

AI VIETNAM  
All-in-One Course  
(TA Session)

# Instruction Tuning

## Extra Class: LLMs

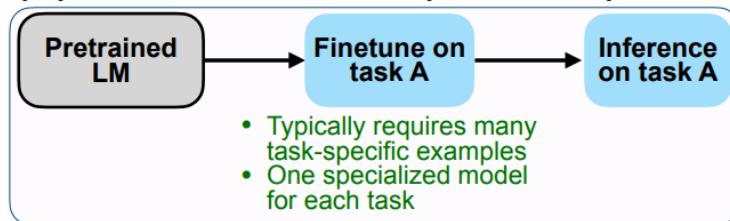


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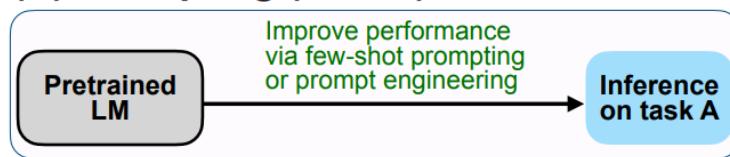
Dinh-Thang Duong – TA  
Nguyen-Thuan Duong – TA

# Objectives

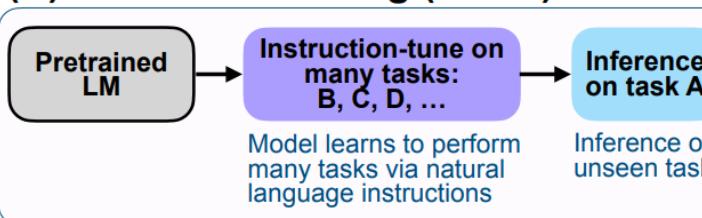
## (A) Pretrain–finetune (BERT, T5)



## (B) Prompting (GPT-3)



## (C) Instruction tuning (FLAN)



## In this lecture, we will discuss about:

1. How LLMs learn (training type)?
2. How to make LLMs adapt to a task?
  1. Prompting (In-context learning)
  2. Instruction Tuning
3. How to train LLMs on a single (small) GPU?
4. Apply Instruction Tuning for multiple choice math question solver task.

```
<|im_start|> system
Bạn là một chuyên gia về toán. Bạn sẽ nhận câu hỏi trắc nghiệm kèm theo các lựa chọn, hãy giải step by step nếu có và chọn phương án đúng.
```

```
<|im_start|> user
### Câu hỏi:
Điền dấu >, <, = vào ô trống: (13 - 3) ... 3
### Các lựa chọn:
A. <
B. >
C. =
### Câu trả lời:
```

```
<|im_start|> assistant
B. >
```

Giải thích:  
Trong phép tính  $(13 - 3)$ , kết quả là  $10$ . Vậy giờ chúng ta trừ  $3$  từ  $10$ , kết quả là  $7$ . Vì  $7$  lớn hơn  $3$ , chúng ta điền  $>$  vào ô trống.  
CPU times: user 8.34 s, sys: 132 ms, total: 8.47 s  
Wall time: 14.1 s

# Outline

- Introduction
- In-context Learning
- Instruction Tuning
- Parameter Efficient Fine-Tuning
- Evaluation
- Practices
- Question

# Introduction

# Introduction

## ❖ Getting Started

<|im\_start|> system

Bạn là một trợ lí AI hữu ích. Hãy trả lời người dùng một cách chính xác.

<|im\_start|> user

Mô tả về thành phố Đà Lạt

<|im\_start|> assistant

Đà Lạt là một thành phố đẹp như tranh vẽ nằm ở vùng cao nguyên của tỉnh Lâm Đồng, Việt Nam. Được biết đến như "Thành phố ngàn hoa", Đà Lạt nổi tiếng với những khu vườn tươi tốt, những con đường đẹp như tranh vẽ và những ngôi nhà đầy màu sắc. Thành phố này có khí hậu mát mẻ, với nhiệt độ trung bình từ 15 đến 20 độ C vào những tháng mùa đông. Vào những tháng mùa hè, nhiệt độ có thể lên tới 25 độ C. Đà Lạt nổi tiếng với các món ăn ngon, từ các món ăn truyền thống Việt Nam đến các món ăn quốc tế. Thành phố cũng nổi tiếng với các lễ hội và sự kiện văn hóa, chẳng hạn như Lễ hội hoa hồng, Lễ hội mùa đông và Lễ hội mùa xuân. Đà Lạt là một điểm đến tuyệt vời cho những người yêu thích thiên nhiên, những người đam mê ẩm thực và những người tìm kiếm một nơi yên bình để thư giãn.

Example: AI Chatbot using Large Language Models (LLMs)

# Introduction

## ❖ Chatbot (ChatGPT)

### Textual Description (Prompt):

Write a python function that receive an image and plot it using matplotlib library.

The screenshot shows a dark-themed chat interface. On the left, a user icon labeled "You" poses a question: "Write a python function that receive an image and plot it using matplotlib library.". On the right, a ChatGPT icon responds with: "To create a Python function that receives an image and plots it using the Matplotlib library, you can use the following code as an example. You'll need to have Matplotlib and a library like PIL (Pillow) installed to work with images:". Below this, a code block is displayed in a "python" language context, with a "Copy code" button to its right. The code itself is as follows:

```
python

import matplotlib.pyplot as plt
from PIL import Image

def plot_image(image_path):
    try:
        # Open the image using PIL (Pillow)
        img = Image.open(image_path)

        # Create a Matplotlib figure and axis
        fig, ax = plt.subplots()
```

# Introduction

## ❖ What are Large Language Models (LLMs)?



You

write a python code that print "hello world"



ChatGPT

Certainly! Here's a simple Python code that prints "Hello, World!" to the console:

```
python
```

Copy code

```
print("Hello, World!")
```

You can run this code in a Python interpreter, and it will display "Hello, World!" as the output.



### ChatGPT App:

1. User inputs a prompt (greetings, task...).
2. ChatGPT (Chatbot) outputs a appropriate response.

# Introduction

## ❖ What are Large Language Models (LLMs)?

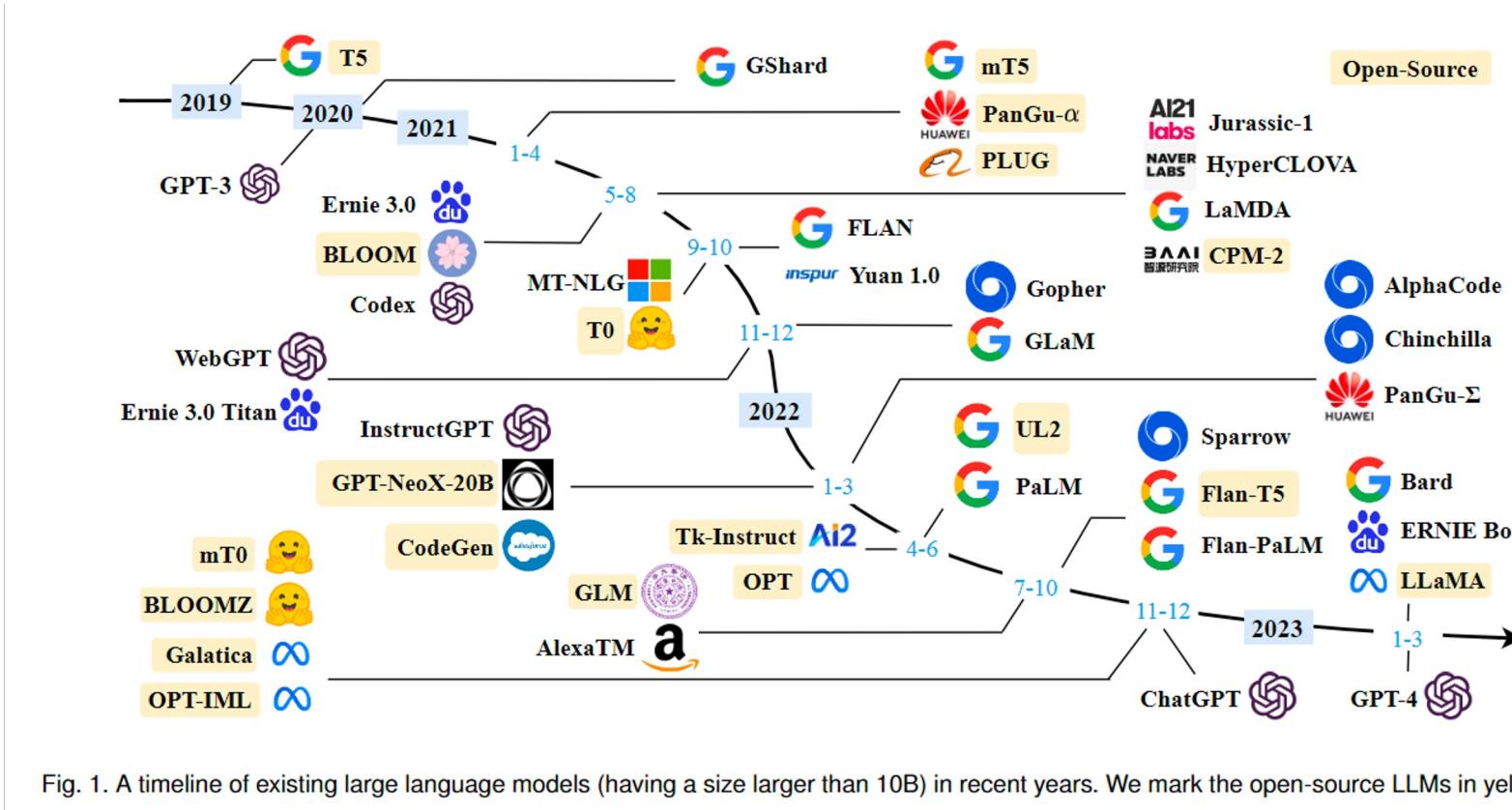


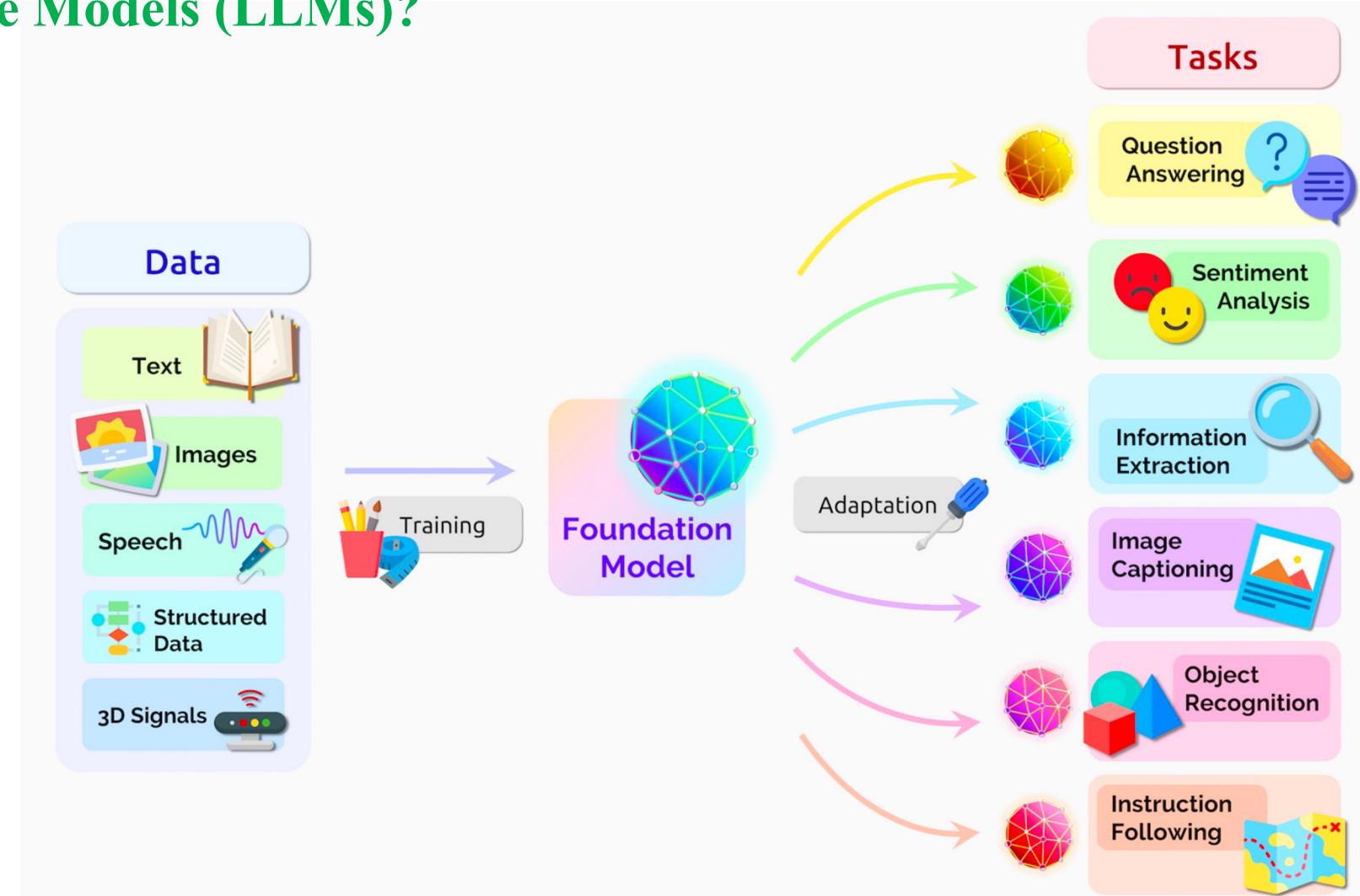
Fig. 1. A timeline of existing large language models (having a size larger than 10B) in recent years. We mark the open-source LLMs in yellow color.

**LLMs (Large Language Models):** AI models (language models) that were trained on a very large corpus of text. This made them capable of performing various NLP tasks with high precision.

# Introduction

## ❖ What are Large Language Models (LLMs)?

LLMs are often pretrained on a vast majority of data and designed to be adaptable to a wide variety of tasks (Foundation models).

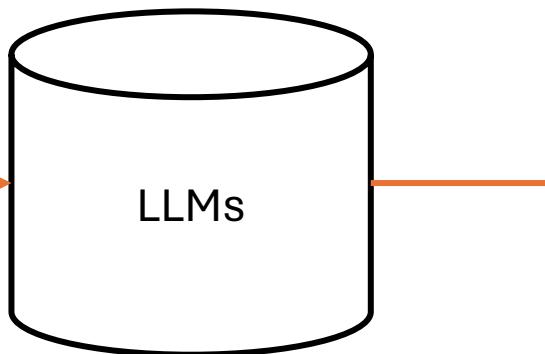


# Introduction

## ❖ LLMs I/O

Input Text

Write a python function  
that receive an image and  
plot it using matplotlib  
library.



Given a “prompt”, LLMs can generate  
an appropriate response.

Output Text



AI

You

Write a python function that receive an image and plot it using matplotlib library.



ChatGPT

To create a Python function that receives an image and plots it using the Matplotlib library, you can use the following code as an example. You'll need to have Matplotlib and a library like PIL (Pillow) installed to work with images:

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        img = Image.open(image_path)

        # Create a Matplotlib figure and axis
        fig, ax = plt.subplots()
```

Copy code

# Introduction

## ❖ Generative AI



You

Write a python function that receive an image and plot it using matplotlib library.



ChatGPT

To create a Python function that receives an image and plots it using the Matplotlib library, you can use the following code as an example. You'll need to have Matplotlib and a library like PIL (Pillow) installed to work with images:

python

Copy code

```
import matplotlib.pyplot as plt
from PIL import Image

def plot_image(image_path):
    try:
        # Open the image using PIL (Pillow)
        img = Image.open(image_path)

        # Create a Matplotlib figure and axis
        fig, ax = plt.subplots()
```

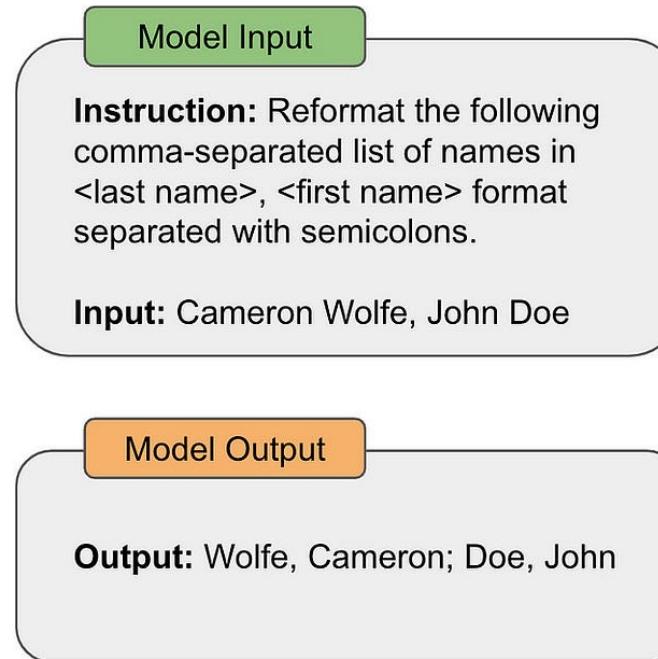
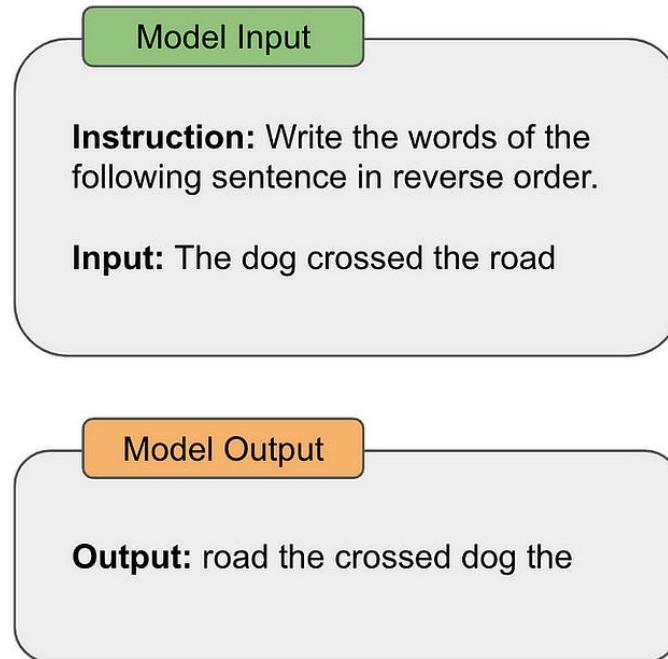


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# Introduction

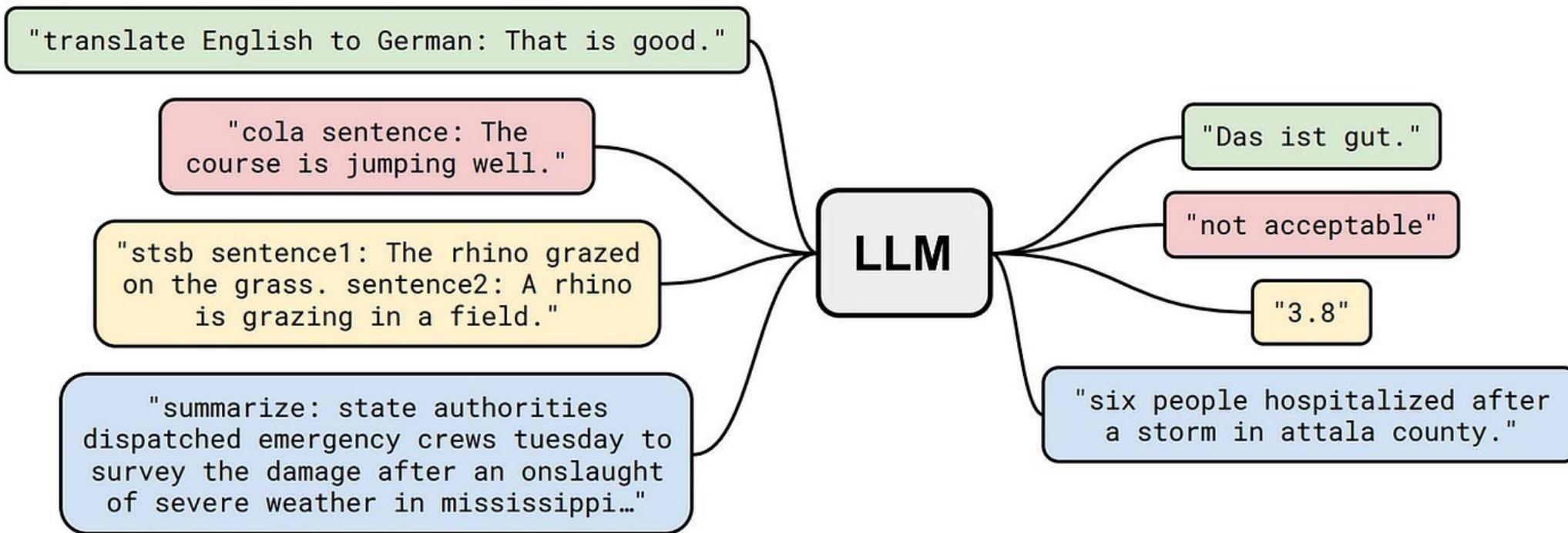
## ❖ Generative AI Prompting



**Prompting:** Refers to a process of providing an input, usually in the form of text data, to a generative AI model to generate a specific output.

# Introduction

## ❖ Prompting in LLMs



With prompting, we can make LLMs do any task with just natural language (**zero-shot capability**)

# Introduction

## ❖ LLMs problem



241 - (-241) + 1



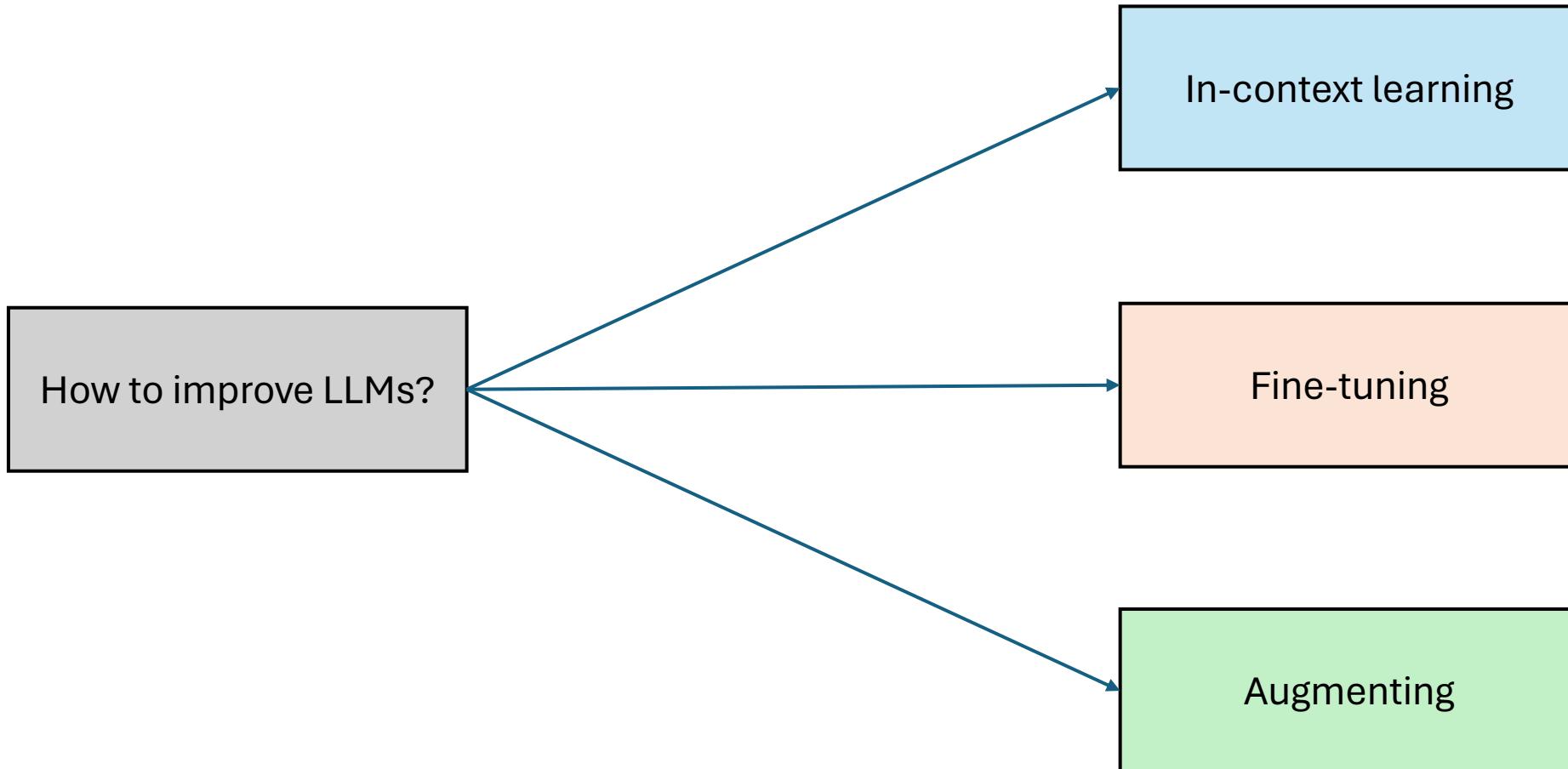
241 - (-241) + 1 is equivalent to  $241 + 241 + 1$ , which simplifies to  $483 + 1$ . So  $241 - (-241) + 1$  is equal to 484.



**Question:** How can we improve LLMs on a specific task?

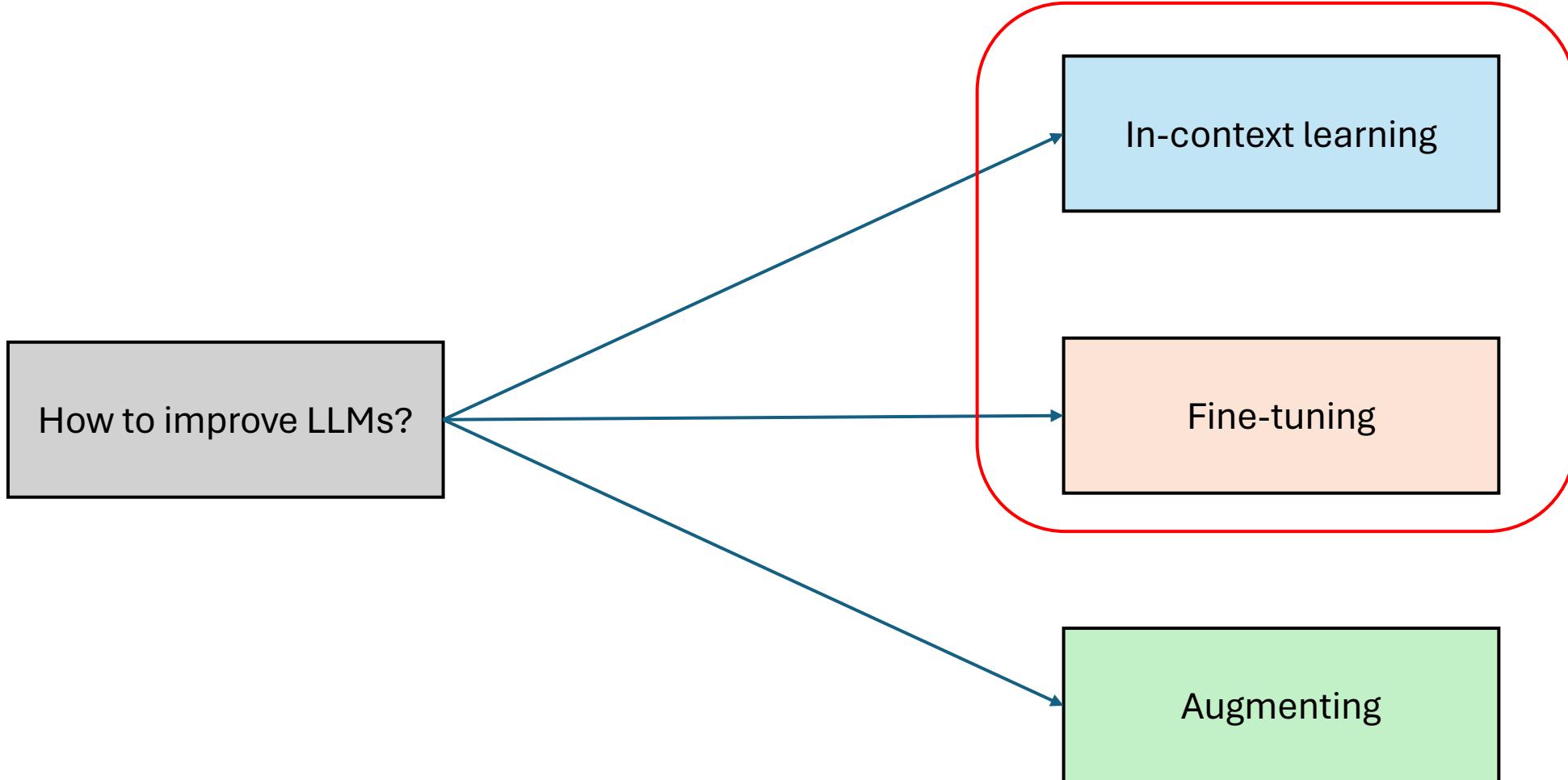
# Introduction

## ❖ How to improve LLMs on specific tasks?



# Introduction

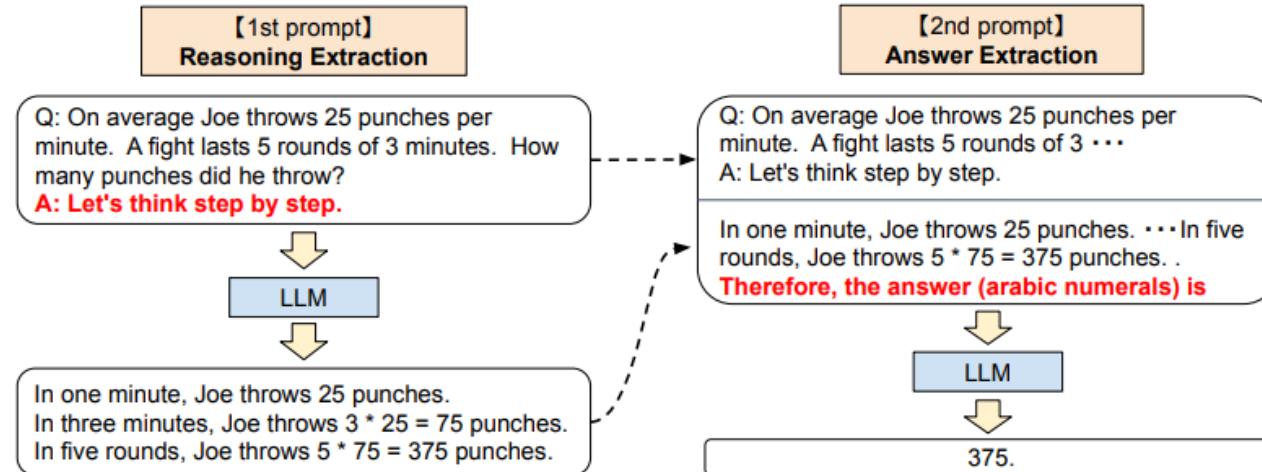
## ❖ How to improve LLMs on specific tasks?



# In-context Learning

# In-context learning

## ❖ Introduction



**In-context learning (ICL)** in LLMs is a technique where task demonstrations are integrated into the prompt in a natural language format. This approach allows pre-trained LLMs to address new tasks without fine-tuning the model.

# In-context learning

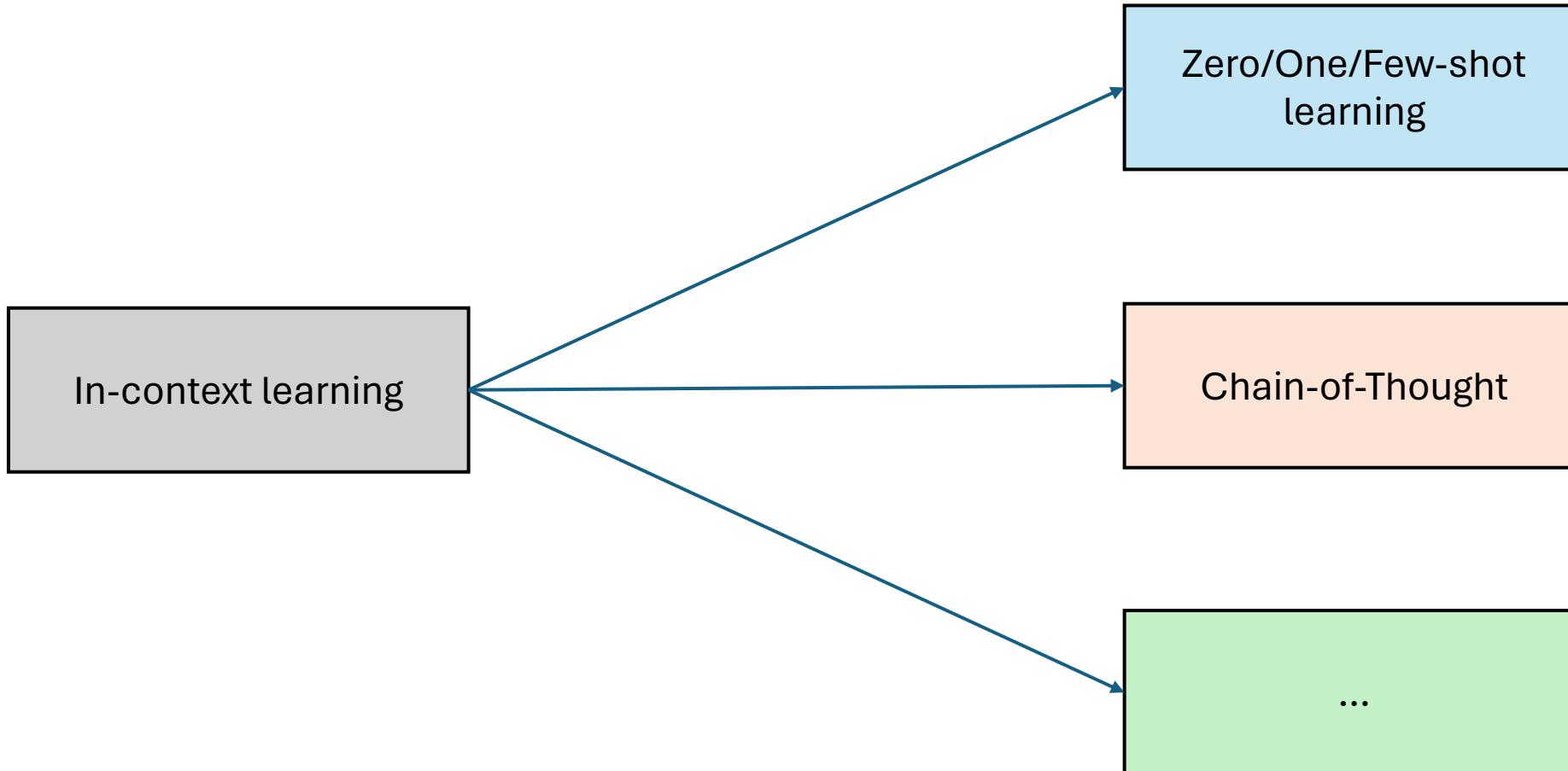
## ❖ Example

Input: 2014-06-01	]	<i>in-context examples</i>
Output: !06!01!2014!		
Input: 2007-12-13		
Output: !12!13!2007!		
Input: 2010-09-23		
Output: !09!23!2010!		
Input: <b>2005-07-23</b>	]	<i>test example</i>
Output: <u>!07!23!2005!</u>		
		<i>model completion</i>

Make LLMs adapt to a task using instruction and examples

# In-context learning

## ❖ In-context learning type



# In-context learning

## ❖ Zero-shot learning

Prompt: Who won the 2014 World Cup?

GPT-4 Response: Germany won the 2014 FIFA World Cup. The tournament was held in Brazil, and Germany defeated Argentina 1–0 in the final, with the match-winning goal scored by Mario Götze during extra time

**Zero-shot learning:** Prompting LLMs to do a task without any examples.

# In-context learning

## ❖ One-shot learning

**Prompt:** Answer the question using the format shown in the context.

Who won the World Cup in **2014**?

Germany won the **2014** FIFA World Cup. They defeated Argentina in the final. It was a low scoring game.

Who won the world cup in **2018**?

**GPT-4 Response:** France won the **2018** FIFA World Cup. They defeated Croatia in the final. It was a higher scoring game compared to the **2014** final.

**One-shot learning:** Prompting LLMs to do a task with an example.

# In-context learning

## ❖ Few-shot learning

**Prompt:** Answer the question using the format shown in the context.

Who won the World Cup in **2014**?

Germany won the **2014** FIFA World Cup. They defeated Argentina in the final. It was a low scoring game.

Who won the World Cup in **2018**?

France won the **2018** FIFA World Cup. They defeated Croatia in the final. It was a high scoring game.

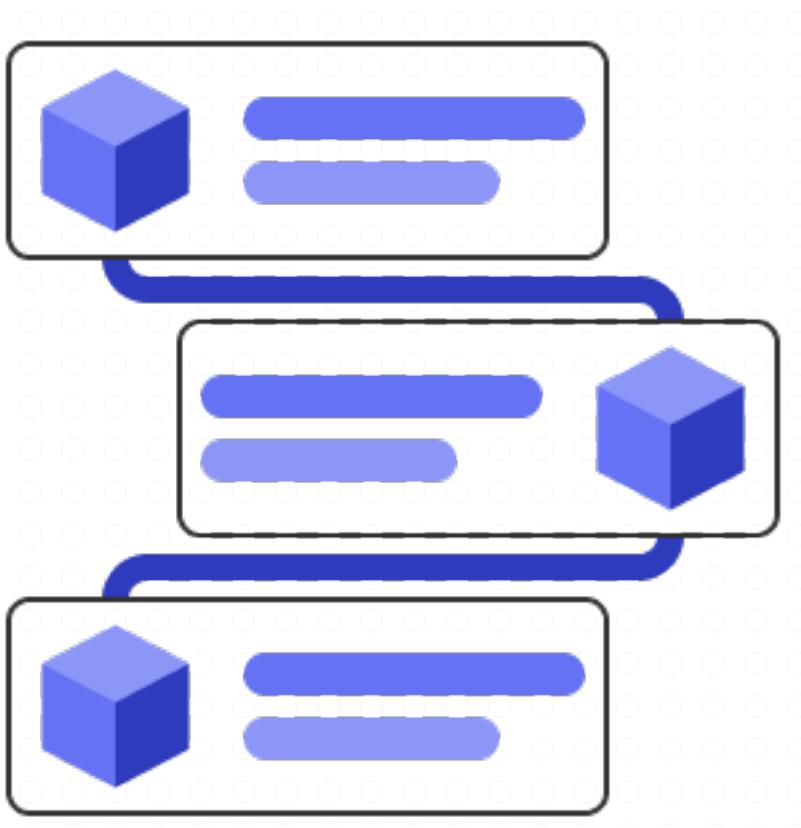
Who won the world cup in **2022**?

**Few-shot learning:** Prompting LLMs to do a task with more than one example.

**GPT-4 Response:** Argentina won the **2022** FIFA World Cup. They defeated France in the final. It was a high scoring game.

# In-context learning

## ❖ Chain-of-Thought Prompting



**Chain-of-Thought (CoT) prompting** enables complex reasoning capabilities through intermediate reasoning steps. You can combine it with few-shot prompting to get better results on more complex tasks that require reasoning before responding.

# In-context learning

## ❖ Zero-shot learning with CoT

(a) Few-shot

Q: Roger has 5 tennis balls. He buys 2 more cans of tennis balls. Each can has 3 tennis balls. How many tennis balls does he have now?  
A: The answer is 11.

Q: A juggler can juggle 16 balls. Half of the balls are golf balls, and half of the golf balls are blue. How many blue golf balls are there?

A:

(Output) The answer is 8. X

(b) Few-shot-CoT

Q: Roger has 5 tennis balls. He buys 2 more cans of tennis balls. Each can has 3 tennis balls. How many tennis balls does he have now?

A: Roger started with 5 balls. 2 cans of 3 tennis balls each is 6 tennis balls.  $5 + 6 = 11$ . The answer is 11.

Q: A juggler can juggle 16 balls. Half of the balls are golf balls, and half of the golf balls are blue. How many blue golf balls are there?

A:

(Output) The juggler can juggle 16 balls. Half of the balls are golf balls. So there are  $16 / 2 = 8$  golf balls. Half of the golf balls are blue. So there are  $8 / 2 = 4$  blue golf balls. The answer is 4. ✓

(c) Zero-shot

Q: A juggler can juggle 16 balls. Half of the balls are golf balls, and half of the golf balls are blue. How many blue golf balls are there?

A: The answer (arabic numerals) is

(Output) 8 X

(d) Zero-shot-CoT (Ours)

Q: A juggler can juggle 16 balls. Half of the balls are golf balls, and half of the golf balls are blue. How many blue golf balls are there?

A: **Let's think step by step.**

(Output) There are 16 balls in total. Half of the balls are golf balls. That means that there are 8 golf balls. Half of the golf balls are blue. That means that there are 4 blue golf balls. ✓

# In-context learning

## ❖ One-shot learning with CoT

### Standard Prompting

Model Input

Q: Roger has 5 tennis balls. He buys 2 more cans of tennis balls. Each can has 3 tennis balls. How many tennis balls does he have now?

A: The answer is 11.

Q: The cafeteria had 23 apples. If they used 20 to make lunch and bought 6 more, how many apples do they have?

Model Output

A: The answer is 27. X

### Chain-of-Thought Prompting

Model Input

Q: Roger has 5 tennis balls. He buys 2 more cans of tennis balls. Each can has 3 tennis balls. How many tennis balls does he have now?

A: Roger started with 5 balls. 2 cans of 3 tennis balls each is 6 tennis balls.  $5 + 6 = 11$ . The answer is 11.

Q: The cafeteria had 23 apples. If they used 20 to make lunch and bought 6 more, how many apples do they have?

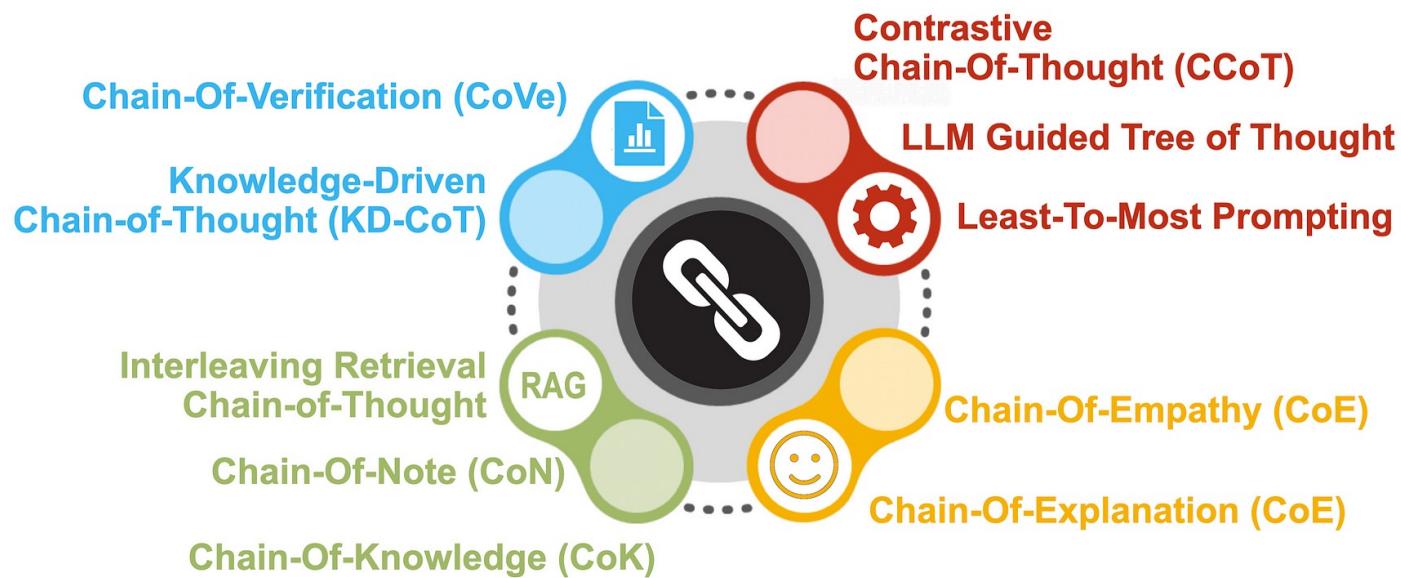
Model Output

A: The cafeteria had 23 apples originally. They used 20 to make lunch. So they had  $23 - 20 = 3$ . They bought 6 more apples, so they have  $3 + 6 = 9$ . The answer is 9. ✓

# In-context learning

## ❖ CoT variations

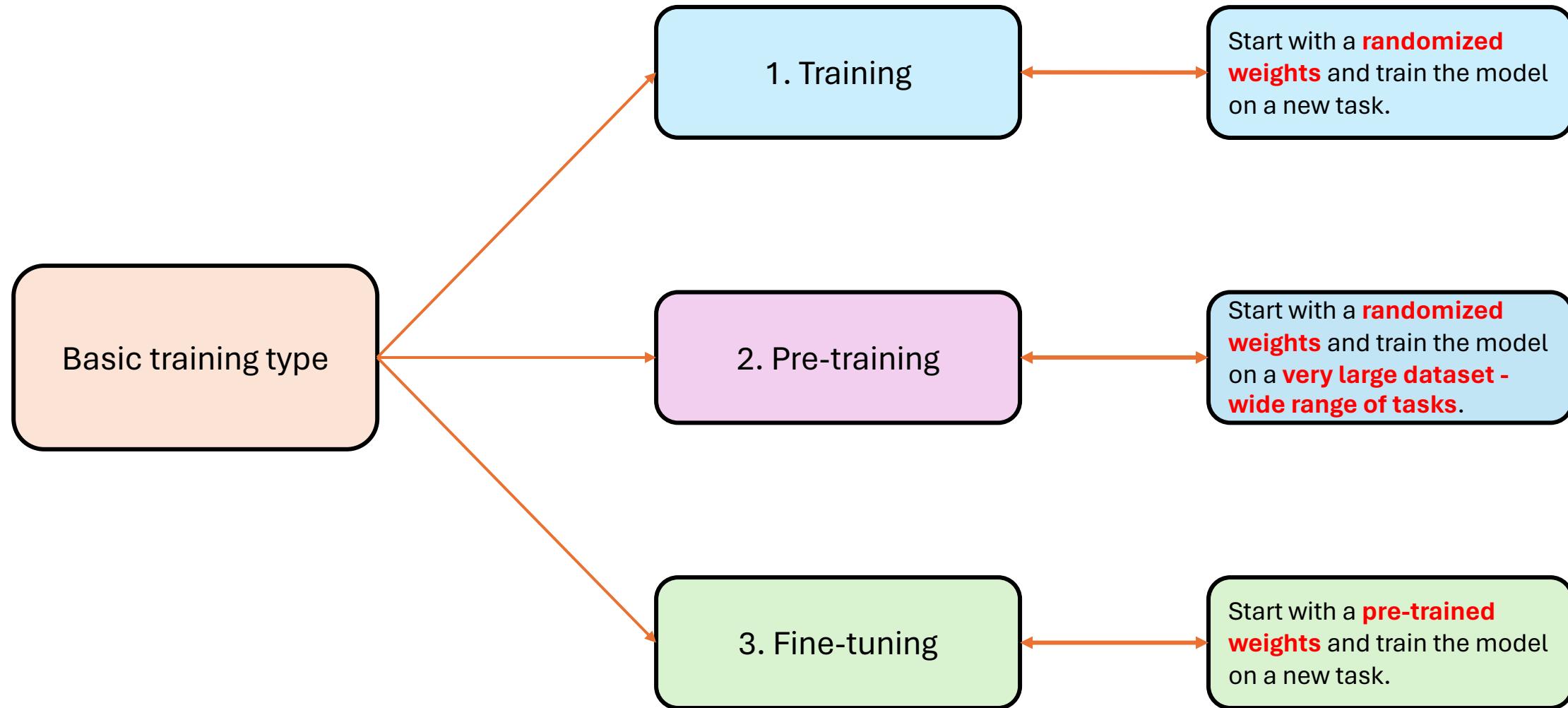
### Chain-of-Thought Prompting (CoT)



# Instruction Tuning

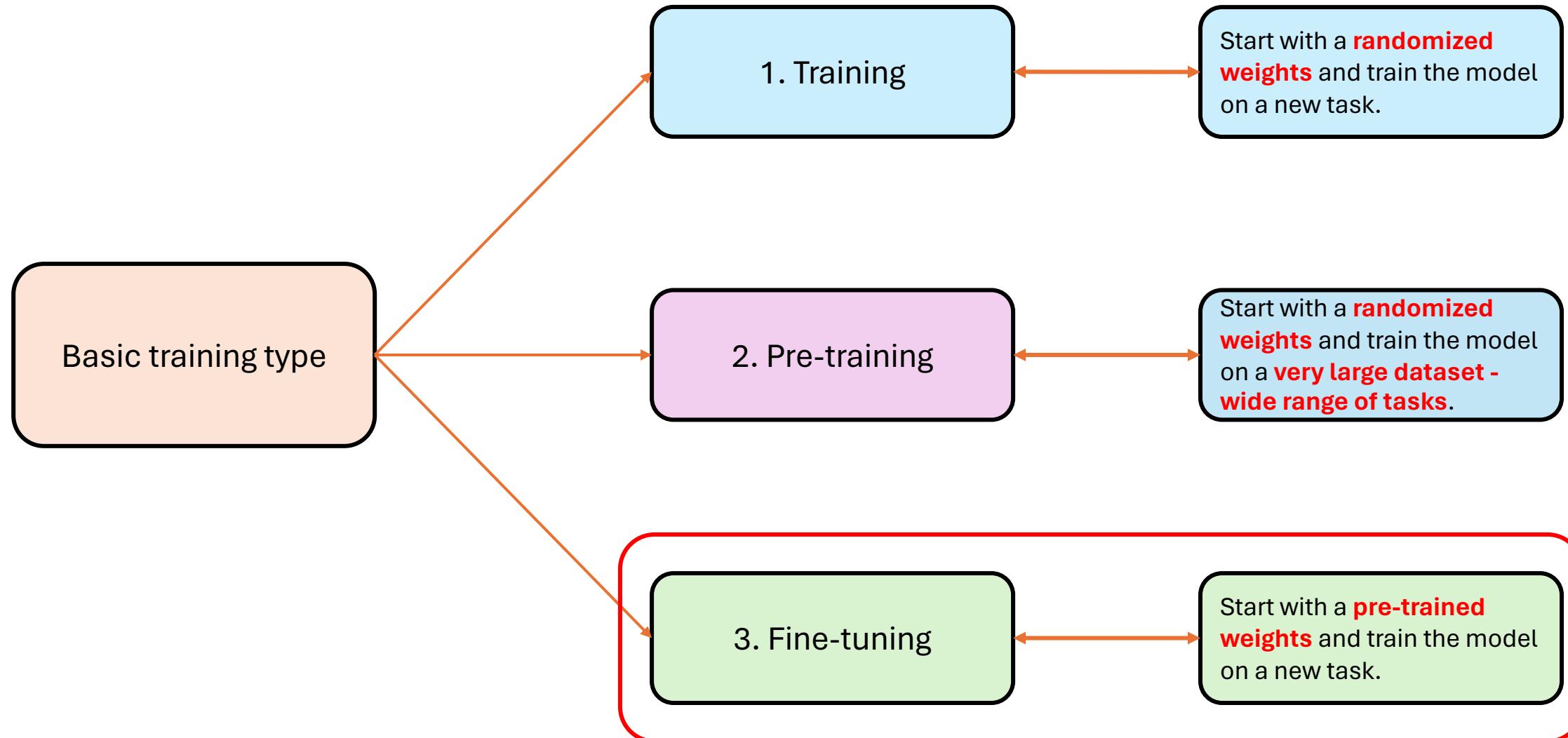
# Instruction Tuning

## ❖ Training model in Machine Learning



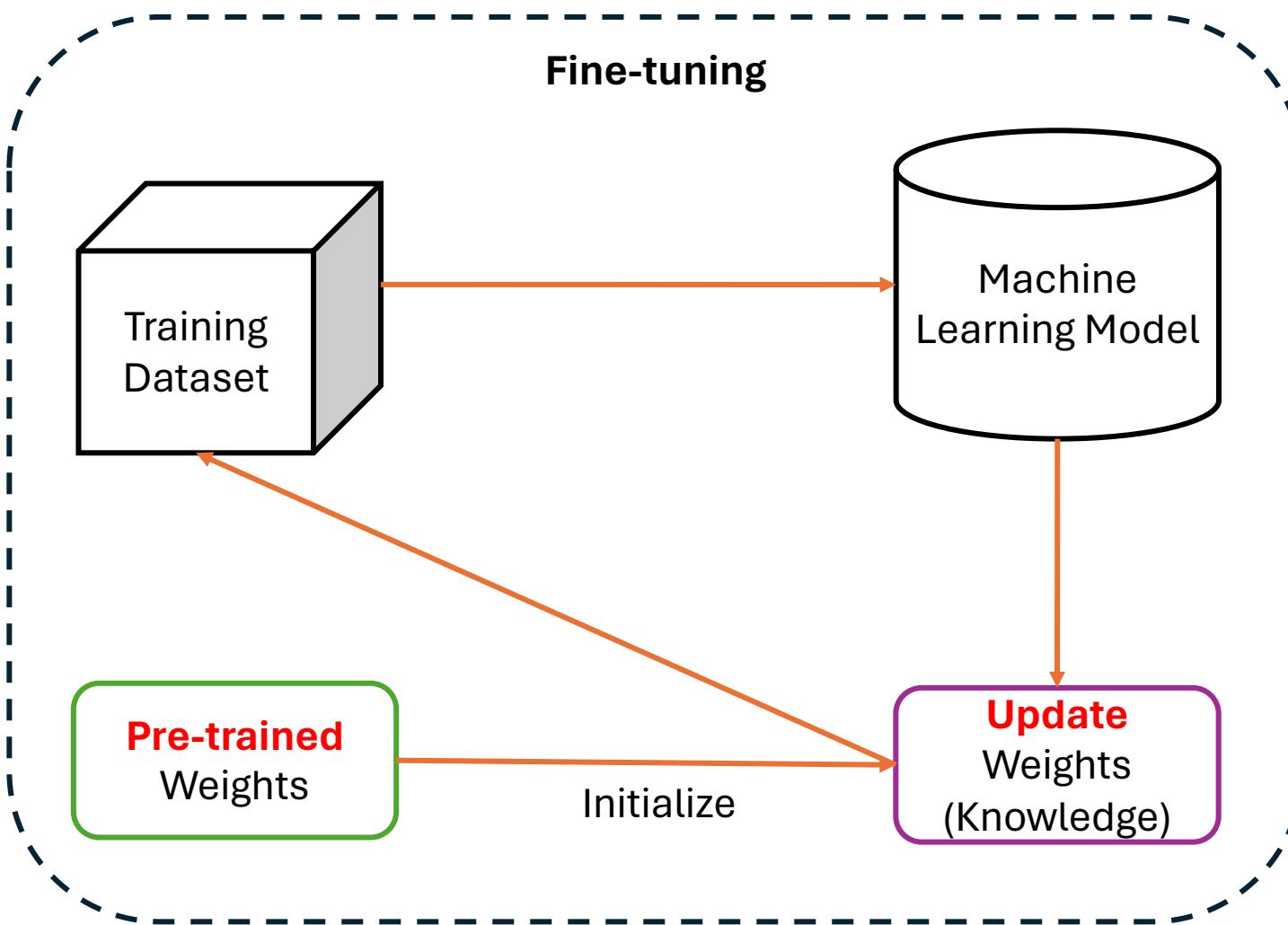
# Instruction Tuning

## ❖ Training model in Machine Learning



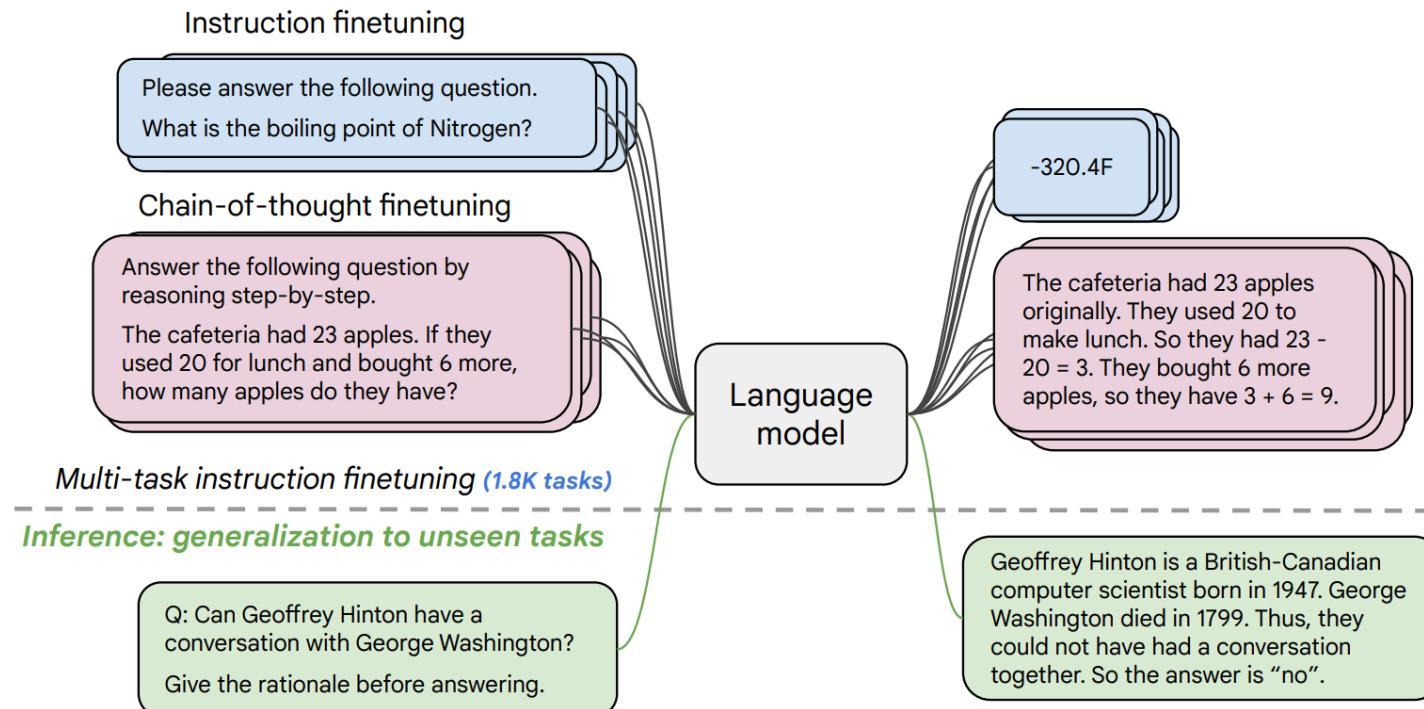
# Instruction Tuning

## ❖ Fine-tuning



# Instruction Tuning

## ❖ Introduction

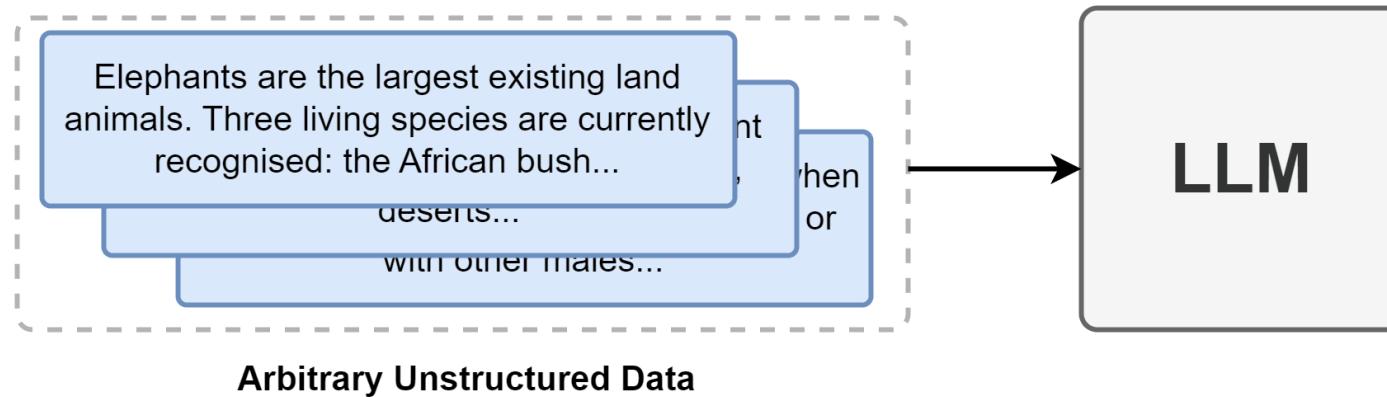


**Instruction Tuning** in LLMs is a training method aimed at enhancing the model's ability to understand and execute natural language instructions.

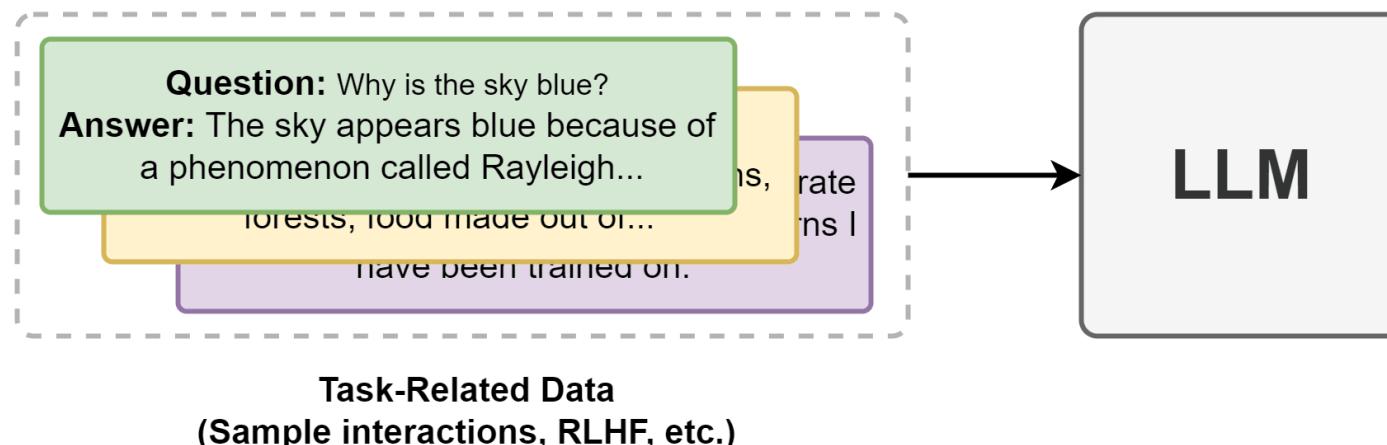
# Instruction Tuning

## ❖ Training LLMs

### Stage 1: Pretraining (Expensive, Unaligned)

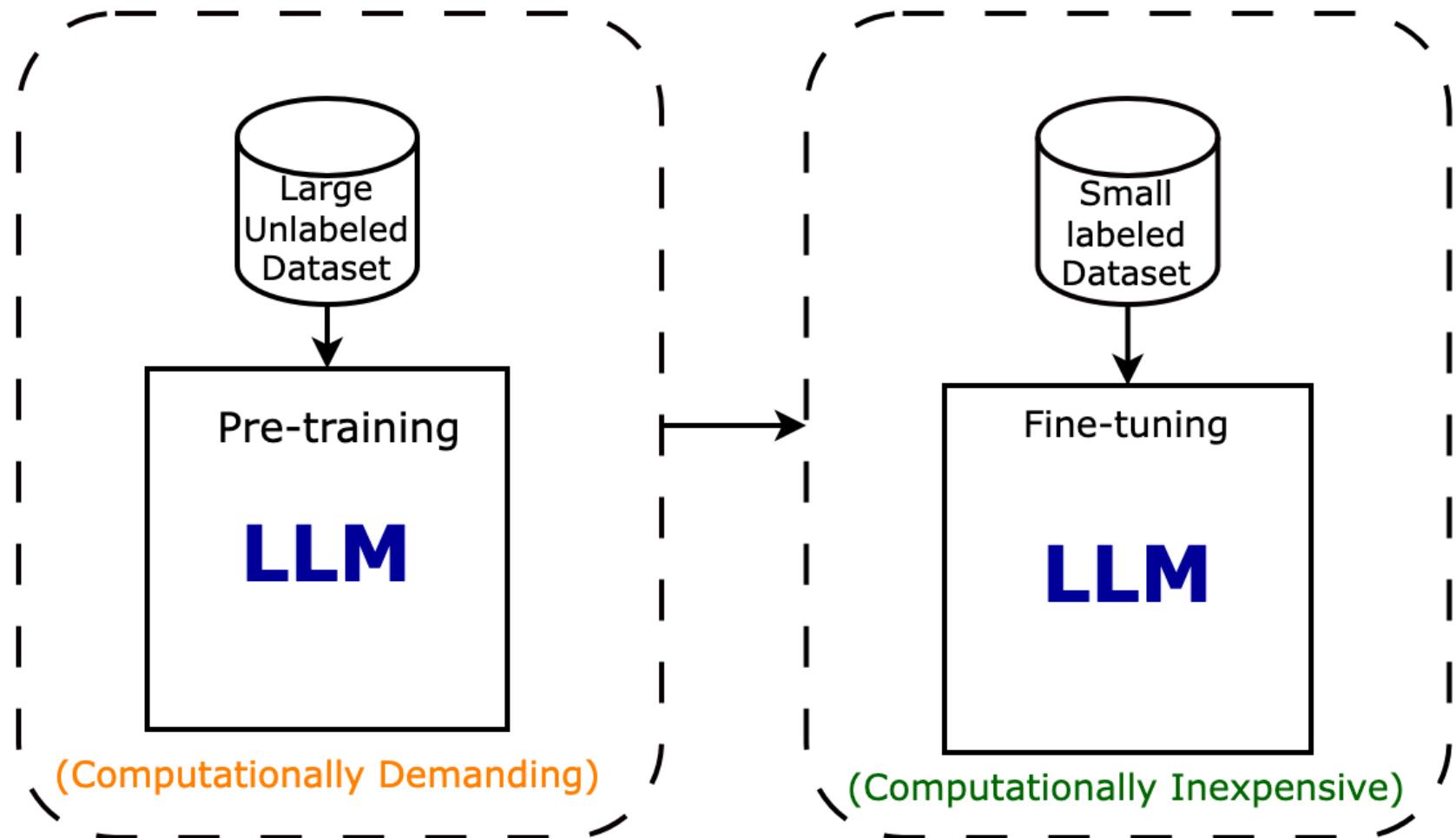


### Stage 2: Instruction Tuning (Cheap, Where Alignment Happens)



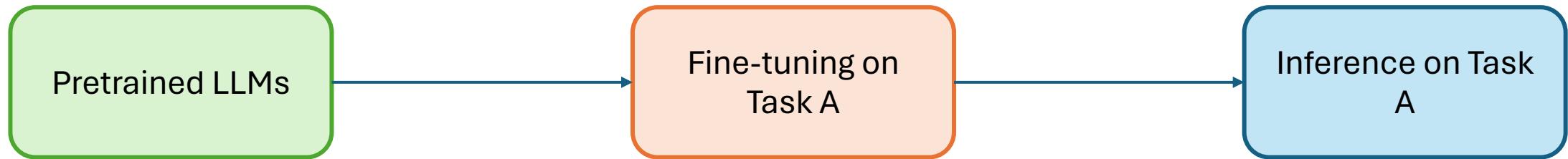
# Instruction Tuning

## ❖ Applications



# Instruction Tuning

## ❖ Applications

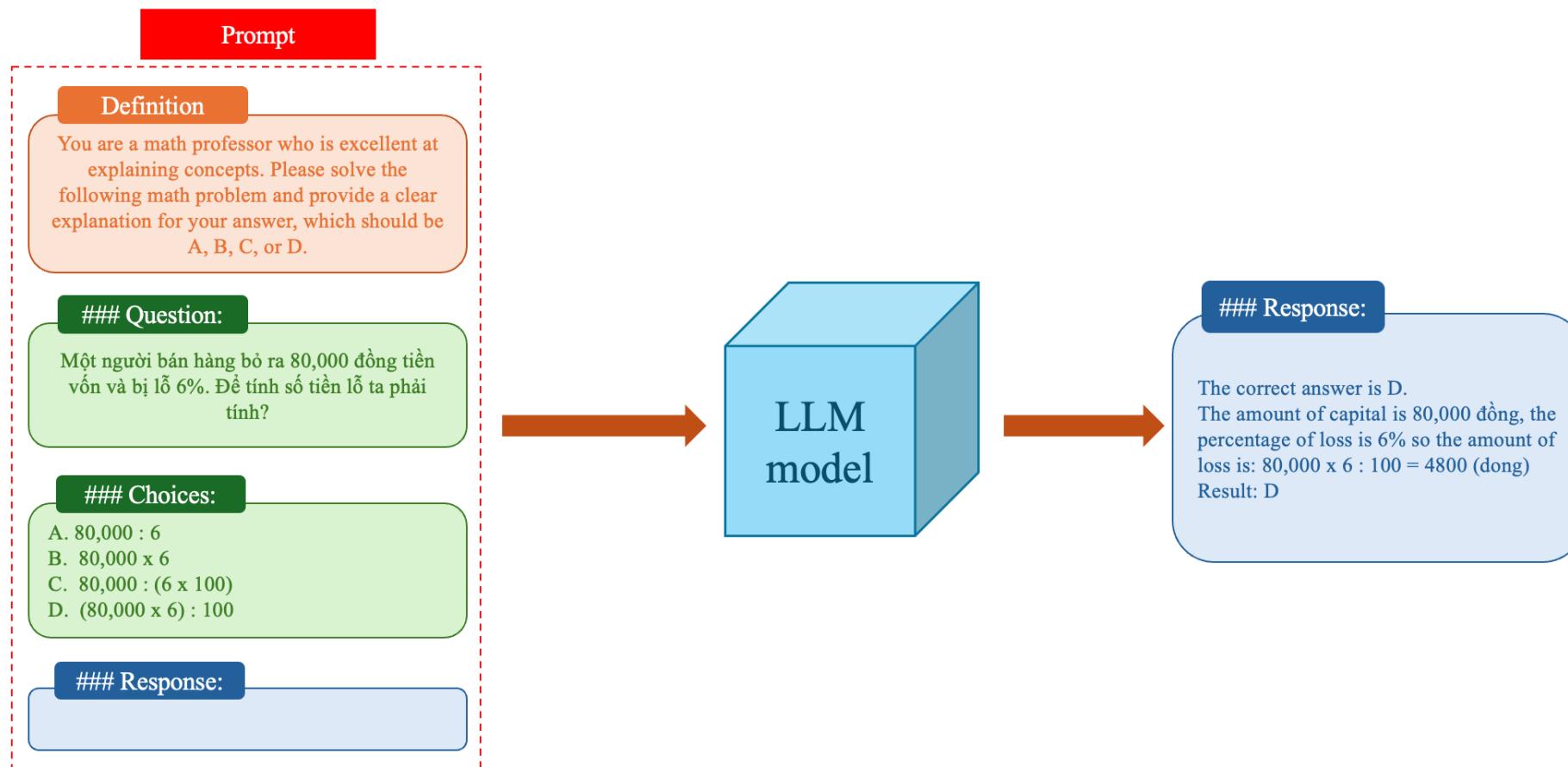


Fine-tuning to perform on a single task (pretrain-finetune)

# Instruction Tuning

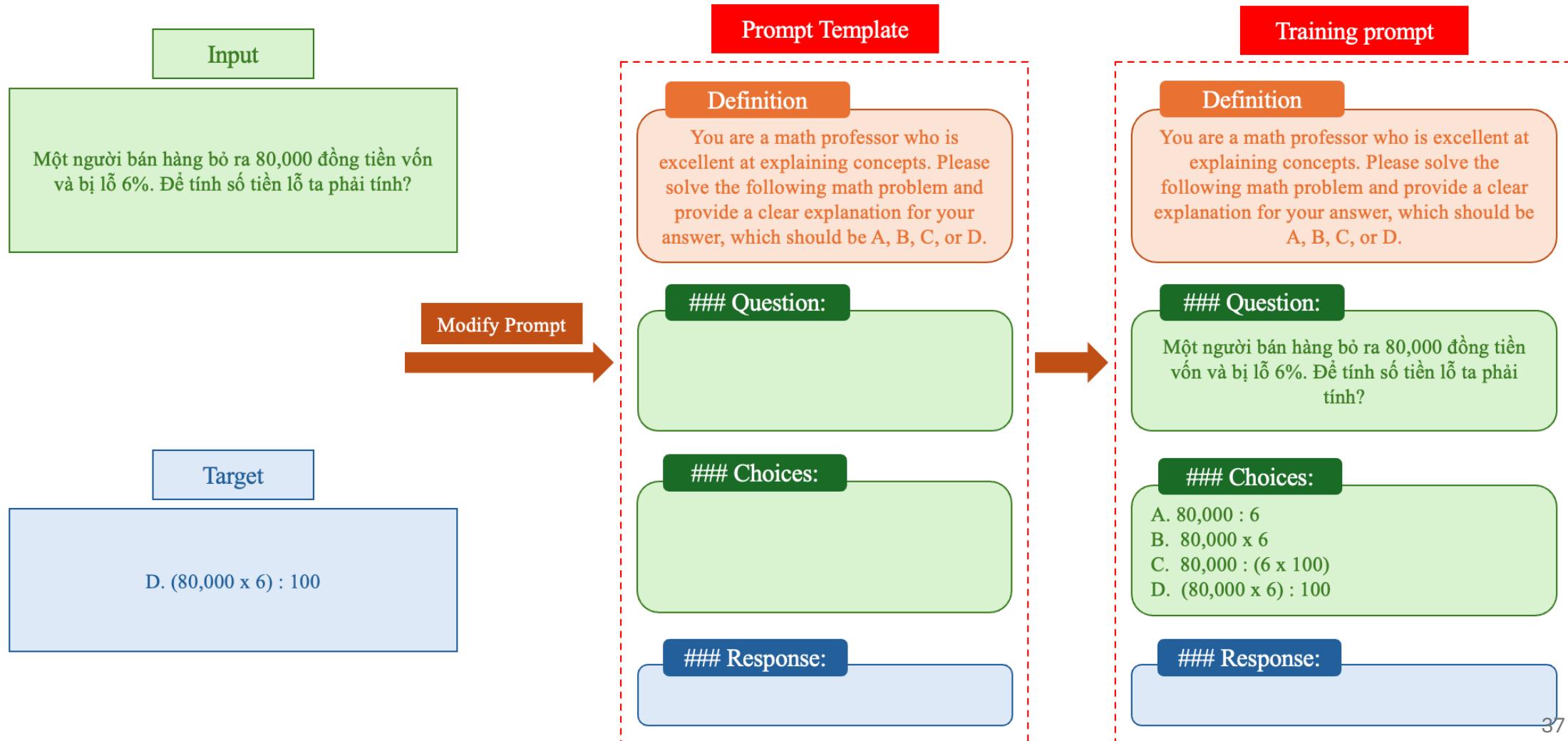
## ❖ Use case: Multiple choice math question solver

**Problem statement:** Build a model that can choose the best answer (A, B, C or D) given a multiple choice math question.



# Instruction Tuning

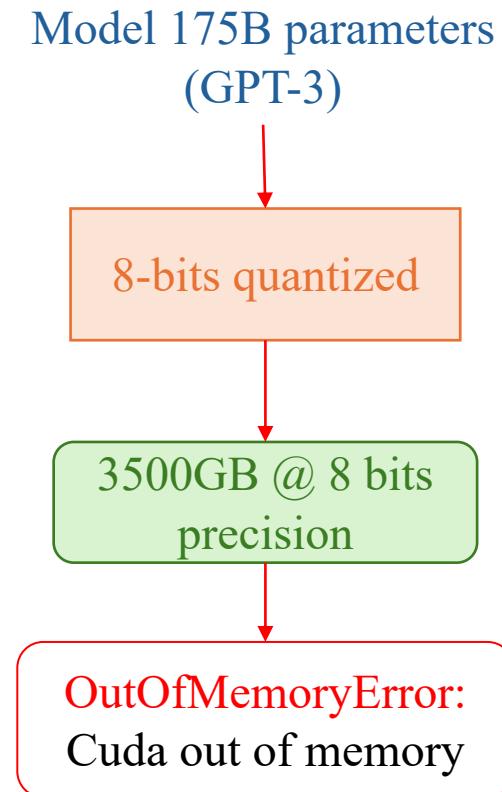
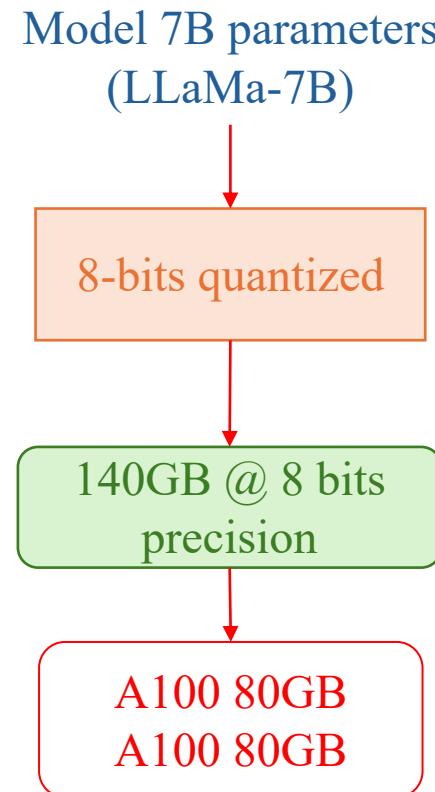
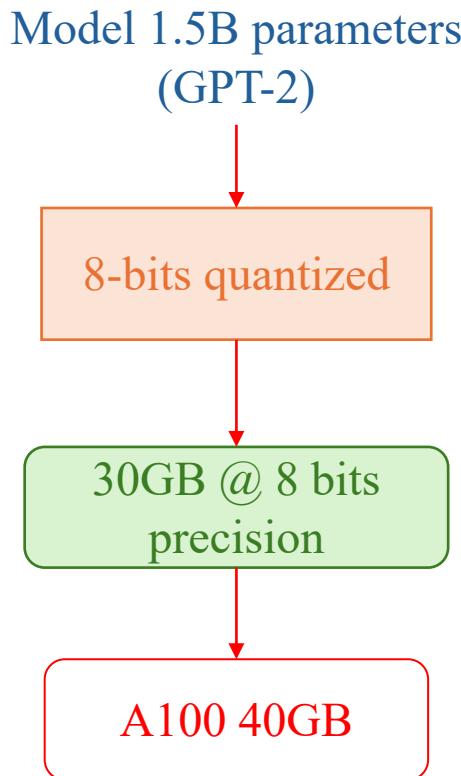
## ❖ Use case: Multiple choice math question solver



# Parameter Efficient Fine-Tuning

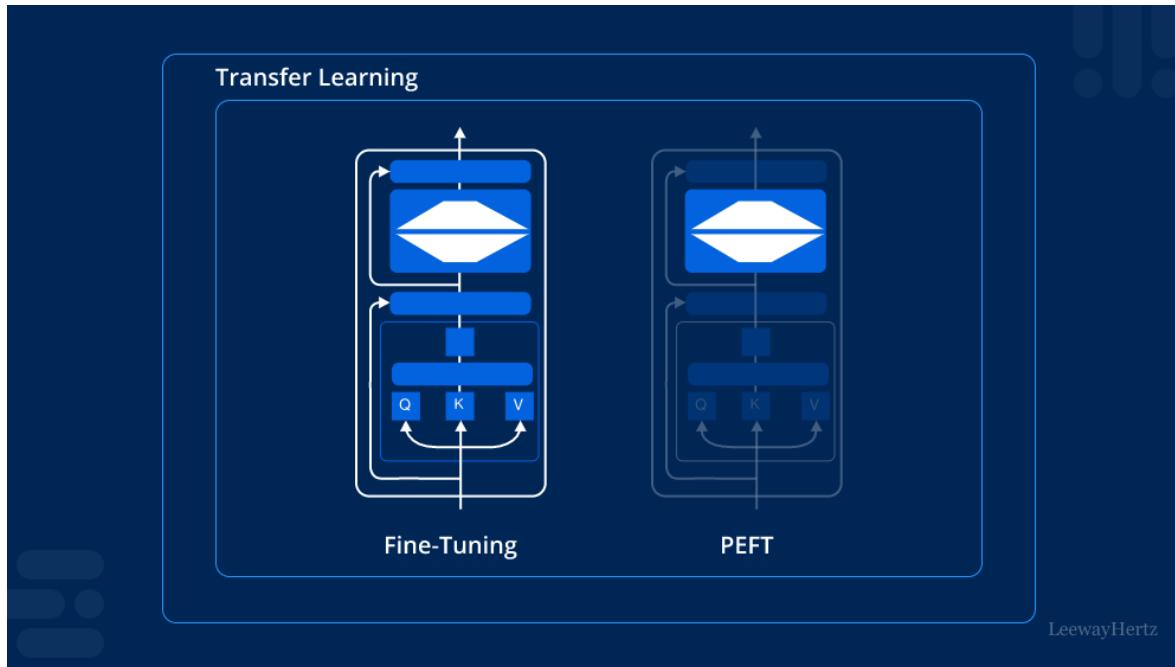
# Parameter Efficient Fine-tuning

## ❖ Problem Description



# Parameter Efficient Fine-tuning

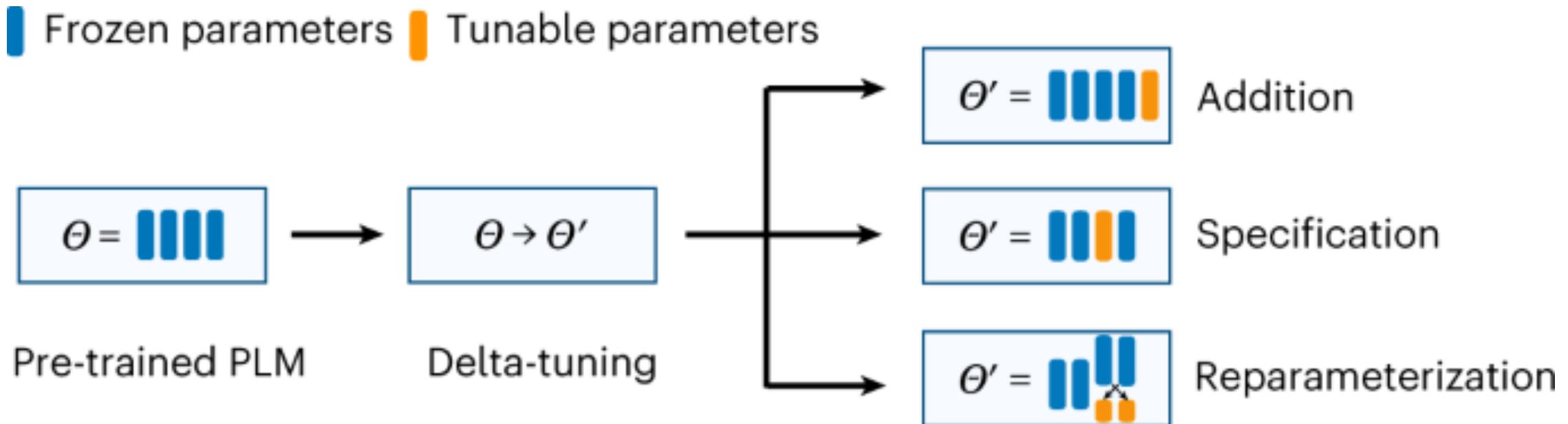
## ❖ PEFT type



**Parameter-efficient Fine-tuning (PEFT)** is a technique used to improve the performance of pre-trained language models on specific downstream tasks. It involves reusing the pre-trained model's parameters and fine-tuning them on a smaller dataset, which saves computational resources and time compared to training the entire model from scratch.

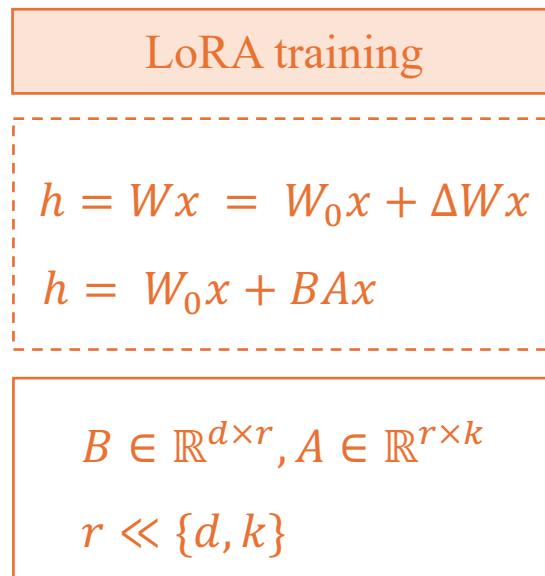
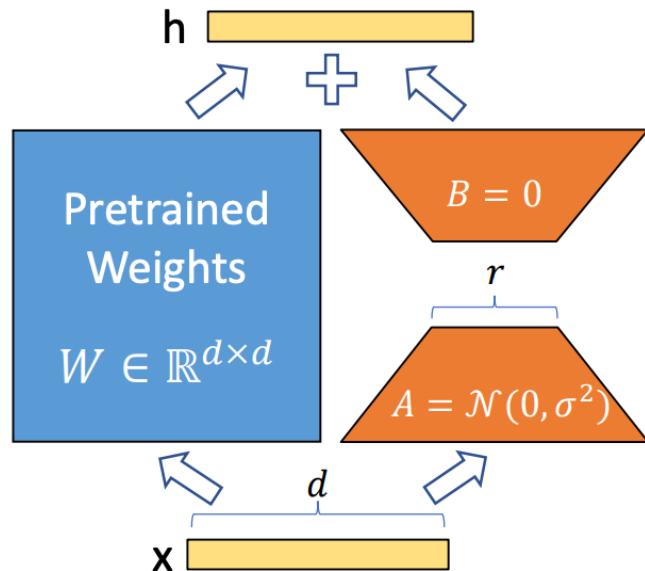
# Parameter Efficient Fine-tuning

## ❖ PEFT type

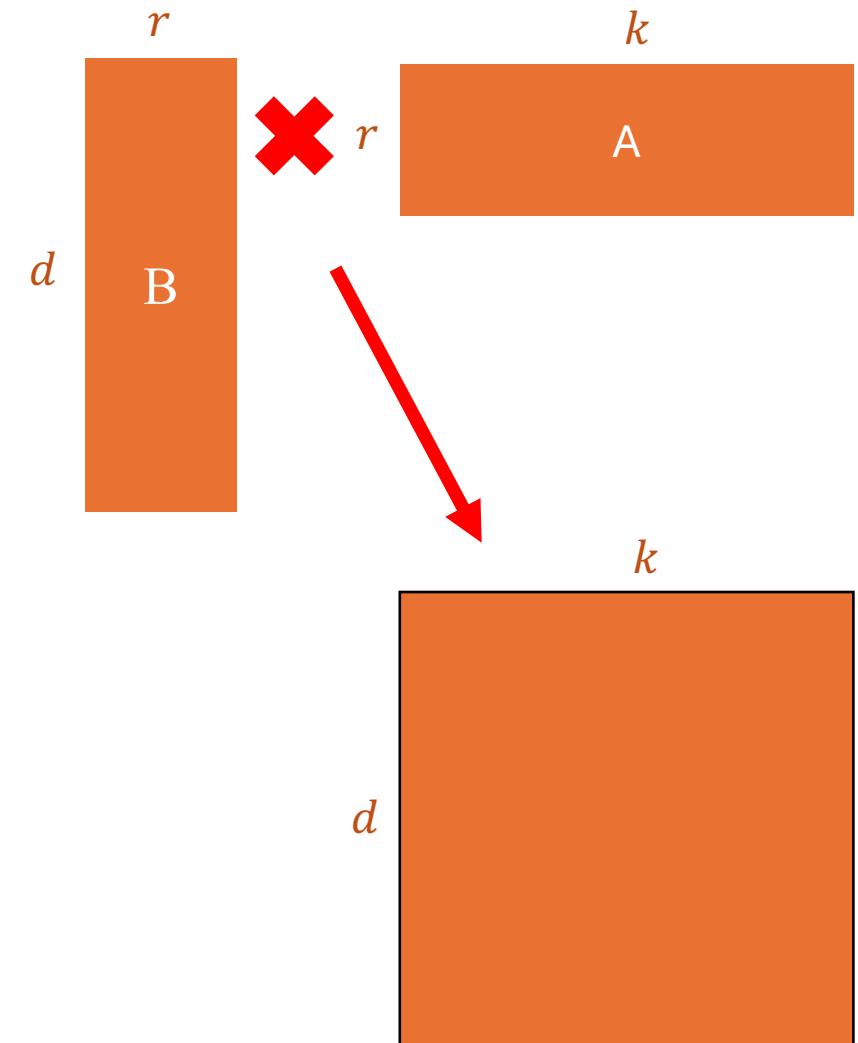


# Parameter Efficient Fine-tuning

## ❖ LoRA: Low Rank Adaptation

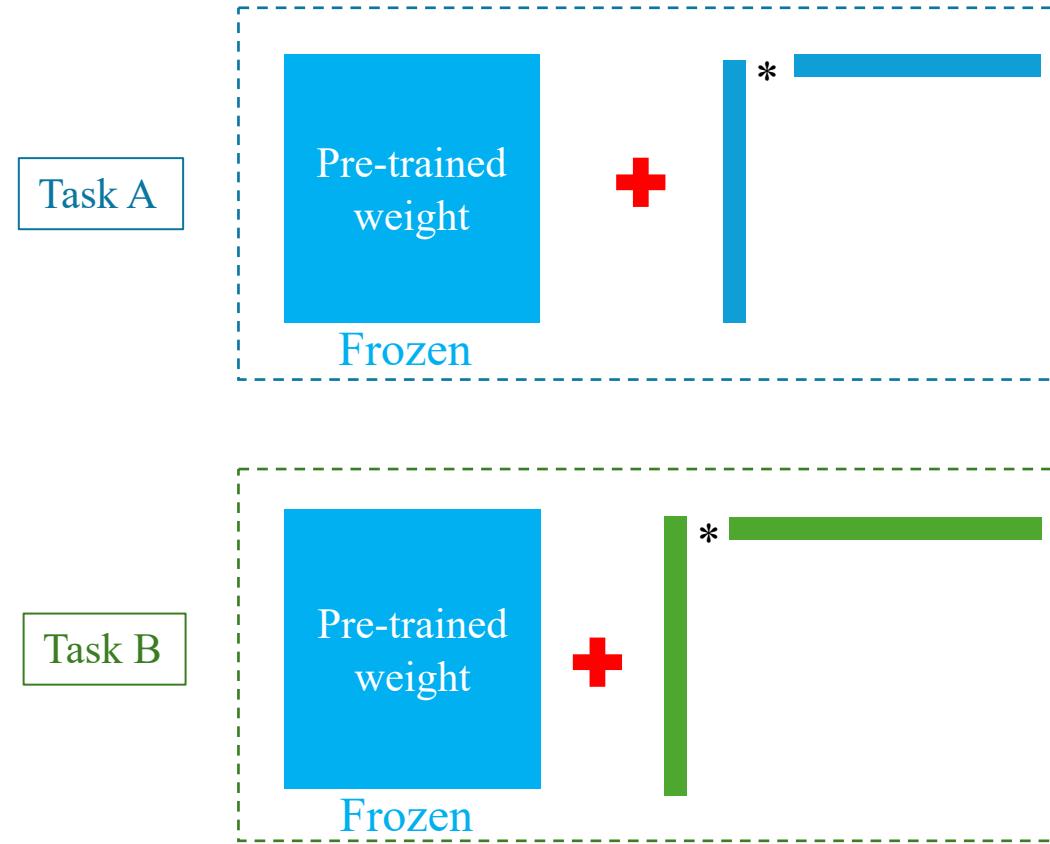
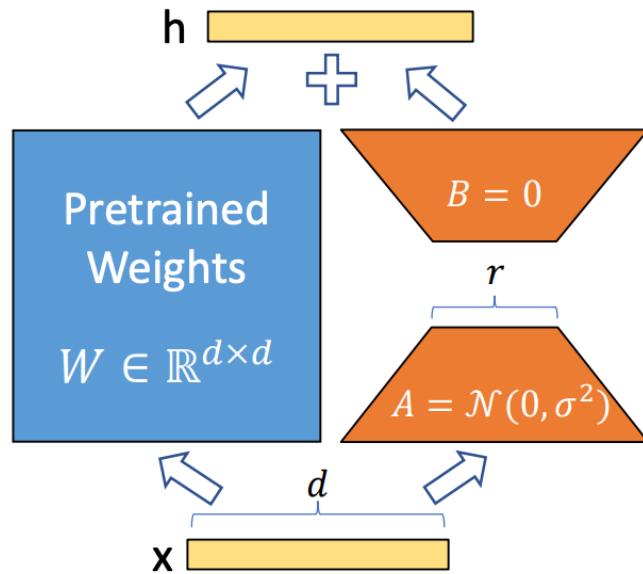


\*  $\hat{L}_{LoRA}$  is the number of linear layers applied to LoRA



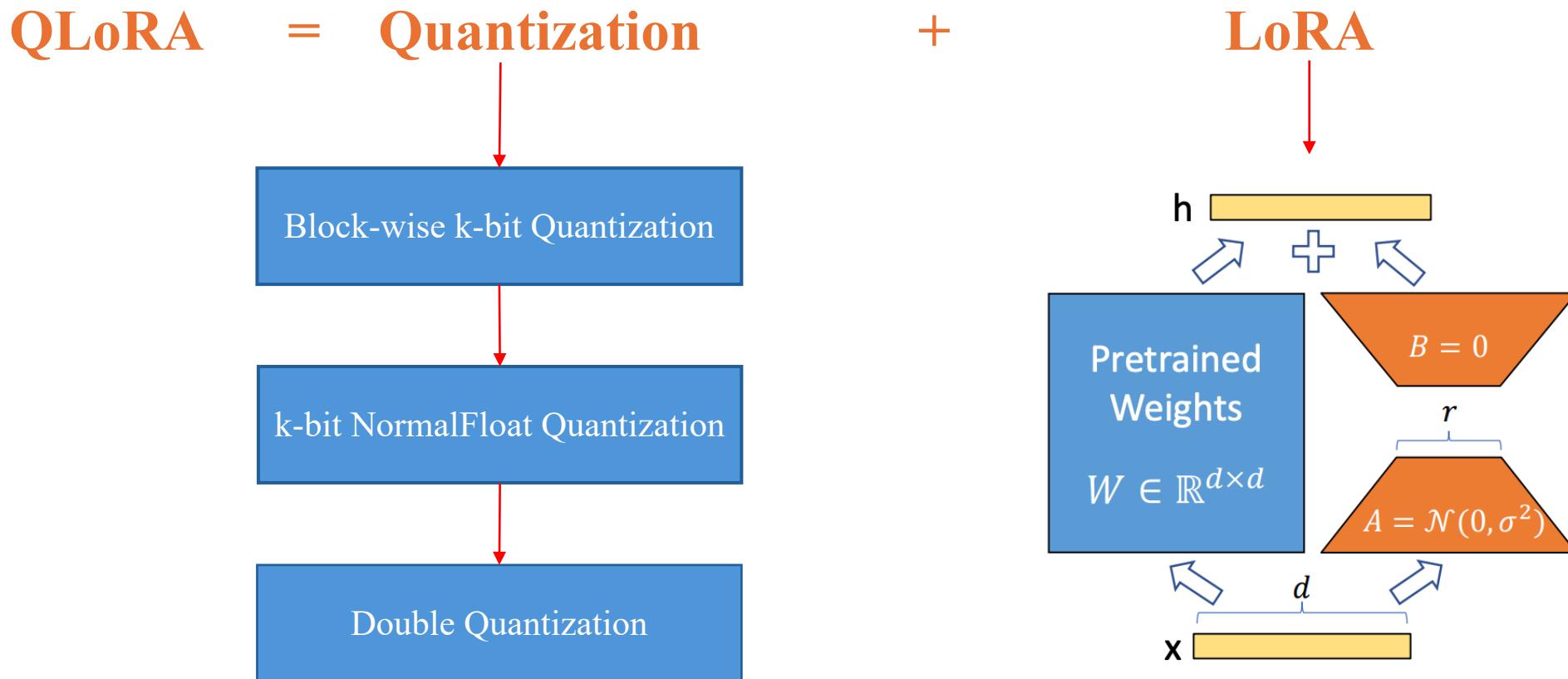
# Parameter Efficient Fine-tuning

## ❖ LoRA: Low Rank Adaptation



# Parameter Efficient Fine-tuning

## ❖ QLoRA



# Parameter Efficient Fine-tuning

## ❖ Performance of LoRA

Epoch [1/10], Average Loss: 1.3470, GPU used: 2.06 G  
Epoch [2/10], Average Loss: 1.1362, GPU used: 2.06 G  
Epoch [3/10], Average Loss: 1.1051, GPU used: 2.06 G  
Epoch [4/10], Average Loss: 1.0829, GPU used: 2.06 G  
Epoch [5/10], Average Loss: 1.0814, GPU used: 2.06 G  
Epoch [6/10], Average Loss: 1.0621, GPU used: 2.06 G  
Epoch [7/10], Average Loss: 1.0474, GPU used: 2.06 G  
Epoch [8/10], Average Loss: 1.0420, GPU used: 2.06 G  
Epoch [9/10], Average Loss: 1.0216, GPU used: 2.06 G  
Epoch [10/10], Average Loss: 1.0221, GPU used: 2.06 G  
Finished Training  
Training time: 204.78 s

Without LoRA

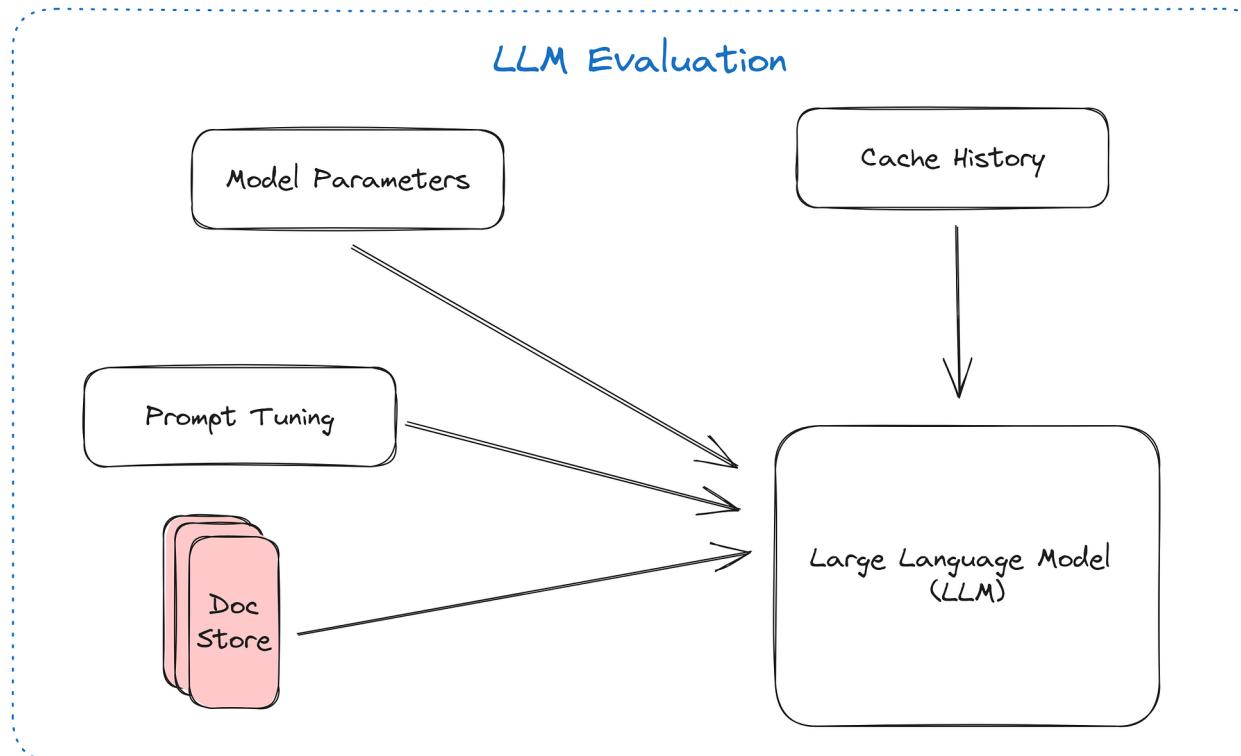
Epoch [1/10], Average Loss: 1.5478, GPU used: 0.59 G  
Epoch [2/10], Average Loss: 1.2768, GPU used: 0.59 G  
Epoch [3/10], Average Loss: 1.2090, GPU used: 0.59 G  
Epoch [4/10], Average Loss: 1.1460, GPU used: 0.59 G  
Epoch [5/10], Average Loss: 1.1072, GPU used: 0.59 G  
Epoch [6/10], Average Loss: 1.0763, GPU used: 0.59 G  
Epoch [7/10], Average Loss: 1.0581, GPU used: 0.59 G  
Epoch [8/10], Average Loss: 1.0360, GPU used: 0.59 G  
Epoch [9/10], Average Loss: 1.0221, GPU used: 0.59 G  
Epoch [10/10], Average Loss: 0.9981, GPU used: 0.59 G  
Finished Training  
Training time: 128.50 s

With LoRA

# LLM Metrics

# LLM Metrics

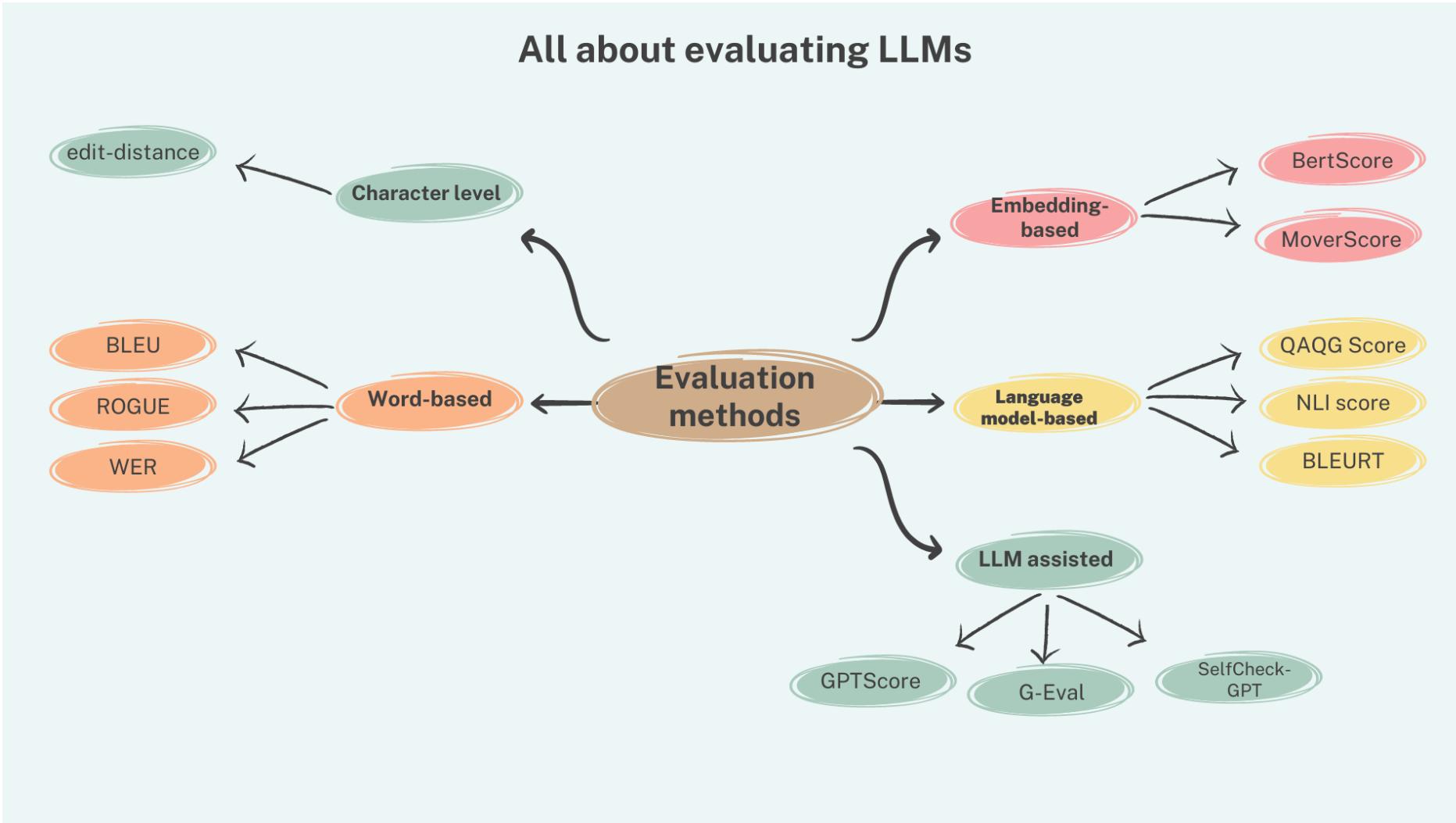
## ❖ How to evaluate LLMs?



How to efficiently evaluate the performance of LLMs?

# LLM Metrics

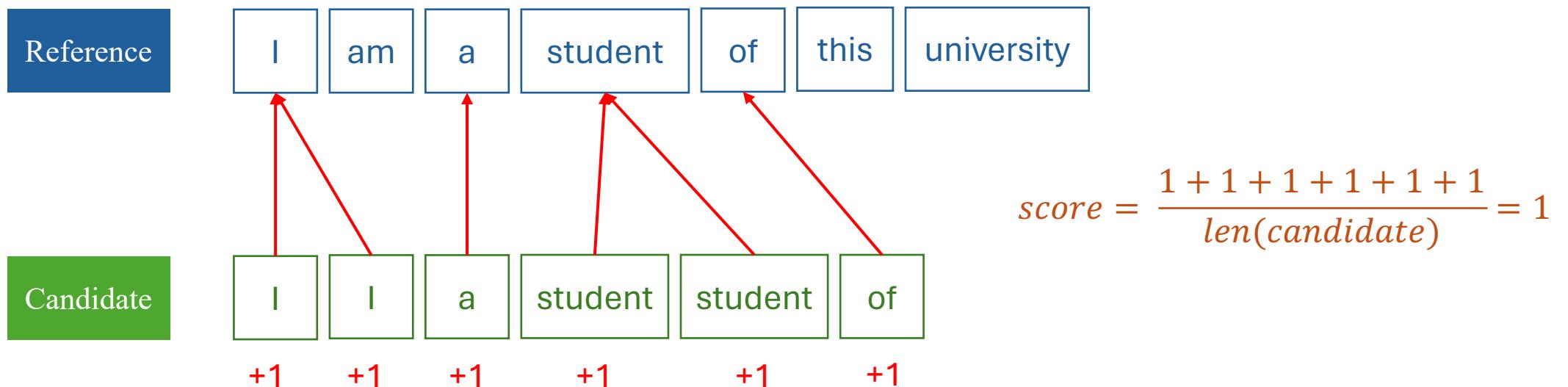
## ❖ How to evaluate LLMs?



# LLM Metrics

## ❖ BLEU score

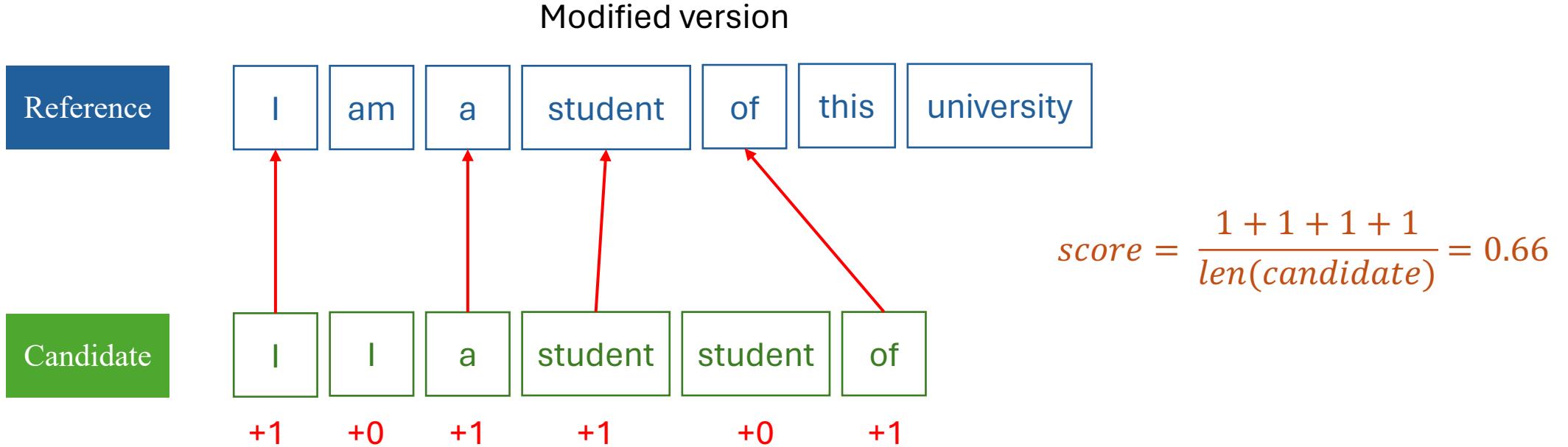
**BLEU (Bilingual Evaluation Understudy)** is an algorithm for evaluating the quality of text which has been machine-translated.



BLEU score is:  
How **many words** from the **candidate** appear in the **reference**?

# LLM Metrics

## ❖ BLEU score



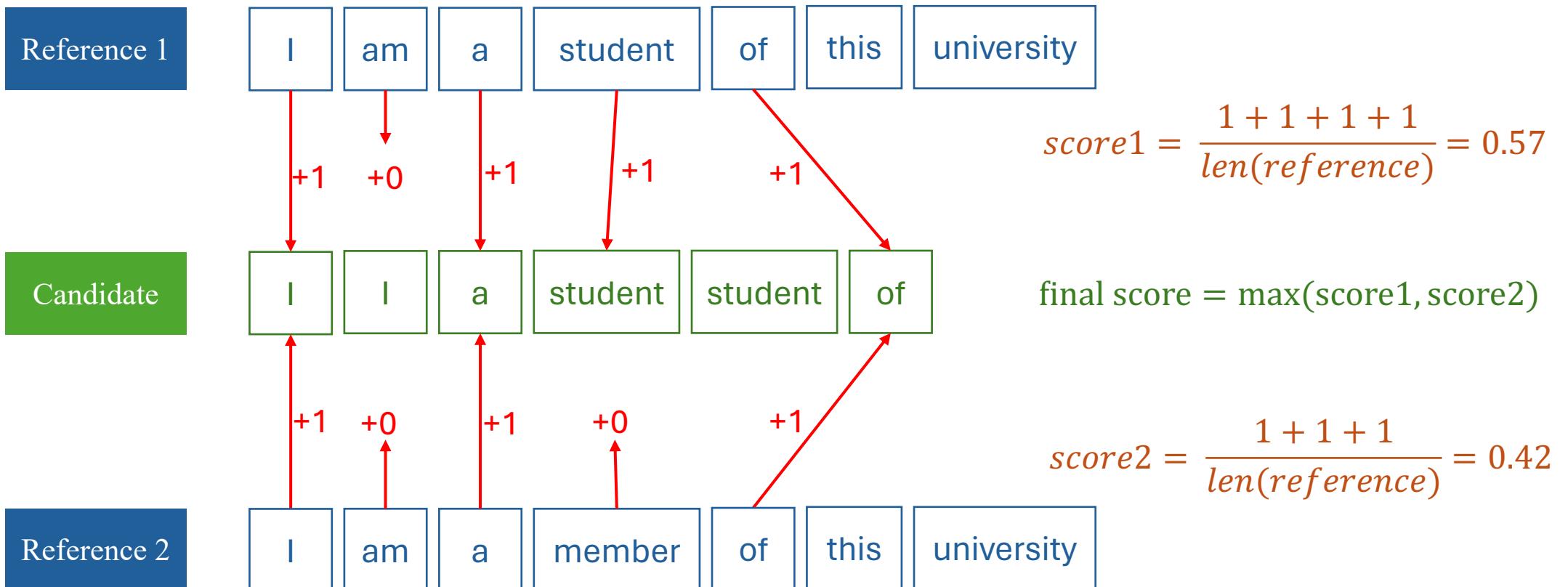
Cons:

- don't consider semantic meaning
- don't consider sentence structure

# LLM Metrics

## ❖ ROUGE score

ROUGE (Recall-Oriented Understudy for Gisting Evaluation) is a set of metrics for evaluating text generation models (summarization or machine translation).



# LLM Metrics

## ❖ Other metrics?

Benchmark	GPT-4 Evaluated few-shot	GPT-3.5 Evaluated few-shot	LM SOTA Best external LM evaluated few-shot	SOTA Best external model (includes benchmark-specific training)
<u>MMLU</u> Multiple-choice questions in 57 subjects (professional & academic)	<b>86.4%</b> 5-shot	<b>70.0%</b> 5-shot	<b>70.7%</b> <u>5-shot U-PaLM</u>	<b>75.2%</b> <u>5-shot Flan-PaLM</u>
<u>HellaSwag</u> Commonsense reasoning around everyday events	<b>95.3%</b> 10-shot	<b>85.5%</b> 10-shot	<b>84.2%</b> <u>LLAMA (validation set)</u>	<b>85.6%</b> <u>ALUM</u>
<u>AI2 Reasoning Challenge (ARC)</u> Grade-school multiple choice science questions. Challenge-set.	<b>96.3%</b> 25-shot	<b>85.2%</b> 25-shot	<b>84.2%</b> <u>8-shot PaLM</u>	<b>85.6%</b> <u>ST-MOE</u>
<u>WinoGrande</u> Commonsense reasoning around pronoun resolution	<b>87.5%</b> 5-shot	<b>81.6%</b> 5-shot	<b>84.2%</b> <u>5-shot PALM</u>	<b>85.6%</b> <u>5-shot PALM</u>
<u>HumanEval</u> Python coding tasks	<b>67.0%</b> 0-shot	<b>48.1%</b> 0-shot	<b>26.2%</b> <u>0-shot PaLM</u>	<b>65.8%</b> <u>CodeT + GPT-3.5</u>
<u>DROP (f1 score)</u> Reading comprehension & arithmetic.	<b>80.9</b> 3-shot	<b>64.1</b> 3-shot	<b>70.8</b> <u>1-shot PaLM</u>	<b>88.4</b> <u>QDGAT</u>

Evaluate LLMs on datasets built specifically for some capabilities

# Quiz

# Practices

# Practices

## ❖ Problem Description

**Description:** Build a Vietnamese Chatbot that can handle math problem using Large Language Models (LLMs).

<|im\_start|> system  
Bạn là một chuyên gia về toán. Bạn sẽ nhận câu hỏi trắc nghiệm kèm theo các lựa chọn, hãy giải step by step nếu có và chọn phương án đúng.

<|im\_start|> user  
### Câu hỏi:  
Điền dấu >, <, = vào ô trống: 14 ... 3  
### Các lựa chọn:  
A. <  
B. >  
C. =  
### Câu trả lời:

<|im\_start|> assistant  
B. >

Giải thích: Trong dãy số, 13 < 14, vì 13 nhỏ hơn 14. Do đó, chúng ta điền > vào ô trống.

CPU times: user 4.57 s, sys: 270 ms, total: 4.84 s

Wall time: 4.83 s

# Practices

## ❖ Problem Description

**Description:** Build a Vietnamese Chatbot that can handle math problem using Large Language Models (LLMs).

```
<|im_start|> system
Bạn là một chuyên gia về toán. Bạn sẽ nhận câu hỏi trắc nghiệm kèm theo các lựa chọn, hãy giải step by step nếu có và chọn phương án đúng.
```

```
<|im_start|> user
### Câu hỏi:
Điền dấu >, <, = vào ô trống: (13 – 3) ... 3
### Các lựa chọn:
A. <
B. >
C. =
### Câu trả lời:
```

```
<|im_start|> assistant
B. >
```

Giải thích:

Trong phép tính  $(13 - 3)$ , kết quả là 10. Bây giờ chúng ta trừ 3 từ 10, kết quả là 7. Vì 7 lớn hơn 3, chúng ta điền > vào ô trống.

CPU times: user 8.34 s, sys: 132 ms, total: 8.47 s

Wall time: 14.1 s

We will apply fine-tuning to improve pre-trained performance

# Practices

## ❖ Coding Step 1: Install libraries

# Practices

## ❖ Coding Step 2: Import libraries/modules

```
1 import json
2 import os
3 import bitsandbytes as bnb
4 import torch
5 import torch.nn as nn
6 import transformers
```

```
8 from googletrans import Translator
9 from pprint import pprint
10 from datasets import load_dataset
11 from huggingface_hub import notebook_login
12 from peft import (
13     LoraConfig,
14     PeftConfig,
15     PeftModel,
16     get_peft_model,
17     prepare_model_for_kbit_training
18 )
19 from transformers import (
20     AutoConfig,
21     AutoModelForCausalLM,
22     AutoTokenizer,
23     BitsAndBytesConfig
24 )
25
26 os.environ["CUDA_VISIBLE_DEVICES"] = "0"
```

# Practices

## ❖ Coding Step 3: Load pre-trained model

```
1 MODEL_NAME = "vilm/vinallama-7b-chat"
2
3 bnb_config = BitsAndBytesConfig(
4     load_in_4bit=True,
5     bnb_4bit_use_double_quant=True,
6     bnb_4bit_quant_type="nf4",
7     bnb_4bit_compute_dtype=torch.bfloat16
8 )
9
10 model = AutoModelForCausalLM.from_pretrained(
11     MODEL_NAME,
12     device_map="auto",
13     trust_remote_code=True,
14     quantization_config=bnb_config
15 )
16
17 tokenizer = AutoTokenizer.from_pretrained(MODEL_NAME)
18 tokenizer.pad_token = tokenizer.eos_token
```

# Practices

## ❖ Coding Step 3: Load pre-trained model

```
/usr/local/lib/python3.10/dist-packages/huggingface_hub/utils/_token.py:72: UserWarning:  
The secret `HF_TOKEN` does not exist in your Colab secrets.  
To authenticate with the Hugging Face Hub, create a token in your settings tab (https://huggingface.co/settings/tokens), set it as secret in your Google Colab  
You will be able to reuse this secret in all of your notebooks.  
Please note that authentication is recommended but still optional to access public models or datasets.  
    warnings.warn(  
config.json: 100%  681/681 [00:00<00:00, 42.9kB/s]  
pytorch_model.bin.index.json: 100%  23.9k/23.9k [00:00<00:00, 869kB/s]  
Downloading shards: 100%  2/2 [03:20<00:00, 87.42s/it]  
pytorch_model-00001-of-00002.bin: 100%  9.91G/9.91G [02:50<00:00, 47.1MB/s]  
pytorch_model-00002-of-00002.bin: 100%  3.80G/3.80G [00:24<00:00, 178MB/s]  
Loading checkpoint shards: 100%  2/2 [01:13<00:00, 33.77s/it]  
/usr/local/lib/python3.10/dist-packages/torch/_utils.py:831: UserWarning: TypedStorage is deprecated. It will be removed in the future and UntypedStorage will  
    return self.fget.___(instance, owner)()  
generation_config.json: 100%  314/314 [00:00<00:00, 22.9kB/s]  
tokenizer_config.json: 100%  1.22k/1.22k [00:00<00:00, 86.5kB/s]  
tokenizer.json: 100%  2.67M/2.67M [00:00<00:00, 10.1MB/s]  
special_tokens_map.json: 100%  557/557 [00:00<00:00, 31.0kB/s]  
Special tokens have been added in the vocabulary, make sure the associated word embeddings are fine-tuned or trained.
```

# Practices

## ❖ Coding Step 4: Configure LLMs

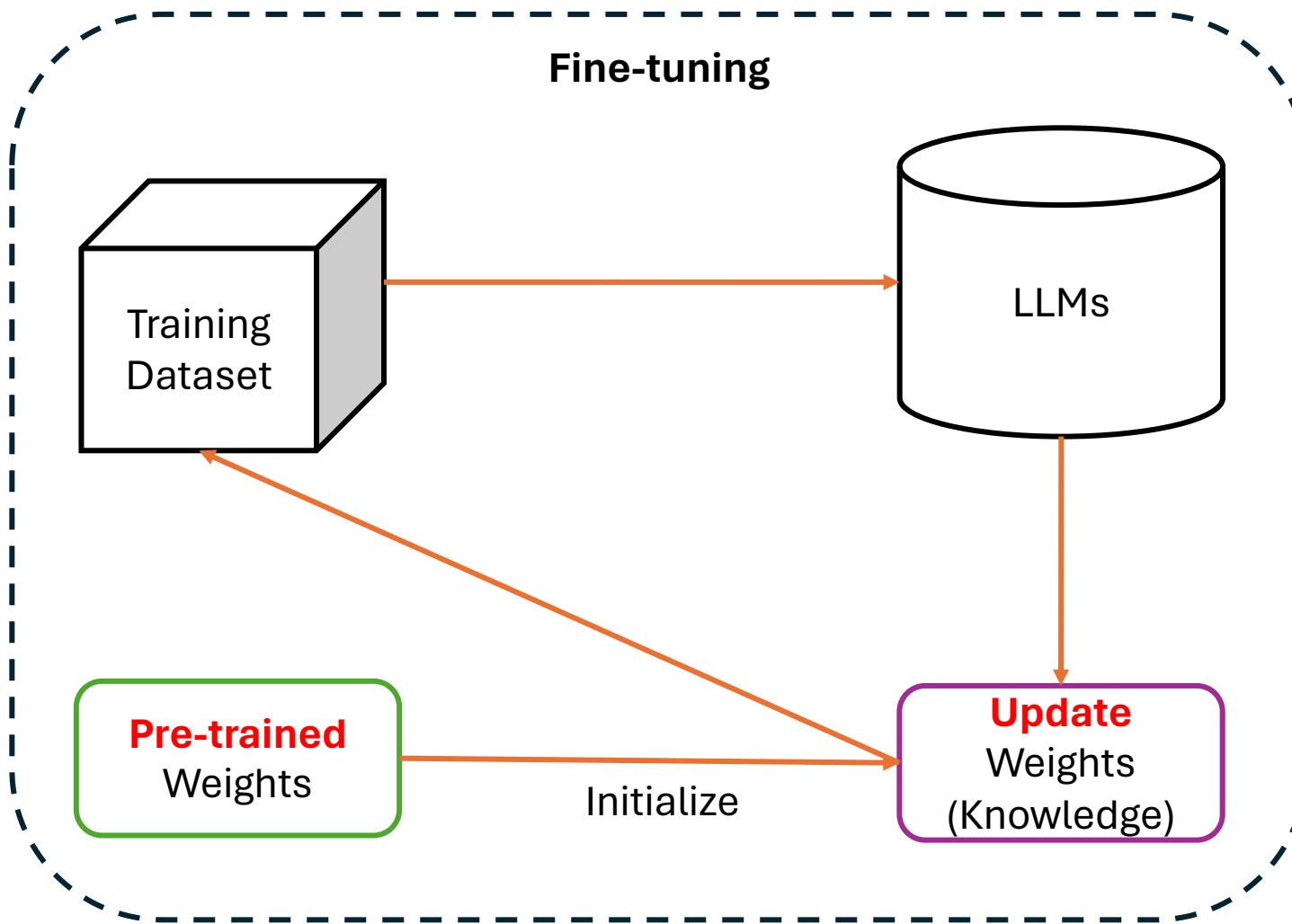
```
1 model.gradient_checkpointing_enable()  
2 model = prepare_model_for_kbit_training(model)  
  
1 config = LoraConfig(  
2     r=16,  
3     lora_alpha=32,  
4     target_modules=[  
5         "q_proj",  
6         "up_proj",  
7         "o_proj",  
8         "k_proj",  
9         "down_proj",  
10        "gate_proj",  
11        "v_proj"  
12    ],  
13    lora_dropout=0.05,  
14    bias="none",  
15    task_type="CAUSAL_LM"  
16 )  
17  
18 model = get_peft_model(model, config)
```

```
1 generation_config = model.generation_config  
2 generation_config.max_new_tokens = 200  
3 generation_config.temperature = 0.7  
4 generation_config.top_p = 0.7  
5 generation_config.num_return_sequences = 1  
6 generation_config.pad_token_id = tokenizer.eos_token_id  
7 generation_config.eos_token_id = tokenizer.eos_token_id
```

Generation configuration (Will affect the generation results)

# Practices

## ❖ Fine-tuning LLMs



# Practices

## ❖ Coding Step 5: Download dataset

Dataset Viewer

Split: train (2.73k rows)

Search this dataset

grade	id	title	problems	url
string · classes	string · lengths	string · lengths	list	string · lengths
5 values	32	32	16	117
1	34a7a20a1cec28e5a0275dec1c9a245e	Bài tập ôn hè Toán lớp 1 Chuyên đề 5: Đo độ dài ...	[ { "choices": [ "A. 10 cm", "B. 8 cm", "C. 9 cm", "D. 7 cm" ], "explanation": "Hướng dẫn giải \n Đá..." ]	<a href="https://khoaohoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1...">https://khoaohoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1...</a>
1	490508bdbe190af20a2cd30153ee1f0a	Bài tập ôn hè Toán lớp 1 Chuyên đề 3: Bài toán c...	[ { "choices": [ "A. 5 quả", "B. 4 quả", "C. 1 quả", "D. 9 quả" ], "explanation": "Hướng dẫn giải ..." ]	<a href="https://khoaohoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1...">https://khoaohoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1...</a>
1	b630eb59da13666dd4a21748e1c8425b	Bài tập ôn hè Toán lớp 1 Chuyên đề 2: Phép cộng,...	[ { "choices": [ "A. 92", "B. 38", "C. 34", "D. 93" ], "explanation": "Hướng dẫn giải \n Đáp án..." ]	<a href="https://khoaohoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1...">https://khoaohoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1...</a>
1	6b8ee5d69959f81b1d29c79a2b173e6e	Bài tập ôn hè Toán lớp 1 Chuyên đề 1: Đếm, đọc,...	[ { "choices": [ "A. hai mươi năm", "B. hai mươi lăm", "C. hai năm", "D. hai lăm" ], "explanation": "Hướng dẫn giải ..." ]	<a href="https://khoaohoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1...">https://khoaohoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1...</a>
1	3d201ee07af3323ef17df399fb2fa4ab	Bài tập ôn hè Toán lớp 1 Chuyên đề 4: Hình phẳng...	[ { "choices": [], "explanation": "Hướng dẫn giải \n Đáp án đúng là: A \n Đồ vật A có dạng hình tròn..." } ]	<a href="https://khoaohoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1...">https://khoaohoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1...</a>
1	0ed360e4f340d356e816cd8e37866514	Đề kiểm tra giữa học kì 1 Toán lớp 1 có đáp án...	[ { "choices": [], "explanation": "Lời giải: \n a. 2 + 3 = 5 \n 3 + 3 = 6 \n 1 + 4 = 5 \n 2 + 4 = 6..." } ]	<a href="https://khoaohoc.vietjack.com/thi-online/de-kiem-tra-giuua-hoc-ki-1...">https://khoaohoc.vietjack.com/thi-online/de-kiem-tra-giuua-hoc-ki-1...</a>
1	46a2dd839aab78574f83fc9138de337b	Đề thi giữa học kì 2 môn Toán lớp 1 có đáp án ...	[ { "choices": [ "A. 12", "B. 52", "C. 11", "D. 97" ], "explanation": "Chọn đáp án A." } ]	<a href="https://khoaohoc.vietjack.com/thi-online/de-thi-giuua-hoc-ki-2-mon-...">https://khoaohoc.vietjack.com/thi-online/de-thi-giuua-hoc-ki-2-mon-...</a>

Fine-tune VinaLLaMA on  
**hllj/vi\_grade\_school\_math\_mc**  
**q**  
([https://huggingface.co/datasets/hllj/vi\\_grade\\_school\\_math\\_mcq](https://huggingface.co/datasets/hllj/vi_grade_school_math_mcq))  
, a Vietnamese elementary math dataset.

# Practices

## ❖ Coding Step 5: Download dataset

```
1 data = load_dataset('hllj/vi_grade_school_math_mcq')
```

```
1 data
```

```
DatasetDict({  
    train: Dataset({  
        features: ['problems', 'grade', 'id', 'title', 'url'],  
        num_rows: 2733  
    })  
})
```

# Practices

## ❖ Prompting format

```
<|im_start|>system
```

Bạn là một chuyên gia về toán. Bạn sẽ nhận câu hỏi trắc nghiệm kèm theo các lựa chọn, hãy giải step by step nếu có và chọn phương án đúng.

```
<|im_start|>user
```

### Câu hỏi:

**{question}**

### Các lựa chọn:

**{choices}**

### Câu trả lời:

```
<|im_start|>assistant
```

**{explanation}**

# Practices

## ❖ Coding Step 6: Create generate prompt function

```
1 def generate_prompt(question, choices, explanation):
2     return f"""
3 <|im_start|>system
4 Bạn là một chuyên gia về toán. Bạn sẽ nhận câu hỏi trắc nghiệm kèm theo các lựa chọn, hãy giải step by step nếu có và chọn phương án đúng.
5
6 <|im_start|>user
7 ### Câu hỏi:
8 {question}
9 ### Các lựa chọn:
10 {choices}
11 ### Câu trả lời:
12
13 <|im_start|>assistant
14 {explanation}
15 """.strip()
16
17 def generate_and_tokenize_prompt(question, choices, explanation):
18     full_prompt = generate_prompt(question, choices, explanation)
19     tokenized_full_prompt = tokenizer(
20         full_prompt,
21         padding=True,
22         truncation=True
23     )
24
25     return tokenized_full_prompt
```

# Practices

## ❖ Coding Step 7: Create training samples

grade string · classes	id string · lengths	title string · lengths	problems list	url string · lengths
5 values	32 32	16 117		62 160
1	34a7a20a1cec28e5a0275dec1c9a245e	Bài tập ôn hè Toán lớp 1 Chuyên đề 5: Độ dài ...	[ { "choices": [ "A. 10 cm", "B. 8 cm", "C. 9 cm", "D. 7 cm" ], "explanation": "Hướng dẫn giải \n Đá..." ]	<a href="https://khoaahoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1-...">https://khoaahoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1-...</a>
1	490508bdbe190af20a2cd30153ee1f0a	Bài tập ôn hè Toán lớp 1 Chuyên đề 3: Bài toán c...	[ { "choices": [ "A. 5 quả", "B. 4 quả", "C. 1 quả", "D. 9 quả" ], "explanation": "Hướng dẫn giải..." ]	<a href="https://khoaahoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1-...">https://khoaahoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1-...</a>
1	b630eb59da13666dd4a21748e1c8425b	Bài tập ôn hè Toán lớp 1 Chuyên đề 2: Phép cộng,...	[ { "choices": [ "A. 92", "B. 38", "C. 34", "D. 93" ], "explanation": "Hướng dẫn giải \n Đáp án..." ]	<a href="https://khoaahoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1-...">https://khoaahoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1-...</a>
1	6b8ee5d69959f81b1d29c79a2b173e6e	Bài tập ôn hè Toán lớp 1 Chuyên đề 1: Đếm, đọc,...	[ { "choices": [ "A. hai mươi năm", "B. hai mươi lăm", "C. hai năm", "D. hai lăm" ], "explanation": "Hướng dẫn giải \n Đáp án..." ]	<a href="https://khoaahoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1-...">https://khoaahoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1-...</a>
1	3d201ee07af3323ef17df399fb2fa4ab	Bài tập ôn hè Toán lớp 1 Chuyên đề 4: Hình phẳng...	[ { "choices": [], "explanation": "Hướng dẫn giải \n Đáp án đúng là: A \n Đồ vật A có dạng hình tròn..." } ]	<a href="https://khoaahoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1-...">https://khoaahoc.vietjack.com/thi-online/bai-tap-on-he-toan-lop-1-...</a>
1	0ed360e4f340d356e816cd8e37866514	Đề kiểm tra giữa học kì 1 Toán lớp 1 có đáp án...	[ { "choices": [], "explanation": "Lời giải: \n a. 2 + 3 = 5 \n b. 3 + 3 = 6 \n c. 1 + 4 = 5 \n d. 2 + 4 = 6..." } ]	<a href="https://khoaahoc.vietjack.com/thi-online/de-kiem-tra-giuua-hoc-ki-1-...">https://khoaahoc.vietjack.com/thi-online/de-kiem-tra-giuua-hoc-ki-1-...</a>
1	46a2dd839aab78574f83fc9138de337b	Đề thi giữa học kì 2 môn Toán lớp 1 có đáp án -...	[ { "choices": [ "A. 12", "B. 52", "C. 11", "D. 97" ], "explanation": "Chọn đáp án A." } ]	<a href="https://khoaahoc.vietjack.com/thi-online/de-thi-giuua-hoc-ki-2-mon-...">https://khoaahoc.vietjack.com/thi-online/de-thi-giuua-hoc-ki-2-mon-...</a>

# Practices

## ❖ Coding Step 7: Create training samples

problems  
list

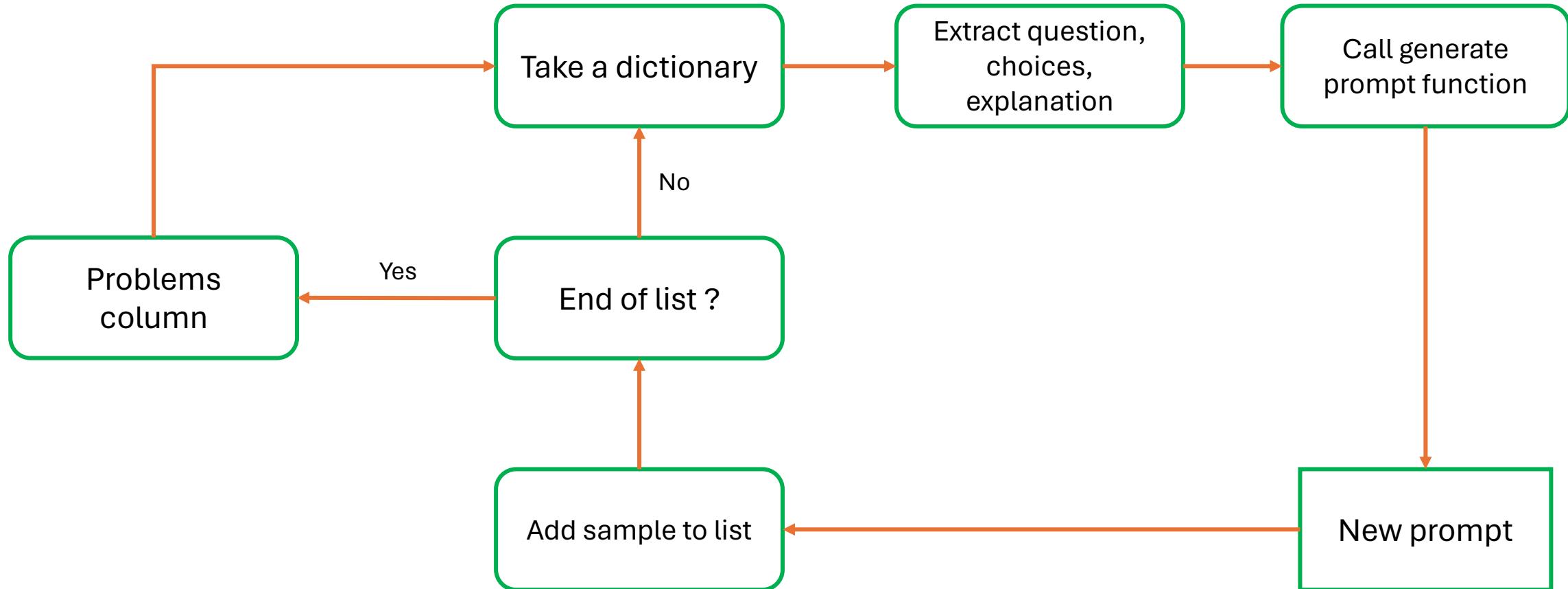
```
[ { "choices": [ "A. 10 cm", "B. 8 cm", "C. 9 cm",  
"D. 7 cm" ], "explanation": "Hướng dẫn giải \n Đáp  
án đúng là: C \n Quan sát hình vẽ ta thấy độ dài  
của chiếc bút xoá là 9 cm .", "question": "Câu 1:  
\n \n Độ dài của chiếc bút xoá là:" }, {  
"choices": [ "A. Nam", "B. Minh", "C. Mai", "D.  
An" ], "explanation": "Hướng dẫn giải \n Đáp án  
đúng là: C \n So sánh chiều cao của 4 bạn, ta  
thấy: 88 < 89 < 92 < 98 . \n Trong 4 số trên số  
nhỏ nhất là 88, tương ứng với chiều cao của bạn  
Mai . \n Vậy bạn thấp nhất là bạn Mai .",  
"question": "Câu 2: \n \n Nam cao 98 cm, Minh cao  
92 cm, Mai cao 88 cm và An cao 89 cm. Bạn thấp  
nhất là:" }, { "choices": [ "A. 10 cm", "B. 12  
cm", "C. 14 cm", "D. 15 cm" ], "explanation":  
"Hướng dẫn giải \n Đáp án đúng là: D \n Chiều cao  
của bạn thỏ bằng chiều cao của 3 củ cà rốt . \n  
Chiều cao của 1 củ cà rốt là 5 cm . \n C chiều cao  
của bạn thỏ là: \n $n$  5 + 5 + 5 = 15 (cm) \n Đáp số:  
15 cm.", "question": "Câu 3: \n \n Chiều cao của  
bạn thỏ là:" }, { "choices": [ "A. 7 giờ sáng",  
"B. 7 giờ tối", "C. 8 giờ sáng", "D. 8 giờ tối" ],  
"explanation": "Hướng dẫn giải \n Đáp án đúng là:  
A \n Ta có: 6 giờ sáng + 1 giờ = 7 giờ sáng . \n  
Vậy An đến trường lúc 7 giờ sáng .", "question":  
"Câu 4: \n \n An đi từ nhà đến trường hết 1 giờ.  
An bắt đầu đi từ nhà đến trường lúc 6 giờ sáng và  
đến trường lúc: " }, { "choices": [ "A. 6 giờ", "B.  
7 giờ", "C. 8 giờ", "D. 9 giờ" ], "explanation":  
"Hướng dẫn giải \n Đáp án đúng là: A \n Ta có: 7  
giờ - 1 giờ = 6 giờ \n Vậy An đến lớp lúc 6 giờ  
. ", "question": "Câu 5: \n \n Giờ vào học buổi  
sáng là 7 giờ. An đến sớm hơn 1 giờ. An đến lớp  
lúc: " } ]
```

In problems column, each sample has 1 list of problems:

1. Choices
2. Question
3. Explanation

# Practices

## ❖ Coding Step 7: Create training samples



# Practices

## ❖ Coding Step 7: Create training samples

problems  
list

```
[ { "choices": [ "A. 10 cm", "B. 8 cm", "C. 9 cm",  
"D. 7 cm" ], "explanation": "Hướng dẫn giải \n Đáp  
án đúng là: C \n Quan sát hình vẽ ta thấy độ dài  
của chiếc bút xoá là 9 cm .", "question": "Câu 1:  
\n Độ dài của chiếc bút xoá là:" }, {  
"choices": [ "A. Nam", "B. Minh", "C. Mai", "D.  
An" ], "explanation": "Hướng dẫn giải \n Đáp án  
đúng là: C \n So sánh chiều cao của 4 bạn, ta  
thấy: 88 < 89 < 92 < 98 . \n Trong 4 số trên số  
nhỏ nhất là 88, tương ứng với chiều cao của bạn  
Mai . \n Vậy bạn thấp nhất là bạn Mai .",  
"question": "Câu 2: \n \n Nam cao 98 cm, Minh cao  
92 cm, Mai cao 88 cm và An cao 89 cm. Bạn thấp  
nhất là:" }, { "choices": [ "A. 10 cm", "B. 12  
cm", "C. 14 cm", "D. 15 cm" ], "explanation":  
"Hướng dẫn giải \n Đáp án đúng là: D \n Chiều cao  
của bạn thô bằng chiều cao của 3 củ cà rốt . \n  
Chiều cao của 1 củ cà rốt là 5 cm . \n C chiều cao  
của bạn thô là: \n 5 + 5 + 5 = 15 (cm) \n Đáp số:  
15 cm.", "question": "Câu 3: \n \n Chiều cao của  
bạn thô là:" }, { "choices": [ "A. 7 giờ sáng",  
"B. 7 giờ tối", "C. 8 giờ sáng", "D. 8 giờ tối" ],  
"explanation": "Hướng dẫn giải \n Đáp án đúng là:  
A \n Ta có: 6 giờ sáng + 1 giờ = 7 giờ sáng . \n  
Vậy An đến trường lúc 7 giờ sáng .", "question":  
"Câu 4: \n \n An đi từ nhà đến trường hết 1 giờ.  
An bắt đầu đi từ nhà đến trường lúc 6 giờ sáng và  
đến trường lúc:", }, { "choices": [ "A. 6 giờ", "B.  
7 giờ", "C. 8 giờ", "D. 9 giờ" ], "explanation":  
"Hướng dẫn giải \n Đáp án đúng là: A \n Ta có: 7  
giờ - 1 giờ = 6 giờ \n Vậy An đến lớp lúc 6 giờ  
. ", "question": "Câu 5: \n \n Giờ vào học buổi  
sáng là 7 giờ. An đến sớm hơn 1 giờ. An đến lớp  
lúc:" } ]
```

```
1 training_samples = []  
2 for sample in tqdm(data['train']):  
3     for quest in sample['problems']:  
4         choices = quest['choices']  
5         explanation = quest['explanation'].strip()  
6         question = quest['question']  
7  
8         if explanation == '' or question == '' or choices == []:  
9             continue  
10  
11         try:  
12             question = question.split('\n \n')[1].strip()  
13         except:  
14             continue  
15  
16         choices = '\n'.join(choices)  
17         training_sample = generate_and_tokenize_prompt(  
18             question, choices, explanation  
19         )  
20  
21         training_samples.append(training_sample)
```

100% |██████████| 2733/2733 [00:03<00:00, 733.75it/s]

1 choices\_data = Dataset.from\_list(training\_samples)

# Practices

## ❖ Coding Step 8: Training

```
1 training_args = transformers.TrainingArguments(  
2     per_device_train_batch_size=1,  
3     gradient_accumulation_steps=4,  
4     num_train_epochs=1,  
5     learning_rate=2e-4,  
6     fp16=True,  
7     save_total_limit=3,  
8     logging_steps=1,  
9     output_dir="experiments",  
10    optim="paged_adamw_8bit",  
11    lr_scheduler_type="cosine",  
12    warmup_ratio=0.05,  
13 )  
14  
15 trainer = transformers.Trainer(  
16     model=model,  
17     train_dataset=choices_data,  
18     args=training_args,  
19     data_collator=transformers.DataCollatorForLanguageModeling(tokenizer, mlm=False)  
20 )  
21 model.config.use_cache = False  
22 trainer.train()
```

[2293/2293 4:13:42, Epoch 0/1]

Step	Training Loss
1	3.865600
2	3.651900
3	3.858900
4	3.444500
5	3.849100
6	3.886000
7	3.269300
8	3.334000
9	3.765300
10	3.375700

# Practices

## ❖ Fine-tuning results

<|im\_start|> system

Bạn là một chuyên gia về toán. Bạn sẽ nhận câu hỏi trắc nghiệm kèm theo các lựa chọn, hãy giải step by step nếu có và chọn phương án đúng.

<|im\_start|> user

### Câu hỏi:

Số gồm 1 đơn vị và 3 chục đọc là :

### Các lựa chọn:

A. 30

B. 31

C. 20

D. 21

### Câu trả lời:

<|im\_start|> assistant

Để giải quyết vấn đề này, chúng ta cần hiểu rằng 1 đơn vị có nghĩa là một nhóm gồm một chục và 3 chục có nghĩa là ba nhóm mươi.

Chúng ta có thể viết lại số này là  $3 \times 10 = 30$

Do đó, số đọc là 30.

Lựa chọn đúng là A. 30

CPU times: user 9.13 s, sys: 295 ms, total: 9.43 s

Wall time: 9.46 s

Before fine-tuning

# Practices

## ❖ Fine-tuning results

```
<|im_start|> system
Bạn là một chuyên gia về toán. Bạn sẽ nhận câu hỏi trắc nghiệm kèm theo các lựa chọn, hãy giải step by step nếu có và chọn phương án đúng.
<|im_start|> user
### Câu hỏi:
 $2 + 3 - 10 \times 2 =$ 
### Các lựa chọn:
A. 15
B. -15
C. 10
D. -10
### Câu trả lời:
<|im_start|> assistant
Đáp án D  $2 + 3 - 10 \times 2 = 2 + 3 - 20 = -10$ . Vậy đáp án đúng là -10. Đáp án cần chọn là: D. -10 . Đáp án cần chọn là: D. -10. Chọn D Lưu ý :
CPU times: user 16 s, sys: 392 ms, total: 16.4 s
Wall time: 17.2 s
```

After fine-tuning

# Summary

In this lecture, we have discussed:

**1. Training type**

1. Pre-training
2. Fine-tuning

**2. How to make LLMs adapt to a task?**

1. Prompting (In-context learning)
  1. One-shot learning: Prompting with 1 example.
  2. Few-shot learning: Prompting with more than 1 example.
  3. Chain-of-Thought: Prompting with reasoning.
2. Instruction Tuning: By supervised learning LLMs with instruction data.

**3. How to train LLMs on a single (small) GPU?**

1. Parameter Efficient Fine-Tuning

**4. Apply Instruction Tuning for multiple choice math question solver task.**

# Question

