INF Informatik
Hochschule Reutlingen

Intelligente Informationssysteme
Overview

Dominik Neumann

Agenda

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- Organisatorisches
- Wechselspiel zwischen Vorlesung und Anwendung
- Wünschenswerte Voraussetzung: Grundkenntnisse in Python
- Ziel der Vorlesung
- Überblick über die Inhalte der Vorlesung
- Prüfung: Referate und Projektarbeit

Organisatorisches

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4 Block-Vorlesungen:

- 09.11.24 08:00 - 17:00 Uhr, Hochschule Reutlingen 9-107 (36) LLMs
- 23.11.24 08:00 - 17:00 Uhr, Hochschule Reutlingen 9-107 (36) Conervsational AI
- 30.11.24 08:00 - 17:00 Uhr, Hochschule Reutlingen 9-107 (36) Referate Projekt Abstimmung
- 07.12.24 08:00 - 17:00 Uhr, Hochschule Reutlingen 9-107 (36) Retrieval Augmented Generation
- 11.01.25 08:00 - 17:00 Uhr, Hochschule Reutlingen 9-107 (36) Multi Agent Systems

Q&A und Besprechung der Übungen:

- 14.11.24 13:15 - 14:45 Uhr Remote
- 06.12.24 13:15 - 14:45 Uhr Remote
- 13.12.24 11:30 - 13:00 Uhr, Remote
- 17.01.25 13:45 - 15:15 Uhr, Remote

Referate:

- 25.01.25 08:00 - 17:00 Uhr, Hochschule Reutlingen 9-107 (36)

Lernziele

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Ziel 1: Grundverständnis für generative künstliche Intelligenz (GenAI) und Sprachmodelle ((Large) Language Models)

Ziel 2: Elemente künstlicher Intelligenz in Informationssysteme für Unternehmenslösungen integrieren lernen

Ziel 3: (Gen) AI Anwendungsfälle verstehen, bewerten und dafür geeignete Software-Architekturen designen können.

01
Artificial Intelligence

Intelligence

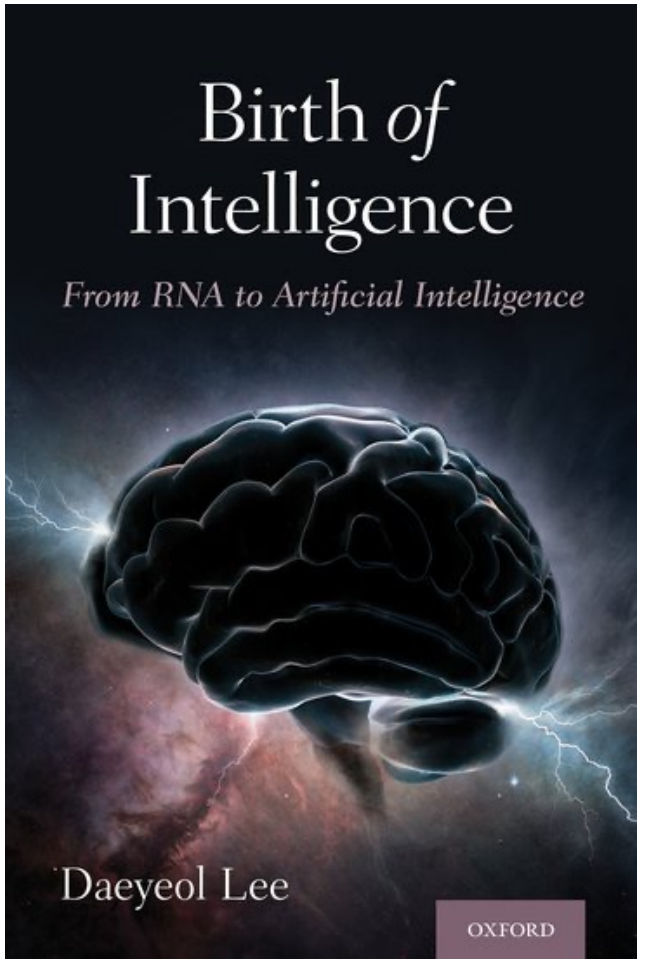
- Intelligence can be defined as the

  ability to solve complex problems or

  make decisions with outcomes **benefiting** the **actor**

  and has evolved in lifeforms to **adapt to diverse environments** for their survival and reproduction.

- For animals, problem-solving and decision-making are functions of their **nervous systems**, including the **brain**, so intelligence is closely related to the nervous system.



https://www.hopkinsmedicine.org/news/articles/2020/10/qa--what-is-intelligence

Intelligence

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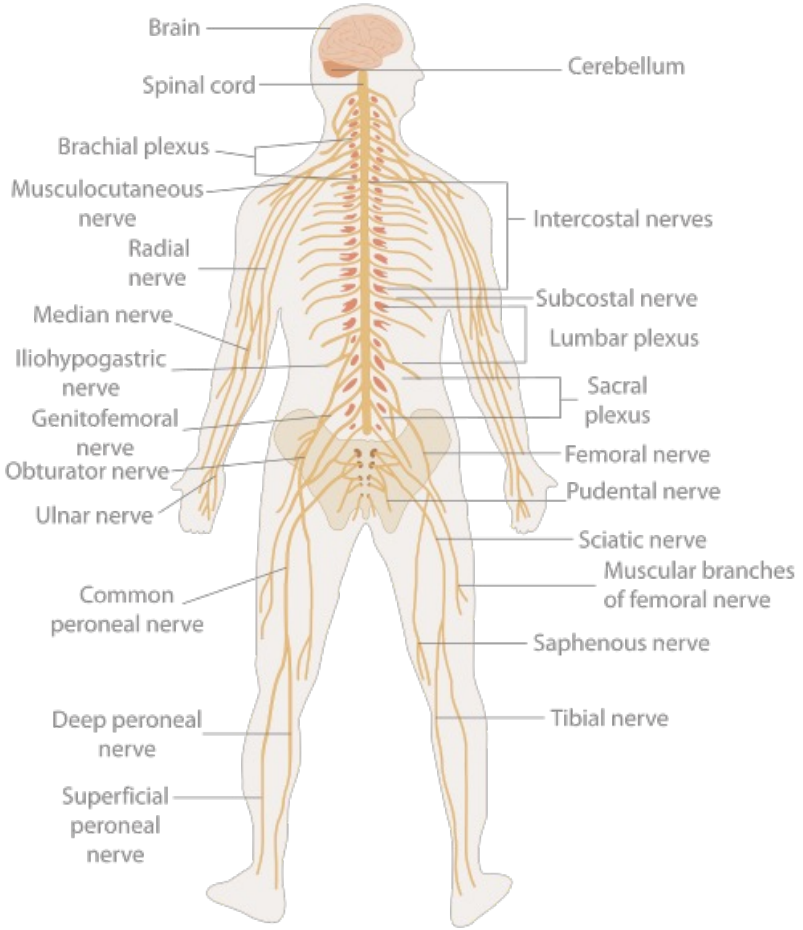
"In biology, the nervous system is the highly complex part of an animal that coordinates its actions and sensory information by transmitting signals to and from different parts of its body.

The nervous system detects environmental changes that impact the body, then works in tandem with the endocrine system to respond to such events."



https://en.wikipedia.org/wiki/Nervous_system

Intelligence

Human intelligence is the ability

- to think,
- to learn from experience,
- to solve problems, and
- to adapt to new situations

Artificial Intelligence

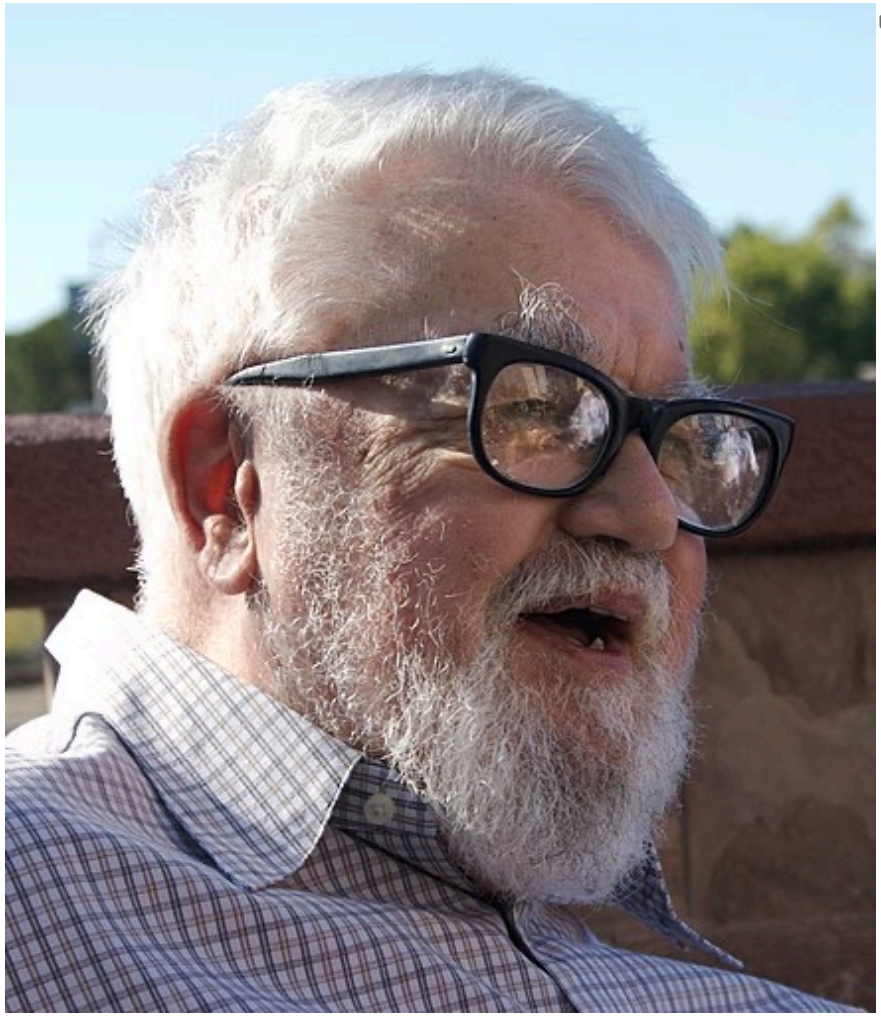
Artificial Intelligence (AI), a term coined by

emeritus Stanford Professor John McCarthy in 1955,

was defined by him as

“the science and engineering of

making intelligent machines”



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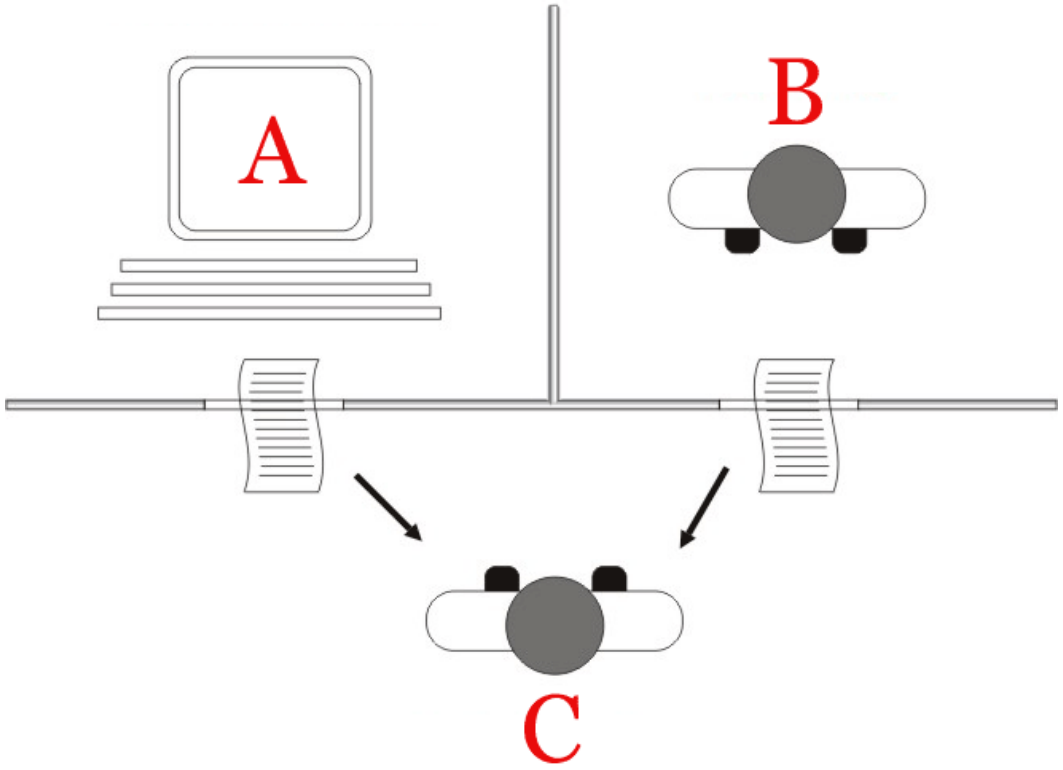
https://en.wikipedia.org/wiki/John_McCarthy_(computer_scientist)

Turing Test approach

The Turing Test proposed by Alan Turing (1950), was designed to provide a satisfactory operational definition of intelligence.

To pass the Turing Test an AI system would need to possess the following capabilities:

- **Natural Language Processing** to be able to communicate
- **Knowledge Representation** to store what it knows or hears
- **Automated Reasoning** to use the stored information to answer questions and to draw new conclusions
- **Machine Learning** to detect patterns and adapt to new circumstances



Turing Test

https://en.wikipedia.org/wiki/Turing_test

Artificial Intelligence - A Modern Approach

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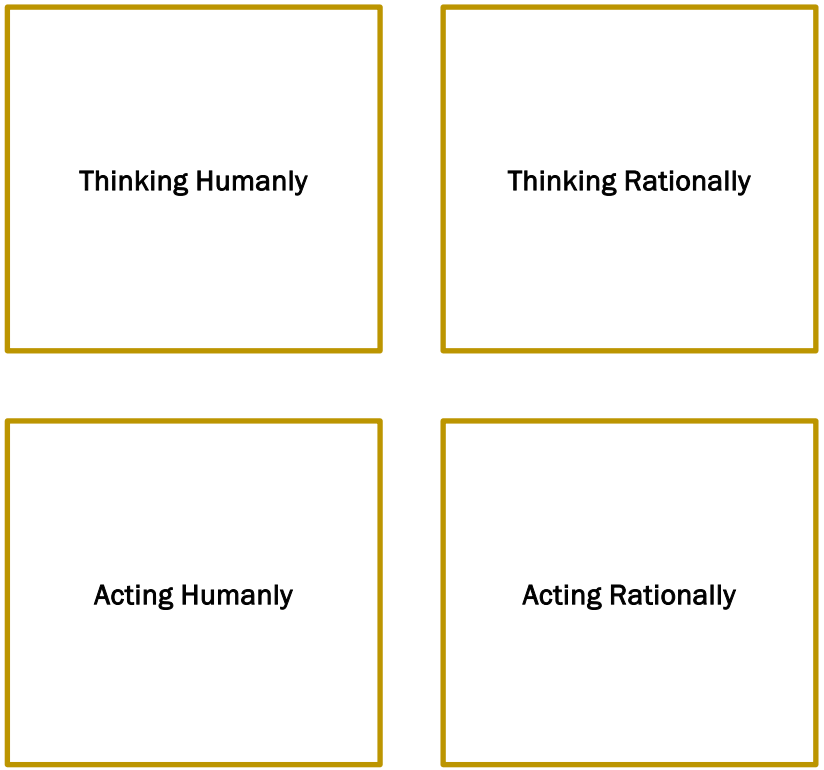
Artificial Intelligence is

- technology that enables computers and machines to **simulate human intelligence** and problem-solving capabilities.
- the ability of machines to think, analyze, learn and decide in **a rational way** that is analogous to how human beings do.
- refers to systems **that display intelligent behavior** by analyzing their environment and taking actions – with some degree of autonomy – to achieve specific goals.



To determine whether a system is intelligent, we have to observe it.

Artificial Intelligence - A Modern Approach (Third Edition)
Stuart J. Russell and Peter Norvig

Artificial Intelligent System (European Commission)

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An AI system is thus first and foremost **rational**. But how does an AI system achieve rationality? It does so by:

- perceiving the environment in which the system is immersed through some sensors, thus collecting and interpreting data,
- reasoning on what is perceived or processing the information derived from this data,
- deciding what the best action is,
- and then acting accordingly, through some actuators, thus possibly modifying the environment.

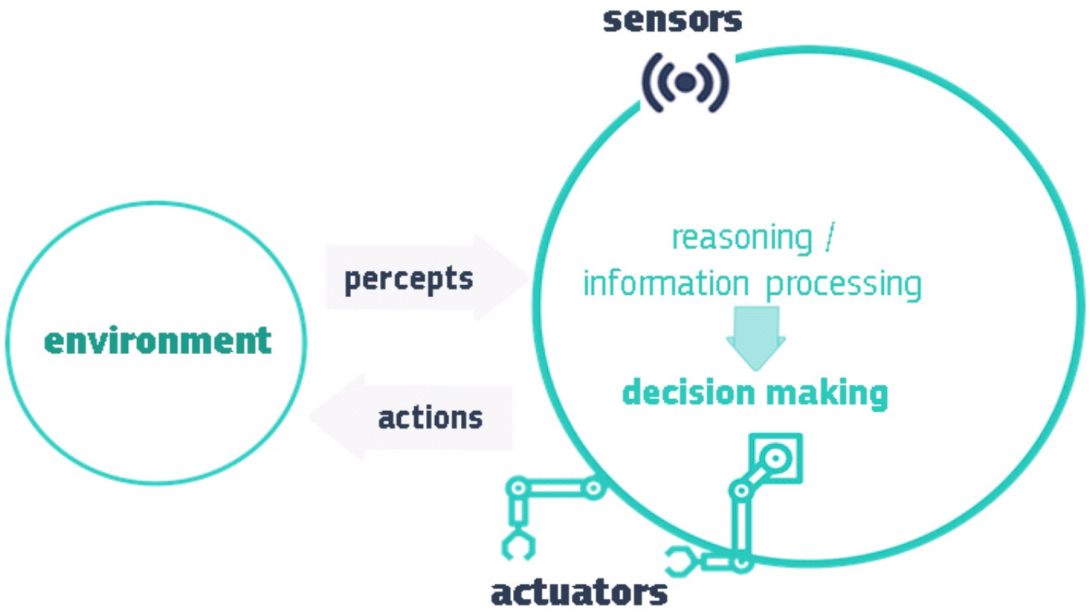


Figure 1: A schematic depiction of an AI system.

https://ec.europa.eu/futurium/en/system/files/ged/ai_hleg_definition_of_ai_18_december_1.pdf

Artificial Intelligent System (European Commission)

AI systems can either use

- symbolic rules or
- learn a numeric model, and

they can also adapt their behavior by analyzing how the environment is affected by their previous actions.

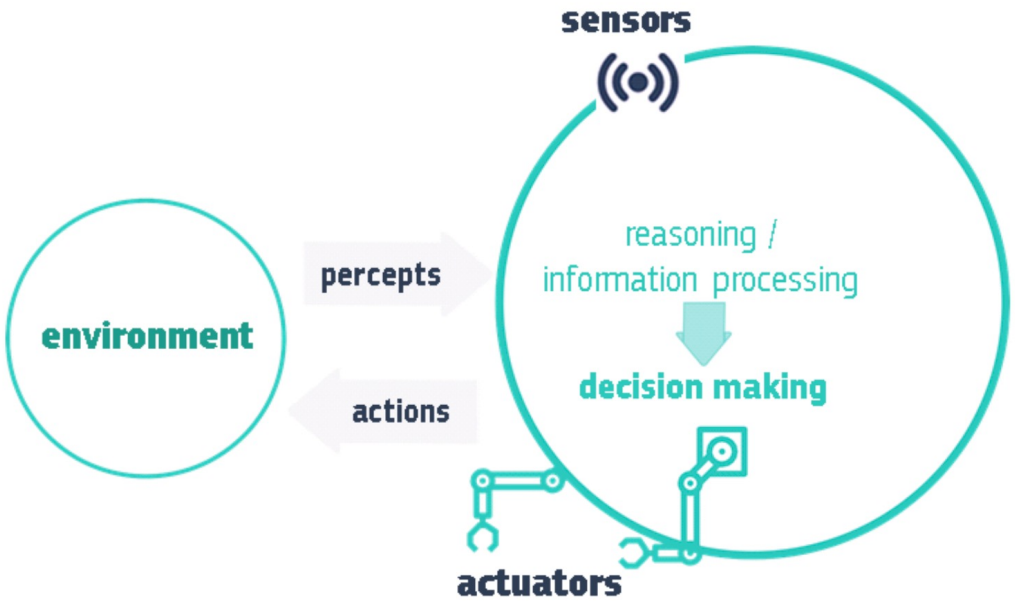
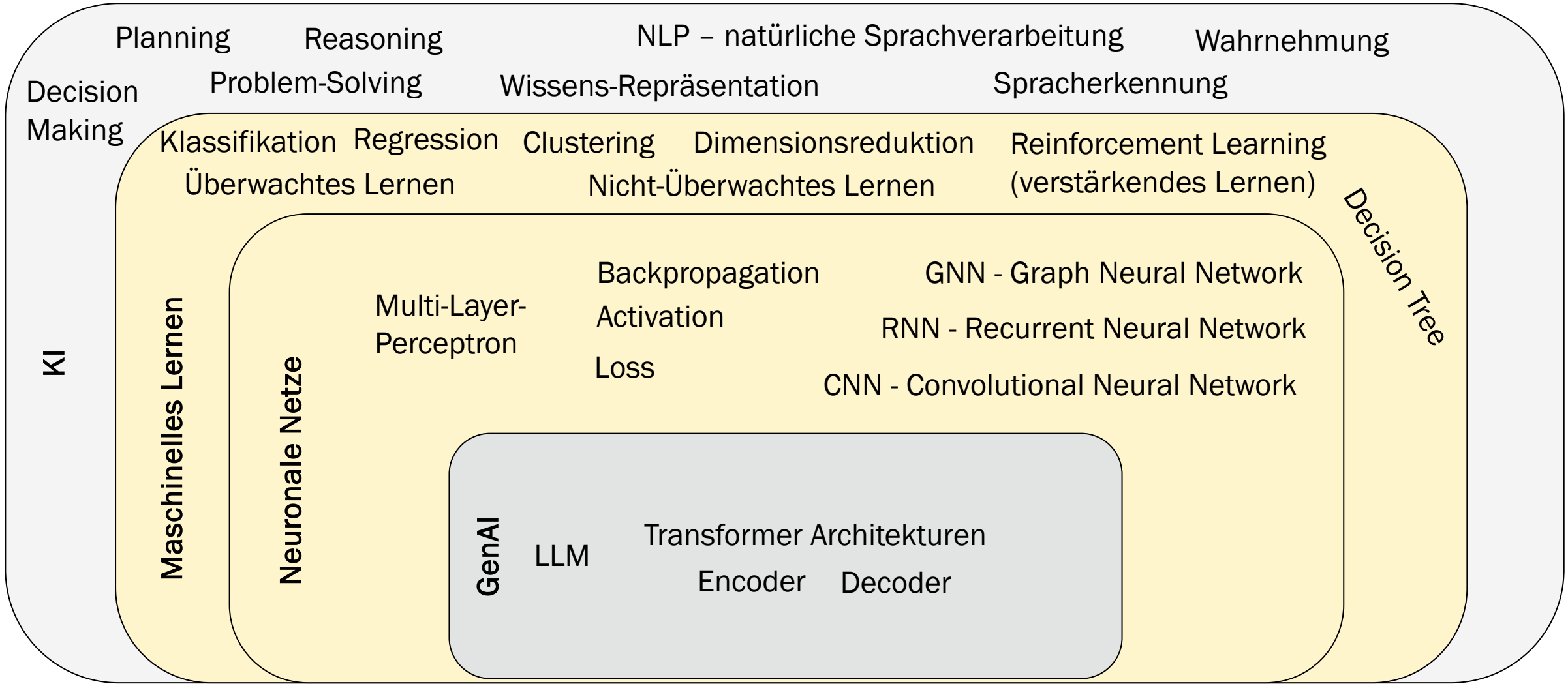


Figure 1: A schematic depiction of an AI system.

https://ec.europa.eu/futurium/en/system/files/ged/ai_hleg_definition_of_ai_18_december_1.pdf

Elements of Artificial Intelligence



Compound AI Systems – Design Patterns

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Conversional AI

Simulate a conversation with the feeling of having a conversation with a human.

- conversational memory
- dialogue generation

CoPilot

Assists a human in his work.
The key differentiator for becoming a CoPilot is understanding of the environment in which the human works.

- access to tools and data,
- reasoning and planning capabilities,
- and specialized profiles

uses

Retrieval Augmented Generation

Knowledge Retrieval and understanding is key

- Access to contextual data

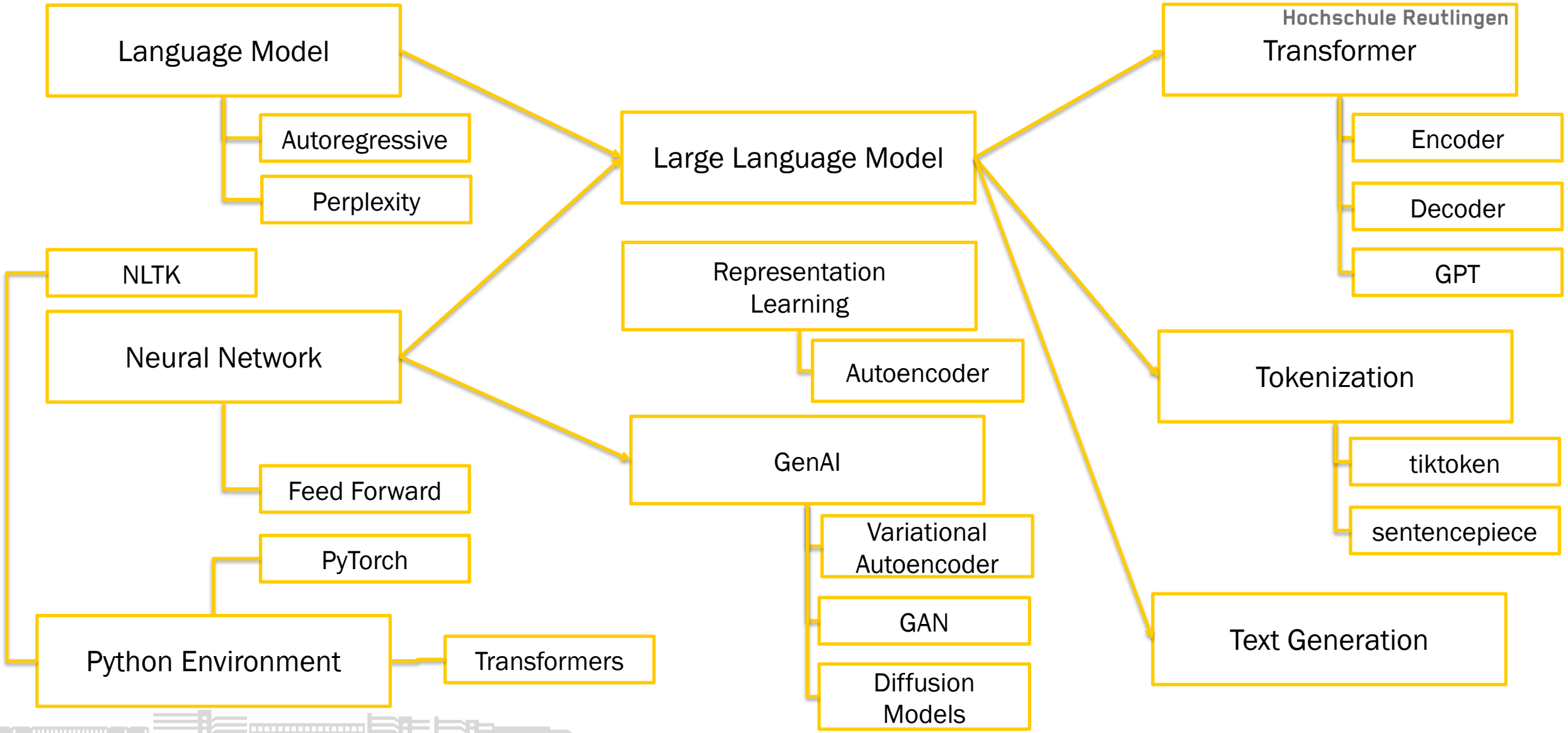
Multi Agent Problem Solver

Agents collaborate to solve a problem

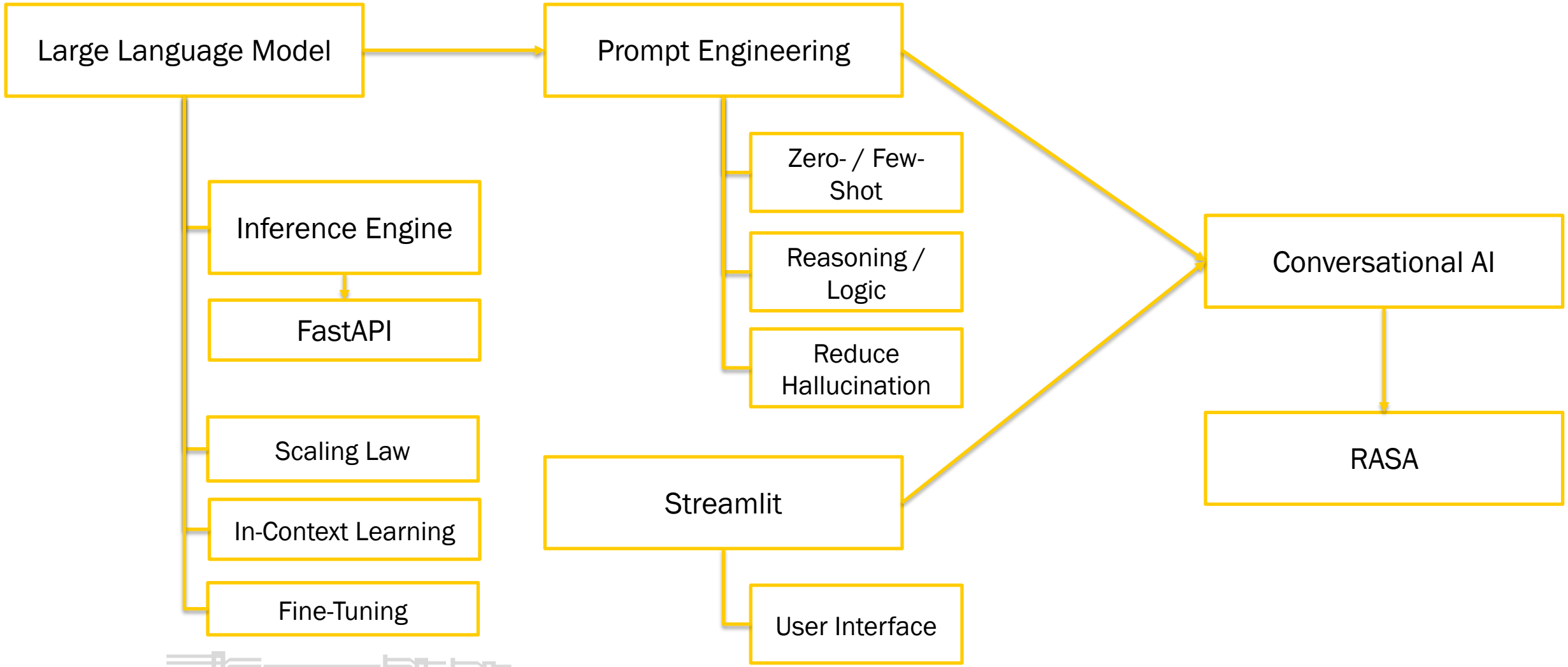
Each agent has access to it's own set of tools and can assume a very specific role while reasoning and planning it's actions.

02
Content

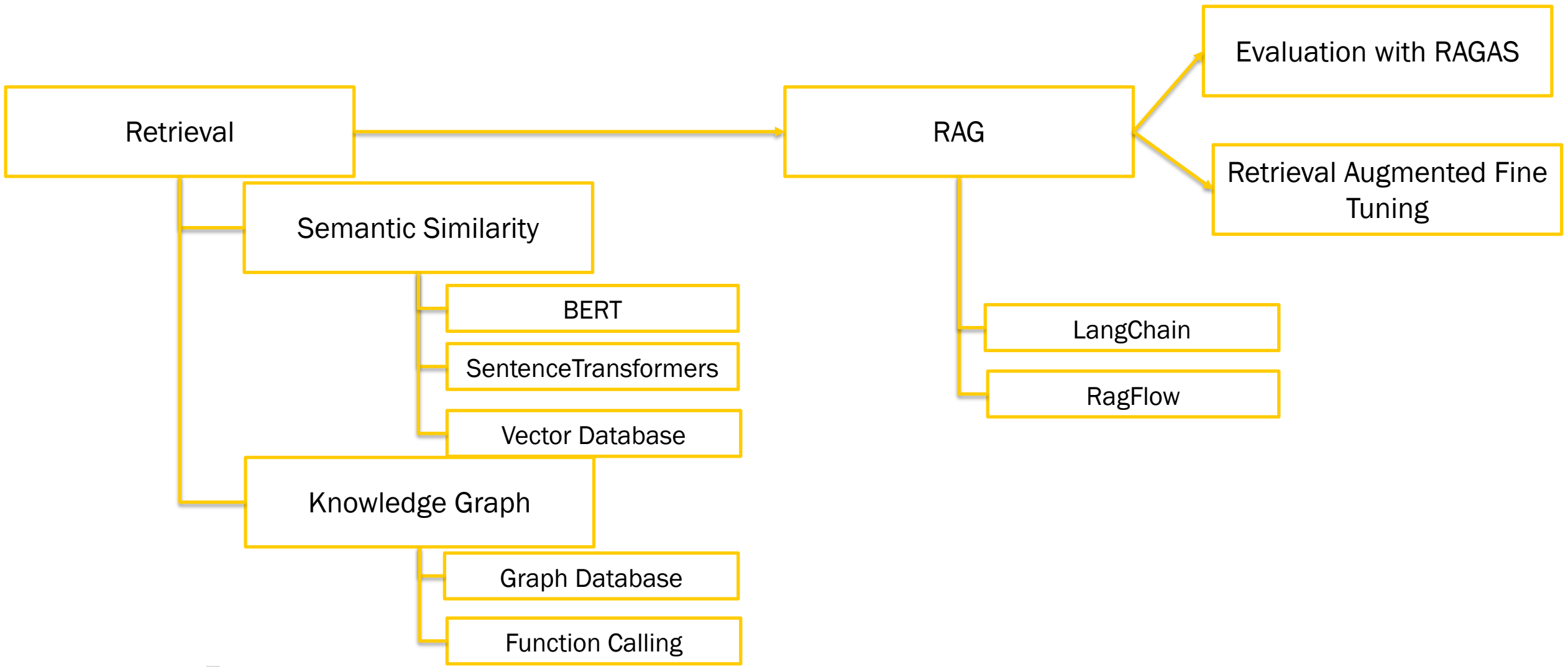
Bock 1 – Generative AI & Transformer



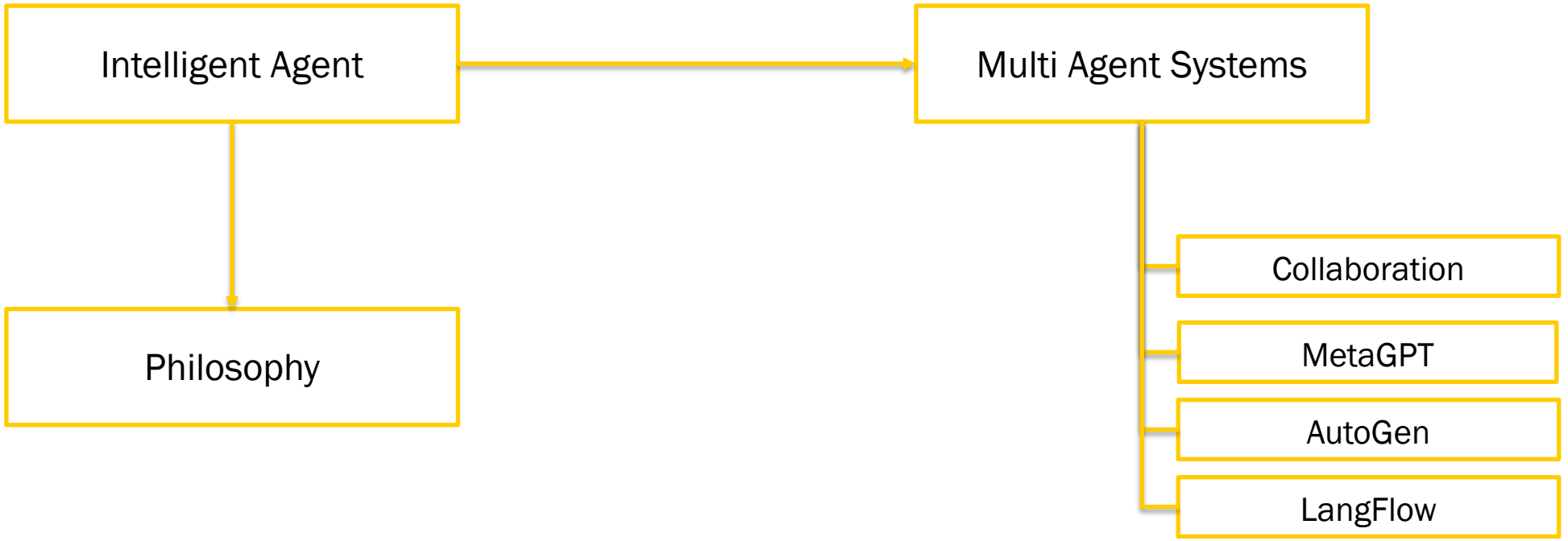
Bock 2 – Conversational AI



Block 3 -Retrieval Augmented Generation



Block 4 - Multi Agent Systems



Referate

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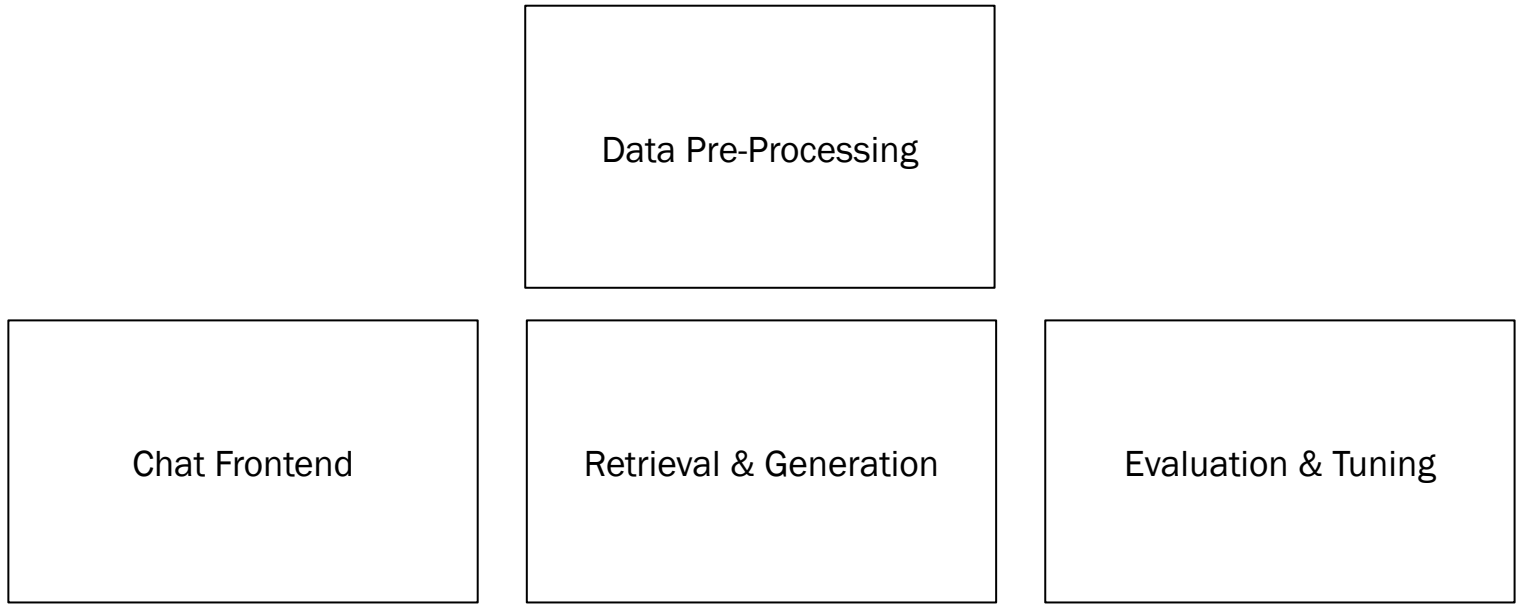
- Idee: Wir erstellen als gemeinsames Projekt ein Retrieval Augmented Generation System, das Vorlesungen aus Youtube verarbeitet.



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Backup Maschinelles Lernen

A historical perspective

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Arthur Samuel between 1952 and 1959 investigated the question of whether a computer can be enabled to do something without explicit instructions.

Is a computer able to learn? That question leads to the first formal definition of machine learning:

Definition:

Machine Learning is the field of study that gives computers the ability to learn without explicity programmed.

A modern perspective

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Several decades later, **Tom Mitchel** specified machine learning in his 1997 definition:

Definition:

Machine Learning is the science that is concerned with the question of how to construct computer programs that automatically improve 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.

http://www.cs.cmu.edu/~tom/mlbook.html

A Data-driven perspective

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Building on this, **Yaser Abu-Mostafa** describes the essence of machine learning very impressively in his Machine Learning lecture from 2012.

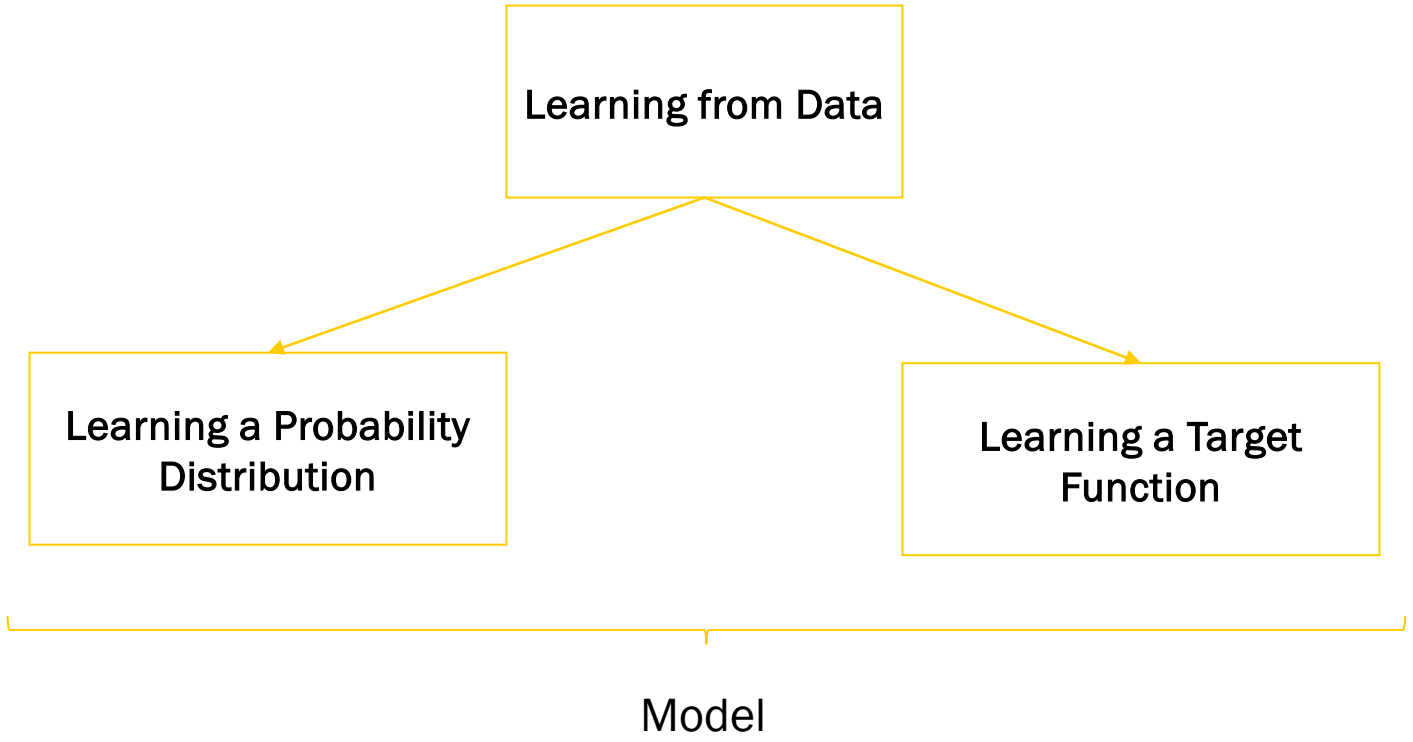
Machine Learning is feasilble when:

1. A pattern exists
2. And we are not able to pin it down. We do not know the maths or rules behind that pattern.
3. But we have a lot of meaningful data or observations that can be used to learn the hidden pattern.

https://work.caltech.edu/telecourse

A Data-driven perspective

Learning from data can be seen from a **probabilistic** or a numerical **analytic** perspective.



The Learning Problem

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To use Arthur Samuel's words, our goal in this lecture is to understand how to enable a computer to learn.

To do this, we obviously need **3 elementary building blocks**:

1. We always start with **data**

2. Then we need a parameterized **model** that can explain the data.
   (given an appropriate choice of parameters.)

3. At least an evaluation procedure, the **loss** function, that allows us to adjust the parameters of our model.

The Learning Problem

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Learning from Data can be seen as learning a function **f** or a probability distribution **P**.

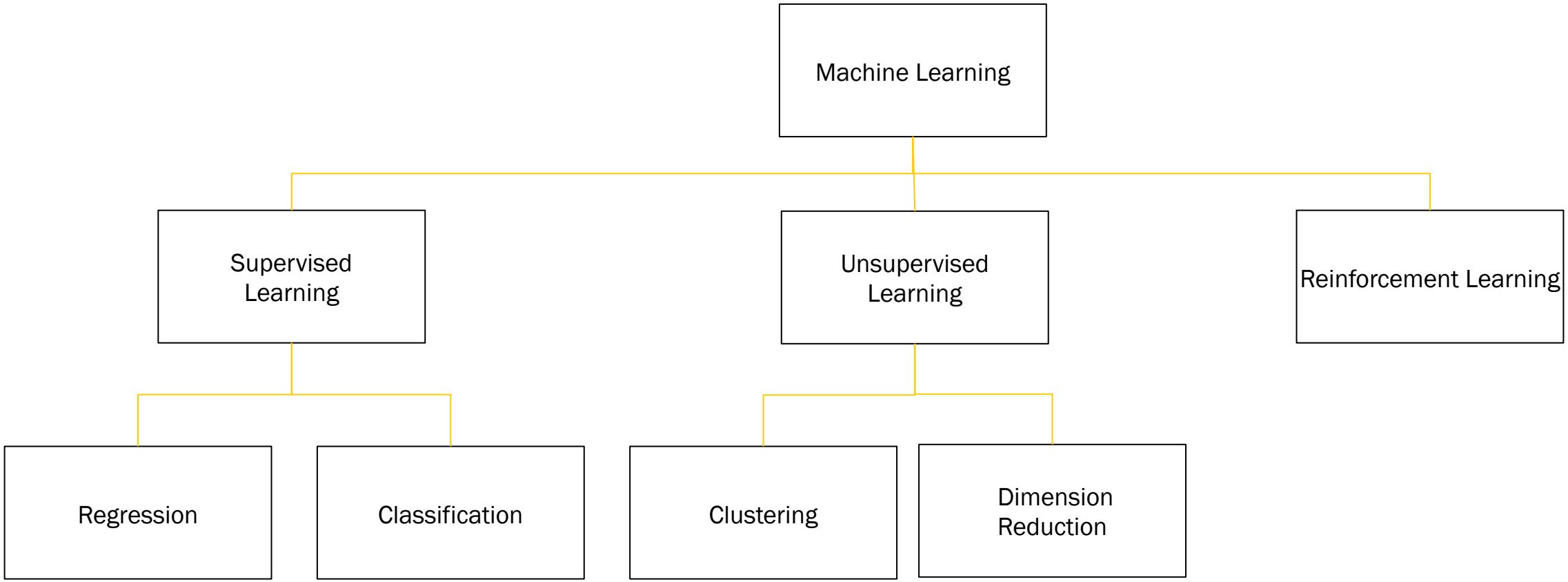
From a probabilistic point of view it is our goal to learn a **joint probability distribution P** that explains our data. With the knowledge of **P** it would be possible to predict based on observations made:

$$P(y|x) = \frac{P(x,y)}{P(x)}, P(x) \neq 0, x \in X, y \in Y.$$

On the other side the problem could be seen as a numeric optimization problem. Then we are searching for a function $\boldsymbol{f}: \boldsymbol{X} \rightarrow \boldsymbol{Y}$ with $f(x) = y$ that explains the data.

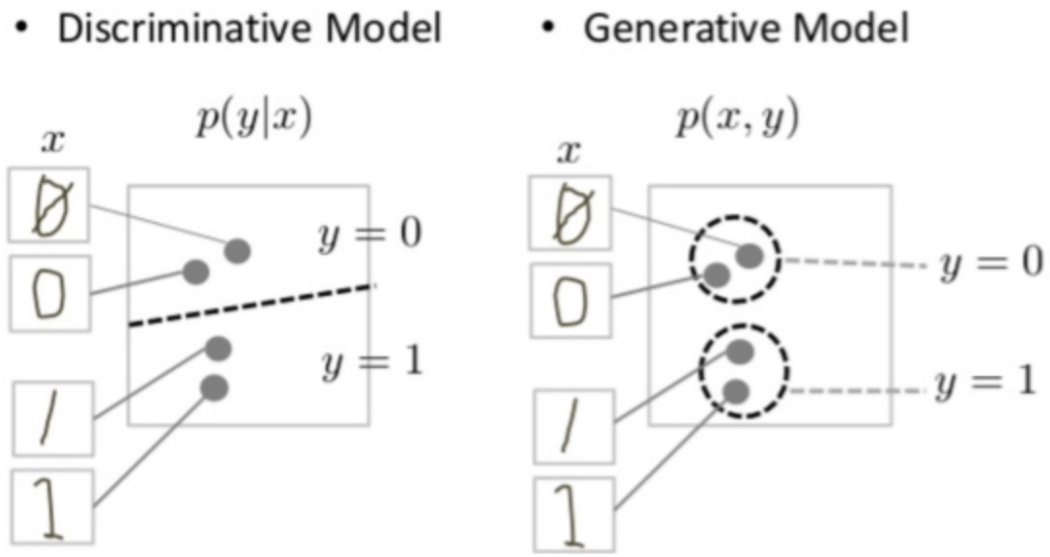
Both the probability distribution P and the function f are unknown. But there is a chance to learn P or f based on data.

Three Types of Machine Learning



Generative versus Discriminative models

- Generative AI refers to deep-learning models that can take raw data and “learn” to generate statistically probable outputs when prompted.
- At a high level, generative models encode a simplified representation of their training data and draw from it to create a new data that are similar, but not identical, to the original data.
- A generative model could generate new photos of animals that look like real animals, while a discriminative model could tell a dog from a cat.
- A generative model includes the distribution of the data itself and tells you how likely a given example is.



Discriminative and generative models of handwritten digits.

Given a set of data instances X and a set of labels Y:

- Generative models capture the joint probability p(X, Y), or just p(X) if there are no labels.
- Discriminative models capture the conditional probability p(Y | X).

https://developers.google.com/machine-learning/gan/generative