Grundlagen der künstlichen Intelligenz – Introduction

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Time and Place

Lecture	Thursday	16.15 - 17.45	Room MW 0001, Gustav-Niemann-Hörsaal
	Friday	13.00 - 13.45	Room MW 2001, Rudolf-Diesel-Hörsaal
Exercise	Friday	13.45 - 14.30	Room MW 2001, Rudolf-Diesel-Hörsaal
Office hours	Thursday	18.00 - 19.00	Room MI 03.07.053
Tutor office hours	Wednesday	10.00 - 12.00	Room MI 03.13.010

Website for the lecture: Moodle

Contact: Moodle forum

Audience

The lecture is **obligatory** in

- Informatik: Games Engineering
- Robotics, Cognition, Intelligence
- Automotive Software Engineering

and an **elective** in

- Informatik
- Data Engineering and Analytics
- Wirtschaftsinformatik
- Bioinformatik
- Mathematik
- Physik
- Maschinenwesen, Ingenieurwissenschaften (MSE)
- Computational Science and Engineering
- Management and Technology, Politics and Technology
- Neuroengineering, etc.

Exam, Course Material and Literature

Written exam, 90 minutes.

Exam Bonus

If you pass 2 programming exercises, you get a 0.3 grade bonus. Topics:

- Search problem;
- constraint satisfaction problem;
- logic problem;
- probabilistic problem.

Course Material

- Lecture slides
- Blackboard notes
- Exercises

Literature

Main Literature

- P. Norvig and S. Russell: Artificial Intelligence: A Modern Approach, Prentice Hall, 3rd edition. (English version)
- P. Norvig and S. Russell: Künstliche Intelligenz: Ein moderner Ansatz, Pearson Studium, 3. Auflage. (German version)

Further Literature

- W. Ertel: Grundkurs Künstliche Intelligenz: Eine praxisorientierte Einführung, Springer, 3. Auflage.
- P. Zöller-Greer: Künstliche Intelligenz: Grundlagen und Anwendungen, composia, 2. Auflage.
- D. L. Poole and A. K. Mackworth: Artificial Intelligence: Foundations of Computational Agents, Cambridge University Press.
- P. C. Jackson Jr: Introduction to Artificial Intelligence, Dover Publications.

Some Quotations

- Artificial intelligence is the study of how to make real computers act like the ones in the movies.

  (Anonymous)

- The question of whether a computer can think is no more interesting than the question of whether a submarine can swim.

  (Edsger W. Dijkstra)

- Machines will be capable, within twenty years, of doing any work that a man can do.

  (Herbert Simon, 1965)

- A year spent in artificial intelligence is enough to make one believe in God.

  (Alan Perlis)

What is Artificial Intelligence?

There exists no clear definition!

We group the definitions into four schools of thought:

	Human-like behavior	**Rational behavior**
Reasoning	Systems that think humanly	Systems that think rationally
Acting	Systems that act humanly	Systems that act rationally

Acting Humanly (I)

The Turing test proposed by Alan Turing in 1950 tests whether a machine acts humanly.

Turing test

A computer passes the Turing test if a human interrogator cannot tell whether the answers from his written questions come from a human or a computer.

The computer would need the following capabilities:

- **natural language processing** to communicate in natural language;
- **knowledge representation** to store what it knows or hears;
- **automated reasoning** to use stored information and to draw new conclusions;
- **machine learning** to adapt to new circumstances and to detect and explore patterns.

Acting Humanly (II)

The Turing test from 1950 deliberately avoids physical interaction because physical presence is not required for intelligence.

Total Turing test

Based on the Turing test and additionally requires that the subject can physically interact and see the other person using video.

The computer would additionally need the following capabilities:

- **computer vision** to perceive objects;
- **robotics** to manipulate objects and move them.

The six aforementioned disciplines compose most of the topics in artificial intelligence.

Thinking Humanly

To test whether machines think like humans, we need to get "inside" the human mind:

- **introspection**: trying to catch our own thoughts as they go by;
- **psychological experiments**: observing a person in action;
- **brain imaging**: observing the brain in action.

Thinking humanly approach

Once one has a sufficiently precise theory of the mind, one could write a computer program of it. If the input-output behavior matches human behavior, some inner workings of the program might correspond to human thinking.

This approach is typically followed in **cognitive sciences**.

Thinking Rationally

Rationality

A system is rational if it does the "right thing", i.e., has an ideal performance (performance measures are not always available).

Logics is often used to mimic rational thinking since it provides correct conclusions given correct premises, e.g.:

Socrates is a man; all men are mortal; therefore, Socrates is mortal.

Difficulties:

- Informal knowledge has to be formalized.
- Computational effort might be infeasible: Problems with a few hundred facts might exhaust the capabilities of today's computers.

Acting Rationally

Agent

An agent is just something that acts (Latin: agere, "to do").

Rational agent

A rational agent is one that acts so as to achieve the best outcome.

- Acting rationally can be based on thinking rationally. However, a fast reaction is sometimes better than thinking longer about the best solution (example: removing your hands from a hot object).
- The skills required for the Turing test allow an agent to act rationally (natural language processing, knowledge representation, automated reasoning, machine learning, computer vision, robotics).

This lecture focuses on acting rationally.

Some History of AI (I)

1943 McCulloch & Pitts: They propose a Boolean circuit model of a brain, in which neurons can only be *on* or *off*.

1950 Turing publishes article "Computing Machinery and Intelligence," in which he introduces the Turing Test, machine learning, genetic algorithms, and reinforcement learning.

1950s Early AI programs, including Samuels checkers program, Newell & Simons Logic Theorist, Gelernters Geometry Engine.

1956 John McCarthy coins the term "artificial intelligence" as the topic of the Dartmouth Conference, the first conference devoted to the subject.

1965 Robinson discovers the resolution method (a complete theorem-proving algorithm for first-order logic).

Some History of AI (II)

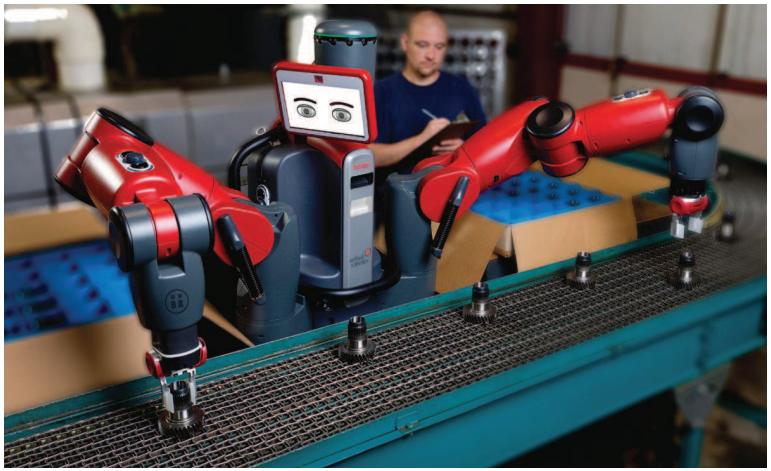
1966-74	AI research moves towards topics of computational complexity, neural network research almost disappears.
1969-79	Early development of knowledge-based systems.
1980-88	Expert systems industry booms (expert systems emulate the decision-making ability of a human expert).
1988-93	Expert systems industry busts: "AI Winter".
1985-95	Neural networks return to popularity.
1988-	Resurgence of probability; general increase in technical depth.
1995-	Agents, agents, everywhere...
2001-	The availability of very large data sets.

State of the Art: Automated Driving

source: Carnegie Mellon University

- In 1995, the driverless car *VaMP* (Universität der Bundeswehr München) drove 1758 km from Munich to Denmark (mean autonomously driven distance without resets: 9 km).
- In 2005, the driverless car *Stanley* (Stanford University) wins a 132-mile race through the Mojave desert.
- In 2007, the driverless car *Boss* (Carnegie Mellon University) wins a course through an urban environment obeying traffic rules in mixed traffic with human drivers.

State of the Art: Robotics



source: Rethink Robotics

source: CPS group, TUM

- First systems become intelligent enough to work together with humans.
- Commercial successes: Robotic vacuum cleaners, robotic lawn mowers, etc.

State of the Art: Planning and Scheduling

source: Technische Universität München

- A hundred million miles from Earth, NASA's Remote Agent program became the first on-board autonomous planning program to schedule the operations of a spacecraft in 2000.
- The robots TUM-Rosie and TUM-James demonstrate their planning abilities by preparing pancakes in the project CoTeSys.

State of the Art: Chess Playing

source: IBM

- In 1996, IBM's DEEP BLUE was defeated in a chess match by the world champion Garry Kasparov. Kasparov won the six-game match 4 to 2.
- In 1997, IBM's DEEP BLUE won the rematch against Garry Kasparov with 3.5 to 2.5.
- The IBM team, which also consisted of chess experts, reprogrammed the system between matches.

State of the Art: Playing Jeopardy!

source: IBM

- In 2011, Watson, an artificially intelligent computer system capable of answering questions posed in natural language defeated Ken Jennings and Brad Rutter (two of the most successful Jeopardy! players).
- Watson had access to 200 million pages of structured and unstructured content consuming four terabytes of disk storage, including the full text of Wikipedia, but was not connected to the Internet during the game.

State of the Art: Speech Recognition

source: Amazon

- Since a few years many cloud-based voice services are available, e.g., Amazon's Alexa or Apple's Siri.
- Many call centers use speech recognition to partially replace humans.

State of the Art: Machine Translation

source: Google

- Many online services nowadays available, e.g., deepL, Google Translate, etc.
- The influence of deep learning in this area has increased in the last years.

State of the Art: Spam Fighting

source: security-faqs.com

- Learning algorithms classify over a billion messages as spam, which corresponds to about 80% of all messages.
- Learning algorithms adapt to changing tactics of spammers.

State of the Art: Video Games

source: Freeciv project

- In video games, artificial intelligence is used to simulate human-like intelligence.
- It is primarily used for non-player characters.
- One of the first examples of AI is the computerized game of Nim, made in 1951 and published in 1952.

Short Game: What can be done today?

- Play a decent game of table tennis yes
- Drive safely along a curving mountain road yes
- Drive safely in a city no
- Buy a week's worth of groceries on the web yes
- Buy a week's worth of groceries in a supermarket no
- Play a decent game of bridge yes
- Discover and prove a new mathematical theorem no
- Design and execute a research program in molecular biology no
- Write an intentionally funny story no
- Give competent legal advice in a specialized area of law yes
- Translate spoken English into spoken Swedish in real time yes
- Converse successfully with another person for an hour no
- Perform a complex surgical operation no
- Unload any dishwasher and put everything away no

Table Tennis Playing Robot from TU Darmstadt

source: TU Darmstadt

Humans vs. Machines

Machine	**Human**
high speed	slower
high accuracy	less accurate
high forces	less powerful
fast feedback	slower feedback

But:

Machine	**Human**
Less adaptive	Highly adaptive in unforeseen situations
Typically specific power and sensitivity	Large range: power vs. sensitivity
Typically designed for specific purpose	Universal capabilities

Enabling Technologies

- computers
- embedded systems
- sensors and actuators
- user interaction
- robots
- Internet
- computation grid

AI in Science Fiction

I, Robot

source: 20th Century Fox

Number 5 from Short Circuit

source: Tristar Pictures

Terminator

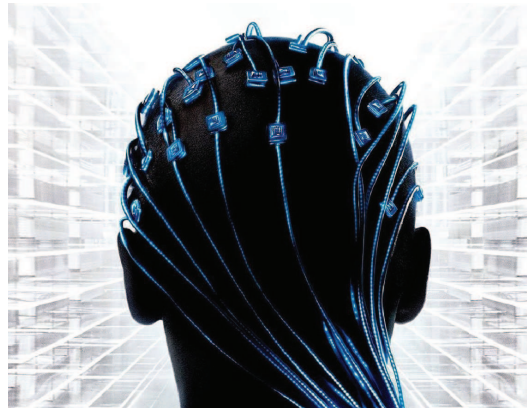
source: Orion Pictures

R2D2 from Star Wars

source: 20th Century Fox

HAL 9000 from 2001: A Space Odyssey

source: Metro-Goldwyn-Mayer



Transcendence

source: Summit Entertainment

New Alliances

'Partnership on AI' formed by Google, Facebook, Amazon, IBM and Microsoft

Two big Silicon Valley names are missing from the alliance, which aims to set societal and ethical best practice for artificial intelligence research

Partnership on Artificial Intelligence hopes to invite 'academics, non-profits and specialists in policy and ethics' to join. Photograph: Alamy

New Players from Established Industries

CarTech

Honda to collaborate with SoftBank towards research on AI for mobility

By Connected CarTech
26 July 2016, 10:10 a.m.
comment

Categories

Artificial Intelligence, Ecosystems

Pleas for Cautious Use

Stephen Hawking, Elon Musk, and Bill Gates Warn About Artificial Intelligence

Google-owned Boston Dynamics released a video showing a 6′ tall 320-lb humanoid robot named Atlas running freely in the woods

By Michael Sainato • 08/19/15 12:30pm

Stephen Hawking, Elon Musk, and Bill Gates. (Photo: Getty Images)

Technological Singularity

Technological Singularity Hypothesis

Accelerating improvement in technology results in a runaway effect wherein artificial intelligence will exceed human intellectual capacity and control, possibly ending civilization in an event called the singularity.

Criticism

The idea of singularity is an ongoing debate, which is not the subject of this lecture. One of the critics is Steven Pinker:

"(...) There is not the slightest reason to believe in a coming singularity. The fact that you can visualize a future in your imagination is not evidence that it is likely or even possible. Look at domed cities, jet-pack commuting, underwater cities, mile-high buildings, and nuclear-powered automobiles – all staples of futuristic fantasies when I was a child that have never arrived. Sheer processing power is not a pixie dust that magically solves all your problems. (...)"

Tweedback Question

Artificial Intelligence will...

A ...be a useful technology that helps us all in the future. Development should be as fast as possible – ethical problems are spread by overly concerned people.

B ...should be carefully developed. We cannot be sure of all future implications at this point.

C ...destroy us all.

Expectations?

- Please immediately ask questions if you do not understand something.
- All questions should be taken seriously.
- Please do not give up if you are not immediately understanding everything.
- Advice: Attend the lecture and exercises (statistically one grade better).
- Only come if you are interested and if you are not a pure "book learner".
- Besides the evaluation: Talk to us after the lecture if you have ideas for improvement.
- **Questions after the lecture: please use Moodle!** Answers can also be read by other students. I will not answer individual emails.

What are your expectations?

Topics of This Lecture

- Intelligent agents
- Solving problems by searching (uninformed + informed search)
- Constraint satisfaction problems
- Logical agents (propositional + first-order logic)
- Probabilistic reasoning (Bayesian networks + Hidden Markov Models)
- Rational decisions
- Learning
- Introduction to robotics

Learning Outcomes (I)

Exam-related

- You can analyze problems of artificial intelligence and judge how difficult it is to solve them.
- You can recall the basic concepts of intelligent agents and know possible task environments.
- You can formalize, apply, and understand search problems.
- You understand the difference between constraint satisfaction and classical search problems as well as apply and evaluate various constraint satisfaction approaches.
- You can critically assess the advantages and disadvantages of logics in artificial intelligence.
- You can formalize problems using propositional and first-order logic.

Learning Outcomes (II)

- You can apply automatic reasoning techniques in propositional and first-order logic.
- You understand the advantages and disadvantages of probabilistic and logic-based reasoning.
- You can apply and critically asses methods for probabilistic reasoning with Bayesian networks and Hidden Markov Models.
- You understand and know how to compute rational decisions.
- You have a basic understanding on how a machine learns.
- You know the basic areas and concepts in robotics.

Summary

- Different people approach AI with different goals in mind. Two important questions to ask are:
  - Are you concerned with thinking or behavior?
  - Do you consider human-like or rational behavior?
- This lecture focuses on **rational behavior**.
- For specific tasks, such as chess playing, AI can outperform humans similarly to calculators outperforming humans in basic arithmetic.
- AI is a topic of wild and interesting speculations, such as the technological singularity. This lecture is on understanding the basics of AI rather than on philosophical aspects.