```
!pip install torch torchvision torchaudio accelerate datasets transformers scikit-learn matplotlib pandas numpy
```

```
Requirement already satisfied: jinja2 in /usr/local/lib/python3.12/dist-packages (from torch) (3.1.6)
Requirement already satisfied: fsspec in /usr/local/lib/python3.12/dist-packages (from torch) (2025.3.0)
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Requirement already satisfied: regex!=2019.12.17 in /usr/local/lib/python3.12/dist-packages (from transformers) (2024.11.6)
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Requirement already satisfied: propcache>=0.2.0 in /usr/local/lib/python3.12/dist-packages (from aiohttp!=4.0.0a0,!=4.0.0a1->fssp
Requirement already satisfied: yarl<2.0,>=1.17.0 in /usr/local/lib/python3.12/dist-packages (from aiohttp!=4.0.0a0,!=4.0.0a1->fss
```

```
import numpy as np
import matplotlib.pyplot as plt
import torch
#import torch.nn as nn
#import accelerate
from datasets import load_dataset

from sklearn.metrics import accuracy_score, f1_score
from collections import Counter

from transformers import BertTokenizer, BertForSequenceClassification
from transformers import Trainer, TrainingArguments, pipeline

from peft import LoraConfig, get_peft_model, TaskType

import os
os.environ["WANDB_DISABLED"] = "true"
```

```
# Check if GPU is available, becouse training on CPU is very slow!!!
print(torch.cuda.is_available())
print(torch.cuda.get_device_name(0) if torch.cuda.is_available() else "No GPU")
```

```
True
Tesla T4
```

```
dataset = load_dataset("go_emotions")

emotions = dataset["train"].features["labels"].feature.names
num_labels = len(emotions)
print(len(dataset["train"]))
print(num_labels)
print(emotions)
```

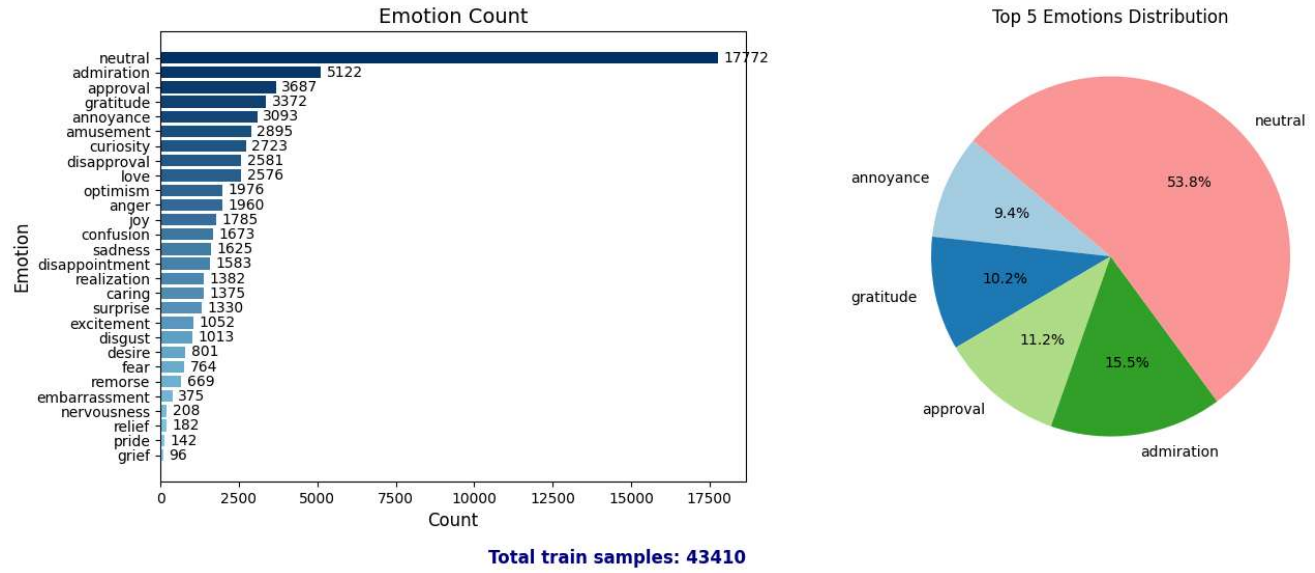
```
/usr/local/lib/python3.12/dist-packages/huggingface_hub/utils/_auth.py:94: UserWarning:
The secret `HF_TOKEN` does not exist in your Colab secrets.
To authenticate with the Hugging Face Hub, create a token in your settings tab (https://huggingface.co/settings/tokens), set it as
You will be able to 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(
README.md:  9.40k/? [00:00<00:00, 554kB/s]
simplified/train-00000-of-00001.parquet: 100%  2.77M/2.77M [00:01<00:00, 19.5kB/s]
simplified/validation-00000-of-00001.par(...): 100%  350k/350k [00:00<00:00, 1.55MB/s]
simplified/test-00000-of-00001.parquet: 100%  347k/347k [00:00<00:00, 1.67MB/s]
Generating train split: 100%  43410/43410 [00:00<00:00, 8621.76 examples/s]
Generating validation split: 100%  5426/5426 [00:00<00:00, 58057.17 examples/s]
Generating test split: 100%  5427/5427 [00:00<00:00, 103764.41 examples/s]
43410
28
['admiration', 'amusement', 'anger', 'annoyance', 'approval', 'caring', 'confusion', 'curiosity', 'desire', 'disappointment', 'disa
```

```
# Get the distribution of emotions in the dataset
emotion_counter = Counter()

for split, split_data in dataset.items():
    for sample in split_data:
        emotion_counter.update(sample["labels"])

emotions_count = {emotion: emotion_counter.get(i, 0) for i, emotion in enumerate(emotions)}

print(emotions_count)
```

```
{'admiration': 5122, 'amusement': 2895, 'anger': 1960, 'annoyance': 3093, 'approval': 3687, 'caring': 1375, 'confusion': 1673, 'cur
```

```
# --- Sort by ascending count ---
sorted_items = sorted(emotions_count.items(), key=lambda x: x[1])
emotions_sorted, counts_sorted = zip(*sorted_items)

fig, axes = plt.subplots(1, 2, figsize=(14, 6))

# --- Horizontal bar plot (left) ---
import matplotlib.colors as mcolors

# Create a colormap from darkblue to lightblue
cmap = mcolors.LinearSegmentedColormap.from_list("blue_gradient", ["#87CEEB", "#003366"])
# Generate colors from the colormap for each bar
colors = [cmap(i / (len(emotions_sorted) - 1)) for i in range(len(emotions_sorted))]
bars = axes[0].barh(emotions_sorted, counts_sorted, color=colors)
for bar, count in zip(bars, counts_sorted):
    axes[0].text(
        bar.get_width() + max(counts_sorted) * 0.01,
        bar.get_y() + bar.get_height() / 2,
        str(count),
        va='center',
        ha='left',
        fontsize=10,
        fontweight='normal'
    )
```

```
axes[0].set_xlabel("Count", fontsize=12)
axes[0].set_ylabel("Emotion", fontsize=12)
axes[0].set_title("Emotion Count", fontsize=14)

# Show total train data at the bottom right
axes[0].text(
    1.0, -0.15, f"Total train samples: {len(dataset['train'])}",
    transform=axes[0].transAxes,
    fontsize=12,
    color="navy",
    ha="right",
    va="top",
    fontweight="bold"
)

# --- Pie chart of top 5 emotions (right) ---
top5_emotions = emotions_sorted[-5:]
top5_counts = counts_sorted[-5:]
axes[1].pie(top5_counts, labels=top5_emotions, autopct='%1.1f%%', startangle=140, colors=plt.cm.Paired.colors[:5])
axes[1].set_title("Top 5 Emotions Distribution")

plt.tight_layout(pad=2)
plt.show()
```




```
def multi_hot_encode(samples):
    multi_hot = np.zeros(len(emotions))

    for label in samples["labels"]:
        multi_hot[label] = 1

    return {"labels": multi_hot.tolist()}

dataset = dataset.map(multi_hot_encode)
```

```
Map: 100%  43410/43410 [00:07<00:00, 5400.44 examples/s]
Map: 100%  5426/5426 [00:00<00:00, 9302.64 examples/s]
Map: 100%  5427/5427 [00:00<00:00, 8487.92 examples/s]
```

```
model_name = 'bert-base-uncased'

tokenizer = BertTokenizer.from_pretrained(model_name)
```

```
def tokenize_function(examples):
    return tokenizer(examples["text"], padding="max_length", truncation=True, max_length=128)

tokenized_dataset = dataset.map(tokenize_function, batched=True)

# Set the format of the dataset to PyTorch tensors
tokenized_dataset.set_format("torch")
```

```
tokenizer_config.json: 100%  48.0/48.0 [00:00<00:00, 3.06kB/s]
vocab.txt: 100%  232k/232k [00:00<00:00, 3.27MB/s]
tokenizer.json: 100%  466k/466k [00:00<00:00, 6.47MB/s]
config.json: 100%  570/570 [00:00<00:00, 21.3kB/s]
Map: 100%  43410/43410 [00:39<00:00, 1572.46 examples/s]
Map: 100%  5426/5426 [00:07<00:00, 603.33 examples/s]
Map: 100%  5427/5427 [00:02<00:00, 2463.85 examples/s]
```

```
convert_to_float = lambda sample: {"float_labels": sample["labels"].to(torch.float)}

tokenized_dataset = (tokenized_dataset
                     .map(convert_to_float, remove_columns=["labels"])
                     .rename_column("float_labels", "labels"))
```

```
Map: 100%  43410/43410 [00:24<00:00, 1820.53 examples/s]
Map: 100%  5426/5426 [00:03<00:00, 1339.87 examples/s]
Map: 100%  5427/5427 [00:03<00:00, 1917.76 examples/s]
```

```
model = BertForSequenceClassification.from_pretrained(
    model_name,
    num_labels=len(emotions),
    problem_type="multi_label_classification"
)
```

```
model.safetensors: 100%  440M/440M [00:06<00:00, 97.1MB/s]
Some weights of BertForSequenceClassification were not initialized from the model checkpoint at bert-base-uncased and are newly ini
You should probably TRAIN this model on a down-stream task to be able to use it for predictions and inference.
```

```
device = "cuda:0" if torch.cuda.is_available() else "cpu"
print(device)
model = model.to(device)
```

```
cuda:0
```

```
# Define parameters
LEARNING_RATE = 2e-5
BATCH_SIZE = 16
EPOCHS = 5
WEIGHT_DECAY = 1e-2
```

```
training_args = TrainingArguments(
    output_dir="./results",
    eval_strategy="epoch",
    learning_rate=LEARNING_RATE,
    per_device_train_batch_size=BATCH_SIZE,
    per_device_eval_batch_size=BATCH_SIZE,
    num_train_epochs=EPOCHS,
    weight_decay=WEIGHT_DECAY,
    fp16=True
)
```

```
Using the `WANDB_DISABLED` environment variable is deprecated and will be removed in v5. Use the --report_to flag to control the in
```

```
def compute_metrics(pred):
    logits, labels = pred
```

```
    preds = (logits > 0.5).astype(int) # Convert probabilities to binary predictions

    f1 = f1_score(labels, preds, average='micro')
    acc = accuracy_score(labels, preds)

    return {
        'f1': f1,
        'accuracy': acc
    }
```

```
trainer = Trainer(
    model=model,
    args=training_args,
    train_dataset=tokenized_dataset["train"],
    eval_dataset=tokenized_dataset["validation"],
    compute_metrics=compute_metrics
)
```

```
trainer.train()
```

[13570/13570 33:41, Epoch 5/5]

Epoch	Training Loss	Validation Loss	F1	Accuracy
1	0.099000	0.092287	0.429033	0.284740
2	0.082200	0.084322	0.503647	0.362882
3	0.069000	0.084496	0.539935	0.407482
4	0.062400	0.087721	0.550580	0.420936
5	0.054700	0.089687	0.558910	0.441946

```
TrainOutput(global_step=13570, training_loss=0.08013967981036305, metrics={'train_runtime': 2023.2431, 'train_samples_per_second':
107.278, 'train_steps_per_second': 6.707, 'total_flos': 1.42803965293056e+16, 'train_loss': 0.08013967981036305, 'epoch': 5.0})
```

```
multilabel_pipeline = pipeline(
    "text-classification",
    model=model,
    tokenizer=tokenizer,
    top_k=None,  # return all pedictions first
)
```

```
Device set to use cuda:0
```

```
#result = multilabel_pipeline("I simply can't stand when my computer freezes")
#result = multilabel_pipeline("I hate you, but i also like you")
result = multilabel_pipeline("I’m Not Mad")
result
```

```
[[{'label': 'LABEL_27', 'score': 0.8333246111869812},
  {'label': 'LABEL_10', 'score': 0.07396337389945984},
  {'label': 'LABEL_3', 'score': 0.04778006672859192},
  {'label': 'LABEL_4', 'score': 0.026759279891848564},
  {'label': 'LABEL_2', 'score': 0.012970387004315853},
  {'label': 'LABEL_22', 'score': 0.0060975621454417706},
  {'label': 'LABEL_5', 'score': 0.0035380858462303877},
  {'label': 'LABEL_9', 'score': 0.003469890682026744},
  {'label': 'LABEL_20', 'score': 0.002387409098446369},
  {'label': 'LABEL_0', 'score': 0.0017961491830646992},
  {'label': 'LABEL_6', 'score': 0.0012893284438177943},
  {'label': 'LABEL_11', 'score': 0.0012497095158323646},
  {'label': 'LABEL_8', 'score': 0.001220795209519565},
  {'label': 'LABEL_26', 'score': 0.0009253848693333566},
  {'label': 'LABEL_17', 'score': 0.0008295890875160694},
  {'label': 'LABEL_13', 'score': 0.0007978335488587618},
  {'label': 'LABEL_25', 'score': 0.0007264874875545502},
  {'label': 'LABEL_7', 'score': 0.0006641048239544034},
  {'label': 'LABEL_15', 'score': 0.000661517377011478},
  {'label': 'LABEL_23', 'score': 0.0005680934991687536},
  {'label': 'LABEL_1', 'score': 0.0005463420529849827},
  {'label': 'LABEL_18', 'score': 0.0005254230345599353},
  {'label': 'LABEL_12', 'score': 0.0003366622258909046},
  {'label': 'LABEL_14', 'score': 0.0003225072287023067},
  {'label': 'LABEL_21', 'score': 0.0003225072287023067},
  {'label': 'LABEL_16', 'score': 0.0003077430592384189},
  {'label': 'LABEL_19', 'score': 0.0002758679038379341},
  {'label': 'LABEL_24', 'score': 0.0002050221373792737}]]
```

```
def get_emotion(pred):
    """
    Gets the int number after the _ in "LABEL_X"
    e.g.: LABEL_18 yields just the integer 18
    We use this integer as index to get the original emotion name
    """
    pred_emotion_idx = int(pred["label"].split('_')[1])
    return emotions[pred_emotion_idx]

predicted_emotions = [get_emotion(pred) for pred in result[0] if pred["score"] > 0.1]
predicted_emotions
```

```
['neutral']
```

```
# === Per-label threshold search (validation) and test evaluation ===
import numpy as np
import pandas as pd
from sklearn.metrics import f1_score, precision_recall_fscore_support, accuracy_score

def _sigmoid(x): return 1 / (1 + np.exp(-x))

def _predict_split(trainer, split_ds):
    out = trainer.predict(split_ds)
    y_true = out.label_ids
    y_score = _sigmoid(out.predictions)
    if y_score.ndim == 1: y_score = y_score.reshape(-1, 1)
    return y_true, y_score

# 1) Get validation scores
y_true_val, y_score_val = _predict_split(trainer, tokenized_dataset["validation"])
L = y_true_val.shape[1]
if "label_names" not in globals():
    label_names = [f"L{i}" for i in range(L)]

# 2) Grid-search a separate threshold for each label
grid = np.round(np.arange(0.05, 0.95 + 1e-9, 0.01), 2)
best_thr_per_label = np.zeros(L)
best_f1_per_label  = np.zeros(L)

for j in range(L):
    yj_true  = y_true_val[:, j]
    yj_score = y_score_val[:, j]
    best_f1, best_t = -1, 0.5
    for t in grid:
        yj_pred = (yj_score >= t).astype(int)
        f1 = f1_score(yj_true, yj_pred, zero_division=0)
        if f1 > best_f1:
            best_f1, best_t = f1, t
    best_thr_per_label[j] = best_t
    best_f1_per_label[j]  = best_f1

thr_table = pd.DataFrame({
    "label": label_names,
    "best_thr": best_thr_per_label,
    "val_f1_at_best_thr": best_f1_per_label
}).sort_values("val_f1_at_best_thr", ascending=False).reset_index(drop=True)
display(thr_table.head(15))

# 3) Evaluate on TEST using per-label thresholds
y_true_test, y_score_test = _predict_split(trainer, tokenized_dataset["test"])
y_pred_test = (y_score_test >= best_thr_per_label[None, :]).astype(int)

# Summary metrics
subset_acc = accuracy_score(y_true_test, y_pred_test)
micro_f1   = f1_score(y_true_test, y_pred_test, average="micro", zero_division=0)
macro_f1   = f1_score(y_true_test, y_pred_test, average="macro", zero_division=0)
samples_f1 = f1_score(y_true_test, y_pred_test, average="samples", zero_division=0)

print("=== TEST (per-label thresholds) ===")
print(f"subset_accuracy: {subset_acc:.4f}")
print(f"micro_f1:       {micro_f1:.4f}")
print(f"macro_f1:       {macro_f1:.4f}")
print(f"samples_f1:     {samples_f1:.4f}")

# Per-label breakdown
p, r, f, s = precision_recall_fscore_support(y_true_test, y_pred_test, average=None, zero_division=0)
```

```
per_label = pd.DataFrame({
    "label": label_names, "precision": p, "recall": r, "f1": f, "support": s, "thr_used": best_thr_per_label
}).sort_values("support", ascending=False).reset_index(drop=True)
display(per_label.head(20))
```

	label	best_thr	val_f1_at_best_thr
0	L15	0.77	0.916545
1	L1	0.24	0.806647
2	L18	0.30	0.781086
3	L24	0.20	0.770270
4	L0	0.51	0.742798
5	L27	0.17	0.670870
6	L14	0.09	0.657277
7	L20	0.29	0.594340
8	L17	0.26	0.587912
9	L21	0.06	0.583333
10	L25	0.55	0.580882
11	L12	0.28	0.566667
12	L26	0.29	0.566308
13	L7	0.17	0.560345
14	L8	0.49	0.548148

```
=== TEST (per-label thresholds) ===
subset_accuracy: 0.4295
micro_f1:       0.6018
macro_f1:       0.5115
samples_f1:     0.6165
```

	label	precision	recall	f1	support	thr_used
0	L27	0.610915	0.776721	0.683912	1787	0.17
1	L0	0.696429	0.696429	0.696429	504	0.51
2	L15	0.962382	0.872159	0.915052	352	0.77
3	L4	0.376559	0.430199	0.401596	351	0.32
4	L3	0.318807	0.434375	0.367725	320	0.26
5	L7	0.456914	0.802817	0.582375	284	0.17
6	L10	0.409524	0.483146	0.443299	267	0.33
7	L1	0.746082	0.901515	0.816467	264	0.24
8	L18	0.733096	0.865546	0.793834	238	0.30
9	L2	0.502347	0.540404	0.520681	198	0.32
10	L20	0.542289	0.586022	0.563307	186	0.29
11	L17	0.555556	0.683230	0.612813	161	0.26
12	L25	0.703704	0.487179	0.575758	156	0.55
13	L6	0.421384	0.437908	0.429487	153	0.37
14	L9	0.314433	0.403974	0.353623	151	0.23
15	L22	0.252101	0.206897	0.227273	145	0.21
16	L26	0.541401	0.602837	0.570470	141	0.29
17	L5	0.474138	0.407407	0.438247	135	0.39
18	L11	0.553398	0.463415	0.504425	123	0.32
19	L13	0.520000	0.378641	0.438202	103	0.46

```
# === Surface interesting errors on TEST ===
import pandas as pd
import numpy as np
```

```
# Ensure we have y_true_test/y_score_test/y_pred_test from A1 cell; otherwise recompute
if 'y_true_test' not in globals() or 'y_pred_test' not in globals():
    y_true_test, y_score_test = _predict_split(trainer, tokenized_dataset["test"])
    y_pred_test = (y_score_test >= 0.5).astype(int)

texts_test = tokenized_dataset["test"]["text"]

def labels_to_str(row):
    return ", ".join(np.array(label_names)[np.where(row==1)[0]])

df_err = pd.DataFrame({
    "text": texts_test,
    "true": [labels_to_str(y_true_test[i]) for i in range(len(texts_test))],
    "pred": [labels_to_str(y_pred_test[i]) for i in range(len(texts_test))]
})
df_err = df_err[df_err["true"] != df_err["pred"]]

print("Total misclassified samples:", len(df_err))
display(df_err.sample(8, random_state=42))
```

```
Total misclassified samples: 3096
```

	text	true	pred
3416	Fair enough. I considered it malicious complia...	L27	L4
2335	Wow, your ex partner sounds exactly like mine.	L22	L26
2838	Yeah, that one. I forgot the name earlier.	L27	L22, L27
4616	Why did we have [NAME] that one year shoot aga...	L6	L6, L7, L27
4270	> This is just a waste of time. Just like maki...	L9, L10	L3, L10
3437	Analytics and instagram... are you joking?	L6, L27	L1, L7
4768	The best ever you are the [NAME]!!	L27	L0
344	Probably, I knew this lawn chair was a bad idea.	L10	L9, L22

```
# === Best & worst labels by F1 (TEST) ===
from sklearn.metrics import precision_recall_fscore_support

p, r, f, s = precision_recall_fscore_support(y_true_test, y_pred_test, average=None, zero_division=0)
table = pd.DataFrame({"label": label_names, "precision": p, "recall": r, "f1": f, "support": s})
best5  = table.sort_values("f1", ascending=False).head(5)
worst5 = table.sort_values("f1", ascending=True).head(5)
print("Top-5 labels by F1:")
display(best5)
print("Bottom-5 labels by F1:")
display(worst5)
```

```
Top-5 labels by F1:
```

	label	precision	recall	f1	support
15	L15	0.962382	0.872159	0.915052	352
1	L1	0.746082	0.901515	0.816467	264
18	L18	0.733096	0.865546	0.793834	238
0	L0	0.696429	0.696429	0.696429	504
27	L27	0.610915	0.776721	0.683912	1787

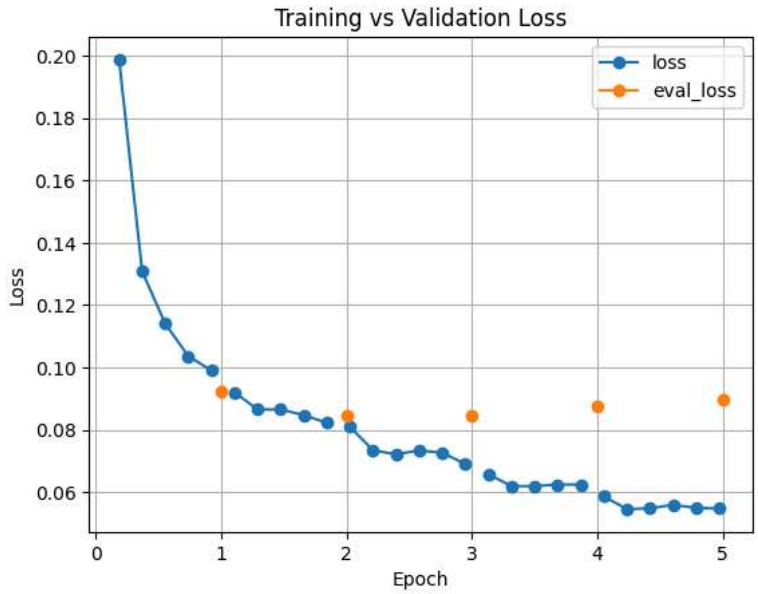
```
Bottom-5 labels by F1:
```

	label	precision	recall	f1	support
16	L16	0.000000	0.000000	0.000000	6
22	L22	0.252101	0.206897	0.227273	145
21	L21	0.571429	0.250000	0.347826	16
9	L9	0.314433	0.403974	0.353623	151
3	L3	0.318807	0.434375	0.367725	320

Next steps: Generate code with best5 | New interactive sheet | Generate code with worst5 | New interactive sheet

```
# === Plot learning curves from Trainer logs ===
import pandas as pd
import matplotlib.pyplot as plt

logs = pd.DataFrame(trainer.state.log_history)
# Keep useful keys only
keys = ["epoch", "loss", "eval_loss", "eval_f1", "eval_accuracy"]
curves = logs[[k for k in keys if k in logs.columns]].dropna(how="all")

# Loss curve
plt.figure()
curves.plot(x="epoch", y=[c for c in ["loss","eval_loss"] if c in curves.columns], marker="o")
plt.title("Training vs Validation Loss")
plt.xlabel("Epoch")
plt.ylabel("Loss")
plt.grid(True)
plt.show()
```

```
<Figure size 640x480 with 0 Axes>
```




```
# === Efficiency snapshot ===
import torch, numpy as np, pandas as pd

def count_params(m):
    total = sum(p.numel() for p in m.parameters())
    trainable = sum(p.numel() for p in m.parameters() if p.requires_grad)
    return total, trainable

total_p, trainable_p = count_params(model)
runtime_sec = float(getattr(trainer.state, "train_runtime", np.nan))
steps_per_sec = float(getattr(trainer.state, "train_steps_per_second", np.nan))
samples_per_sec = float(getattr(trainer.state, "train_samples_per_second", np.nan))

try:
    vram_mb = torch.cuda.max_memory_allocated() / (1024**2)
except:
    vram_mb = np.nan

eff = pd.DataFrame([{
    "strategy": "current_model",
    "total_params": total_p,
    "trainable_params": trainable_p,
    "train_runtime_s": runtime_sec,
    "steps_per_s": steps_per_sec,
    "samples_per_s": samples_per_sec,
    "approx_max_VRAM_MB": vram_mb
}])
display(eff)
```

	strategy	total_params	trainable_params	train_runtime_s	steps_per_s	samples_per_s	approx_max_VRAM_MB
0	current_model	109503772	109503772	NaN	NaN	NaN	2297.915039

```
# === Single-threshold sensitivity (VAL) ===
import numpy as np, matplotlib.pyplot as plt
from sklearn.metrics import f1_score, accuracy_score

y_true_val, y_score_val = _predict_split(trainer, tokenized_dataset["validation"])
ths = np.linspace(0.05, 0.95, 19)
micro_f1s, macros, accs = [], [], []

for t in ths:
    y_pred = (y_score_val >= t).astype(int)
    micro_f1s.append(f1_score(y_true_val, y_pred, average="micro", zero_division=0))
    macros.append(f1_score(y_true_val, y_pred, average="macro", zero_division=0))
    accs.append(accuracy_score(y_true_val, y_pred))

plt.figure()
plt.plot(ths, micro_f1s, marker="o", label="micro F1")
plt.plot(ths, macros, marker="o", label="macro F1")
plt.plot(ths, accs, marker="o", label="subset accuracy")
plt.xlabel("Threshold")
plt.ylabel("Score")
plt.title("Threshold Sensitivity (Validation)")
plt.grid(True)
plt.legend()
plt.show()
```