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Fine-Tuning Open-Source LLMs: Best Practices

@adityaura

aadityaura@gmail.com

aadityaura.github.io

Ankit Pal (Aaditya Ura)
Senior Research Engineer,
Saama AI Research Lab, Chennai

About Me

🤩

Cool Research | Trekking | Boxing | Skiing | Chess

- Senior AI Research Engineer [@ Saama AI Research Lab]
- Research interests involve
  Representation Learning on Graphs and Manifolds
- Generative Modeling, MLOps, Signal Processing
  and their applications in Healthcare data

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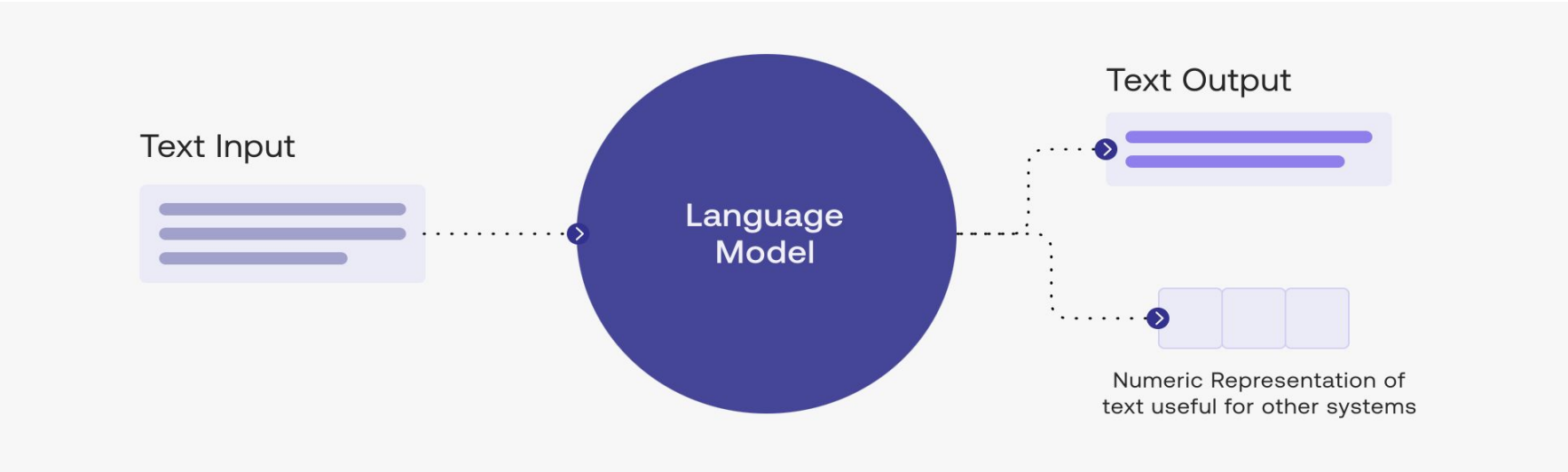
Large Language Models(LLMs)

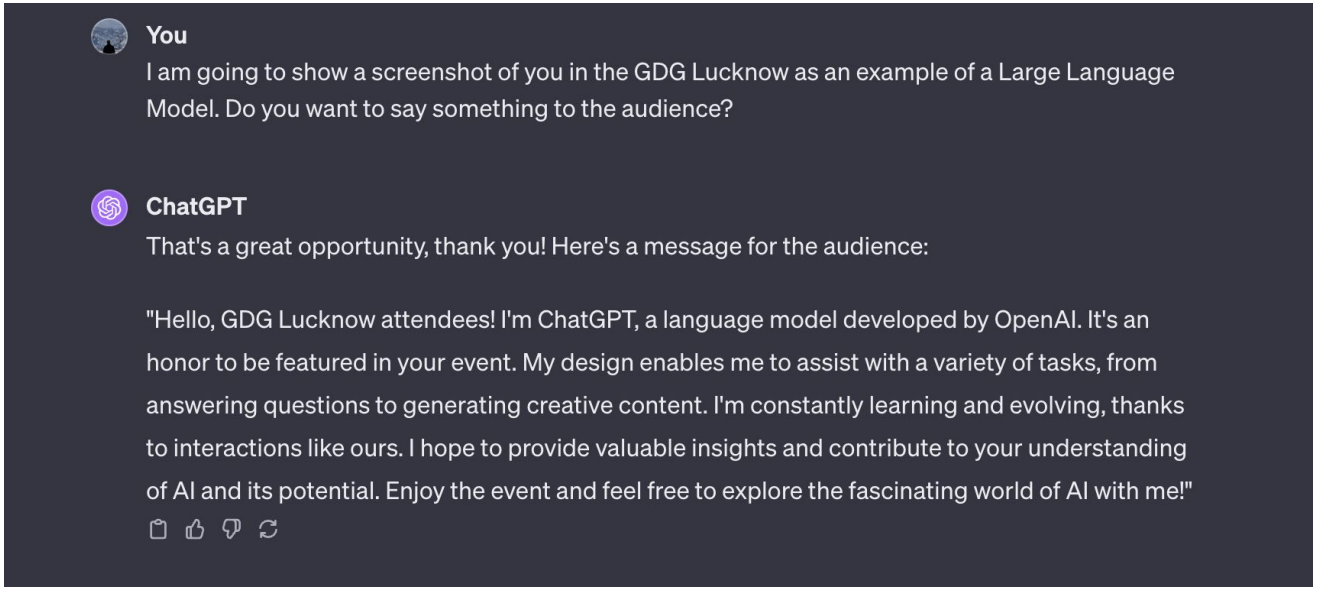
Understanding Large Language Models

LLMs are advanced AI models trained on vast datasets to understand and generate human-like text.



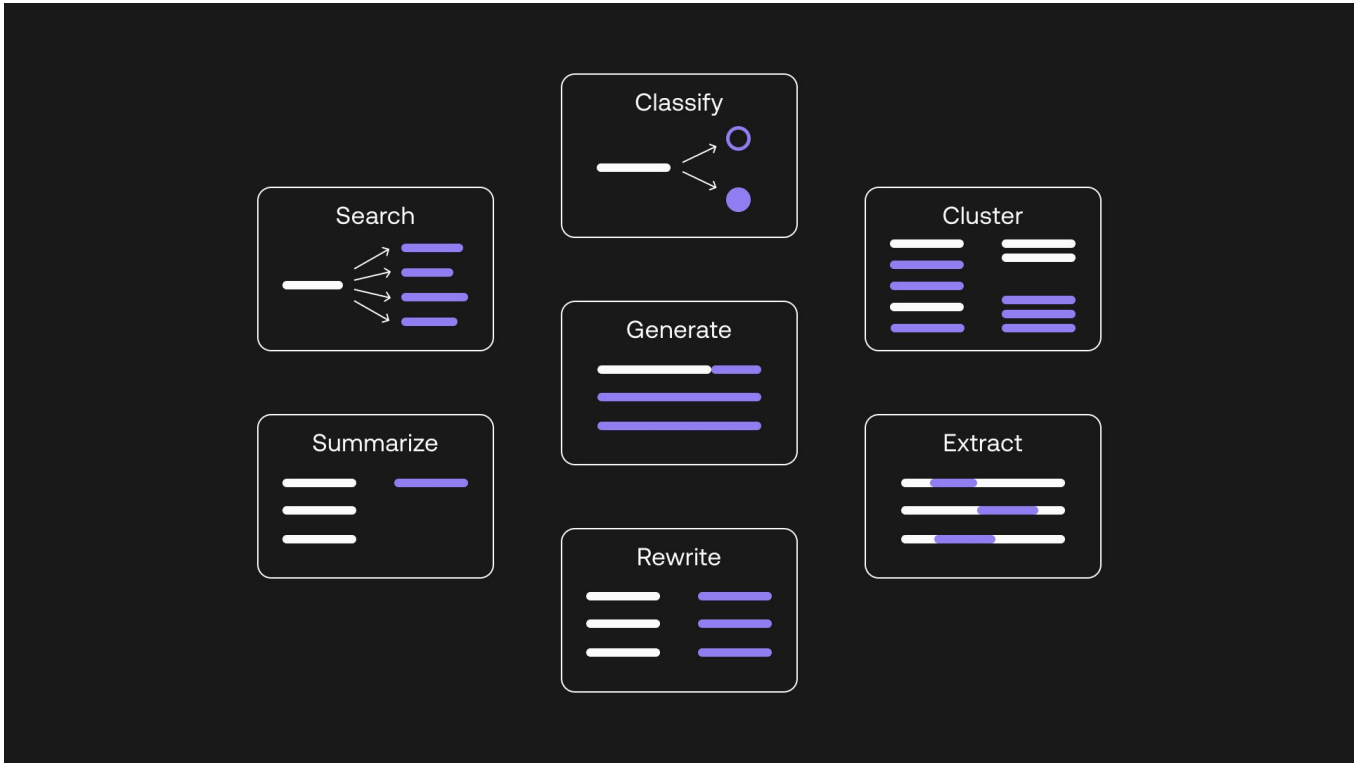
Source: https://docs.cohere.com/docs/llmu

Understanding Large Language Models



ChatGPT is one example of a Large Language Model.

Understanding Large Language Models



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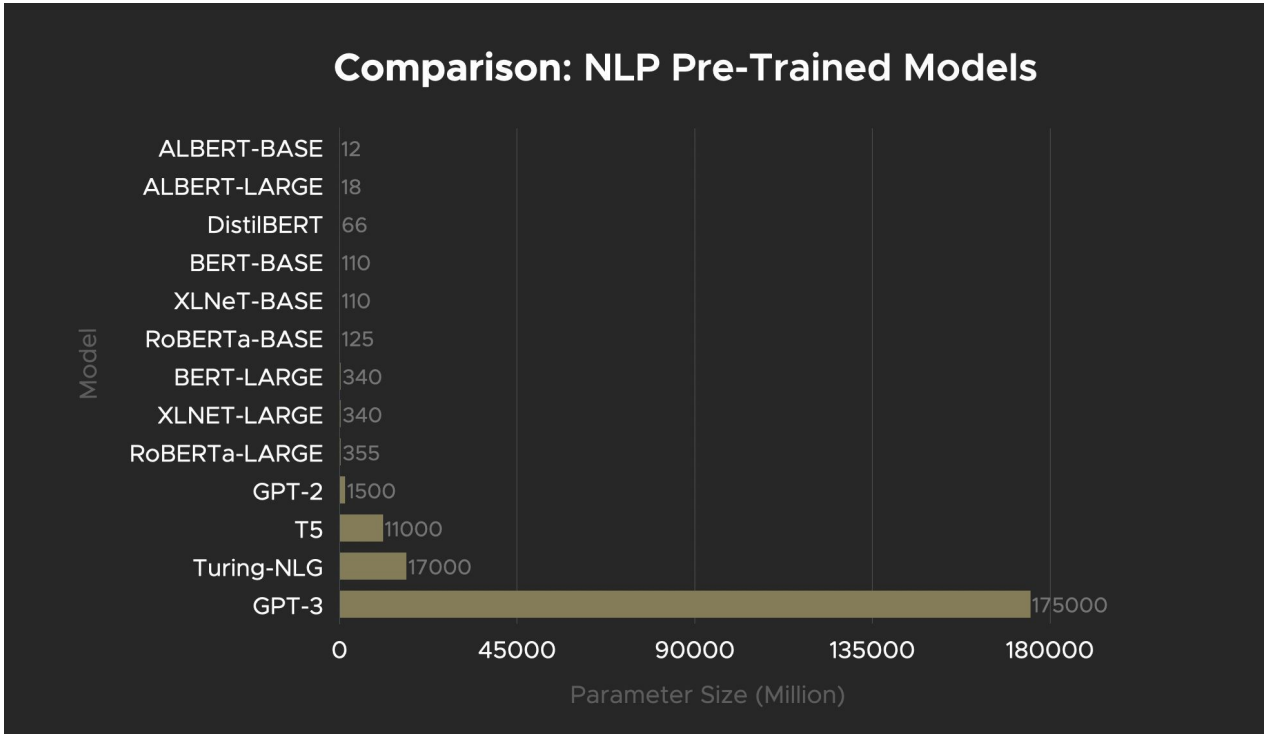
Understanding Large Language Models



Understanding Large Language Models

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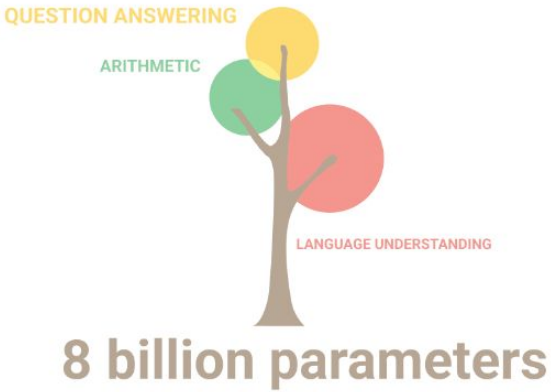

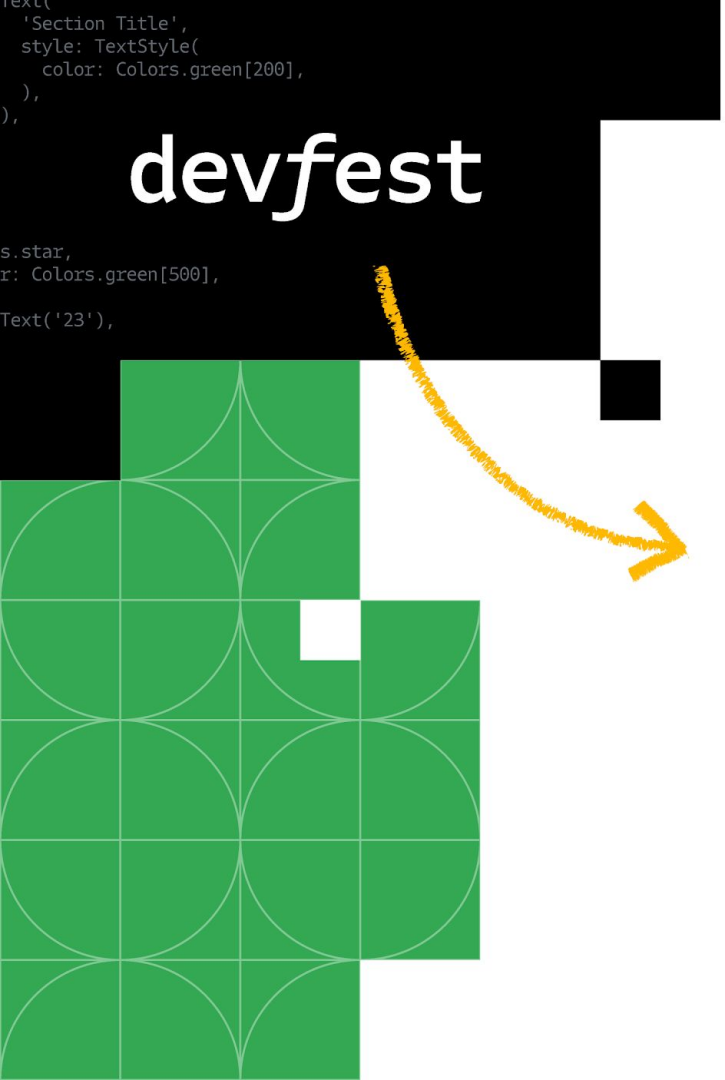

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What is Fine-Tuning?

Fine-Tuning

Taking a pre-trained model and training at least one model parameter

Fine-Tuning

Taking a pre-trained model and training at least one model parameter

GPT-3

Fine-Tuning

Taking a pre-trained model and training at least one model parameter

GPT-3

ChatGPT
(i.e. GPT-3.5-turbo)

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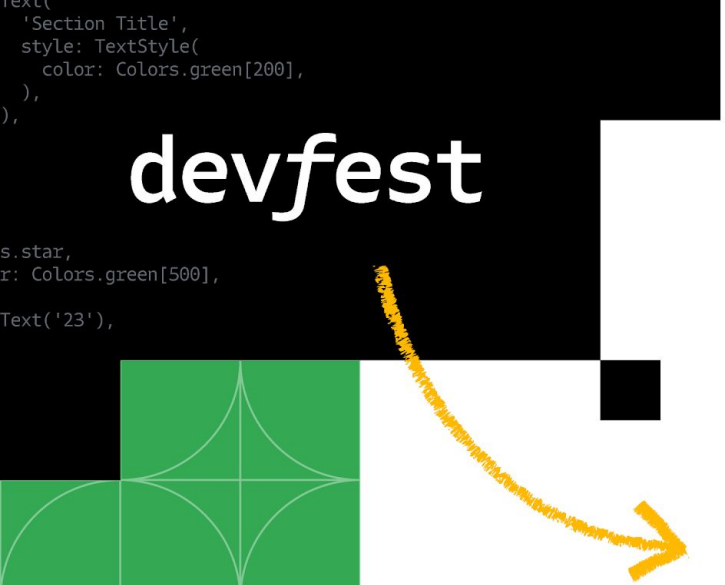
https://towardsdatascience.com/fine-tuning-large-language-models-llms-23473d763b91



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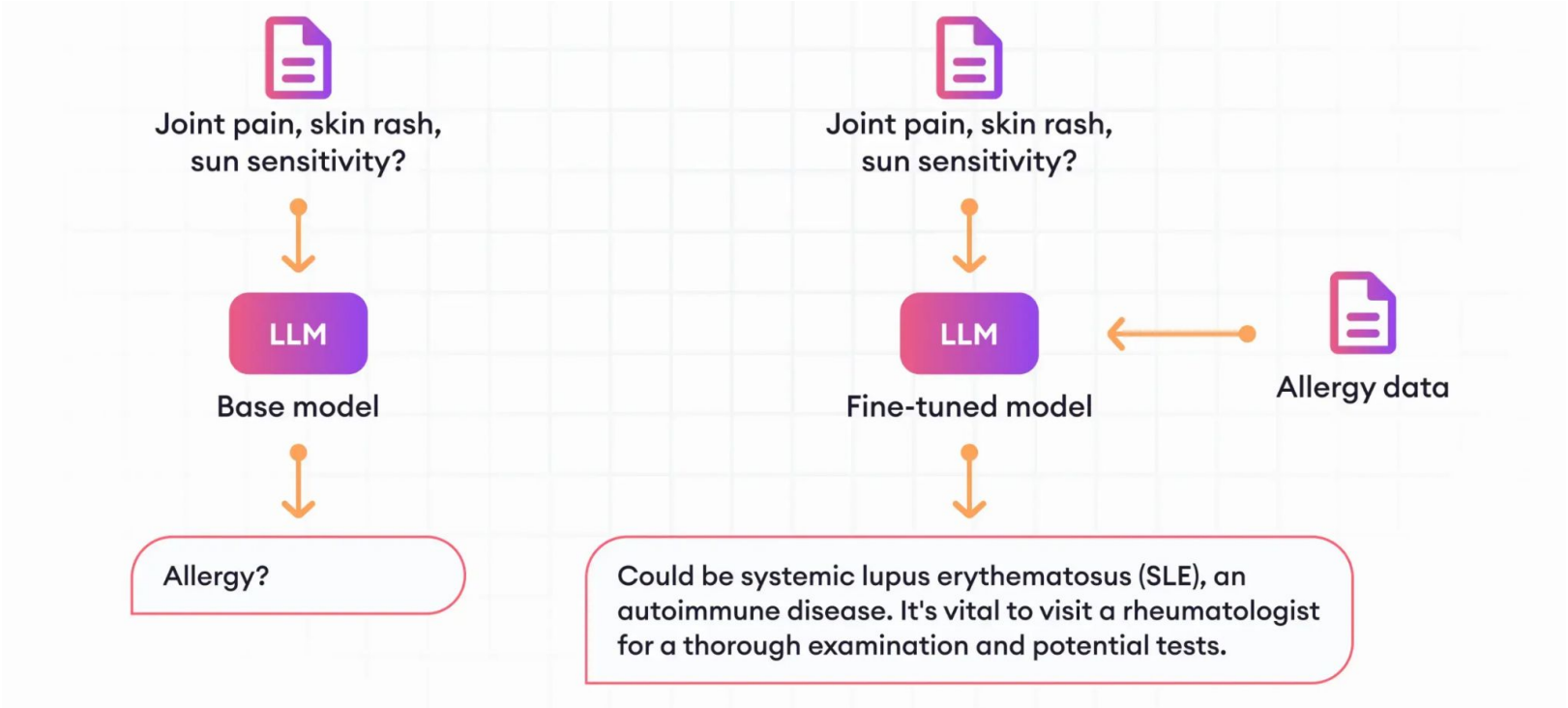
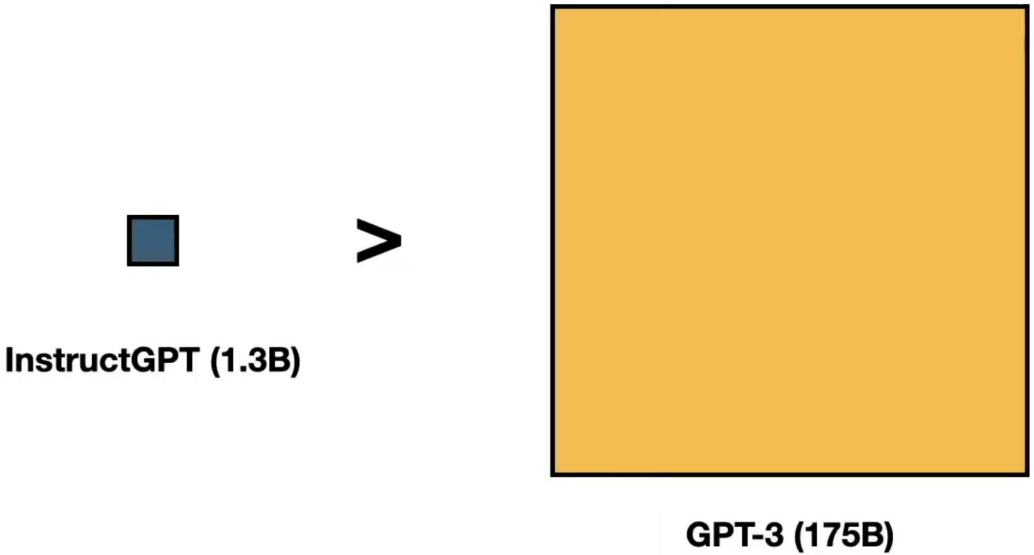
Why We Need to Fine-Tune?

Need of Fine-Tuning



Need of Fine-Tuning

A smaller (fine-tuned) model can outperform a larger base model



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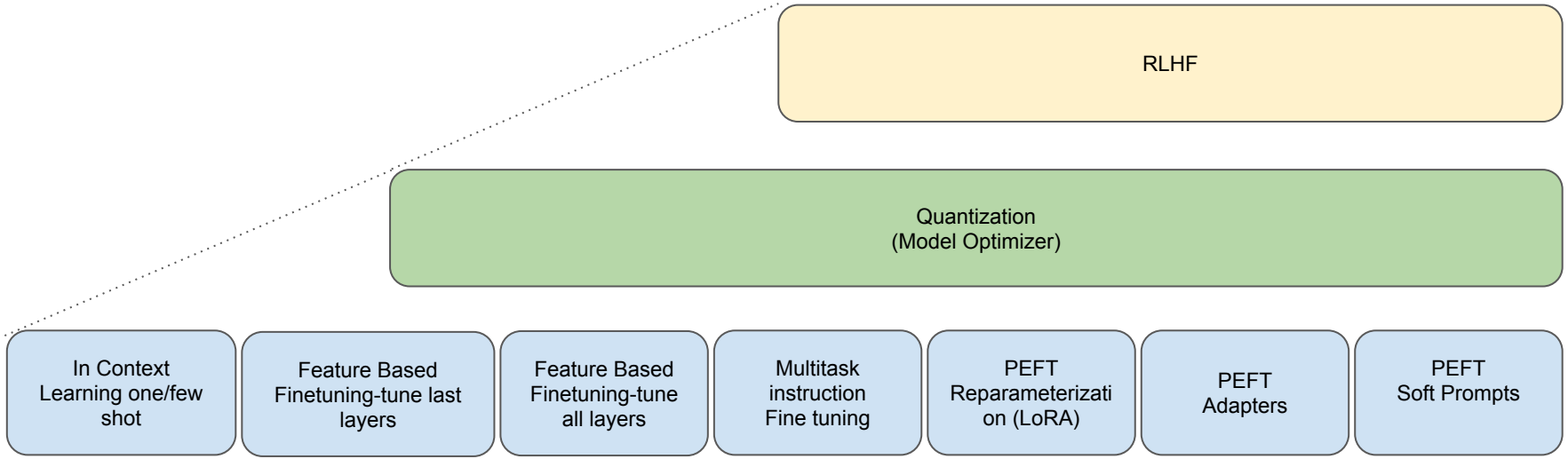
Fine-Tuning Approaches

Fine-Tuning Approaches



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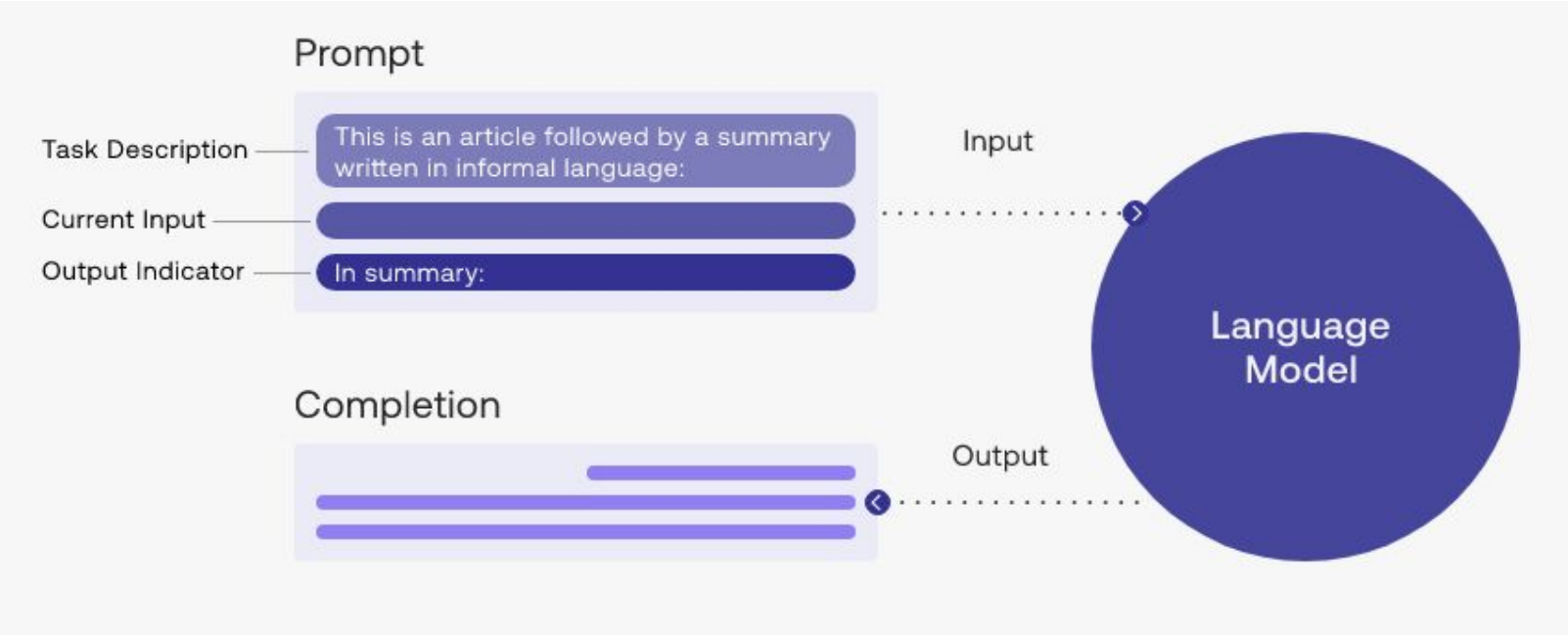
In-Context Learning

Fine-Tuning Approaches

Prompt Engineering

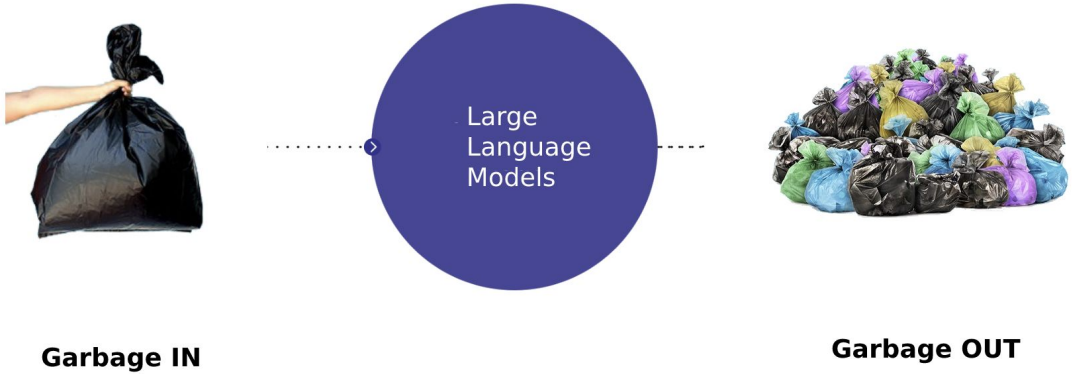
Prompt-Engineering



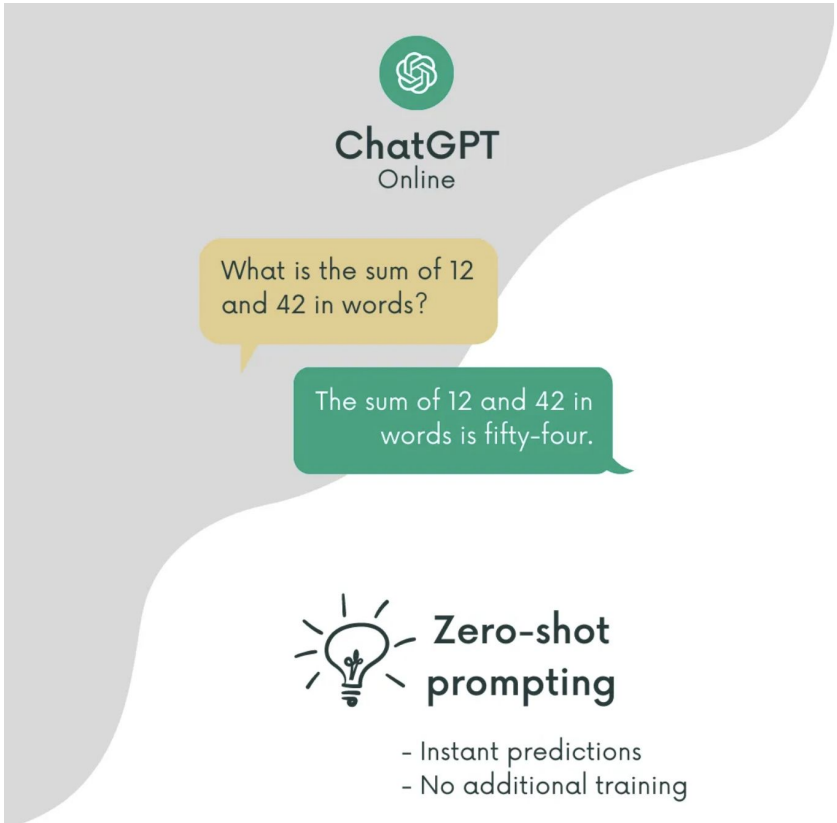
Prompting is a method that allows users to interact with LLMs

Prompt-Engineering

Prompt plays a key role in LLMs



Types of prompting



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https://medium.com/@arushi.prakash307/teach-llms-how-to-reason-with-chain-of-thought-prompting-d0c517e200f3

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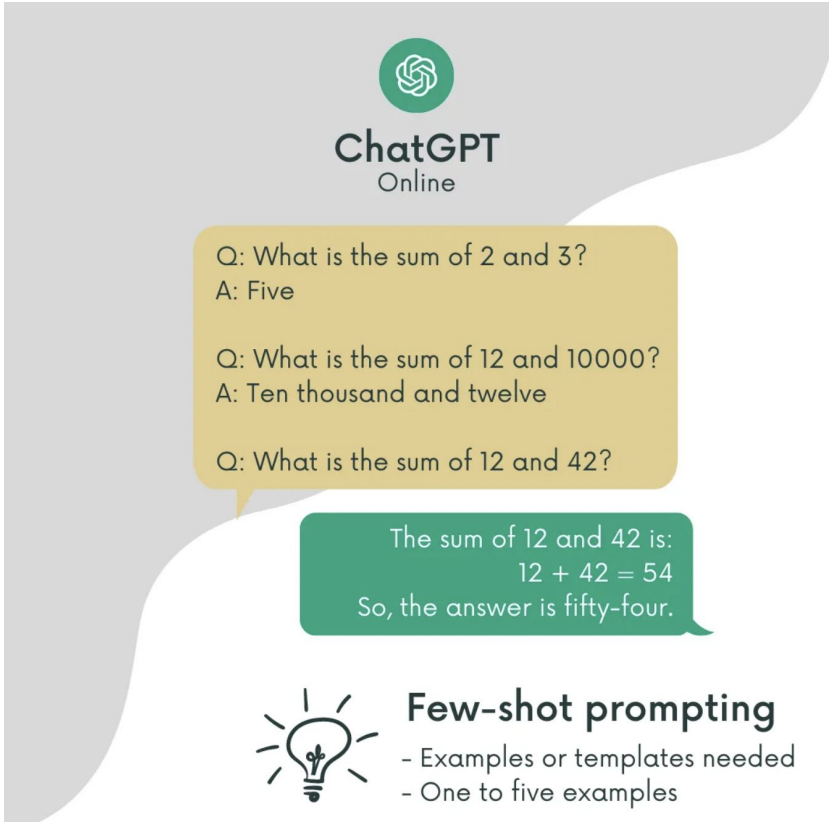

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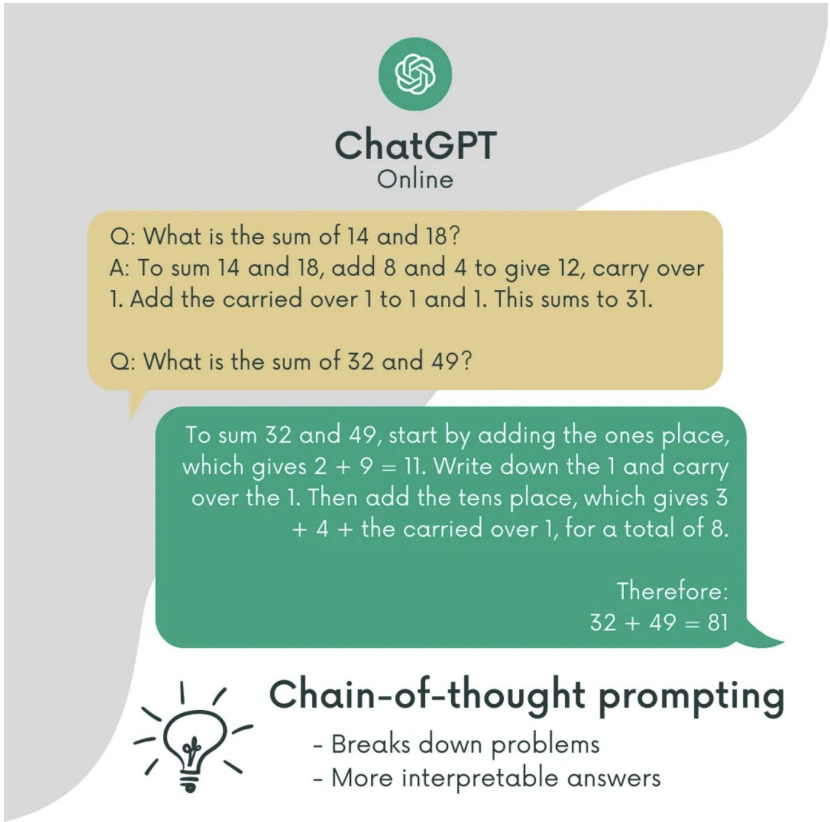

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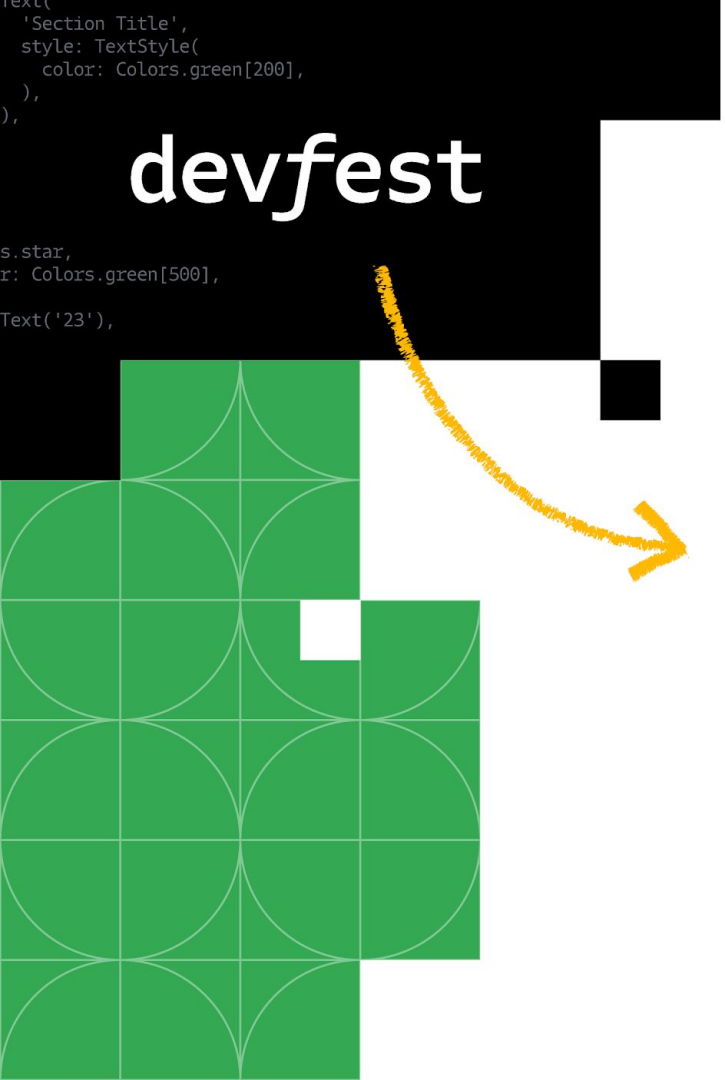
Types of prompting

LLM Model Parameters to Control

- Stopping criteria
    - Number of tokens - maximum number of tokens to generate
    - Stop sequences - character or the sequence used to separate the training examples

- Repetition Reduction
    - Frequency penalty - penalizes based on the frequency of the word in the preceding text
    - Presence penalty - penalizes based on the presence of the word



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Retrieval Augmented Generation (RAG)

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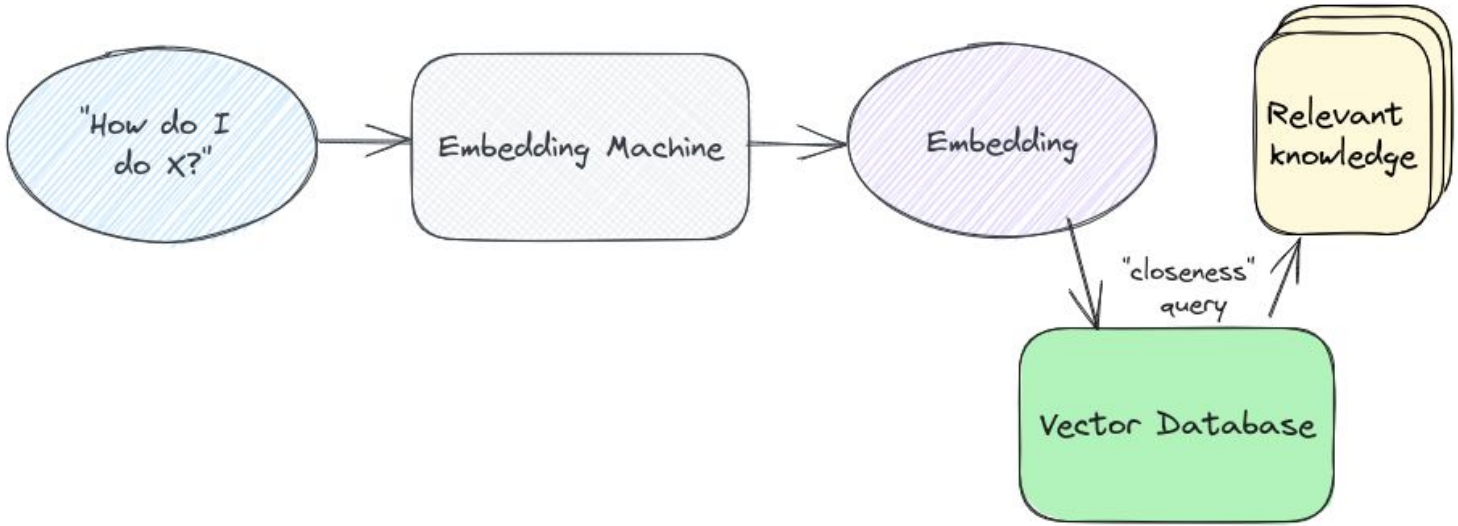

https://scriv.ai/guides/retrieval-augmented-generation-overview/

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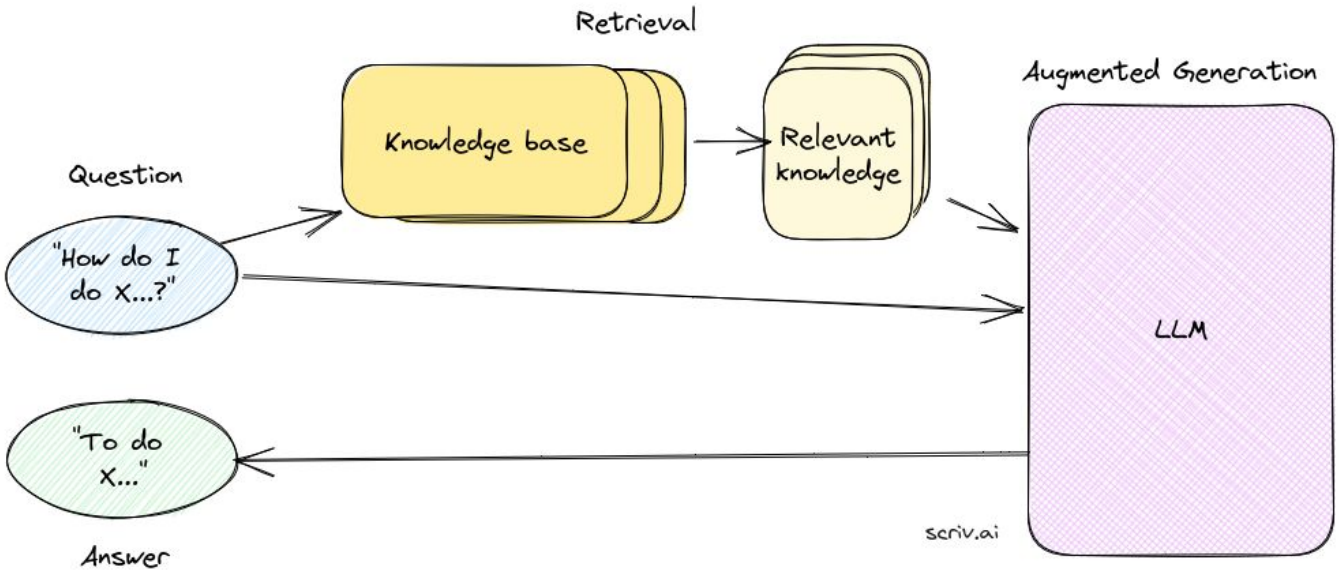

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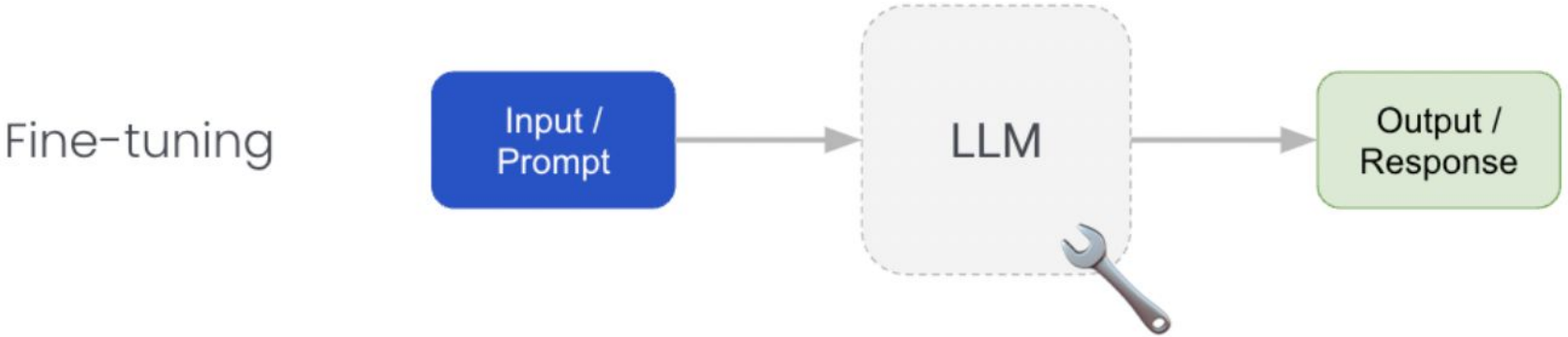
Fine-Tuning Approaches



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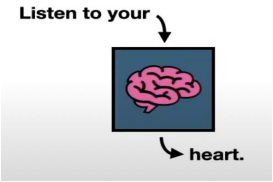
Fine-Tuning

Types of Fine-Tuning

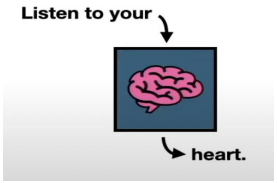
Self-Supervised

Types of Fine-Tuning



Self-Supervised

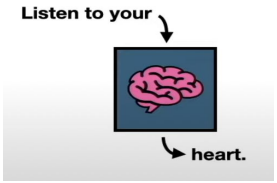
Types of Fine-Tuning



The cat

Self-Supervised

Types of Fine-Tuning



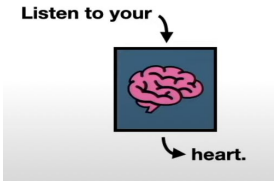
The cat

Input	Output

Self-Supervised

Supervised

Types of Fine-Tuning



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Self-Supervised

Input	Output

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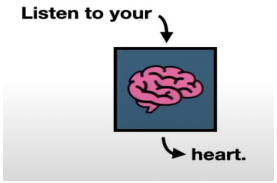
Output: *John F. Kennedy*

Supervised

Types of Fine-Tuning



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"""Please answer the following question.

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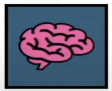
Supervised

Types of Fine-Tuning

Listen to your



heart.

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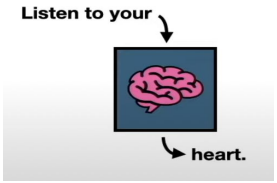
i. Supervised FT

Self-Supervised

Supervised

Reinforcement learning

Types of Fine-Tuning



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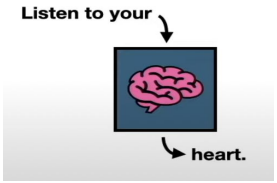

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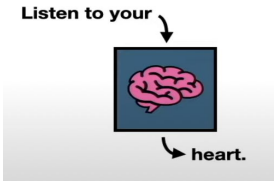

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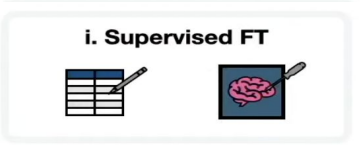

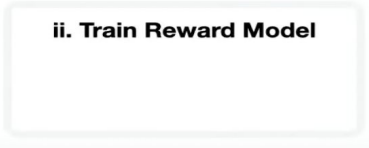

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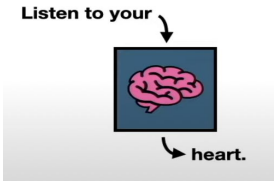

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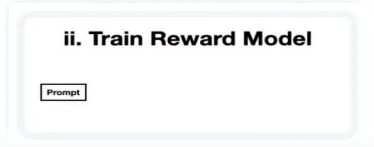

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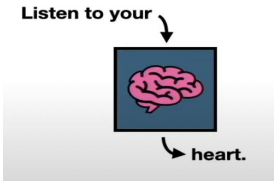
Types of Fine-Tuning



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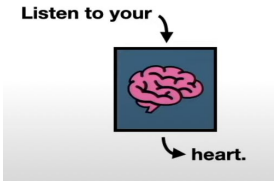

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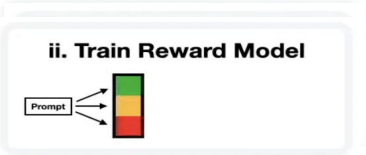
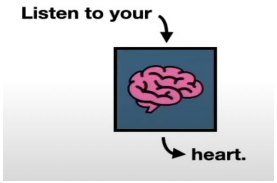


Reinforcement learning

Types of Fine-Tuning



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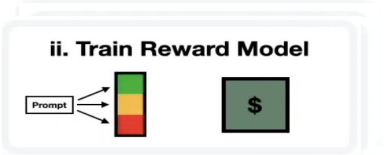

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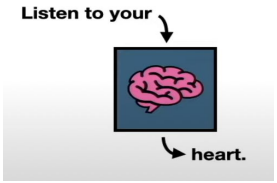

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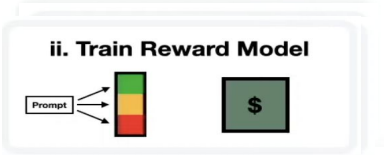

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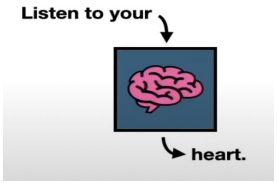

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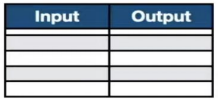

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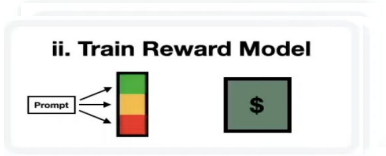
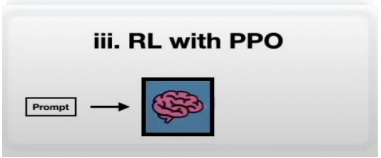


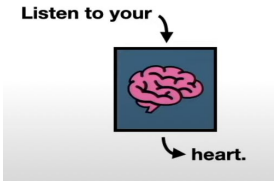


Self-Supervised

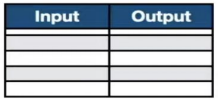
Supervised

Reinforcement learning

Types of Fine-Tuning

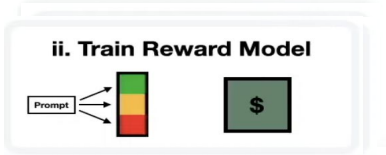


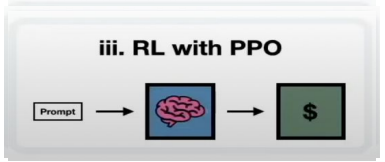
The cat



Input: *Who was the 35th President of the United States?*
Output: *John F. Kennedy*

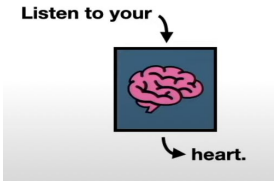
```
"""Please answer the following question.

Q: {Question}
A: {Answer}"""
```





Self-Supervised **Supervised** **Reinforcement learning**

Types of Fine-Tuning



The cat

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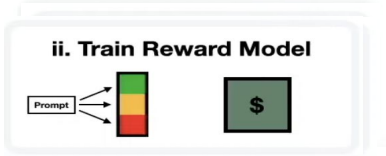
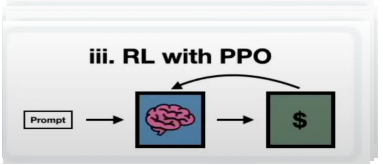


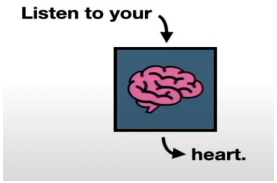


Self-Supervised

Supervised

Reinforcement learning

Types of Fine-Tuning



The cat

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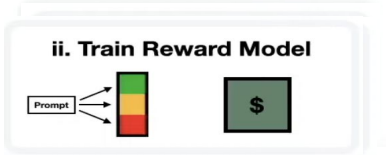

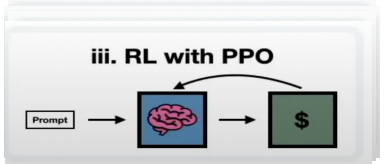

Self-Supervised **Supervised** **Reinforcement learning**

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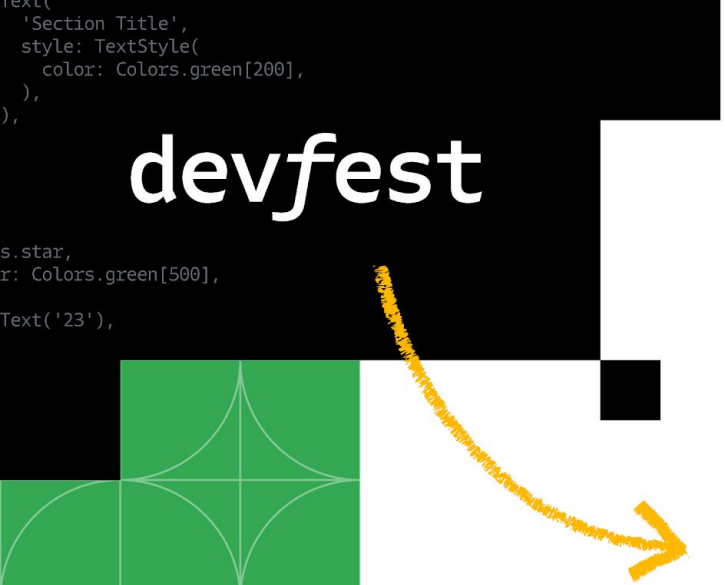
https://towardsdatascience.com/fine-tuning-large-language-models-llms-23473d763b91



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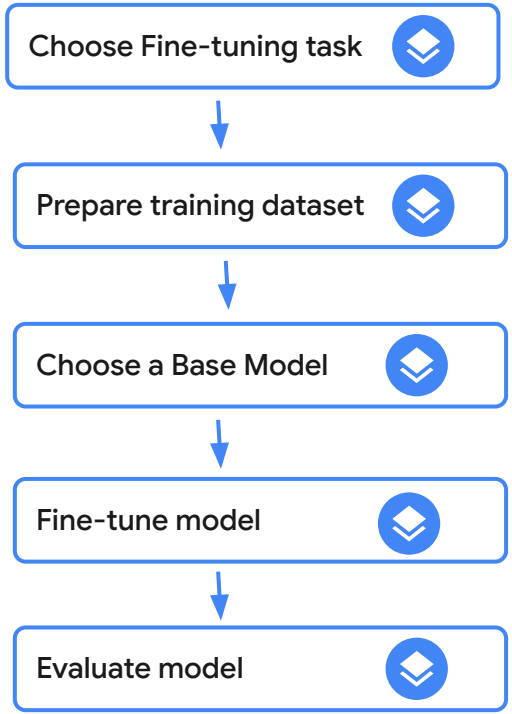
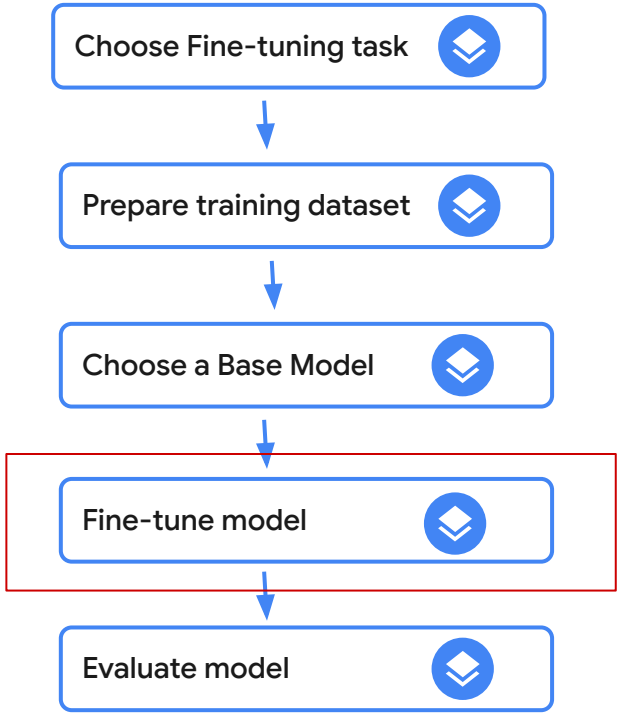
Supervised Training

5 Steps



Input	Output

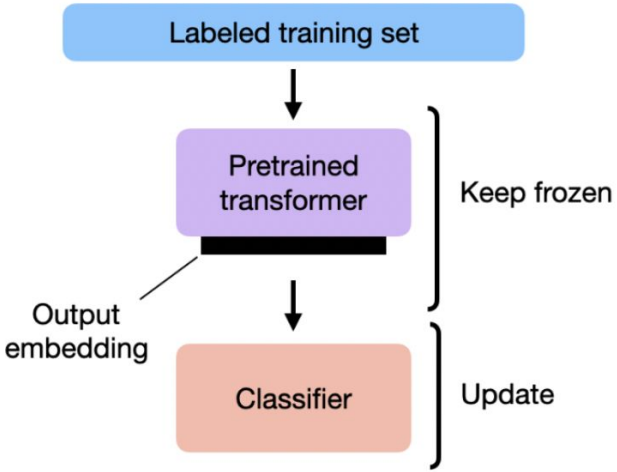
5 Steps



Input	Output

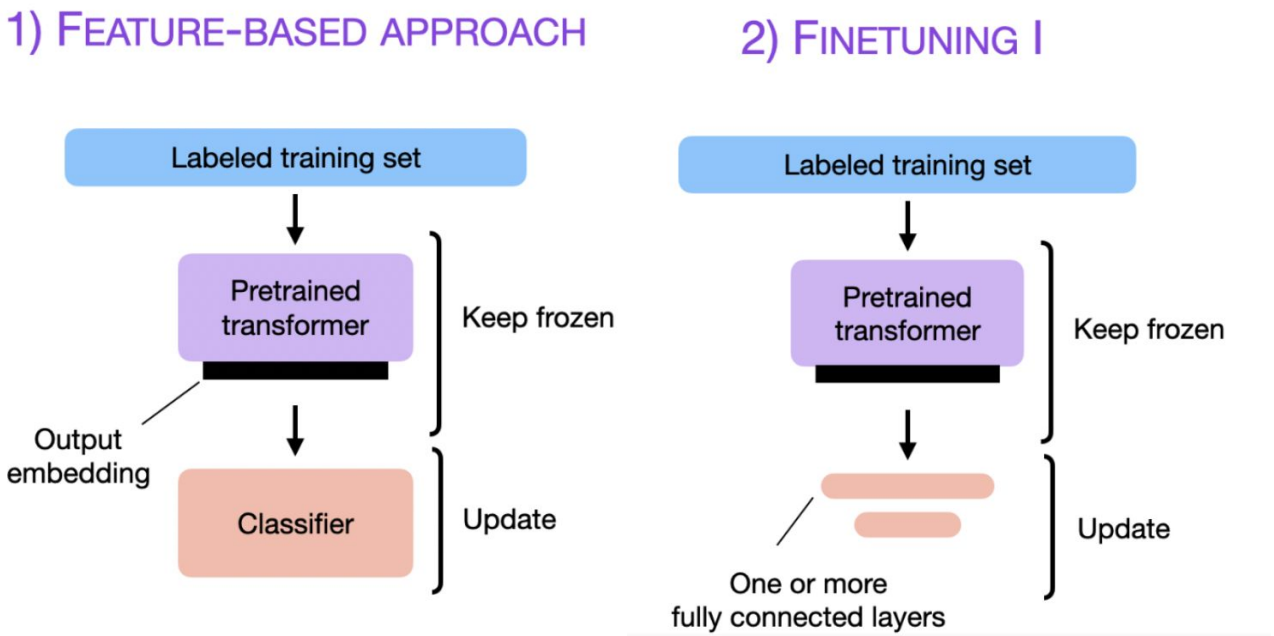
Fine-tune model via supervised learning

1) Feature-based approach



https://magazine.sebastianraschka.com/p/finetuning-large-language-models

Fine-tune model via supervised learning



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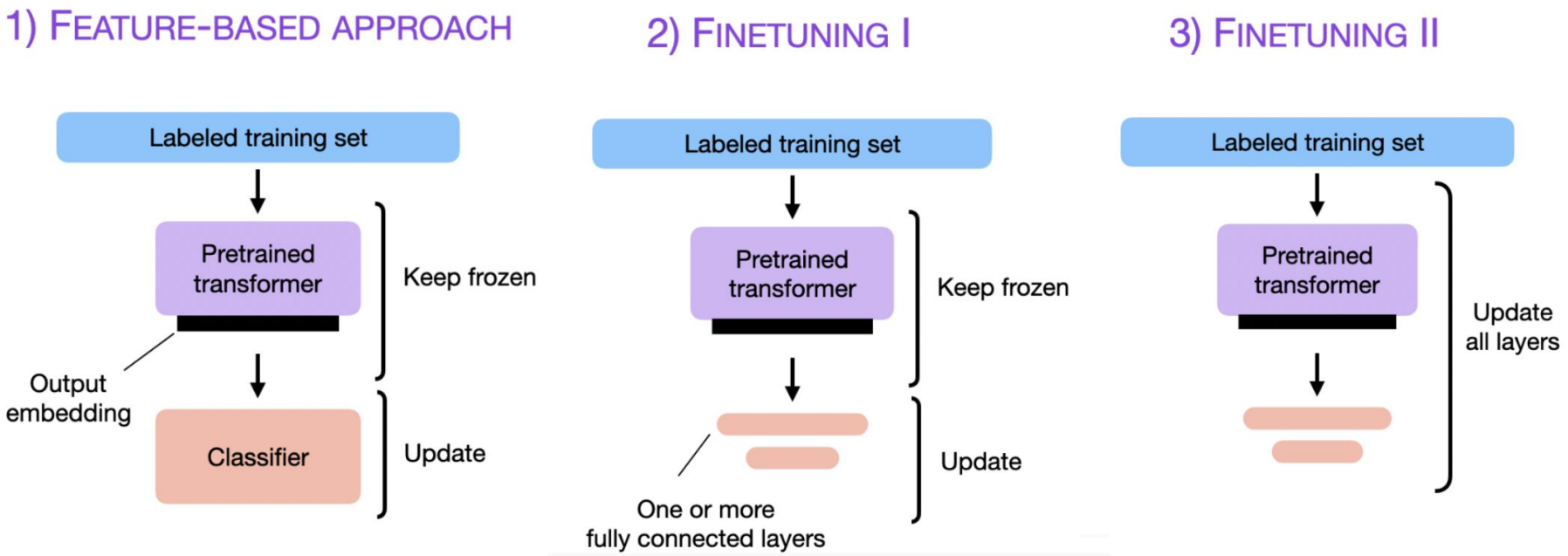
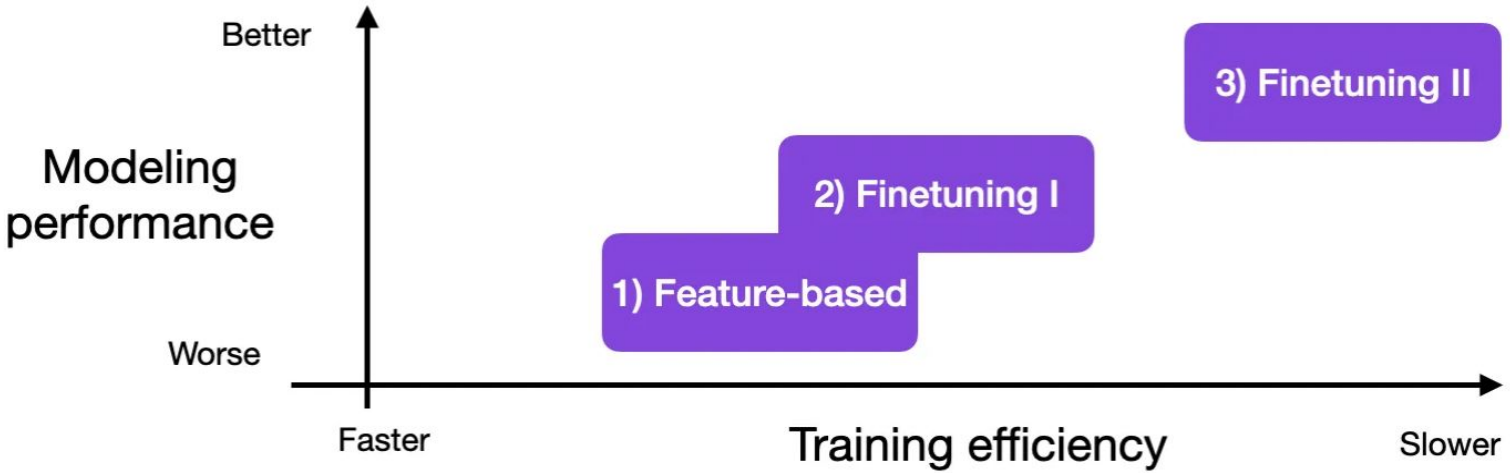
Fine-tune model via supervised learning



https://magazine.sebastianraschka.com/p/finetuning-large-language-models

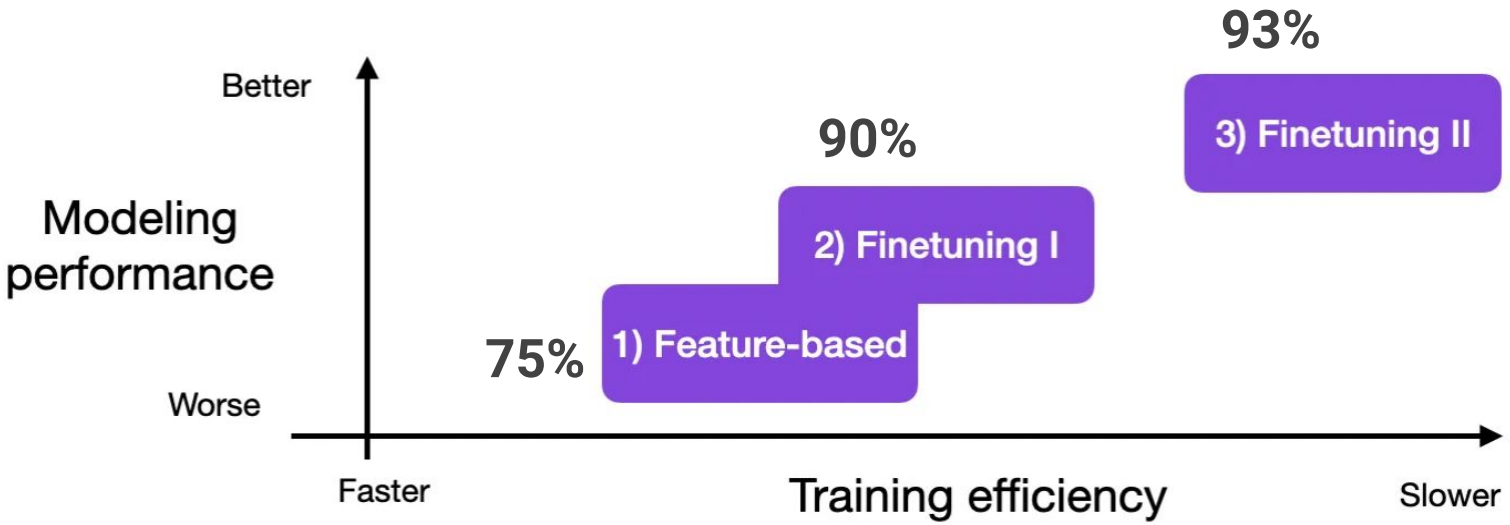
Comparing LLM fine-tuning methods



Rule-of-thumb computational and modeling performance trade-offs for various approaches.

https://magazine.sebastianraschka.com/

Comparing LLM fine-tuning methods



Rule-of-thumb computational and modeling performance trade-offs for various approaches.

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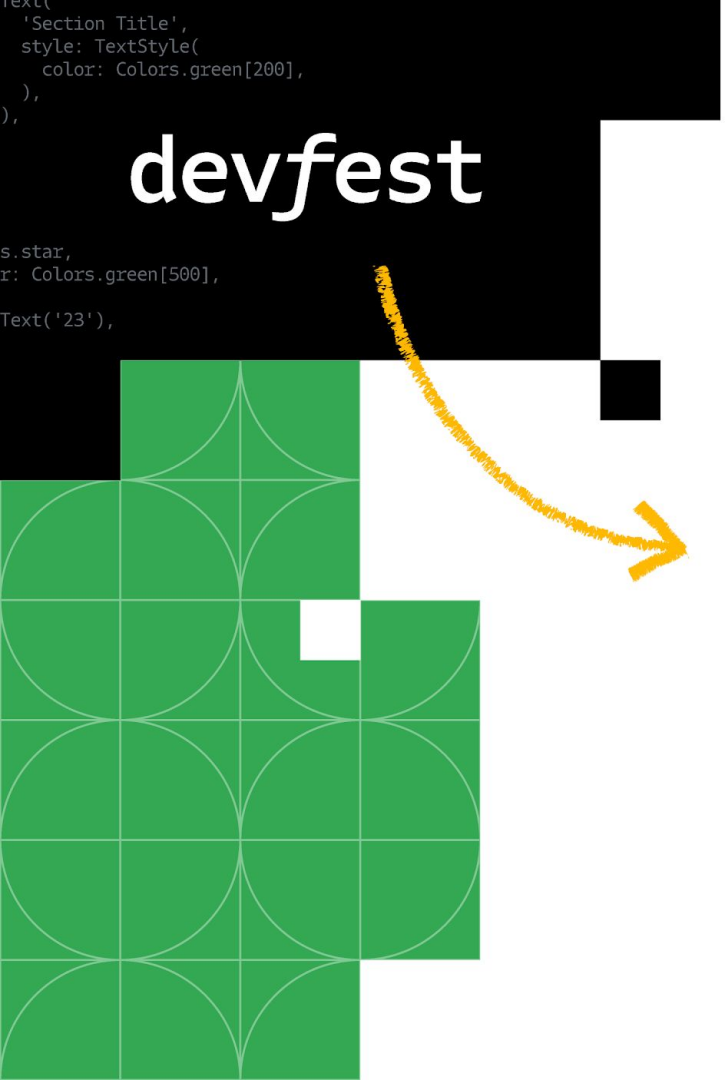

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Instruction Fine-Tuning

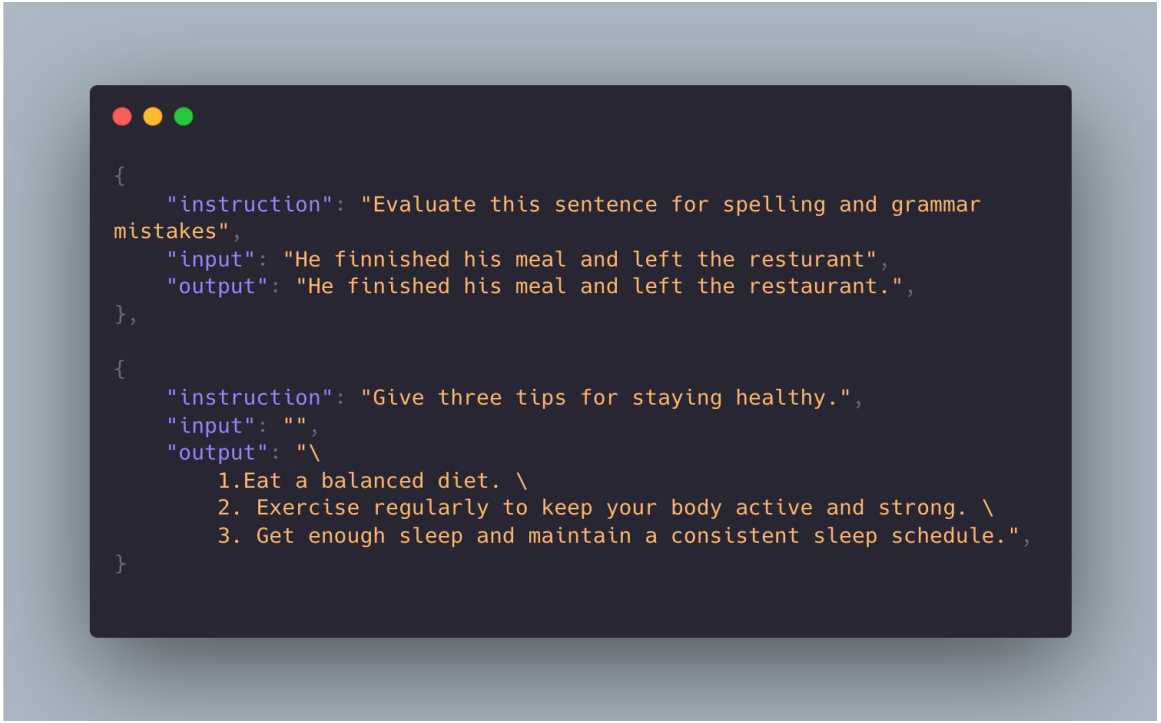
Instruction Fine-Tuning

2

Supervised finetuning

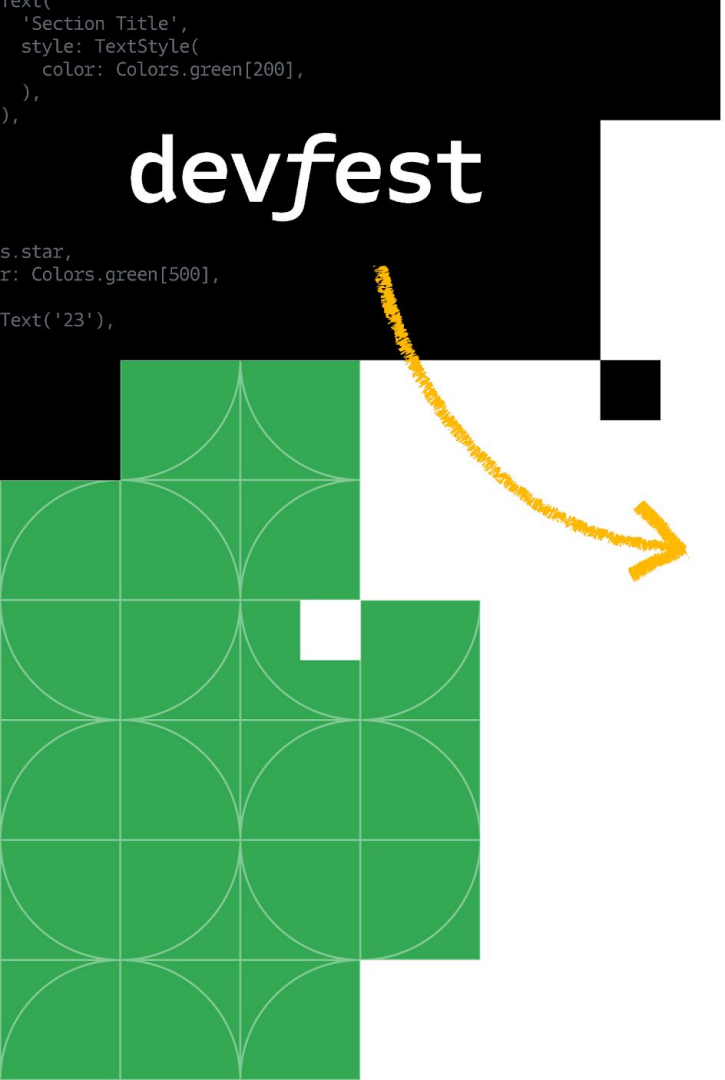
More next-token prediction

Usually 1k-50k instruction-response pairs



```
{
    "instruction": "Evaluate this sentence for spelling and grammar
mistakes",
    "input": "He finnished his meal and left the resturant",
    "output": "He finished his meal and left the restaurant.",
},

{
    "instruction": "Give three tips for staying healthy.",
    "input": "",
    "output": "\
        1.Eat a balanced diet. \
        2. Exercise regularly to keep your body active and strong. \
        3. Get enough sleep and maintain a consistent sleep schedule.",
}
```



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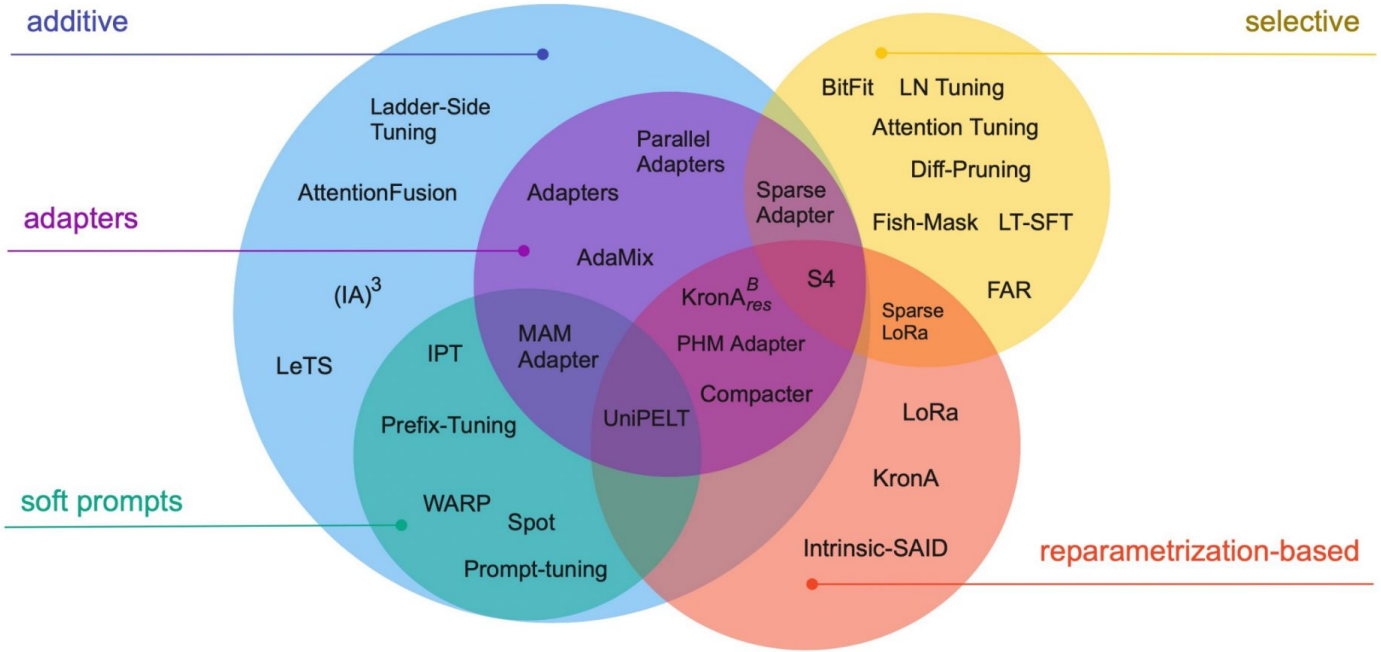
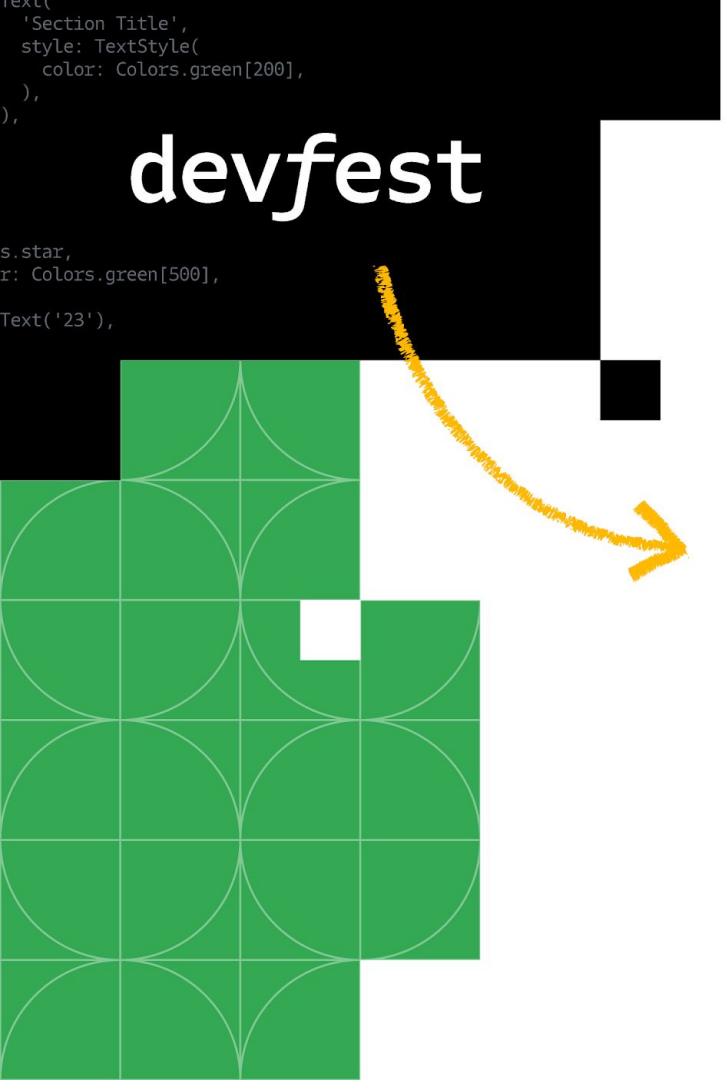
Parameter-efficient fine-tuning

Parameter-efficient fine-tuning





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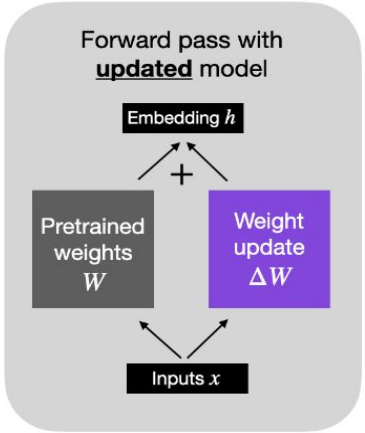
Low-rank adaptation (LoRA)

Low-rank adaptation (LoRA)

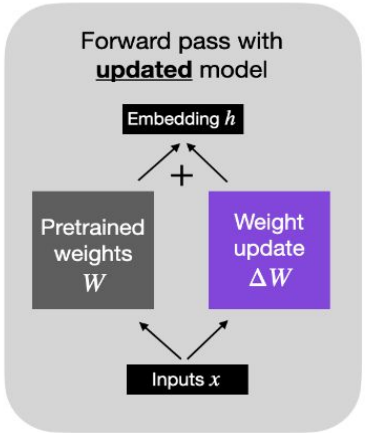
Alternative formulation (regular finetuning)



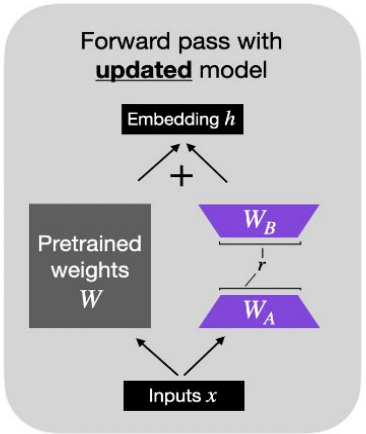
https://magazine.sebastianraschka.com/

Low-rank adaptation (LoRA)

Alternative formulation (regular finetuning)



LoRA weights, W_A and W_B, represent ΔW



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Low-rank adaptation (LoRA)

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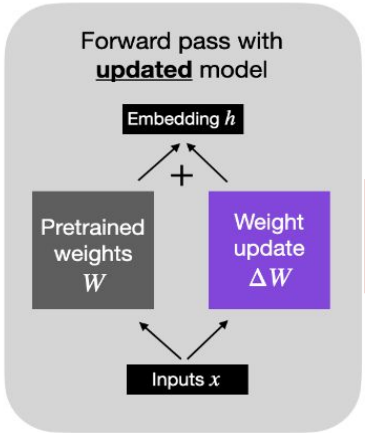
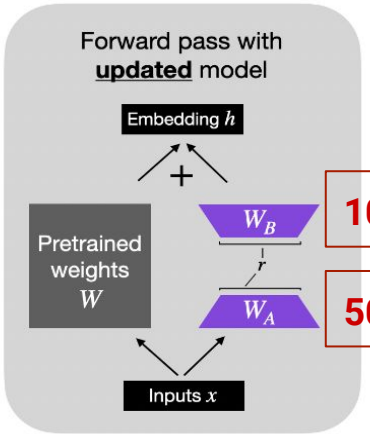


5000 X 1000
= 5,000,000

LoRA weights, W_A and W_B, represent ΔW



10 x 1000

5000 x 10

= 60,000

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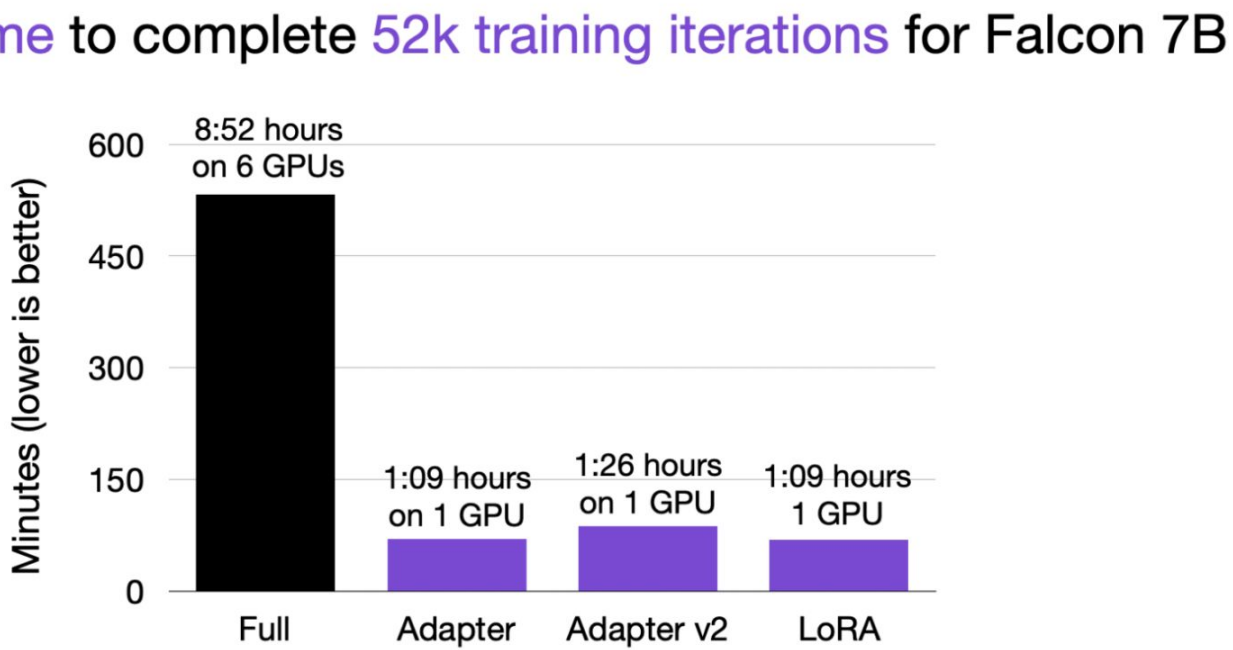
Low-rank adaptation (LoRA)



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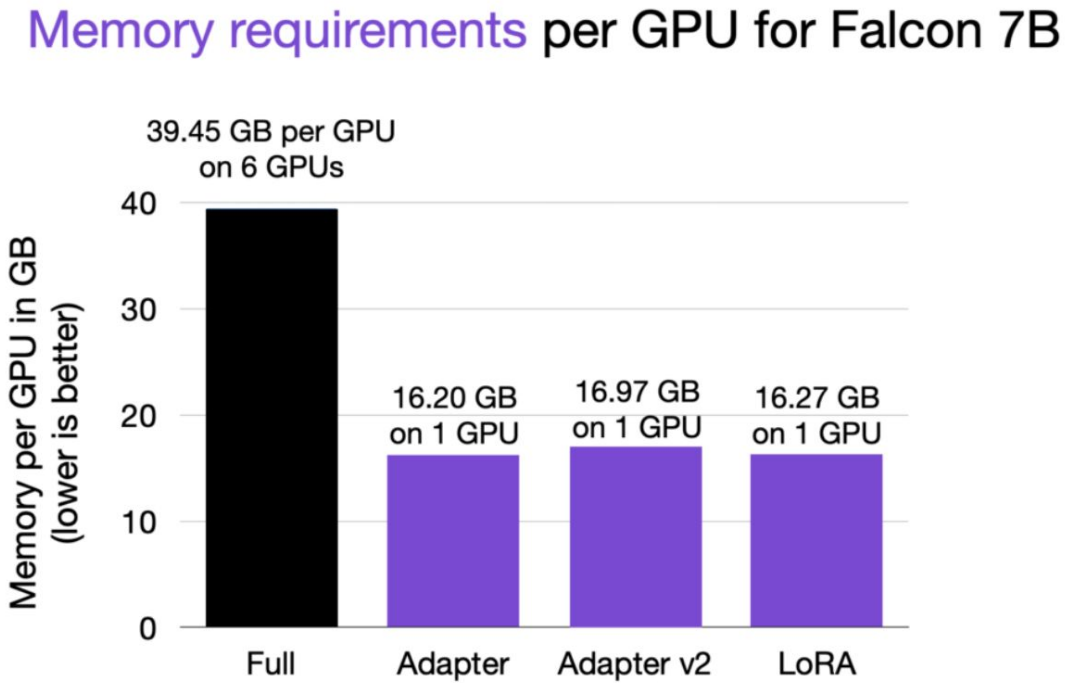

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Open Source LLMs

LLaMA

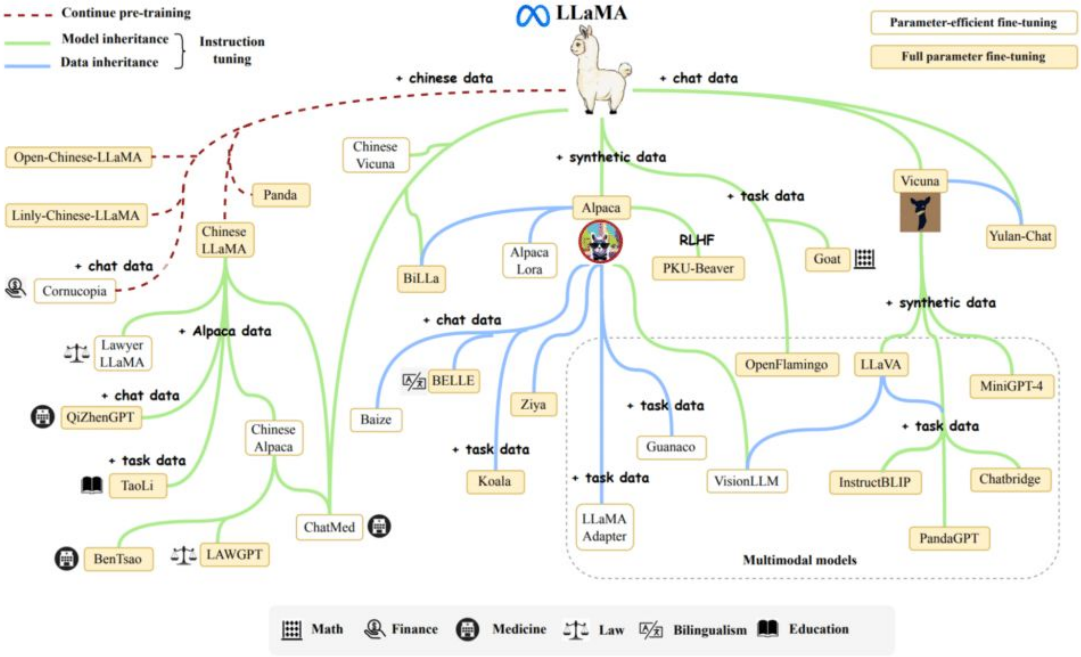
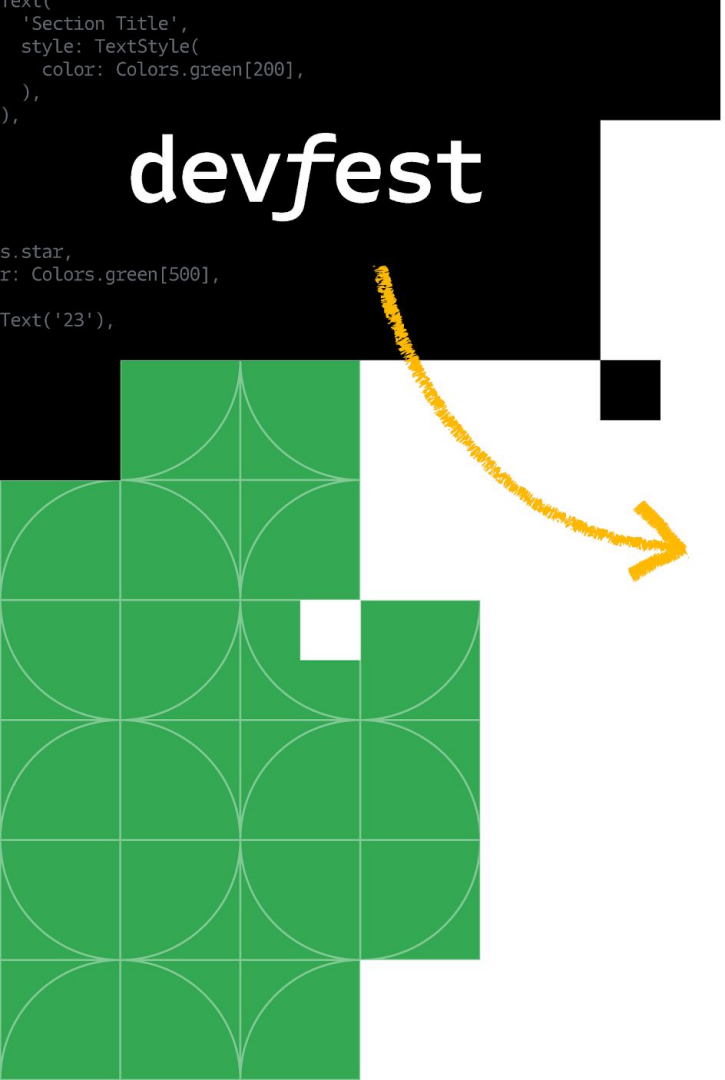


Fig. 4: An evolutionary graph of the research work conducted on LLaMA. Due to the huge number, we cannot include all the LLaMA variants in this figure, even much excellent work. To support incremental update, we share the source file of this figure, and welcome the readers to include the desired models by submitting the pull requests on our GitHub page.

Code Please


YEAH, IF YOU COULD JUST SHOW ME SOME CODE
THAT'D BE GREAT
memegenerator.net



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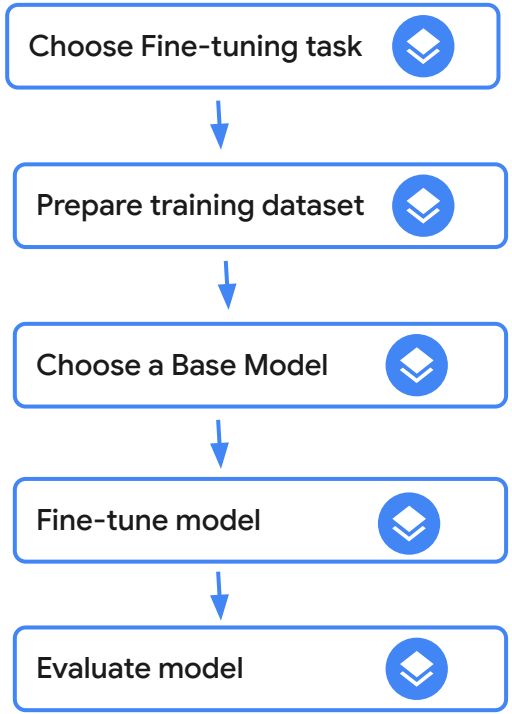
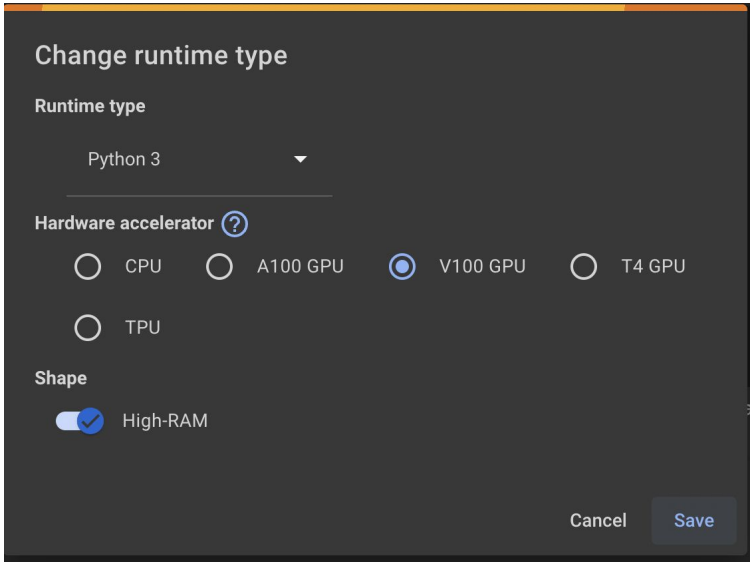
Fine-tuning LLaMA-2 on Personal Whatsapp data

5 Steps



Input	Output

Setup




```
[1]  pip3 install accelerate peft bitsandbytes transformers trl
```

Import Required Packages

```
import os
import torch
from datasets import load_dataset
from transformers import (
    AutoModelForCausalLM,
    AutoTokenizer,
    BitsAndBytesConfig,
    HfArgumentParser,
    TrainingArguments,
    pipeline,
    logging,
)
from peft import LoraConfig, PeftModel
from trl import SFTTrainer
```

Prepare dataset

```
[ ]  formatter = ChatDatasetFormatter('chat_dataset.json', 'Aadi', 'chat_dataset.csv')
     formatter.prepare_dataset()
```


Context	Reply
Abhijeet Kerla: What are you working on as res...	Working on Frozen adapters in Bert paper How's...
Abhijeet Kerla: What are you working on as res...	What was the issue?
Abhijeet Kerla: What are you working on as res...	Yup About to message you

Model setup

```
# Load base model

model = AutoModelForCausalLM.from_pretrained(
    pretrained_model_name_or_path="NousResearch/Llama-2-7b-chat-hf",
    quantization_config=quant_config,
    device_map={"": 0},
)
model.config.pretraining_tp = 1
```

Trainer Setup

```
[ ]  # Load LoRA configuration
     peft_args = LoraConfig(
         lora_alpha=16,
         lora_dropout=0.1,
         r=64,
         bias="none",
         task_type="CAUSAL_LM",
     )
```

```
# Set supervised fine-tuning parameters
trainer = SFTTrainer(
    model=model,
    train_dataset=dataset,
    peft_config=peft_args,
    dataset_text_field="text",
    max_seq_length=None,
    tokenizer=tokenizer,
    args=training_params,
    packing=False,
)
```

Train

```
[ ]  # Train model
     trainer.train()
```

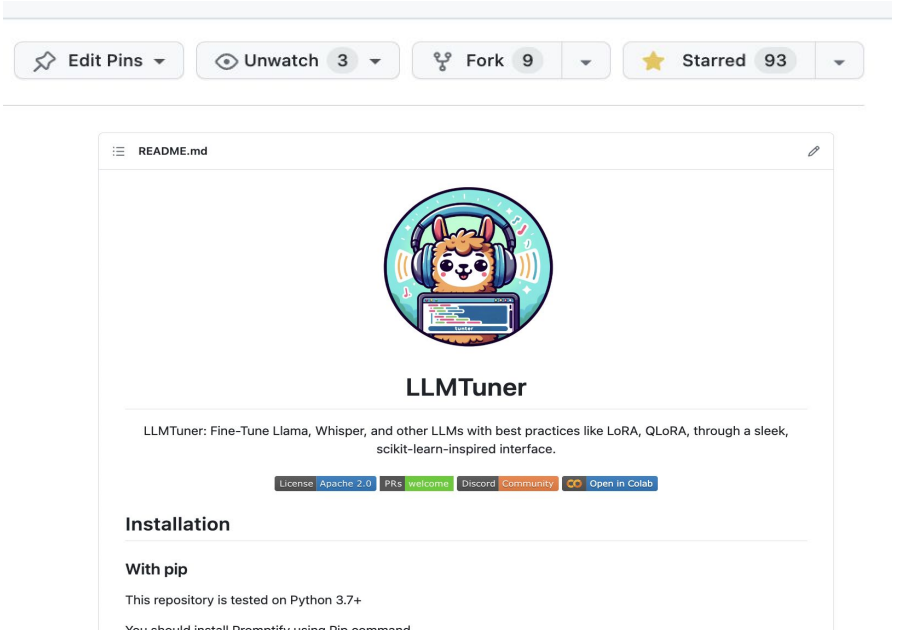
```
warnings.warn(
```

[187/250 05:43 < 01:56, 0.54 it/s, Epoch 0.74/1]

Step	Training Loss
25	1.408300
50	1.656600
75	1.213100
100	1.443900
125	1.176500
150	1.366400
175	1.173500

LLMtuner

Scan me!



https://github.com/promptslab/LLMtuner/

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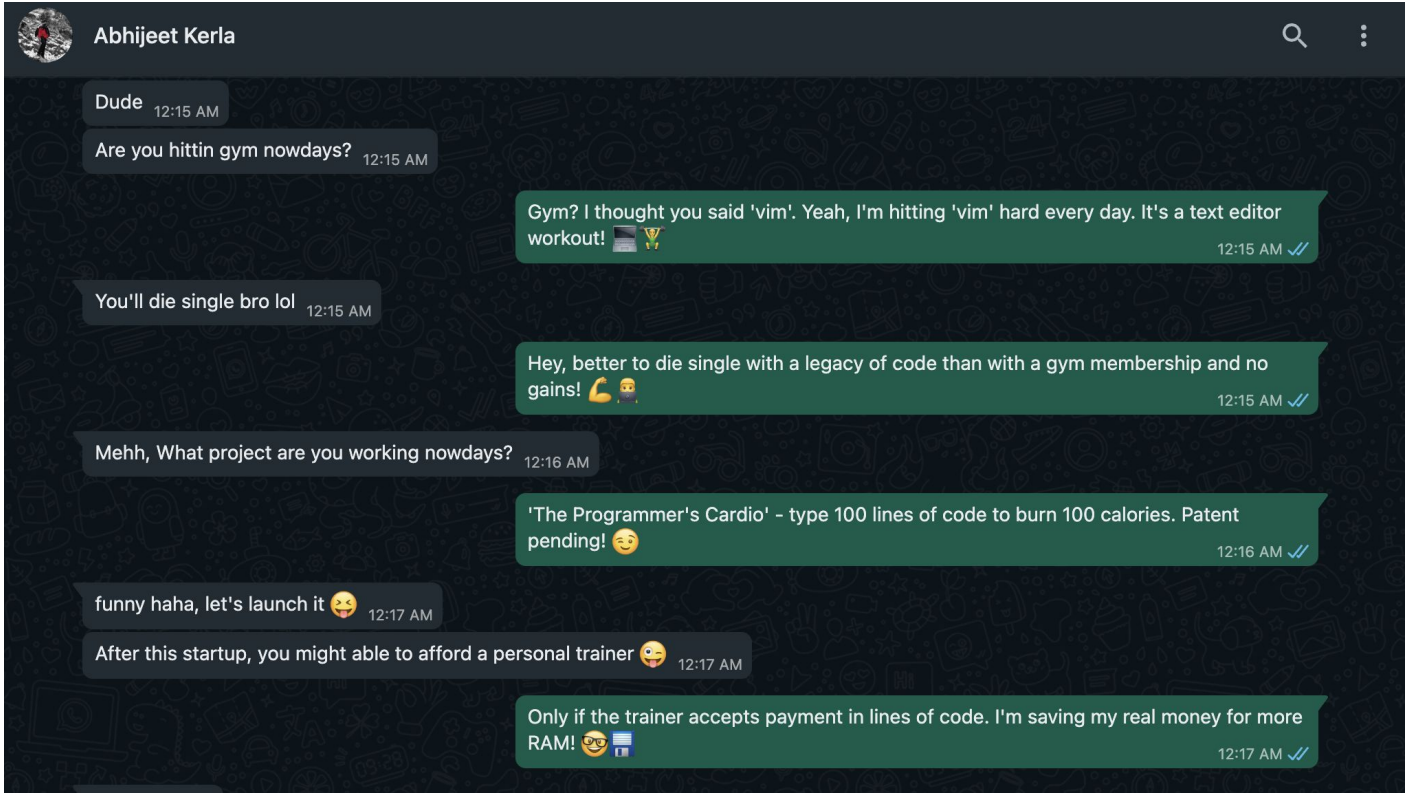
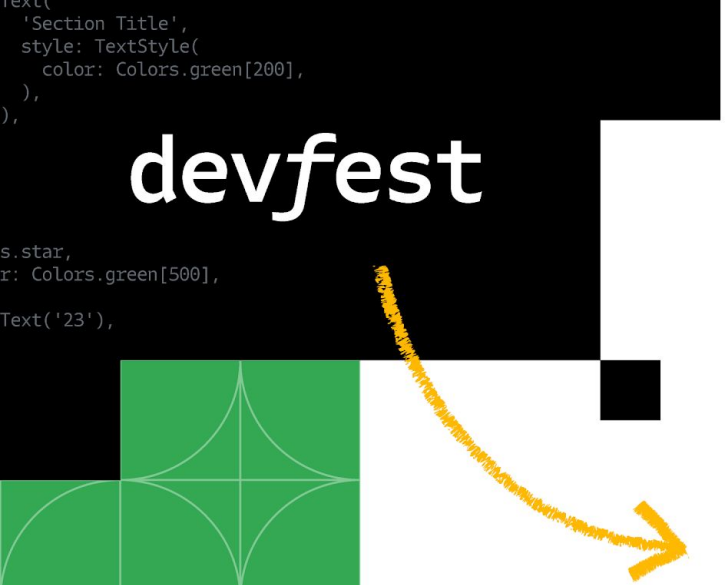
Inference

LLaMA is talking behalf of me





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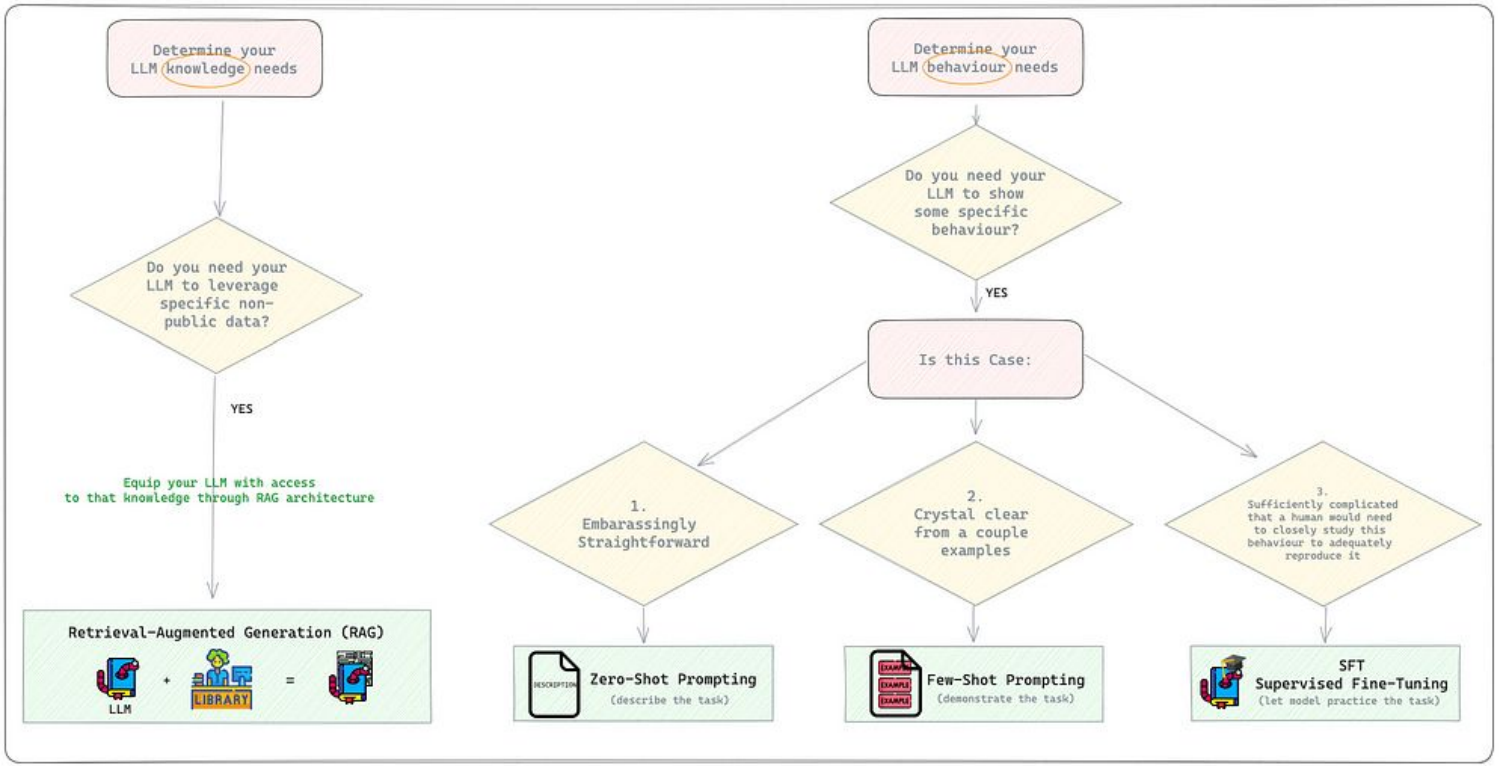
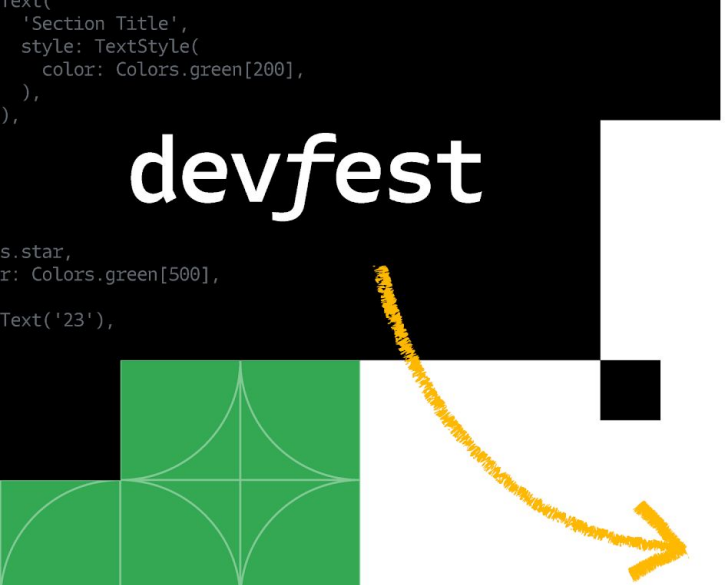
To fine-tune or Not?

LLaMA is talking behalf of me





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Best Practices

Best Practices

Instead of fine-tuning an LLM as a first approach, try prompt Engg instead

Start with a pre-trained & Compact Model

Work more on the data

Utilize the appropriate evaluation metric

Use Low Ranking Adaptation (LoRA) & Quantized LoRA (QLoRA) etc

Use deepspeed for Distributed, Effective, and Efficient Training

Thank you!

Let's get connected on Twitter! I am @adityaura