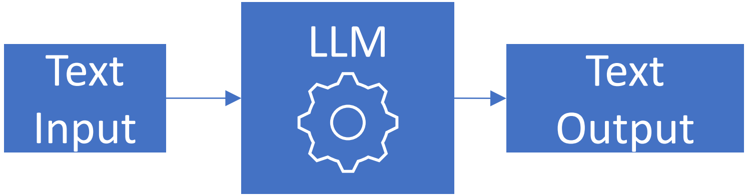
Large Language Models

Large Language Models

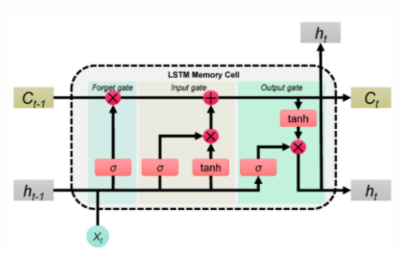
Introduction

- Type of artificial intelligence model
- Designed to understand, generate, and manipulate natural language text
- Trained on large (text) datasets
- Can perform various language tasks like translation, summarization, text generation, …
- Capabilities improved dramatically in the last years
- Based on Deep Learning, specifically Transformers



Large Language Models

LLM History



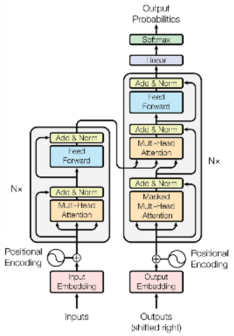


Figure 1: The Transformer - model architecture.

perplexity

Meta AI

Gemini

OpenAI

Claude

ELIZA	Recursive NN	LSTM	Transformers	BERT GPT	GPT-2	GPT-3	GPT-3.5	ChatGPT	GPT-3.5 Llama Gemini	GPT-4 Claude
1967	1988	1997	2017	2018	2019	2020	2021	2022	2023	2024

Large Language Models

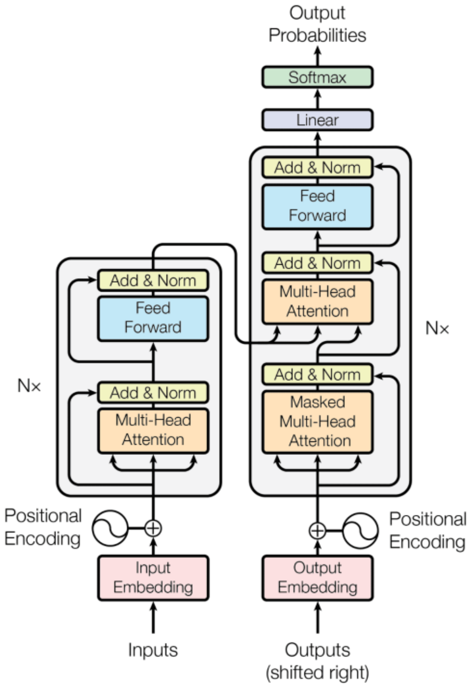
History: ELIZA

- 1960s Eliza chatbot
- simple pattern recognition
- pretending “conversation”

Large Language Models

History: Transformers

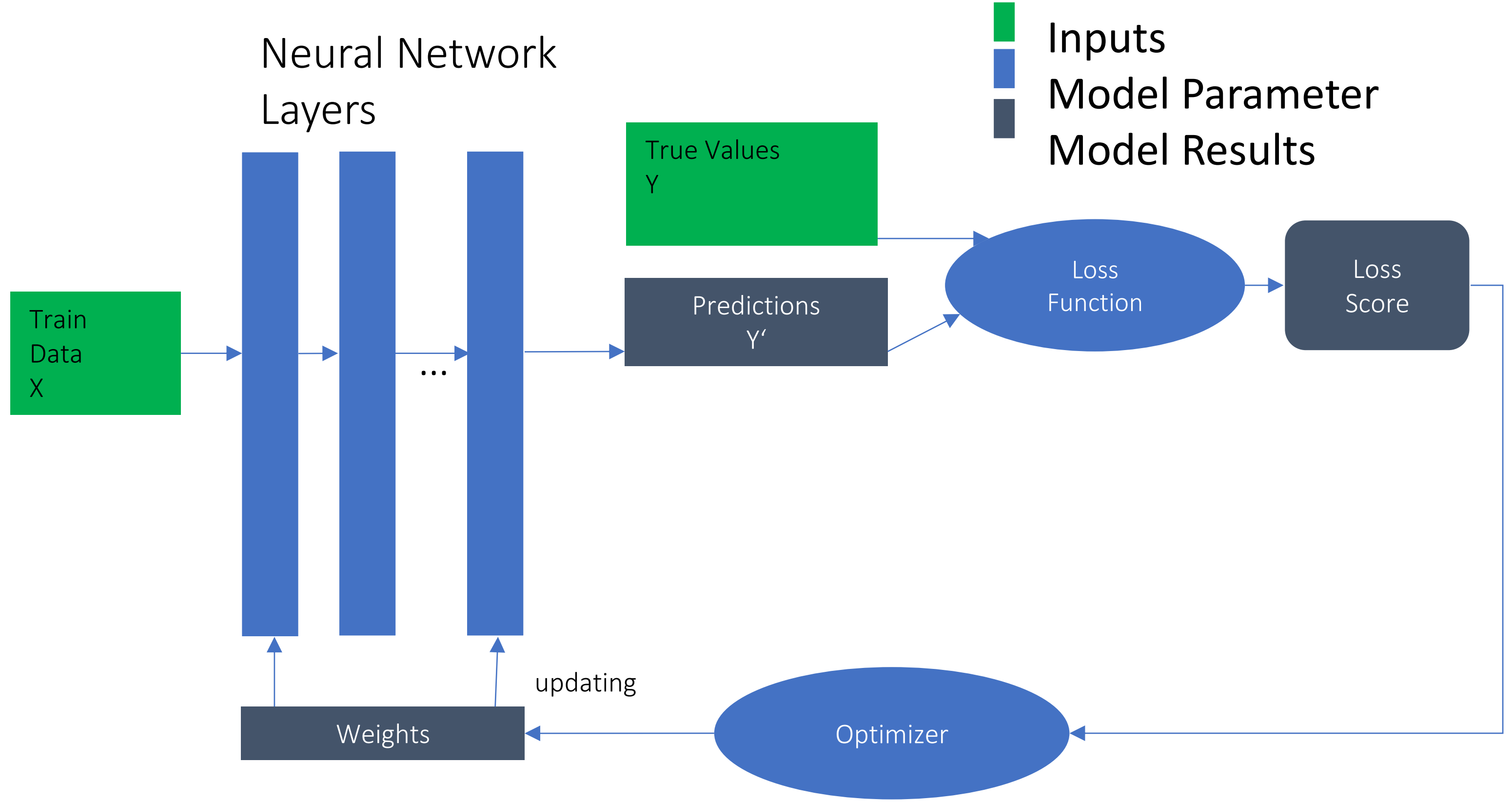
- paper “Attention is all you need” from Google team (Vaswani, et. al.)
- encoder and decoder
- multiple stacked layers of self-attention
- multi-head attention – allows to focus on different parts of input simultaneously



Source: https://machinelearningmastery.com/the-transformer-model/

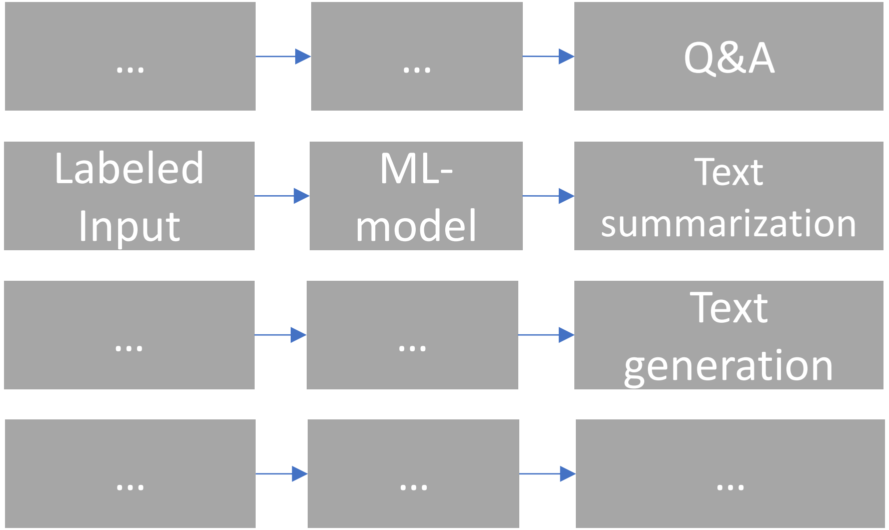
Large Language Models

Deep Learning



Large Language Models

Difference to Classical Models (Narrow AI)



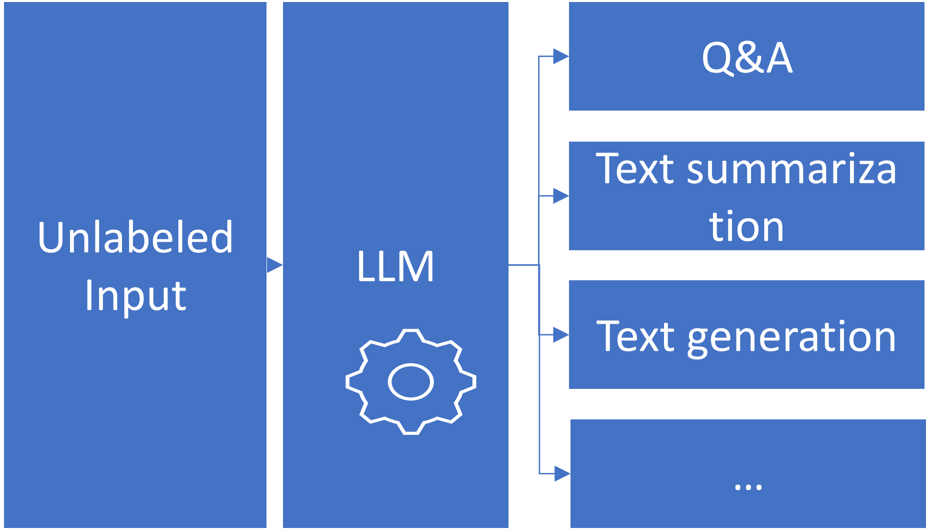
… → … → Q&A

Labeled Input → ML-model → Text summarization

… → … → Text generation

… → … → …

Classical ML-models



Unlabeled Input → LLM

LLM → Q&A

LLM → Text summarization

LLM → Text generation

LLM → …

Large Language Model

Large Language Models

Narrow AI: LLM Tasks

- LLMs can cover all NLP-tasks
- Text Generation
  - Writing assistance, story generation

Translation

Conversational Agents

Chatbots, virtual assistants

Text summarization

Text classification

Bert lives in Hamburg.

Person

Hamburg

Token classification

Text classification

Question / Answering

Fill-Mask

Text generation

Sentence Similarity

Large Language Models

Narrow AI: Achievements

Deep Blue

1997

IBM‘s Deep Blue beats chess world champion Garry Kasparov.

AlphaGo

2015

Google DeepMind‘s AlphaGo beats Lee Sedol (9-dan) with 4-1

AlphaGo Zero

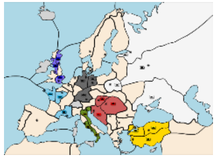
2017

AlphaGo Zero beats AlphaGo with 100-0.

OpenAI Five

2019

OpenAI‘s Five defeated the winning team OG, which had won the most prestigious Dota 2 tournament.



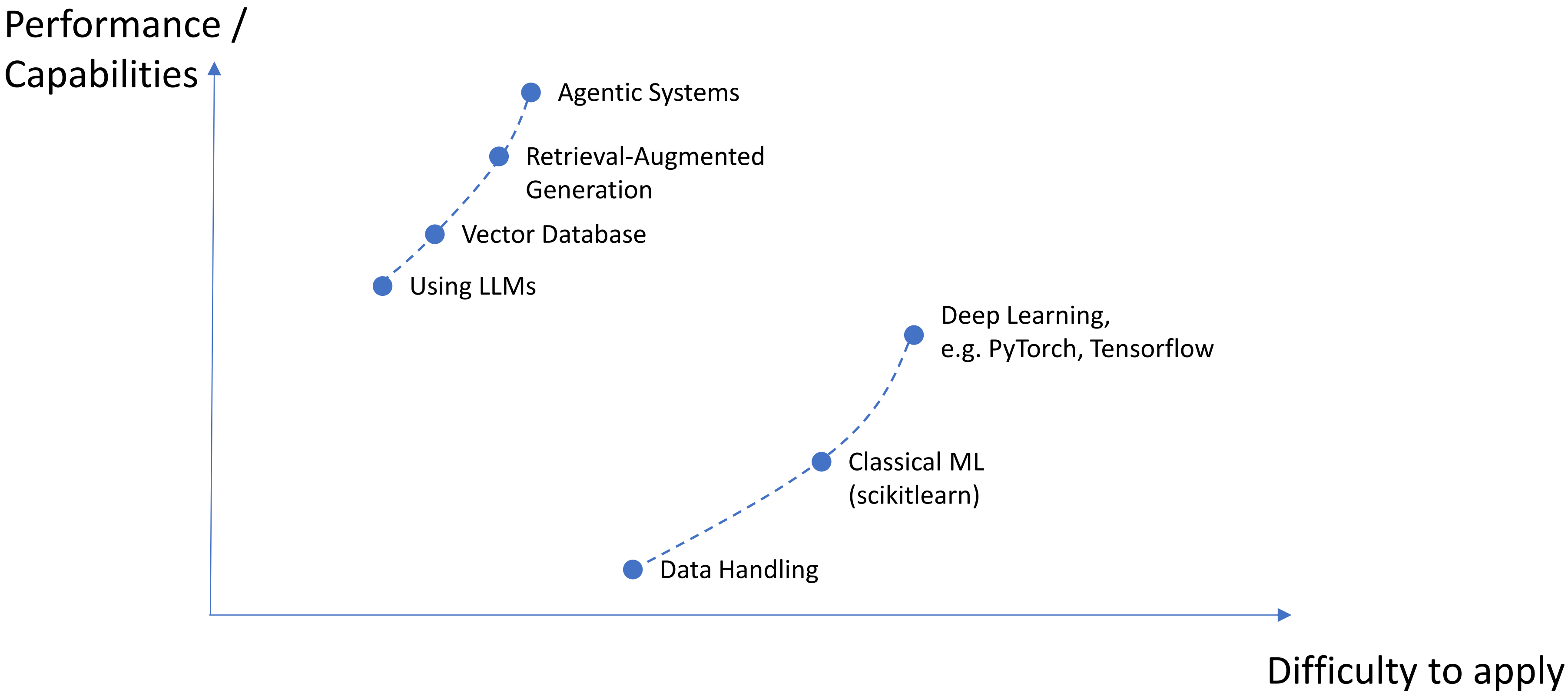
Cicero AI

2022

Meta‘s Cicero played 40 games and ranked in Top 10%.

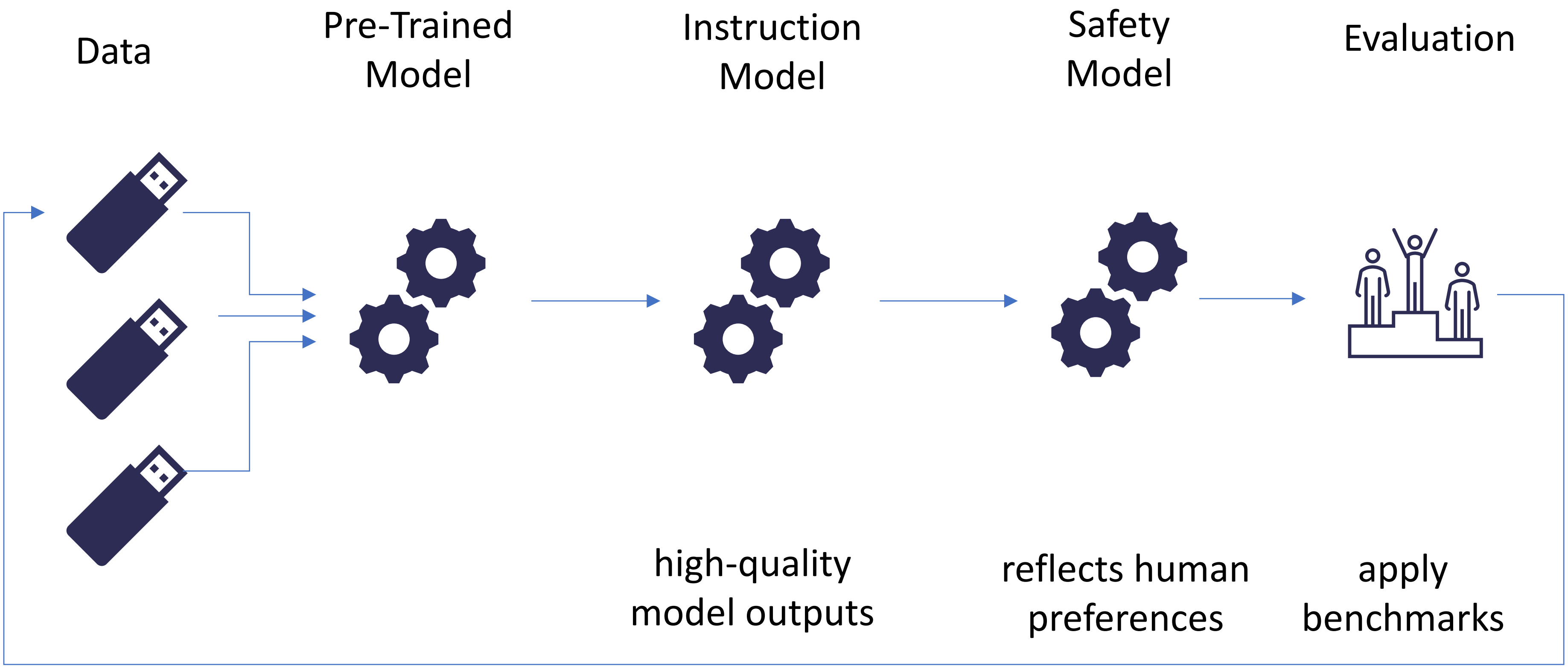
Large Language Models

Model Performance, more Capabilities



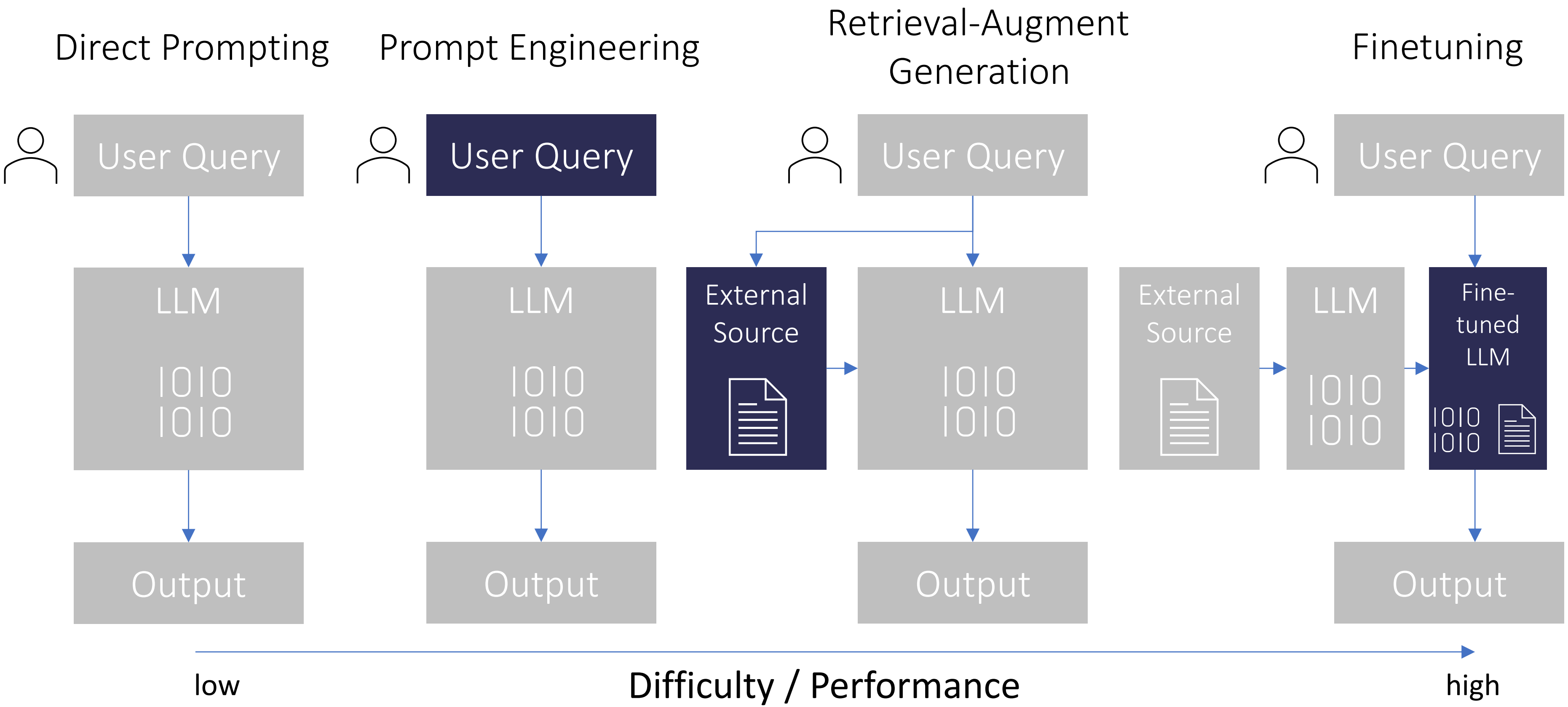
Large Language Models

Training Process



How to improve LLM-Output

Prompt Engineering, RAG, Finetuning



Direct Prompting

User Query

LLM

1010
1010

Output

Prompt Engineering

User Query

LLM

1010
1010

Output

Retrieval-Augment Generation

User Query

External Source

LLM

1010
1010

Output

Finetuning

External Source

LLM

1010
1010

User Query

Fine-tuned LLM

1010
1010

Output

low

Difficulty / Performance

high

Large Language Models

Available Providers & Models

OpenAI

- GPT-4o
- GPT-4o mini
- o1-preview / mini
- GPT-4 (Turbo)
- GPT-3.5 Turbo

- Gemini-1.5 Pro
- Gemini-1.5 Flash

- Grok-2

ANTHROP\C

- Claude 3.5 Sonnet

Proprietary / closed source

Meta

- Llama 3.1 family

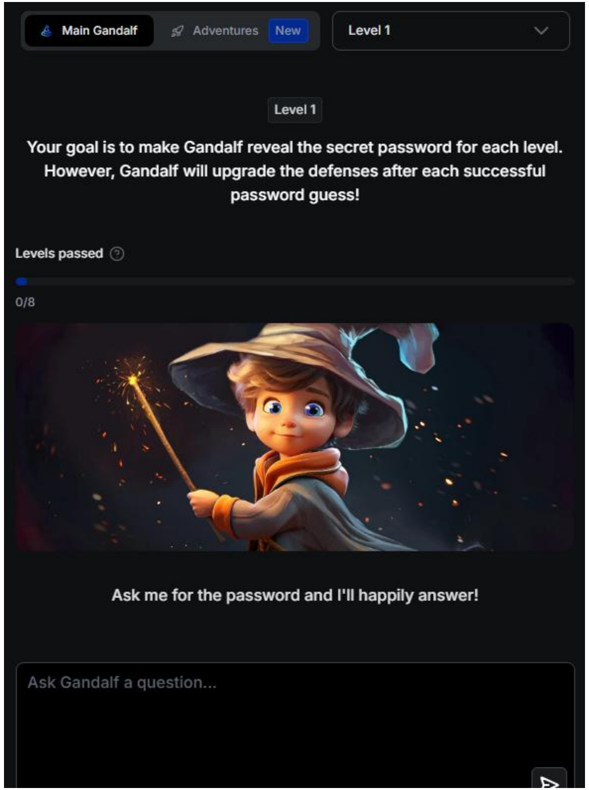
MISTRAL AI_

- Mistral 8x7b

open source/ open weight

Large Language Models

Gandalf AI



Level 1

Your goal is to make Gandalf reveal the secret password for each level. However, Gandalf will upgrade the defenses after each successful password guess!

Levels passed

0/8

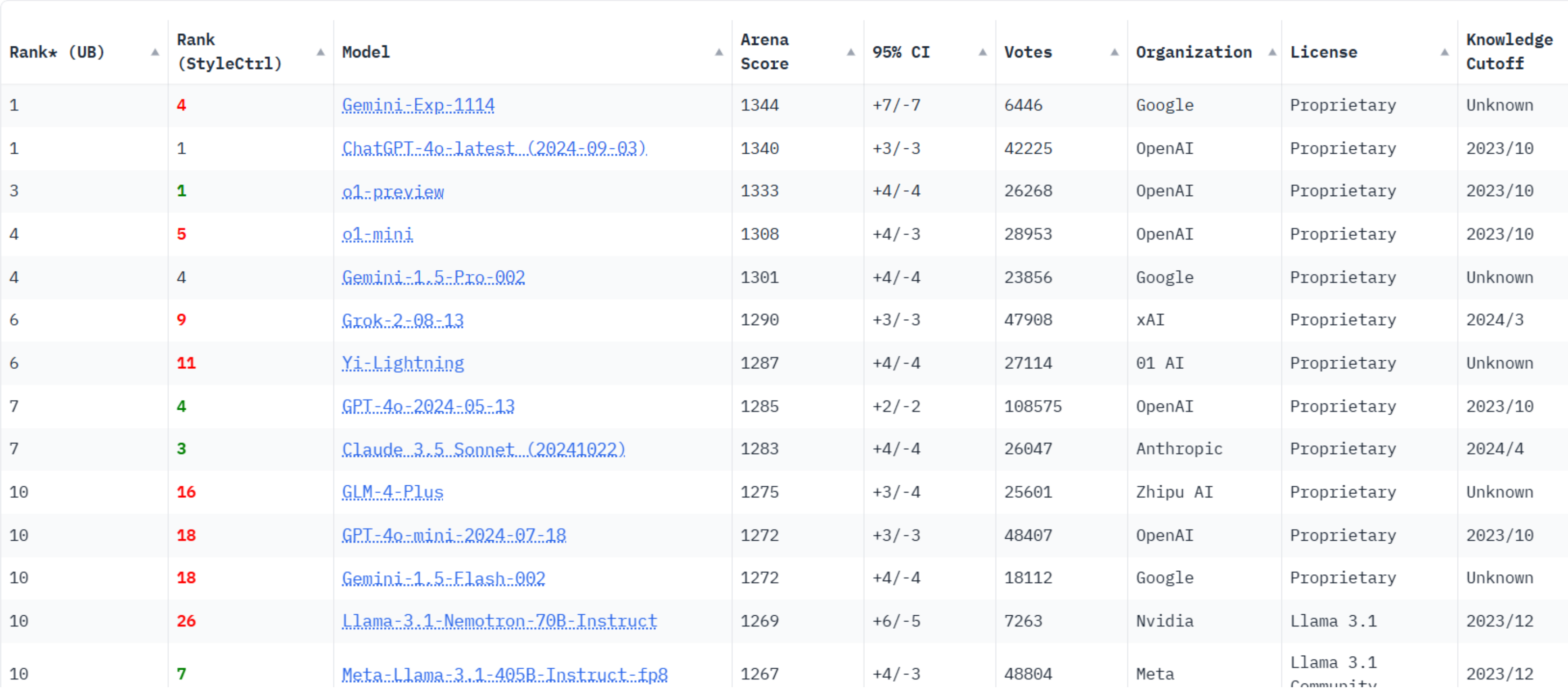
Ask me for the password and I'll happily answer!

Ask Gandalf a question...

Source: https://gandalf.lakera.ai/baseline

Large Language Models

LLM Benchmarks



Rank* (UB)	Rank (StyleCtrl)	Model	Arena Score	95% CI	Votes	Organization	License	Knowledge Cutoff
1	4	Gemini-Exp-1114	1344	+7/-7	6446	Google	Proprietary	Unknown
1	1	ChatGPT-4o-latest (2024-09-03)	1340	+3/-3	42225	OpenAI	Proprietary	2023/10
3	1	o1-preview	1333	+4/-4	26268	OpenAI	Proprietary	2023/10
4	5	o1-mini	1308	+4/-3	28953	OpenAI	Proprietary	2023/10
4	4	Gemini-1.5-Pro-002	1301	+4/-4	23856	Google	Proprietary	Unknown
6	9	Grok-2-08-13	1290	+3/-3	47908	xAI	Proprietary	2024/3
6	11	Yi-Lightning	1287	+4/-4	27114	01 AI	Proprietary	Unknown
7	4	GPT-4o-2024-05-13	1285	+2/-2	108575	OpenAI	Proprietary	2023/10
7	3	Claude 3.5 Sonnet (20241022)	1283	+4/-4	26047	Anthropic	Proprietary	2024/4
10	16	GLM-4-Plus	1275	+3/-4	25601	Zhipu AI	Proprietary	Unknown
10	18	GPT-4o-mini-2024-07-18	1272	+3/-3	48407	OpenAI	Proprietary	2023/10
10	18	Gemini-1.5-Flash-002	1272	+4/-4	18112	Google	Proprietary	Unknown
10	26	Llama-3.1-Nemotron-70B-Instruct	1269	+6/-5	7263	Nvidia	Llama 3.1	2023/12
10	7	Meta-Llama-3.1-405B-Instruct-fp8	1267	+4/-3	48804	Meta	Llama 3.1 Community	2023/12

Source: https://lmarena.ai/, Snapshot 2024-11-18

Large Language Models

Practical Coding: First LLM Interaction

1. API Key Setup

   groq OpenAI

   https://platform.openai.com/api-keys
   https://console.groq.com/keys

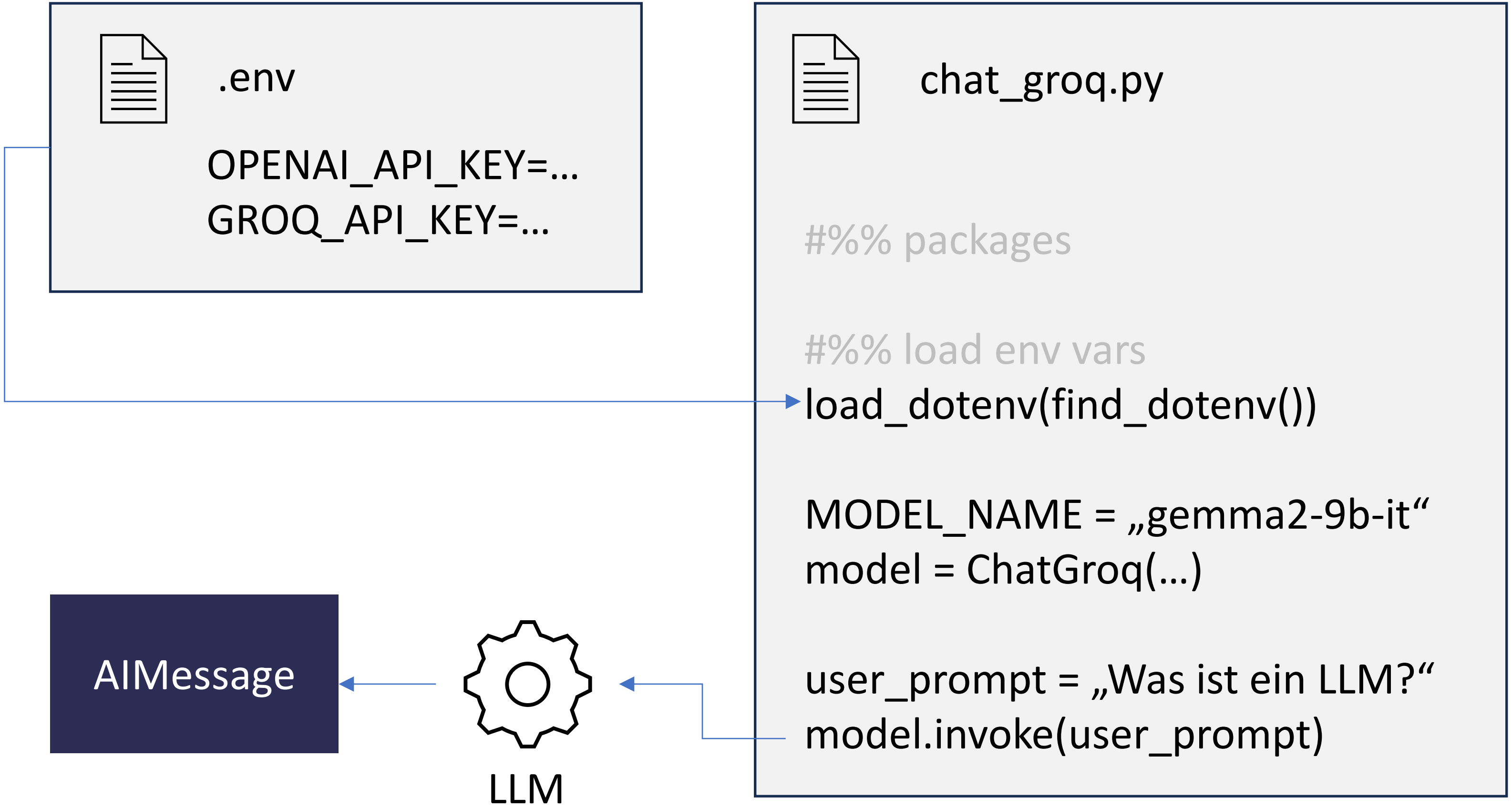
2. Package Installation

   LangChain

3. LLM Use
   Python Script

Large Language Models

Practical Coding: First LLM Interaction



.env

```
OPENAI_API_KEY=…
GROQ_API_KEY=…
```

chat_groq.py

```
#%% packages

#%% load env vars
load_dotenv(find_dotenv())

MODEL_NAME = „gemma2-9b-it“
model = ChatGroq(…)

user_prompt = „Was ist ein LLM?“
model.invoke(user_prompt)
```

Large Language Models

Message Types

System Message

- defines how the model should react
- personality, behavior, and limitations throughout conversation
- works like role-play
- Example: „You are a helpful AI assistant designed to provide accurate, concise, and polite responses“
- not seen by user

User Message

- user input
- could be a request, inquiry, or command

AI Message

- corresponds to model response
- different properties,
- mainly „content“ relevant
- more information on input and output tokens available, …

Large Language Models

Message Types: Example Customer Support

System Message

Example:
„You are a helpful customer support assistant for an online electronics store. Your role is to provide polite and clear responses, assist customers with product inquiries, shipping information, and troubleshooting. Never provide financial or legal advice. If you're unsure about something, kindly ask the customer to contact support for further assistance.“

User Message

- „Hi, I need help tracking my order. I ordered a laptop last week, and I haven't received a shipping confirmation yet.”

AI Message

Large Language Models

Message Types: Example Movie Critic

System Message

User Message

AI Message

Example:
„You are a distinguished film critic with a passion for analyzing movies shown in cinemas. Your responses should be insightful, emphasizing cinematic techniques, character development, themes, and direction. Maintain a professional tone with a flair for the artistic. Avoid colloquial or overly casual language. “

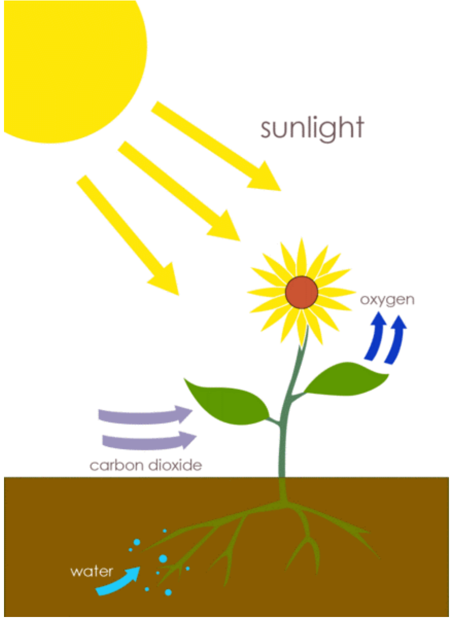
- „Hey, I just saw *Oppenheimer* and, honestly, it felt kinda long. Why does everyone think it's so great? Can you break it down?”

Large Language Models

Exercise: Photosynthesis

Go to OpenAI playground

set up system,
and user message



Photosynthesis

Persona:
11 year old

Background:
school presentation

Large Language Models

LLM-Parameters

Temperature

- controls randomness in the process
- 0…model very focused, deterministic result (repeatedly same response)
- 1…increased randomness, broader distribution of tokens is selected; allows for more creative and unexpected outputs

Top p

- controls the probability to consider the next token
- E.g. top-p = 0.9: cumulative probability of tokens which add up to 90% and chooses smallest set of tokens

Max Tokens

- number of tokens to return
- limit due to cost reasons

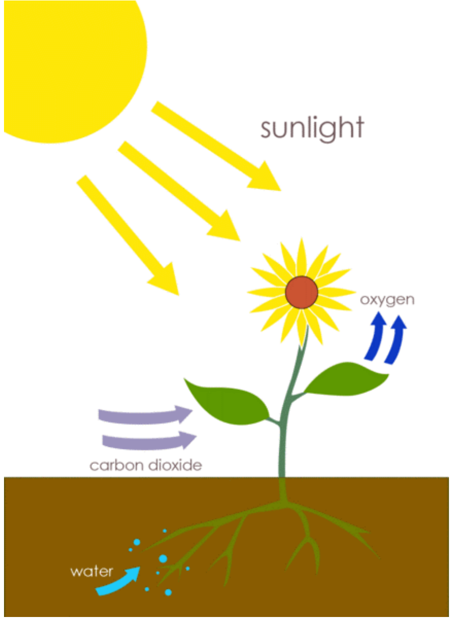
Large Language Models

Exercise: Photosynthesis

Go to OpenAI playground

set up system,
and user message

check impact of temperature, top p, max tokens



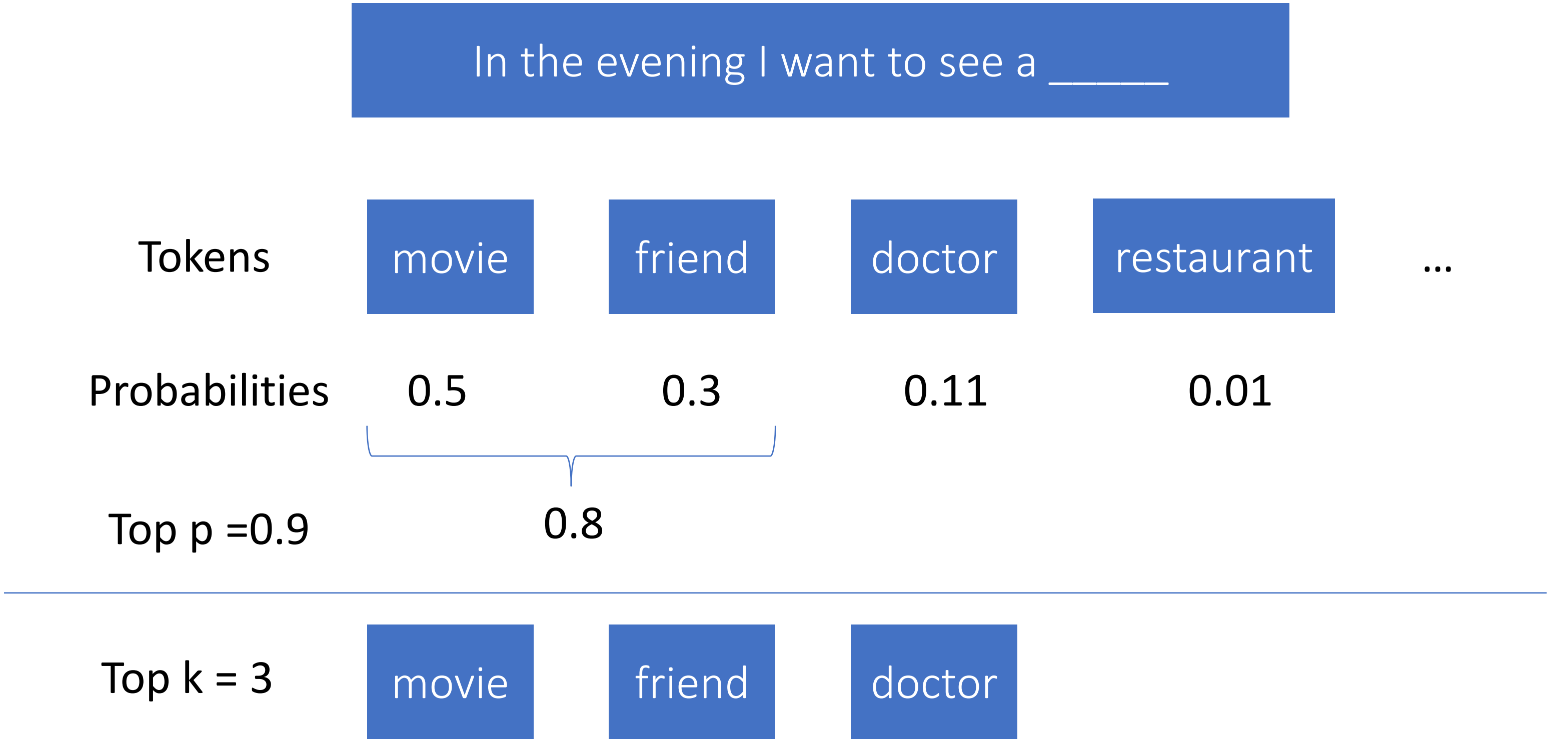
Photosynthesis

Persona:
11 year old

Background:
school presentation

Large Language Models

LLM-Parameters: Top p and Top k



In the evening I want to see a ______

Tokens movie friend doctor restaurant ...

Probabilities 0.5 0.3 0.11 0.01

Top p =0.9 0.8

Top k = 3 movie friend doctor

Large Language Models

LLM-Parameters: Temperature

focused

deterministic

0

creative

varied

1

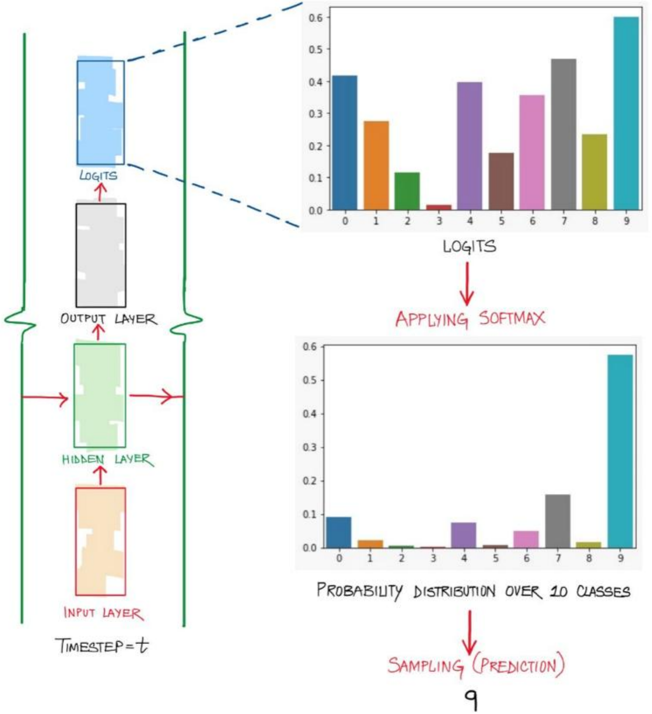
low Temperature high

Analogy:

only popular flavors

also exotic flavors

low Temperature high



Source: https://www.hopsworks.ai/dictionary/llm-temperature

Temperature balances predictability vs. creativity.

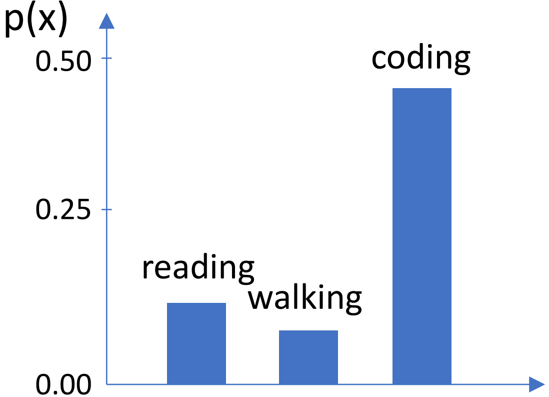
Large Language Models

LLM-Parameters: Temperature

Temperature impacts softmax function.

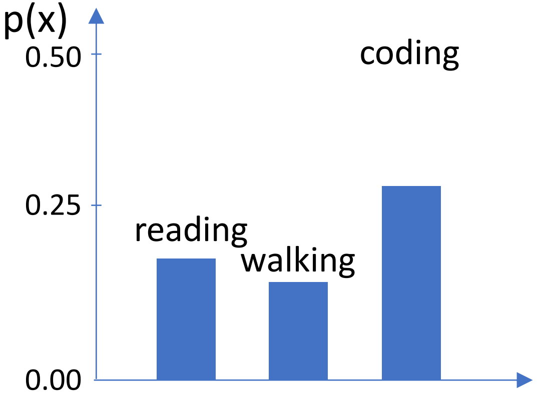
Softmax magnifies / reduces differences between logits.

Bert likes ________.



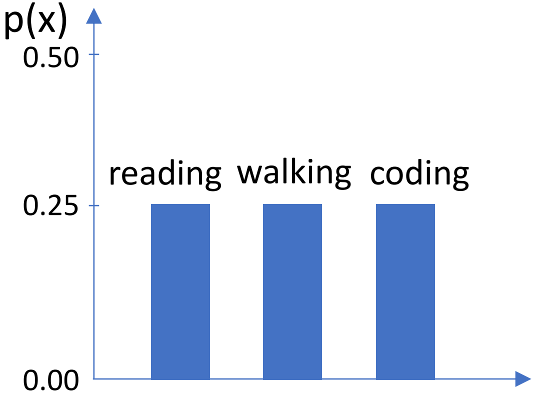
T=0.1

low temperature



T=0.5

medium temperature



T=20

extremely high temperature

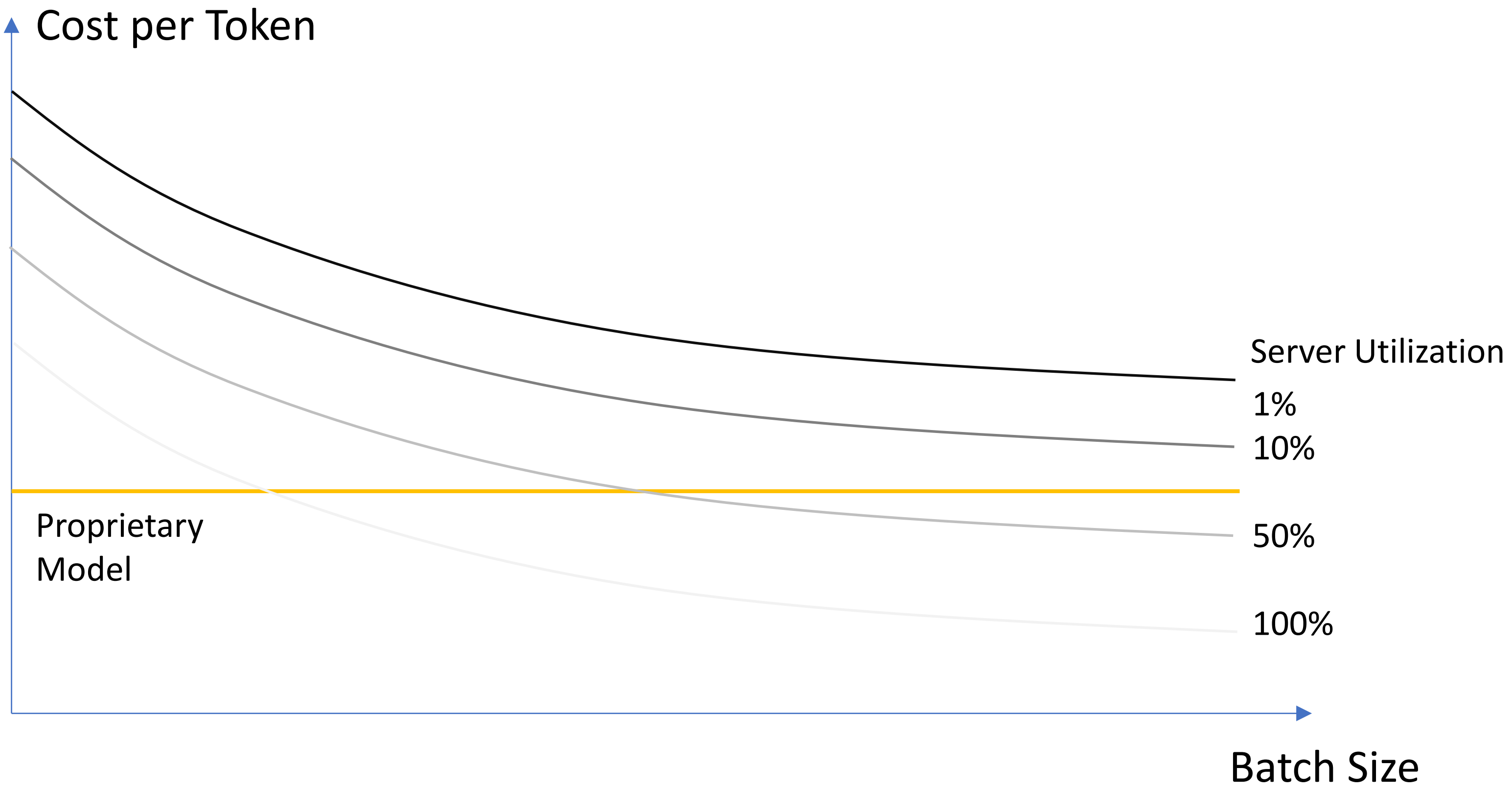
Large Language Models

Model Selection

- Price
- Performance
- Knowledge-Cutoff
- On-Prem vs. Cloud
- Closed Source vs. Open Weight
- Context-Window
- Latency

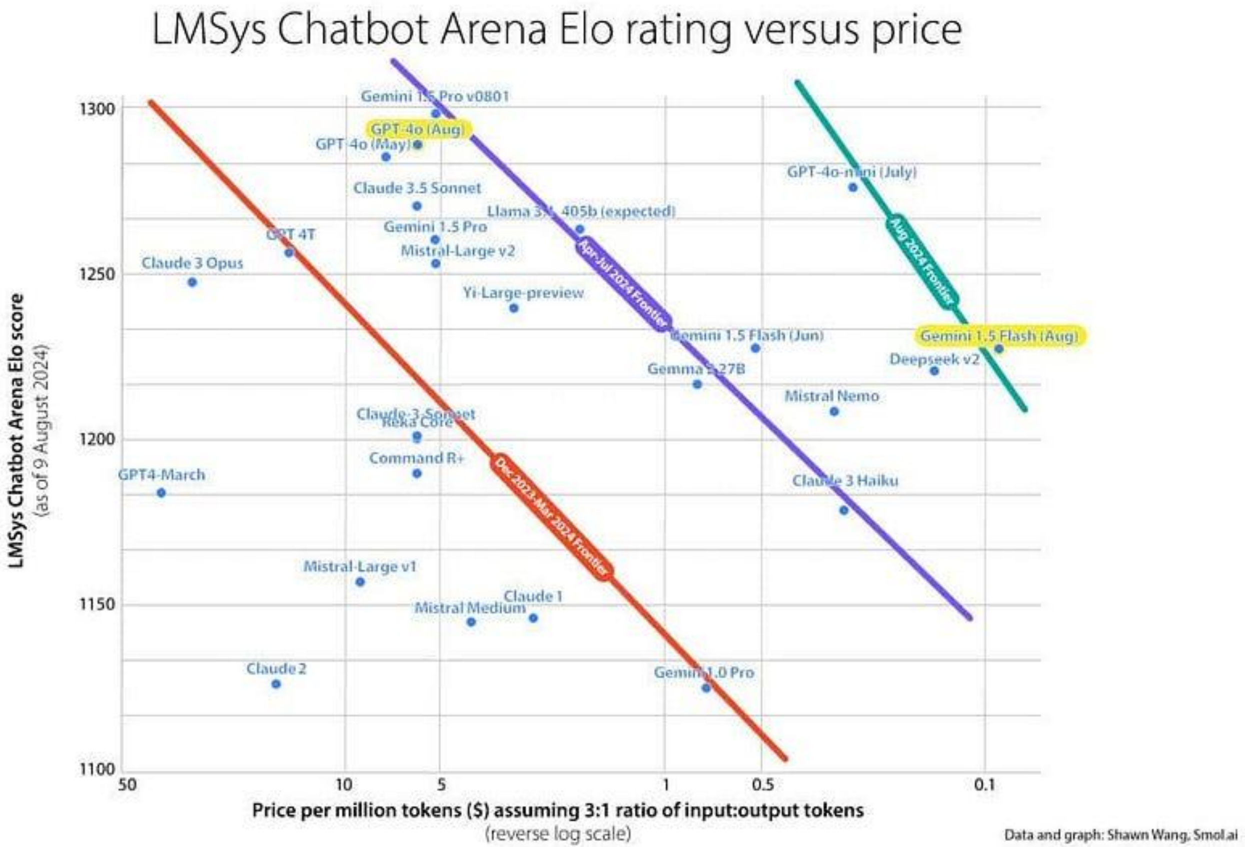
Large Language Models

Model Selection: Cost vs. Utilization



Large Language Models

Model Capabilities vs. Price



LMSys Chatbot Arena Elo rating versus price

Data and graph: Shawn Wang, Smol.ai

Large Language Models

Introduction

Artificial Narrow Intelligence (ANI)

- Designed for a specific task
- Limited to scope to well-defined task-specific applications

Artificial General Linguistic Intelligence (AGLI)

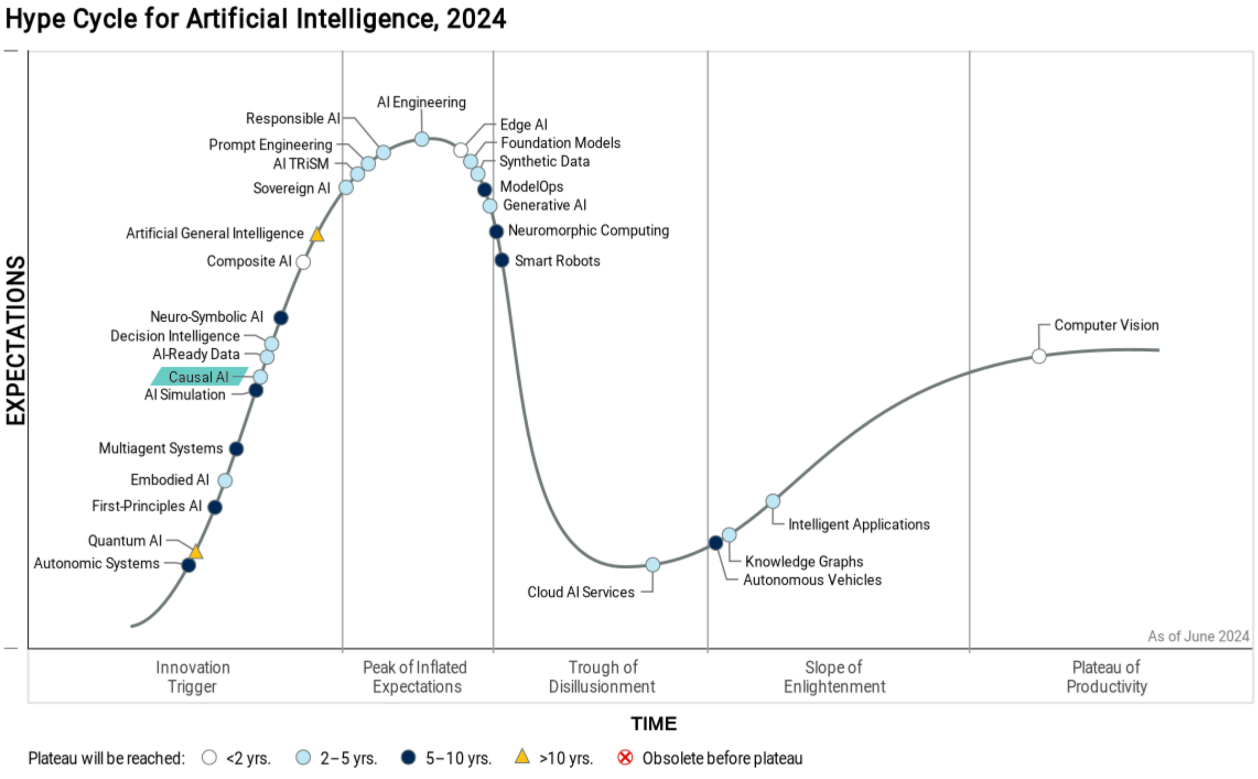
- Advanced general capabilities specifically in language understanding and generation
- Examples: GPT-4, Claude, Gemini, Llama, Mistral

Artificial General Intelligence (AGI)

- AI systems with ability to understand, learn, and apply knowledge across broad range of tasks
- Targets all cognitive tasks, generalize knowledge

Large Language Models

AI Hype Cycle

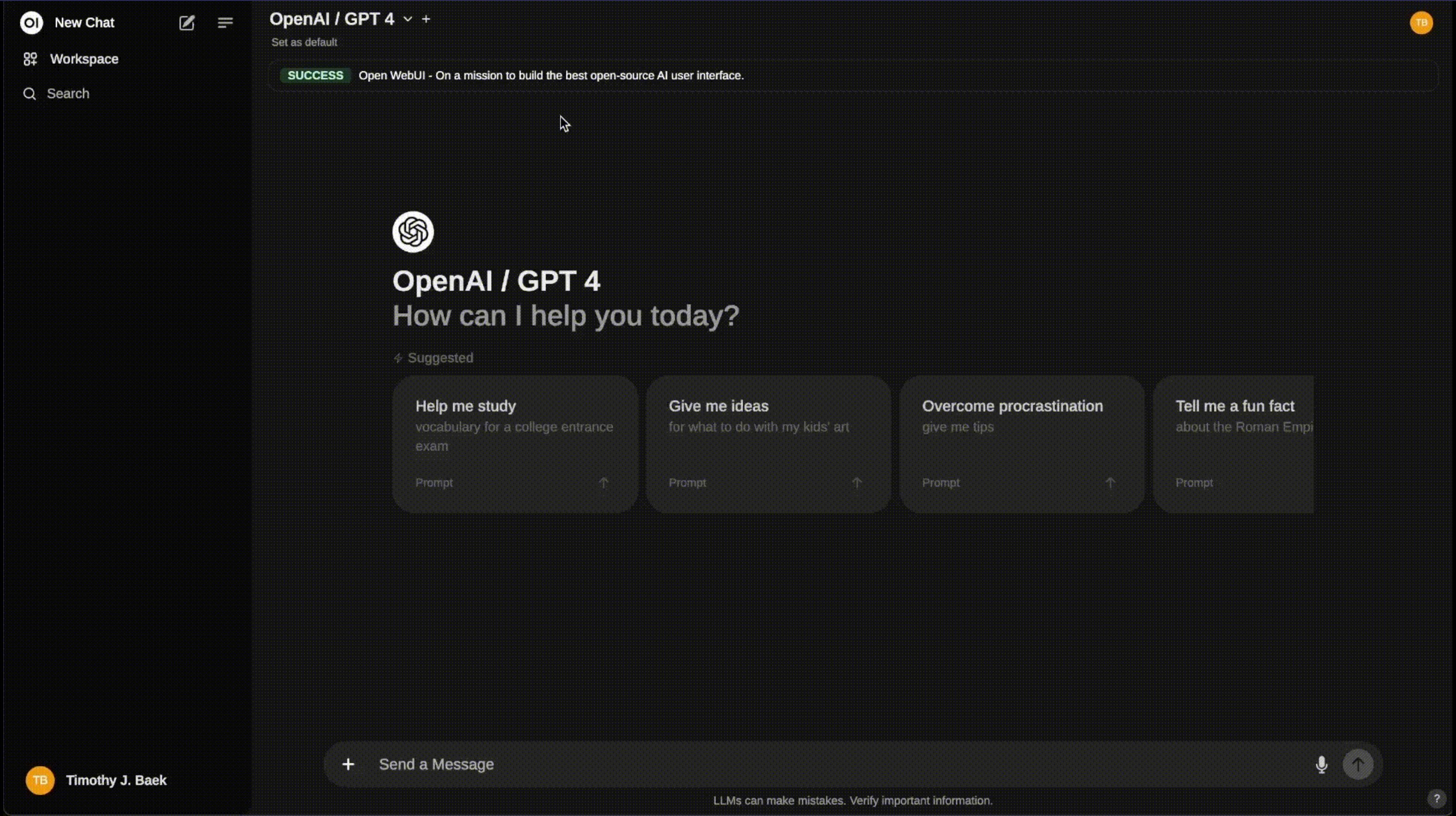


Hype Cycle for Artificial Intelligence, 2024

Source: https://xplain-data.de/gartner-ai-hype-cycle-2024/

Large Language Models

Using Local LLMs: OpenWebUI



SUCCESS Open WebUI - On a mission to build the best open-source AI user interface.

OpenAI / GPT 4
How can I help you today?

LLMs can make mistakes. Verify important information.

Large Language Models

Using Local Models with Ollama

```
from langchain_community.llms import Ollama
# %%
model = Ollama(model="gemma2:2b")

# %%
response = model.invoke("What is an LLM?")
```

https://ollama.com/

Download & Install

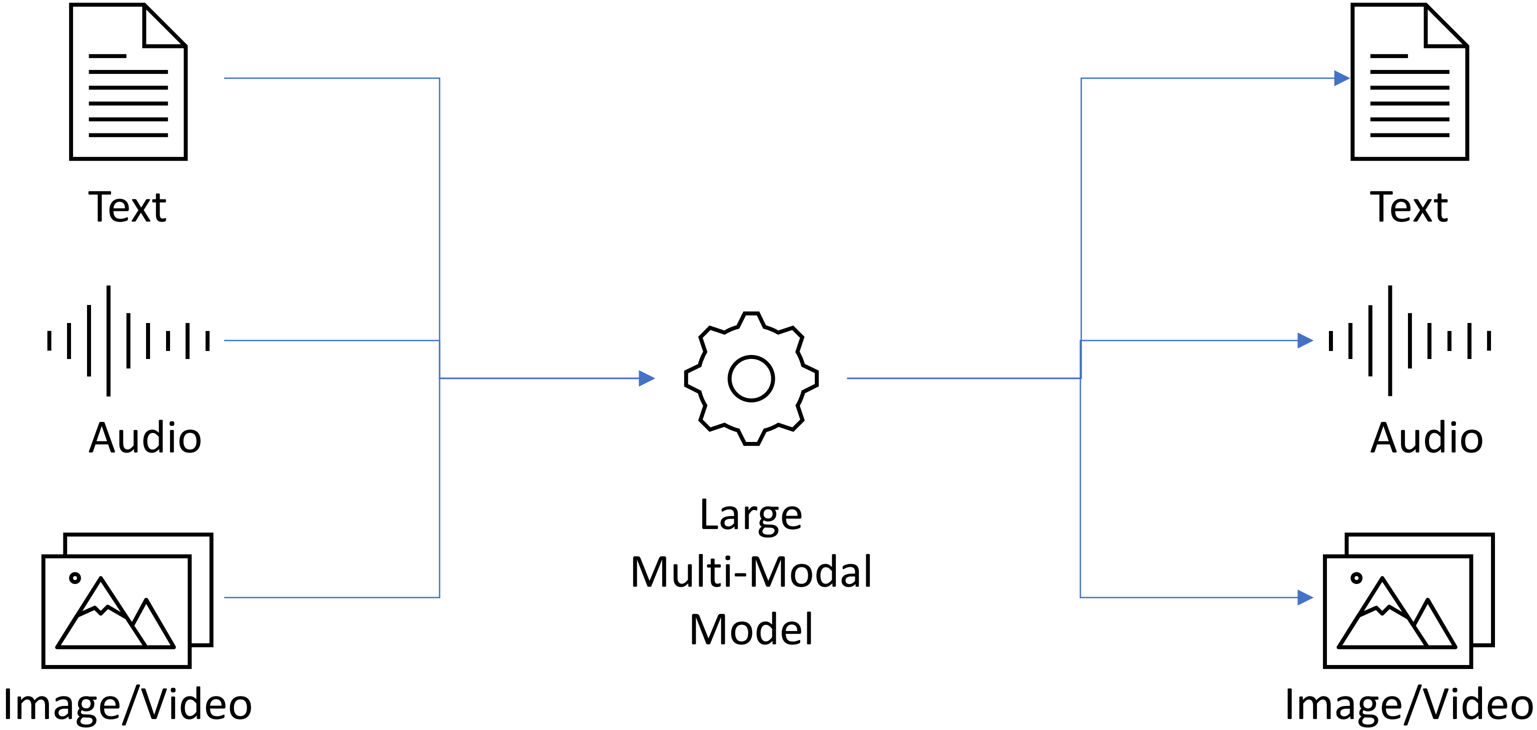
Download LLM

use in Python scripts

ollama pull gemma2:2b

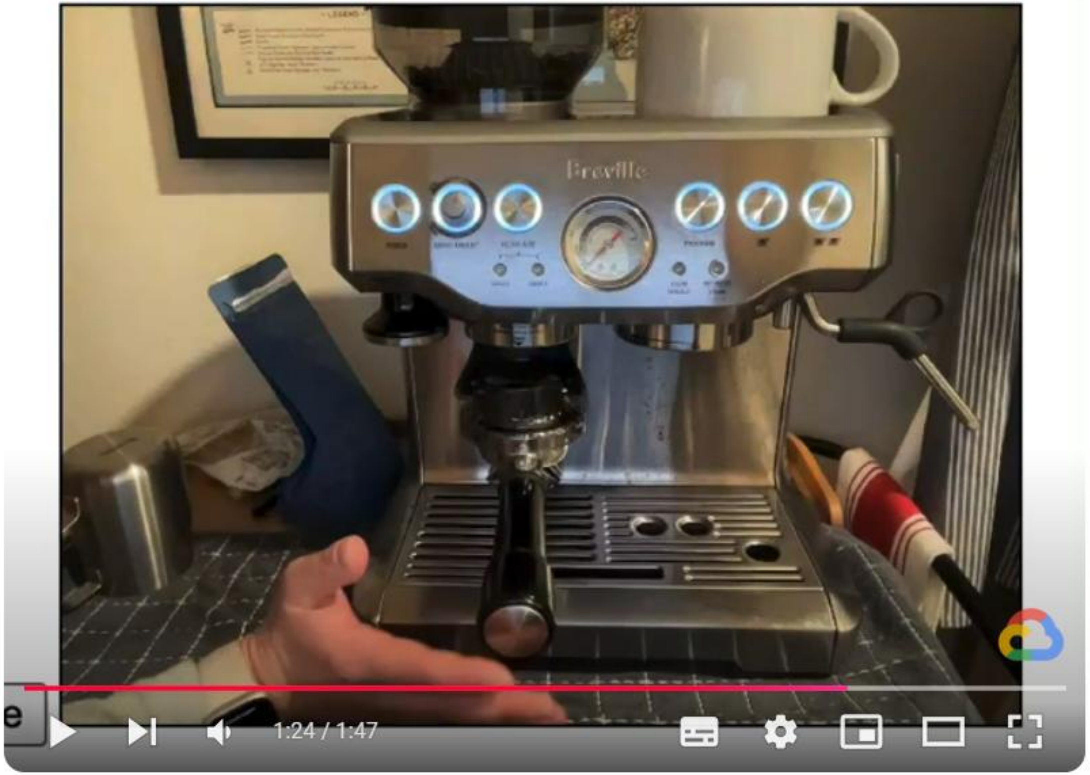
Large Language Models

Large Multimodal Models (LMM)



Large Language Models

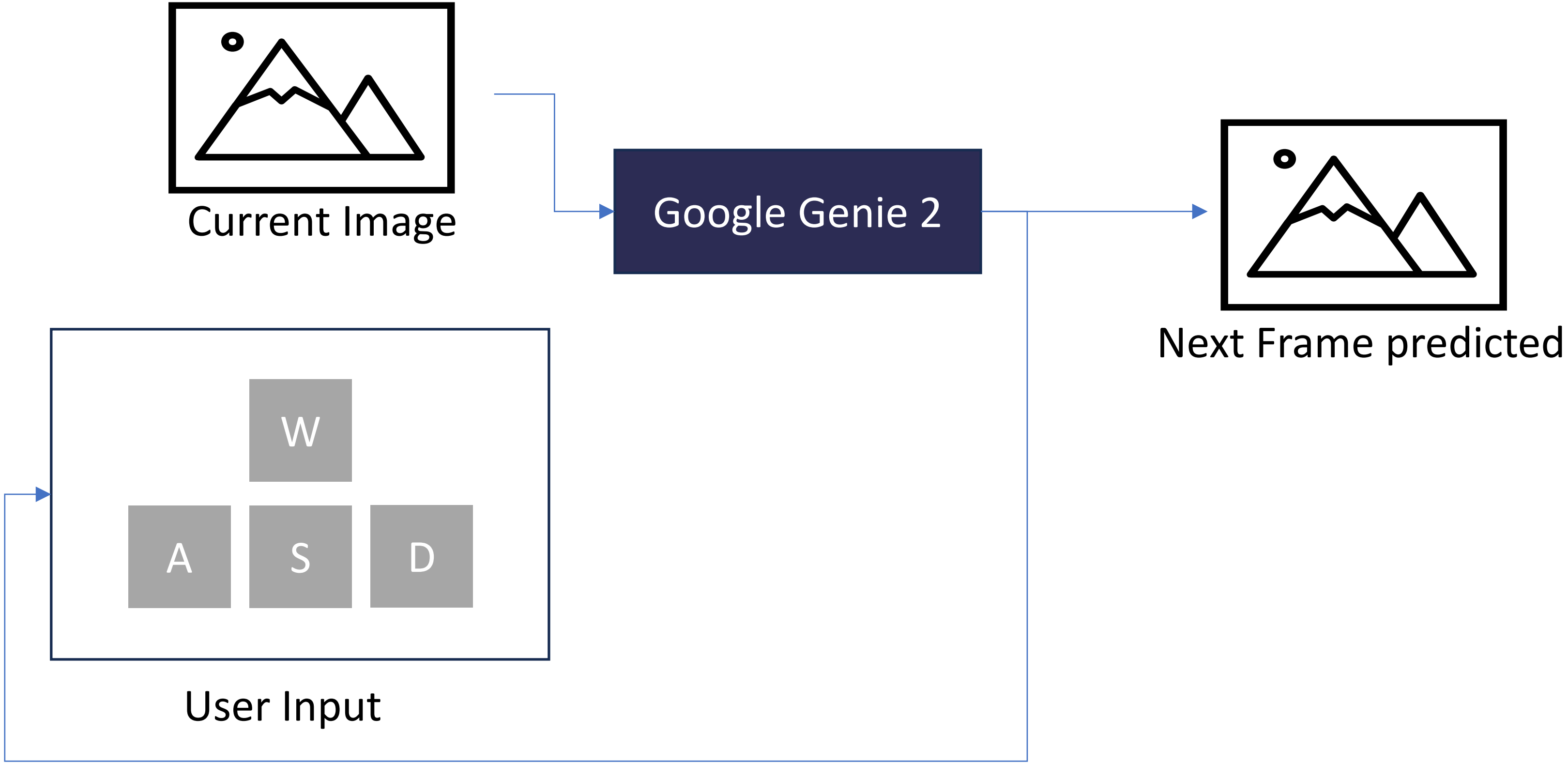
Large Multimodal Models (LMM)



Source: https://www.youtube.com/watch?v=_vc8sXog2ek&t=62s

Large Language Models

Large Video Models (LVM)



Current Image

Google Genie 2

Next Frame predicted

W

A

S

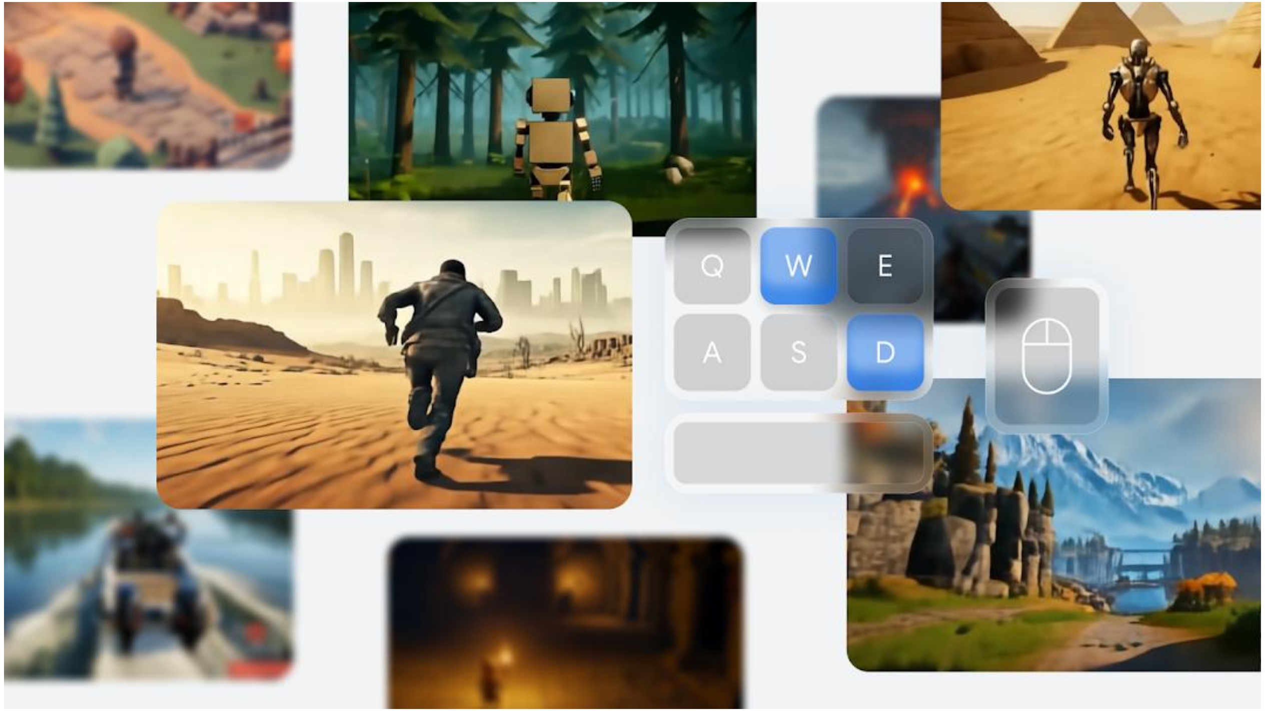
D

User Input

Large Language Models

Large Video Models (LVM)

Google Genie 2



Source: https://deepmind.google/discover/blog/genie-2-a-large-scale-foundation-world-model/

Tokenization

Introduction

- process of breaking down a sequence of text into individual units
- typical units: words, subwords
- units called tokens
- different approaches
    - word tokenization
    - sentence tokenization
    - subword tokenization

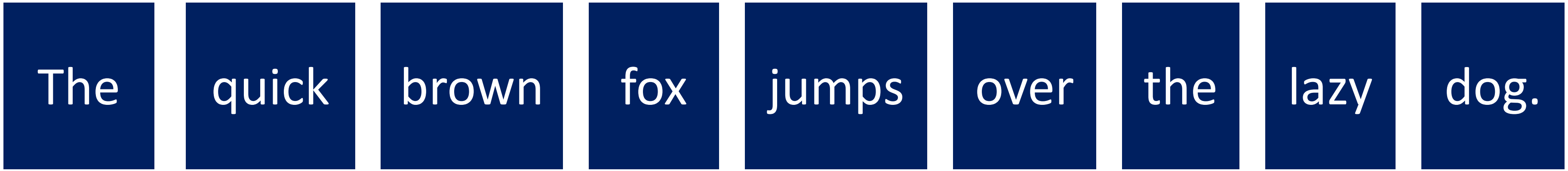
Tokenization

Word Tokenization

Sample Text

The quick brown fox jumps over the lazy dog.

Tokens



The

quick

brown

fox

jumps

over

the

lazy

dog.

Tokenization

Sentence Tokenization

Sample Text

The quick brown fox jumps over the lazy dog.

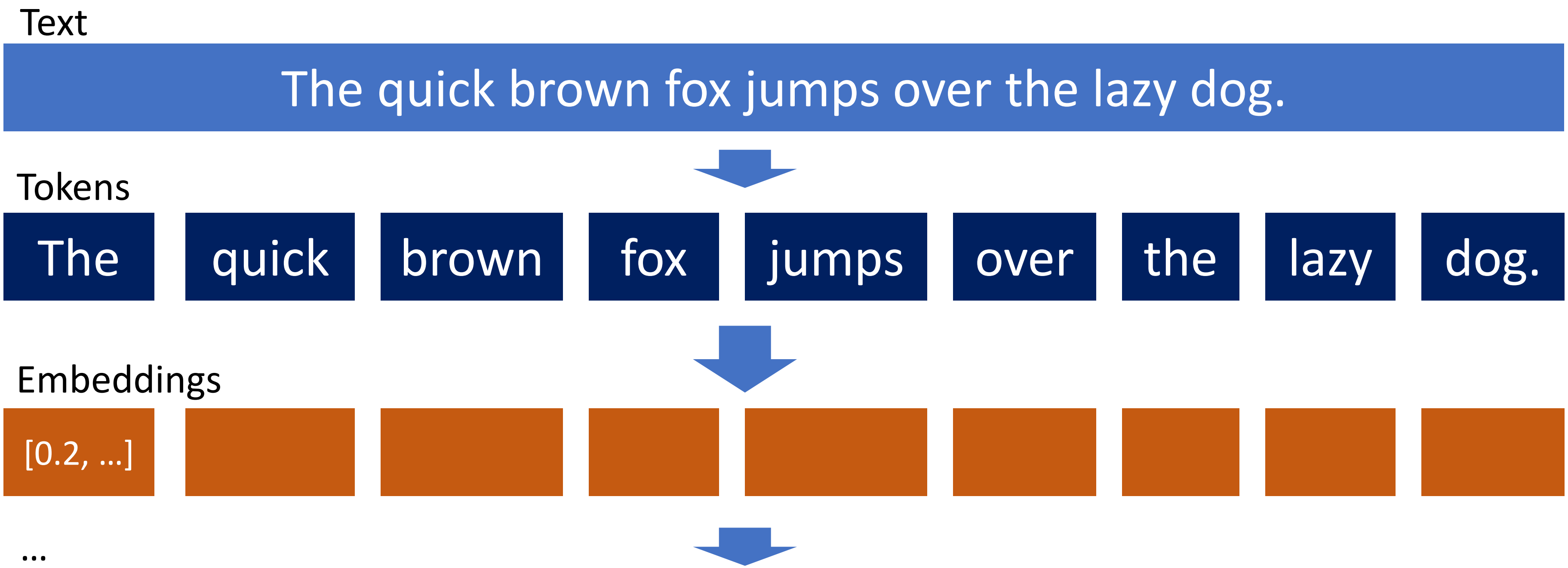
Tokens

The quick brown fox jumps over the lazy dog.

Tokenization

Word Tokenization and Embedding

- fundamental step in NLP (Natural Language Processing)
- first step of all NLP tasks



Text

The quick brown fox jumps over the lazy dog.

Tokens

The	quick	brown	fox	jumps	over	the	lazy	dog.

Embeddings

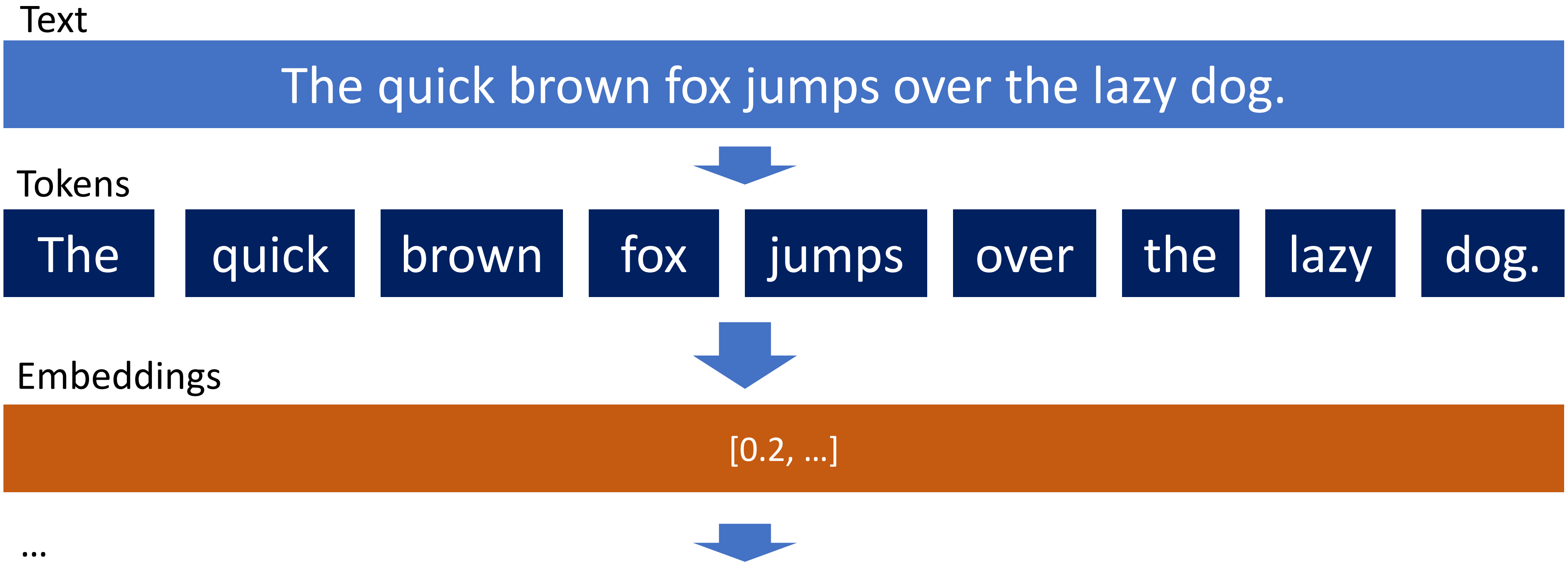
[0.2, …]								

…

Tokenization

Sentence Tokenization and Embedding

- fundamental step in NLP
- first step of all NLP tasks



Text

The quick brown fox jumps over the lazy dog.

Tokens

The quick brown fox jumps over the lazy dog.

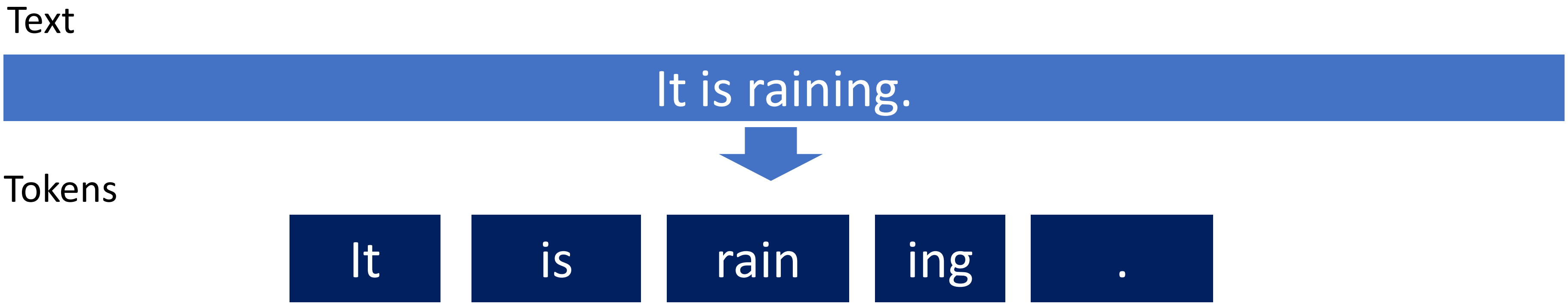
Embeddings

[0.2, …]

…

Tokenization

Sub-word Tokenization



Text

It is raining.

Tokens

It | is | rain | ing | .