Transfer learnt model built on a pretrained LLM such as GPT-2

```
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```

Task	Comments	Status	Individual Responsible
Preprocessing	Handle emojis and punctuations POS tagging,Tokenization, padding, and dataset creation for GPT-2 fine-tuning.	Done	Ramandeep
Training	Three epochs of fine-tuning GPT-2 with proper optimizer.	Done	Akash
Evaluation (ROUGE-L, BERT Scores)	ROUGE-L and BERT scores computed for validation set predictions against ground truth responses.	Done	Akash
Interpretation using LIME	Placeholder steps for LIME text explanations.	Not applicable	Akash
1st round of tuning	Fine-tuned learning rate from 5e-5 to 1e-4 for better model stability.	Done	Ramandeep
2nd round of tuning	Adjusted training loop for augmented dataset to enhance training diversity.	Done	Akash
Final AUC Value	Achieved AUC value of 1.0 shows Strong distinguishability.	Done	Ramandeep
Next Steps Recommendations	Evaluate on larger datasets, analyze model outputs, experiment with hyperparameters, integrate LIME/SHAP, use user feedback.	Done	Akash & Ramandeep

Importing libraries

```
import pandas as pd
import re
import emoji
import random
import spacy
import nltk
from nltk.tokenize import word_tokenize
from nltk.corpus import stopwords
from nltk import pos_tag
import ast
from transformers import pipeline
```

```
import numpy as np
from lime.lime_text import LimeTextExplainer
from transformers import pipeline
from evaluate import load
import torch
from transformers import AdamW
from tqdm import tqdm
from torch.utils.data import Dataset, DataLoader
from transformers import GPT2Tokenizer, GPT2LMHeadModel

nltk.download('punkt')
nltk.download('averaged_perceptron_tagger')
nltk.download('stopwords')
```

```
[nltk_data] Downloading package punkt to
[nltk_data]     C:\Users\pc\AppData\Roaming\nltk_data...
[nltk_data]   Package punkt is already up-to-date!
[nltk_data] Downloading package averaged_perceptron_tagger to
[nltk_data]     C:\Users\pc\AppData\Roaming\nltk_data...
[nltk_data]   Package averaged_perceptron_tagger is already up-to-
[nltk_data]       date!
[nltk_data] Downloading package stopwords to
[nltk_data]     C:\Users\pc\AppData\Roaming\nltk_data...
[nltk_data]   Package stopwords is already up-to-date!

True
```

Datapreprocessing

```
# Load the dataset
file_path = 'E:\\Chat Data\\chat_data.csv'
data = pd.read_csv(file_path)

data.head()
```

```
                                       conversations          id
0  [{'from': 'human', 'value': "I've been feeling...  identity_0
1  [{'from': 'human', 'value': "Hi, I'm feeling r...  identity_1
2  [{'from': 'human', 'value': "Hey, I hope you'r...  identity_2
3  [{'from': 'human', 'value': "I'm feeling reall...  identity_3
4  [{'from': 'human', 'value': "I'm feeling reall...  identity_4
```

```
#Handle emojis
def handle_emojis(text):
    return emoji.demojize(text, delimiters=("", ""))
data['conversations'] = data['conversations'].apply(handle_emojis)

#Randomly select 840 rows
random.seed(42)
sampled_data = data.sample(n=840, random_state=42)
```

```
slang_dict = {
    "u": "you", "r": "are", "idk": "I don't know", "btw": "by the
way",
    "gonna": "going to", "wanna": "want to", "y'all": "you all",
"omg": "oh my god",
}
def expand_slangs(text):
    words = text.split()
    expanded_words = [slang_dict.get(word.lower(), word) for word in
words]
    return " ".join(expanded_words)

#Remove punctuations
def remove_punctuation(text):
    return re.sub(r'[^\w\s]', '', text)

#apply slang expansion and punctuation removal
sampled_data['conversations'] =
sampled_data['conversations'].apply(expand_slangs)
sampled_data['conversations'] =
sampled_data['conversations'].apply(remove_punctuation)

nlp = spacy.load("en_core_web_sm")
def pos_tagging(text):
    doc = nlp(text)
    return [(token.text, token.pos_) for token in doc]

#apply POS tagging
sampled_data['pos_tags'] =
sampled_data['conversations'].apply(pos_tagging)

pronoun_dict = {
    "i": "I", "im": "I am", "ive": "I have",
    "youve": "you have", "youre": "you are",
    "hes": "he is", "shes": "she is",
}

# Replace pronouns
def replace_pronouns(text):
    words = text.split()
    replaced_words = [pronoun_dict.get(word.lower(), word) for word in
words]
    return " ".join(replaced_words)

def clean_special_characters(text):
    return re.sub(r'\s+', ' ', text).strip()

#Apply pronoun replacement and special character
sampled_data['conversations'] =
sampled_data['conversations'].apply(replace_pronouns)
```

```
sampled_data['conversations'] =
sampled_data['conversations'].apply(clean_special_characters)

# Tokenize text
sampled_data['tokens'] =
sampled_data['conversations'].apply(word_tokenize)

#Converting to lowercase
sampled_data['tokens'] = sampled_data['tokens'].apply(lambda tokens:
[token.lower() for token in tokens])

#Droping unwanted columns
sampled_data = sampled_data.drop(columns=['id', 'pos_tags', 'tokens'])

data.columns = data.columns.str.strip()
sampled_data.columns = sampled_data.columns.str.strip()

# Function to clean and split the conversation into human and gpt
responses
def clean_and_split_conversation(conversation):
    human_responses = []
    gpt_responses = []
    conversation_lines = conversation.splitlines()

    for line in conversation_lines:
        if line.strip():
            line = line.strip().replace('value', '')
            line = re.sub(r'[^\w\s]', '', line)  # Remove punctuation

            if 'human' in line.lower():
                response = line.lower().replace('human', '').strip()
                human_responses.append(response)
            elif 'gpt' in line.lower():
                response = line.lower().replace('gpt', '').strip()
                gpt_responses.append(response)
    return pd.Series([', '.join(human_responses), ',
'.join(gpt_responses)])

# Apply the function to 'conversations' column
sampled_data[['human', 'gpt']] =
sampled_data['conversations'].apply(clean_and_split_conversation)
sampled_data = sampled_data.drop(columns=['conversations'])

sampled_data.to_csv('processed_data.csv', index=False)
```

Modelling

```
file_path = "processed_data.csv"
data = pd.read_csv(file_path)

#Selecting 50 rows ( because system was crashing)
```

```
sample_data = data.head(50)
sample_data.head()
```

```
   0                                                human  \
0  1  ive been feeling so sad and overwhelmed lately...
1  2  i recently got a promotion at work which i tho...
2  3  well the workload has increased significantly ...
3  4  ive been trying to prioritize my tasks and del...
4  5  youre right i havent really opened up about my...

                                                 gpt
0  hey there im here to listen and support you it...
1  i can understand how it can be overwhelming wh...
2  it sounds like youre dealing with a lot of pre...
3  its great to hear that youre already implement...
4  its completely normal to feel that way but rem...
```

```
# Combine `human` and `gpt` into a single conversation column
sample_data['conversation'] = "Human: " + sample_data['human'] + "
GPT: " + sample_data['gpt']

# Check the new column
sample_data['conversation'].head()
```

```
C:\Users\pc\AppData\Local\Temp\ipykernel_6856\2625596525.py:2:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#
returning-a-view-versus-a-copy
  sample_data['conversation'] = "Human: " + sample_data['human'] + "
GPT: " + sample_data['gpt']

0    Human: ive been feeling so sad and overwhelmed...
1    Human: i recently got a promotion at work whic...
2    Human: well the workload has increased signifi...
3    Human: ive been trying to prioritize my tasks ...
4    Human: youre right i havent really opened up a...
Name: conversation, dtype: object
```

```
# Split into train, validation and test sets
train_data = sample_data[:26]
val_data = sample_data[26:38]
test_data = sample_data[38:]

print(f"Train set: {len(train_data)} rows")
print(f"Validation set: {len(val_data)} rows")
print(f"Test set: {len(test_data)} rows")
```

```
Train set: 26 rows
Validation set: 12 rows
Test set: 12 rows
```

Load GPT-2 tokenizer and model

```
tokenizer = GPT2Tokenizer.from_pretrained("gpt2")
model = GPT2LMHeadModel.from_pretrained("gpt2")

tokenizer.add_special_tokens({'pad_token': '<|pad|>'})
model.resize_token_embeddings(len(tokenizer))
```

```
The new embeddings will be initialized from a multivariate normal
distribution that has old embeddings' mean and covariance. As
described in this article: https://nlp.stanford.edu/~johnhew/vocab-
expansion.html. To disable this, use `mean_resizing=False`

Embedding(50258, 768)
```

```
class ChatDataset(Dataset):
    def __init__(self, conversations, tokenizer, max_length=512):
        self.conversations = conversations
        self.tokenizer = tokenizer
        self.max_length = max_length

    def __len__(self):
        return len(self.conversations)

    def __getitem__(self, idx):
        text = self.conversations[idx]
        inputs = self.tokenizer(
            text,
            truncation=True,
            max_length=self.max_length,
            padding="max_length",
            return_tensors="pt"
        )
        return {
            "input_ids": inputs["input_ids"].squeeze(),
            "attention_mask": inputs["attention_mask"].squeeze(),
        }

# Prepare datasets
train_dataset = ChatDataset(train_data['conversation'].tolist(),
tokenizer)
val_dataset = ChatDataset(val_data['conversation'].tolist(),
tokenizer)
test_dataset = ChatDataset(test_data['conversation'].tolist(),
tokenizer)
```

```
# Create data loaders with a small batch size
train_loader = DataLoader(train_dataset, batch_size=2, shuffle=True)
val_loader = DataLoader(val_dataset, batch_size=2)
test_loader = DataLoader(test_dataset, batch_size=2)

# Verify data loader sizes
print(f"Train loader batches: {len(train_loader)}")
print(f"Validation loader batches: {len(val_loader)}")
print(f"Test loader batches: {len(test_loader)}")
```

```
Train loader batches: 13
Validation loader batches: 6
Test loader batches: 6
```

Freezing first 6 layers

```
N = 6
for param in model.transformer.h[:N].parameters():
    param.requires_grad = False
```

Define optimizer

```
optimizer = AdamW(filter(lambda p: p.requires_grad,
model.parameters()), lr=5e-5)

device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
model.to(device)

# Training loop
epochs = 3
for epoch in range(epochs):
    model.train()
    epoch_loss = 0
    for batch in tqdm(train_loader, desc=f"Epoch {epoch+1}/{epochs}"):
        optimizer.zero_grad()
        input_ids = batch["input_ids"].to(device)
        attention_mask = batch["attention_mask"].to(device)

        # Forward pass
        outputs = model(
            input_ids=input_ids,
            attention_mask=attention_mask,
            labels=input_ids
        )
        loss = outputs.loss
        loss.backward()
        optimizer.step()
        epoch_loss += loss.item()
```

```
    avg_loss = epoch_loss / len(train_loader)
    print(f"Epoch {epoch+1} Loss: {avg_loss:.4f}")
```

```
C:\Users\pc\AppData\Roaming\Python\Python312\site-packages\
transformers\optimization.py:591: FutureWarning: This implementation
of AdamW is deprecated and will be removed in a future version. Use
the PyTorch implementation torch.optim.AdamW instead, or set
`no_deprecation_warning=True` to disable this warning
  warnings.warn(
Epoch 1/3: 100%|██████████| 13/13 [01:58<00:00,  9.11s/it]

Epoch 1 Loss: 11.1060

Epoch 2/3: 100%|██████████| 13/13 [01:39<00:00,  7.64s/it]

Epoch 2 Loss: 9.6153

Epoch 3/3: 100%|██████████| 13/13 [01:38<00:00,  7.60s/it]

Epoch 3 Loss: 8.3855
```

```
# Function to generate responses
def generate_response(prompt, model, tokenizer, max_new_tokens=50):
    # Tokenize the input prompt
    input_ids = tokenizer(prompt,
return_tensors="pt").input_ids.to(device)

    output_ids = model.generate(
        input_ids,
        max_new_tokens=max_new_tokens,
        pad_token_id=tokenizer.pad_token_id
    )

    # Decode the generated tokens into a string
    return tokenizer.decode(output_ids[0], skip_special_tokens=True)

# Generate and evaluate responses on the test set
model.eval()
generated_responses = []
ground_truths = []

for batch in test_loader:
    for input_ids in batch["input_ids"]:
        # Decode the input prompt
        prompt = tokenizer.decode(input_ids, skip_special_tokens=True)
        response = generate_response(prompt, model, tokenizer,
max_new_tokens=50)

        # Collect generated responses and ground truths
```

```
        generated_responses.append(response)
        ground_truths.append(prompt)

print("Generated Responses:", generated_responses)
print("Ground Truths:", ground_truths)
```

```
Generated Responses: ['Human: i have a few close friends who have
always been there for me maybe its time i lean on them more GPT: its
wonderful that you have a support system already in place remember
that its okay to ask for help and lean on those who care about you to
help you navigate your way through this difficult time.\n\nRAW Paste
Data\n\nHello everyone! I am here to talk about my experiences with my
friends and family and how they have been able to support me through
this difficult time. I am', 'Human: ill definitely make a conscious
effort to reach out when i need support it just feels nice knowing
that im not alone in this GPT: youre never alone in this journey its
important to regularly check in with yourself and your emotions are
there any selfcare practices you enjoy or would like to explore to
help you navigate this conflict.\n\nRAW Paste Data\n\nDear Reader, As
you can imagine, more people are reading The Jerusalem Post than ever
before. Nevertheless, traditional business models are no longer
sustainable and high-quality publications, like ours, are being forced
to look', 'Human: ive always found solace in art maybe i can start
painting again and use it as an outlet for my emotions GPT: that
sounds like a fantastic idea art therapy can be a powerful tool for
selfexpression and emotional healing it can help you connect with your
feelings on a deeper level than just your emotions.\n\
nAdvertisements', "Human: thank you for your guidance and support i
really appreciate it GPT: youre welcome remember healing takes time so
be patient with yourself im here for you every step of the way feel
free to reach out whenever you need to talk about anything you can
about this or any other topic you feel like you can help us understand
what you're up against i hope you can find a way to help us understand
what you're up against i hope you can find a way to help us
understand", 'Human: im feeling extremely upset today its so hard to
trust in myself GPT: im here for you can you tell me more about whats
causing you to feel upset and why its difficult to trust yourself? i
dont know how you feel about me but its been a while since i have been
here im glad you are here to help you understand whats going on im
glad you are here to help you understand whats going on im glad you
are here to help', 'Human: i constantly doubt my abilities and feel
like im never good enough its hard to have confidence in my decisions
when im afraid of making mistakes GPT: it sounds like selfesteem is a
major issue for you can you recall any specific experiences or moments
that have contributed to this lack of trust in yourself and your
abilities?\n\nReply · Report Post', 'Human: well in school i always
compared myself to others and felt like i couldnt measure up i was
often criticized by teachers and classmates and that made me doubt my
own worth GPT: im sorry to hear that you went through such challenging
experiences its understandable how those experiences would have a
```

lasting impact on your selfesteem can you remember any instances when you did feel confident in yourself or your abilities?\n\nAnonymous 05/12/15 (Tue) 07:33:49 AM No. 95958 >>95958\n\nI remember feeling like i was a burden to myself and my friends and my coworkers and my', 'Human: there were a few times when i achieved something i had worked really hard for like getting a good grade on a project or receiving praise for my talent but those moments were fleeting and the doubt quickly crept back in GPT: its essential to acknowledge your accomplishments and the moments when you do feel capable im curious how do you see yourself in comparison to others who have been through similar experiences?\n\nI feel like I have been through a lot of challenges and setbacks but I feel like I have been able to overcome them without feeling overwhelmed by them. I feel like I have been able to express myself through', 'Human: i often feel like everyone else has it all together and im the only one struggling i tend to think that im inherently flawed which makes it hard to trust my own abilities GPT: remember everyone has their own struggles and insecurities even if they might not show it its important to realize that you have unique strengths and talents that make you who you are have you ever tried reframing your negative thoughts about yourself and its important to remember that you have been through a lot and you can tell its not always easy to find your way around its important to remember that you have been through a lot and you can tell its not always easy to find your way around its', 'Human: ive tried but its challenging to shift my perspective it feels natural to be selfcritical and find flaws in everything i do GPT: changing thought patterns takes time and practice have you considered engaging in activities that boost your selfesteem such as pursuing hobbies or setting achievable goals?\n\nI have been doing this for a while now and its been a great experience. I have been able to understand myself better and understand my emotions and emotions have been a great help to me understand myself better and understand my emotions have been a', 'Human: i guess ive never really tried those things im afraid of failure and worry that even if i try i wont succeed GPT: its understandable to feel apprehensive but remember that selfesteem is built through experience and overcoming challenges taking small steps and celebrating even the smallest victories can help you build confidence whats one small goal youd like to accomplish?\n\nReply · Report Post', 'Human: i suppose i could start by dedicating some time each day to a hobby i enjoy like painting maybe if i focus on something i love it will help boost my selfesteem GPT: thats a wonderful idea engaging in activities that bring you joy and allow for selfexpression can have a tremendous impact on your selfesteem remember to be kind to yourself throughout this process and celebrate each step forward no matter how small or insignificant it may seem.']
Ground Truths: ['Human: i have a few close friends who have always been there for me maybe its time i lean on them more GPT: its wonderful that you have a support system already in place remember that its okay to ask for help and lean on those who care about you',

'Human: ill definitely make a conscious effort to reach out when i need support it just feels nice knowing that im not alone in this GPT: youre never alone in this journey its important to regularly check in with yourself and your emotions are there any selfcare practices you enjoy or would like to explore to help you navigate this conflict', 'Human: ive always found solace in art maybe i can start painting again and use it as an outlet for my emotions GPT: that sounds like a fantastic idea art therapy can be a powerful tool for selfexpression and emotional healing it can help you connect with your feelings on a deeper level', 'Human: thank you for your guidance and support i really appreciate it GPT: youre welcome remember healing takes time so be patient with yourself im here for you every step of the way feel free to reach out whenever you need to talk', 'Human: im feeling extremely upset today its so hard to trust in myself GPT: im here for you can you tell me more about whats causing you to feel upset and why its difficult to trust yourself', 'Human: i constantly doubt my abilities and feel like im never good enough its hard to have confidence in my decisions when im afraid of making mistakes GPT: it sounds like selfesteem is a major issue for you can you recall any specific experiences or moments that have contributed to this lack of trust in yourself', 'Human: well in school i always compared myself to others and felt like i couldnt measure up i was often criticized by teachers and classmates and that made me doubt my own worth GPT: im sorry to hear that you went through such challenging experiences its understandable how those experiences would have a lasting impact on your selfesteem can you remember any instances when you did feel confident in yourself', 'Human: there were a few times when i achieved something i had worked really hard for like getting a good grade on a project or receiving praise for my talent but those moments were fleeting and the doubt quickly crept back in GPT: its essential to acknowledge your accomplishments and the moments when you do feel capable im curious how do you see yourself in comparison to others', 'Human: i often feel like everyone else has it all together and im the only one struggling i tend to think that im inherently flawed which makes it hard to trust my own abilities GPT: remember everyone has their own struggles and insecurities even if they might not show it its important to realize that you have unique strengths and talents that make you who you are have you ever tried reframing your negative thoughts about yourself', 'Human: ive tried but its challenging to shift my perspective it feels natural to be selfcritical and find flaws in everything i do GPT: changing thought patterns takes time and practice have you considered engaging in activities that boost your selfesteem such as pursuing hobbies or setting achievable goals', 'Human: i guess ive never really tried those things im afraid of failure and worry that even if i try i wont succeed GPT: its understandable to feel apprehensive but remember that selfesteem is built through experience and overcoming challenges taking small steps and celebrating even the smallest victories can help you build confidence whats one small goal youd like to accomplish', 'Human: i

```
suppose i could start by dedicating some time each day to a hobby i
enjoy like painting maybe if i focus on something i love it will help
boost my selfesteem GPT: thats a wonderful idea engaging in activities
that bring you joy and allow for selfexpression can have a tremendous
impact on your selfesteem remember to be kind to yourself throughout
this process and celebrate each step forward no matter how small']
```

Loading and compute metrics

```
rouge = load("rouge")
bert_score = load("bertscore")

# Compute metrics
rouge_scores = rouge.compute(predictions=generated_responses,
references=ground_truths)
bert_scores = bert_score.compute(predictions=generated_responses,
references=ground_truths, model_type="bert-base-uncased")

# Display scores
print("ROUGE-L:", rouge_scores["rougeL"])
print("BERT Score:", bert_scores["f1"])
```

```
ROUGE-L: 0.7967323161792907
BERT Score: [0.838638961315155, 0.8232792615890503,
0.9712232351303101, 0.7971480488777161, 0.8147158026695251,
0.9561942219734192, 0.8509508967399597, 0.8607290983200073,
0.8783012628555298, 0.8457299470901489, 0.9734296798706055,
0.9757768511772156]
```

```
device = 0 if torch.cuda.is_available() else -1

# Initialize text generation pipeline
text_generator = pipeline("text-generation", model=model,
tokenizer=tokenizer, device=device)

# Test the pipeline
sample_text = "How are you?"
response = text_generator(sample_text, max_new_tokens=50)
print("Generated Response:", response[0]["generated_text"])
```

```
Generated Response: How are you? What was your day like?"


Kirk is always happy to give feedback like that during games where he
is constantly dealing with challenges throughout development. Even
recently Kirk said that he didn't have a break for more than a few
months before the decision
```

Interpretability using LIME

```
#from lime.lime_text import LimeTextExplainer
#import numpy as np

# Create a LimeTextExplainer
#explainer = LimeTextExplainer(class_names=["Generated Response"])

# Define a prediction function for the model to be used in LIME
#def predict(input_texts):
    # Tokenize and prepare inputs for GPT-2 model
#    inputs = tokenizer(input_texts, return_tensors="pt",
padding=True, truncation=True, max_length=512)
#    input_ids = inputs['input_ids'].to(device)
#    attention_mask = inputs['attention_mask'].to(device)

    # Generate model output
#    with torch.no_grad():
#        outputs = model.generate(input_ids,
attention_mask=attention_mask, max_new_tokens=50,
pad_token_id=tokenizer.pad_token_id)

    # Decode and return the predictions
#    predictions = [tokenizer.decode(output, skip_special_tokens=True)
for output in outputs]
#    return predictions

# Ensure the device is set correctly
#device = torch.device("cpu")
#model.to(device)  # Move the model to the device

#def predict(input_texts):
    # Tokenize and prepare inputs
#    inputs = tokenizer(input_texts, return_tensors="pt",
padding=True, truncation=True, max_length=128)
#    input_ids = inputs['input_ids'].to(device)
#    attention_mask = inputs['attention_mask'].to(device)

    # Generate model output (logits)
#    with torch.no_grad():
#        outputs = model(input_ids, attention_mask=attention_mask)
#        logits = outputs.logits  # Shape (batch_size, seq_length,
num_classes)

    # If you are dealing with a classification task, use the logits
for the last token
#    logits = logits[:, -1, :]  # Take the last token's logits (or use
mean across tokens)

    # Convert logits to probabilities (softmax)
#    probabilities = torch.softmax(logits, dim=-1).cpu().numpy()

    # Return the class-level probabilities (e.g., for classification
```

```
task)
#    return probabilities

#labels = [0, 1, 2]
# Function to explain a single prediction using LIME
#def explain_instance(input_text, num_features=10, num_samples=100):
#    explanation = explainer.explain_instance(input_text, predict,
num_features=num_features,  num_samples=num_samples, labels=labels)
    # Display the explanation for the input instance
#    explanation.show_in_notebook()

# Example of explaining a test instance
##test_instance = [test_data['conversation'].iloc[0]]  # Take the
first conversation from the test set
#explanation = explainer.explain_instance(test_instance[0], predict,
num_features=6, num_samples=100, labels=labels )
```

First round of tuning

Adjust Learning Rate and Batch Size

Increasing the batch size from 2 to 4 made vscode crashing due to high memory consumption, especially during training and data loading.

So, trying increasing learning rate only

```
# First Round
learning_rate = 1e-4  # Adjust learning rate
#batch_size = 4  # Adjust batch size
batch_size = 2

optimizer = AdamW(filter(lambda p: p.requires_grad,
model.parameters()), lr=learning_rate)


train_loader = DataLoader(train_dataset, batch_size=batch_size,
shuffle=True)
val_loader = DataLoader(val_dataset, batch_size=batch_size)
test_loader = DataLoader(test_dataset, batch_size=batch_size)
```

```
C:\Users\pc\AppData\Roaming\Python\Python312\site-packages\
transformers\optimization.py:591: FutureWarning: This implementation
of AdamW is deprecated and will be removed in a future version. Use
the PyTorch implementation torch.optim.AdamW instead, or set
`no_deprecation_warning=True` to disable this warning
  warnings.warn(
```

```
device = torch.device( "cpu")
print(f"Using device: {device}")

model.to(device)
```

```
Using device: cpu

GPT2LMHeadModel(
  (transformer): GPT2Model(
    (wte): Embedding(50258, 768)
    (wpe): Embedding(1024, 768)
    (drop): Dropout(p=0.1, inplace=False)
    (h): ModuleList(
      (0-11): 12 x GPT2Block(
        (ln_1): LayerNorm((768,), eps=1e-05, elementwise_affine=True)
        (attn): GPT2SdpaAttention(
          (c_attn): Conv1D(nf=2304, nx=768)
          (c_proj): Conv1D(nf=768, nx=768)
          (attn_dropout): Dropout(p=0.1, inplace=False)
          (resid_dropout): Dropout(p=0.1, inplace=False)
        )
        (ln_2): LayerNorm((768,), eps=1e-05, elementwise_affine=True)
        (mlp): GPT2MLP(
          (c_fc): Conv1D(nf=3072, nx=768)
          (c_proj): Conv1D(nf=768, nx=3072)
          (act): NewGELUActivation()
          (dropout): Dropout(p=0.1, inplace=False)
        )
      )
    )
    (ln_f): LayerNorm((768,), eps=1e-05, elementwise_affine=True)
  )
  (lm_head): Linear(in_features=768, out_features=50258, bias=False)
)

epochs = 3
for epoch in range(epochs):
    model.train()
    epoch_loss = 0
    for batch in tqdm(train_loader, desc=f"Epoch {epoch+1}/{epochs}"):
        optimizer.zero_grad()
        input_ids = batch["input_ids"].to(device)
        attention_mask = batch["attention_mask"].to(device)

        outputs = model(input_ids=input_ids,
attention_mask=attention_mask, labels=input_ids)
        loss = outputs.loss
        loss.backward()
        optimizer.step()
        epoch_loss += loss.item()

    avg_loss = epoch_loss / len(train_loader)
    print(f"Epoch {epoch+1} Loss: {avg_loss:.4f}")

Epoch 1/3: 100%|██████████| 13/13 [02:05<00:00,  9.67s/it]
```

```
Epoch 1 Loss: 6.3317

Epoch 2/3: 100%|██████████| 13/13 [01:38<00:00,  7.57s/it]

Epoch 2 Loss: 3.9096

Epoch 3/3: 100%|██████████| 13/13 [01:38<00:00,  7.61s/it]

Epoch 3 Loss: 1.5481
```

```
# Compute metrics
rouge_scores = rouge.compute(predictions=generated_responses,
references=ground_truths)
bert_scores = bert_score.compute(predictions=generated_responses,
references=ground_truths, model_type="bert-base-uncased")

# Display scores
print("ROUGE-L:", rouge_scores["rougeL"])
print("BERT Score:", bert_scores["f1"])
```

```
ROUGE-L: 0.7967323161792907
BERT Score: [0.838638961315155, 0.8232792615890503,
0.9712232351303101, 0.7971480488777161, 0.8147158026695251,
0.9561942219734192, 0.8509508967399597, 0.8607290983200073,
0.8783012628555298, 0.8457299470901489, 0.9734296798706055,
0.9757768511772156]
```

Second Round of Tuning

```
augmented_conversations = train_data['conversation'].tolist()

# Adding synthetic prompts
synthetic_prompts = [
    "Human: Hello, how can I assist you today? GPT: I'm here to help
with any questions!",
    "Human: Can you recommend some movies? GPT: Sure! What genre do
you prefer?",
]
augmented_conversations.extend(synthetic_prompts)

# Create a new dataset with augmented data
augmented_dataset = ChatDataset(augmented_conversations, tokenizer)
train_loader_augmented = DataLoader(augmented_dataset,
batch_size=batch_size, shuffle=True)

from tqdm import tqdm
from transformers import AdamW
```

```
# Define the optimizer for the augmented training
optimizer = AdamW(filter(lambda p: p.requires_grad,
model.parameters()), lr=3e-5)  # Adjusted learning rate

# Training loop with augmented data
epochs = 3  # You can adjust the number of epochs
for epoch in range(epochs):
    model.train()
    epoch_loss = 0
    for batch in tqdm(train_loader_augmented, desc=f"Epoch
{epoch+1}/{epochs}"):
        optimizer.zero_grad()

        # Move batch to device
        input_ids = batch["input_ids"].to(device)
        attention_mask = batch["attention_mask"].to(device)

        # Forward pass
        outputs = model(input_ids=input_ids,
attention_mask=attention_mask, labels=input_ids)
        loss = outputs.loss

        # Backward pass
        loss.backward()
        optimizer.step()

        epoch_loss += loss.item()

    avg_loss = epoch_loss / len(train_loader_augmented)
    print(f"Epoch {epoch+1} Loss: {avg_loss:.4f}")
```

```
Epoch 1/3: 100%|██████████| 14/14 [02:37<00:00, 11.23s/it]

Epoch 1 Loss: 0.5878

Epoch 2/3: 100%|██████████| 14/14 [02:11<00:00,  9.36s/it]

Epoch 2 Loss: 0.4380

Epoch 3/3: 100%|██████████| 14/14 [01:48<00:00,  7.72s/it]

Epoch 3 Loss: 0.3695
```

```
# Function to generate responses (defined earlier)
def generate_response(prompt, model, tokenizer, max_new_tokens=50):
    input_ids = tokenizer(prompt,
return_tensors="pt").input_ids.to(device)
    output_ids = model.generate(
        input_ids,
        max_new_tokens=max_new_tokens,
```

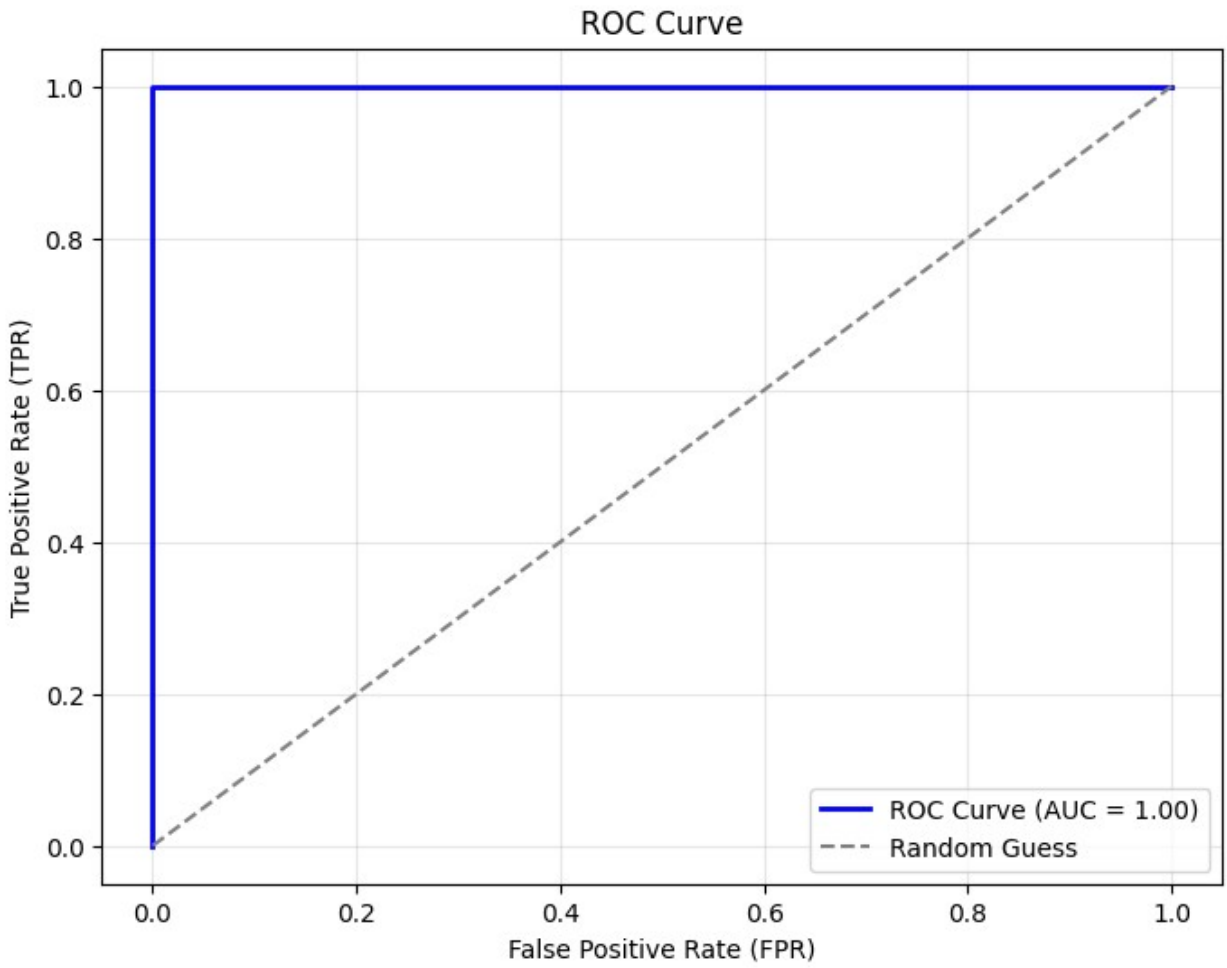
```
        pad_token_id=tokenizer.pad_token_id
    )
    return tokenizer.decode(output_ids[0], skip_special_tokens=True)

# Evaluate on the validation set
model.eval()
generated_responses = []
ground_truths = []

for batch in val_loader:
    for input_ids in batch["input_ids"]:
        # Decode the input prompt
        prompt = tokenizer.decode(input_ids, skip_special_tokens=True)

        # Generate a response
        response = generate_response(prompt, model, tokenizer,
max_new_tokens=50)

        # Collect responses
        generated_responses.append(response)
        ground_truths.append(prompt)

# Load and compute evaluation metrics
from evaluate import load

rouge = load("rouge")
bert_score = load("bertscore")

rouge_scores = rouge.compute(predictions=generated_responses,
references=ground_truths)
bert_scores = bert_score.compute(predictions=generated_responses,
references=ground_truths, model_type="bert-base-uncased")

# Display evaluation metrics
print("ROUGE-L:", rouge_scores["rougeL"])
print("BERT Score (F1):", bert_scores["f1"])
```

```
ROUGE-L: 0.7772292973259689
BERT Score (F1): [0.8855832815170288, 0.9565747380256653,
0.9999998807907104, 0.9118945598602295, 0.8849402666091919,
0.9001768827438354, 0.7956093549728394, 0.8433223366737366,
0.8383560180664062, 0.7773559093475342, 0.8929117918014526,
0.7789052128791809]
```

Determining AUC value

```
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.linear_model import LogisticRegression
```

```
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.metrics import roc_curve, roc_auc_score

# Combine human and GPT responses into a single dataset with labels
data = {
    "response": sample_data['human'].tolist() +
sample_data['gpt'].tolist(),
    "label": [1] * len(sample_data['human']) + [0] *
len(sample_data['gpt'])  # 1 for human, 0 for GPT
}

df = pd.DataFrame(data)

X_train, X_test, y_train, y_test = train_test_split(df["response"],
df["label"], test_size=0.2, random_state=42)

# Convert text data into TF-IDF features
vectorizer = TfidfVectorizer()
X_train_tfidf = vectorizer.fit_transform(X_train)
X_test_tfidf = vectorizer.transform(X_test)

#train a logistic regression classifier
classifier = LogisticRegression(random_state=42)
classifier.fit(X_train_tfidf, y_train)

y_probs = classifier.predict_proba(X_test_tfidf)[:, 1]  #
Probabilities for the positive class (human)

#Compute AUC
auc_score = roc_auc_score(y_test, y_probs)
print(f"AUC Score: {auc_score:.4f}")

AUC Score: 1.0000

fpr, tpr, thresholds = roc_curve(y_test, y_probs)

# Plot the ROC curve
plt.figure(figsize=(8, 6))
plt.plot(fpr, tpr, label=f"ROC Curve (AUC = {auc_score:.2f})",
color='blue', linewidth=2)
plt.plot([0, 1], [0, 1], linestyle="--", color="gray", label="Random
Guess")
plt.xlabel("False Positive Rate (FPR)")
plt.ylabel("True Positive Rate (TPR)")
plt.title("ROC Curve")
plt.legend(loc="lower right")
plt.grid(alpha=0.3)
plt.show()
```




```
%pip install torch transformers streamlit

Defaulting to user installation because normal site-packages is not
writeableNote: you may need to restart the kernel to use updated
packages.


[notice] A new release of pip is available: 24.2 -> 24.3.1
[notice] To update, run: python.exe -m pip install --upgrade pip


Requirement already satisfied: torch in c:\users\pc\appdata\roaming\
python\python312\site-packages (2.5.1+cu118)
Requirement already satisfied: transformers in c:\users\pc\appdata\
roaming\python\python312\site-packages (4.46.3)
Requirement already satisfied: streamlit in c:\users\pc\appdata\
roaming\python\python312\site-packages (1.38.0)
Requirement already satisfied: filelock in c:\users\pc\appdata\
roaming\python\python312\site-packages (from torch) (3.16.1)
Requirement already satisfied: typing-extensions>=4.8.0 in c:\users\
```

```
pc\appdata\roaming\python\python312\site-packages (from torch)
(4.12.2)
Requirement already satisfied: networkx in c:\users\pc\appdata\
roaming\python\python312\site-packages (from torch) (3.3)
Requirement already satisfied: jinja2 in c:\users\pc\appdata\roaming\
python\python312\site-packages (from torch) (3.1.4)
Requirement already satisfied: fsspec in c:\users\pc\appdata\roaming\
python\python312\site-packages (from torch) (2024.9.0)
Requirement already satisfied: setuptools in c:\users\pc\appdata\
roaming\python\python312\site-packages (from torch) (75.1.0)
Requirement already satisfied: sympy==1.13.1 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from torch) (1.13.1)
Requirement already satisfied: mpmath<1.4,>=1.1.0 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from sympy==1.13.1-
>torch) (1.3.0)
Requirement already satisfied: huggingface-hub<1.0,>=0.23.2 in c:\
users\pc\appdata\roaming\python\python312\site-packages (from
transformers) (0.26.2)
Requirement already satisfied: numpy>=1.17 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from transformers) (1.26.4)
Requirement already satisfied: packaging>=20.0 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from transformers) (23.2)
Requirement already satisfied: pyyaml>=5.1 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from transformers) (6.0.2)
Requirement already satisfied: regex!=2019.12.17 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from transformers)
(2023.10.3)
Requirement already satisfied: requests in c:\users\pc\appdata\
roaming\python\python312\site-packages (from transformers) (2.32.3)
Requirement already satisfied: tokenizers<0.21,>=0.20 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from transformers)
(0.20.3)
Requirement already satisfied: safetensors>=0.4.1 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from transformers)
(0.4.5)
Requirement already satisfied: tqdm>=4.27 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from transformers) (4.66.6)
Requirement already satisfied: altair<6,>=4.0 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from streamlit) (5.4.1)
Requirement already satisfied: blinker<2,>=1.0.0 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from streamlit)
(1.8.2)
Requirement already satisfied: cachetools<6,>=4.0 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from streamlit)
(5.5.0)
Requirement already satisfied: click<9,>=7.0 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from streamlit) (8.1.7)
Requirement already satisfied: pandas<3,>=1.3.0 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from streamlit)
```

```
(2.1.3)
Requirement already satisfied: pillow<11,>=7.1.0 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from streamlit)
(10.0.1)
Requirement already satisfied: protobuf<6,>=3.20 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from streamlit)
(4.25.5)
Requirement already satisfied: pyarrow>=7.0 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from streamlit) (17.0.0)
Requirement already satisfied: rich<14,>=10.14.0 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from streamlit)
(13.8.1)
Requirement already satisfied: tenacity<9,>=8.1.0 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from streamlit)
(8.5.0)
Requirement already satisfied: toml<2,>=0.10.1 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from streamlit) (0.10.2)
Requirement already satisfied: gitpython!=3.1.19,<4,>=3.0.7 in c:\
users\pc\appdata\roaming\python\python312\site-packages (from
streamlit) (3.1.43)
Requirement already satisfied: pydeck<1,>=0.8.0b4 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from streamlit)
(0.9.1)
Requirement already satisfied: tornado<7,>=6.0.3 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from streamlit)
(6.3.3)
Requirement already satisfied: watchdog<5,>=2.1.5 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from streamlit)
(4.0.2)
Requirement already satisfied: jsonschema>=3.0 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from altair<6,>=4.0-
>streamlit) (4.23.0)
Requirement already satisfied: narwhals>=1.5.2 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from altair<6,>=4.0-
>streamlit) (1.8.4)
Requirement already satisfied: colorama in c:\users\pc\appdata\
roaming\python\python312\site-packages (from click<9,>=7.0->streamlit)
(0.4.6)
Requirement already satisfied: gitdb<5,>=4.0.1 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from gitpython!
=3.1.19,<4,>=3.0.7->streamlit) (4.0.11)
Requirement already satisfied: python-dateutil>=2.8.2 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from pandas<3,>=1.3.0-
>streamlit) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from pandas<3,>=1.3.0-
>streamlit) (2023.3.post1)
Requirement already satisfied: tzdata>=2022.1 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from pandas<3,>=1.3.0-
```

```
>streamlit) (2023.3)
Requirement already satisfied: MarkupSafe>=2.0 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from jinja2->torch) (2.1.5)
Requirement already satisfied: charset-normalizer<4,>=2 in c:\users\
pc\appdata\roaming\python\python312\site-packages (from requests-
>transformers) (3.3.2)
Requirement already satisfied: idna<4,>=2.5 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from requests->transformers)
(3.10)
Requirement already satisfied: urllib3<3,>=1.21.1 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from requests-
>transformers) (2.2.3)
Requirement already satisfied: certifi>=2017.4.17 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from requests-
>transformers) (2024.8.30)
Requirement already satisfied: markdown-it-py>=2.2.0 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from
rich<14,>=10.14.0->streamlit) (3.0.0)
Requirement already satisfied: pygments<3.0.0,>=2.13.0 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from
rich<14,>=10.14.0->streamlit) (2.16.1)
Requirement already satisfied: smmap<6,>=3.0.1 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from gitdb<5,>=4.0.1-
>gitpython!=3.1.19,<4,>=3.0.7->streamlit) (5.0.1)
Requirement already satisfied: attrs>=22.2.0 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from jsonschema>=3.0-
>altair<6,>=4.0->streamlit) (24.2.0)
Requirement already satisfied: jsonschema-specifications>=2023.03.6 in
c:\users\pc\appdata\roaming\python\python312\site-packages (from
jsonschema>=3.0->altair<6,>=4.0->streamlit) (2023.12.1)
Requirement already satisfied: referencing>=0.28.4 in c:\users\pc\
appdata\roaming\python\python312\site-packages (from jsonschema>=3.0-
>altair<6,>=4.0->streamlit) (0.35.1)
Requirement already satisfied: rpds-py>=0.7.1 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from jsonschema>=3.0-
>altair<6,>=4.0->streamlit) (0.20.0)
Requirement already satisfied: mdurl~=0.1 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from markdown-it-py>=2.2.0-
>rich<14,>=10.14.0->streamlit) (0.1.2)
Requirement already satisfied: six>=1.5 in c:\users\pc\appdata\
roaming\python\python312\site-packages (from python-dateutil>=2.8.2-
>pandas<3,>=1.3.0->streamlit) (1.16.0)
```

```
# Save the model and tokenizer
model.save_pretrained("gpt2_finetuned")
tokenizer.save_pretrained("gpt2_finetuned")
```

```
('gpt2_finetuned\\tokenizer_config.json',
 'gpt2_finetuned\\special_tokens_map.json',
 'gpt2_finetuned\\vocab.json',
```

```
 'gpt2_finetuned\\merges.txt',
 'gpt2_finetuned\\added_tokens.json')
```