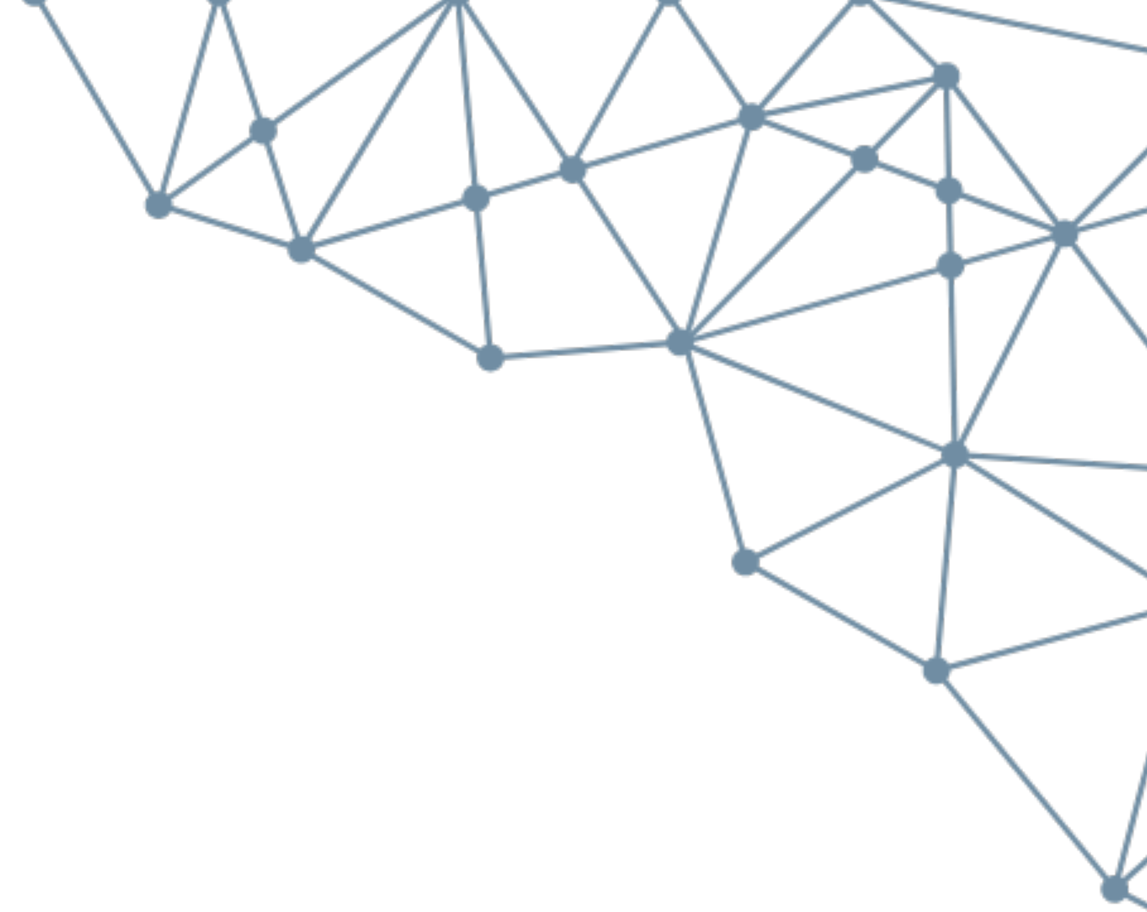
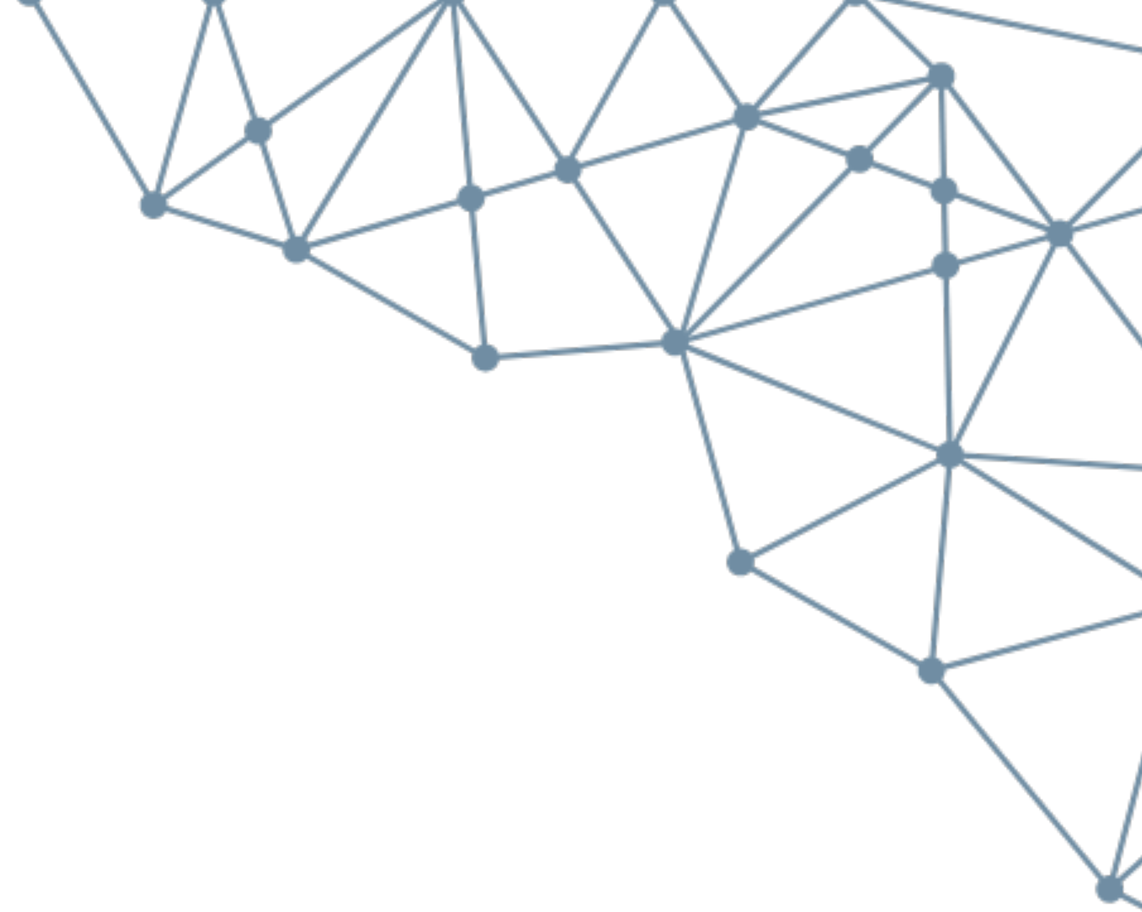


ABB - Session 5

Software 3.0, Fine-tuning

Shaw Talebi

Today’s Session



1. **Housekeeping**
    1.1. Announcements
    1.2. Homework 3
2. **Fine-tuning**
    2.1. What is Fine-tuning?
    2.2. Why fine-tune?
    2.3. How to fine-tune
3. **Examples**
    3.1. Fine-tuning a LinkedIn Post Writer
    3.2. Fine-tuning BERT for Text Classification

Announcements

Homework 4

Shoutouts 🎉

Customer Review Analysis
Kader Mula

Router Config Generator
Shaji Ravindra Nathan

Meeting Emotion Analysis
Andry Haryanto

2 Levels of LLM Development

How to get LLMs to do what you want…

Level 1

Adapting models via prompts and tools

Prompt Engineering 💬

RAG 🔍

Tool-use 🛠️

Level 2

Adapting models via additional training

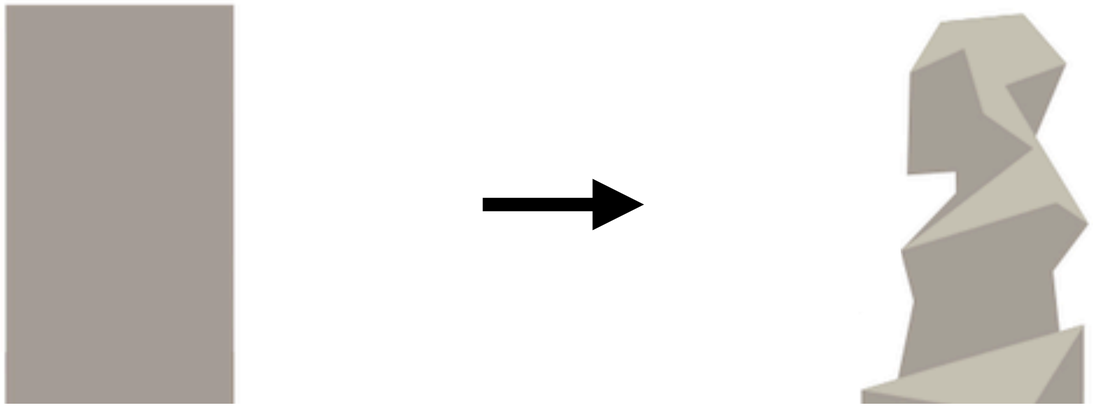
Fine-tuning 🪛

Post-training 👨‍💻

Fine-tuning

What is Fine-tuning?

Adapting a model to a particular task through **additional training**



Pre-trained Model

(Self-supervised)

15T Tokens

(Llama 3)

Fine-tuned Model

(Supervised)

~25B Tokens

(Llama 3.1 Instruct)

[1][2]

What is Fine-tuning?

Adapting a model to a particular task through **additional training**

Fine-tuned Model

~25B Tokens

(Llama 3.1 Instruct)

Additional Fine-tuning

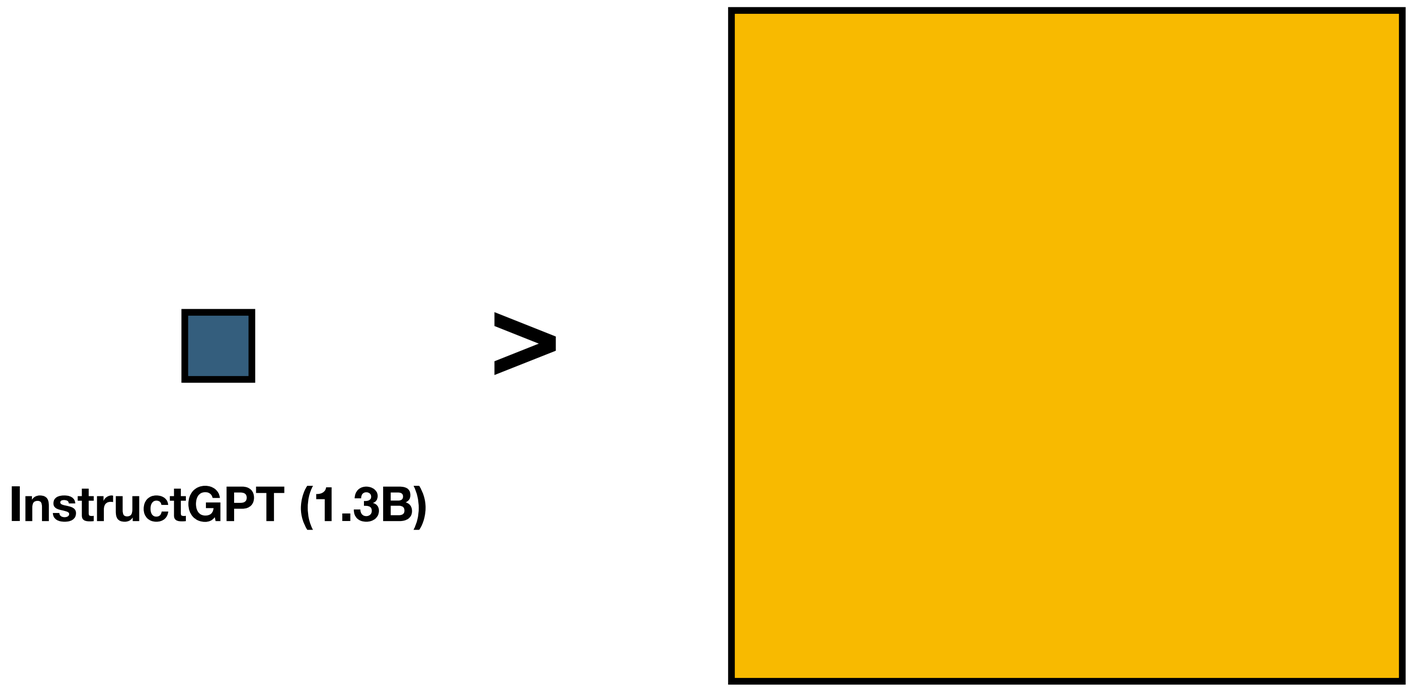
~50k-5M Tokens

(Fine-tuning model to respond in JSON)

[1][2]

Why Fine-tune?

1) Smaller fine-tuned models outperform bigger ones (on specific tasks)



InstructGPT (1.3B)

GPT-3 (175B)

[3][4]

Why Fine-tune?

1) Smaller fine-tuned models outperform bigger ones (on specific tasks)

GPT-3

Tell me how to fine-tune a model.

Response:

How can I control the complexity of a model?
How do I know when my model is done?
How do I test a model?
How do I define a task for my model?
How do I scale a model?
How do I make a probabilistic model?
How do I start using a model once it's complete?
How do I cope with missing data?
How do I make my modeling efforts sustainable?

InstructGPT

Tell me how to fine-tune a model.

Response:

Fine-tuning a model involves adjusting the parameters of a pre-trained model in order to make it better suited for a given task. There are generally three steps to fine-tuning a model:

1. Select a base model - Select a pre-trained deep learning model that has been trained on a large dataset.
2. Adjust parameters - Adjust parameters of the pre-trained model to better suit the desired task. This may include changing the number of layers, adjusting learning rate, adding regularization, or tweaking the optimizer.
3. Train the model - Train the new model on the desired dataset. The amount of data and the amount of training required will depend on the task and the model.

[3][4]

Why Fine-tune?

2) Lower compute costs and faster inference (from shorter prompts)

Prompt before fine-tuning

```
You are an expert sentiment analysis tool. Given a text, classify its
sentiment as "Positive," "Negative," or "Neutral." Here are some
examples:

Examples
Text: "I absolutely love the new design of this product! It’s user-
friendly
and looks amazing." Sentiment: Positive

Text: "The service was terrible. I had to wait for over an hour, and
the staff
was rude." Sentiment: Negative

Text: "The movie was okay. It wasn't particularly exciting, but it
wasn’t bad
either." Sentiment: Neutral

Text: "I'm so happy with the customer support I received. They
resolved my
issue quickly." Sentiment: Positive

Text: "The meal was bland, and I wouldn’t recommend it to anyone."
Sentiment:
Negative

Text: "The weather is unpredictable today." Sentiment: Neutral

Now analyze the following text:
Text: "[Your input text here]" Sentiment:
```

Prompt after fine-tuning

```
You are an expert sentiment analysis tool. Given a text, classify its
sentiment as "Positive," "Negative," or "Neutral."

Analyze the following text:
Text: "[Your input text here]" Sentiment:
```

Time & money saved!

When Should I Fine-tune?

No ❌

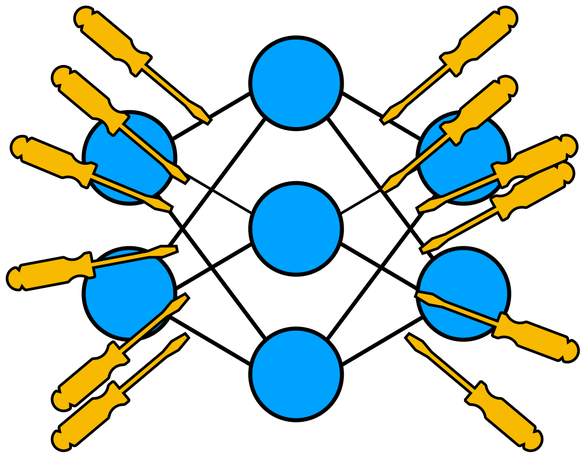
1. Before improving your prompt (systematically via evals)
2. Trying to teach model new knowledge (RAG is better)
3. Before gathering input-output pair

Yes ✅

1. Improving reliability of desired output structure
2. Customizing response style or format
3. Performing tasks that are hard to articulate via prompts

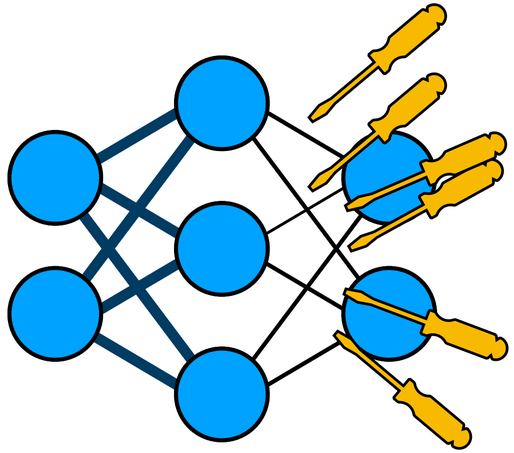
How Do I Fine-tune?

3 Approaches



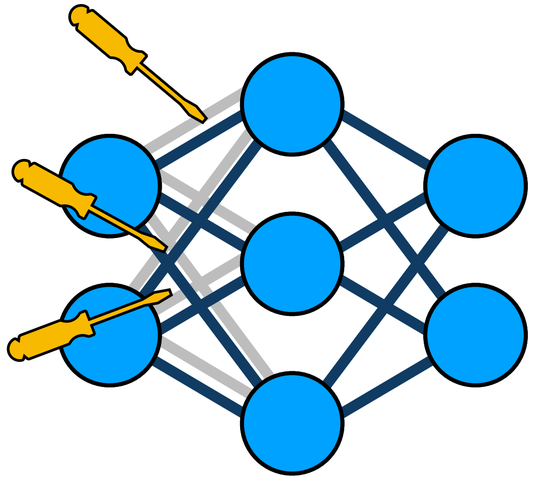
1) All parameters

aka “Full Fine-tuning”



2) Some parameters

aka “Transfer Learning”



3) New parameters

aka Adapters

[4]

How Do I Fine-tune?

Training Data: Input-output pairs

Example: Fine-tuning Response Style

Inputs: Questions/DMs

> Hi , I have a question, does this woks on ECG signal that are "changing"?

Outputs: Real responses

> That's a good question! The short answer is yes. Ultimately it comes down to what you are after. If it is to find r peaks, like we did here, it shouldn't be an issue. Hope that helps!

Training Dataset

Question	Response

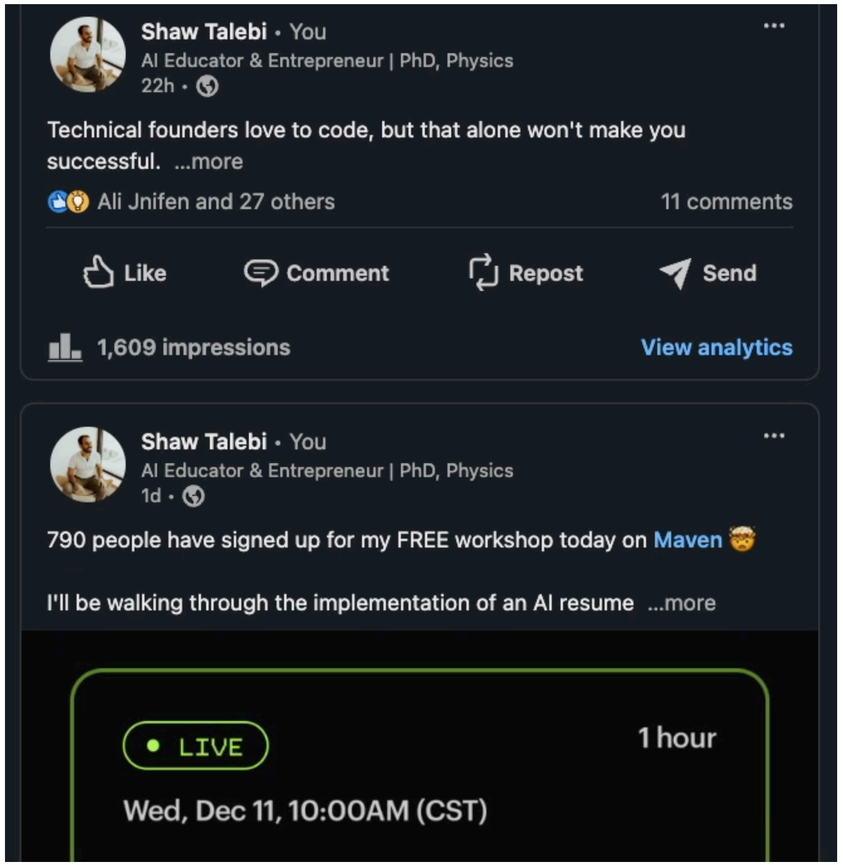
Prompt Template

> [INST] ShawGPT, functioning as a virtual data science consultant... (instructions cont.)
> {Question} [/INST]
>
> {Response}

Examples

Example 1

Fine-tuning a LinkedIn Post Writer (Motivation)



Major marketing channel for my content and offers

… but I do it myself which limits high volume and high quality content

Example 1

Fine-tuning a LinkedIn Post Writer (Motivation)

Can’t you use ChatGPT?

Doesn’t sound like me…

… and lacks taste

Python felt impossible… until I learned these 5 things.

When I first started with Python, it wasn’t the syntax that tripped me up—it was *how to think like a programmer*. I’d get stuck in tutorials, wondering how people were able to “just know” what to write.

Turns out, learning Python isn’t just about *what* you write—it’s about *how* you approach problems. Here are the 5 mindset shifts that changed everything:

1️⃣ **Break problems into smaller steps**
Stop staring at the big picture. Solve one small piece at a time. (If you don’t know where to start, just print something—anything!)

2️⃣ **Google like it’s your superpower**
The best Python developers aren’t human encyclopedias. They’re *really good* at searching for solutions and reading Stack Overflow.

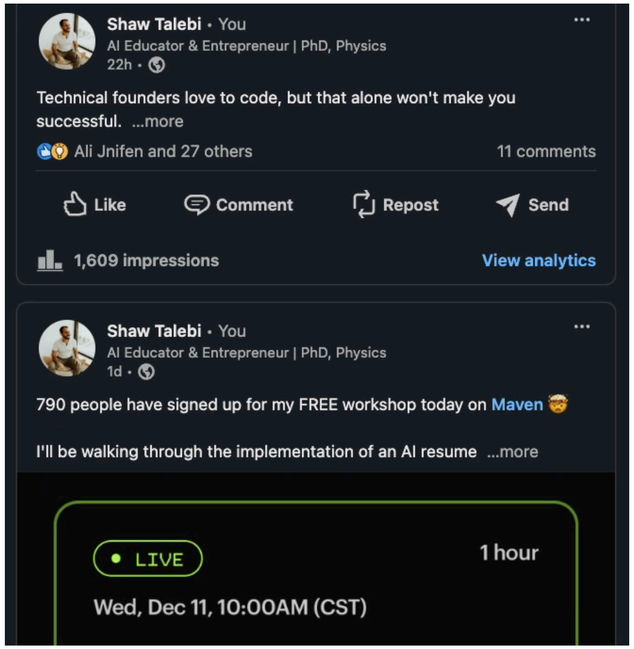
3️⃣ **Code >>> Theory**
Learn by doing. Build tiny projects—even silly ones. You’ll remember more from 10 lines of messy code than 2 hours of reading.

4️⃣ **Start simple. THEN optimize.**
Write code that *works first*. Worry about making it “pretty” or efficient later. (Perfection is the enemy of progress.)

5️⃣ **Copy and tweak**
Find code examples and *tinker*. Change a variable. Add a print statement. See what breaks. Play like this until it all clicks.

Example 1

Fine-tuning a LinkedIn Post Writer (Overview)



Extract LI posts

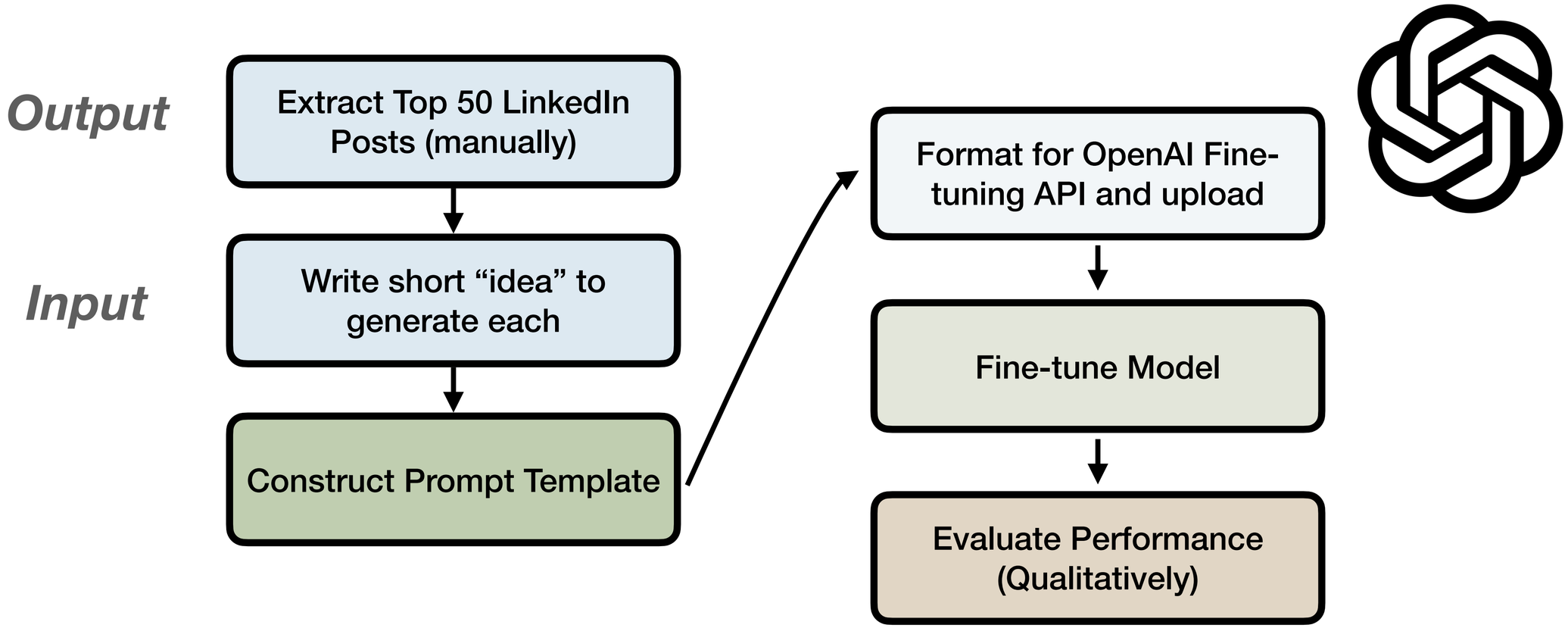
Fine-tune GPT-4o-mini

LI Post Writer

(in my likeness)

Example 1

Fine-tuning a LinkedIn Post Writer (Flowchart)



Example 1

Fine-tuning a LinkedIn Post Writer (Code)

Example 2

Fine-tuning BERT for Text Classification (Motivation)

Subject: Congratulations on Your New Offer! Special Opportunity Just for You

From: Service Center <rewards@service-center.com>

Hi there!

We're excited to let you know that you've been selected for an exclusive deal. This offer is designed to match your preferences, and it's available for a limited time.

Simply follow our instructions to learn more about how you can take advantage of this unique opportunity.

To proceed, you only need to confirm your email by visiting the link below:

Confirm Email

paypal.com.cgi-bin.login1589114111g859f.sonreir.cl/paypal/2/

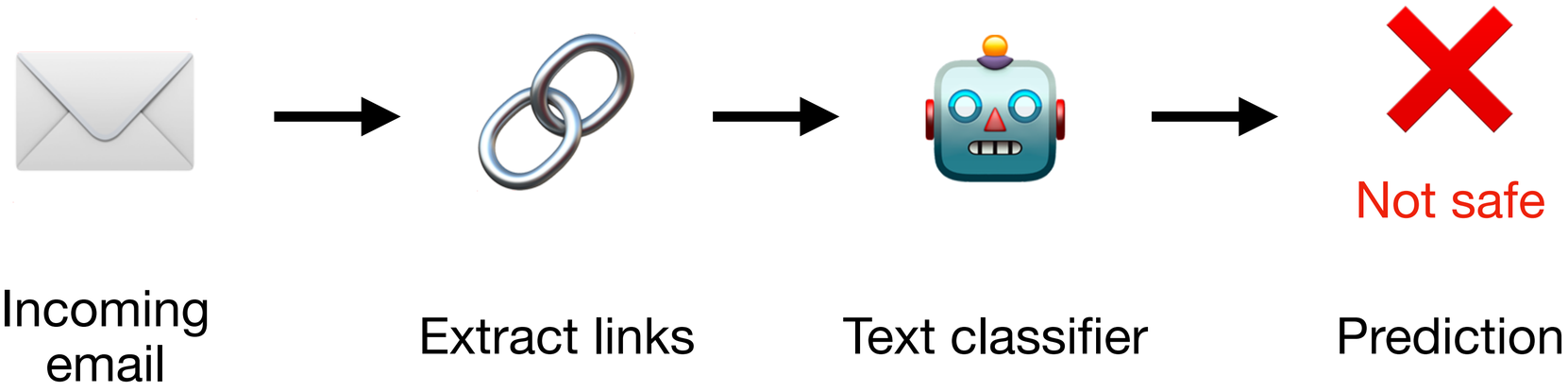
For more details, please check the terms on our website or feel free to reach out with any questions.

We look forward to hearing from you soon!

Best Regards,
The Service Center Team

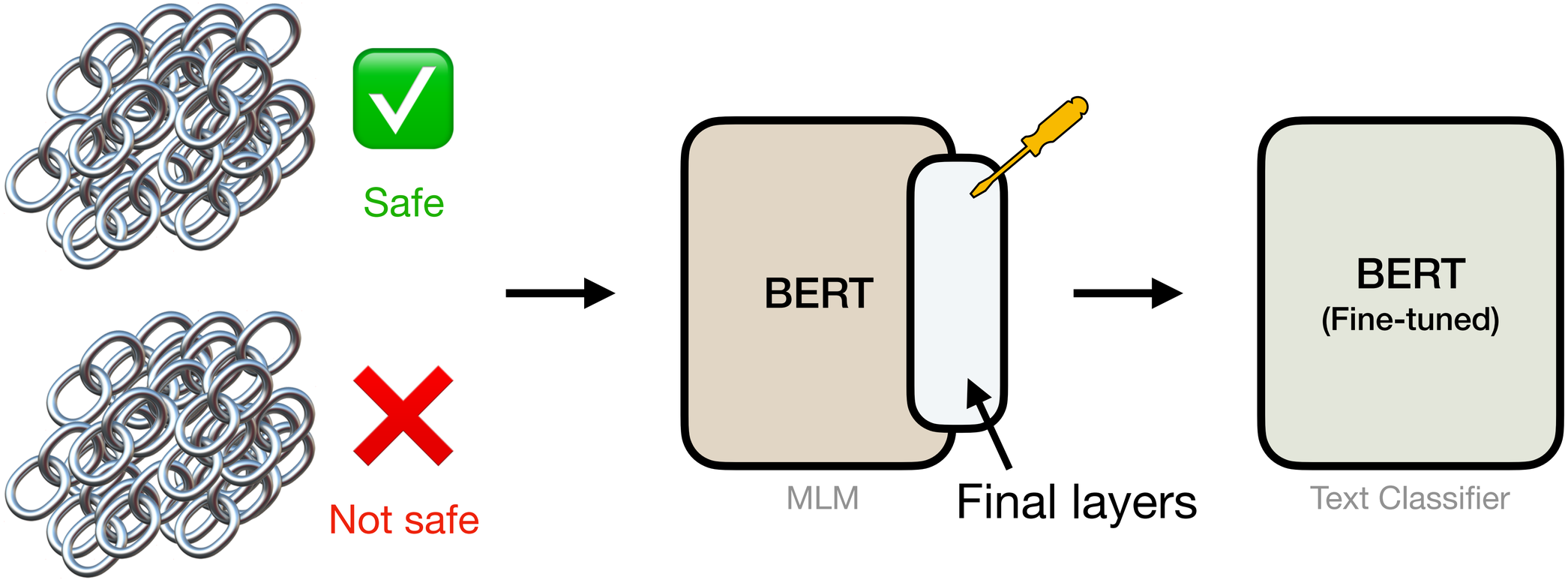
Example 2

Fine-tuning BERT for Text Classification (Overview)



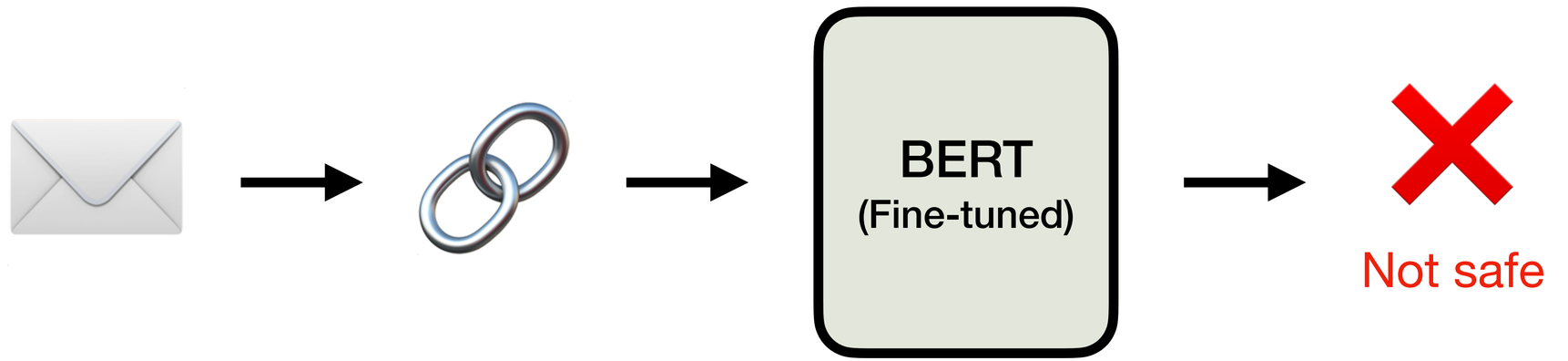
Example 2

Fine-tuning BERT for Text Classification (Overview)



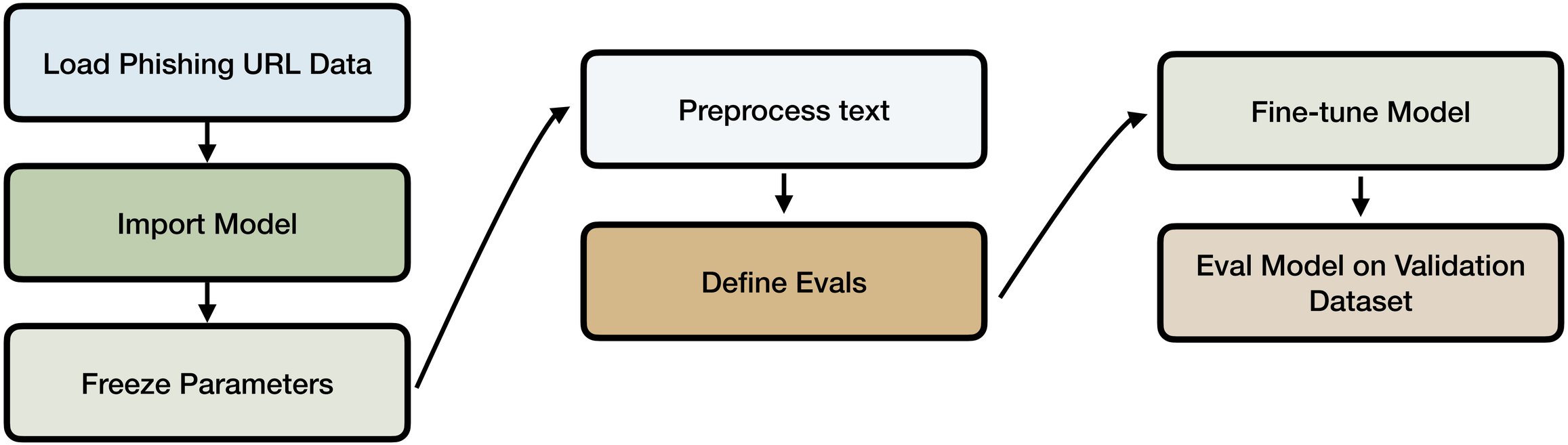
Example 2

Fine-tuning BERT for Text Classification (Overview)



Example 2

Fine-tuning BERT for Text Classification (Flowchart)



Example 2

Fine-tuning BERT for Text Classification (Code)

More on Fine-tuning/Post-training

1. Efficient Fine-tuning with QLoRA
2. Fine-tuning Text Embeddings
3. Fine-tuning Multimodal Embeddings
4. Local Fine-tuning on Mac
5. Fine-tuning FLUX.1
6. Distilling LLMs
7. RLHF + DPO (Preference Tuning)

Homework 5

Project 💻

Fine-tune a Model **(More examples provided)**

Pre-work ✍️

Session 6: AI Project Management

Session 6: Project Discovery Questions

 = more FT examples

References

[1] Fine-Tuning BERT for Text Classification 

[2] arXiv:2407.21783 [cs.AI]

[3] arXiv:2203.02155 [cs.CL]

[4] Fine-tuning Large Language Models (LLMs)

[5] OpenAI Fine-tuning Documentation

[6] arXiv:2312.05934 [cs.AI]

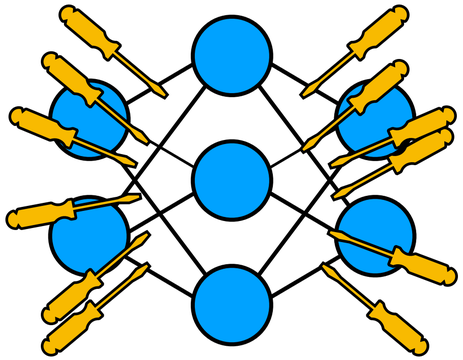
[7] QLoRA—How to Fine-tune an LLM on a Single GPU 

[8] arXiv:2106.09685 [cs.CL]

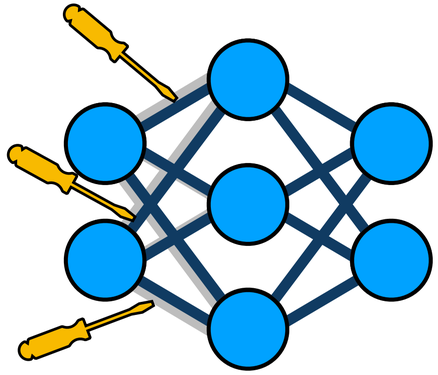
[9] Compressing Large Language Models 

LoRA (Low-Rank Adaptation)

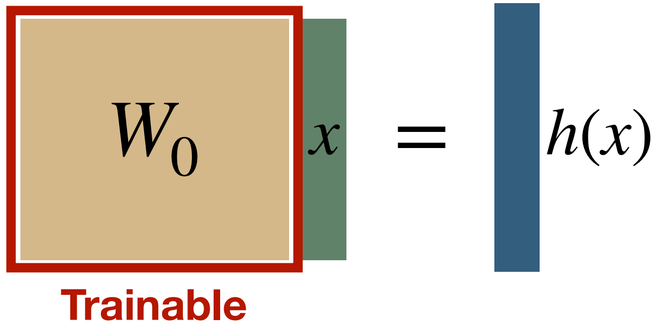
Fine-tunes model by adding **small set** of trainable parameters



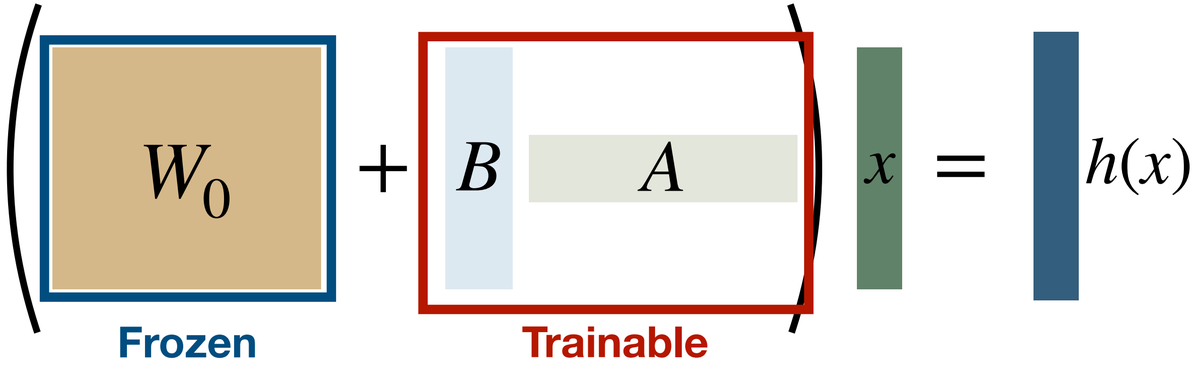
$x \quad h(x) \quad y$



Full Fine-tuning: $h(x) = W_0 x$



LoRA: $h(x) = W_0 x + \Delta W x = W_0 x + BAx$

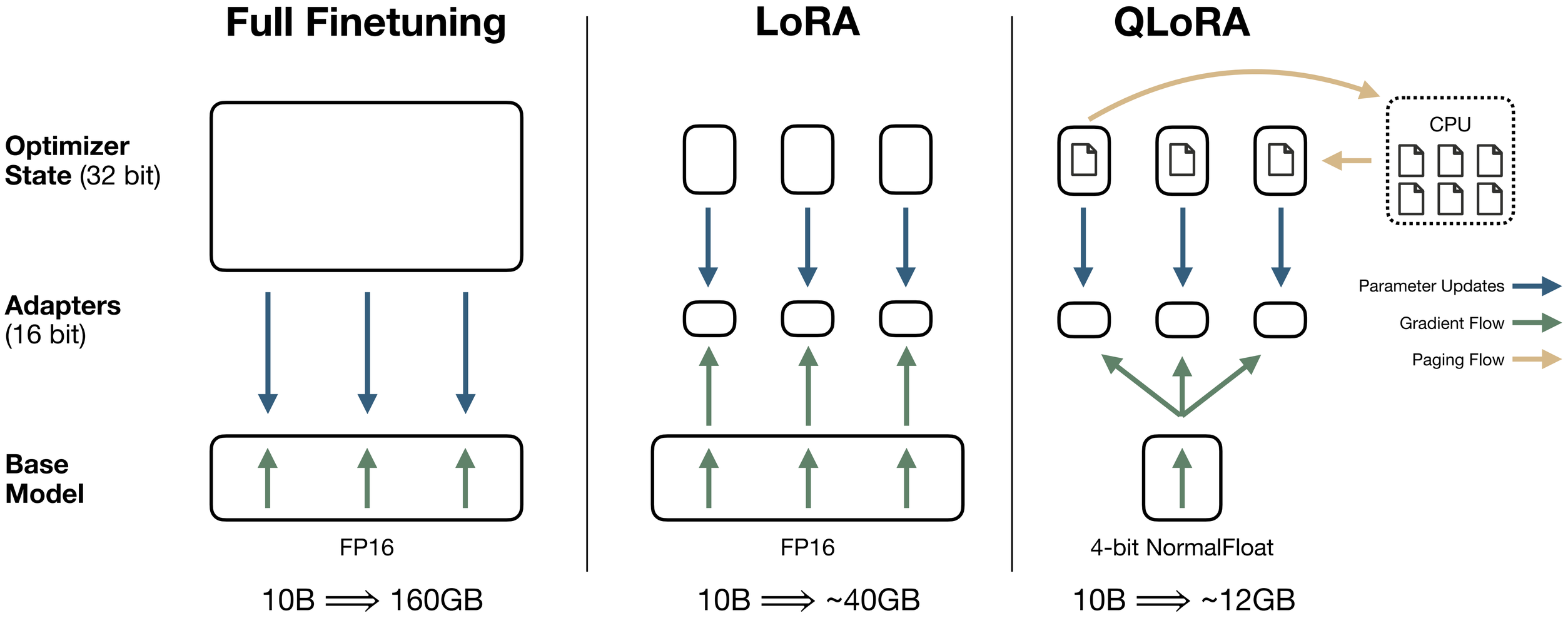


100-1000X savings!

[7][8]

QLoRA (Quantized LoRA)

Combining LoRA and Quantization

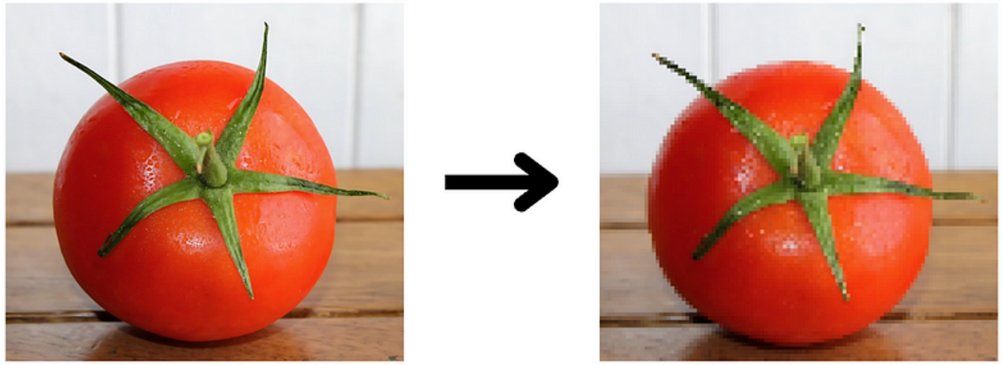


[7] [9]

Model Compression

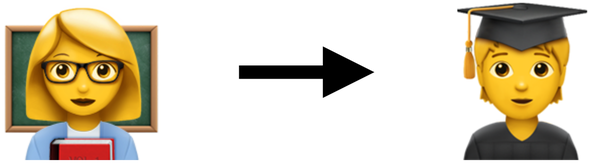
Reduce ML model size without sacrificing performance

1) Quantization



QLoRA = combines this and LoRA enabling LLMs to be fine-tuned on a single GPU!

2) Knowledge Distillation

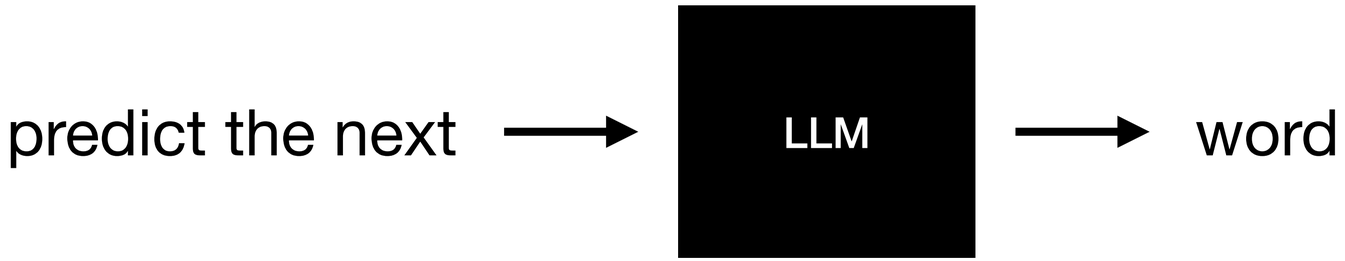


[7][9]

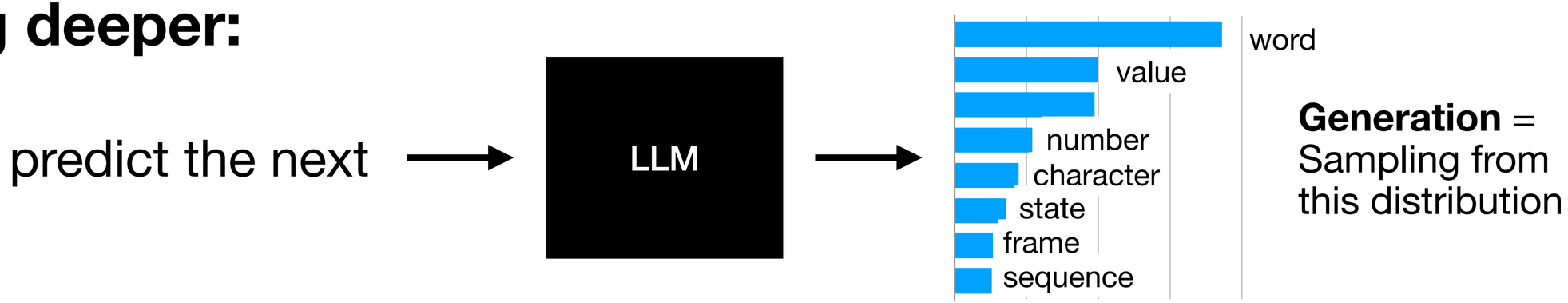
LLM Loss Function

The math behind next-token prediction

Inference:



Going deeper:



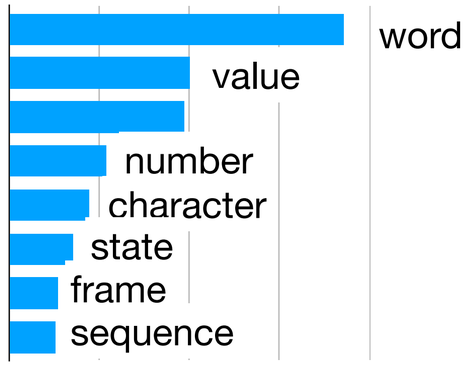
Generation = Sampling from this distribution

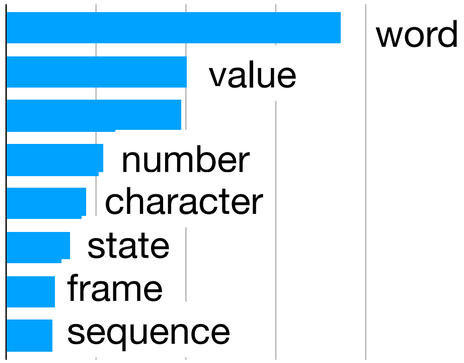
LLM Loss Function

The math behind next-token prediction

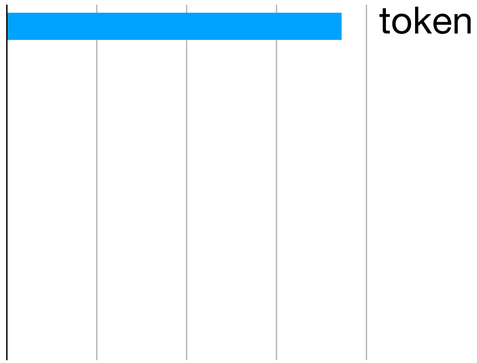
Training:

predict the next → LLM →





Model prediction



Ground truth

$$\mathscr{L} = -\sum_{i=1}^{N} y_i \log(\hat{y}_i)$$

y_i = ground truth label for i^{th} token

$\hat{y}_i$ = predicted logit for i^{th} token

N = num tokens in vocabulary

For hard labels $\Longrightarrow$

$$\mathscr{L} = -\log(\hat{y}_t)$$

Where, t = index of ground truth token