Artificial Intelligence

Algorithms and Applications with Python

Chapter 1

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</> course material: ↗ www.github.com/dominikjung42 | recordings: ↗ www.youtube.com/c/dominikjung42

Outline

1 Introduction into Artificial Intelligence

► **What we will learn:**

- What artificial intelligence (AI) is and some illustrative use cases to show the potential of AI in context of information systems
- Why the industry needs AI experts like you, and how typical AI job profiles and their every day's work life looks like
- How we will organize the following lecture and what you can expect to learn

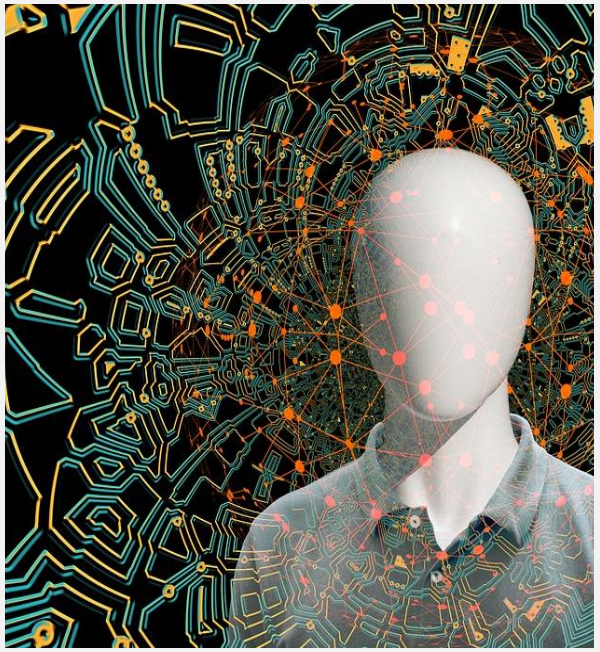


Image source: ↗ Pixabay (2019) / ↗ CC0

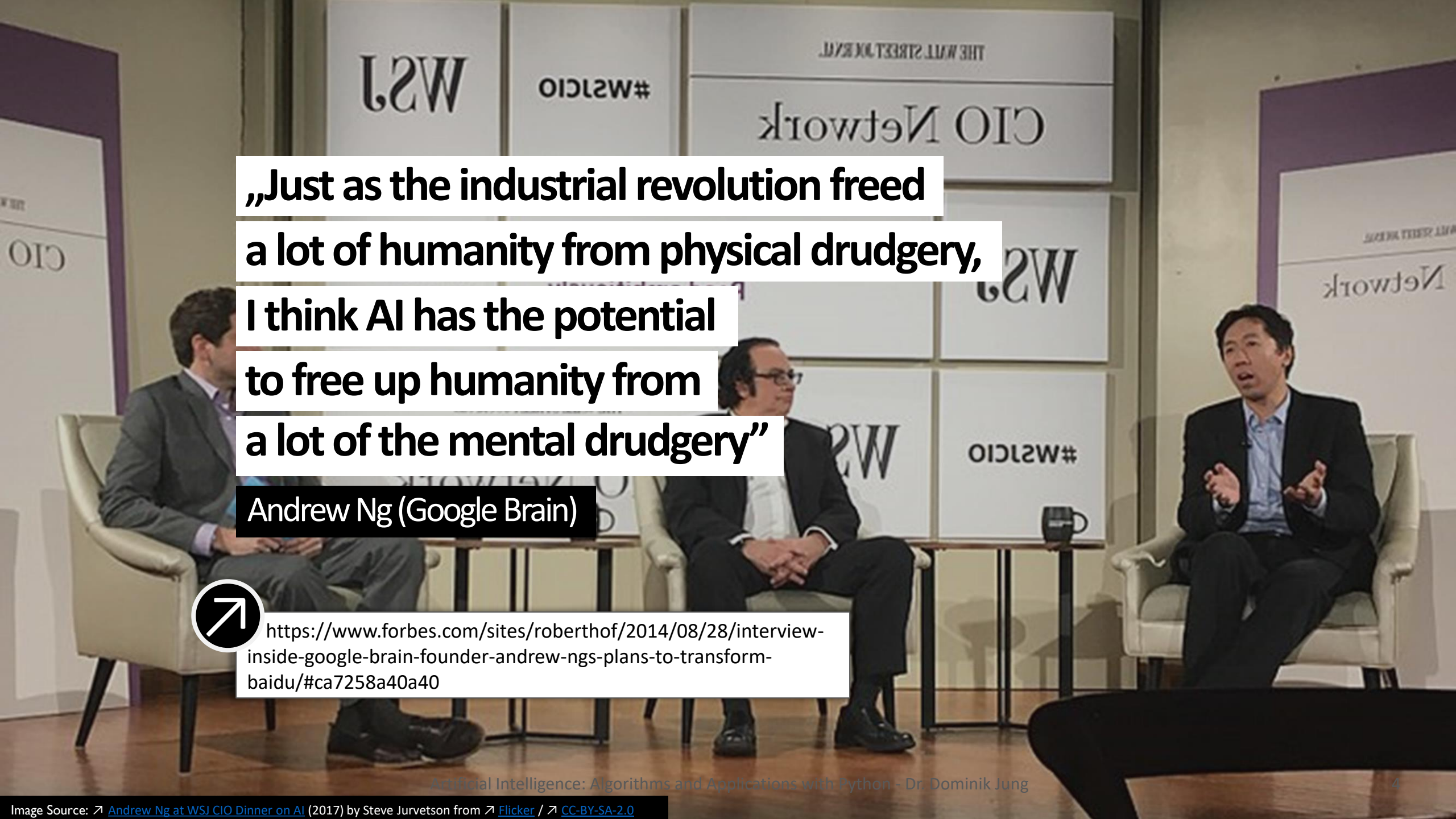
► **Duration:**

- 90 min

► **Relevant for Exam:**

- 1.1 - 1.3

Microsoft AI ft. Common
https://www.youtube.com/watch?v=9tucY7Jhhs4



1.1 (Intelligent) Automation @my Home

Image sources: Dominik Jung (2019)

1.1 Automation Means Automation of Human Work

Physical Robots

- Do simple work, humans do not want to or can not do
- E.g. automate moving heavy and dangerous loads or performing many repetitions, automate boring tasks
- Fast and safe execution, without or with less errors than humans
- **Domain**: cybernetics, control theory, engineering

Physical robots support <u>physical</u> work

Artificial Intelligence

- Modeling intelligent behavior to automate work humans do not want to do
- E.g. Detect patterns in huge amount of data or automate the credit decision process in a bank
- Independent processing of different individual tasks
- **Domain**: computer science, statistics

Artificial Intelligence supports <u>intellectual</u> work

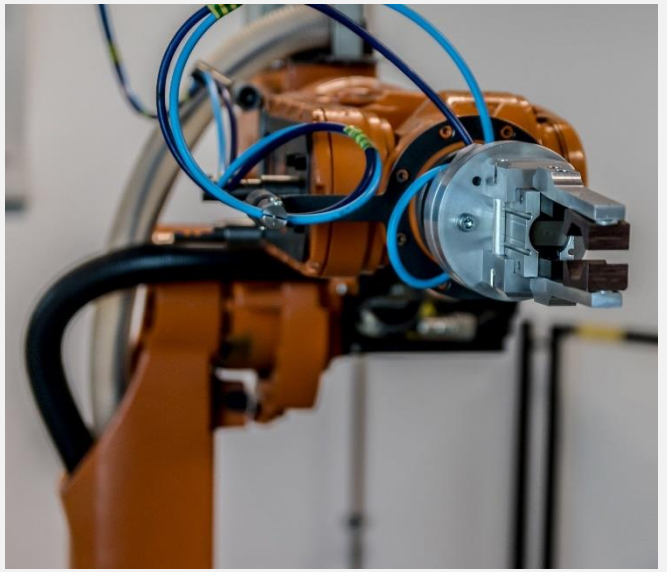


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Image sources: Dominik Jung (2019)

1.1 Automation – The Job Killer?

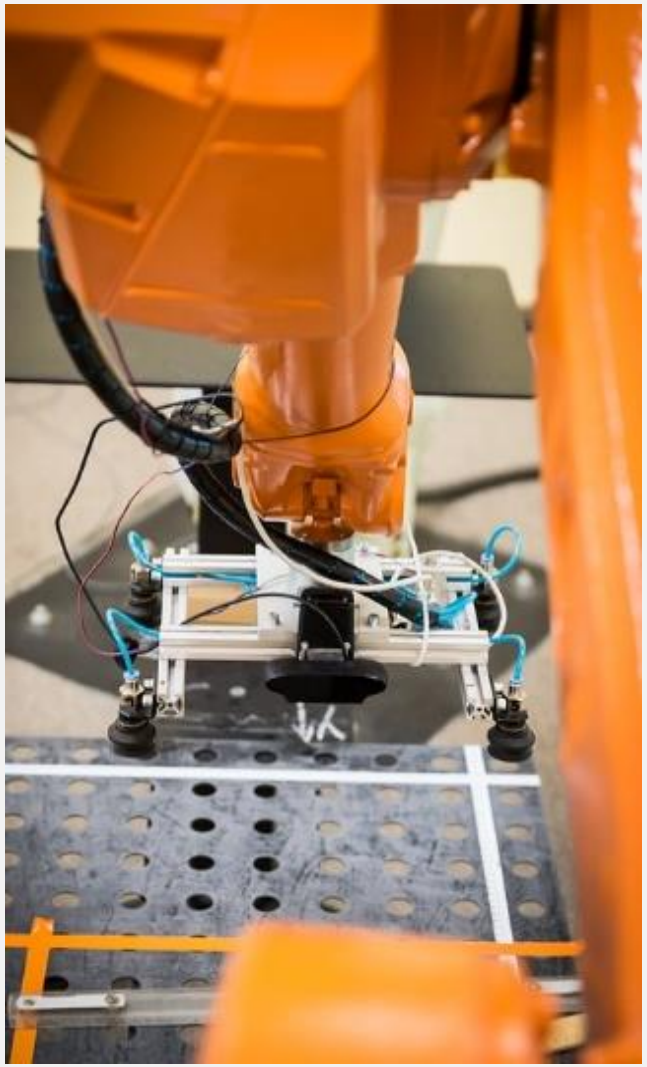
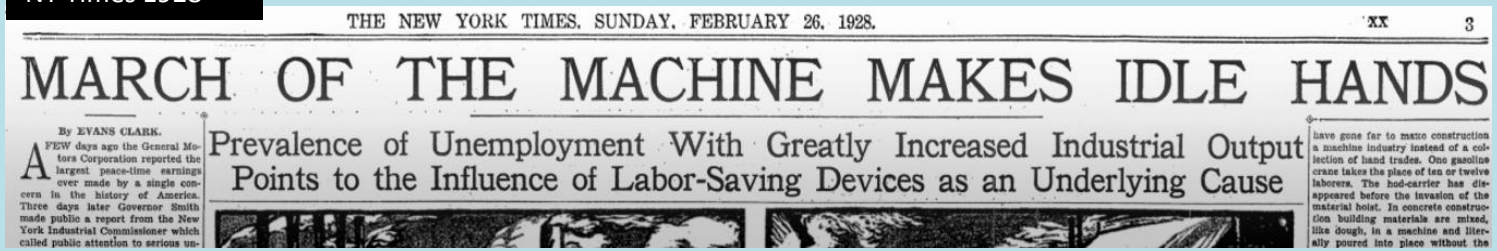


Image source: ↗ Pixabay (2019) / ↗ CC0

Forbes, 2018

The Upside Of Automation: New Jobs, Increased Productivity And Changing Roles For Workers

NY Times 1928



THE NEW YORK TIMES, SUNDAY, FEBRUARY 26, 1928. XX 3

MARCH OF THE MACHINE MAKES IDLE HANDS

By EVANS CLARK.

A FEW days ago the General Motors Corporation reported the largest peace-time earnings ever made by a single concern in the history of America. Three days later Governor Smith made public a report from the New York Industrial Commissioner which called public attention to serious un-

Prevalence of Unemployment With Greatly Increased Industrial Output Points to the Influence of Labor-Saving Devices as an Underlying Cause

have gone far to make construction a machine industry instead of a collection of hand trades. One gasoline crane takes the place of ten or twelve laborers. The hod-carrier has disappeared before the invasion of the material hoist. In concrete construction building materials are mixed, like dough, in a machine and literally poured into place without the

- Research on the impact of AI on the labor market suggests that monotonous jobs are replaced and new hybrid expert jobs are created. Current findings suggest that there is no relevant job loss due to AI (see e.g. Brynjolfsson & McAfee 2014).

1.1 Classroom Task

Your turn!

Task

Please think for yourself:

- Where do you have contact with AI, and how does it make our everyday life easier?

Outline

1 Introduction into Artificial Intelligence

- 1.1 Motivation
- 1.2 Historical Foundations of Artificial Intelligence
- 1.3 Artificial Intelligence in Practice
- 1.4 Lecture Syllabus

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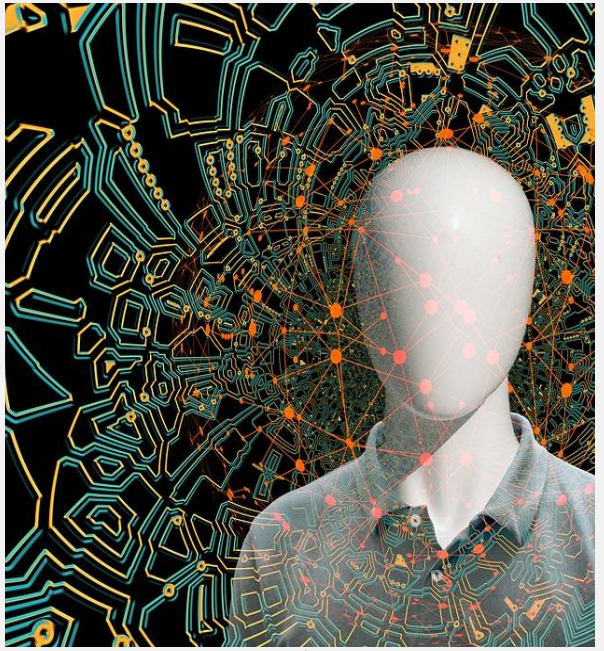

Image source: ↗ Pixabay (2019) / ↗ CC0

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1.2 Dartmouth Conference 1956

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Image source ↗ Hanover Main Street (2015) by Ken Gallager / ↗ CC BY-SA 3.0

Image source: ↗ Open Street Maps (2019)

1.2 Dartmouth Conference (1956)

Image source: ↗ Pixabay (2019) / ↗ CC0

„We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 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****. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.“ – Proposal Rockefeller Foundation*

Participants

Ray Solomonoff, Marvin Minsky, Claude Shannon, Trenchard More, Nat Rochester, Oliver Selfridge, Julian Bigelow, W. Ross Ashby, W.S. McCulloch, Abraham Robinson, Tom Etter, John Nash, David Sayre, Arthur Samuel, Kenneth R. Shoulders, Shoulders' friend, Alex Bernstein, Herbert Simon, Allen Newell

1.2 What is Artificial Intelligence (AI)?

D **Artificial Intelligence**

The science and engineering of making intelligent machines, especially intelligent computer programs (McCarthy, 1956)

- Simulates human abilities such as the recognition of patterns, the solution of problems and the making of logical inferences
- Includes algorithms that learn from data and accurately predict future behavior
- Should in the future be able to make simple decisions for themselves and relieve, supplement and additionally enable people

Image source: ↗ John McCarthy (2006) by null0 from ↗ Flicker / ↗CC-BY-SA-2.0

? What could be a potential problem of the definition of John McCarthy?

1.2 Different Research Perspectives on Intelligence in Artificial Intelligence

- Different research perspectives due to different understandings of intelligence

- Two dimensions:
  - Thought processes/reasoning vs. behavior/action
  - Success according to human standards vs. success according to an ideal concept of intelligence rationality.

Systems that act like humans	Systems that act rationally
Systems that think like humans	Systems that think rationally

Adapted from Rusell, S., & Norvig, P. (2016), p.2

1.2 Different Research Perspectives on Intelligence in Artificial Intelligence

Acting Humanly

- "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)

Acting Rationally

- "Computational Intelligence is the study of the design of intelligent agents." (Poole et al., 1998)
- "AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

Thinking Humanly

- "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)

Thinking Rationally

- "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)

Adapted from Rusell, S., & Norvig, P. (2016), p.2

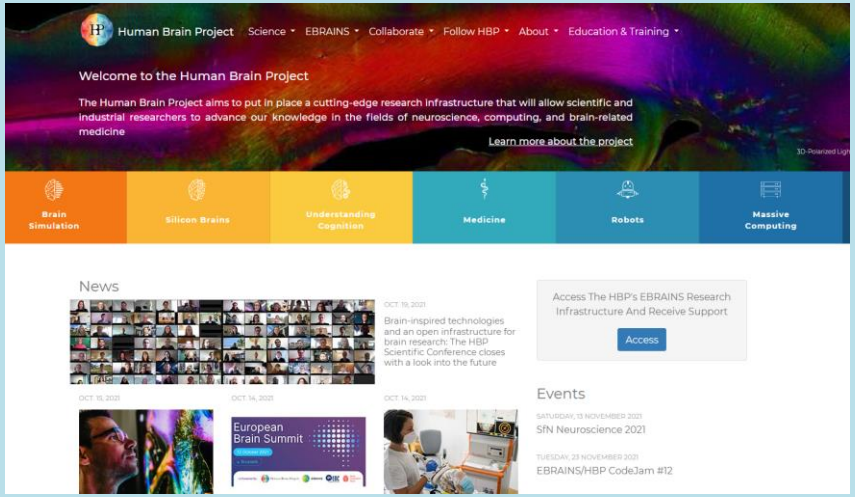
1.2 AI Perspectives – Thinking Rationally

- Rationality is the idealized or “right” way of thinking
- Beginning with the Greek philosopher Aristotle, researchers have attempted to formalize the rules of rational thought by logic
- **Logicist perspective to AI:** describe problem in formal logical notation and apply general deduction procedures to solve it
- Problems with the logicist approach
  - Computational complexity of finding the solution
  - Describing real-world problems and knowledge in logical notation
  - A lot of intelligent or “rational” behavior has nothing to do with logic

1.2 AI Perspectives – Thinking Humanly

- Requires scientific theories of internal thinking (Mind-Body Problem!)
- **Cognitive** perspective: This type of research (cognitive science and neuroscience) are now distinct from artificial research due to complexity

- Problems with this approach
  - Computational complexity of finding the solution
  - Can a system understand itself?



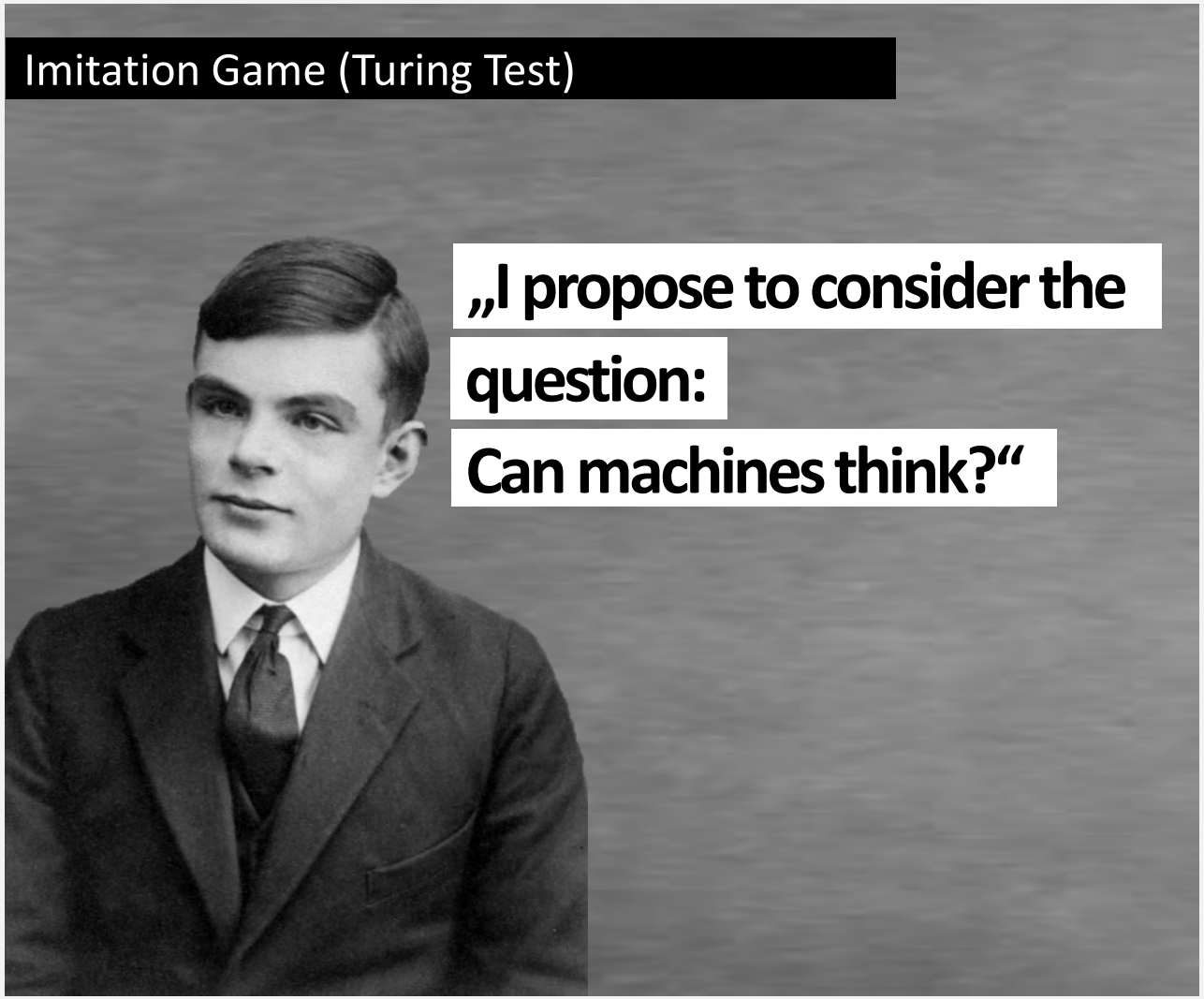
Human Brain Project of the European Union
https://www.humanbrainproject.eu

1.2 AI Perspectives – Acting Rationally

- A rational agent is one that acts to achieve the best expected outcome
  - Goals are application-dependent and are expressed in terms of the **utility of outcomes**
  - Being rational means **maximizing your expected utility**
  - In practice, utility optimization is subject to the agent's computational constraints (*bounded rationality* or *bounded optimality*)

- This definition of rationality only concerns the decisions/actions that are made, not the cognitive process behind them
- Rationality is only feasible in ideal environments
- Rationality is not a very good model of reality (see decision support literature)

1.2 AI Perspectives – Acting Humanly



Jajal T (2018) | Image source: ↗ Passport photo of Alan Turing at age 16 (1928?) / Public Domain

- The Turing Test, proposed by Alan Turing (1950), was designed to provide a satisfactory operational definition of intelligence
- A computer passes the test if a human interrogator, after posing some written questions, cannot tell whether the written responses come from a person or from a computer.
- Turing predicted that by the year 2000, machines would be able to fool 30% of human judges for five minutes
- (-) Turing Test meaningless due to Chinese room argument?

1.2 The Chinese Room Argument

Jajal T (2018); Searle J (1980) | Image source: ↗ Pixabay (2019) / ↗ CC0

Some potential problems with the Turing Test:

- Human behavior is not (always) intelligent (see decision support literature)
- Some intelligent behavior may not be human
- Human observers may be easy to fool

Chinese Room argument:

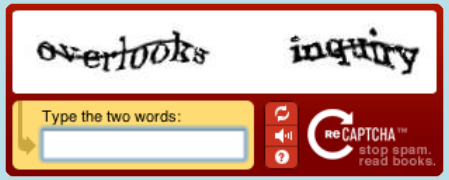
- one may simulate intelligence without having true intelligence

General Problem with these tests

- Results are not reproducible, constructive or amenable to mathematical analysis

1.2 CAPTCHAs, or the Turing Test backwards

- Abbreviation of "**C**ompletely **A**utomated **P**ublic **T**uring test to tell **C**omputers and **H**umans **A**part"
- We know that computers cannot pass a Turing test, hence we give them simple questions that can only be answered by humans
- Examples:



- Computers can't see and have to learn how to solve such tasks

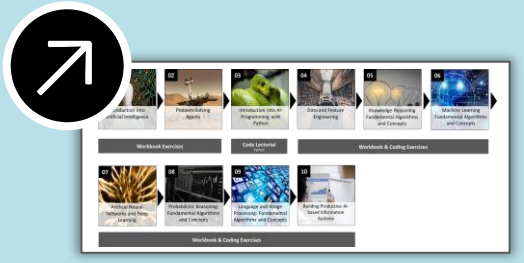
- Computers can do the math, but don't understand the question

1.2 Research Areas of Artificial Intelligence

What are abilities of an intelligent computer systems?

Artificial Intelligence

- Lecture 6+7 — **Machine Learning**
- Lecture 9 — **Speech Processing**
- Lecture 2+8 — **Planning and Optimization**
- Lecture 10 — **Robotics**
- **Natural Language Processing (NLP)** — Lecture 9
- **Knowledge Reasoning / Expert Systems** — Lecture 5
- **Computer Vision** — Lecture 9



And many others like game theory, machine translation etc.

Adapted from Rusell, S., & Norvig, P. (2016), p.2

1.1 Foundations of AI Research

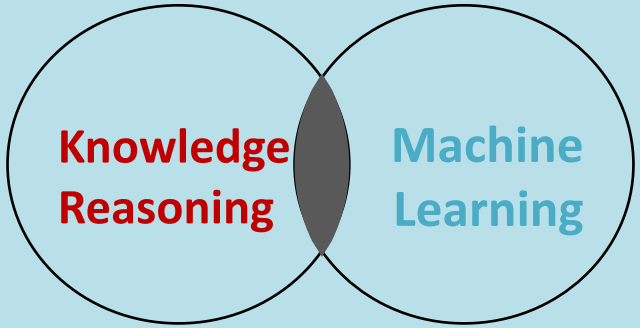
Different fields have contributed to AI in the form of ideas, viewpoints and techniques:

- Philosophy: Logic, reasoning, mind as a physical system, foundations of learning, language and rationality
- Mathematics: Formal representation and proof algorithms, computation, (un)decidability, (in)tractability, probability
- Psychology: adaptation, phenomena of perception and motor control
- Economics: formal theory of rational decisions, game theory
- Linguistics: knowledge representation, grammar
- Neuroscience: physical substrate for mental activities
- Cybernetics and control theory: homeostatic systems, stability, optimal agent design

Adapted from Rusell, S., & Norvig, P. (2016), p.2

1.2 KBS and ML Are Different, But Partially Overlapping Concepts

Automation of simple, repetitive activities in information systems on the basis of known, defined rules



Automation and support of individual human tasks based on data

	Knowledge Reasoning (and Representation)	Machine Learning
Intelligence	Symbolic	Subsymbolic, computational (numeric)
Automation	Rules based on defined formulas	Probabilities from learning experience
Input	Can process structured and semi-structured data	Can process structured, semi-structured and to some extent also unstructured data
Examples	Expert systems, case-based reasoning,…	Neuronal networks, statistical learning, knowledge discovery…

1.2 Example: Knowledge-based System

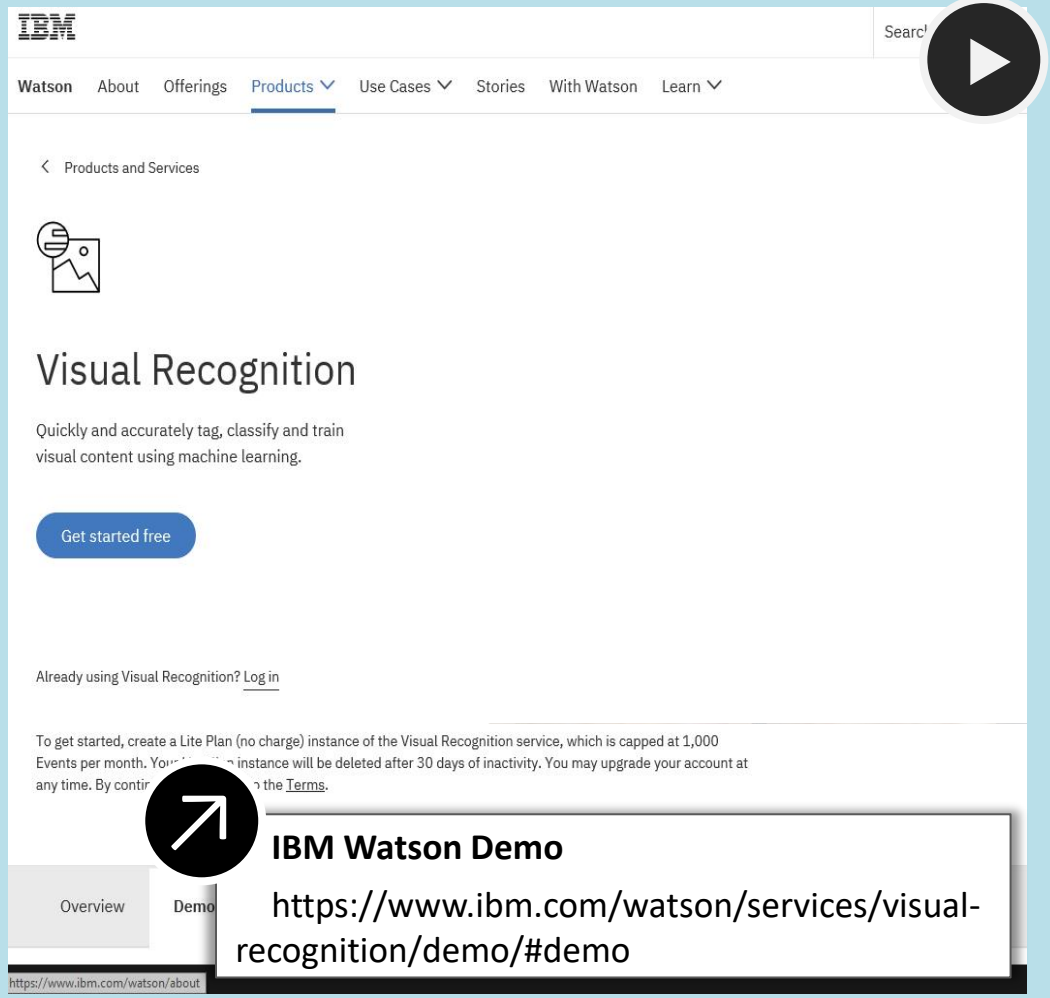
- **Dendral**: Pioneering work developed in 1965 for NASA at Standford University
- **Drilling Advisor**: Developed in 1983 by Teknowledge for oil companies to replace human drilling advisors
- **Mycin**: Developed in 1970 at Stanford by Shortcliffe to assist internists in diagnosis and treatment of infectious diseases
- **Xcon/RI**: Developed in 1978 to assist the ordering of computer systems by automatically selecting the system components based on customer‘s requirements

Image source: ↗ A Symbolics Lisp Machine (2019) by Michael L. Umbricht and Carl R. Friend (Retro-Computing Society of RI) / ↗ CC BY-SA 3.0

D **Knowledge-based System**

An expert system or knowledge-based system is one that solves problems by applying knowledge that has been garnered from one or more experts in a field (Norvig, 1992)

1.2 Current State of AI and Knowledge-based Systems



- Even if knowledge-based systems seem to be outdated, they are still used these days when policies need to be automated (loan processing, fraud review, investment management, etc.).
- Modern knowledge-based systems are parts of general AI tools like IBM Watson
- Watson stores more information than any single human can store and gives responses to natural language queries

1.2 Example: Machine Learning

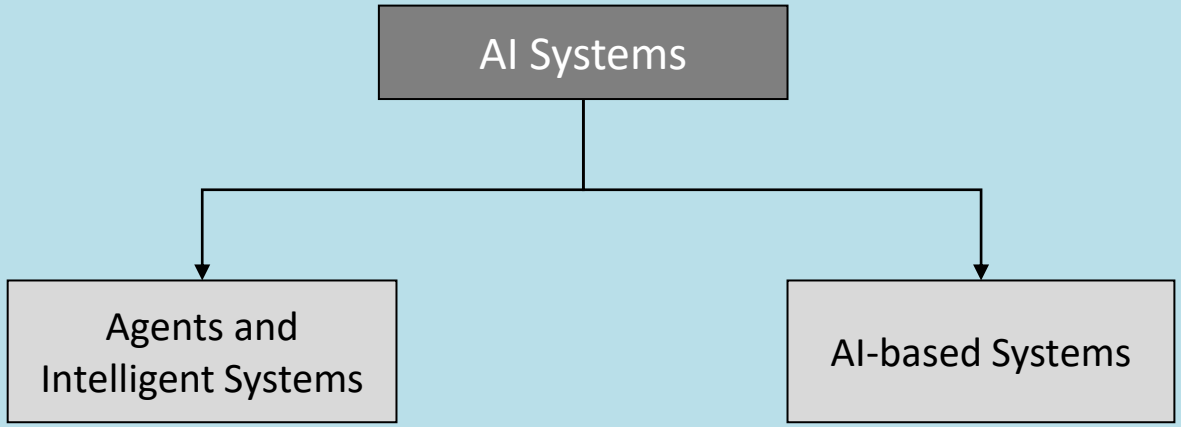
Image source: ↗ DB2018AL00555 (VW) | free for editorial purposes

Image source: ↗ Pixabay (2019) / ↗ CC0

D **Machine Learning**

A computer program is said to learn from experience ‘E’, with respect to some class of tasks ‘T’ and performance measure ‘P’ if its performance at tasks in ‘T’ as measured by ‘P’ improves with experience ‘E’. (Mitchel, 2011)

1.2 Two Different Use Cases for AI in Computer Science



"Agents" or "intelligent systems" is a very popular concept in computer science and **you will find many different definitions and conceptualizations**. Most of the understandings of agents/intelligent system and AI-based systems **will overlap**. In this lecture we will use the presented understanding **to distinguished between two different use cases** of AI.

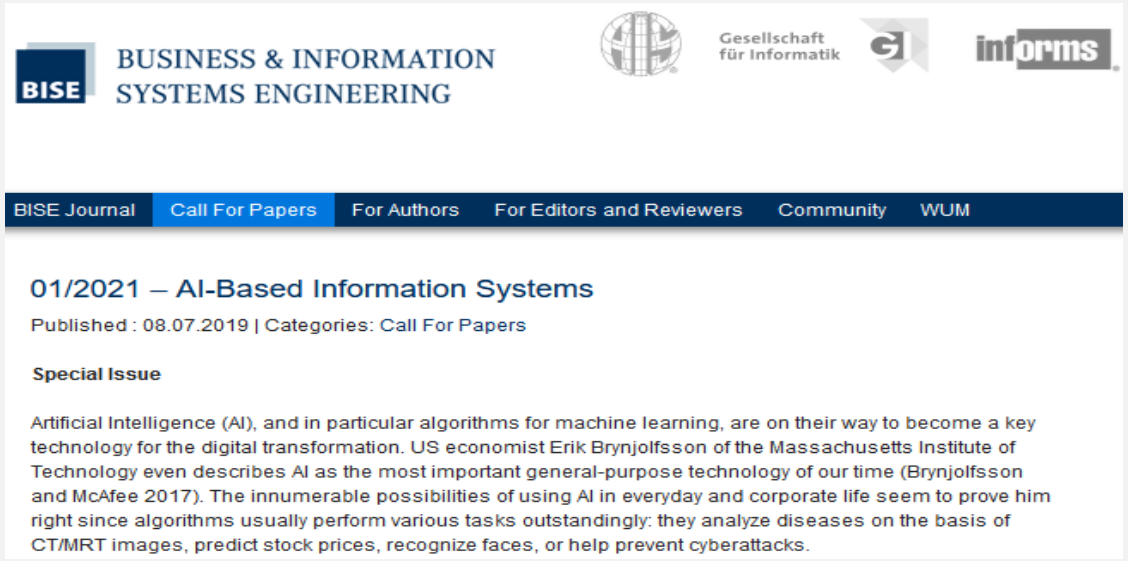
Agents (or „intelligent" systems)

- Use AI as autonomous entity acting intelligent (achieving specific goals) embedded in an environment
- **Examples**: factory robot, chatbot, trading bot, Fraud detection agent etc.

AI-based System

- Use AI in a computer system integrating AI-based components or methods for a specific purpose
- **Examples**: expert systems, decision support systems, planning systems, diagnosis system etc.

1.2 Special Use Case: Business Informatics



AI-based Information Systems in Business and Organizational Context

- How do individuals and societies react to intelligent machines which outperform their human counterparts? For instance, what is the impact on HR management and educational institutions?
- How do emerging technologies affect labor markets and jurisdictions? Should new regulations be introduced?
- What are AI's possible effects on organizational governance and hierarchy, structure, and processes? Are current managerial models, strategy development, and quality management techniques still applicable?
- Which behavioral, ethical, and societal issues are bound to arise from increased AI use and how can these be countered?

1.2 Different Conceptualizations of Real-Life Artificial Intelligence

Jajal T (2018)

1.2 Artificial Intelligence Today and Tomorrow

Today

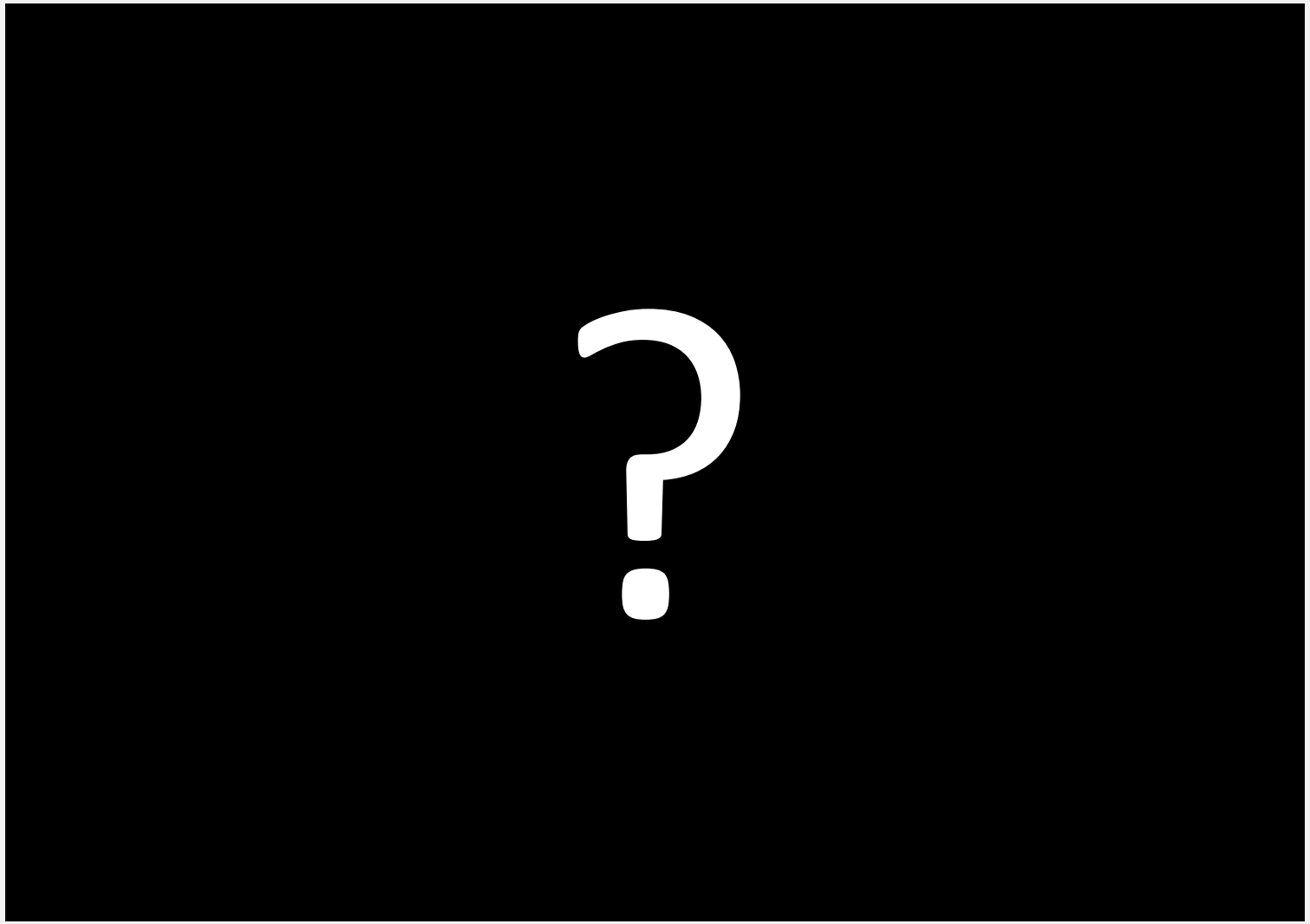
„Artificial Narrow Intelligence “

- Operates within a pre-determined, pre-defined range, even if it appears to be much more sophisticated
- Google assistant, google translate, and Siri are examples of narrow AI

Jajal T (2018)

Image source: Dominik Jung (2019)

1.2 Artificial Intelligence Today and Tomorrow



Jajal T (2018) | Image source: ↗ Pixabay (2019) / ↗ CC0

Research

„General Artificial Intelligence“

- Can successfully perform any intellectual task that a human being can (see research areas of artificial intelligence)
- So far: Machines do not have the ability to think abstractly, creatively, strategize, and tap into our thoughts and memories to make informed decisions

1.2 Moravec's Paradox

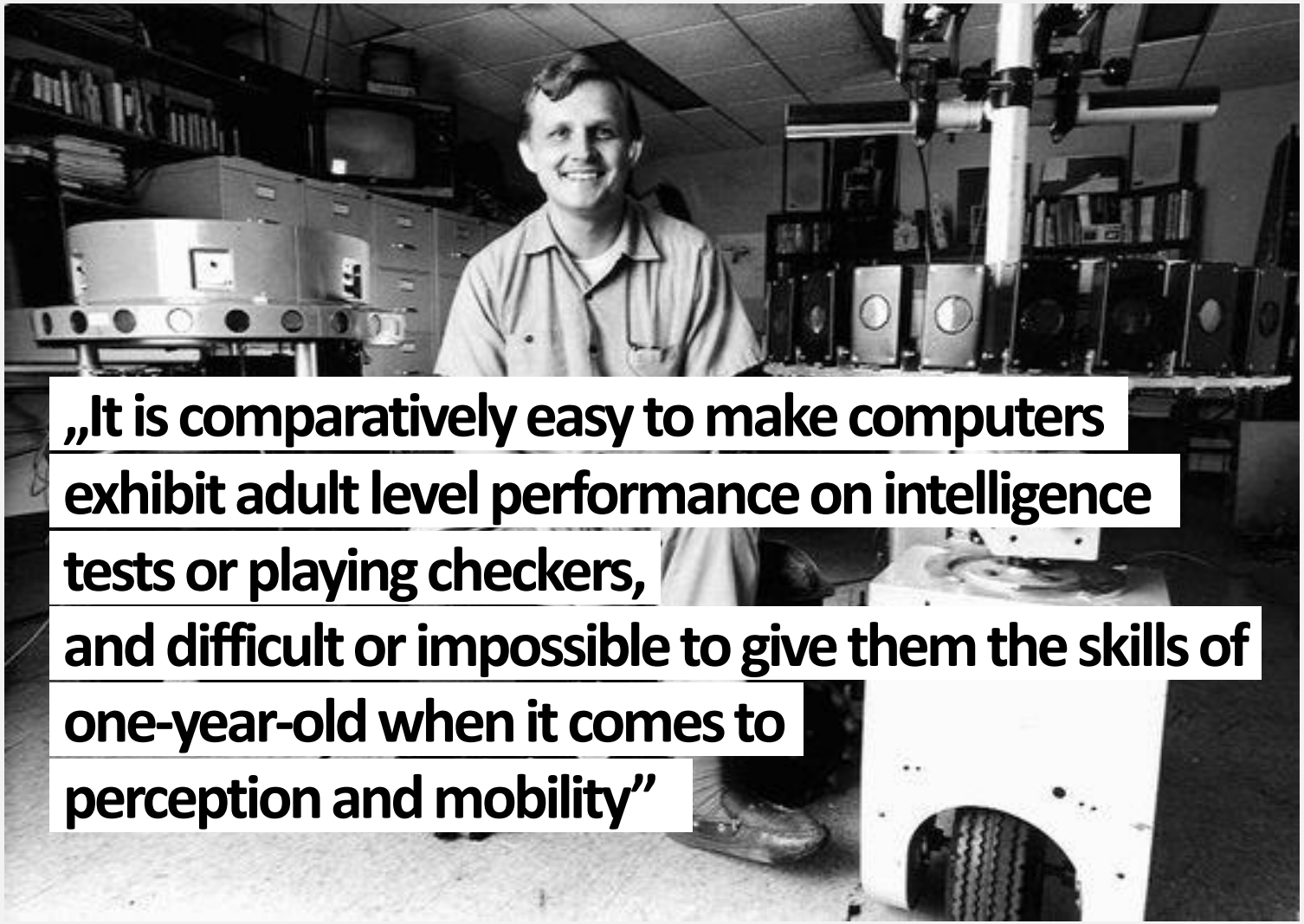


Image source: ↗ Museum of Computer History (1990)

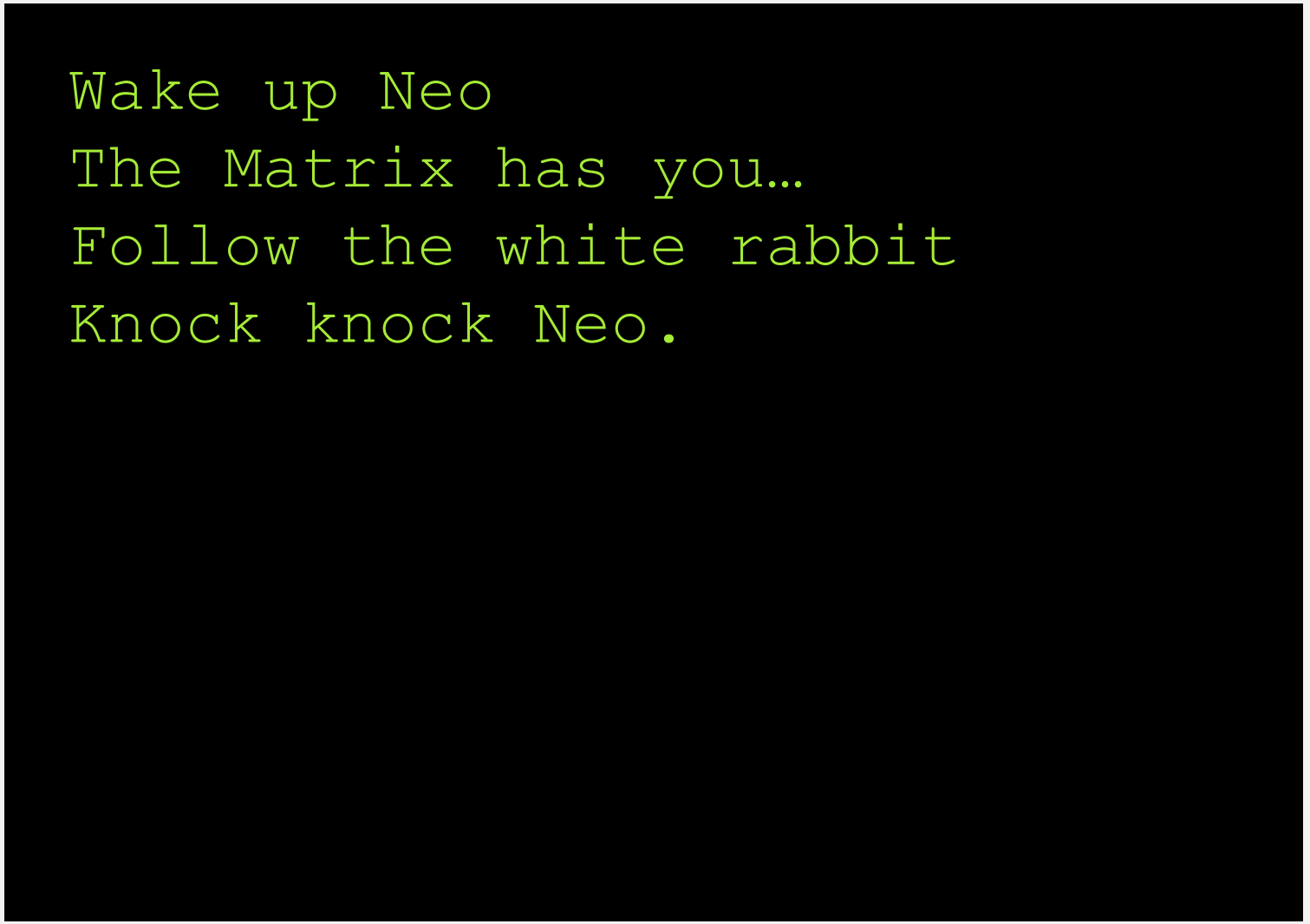
- Early AI researchers concentrated on the tasks that (male) scientists found the most challenging, abilities of animals and two-year-olds were overlooked
- We are least conscious of what our brain does best
- Sensorimotor skills took millions of years to evolve
- Our brains were not designed for abstract thinking

1.2 Artificial Intelligence Today and Tomorrow

Science Fiction

„Super Artificial Intelligence“

- Oxford philosopher Nick Bostrom: “any intellect that greatly exceeds the cognitive performance of humans in virtually all domains of interest”
- Surpass human intelligence in all aspects



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- Surpass human intelligence in all aspects

AI will be used as a supporter and partly as a decision maker, but will not make people obsolete.

Jajal T (2018)

1.2 Classroom Task

Your turn!

Task

Please discuss with your neighbors:

- What is AI? What are characteristics and abilities that can emerge in “intelligence”?
- Which of these abilities needs an artificial intelligence to pass the imitation game?

Outline

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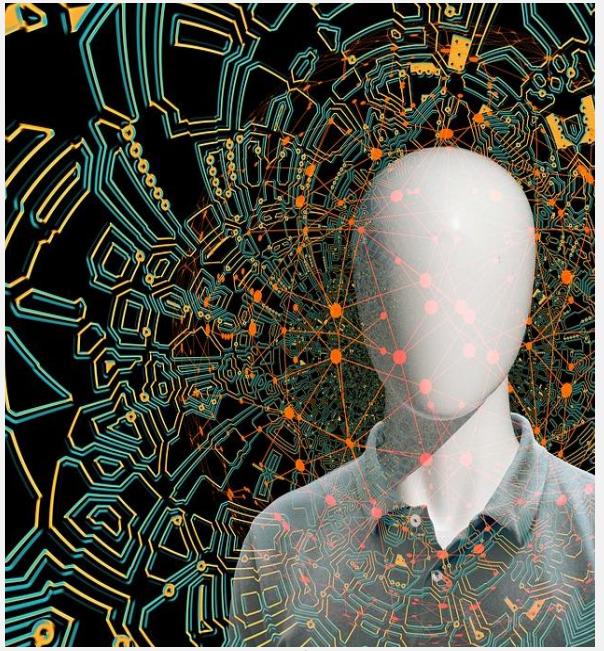

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https://hbr.org/2012/10/data-scientist-the-sexiest-job-of-the-21st-century

Data Scientist: The Sexiest Job of the 21st Century

Thomas H. Davenport and D.J. Patil

"The shortage of data scientists is becoming a serious constraint in some sectors."

1.3 Job Profiles in AI (Examples)

AI Specialist

- Professional responsible for AI related topics at companys
- Designing, developing and maintaining simple AI related solutions
- Product owner in AI-related projects

Data Engineer

- Models scalable database and data flow architectures
- Develops and improves the IT infrastructure on the hardware and software side
- Deals with topics such as IT Security , Data Security and Data Protection

Data Scientist

- AI-Expert responsible for collecting, analyzing and interpreting extremely large amounts of data
- The role is an offshoot of several traditional technical roles, including mathematician, scientist, statistician and computer professional

Robotics Scientist

- Engineer responsible for implementing intelligent robots
- Bridge between mechanical engineering, electrical engineering, computer science

BI Developer

- Designing, developing and maintaining business intelligence solutions
- Crafting and executing queries upon request for data
- Presenting information through reports and visualization

Machine Learning Engineer

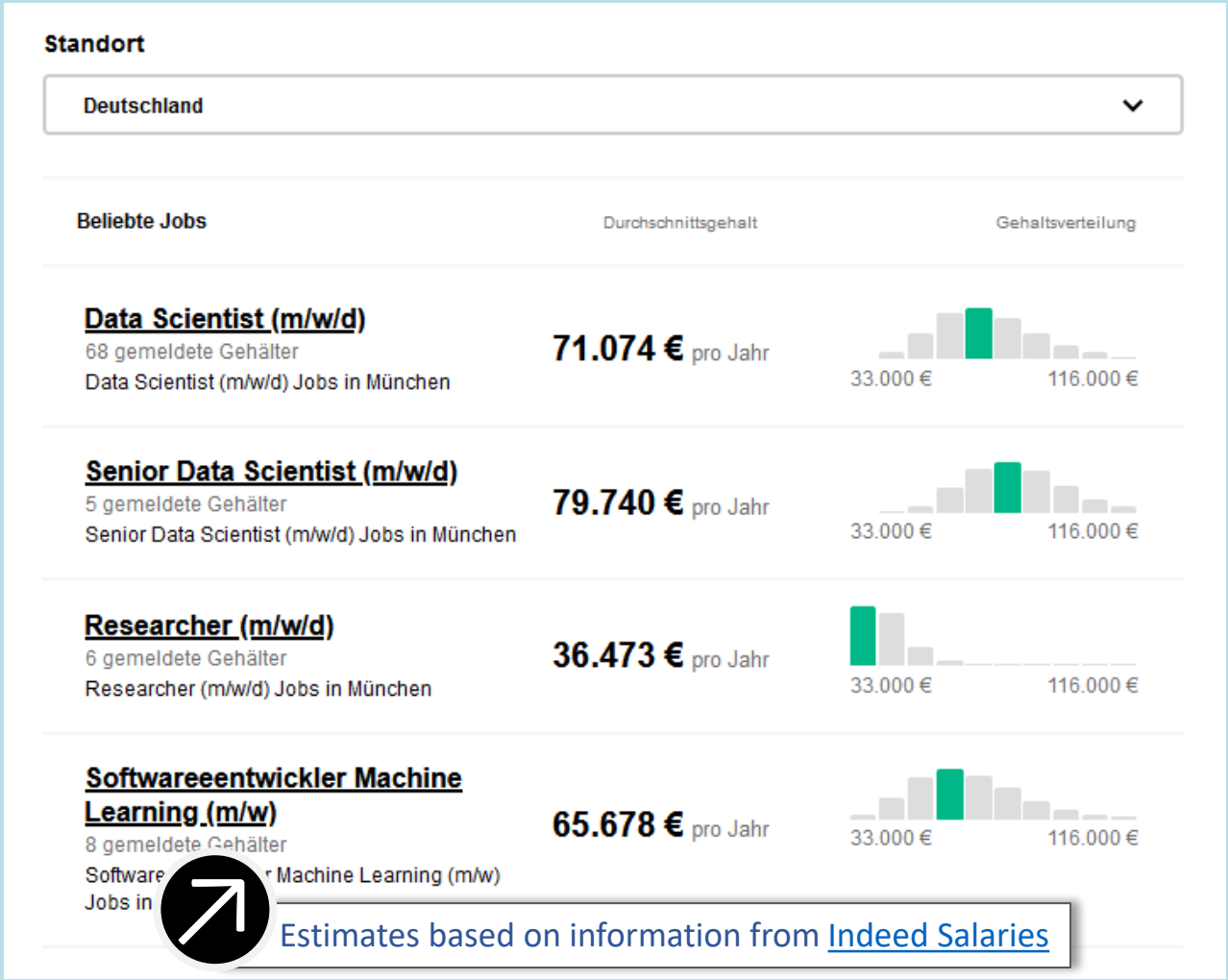
- Engineer responsible for implementing intelligent robots
- Bridge between mechanical engineering, electrical engineering, computer science

AI Research Scientist

- Works mostly for universities or big companies
- Passionately drive and further advance innovations in the field of computer vision

...

1.3 How is the Job Situation? What Can You Expect to Earn?



- **Various factors influence the starting salary:** size of the company, location, industry, degree and professional experience all play a role.
- **Internships** or **experience** gained through a working student job are good prerequisites for a higher starting salary

1.3 Research Jobs for AI Specialists

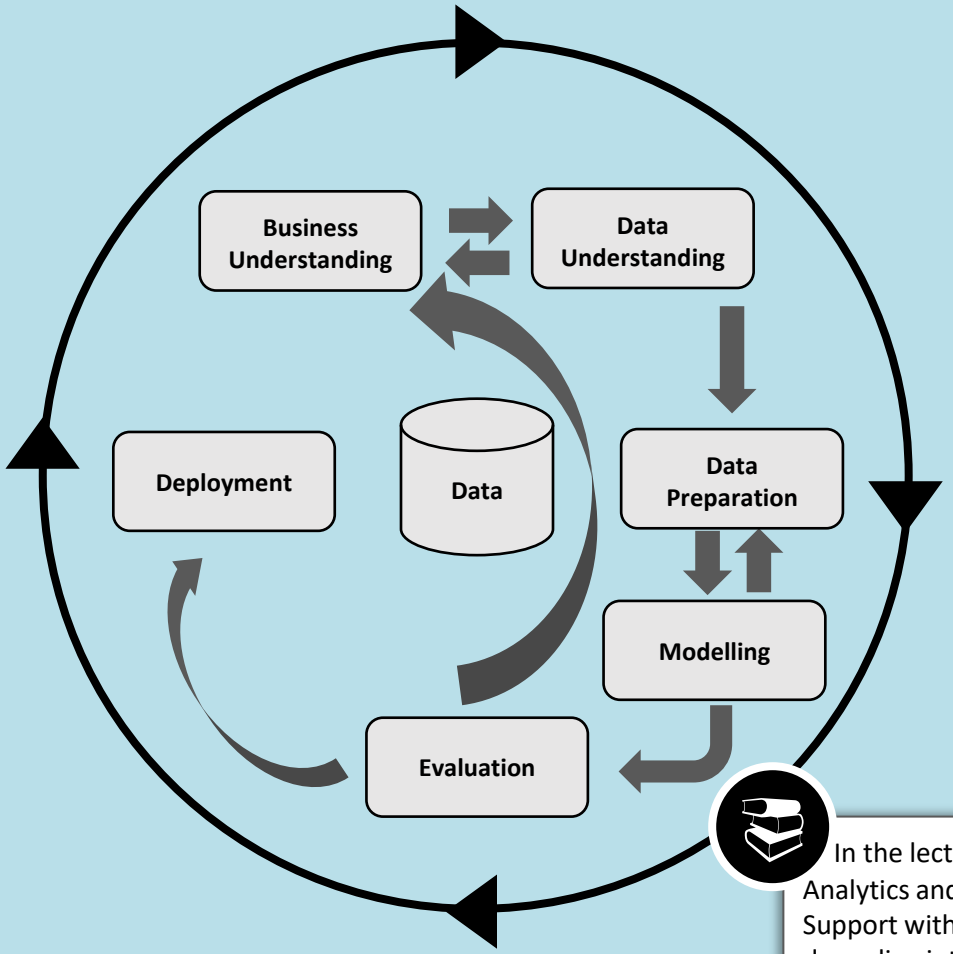
- PhD in AI topics (e.g. computer science) has a positive influence on the starting salary
- However, in the course of a career, **practical knowledge** and **project experience** are more important, so that the salaries of doctoral candidates and employees **without a doctorate are at a similar level later** in the job
- However, in **AI teams at big companies, many** people have a **PhD**.

How will your AI Job Workday look like: CRISP-DM

- Cross-Industry Standard Process for Data Mining (CRISP-DM)
- Process model describing commonly used approaches that data science experts use to tackle problems

Free "CRISP-DM 1.0 *Step-by-step data mining guide*"

In-depth documentation and process guide

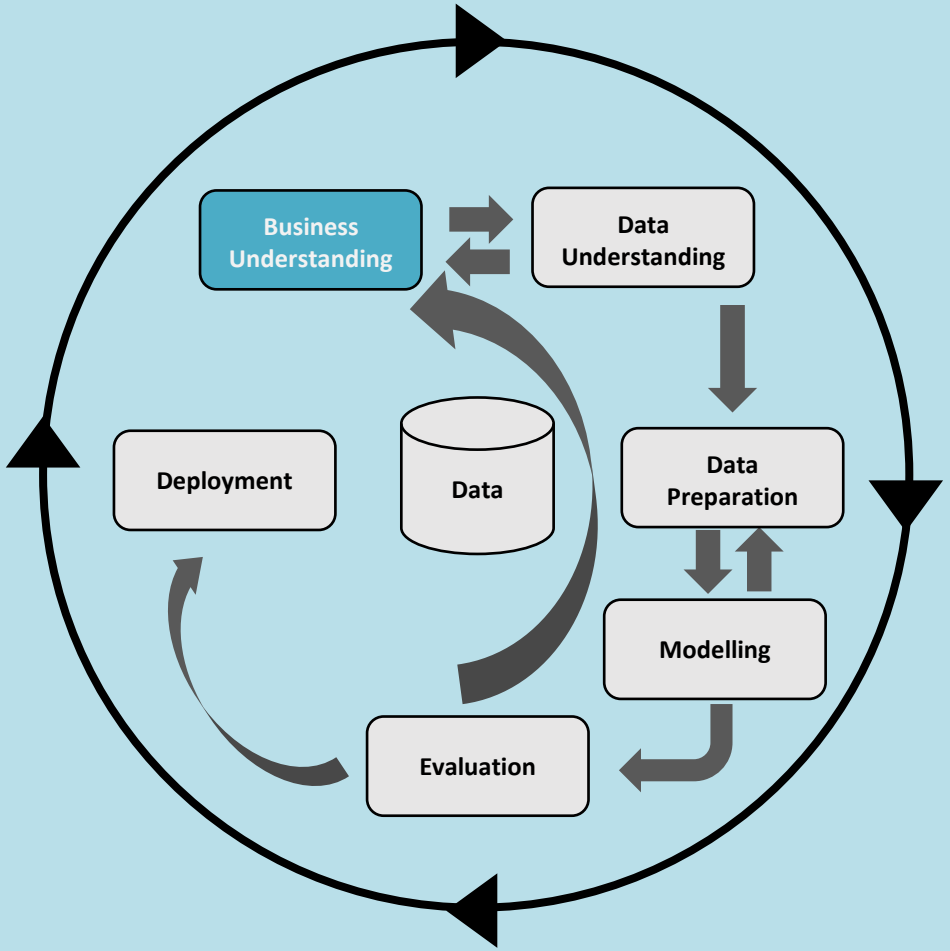


In the lecture "Business Analytics and Decision Support with R" we make a deep dive into the CRISP-DM

Chapman Pete et al. (1999)

1.3 CRISP-DM – Business Understanding

- **What activities are related to the business understanding phase?**
  - Specifying the problem
  - Identifying objectives
  - Understanding of requirements
- **Other common activities:**
  - Make a project plan
  - Define project team
  - Specify project method (e.g. SCRUM)

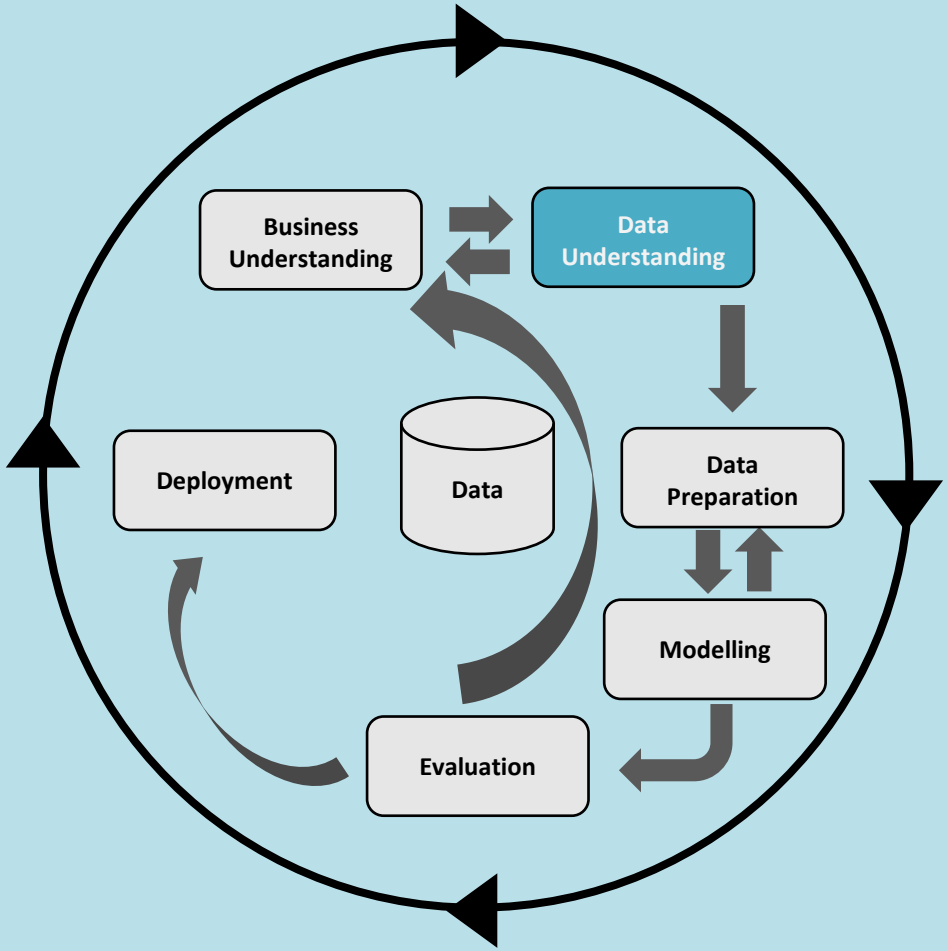


Chapman Pete et al. (1999)

1.3 CRISP-DM – Data Understanding

- **What activities are related to the data understanding phase?**
  - Initial data collection and familiarization
  - Data quality problems identification

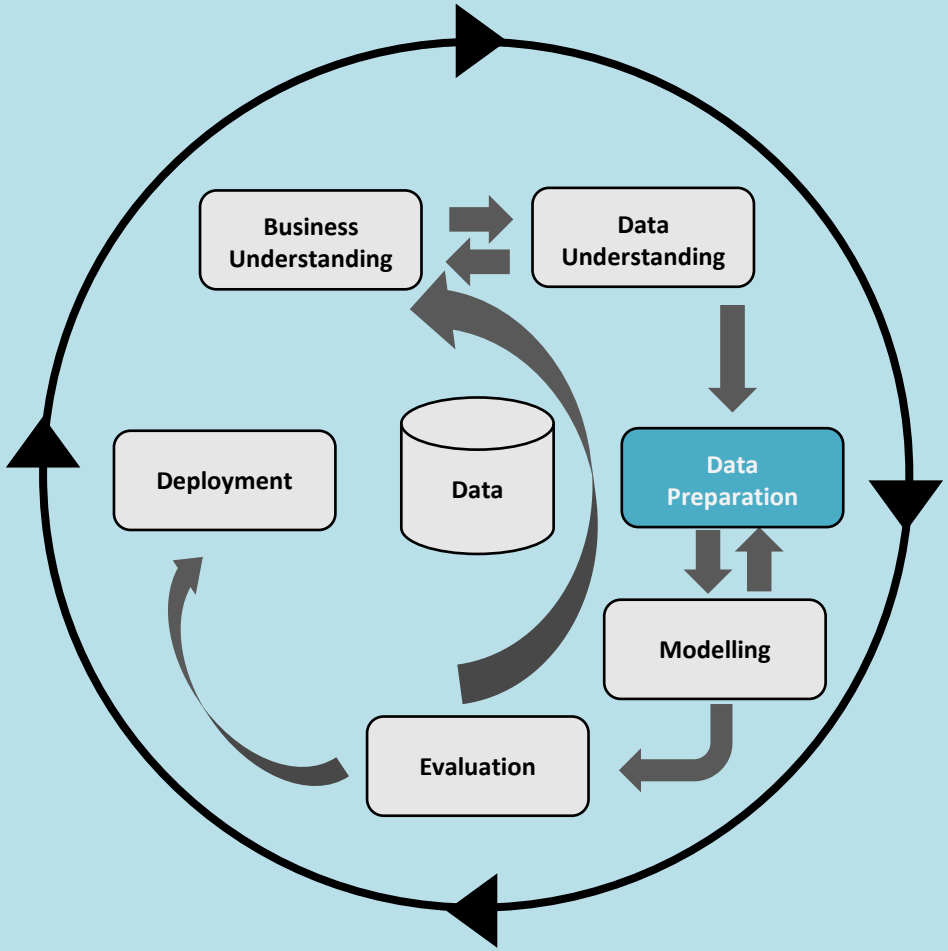
- **Other common activities:**
  - Make a data catalogue
  - Define data requirements



Chapman Pete et al. (1999)

1.3 CRISP-DM – Data Preparation

- **What activities are related to the data preparation phase?**
  - Table, record and attribute selection
  - Data integration
  - Data preprocessing, transformation and cleaning
- **Other common activities:**
  - Define data architecture

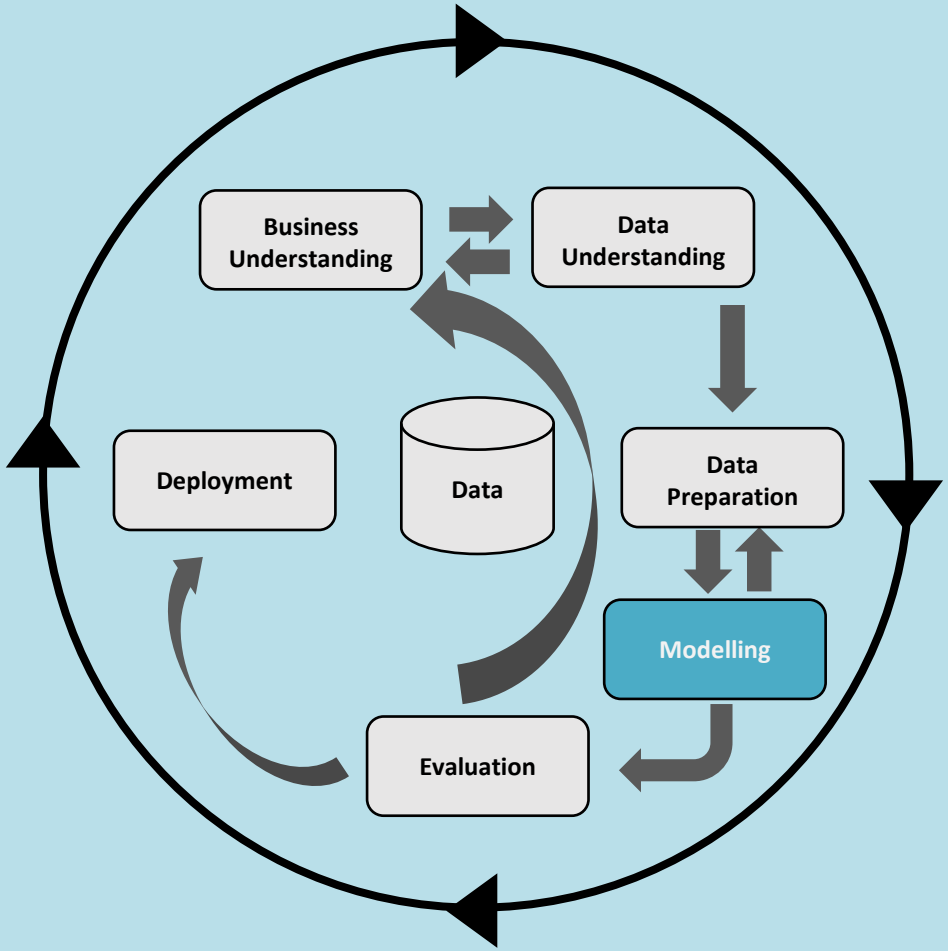


Chapman Pete et al. (1999)

1.3 CRISP-DM – Modelling

▶ **What activities are related to the modelling phase?**

- Modeling techniques selection
- Model application to the problem
- Parameter calibration of the used algorithms
- Model assessment
- Understand the logic behind the model

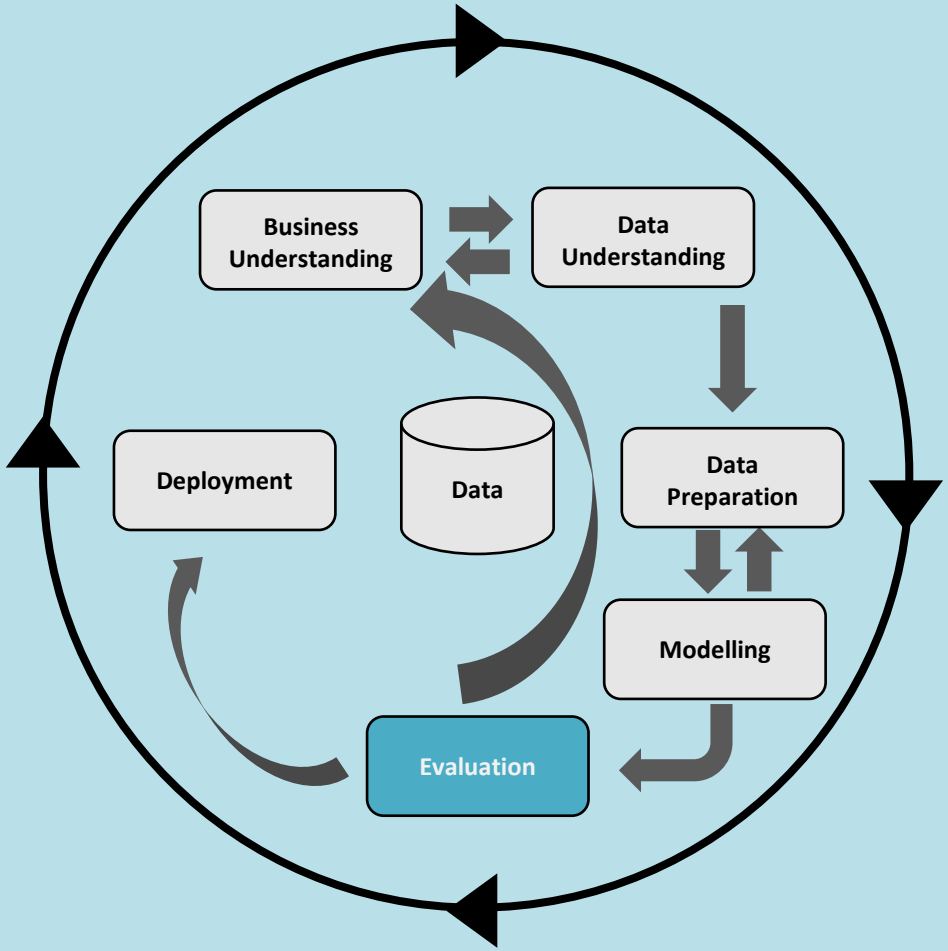


Chapman Pete et al. (1999)

1.3 CRISP-DM – Evaluation

- **What activities are related to the evaluation phase?**
  - Objectives achievement evaluation
  - Build measurement model

- **Other common activities:**
  - Make a presentation for management
  - Define measures
  - Compute business impact

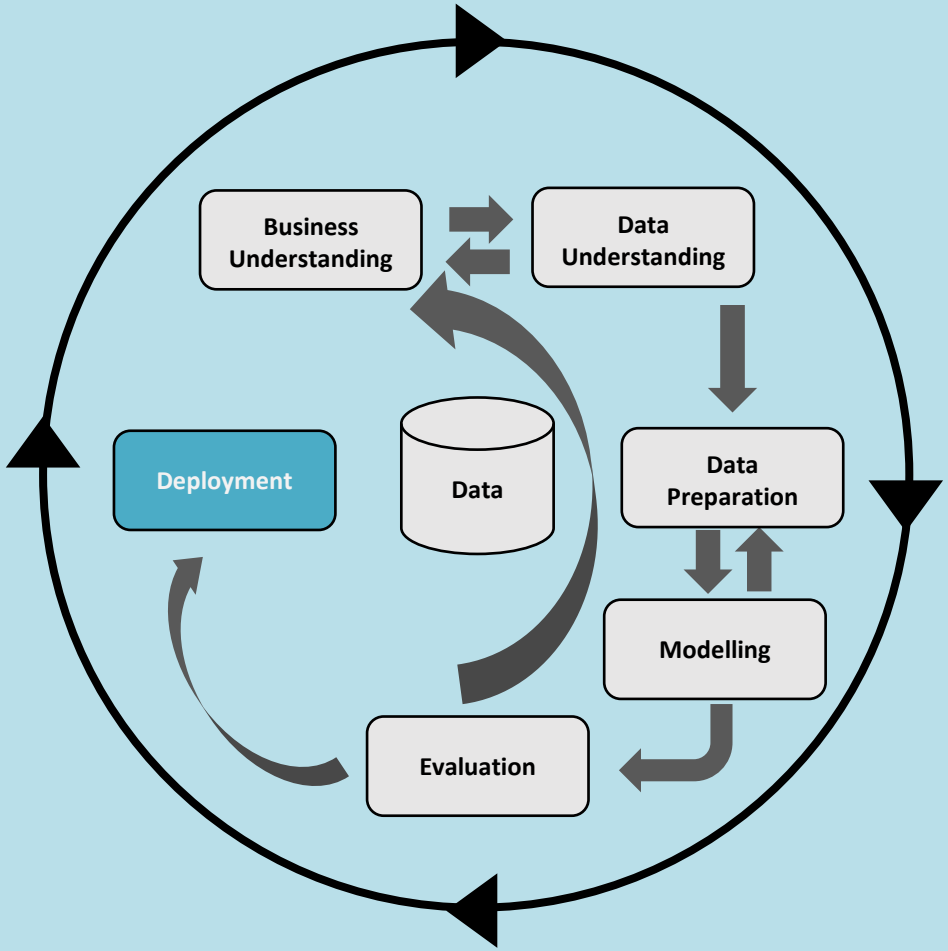


Chapman Pete et al. (1999)

1.3 CRISP-DM – Deployment

- **What activities are related to the deployment phase?**

  - Implement an AI-based Information System (result of model deployment)
  - Repeatable analytic process implementation
  - Communicate results



Chapman Pete et al. (1999)

1.3 Classroom Task

Your turn!

Task

Please discuss with your neighbors:

- What is the difference between Data Understanding and Business Understanding? Why is there an interaction between these two phases?

Exercises

Workbook Exercises

- Please read the chapter 1.1-1.2 from Rusell S. & Norvig P. (2016) to understand the origins and historical backgrounds of AI. Then work through the exercises 1.1, 1.3 – 1.15. You can skip the parts about „agents“, we will handle this topic in the next chapter.
- Take a look at the different AI job profiles in this lecture and search for related current job positions in the internet. Compare the job requirements with the content of the syllabus. Make yourself a list with things you want to learn for AI jobs you are interested in. At the end of the lecture check if you learnt all the stuff you want to learn – if something is missing write me an email with the content you would like to see in the future in this lecture.

Coding Exercises

- *Coding exercises start after lecture 3*

References

Literature

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3. Géron, A. (2017). *Hands-on machine learning with Scikit-Learn and TensorFlow: concepts, tools, and techniques to build intelligent systems.*
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2. Hof R (2014): Interview: Inside Google Brain Founder Andrew Ng's Plans To Transform Baidu. Forbes Online. Online available at: https://www.forbes.com/sites/roberthof/2014/08/28/interview-inside-google-brain-founder-andrew-ngs-plans-to-transform-baidu/#ca7258a40a40
3. LinkedIn (2020): The jobs of tomorrow. Online available at https://blog.linkedin.com/2019/december/10/the-jobs-of-tomorrow-linkedins-2020-emerging-jobs-report

Images

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AI Research Overview

Conferences

- Biennial International Joint Conference on AI (IJCAI)
- Annual National Conference on AI (AAAI)
- Biennial European Conference on AI (ECAI)

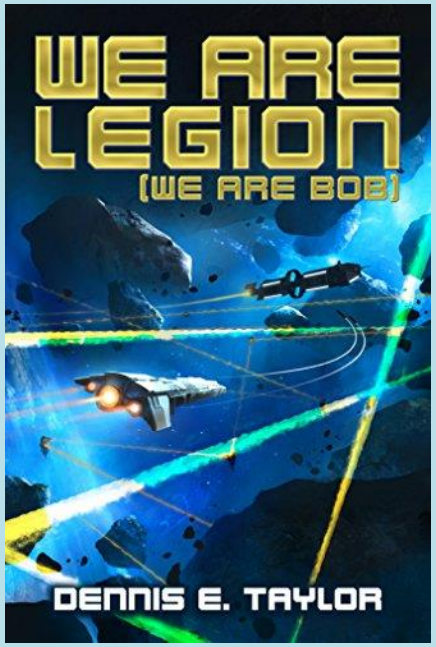
Journals

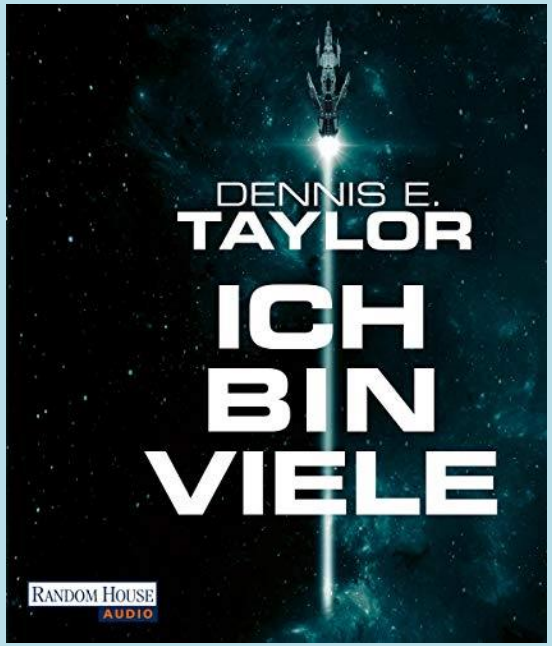
- Artificial Intelligence (Elsevier)
- Computational Intelligence
- Journal of Artificial Intelligence Research, pioneered free on-line publication (http://www.jair.org)
- IEEE Transactions on Pattern Analysis and Machine Intelligence

Since the 1980s various subfields emerged, joined forces with related fields. Many journals and annual conferences in subareas like e.g.

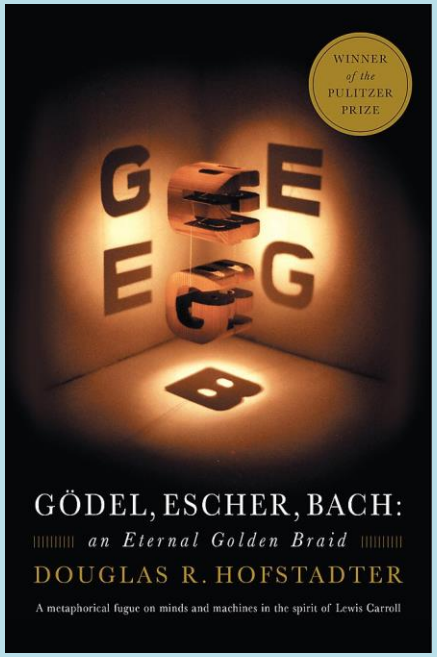
- Conference on Neural Information Processing Systems (NIPS or NeurIPS)

Non-Scientific Book/Movie Recommendations





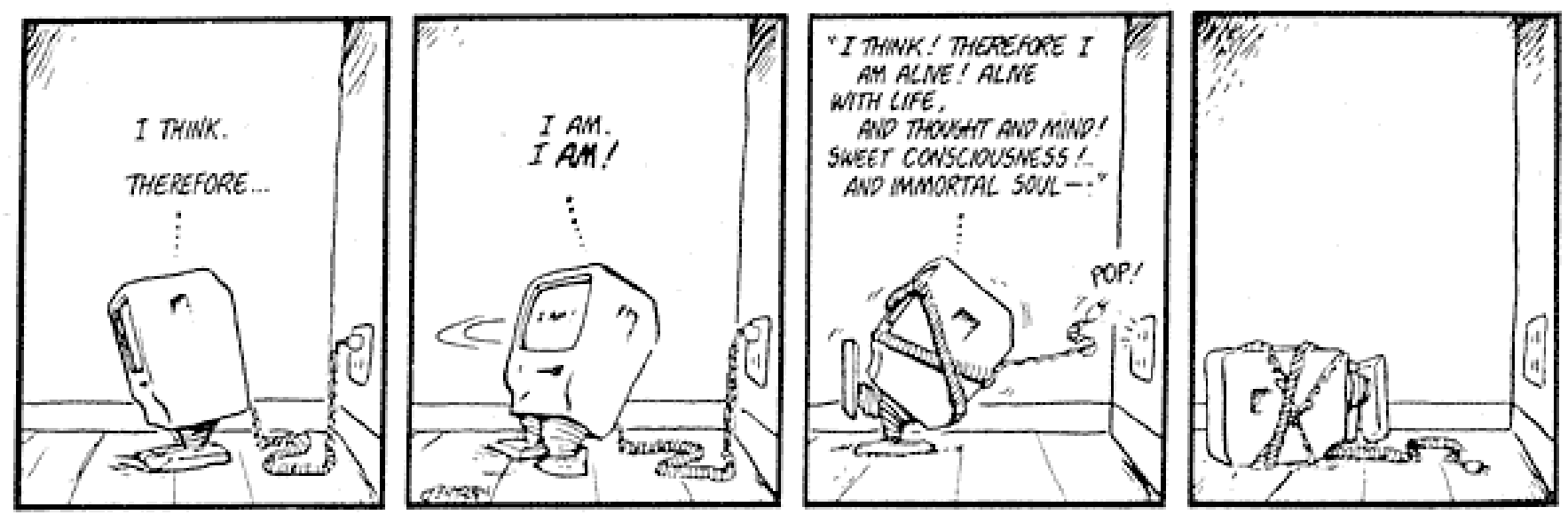
- We are Legion, we are Bob - Dennis F Taylor (↗ Amazon)
- Ich bin viele - Dennis F Taylor (↗ Amazon)



- Gödel, Escher, Bach: An Eternal Golden Braid - Douglas R Hofstadter (↗ Amazon)
- Gödel, Escher, Bach: Ein Endloses Geflochtenes Band Douglas R Hofstadter (↗ Amazon)

Glossary

Artificial Intelligence	*The science and engineering of making intelligent machines, especially intelligent computer programs (McCarthy, 1956/2007)*
CRISP-DM	*Cross-industry standard process for data-mining. The defacto standard framework for analytics and AI in industry.*
Dartmouth Conference	*Popular conference which gave rise of artificial intelligence as a research field*
Knowledge Reasoning	*Automation of simple, repetitive activities in information systems on the basis of known, defined rules*
Knowledge-based System	*An expert system or knowledge-based system is one that solves problems by applying knowledge that has been garnered from one or more experts in a field (Norvig, 1992)*
Machine Learning	*A computer program is said to learn from experience 'E', with respect to some class of tasks 'T' and performance measure 'P' if its performance at tasks in 'T' as measured by 'P' improves with experience 'E'. (Mitchel, 2011); Automation and support of individual human tasks based on data*


I THINK.
THEREFORE...
I AM.
I AM!
"I THINK! THEREFORE I AM ALIVE! ALIVE WITH LIFE, AND THOUGHT AND MIND! SWEET CONSCIOUSNESS!.. AND IMMORTAL SOUL—!"
POP!