Artificial Intelligence

Algorithms and Applications with Python

Chapter 01

Dr. Dominik Jung
dominik.jung42@gmail.com

</> course material: ↗ https://github.com/dominikjung42

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

► **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 everyday's worklife looks like
- How we will organize the following lecture and what you can expect to learn

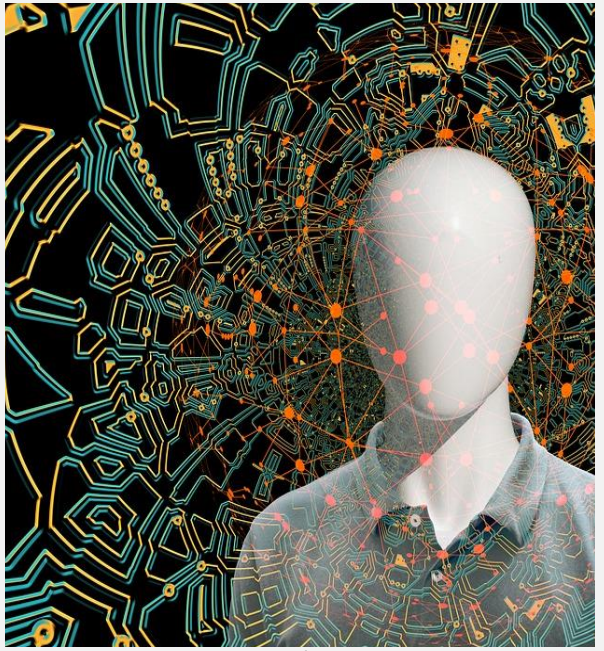


Image source: ↗ Pixabay (2019) / ↗ CC0

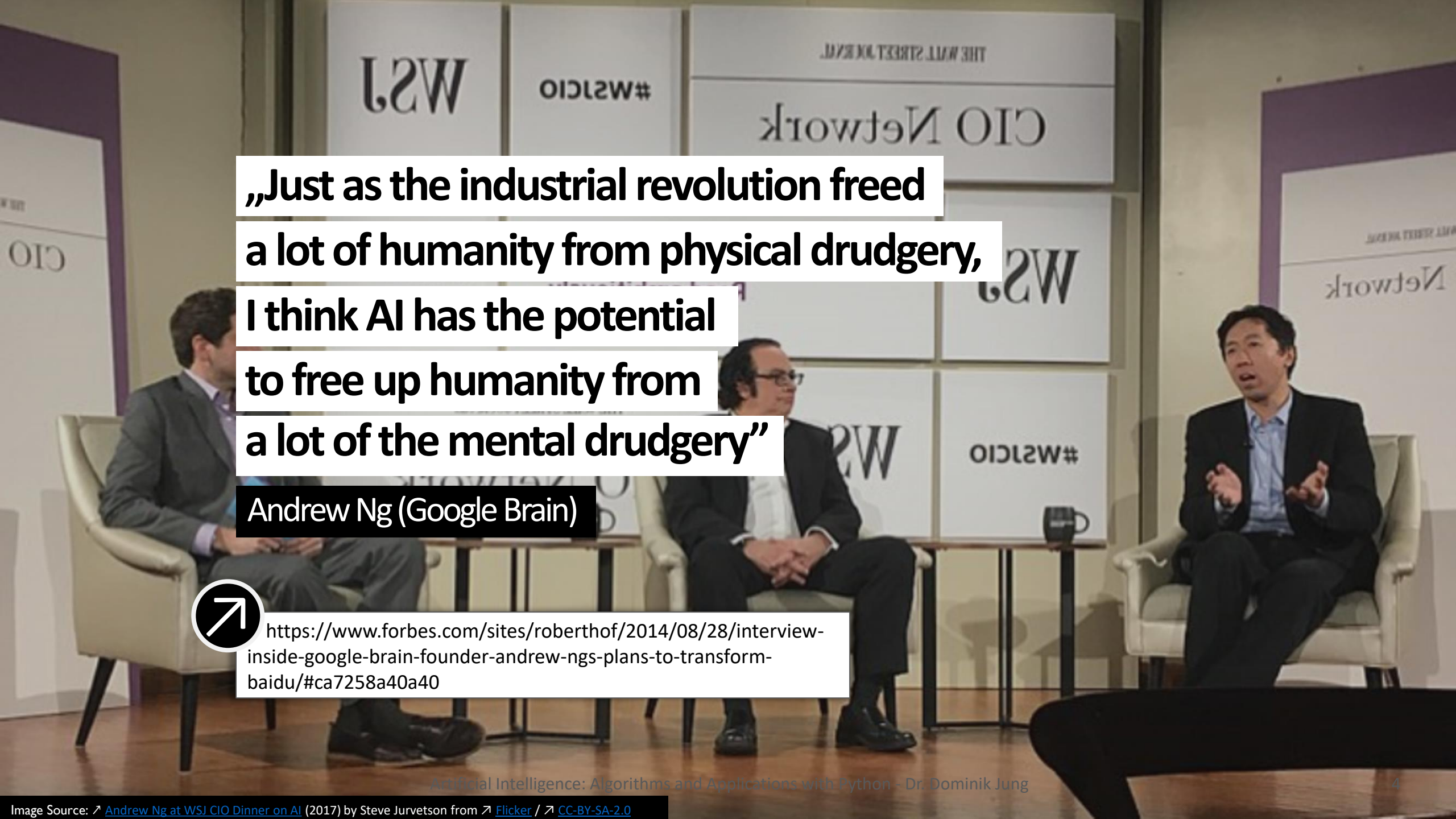
► **Duration:**

- 90 min

► **Relevant for Exam:**

- 1.1 - 1.3

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



1.1 Automation @my Home

Image sources: Dominik Jung (2019)

1.1 Automation - Driver of Today's Wealth?

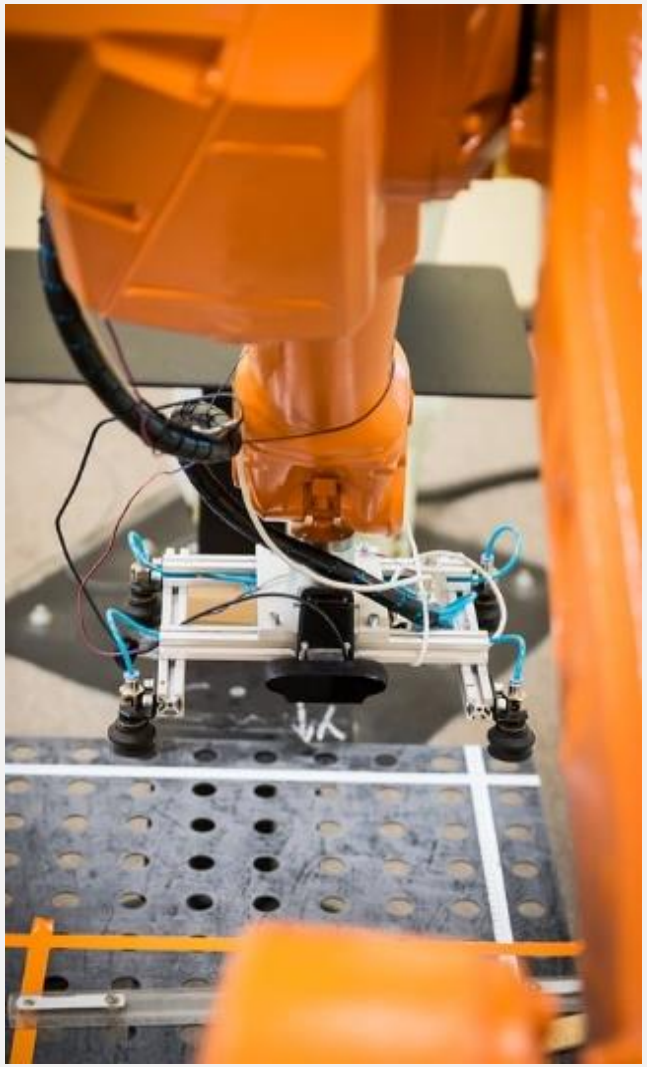
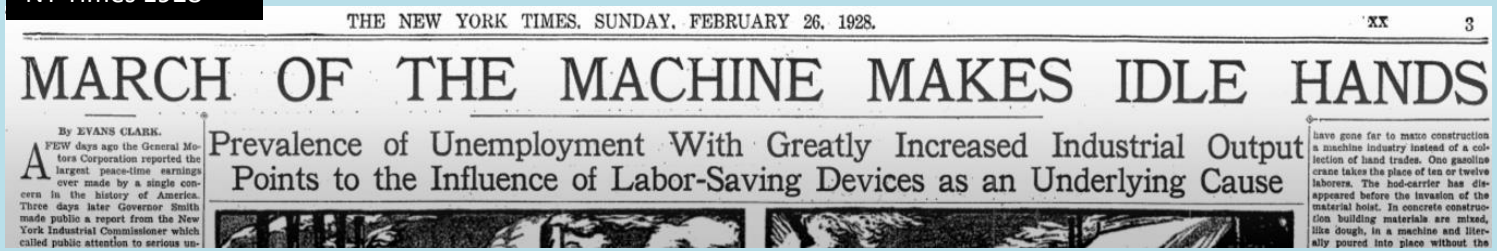


Image source: ↗ Pixabay (2019) / ↗ CC0

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

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

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-

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

Welt Online, 2016

Künstliche Intelligenz wird zum Turbo für unseren Wohlstand

1.1 Automation Means Automation of Human Work

Physical Robots

- Do work, humans do not want to do
- Moving heavy and dangerous loads
- Performing many repetitions, automate boring tasks
- Fast and safe execution, without or with less errors than humans

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

Artificial Intelligence

Knowledge Reasoning

- KBSs use explicit representations of knowledge in the form of words and symbols
- Manage rule-based and repetitive processes

Machine Learning

- Modeling intelligent behavior through machine learning
- Independent processing of individual tasks

In a narrow sense also Planning, Optimization, Natural Language Processing etc. (see chapter 1.2)

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

1.2 Dartmouth Conference 1965

Image source: ↗ Pixabay (2019) / ↗ CC0

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

Image source: ↗ Open Street Maps (2019)

1.2 Dartmouth Conference (1965)

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, 1956/2007)

AI-based Information Systems

- 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 Other Perspectives on AI

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)

Acting Humanly

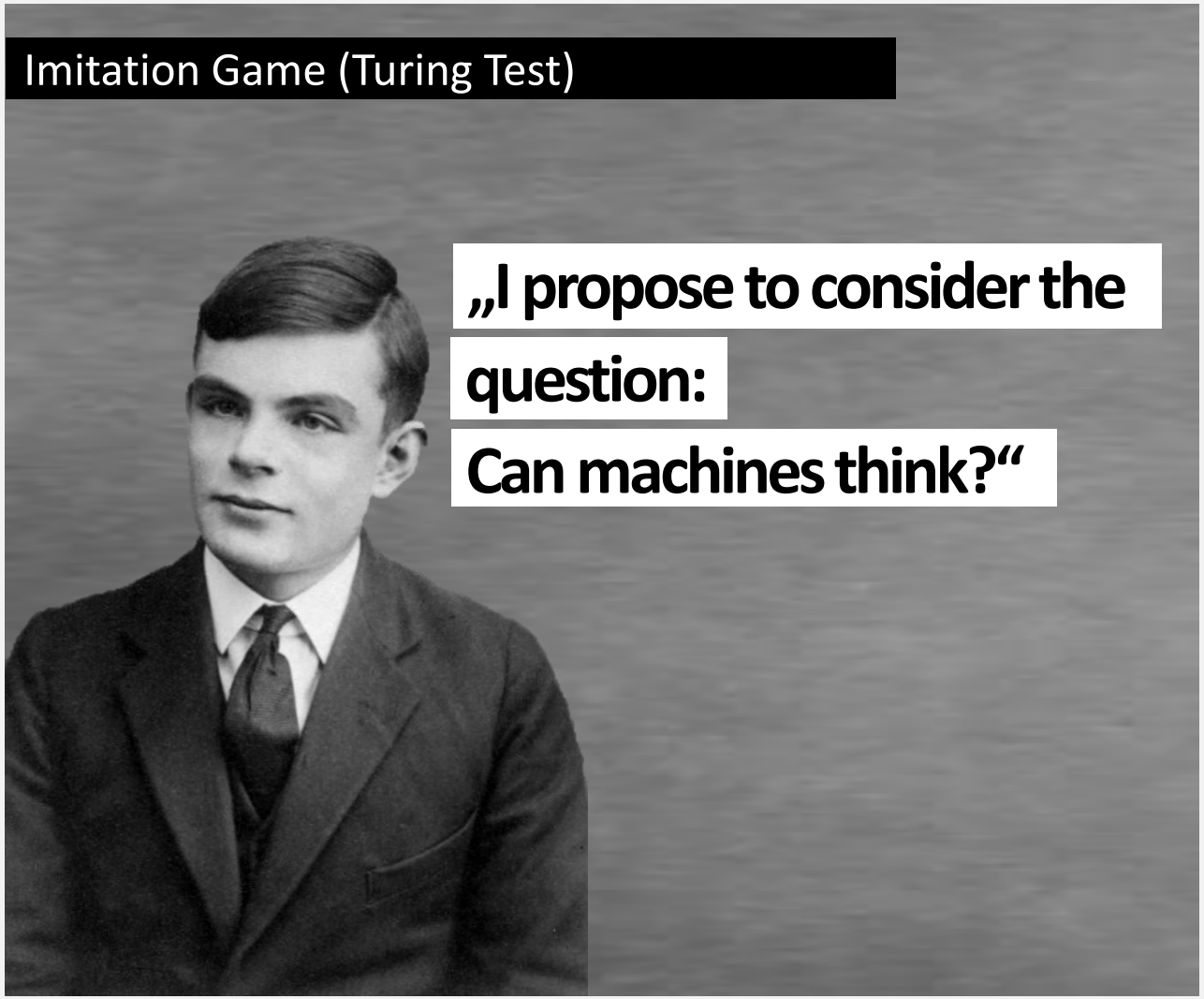
- "The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990)
- "The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)

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)

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

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

1.2 AI Perspectives – Thinking Rationally

- Idealized or “right” way of thinking
- **Logic:** patterns of argument that always yield correct conclusions when supplied with correct premises
  - “Socrates is a man; all men are mortal; therefore Socrates is mortal.”
- Beginning with Aristotle, philosophers and mathematicians have attempted to formalize the rules of logical thought
- ***Logicist* approach 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 – 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

1.2 Domains with AI Connections

Philosophy	Logic, methods of reasoning, mind vs. matter, foundations of thinking
Mathematics	Logic, probability, optimization
Economics	Utility, decision theory
Neuroscience	Biological basis of intelligence
Cognitive science	Computational models of human intelligence
Linguistics	Rules of language, language acquisition
Machine learning	Design of systems that use experience to improve performance
Control theory	Design of dynamical systems that use a controller to achieve desired behavior

1.2 Research Areas of Artificial Intelligence

Artifical Intelligence

Lecture 6

Machine Learning

Natural Language Processing (NLP)

Speech

Knowledge Reasoning / Expert Systems

Lecture 5

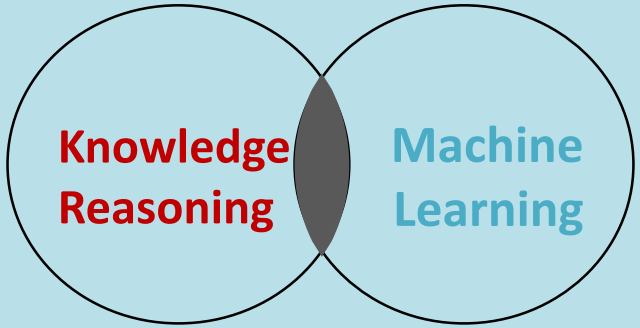
Planning and Optimization

Computer Vision

Robotics

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 Example: Machine Learning

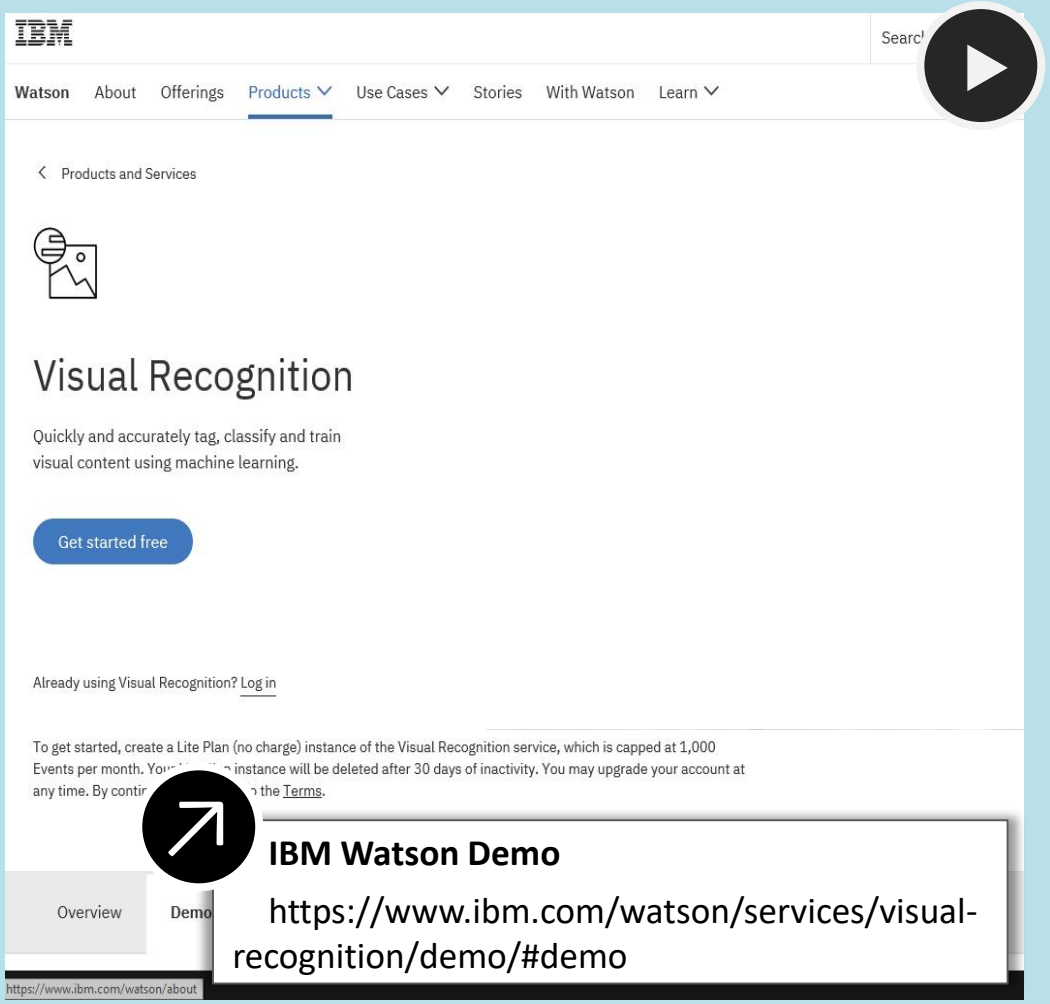
Image source: ↗ DB2018AL00555 (VW) | free for editorial purposes

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 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 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); Searle J (1980) | 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

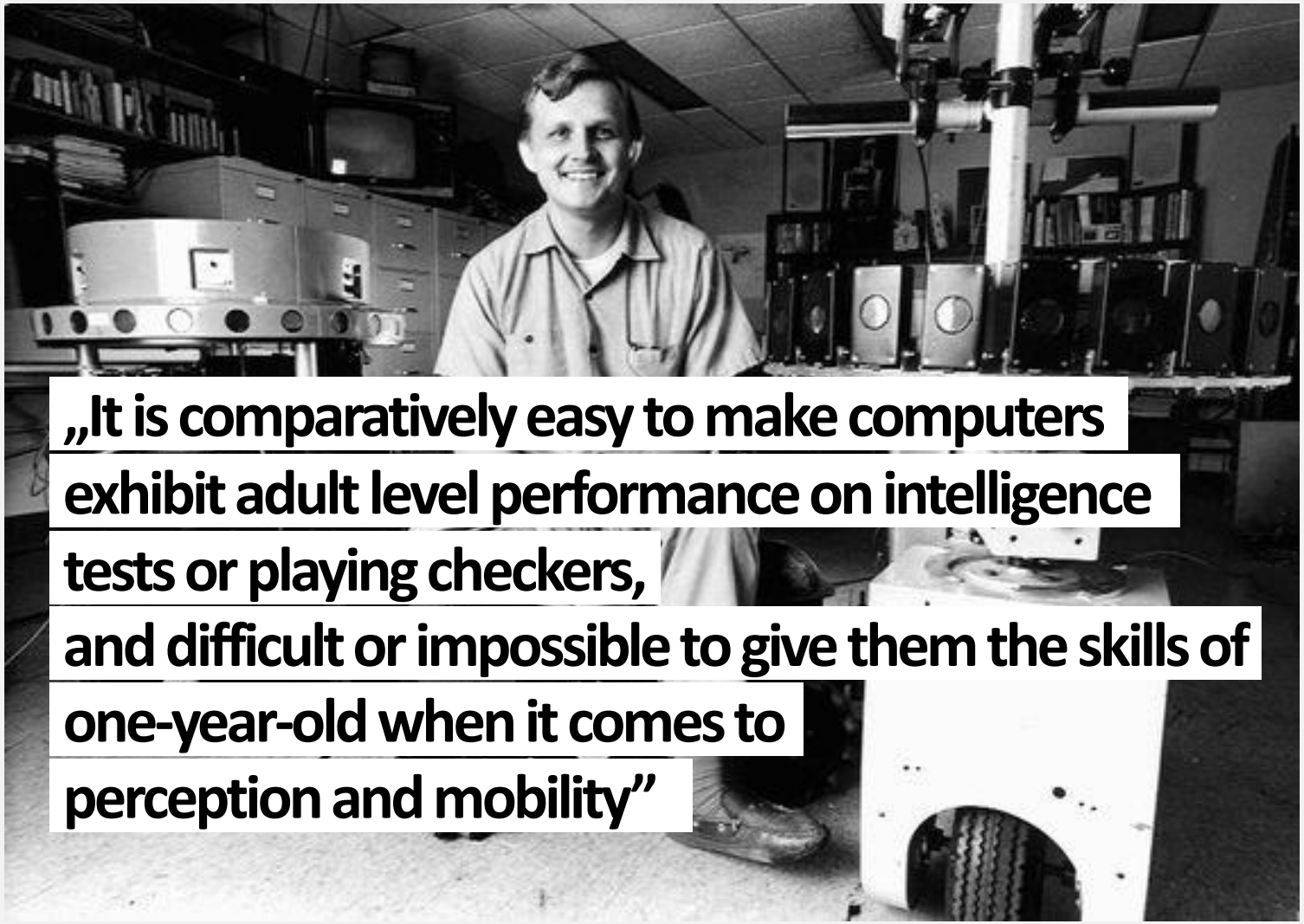


Image source: ↗ Museum of Computer History (1990)

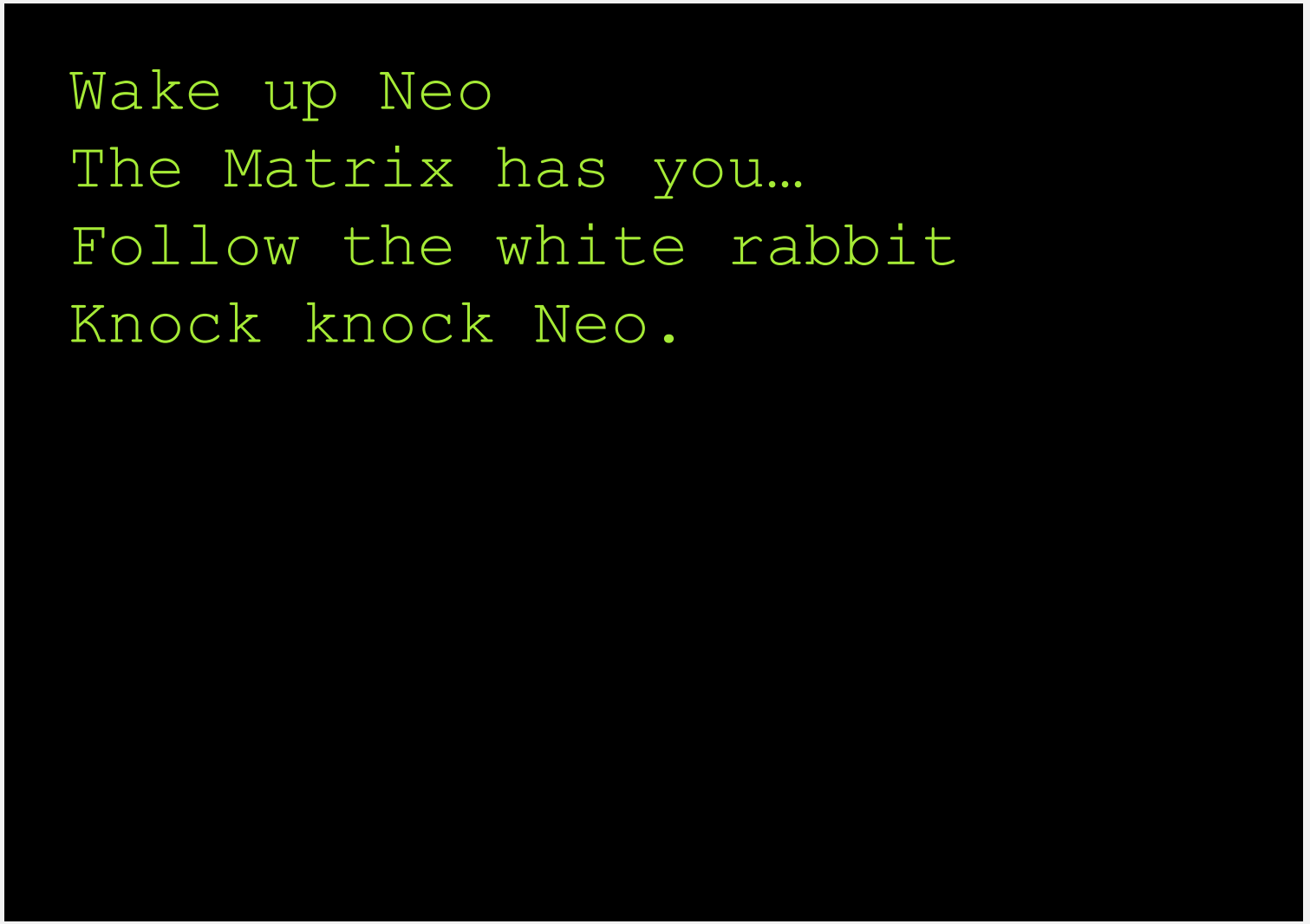
- Early AI researchers concentrated on the tasks that "white male scientists" found the most challenging, abilities of animals and two-year-olds were overlooked
- We are least conscious of what our brain does best
- Sensorimotor skills took millions of years to evolve
- Our brains were not designed for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



Jajal T (2018)

1.2 Artificial Intelligence Today and Tomorrow

Today

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Research

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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 make “intelligence”?
- Which abilities needs an artificial intelligence to pass the imitation game?

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

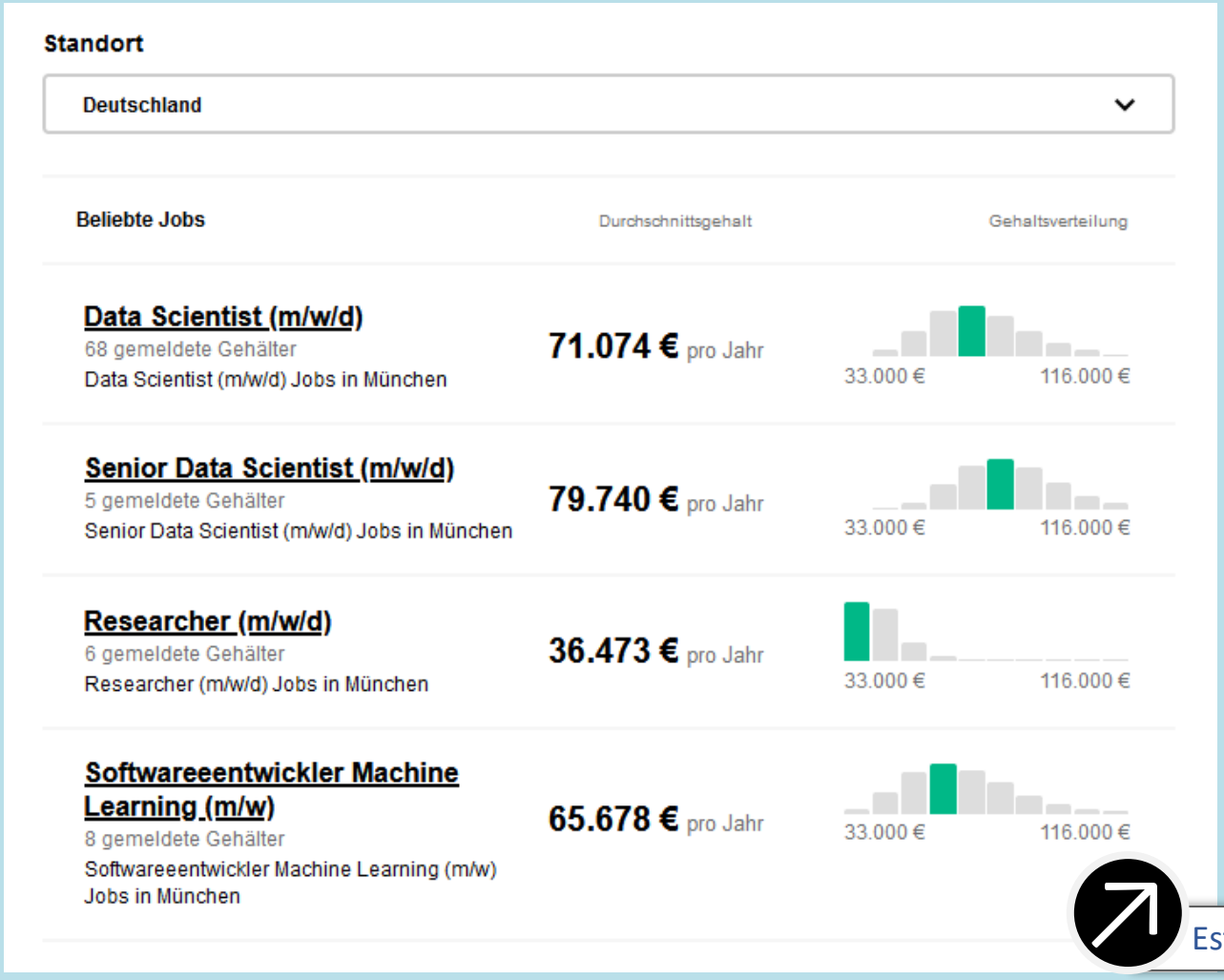
- Engineer responsible for implementing intelligent robots
- Bridge between mechanical engineering, electrical engineering, computer science

AI Research Scientist

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

…

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

Estimated content based on information from Indeed Salaries

1.3 Research Jobs for AI Specialists

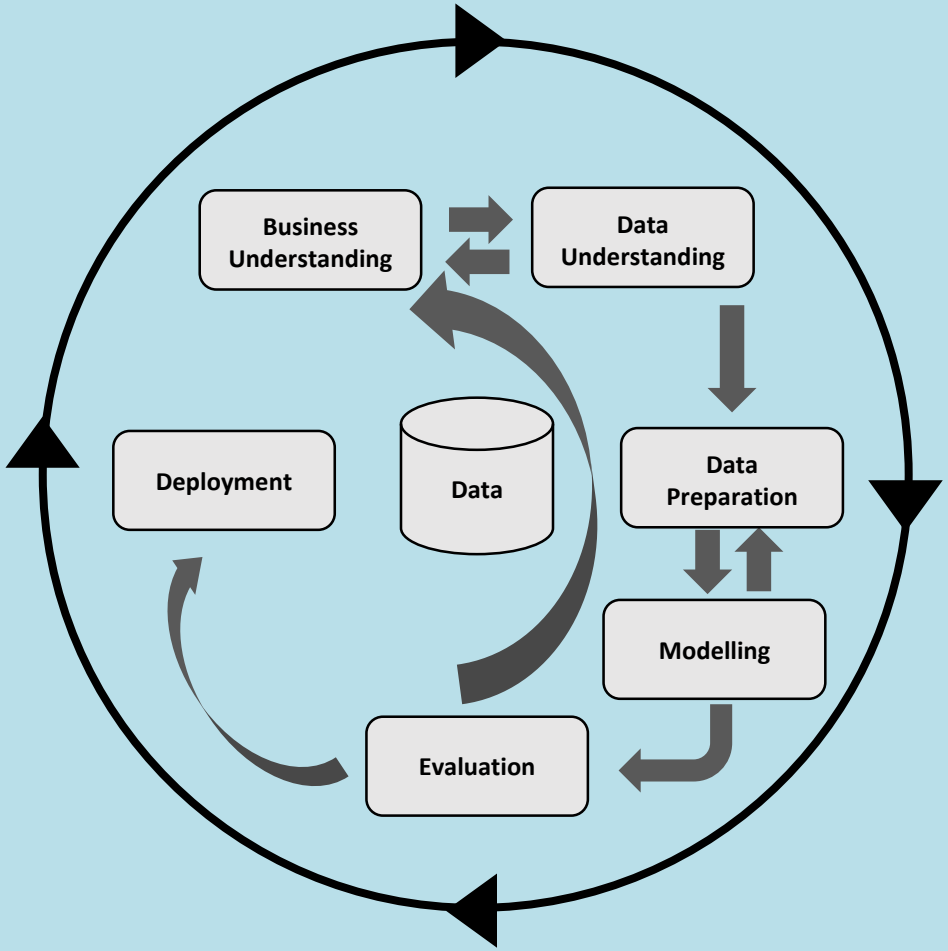
- PhD in AI topics (e.g. computer science) has a positive influence on the starting salary
- However, in the course of a career, practical knowledge and project experience are more important, so that the salaries of doctoral candidates and employees without a doctorate are at a similar level later in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

How will your Workday look like in AI Jobs: 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*"

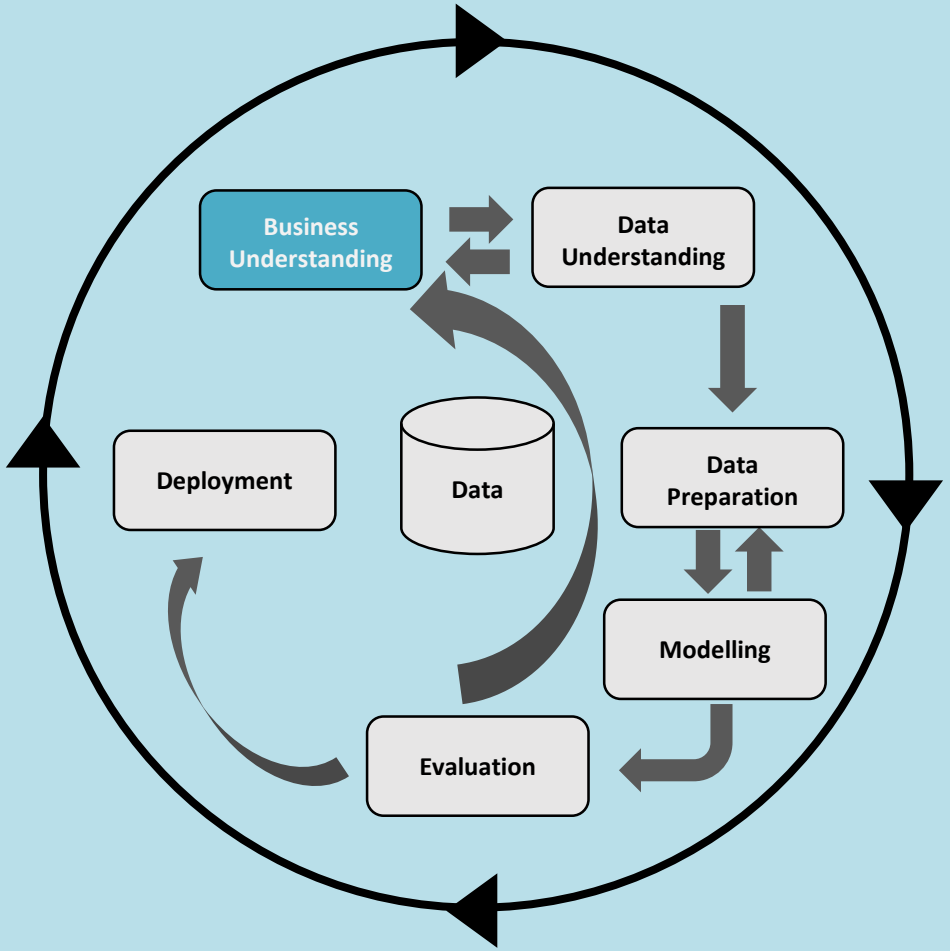
In-depth documentation and process guide



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)

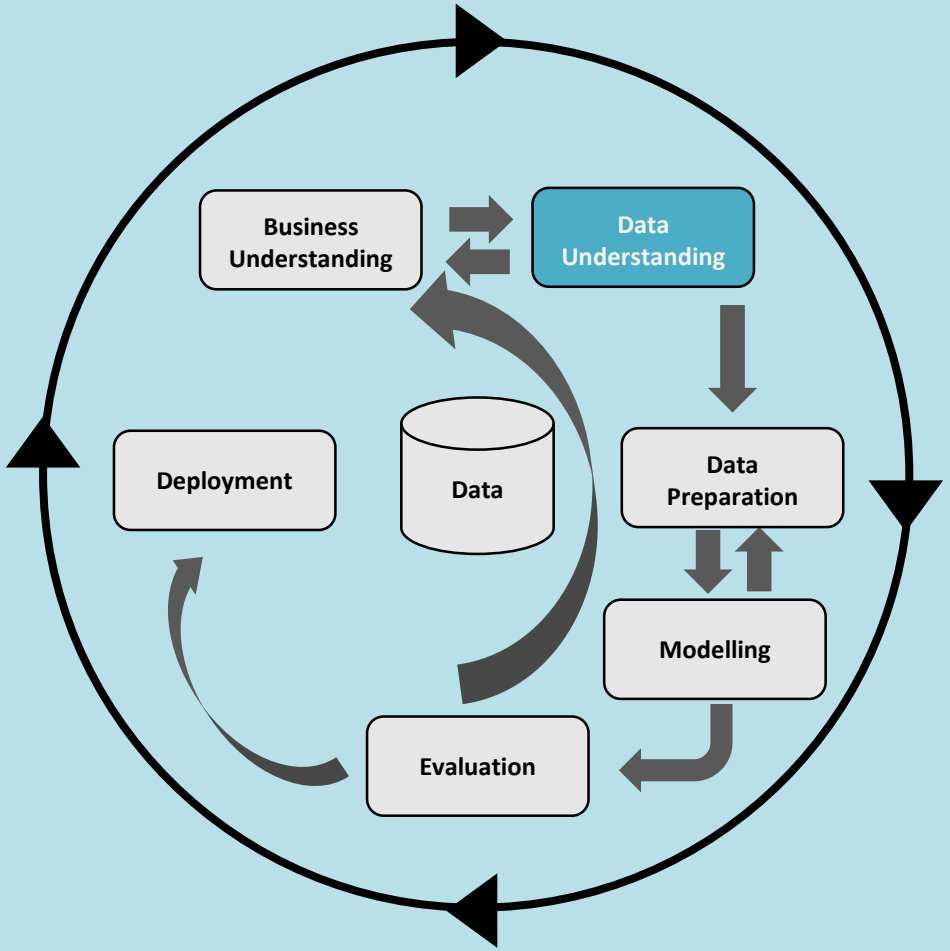


Chapman Pete et al. (1999)

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

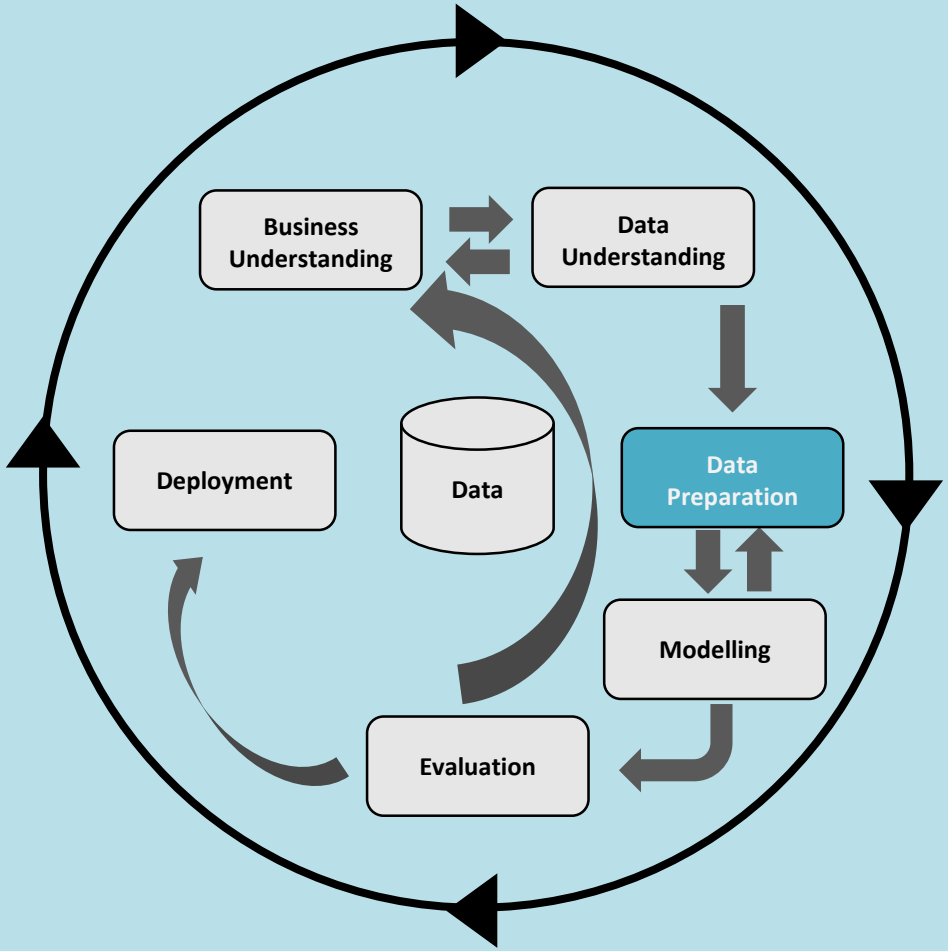


Chapman Pete et al. (1999)

1.3 CRISP-DM – Data Preparation

- **What activities are related to the data preparation phase?**
  - Table, record and attribute selection
  - Data transformation and cleaning

- **Other common activities:**
  - Define data architecture

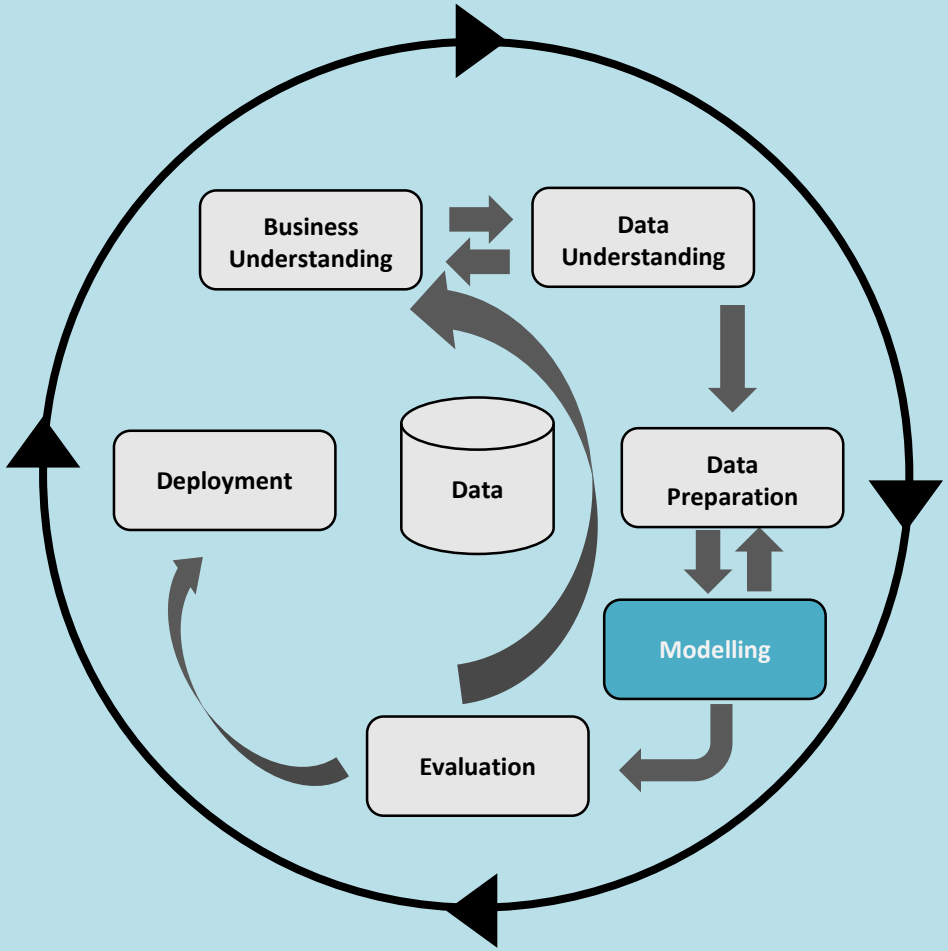


Chapman Pete et al. (1999)

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

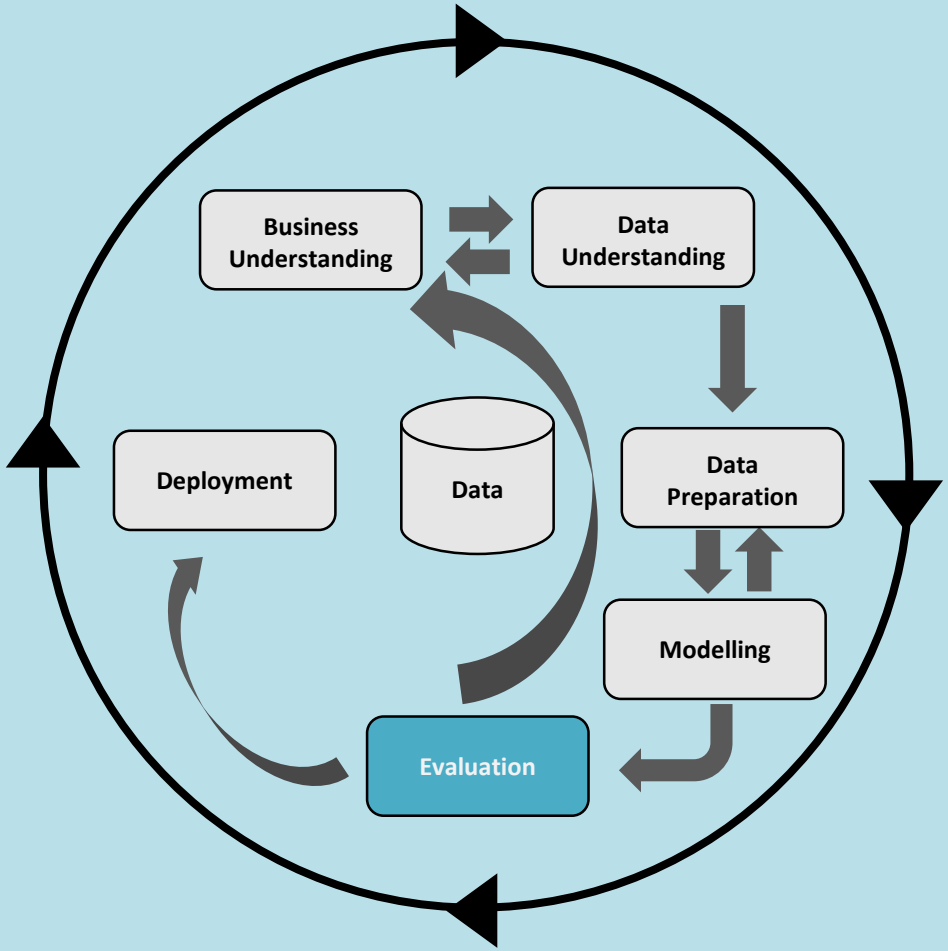


Chapman Pete et al. (1999)

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

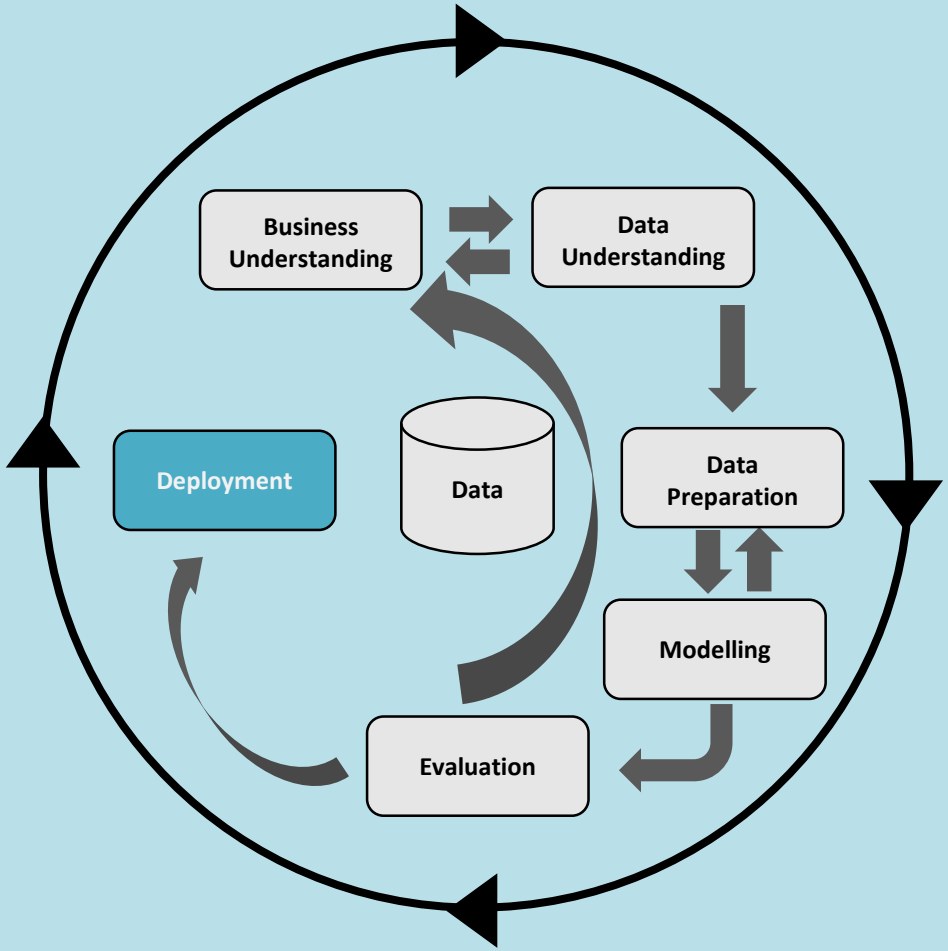


Chapman Pete et al. (1999)

1.3 CRISP-DM – Deployment

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

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



Chapman Pete et al. (1999)

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 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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News articles

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Images

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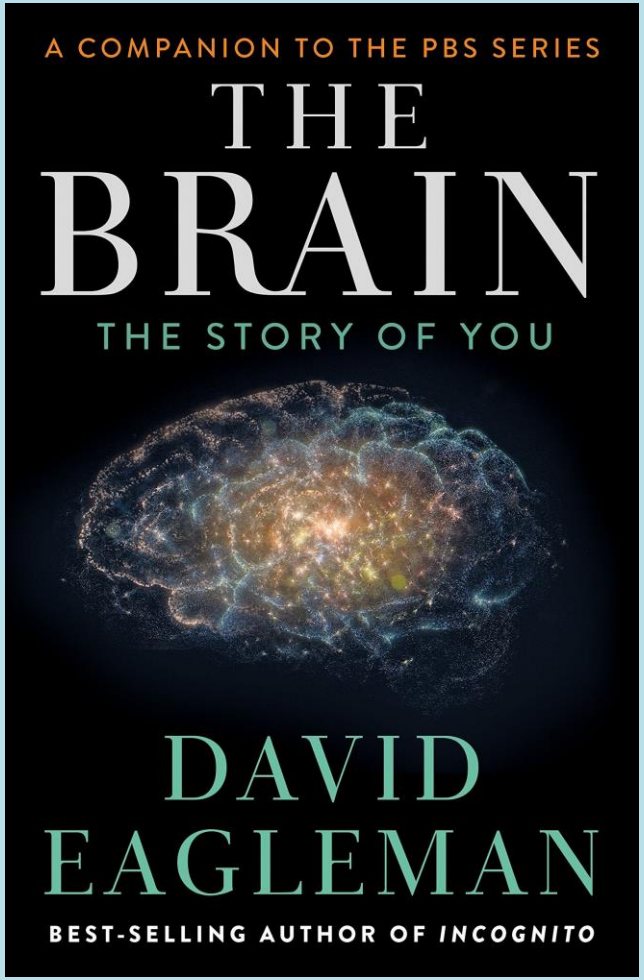
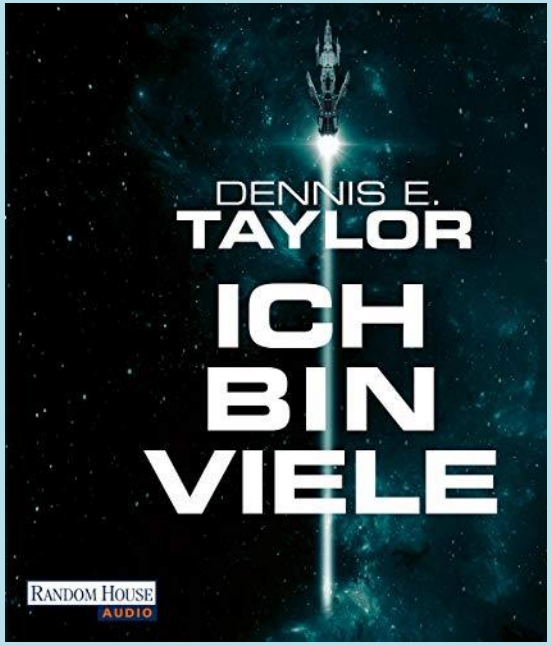
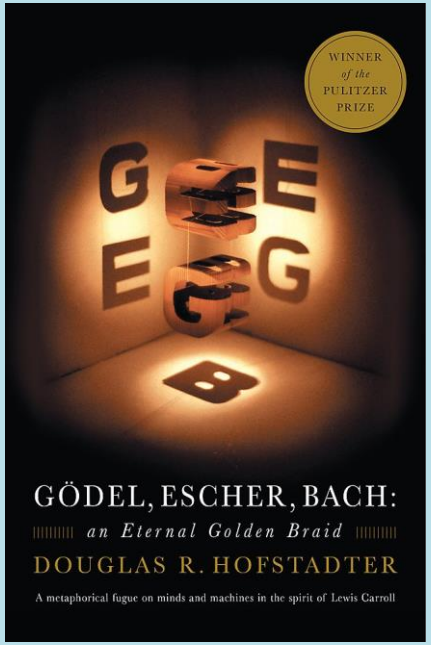
Non-Scientific Book/Movie Recommendations about ☺







- The Brain: Die Geschichte von dir - David Eagleman (↗Amazon)
- Ich bin viele - Dennis F Taylor (↗Amazon)
- Gödel, Escher, Bach - Douglas R Hofstadter (↗Amazon)
- Ich der Roboter - Isaac Asimov (↗Amazon); I Robot (2013) – FOX (↗Amazon)

Glossary

Artificial Intelligence	*The science and engineering of making intelligent machines, especially intelligent computer programs (McCarthy, 1956/2007)*
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*