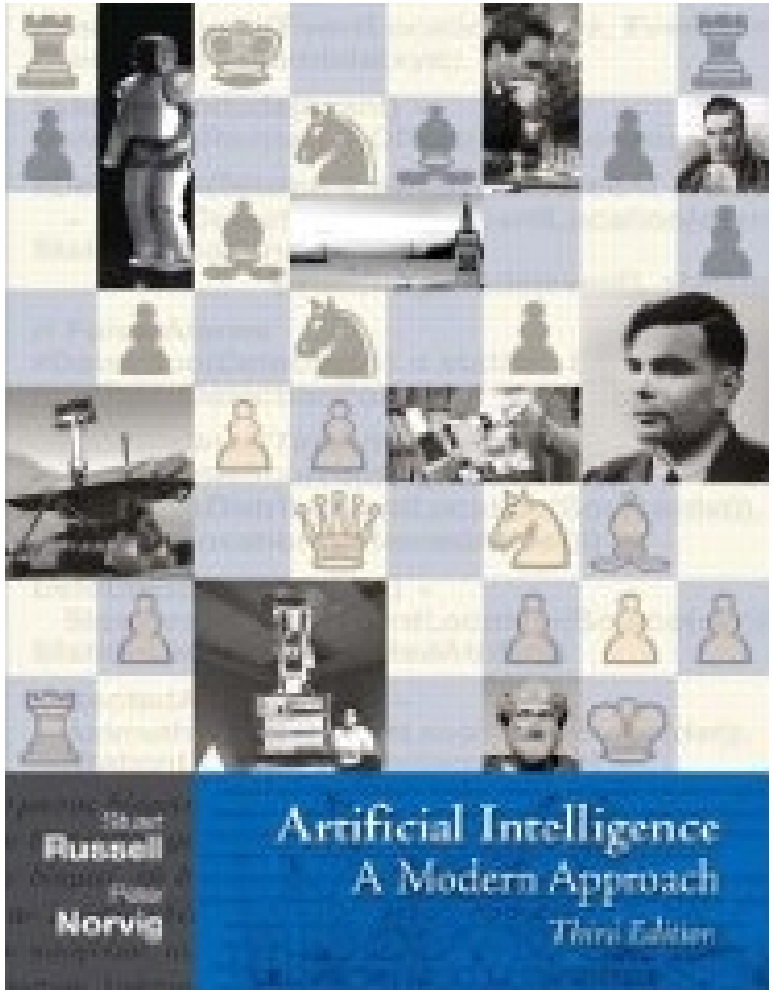
Textbook

Stuart Russell und Peter Norvig
Artificial Intelligence
— A Modern Approach —
Prentice Hall, 3rd Ed., 2010
(2nd Edition ok)



Bachelor Informatik

Die Vorlesung kann als Wahlpflichtfach in der praktischen Informatik gewählt werden.

Prüfungsform: schriftlich (120 Minuten, 16. Februar und 29. März)

(Freiwillige) Teilnahme an den Übungen. Übungen sollen in Gruppen von 2–4 Personen bearbeitet werden. Ausarbeitungen in Deutsch oder Englisch.

Master: Informatik/Software Systems Engineering etc.

Course can be used for Data and Information Management

Requirements:
Written exam (120 Minutes, February 16 and March 29).

Homework assignments are optional but strongly recommended.
Prepare solutions in groups of 2–4 students.
Solutions can be written in English or German.

What is AI (1)

. . . or: *when is an artifact "artificially" intelligent?*

1. Systems that act like humans:

   Turing Test (1950)

   - Interrogator asks questions by typing them in.
   - Answers are displayed on a screen.
   - Deduce from the answers whether answers come from a machine or a person.

   very difficult; needs at least:

   - Natural language processing
   - Knowledge Representation
   - Automated Reasoning
   - Machine Learning

What is AI? (2)

2. Systems that think like humans

- Attempts to understand human thought processes.
- Not just the solution to a problem counts, but the way it is achieved.
- Research topic of Cognitive Science and Psychology
- Not dealt with in this course.

What is AI? (3)

3. Systems that think rationally

Example: Aristotelian Syllogisms:

- Socrates is a man.
- All men are mortal.
- Therefore: Socrates is mortal.

Research topic of Philosophy, Logic and Mathematics.

Largely the foundation of Knowledge Representation

What is AI? (4)

4. Systems that act rationally. more general than 3.

rational thought is often, but not always necessary

- Example: Reflexes for self-protection.

Central idea:

- Agents which perceive their environment and act in a reasonable way.
- The goal is to select actions with the highest *utility*.
- Optimality is not always possible because of *limited resources*.

AI as "Acting rationally" is the foundation of this course!

Questions we will try to answer:

What are the components which allow an artifact to act rationally?

AI at RWTH Aachen University

Prof. St. Decker

Web Science, Semantic Web

Prof. M. Jarke

Knowledge Management, Semantic Web

Prof. G. Lakemeyer

Knowledge Representation, Cognitive Robotics

Prof. B. Leibe

Machine Learning, Computer Vision

Prof. H. Ney

Speech and Pattern Recognition

Sources for Research Literature

Conferences

- International Joint Conference on Artificial Intelligence (IJCAI)
- Conference of the Association for the Advancement of AI (AAAI)
- European Conference on AI (ECAI)
- German AI Conference (KI)

Journals (among many others)

- Artificial Intelligence, Elsevier
- Journal of Artificial Intelligence Research (Open Access!)

Other resources

- Internet (Most authors post pre-prints on the web)
  Google Scholar is a good starting point.

A Very Brief History of AI

Important ideas predating AI:

- Aristotle (384–322 B.C.)
  Logical syllogisms.
- Leibniz (1646–1716),
  Idea of the “Calculus Philosphicus,” tried to formalize all of human thought.
- Frege, founder of modern logic (1879).

History of AI (2)

The early days of AI: 1940–1956

1943	Neural Nets (NN), McCulloch + Pitts
1949	Learning in NN, Hebb
since 1950	First chess programs: Shannon, Turing
1956	*Dartmouth Conference* McCarthy, Minsky, Shannon, Rochester, More, Samuel, Solomonoff, Selfridge, Newell, Simon.
	Giving it a name: *Artificial Intelligence*.

History of AI (3)

First enthusiasm: 1952–1969

since 1952	Samuel: a checker program that could learn, eventually could beat Samuel!
since 1955	Newell + Simon: Logic Theorist, proved theorems from *Principia Mathematica*
1957	Chomsky: Theory of natural language processing
1958	McCarthy: Lisp
1962	Rosenblatt: Proved that perceptrons (simple NN's) could learn effectively if function representable.
1969	Green: Planning using logic.

History of AI (4)

Setbacks: 1966–1974

1966	abrupt end of funding for machine translation
1969	Minsky + Papert:
	Perceptrons able to learn almost nothing!
1973	Lighthill Report (UK)
	“AI is just too hard, hence will never work.”

History of AI (5)

Knowledge-Based Systems (then: expert systems): 1969–1985

1969	Buchanan et al.: DENDRAL Recognizing molecular structures
1975	Shortliffe: MYCIN Diagnosing infectious diseases (often better than specialist MD's!)
1982	J. McDermott: R1 (XCON) Configuration of Computer Systems (VAX) Beginning of the Commercialization of AI

Special AI hardware: Lisp Machines

(dead-end because of cheaper and powerful workstations, PCs)

History of AI (6)

The return of NN's: 1982–

since 1982	Learning methods for multi-layered feed-forward nets (back-propagation algorithm)
1982	Hopfield: Associative Memory
1986	Hinton, Sejnowski: NN's learn how to read written text aloud.
2006	Hinton: Deep Learning

State of the Art

Today: AI methods are used routinely.

Some examples:

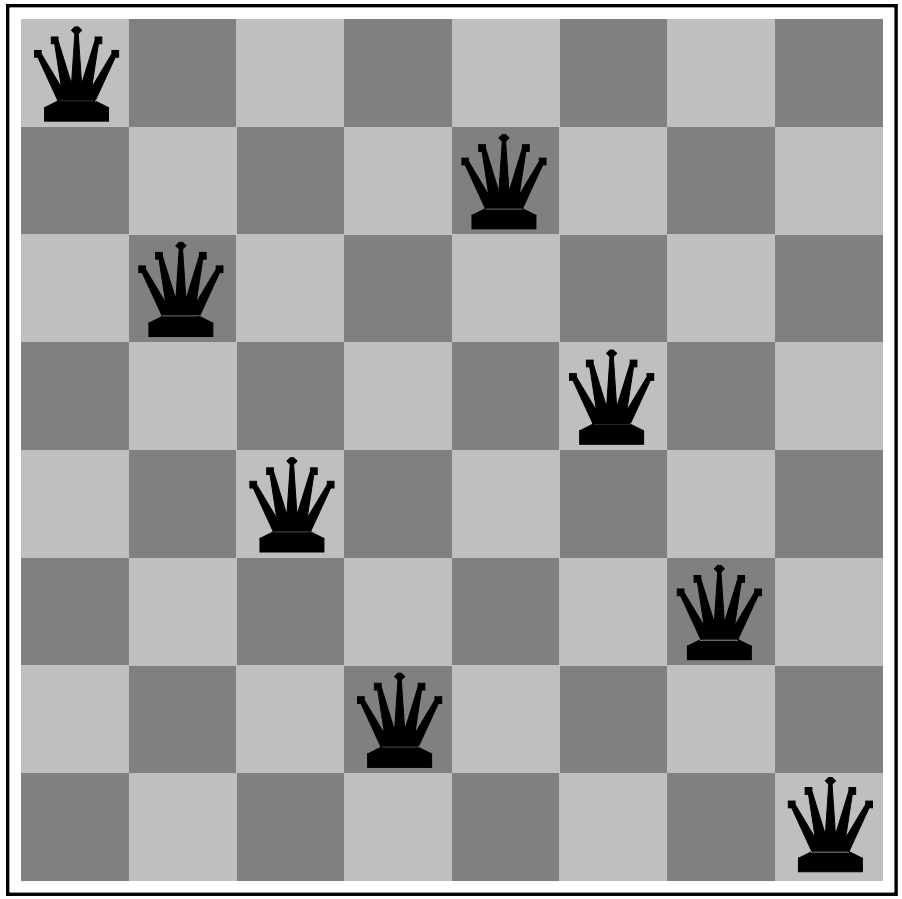
- *Chess*: Deep Blue (IBM) beats Kasparov (1997).
- *Diagnostic Systems*: Medicine, Space Shuttle, MS Windows.
- *Machine Translation*: SYSTRAN, Google translate.
- *Planning*: Mars Rover, Curiosity.
- *Robotics*: “Stanley” wins the Grand Challenge
  200km autonomous driving through the desert, 2005.
- *Question/Answering*: Watson (IBM) wins *Jeopardy!* contest, 2011.
- 2012: Nevada, California legalize autonomous cars.
- DARPA Robotics Challenge
  Humanoid robots in rescue scenarios, 2015.
- *Go*: AlphaGo beats Lee Sedol 4:1, 2016.

Topics Covered in the Course

- *Introduction*
- Agent Architectures
- Problem Solving as Search
- Games
- Knowledge Representation
- Planning
- Reasoning under Uncertainty
- Learning
- Robotics
- Philosophical Aspects

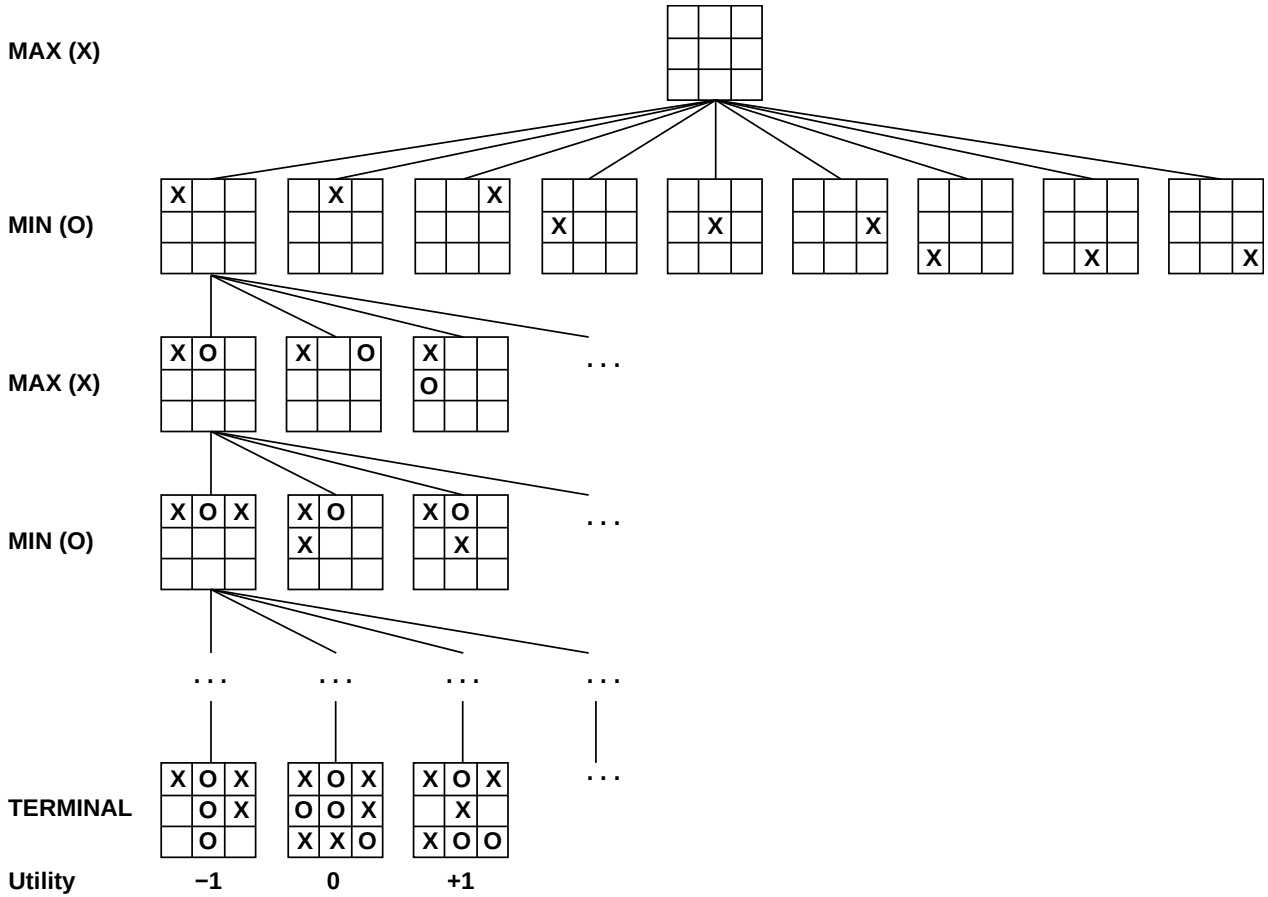
Problem Solving as Search

Example: The 8-Queens Problem



Games

Example: Tic-Tac-Toe



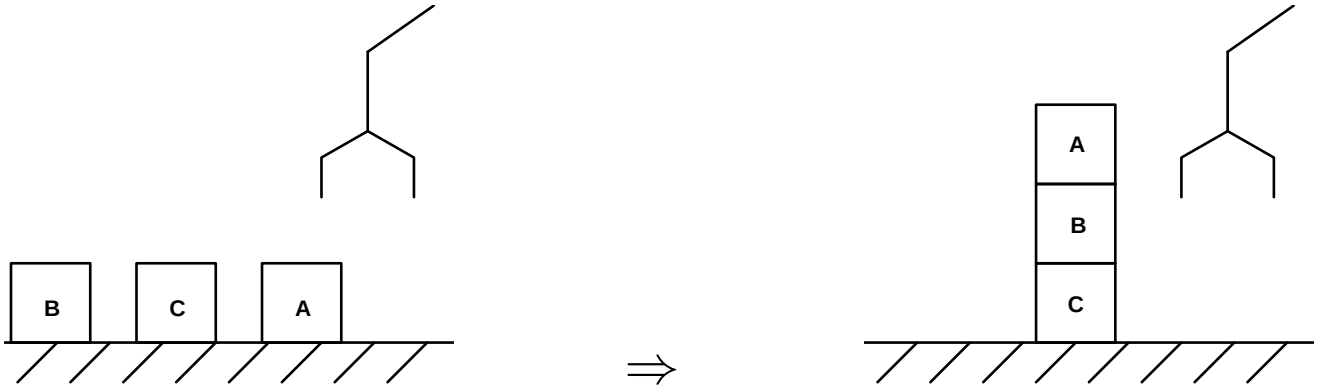
Knowledge Representation

Example: logical representations

A proud mother is someone whose children are all doctors:

$$\forall x \mathit{ProudMother}(x) \equiv$$
$$\exists y.\mathit{MotherOf}(x,y) \wedge \forall z.\mathit{MotherOf}(x,z) \supset \mathit{Doctor}(z).$$

Planning



Primitive Actions:

$pickup(x), puton(x, y)$

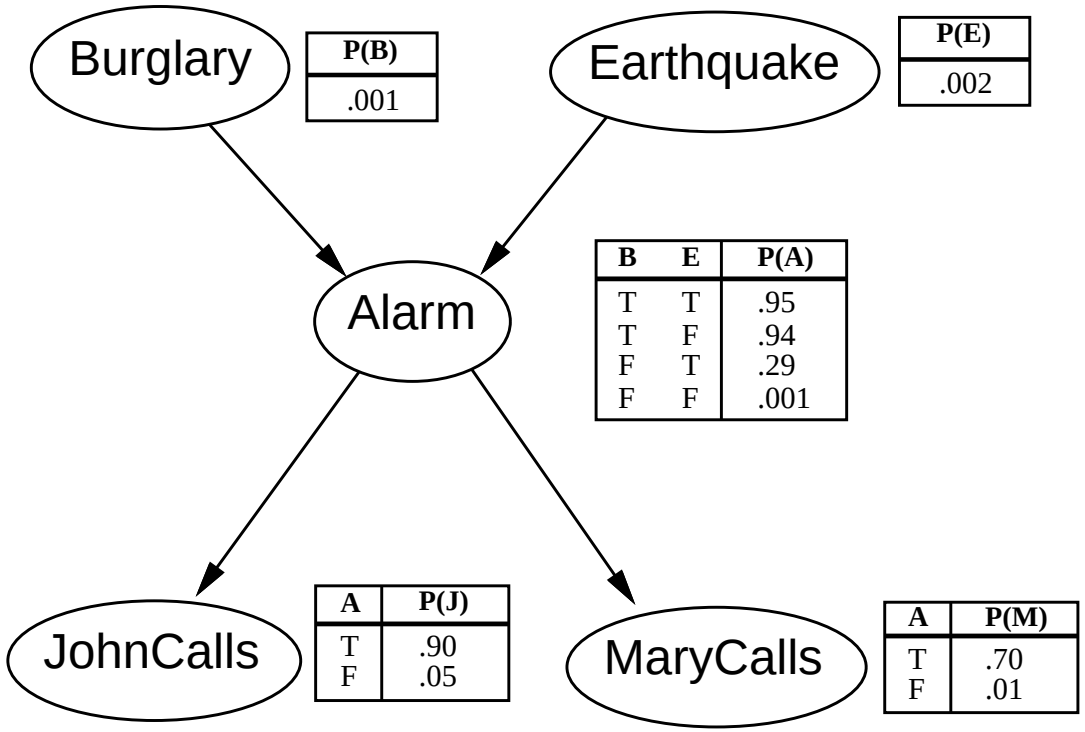
Possible successful action sequence:

$pickup(\mathrm{B}); puton(\mathrm{B}, \mathrm{C}); pickup(\mathrm{A}); puton(\mathrm{A}, \mathrm{B})$

Problem: How to plan action sequences in general such that a given initial state is transformed into a goal state.

Reasoning under Uncertainty

Example: Causal (Bayesian) Nets



Learning

Example: Neural Nets

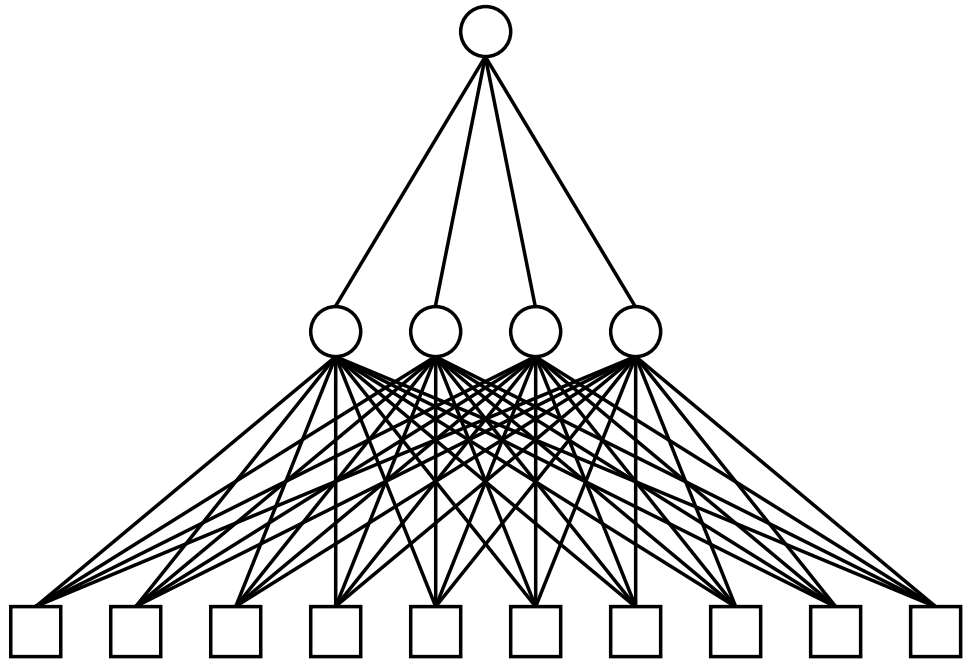
Output units O_i

$W_{j,i}$

Hidden units a_j

$W_{k,j}$

Input units I_k



Robotics