LECTURER: TAI LE QUY

ARTIFICIAL INTELLIGENCE

Who am I?

- Name: Tai Le Quy
- PhD candidate at L3S Research Center – Leibniz University Hannover
  - Topic: Fairness-aware machine learning in educational data mining
  - Project: LernMINT (lernmint.org)
- MSc in Information Technology at National University of Vietnam
- Profile: tailequy.github.io
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Who are you?

- Name
- Employer
- Position/responsibilities
- Fun Fact
- Previous knowledge? Expectations?

TOPIC OUTLINE

TUTORING SCHEDULE

- 6 weeks (sections)
- Buildings: Berlin Frankfurter Allee
- Rooms: BER 2.06 Lichtenberg (Eingang 73 A)

	Date	Time	Title	Event type	Content
	17.04.2023	13:00 - 15:30	Artificial Intelligence - MSE_BER_DLBDSEAIS01_2023_SoSe_Q2_BAAI	Tutorial (On Campus)	Unit 1
	24.04.2023	13:00 - 15:30	Artificial Intelligence - MSE_BER_DLBDSEAIS01_2023_SoSe_Q2_BAAI	Tutorial (On Campus)	Unit 2
	05.05.2023	13:00 - 15:30	Artificial Intelligence - MSE_BER_DLBDSEAIS01_2023_SoSe_Q2_BAAI	Tutorial (On Campus)	Unit 3
	08.05.2023	13:00 - 15:30	Artificial Intelligence - MSE_BER_DLBDSEAIS01_2023_SoSe_Q2_BAAI	Tutorial (On Campus)	Unit 4
	15.05.2023	13:00 - 15:30	Artificial Intelligence - MSE_BER_DLBDSEAIS01_2023_SoSe_Q2_BAAI	Tutorial (On Campus)	Unit 4
	22.05.2023	13:00 - 15:30	Artificial Intelligence - MSE_BER_DLBDSEAIS01_2023_SoSe_Q2_BAAI	Tutorial (On Campus)	Unit 5

- Additional teaching materials: https://github.com/tailequy/IU-ArtificialIntelligence

UNIT 1

HISTORY OF AI

STUDY GOALS

- What is Artificial Intelligence (AI)?
- Developments of AI as a scientific discipline
- The AI winters
- Basics of expert systems
- Advances of AI

EXPLAIN SIMPLY

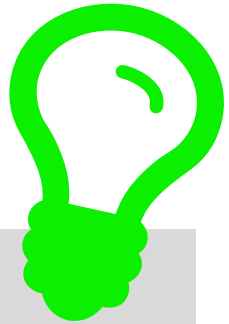
1. How did AI develop as a scientific discipline?

2. What are the main reasons for AI winters?

3. How does an expert system work?

4. What does the Gartner hype cycle curve reflect?

WHAT IS ARTIFICIAL INTELLIGENCE?



"The science and engineering
of making intelligent machines,
especially intelligent computer programs."

Source of the text: McCarthy, 2007, p. 2.

The term Artificial Intelligence was first introduced in the proposal for the Dartmouth summer research project by J. McCarthy (Dartmouth College), M. L. Minsky (Harvard University), N. Rochester (I.B.M. Corporation), C.E. Shannon (Bell Telephone Laboratories), August 31, 1955.

> 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.

Source of the text: McCarthy et. al, 1955, http://jmc.stanford.edu/articles/dartmouth/dartmouth.pdf

Narrow AI

- Performs specialized functions, in controlled environments
- The capabilities are limited, i.e., cannot generalize from a specific task to a task from another domain

General AI

- Comprises open-ended, flexible, and domain independent forms, have some sort of consciousness and self-awareness
- Still far away

THE HISTORY OF AI

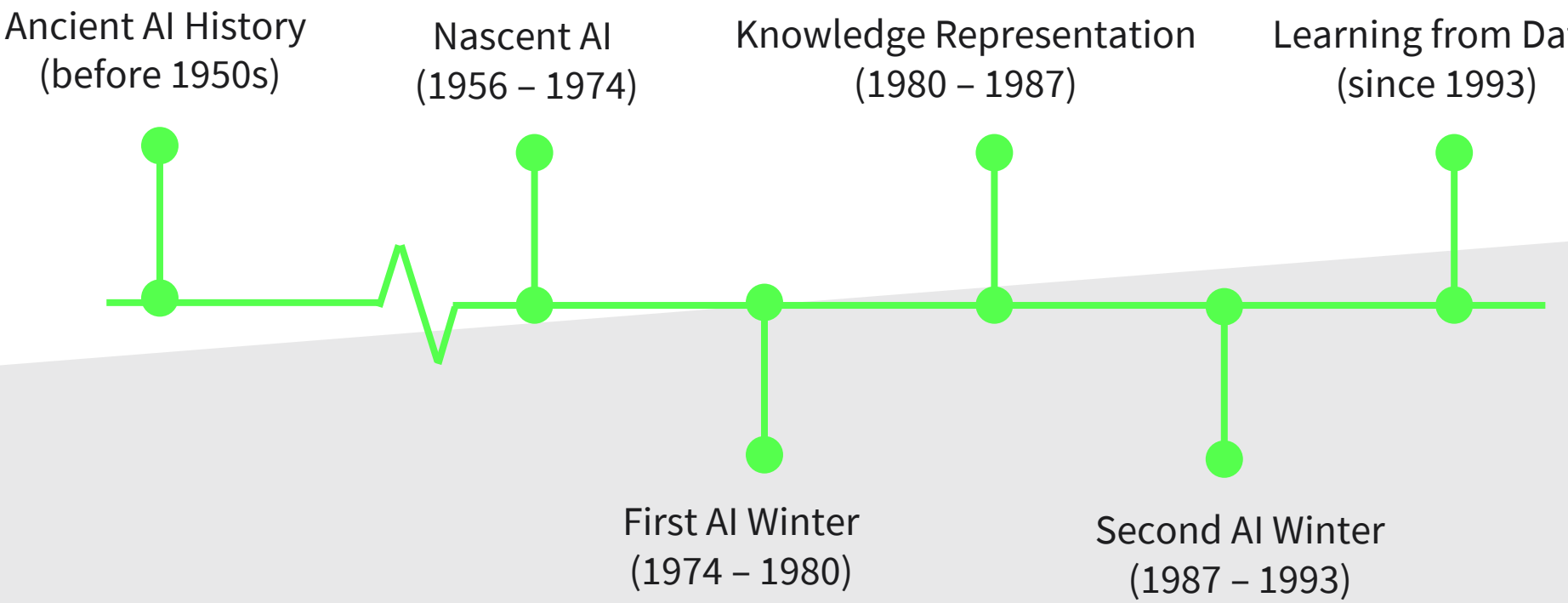


Image Source: Custom Depiction

Ancient AI history (before 1950s)

- Aristotle, Greek Philosopher (384-322 BCE)
  - Formalized human thinking in a way to be able to imitate
- Leonardo da Vinci, Italian Polymath (1452-1519)
  - Designed a hypothetical computing machine on paper
- René Descartes, French Philosopher (1596-1650)
  - Believed that rationality and reason can be defined using principles form mechanics and mathematics
- Thomas Hobble, British Philosopher (1588-1679)
  - Identified similarities between human reasoning and computations of machines
- David Hume, Scottish Philosopher (1711-1776)
  - Fundamental contributions to questions of logical induction and the concept of causal reasoning

Nascent AI (1956-1974)

- “Symbolic” AI: rules from formal logic are used to formalize thought processes as manipulation of symbolic representations of information → implementation of logical calculus (done by a search strategy)
- First attempts for natural language processing, on limited environments and settings
- First theoretical models of neurons (focusing on the interactions between cells to implement basic logical function in networks)

AI winters

- First AI winter (1974-1980)
  - Automatic language translation was one of the major drivers to fund AI research activities, however, there were not enough translators to meet the demand (not accurate, nor faster or cheaper)
- Second AI winter (1987-1993)
  - The collapse of the Lisp machine business
  - It was not possible to develop early successful examples of expert systems beyond a certain point
- Causes of the AI winters
  - Algorithms, computing capacity, the availability of data

Knowledge representation (1980-1987)

- Attempted to solve the problems of knowledge representation (day-by-day situations intelligent behavior is based on general knowledge about the world works)
- Domain-relevant knowledge was systematically stored in databases
- New network models and the use of backpropagation as a training method in layered networks

Learning from data (since 1993)

- Major advances of AI in games (“Deep Blue” was able to beat Garry Kasparov, the world champion in chess, in 1997)
- Significant increase in data storage and computational capacities
- Deep learning was developed based on advances in connectionists machine learning models (2012)
- Well-established learning models, e.g. reinforcement learning, adversarial learning

Source of the image: https://en.wikipedia.org/wiki/Deep_Blue_versus_Garry_Kasparov

Key personalities

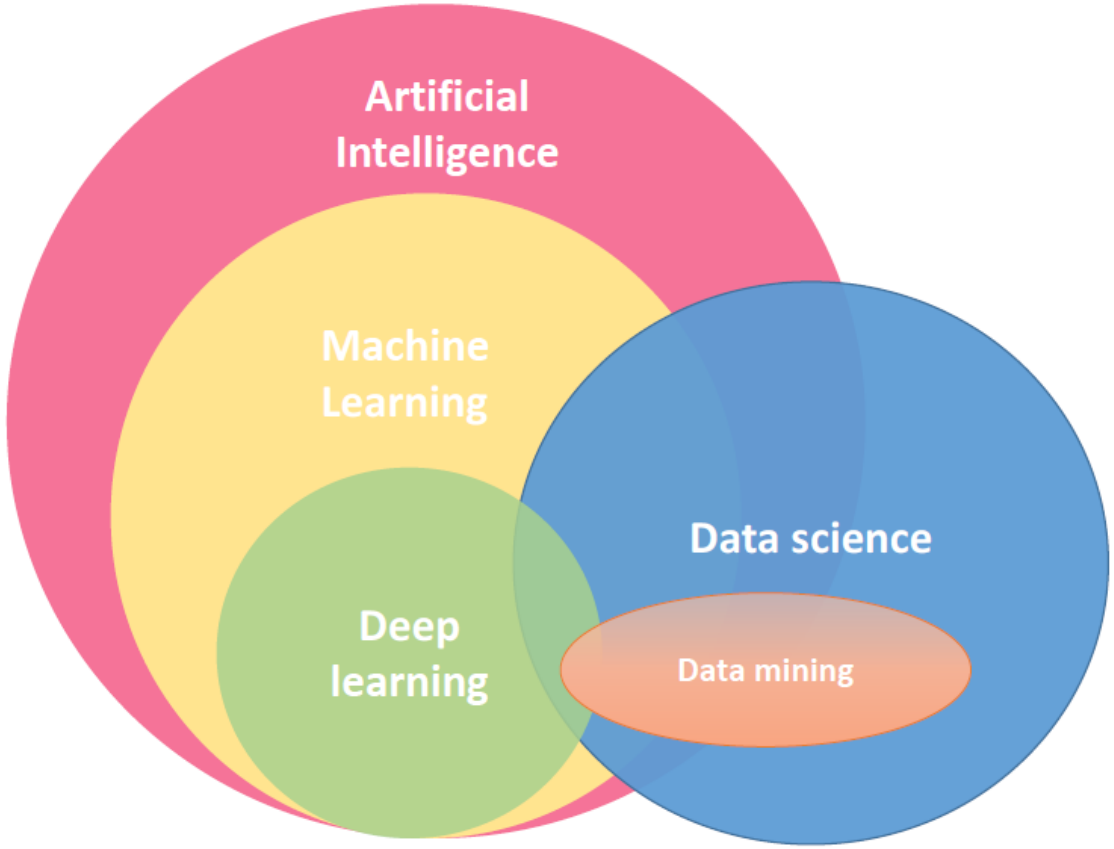
- Alan Turing
  - Conceptualized the well-known Turing Test (1950): if the human cannot identify an AI in a conversation, it is considered a real AI
- John McMarthy
  - Coined the term “artificial intelligence”, invented the Lisp programming language (used in fraud detection, robotics for more than 30 years)
- Marvin Minsky
  - Combined insights from AI and cognitive science
- Noam Chomsky
  - Formal language theory which plays an important role in natural language processing(NLP)

Key disciplines contributing to the development of AI

- Decision theory
  - Combination of mathematical probability and economic utility
- Game theory
  - Important foundation for rational agents to learn strategies to solve games
- Neuroscience
  - Emulate the way the brain stores information and solve problems (artificial neural networks – ANN)
- Natural language processing
  - Combines linguistics and computer science to process written and spoken languages

Artificial Intelligence (AI) vs:

- Data science (DS)
- Data mining (DM)
- Machine learning (ML)
- Deep learning (DL)



Source: Kulin, M., Kazaz, T., De Poorter, E., & Moerman, I. (2021). A survey on machine learning-based performance improvement of wireless networks: PHY, MAC and network layer. Electronics, 10(3), 318. https://doi.org/10.3390/electronics10030318

Data science

- Data science is the study of the generalizable extraction of knowledge from data
- Studies everything related to data, from data acquisition, data storage, data analysis, data cleaning, data visualization, data interpretation, making decisions based on data, determining how to create value from data and how to communicate insights relevant to the business

Data mining

- Data mining refers to the application of algorithms for extracting patterns from data
- Aims to understand and discover new, previously unseen knowledge in the data

Machine learning

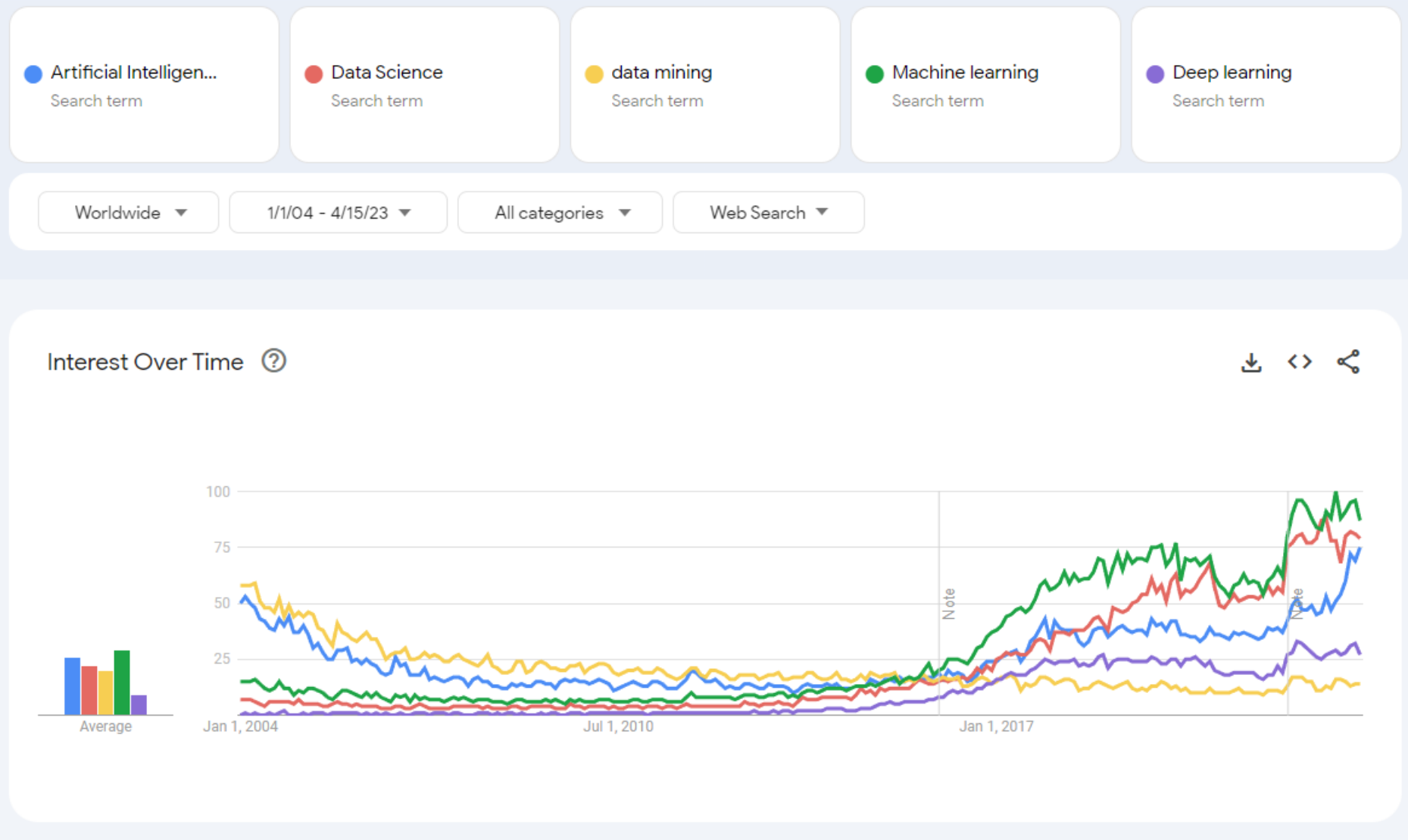
- A subset of AI, aims to develop algorithms that can learn from historical data and improve the system with experience
- *A computer program is said to learn from experience **E** with respect to some class of tasks **T** and performance measure **P**, if its performance at tasks in **T**, as measured by **P**, improves with experience **E*** (Mitchell et al. 1990).

Deep learning

- A subset of ML, data is passed via multiple number of non-linear transformations to calculate an output. The term deep refers to many steps.
- Deep learning allows computational models that are composed of multiple processing layers to learn representations of data with multiple levels of abstraction

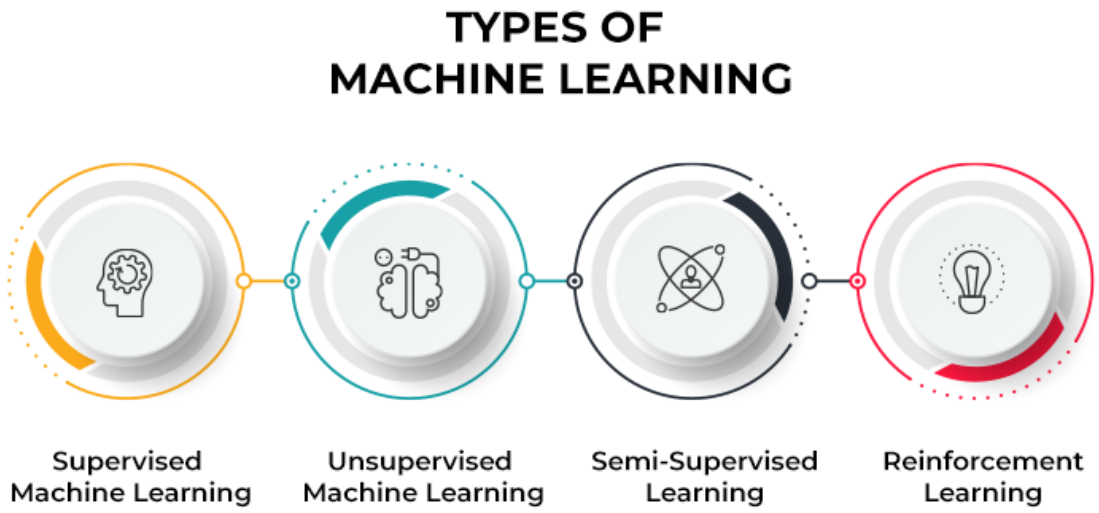
Mitchell, T.; Buchanan, B.; DeJong, G.; Dietterich, T.; Rosenbloom, P.; Waibel, A. Machine learning. Annu. Rev. Comput. Sci. 1990, 4, 417–433.

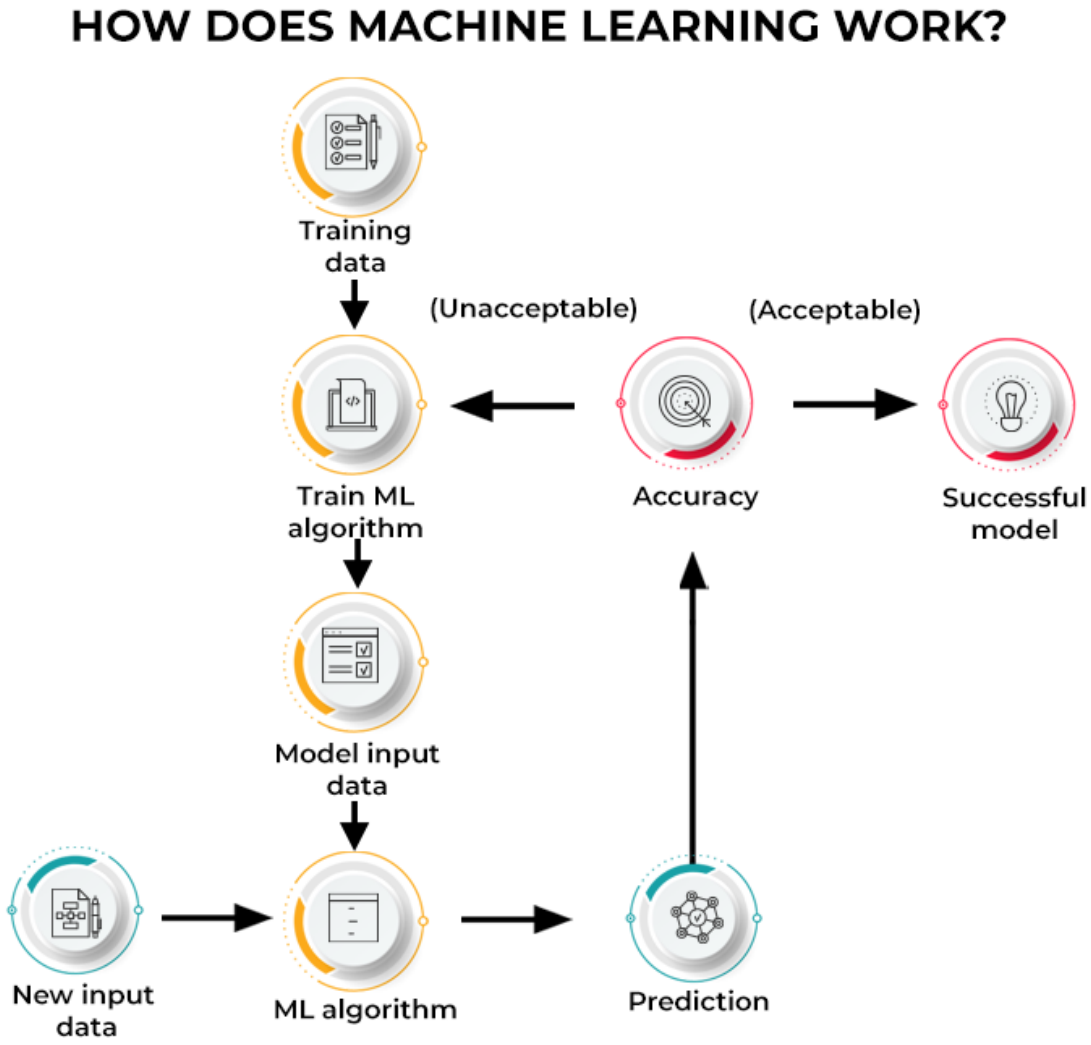
ARTIFICIAL INTELLIGENCE AND OTHER DISCIPLINES



Source: Google Trends (accessed by 15.04.2023)

Machine learning





Source: https://www.spiceworks.com/tech/artificial-intelligence/articles/what-is-ml/

BASIC CONCEPT OF EXPERT SYSTEMS

- An expert system is a computer system that simulates the decision making ability of a human expert.
- Expert systems are designed to help non-expert user make decisions based on the knowledge of an expert.

BASIC CONCEPT OF EXPERT SYSTEMS

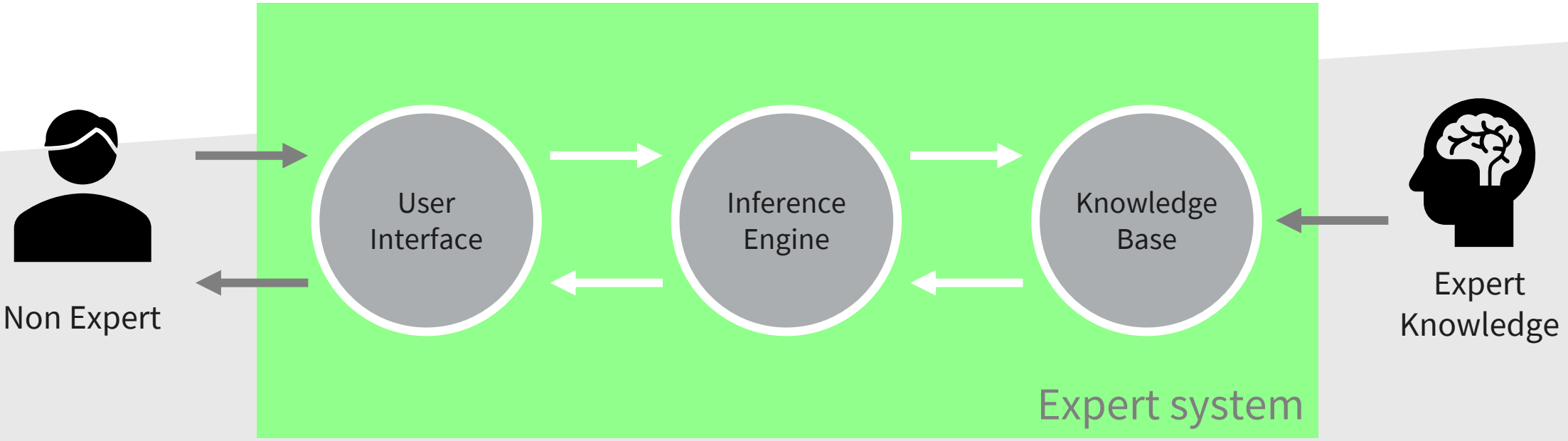


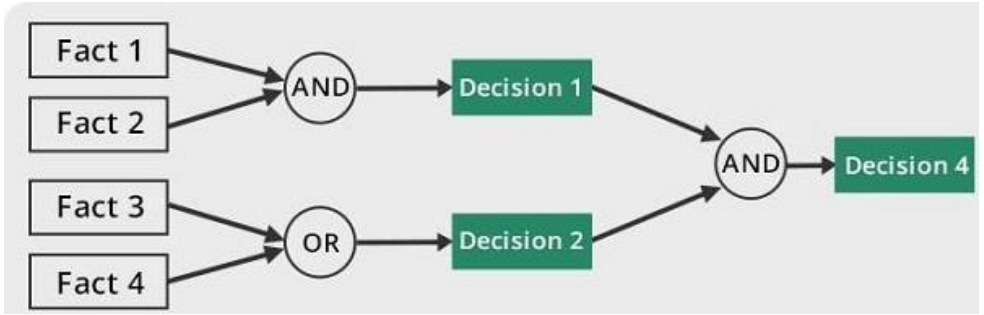
Image Source: Custom Depiction

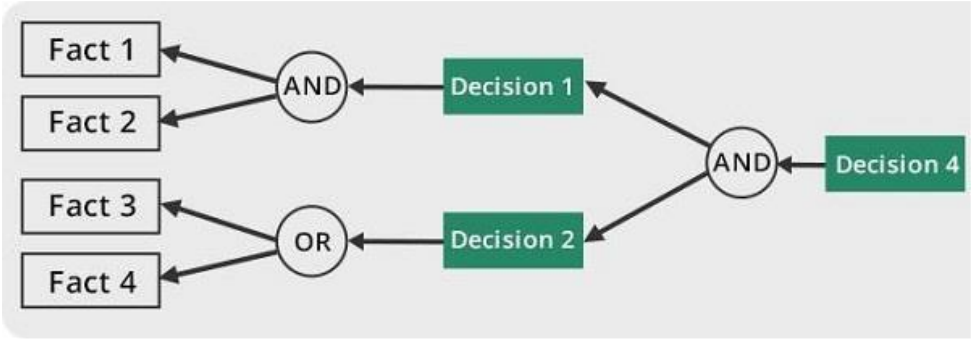
BASIC CONCEPT OF EXPERT SYSTEMS

- Knowledge base
  - Data is collection of facts, experience
  - Factual and heuristic knowledge
  - The form of IF-ELSE rules
- Inference engine
  - Use the knowledge base to draw conclusions from the rules and facts in the knowledge
  - Forward and backward chaining
- User interface
  - Allow user to interact with the expert system
  - Natural language displayed on the screen
  - Verbal narrations via speaker

Forward and backward chaining

- Forward chaining
  - To answer the question “what can happen next?”
  - Follows the chain of conditions, derivations and finally deduces the outcome
- Backward chaining
  - To answer the question „why this happened?“
  - Finds out which conditions could have happened in the past for the current result





Source: https://www.section.io/engineering-education/forward-and-backward-chaining-in-ai/

TYPES OF EXPERT SYSTEMS

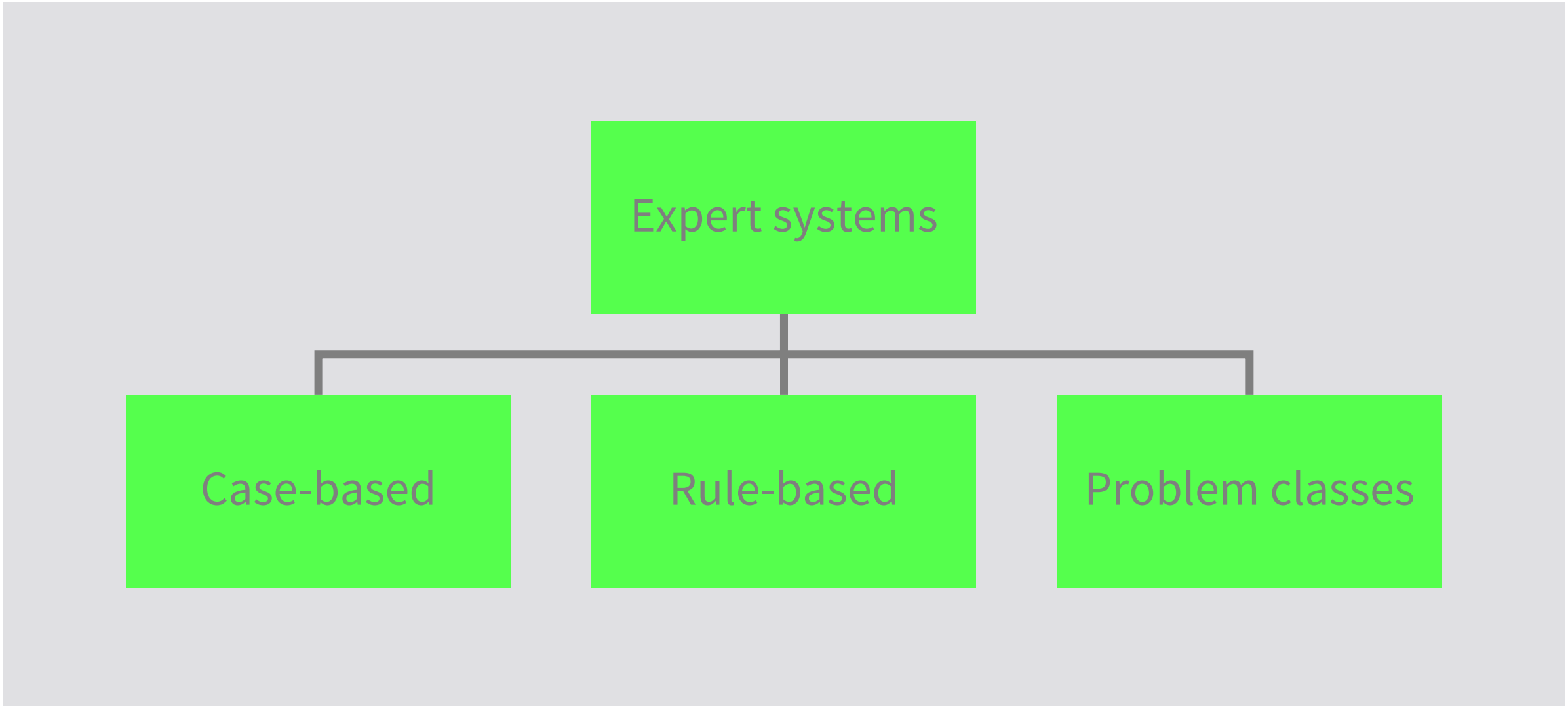
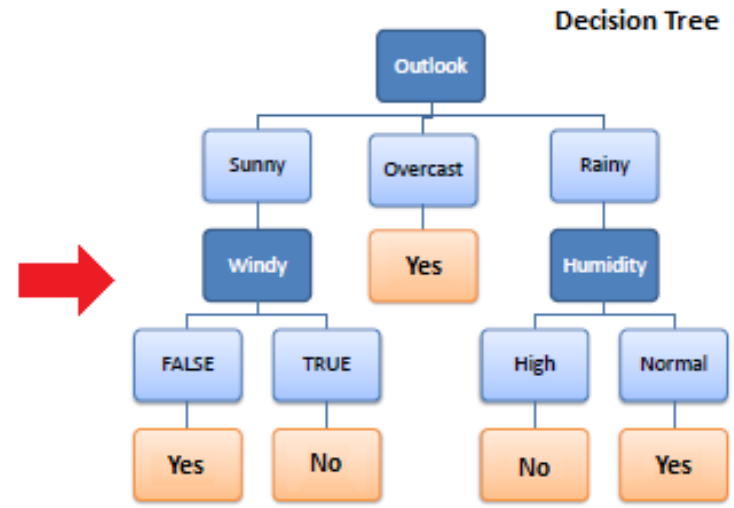


Image Source: Custom Depiction

Decision tree

- Decision tree builds classification or regression models in the form of a tree structure.
- It breaks down a dataset into smaller and smaller subsets while at the same time an associated decision tree is incrementally developed.
- The final result is a tree with decision nodes and leaf nodes.

Predictors				Target
Outlook	Temp	Humidity	Windy	Play Golf
Rainy	Hot	High	False	No
Rainy	Hot	High	True	No
Overcast	Hot	High	False	Yes
Sunny	Mild	High	False	Yes
Sunny	Cool	Normal	False	Yes
Sunny	Cool	Normal	True	No
Overcast	Cool	Normal	True	Yes
Rainy	Mild	High	False	No
Rainy	Cool	Normal	False	Yes
Sunny	Mild	Normal	False	Yes
Rainy	Mild	Normal	True	Yes
Overcast	Mild	High	True	Yes
Overcast	Hot	Normal	False	Yes
Sunny	Mild	High	True	No



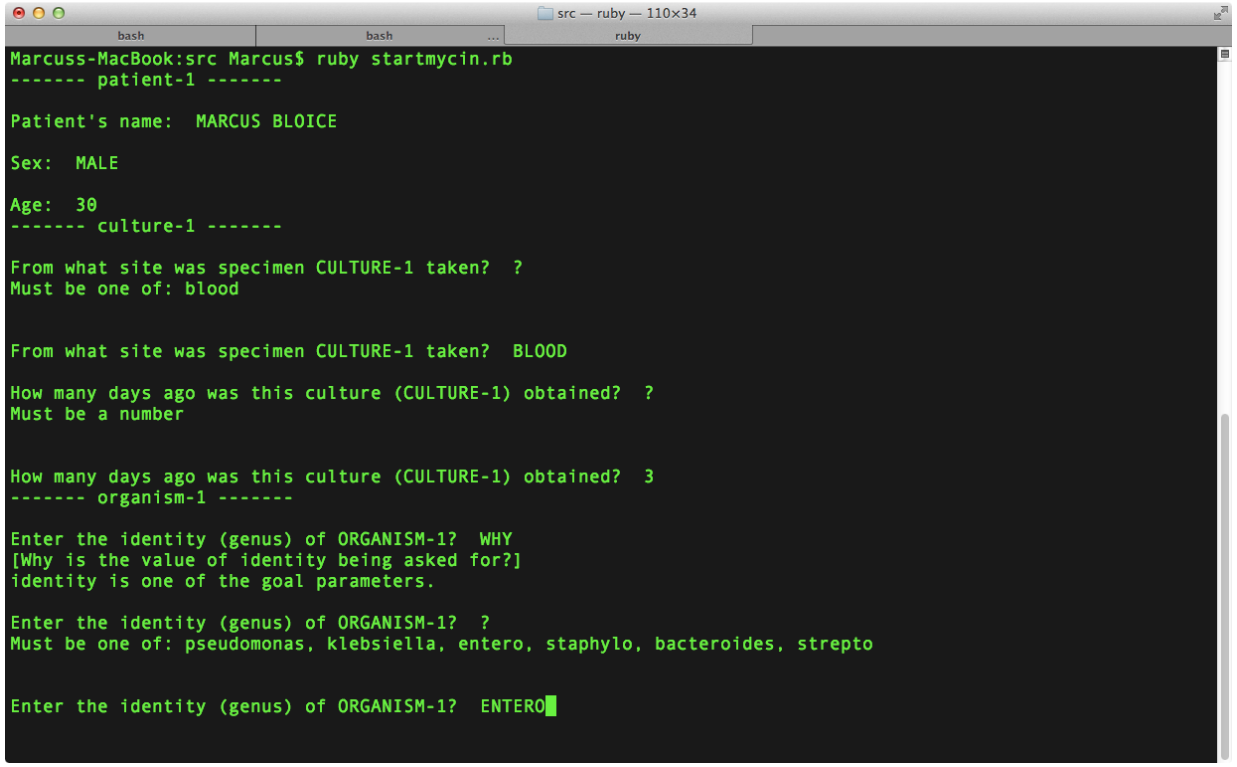
Source: https://www.saedsayad.com/decision_tree.htm

FEATURES OF GOOD EXPERT SYSTEMS

- Useful: meet a specific need
- Usable: even a notice computer user finds them easy to use
- Educational: an expert system may be used by non-experts who can then increase their own expertise by using it
- Able to explain the given advice: explain the reasoning process
- Able to learn new knowledge: ask questions to gain additional knowledge
- Exhibit a high performance: high quality output →satisfy users
- Make timely decisions: able to produce decisions on time

MYCIN

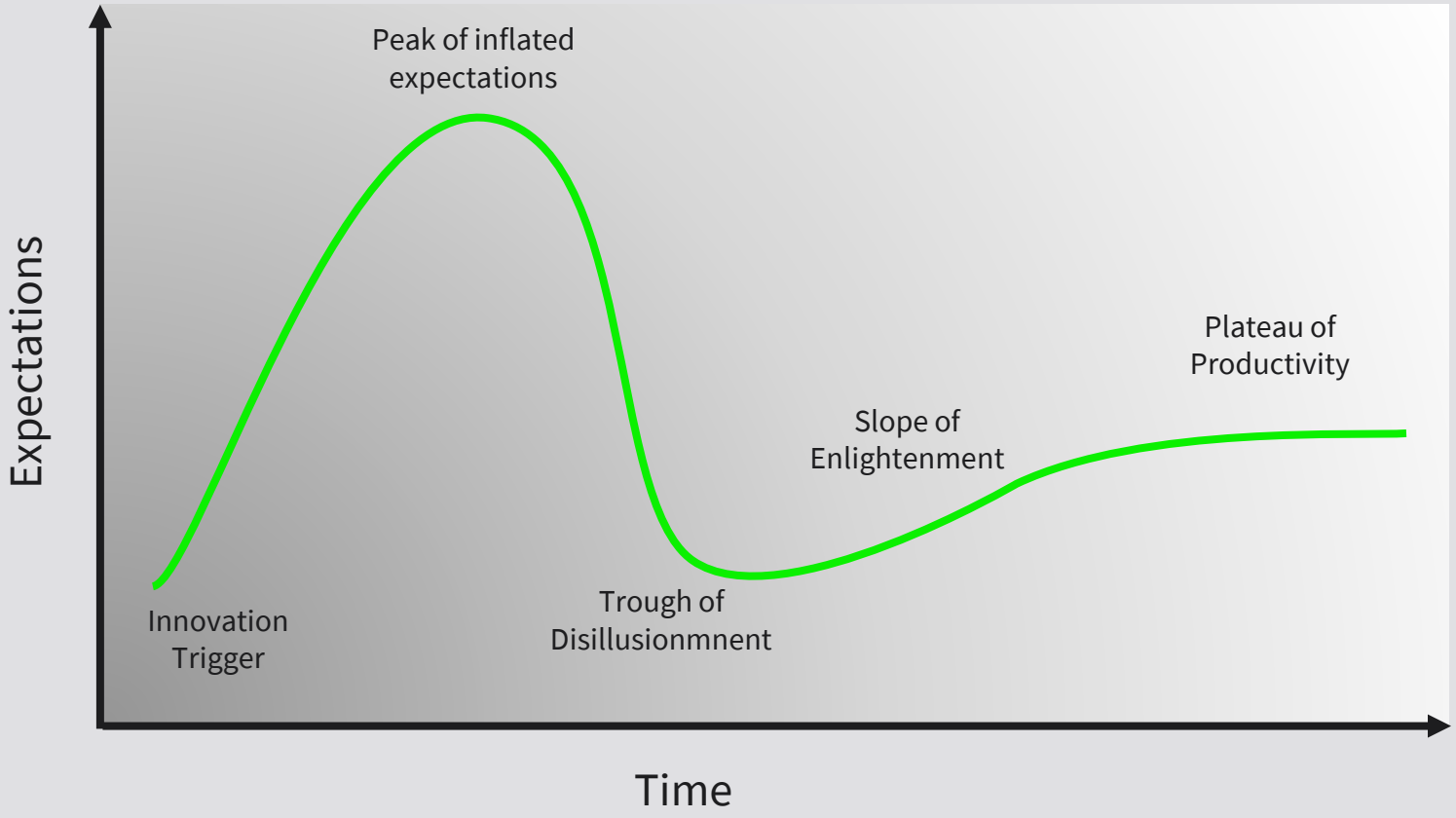
- Designed upon the fundamental of backward chaining and was capable to identify infection-causing bacteria.



A Symbolics 3640 Lisp machine: an early (1984) platform for expert systems

Source of the image: https://user.medunigraz.at/marcus.bloice/seminars/dss/g3/g3.htm; https://en.wikipedia.org/wiki/Expert_system

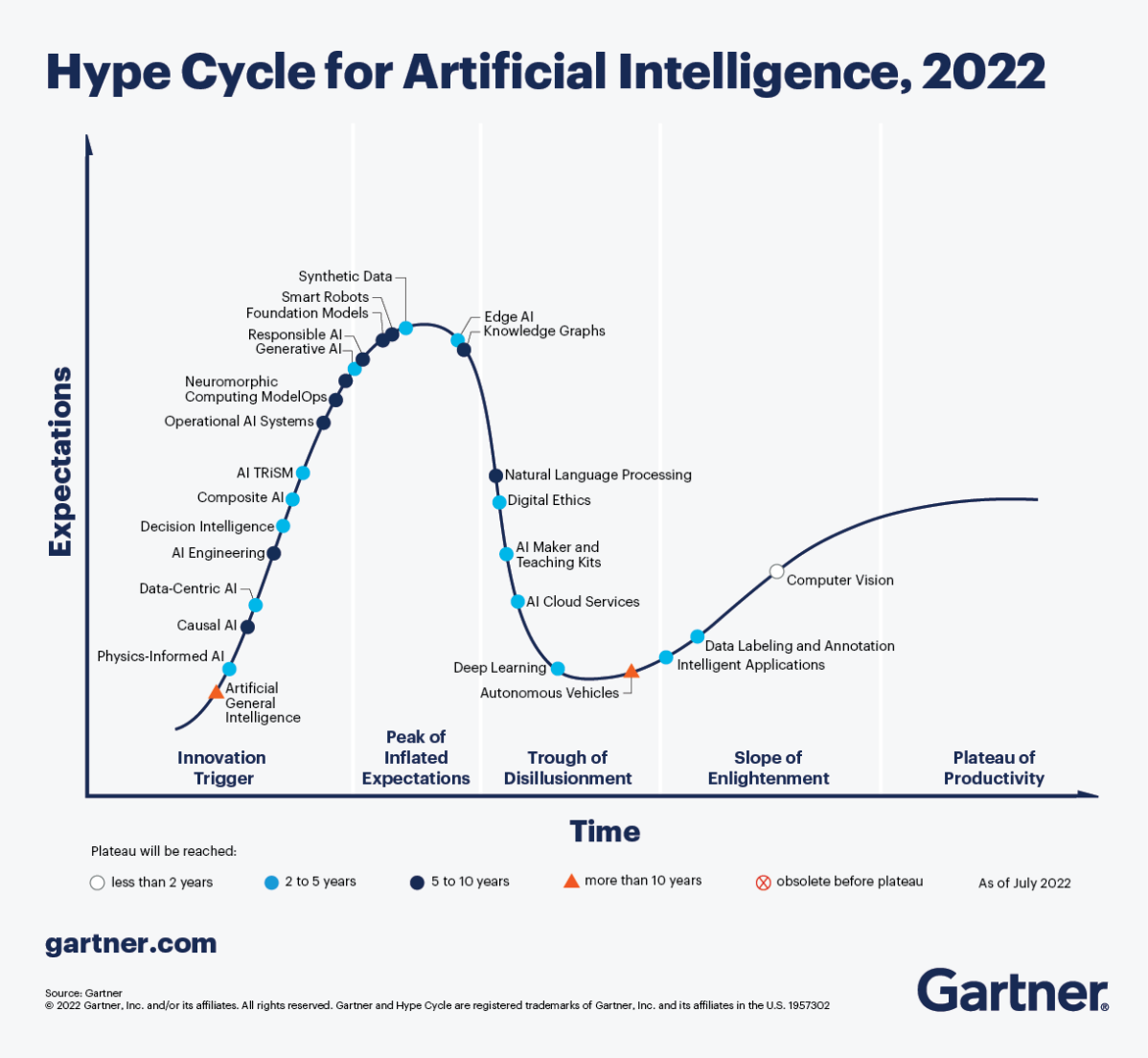
THE GARTNER HYPE CYCLE CURVE



https://www.gartner.com/en/research/methodologies/gartner-hype-cycle

Image Source: Custom Depiction

THE GARTNER HYPE CYCLE CURVE



Source: https://emtemp.gcom.cloud/ngw/globalassets/en/articles/images/hype-cycle-for-artificial-intelligence-2022.png

REVIEW STUDY GOALS

- AI is the science of making intelligent machines.
- Early considerations about AI date back to the ancient Greek history.
- Nowadays, AI is an important component of computer science.
- Expert systems emulate decision making by using domain-specific knowledge of an expert.
- The Gartner hype cycle curve evaluates the potential of new technologies.

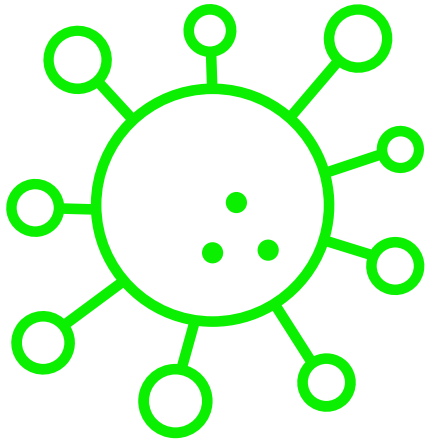
SESSION 1

TRANSFER TASK

TRANSFER TASK

1. Describe how artificial intelligence can affect the future of learning.

2. Outline how the knowledge base for an expert system to detect COVID-19 could look like.



3. How would you assign the following technologies on the hype cycle curve?

- Chatbots
- Smart robots
- Deep learning
- Autonomous vehicles
- Artificial general intelligence

How long do you think it will take until the plateau of productivity is reached?

TRANSFER TASK
PRESENTATION OF THE RESULTS

Please present your results.

The results will be discussed in plenary.

LEARNING CONTROL QUESTIONS

1. Which event was key for the recent history of AI?

2. For which group of end users are expert systems developed?

3. What proportion of AI systems have already reached the plateau of productivity at the Gartner hype cycle?

LIST OF SOURCES

McCarthy, J. (2007). *What is Artificial Intelligence?* Stanford University. http://jmc.stanford.edu/articles/whatisai/whatisai.pdf