Multi-label Classification

Installing/Importing Libararies and setting enviornment

```
%load_ext autoreload
%autoreload 2


import sys


# If in Colab, then import the drive module from google.colab
if 'google.colab' in str(get_ipython()):
  from google.colab import drive
  # Mount the Google Drive to access files stored there
  drive.mount('/content/drive')

  # Install the latest version of torchtext library quietly without showing output
  !pip install torchtext -qq
  !pip install transformers evaluate wandb datasets accelerate -U -qq ## NEW LINES ##
  basepath = '/content/drive/MyDrive/6342_NLP_COURSE'

else:
    sys.path.append('/content/drive/MyDrive/6342_NLP_COURSE/model')
```

```
 Mounted at /content/drive
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 23.7/23.7 MB 45.4 MB/s eta 0:00:00
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 823.6/823.6 kB 66.0 MB/s eta 0:00:00
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 14.1/14.1 MB 41.8 MB/s eta 0:00:00
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 731.7/731.7 MB 1.7 MB/s eta 0:00:00
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 410.6/410.6 MB 3.0 MB/s eta 0:00:00
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 121.6/121.6 MB 6.0 MB/s eta 0:00:00
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 56.5/56.5 MB 6.6 MB/s eta 0:00:00
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 124.2/124.2 MB 5.6 MB/s eta 0:00:00
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 196.0/196.0 MB 3.6 MB/s eta 0:00:00
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 166.0/166.0 MB 2.6 MB/s eta 0:00:00
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 99.1/99.1 kB 2.2 MB/s eta 0:00:00
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 21.1/21.1 MB 2.1 MB/s eta 0:00:00
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8.8/8.8 MB 25.3 MB/s eta 0:00:00
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 84.1/84.1 kB 12.9 MB/s eta 0:00:00
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      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 510.5/510.5 kB 53.6 MB/s eta 0:00:00
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 297.3/297.3 kB 38.6 MB/s eta 0:00:00
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 116.3/116.3 kB 16.6 MB/s eta 0:00:00
      ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 194.1/194.1 kB 25.7 MB/s eta 0:00:00
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```

```
# Importing PyTorch library for tensor computations and neural network modules
import torch
import torch.nn as nn

# For working with textual data vocabularies and for displaying model summaries
from torchtext.vocab import vocab

# General-purpose Python libraries for random number generation and numerical operations
import random
import numpy as np

# Utilities for efficient serialization/deserialization of Python objects and for element tallying
import joblib
from collections import Counter

# For creating lightweight attribute classes and for partial function application
from functools import partial

# For filesystem path handling, generating and displaying confusion matrices, and date-time manipulations
from pathlib import Path
from sklearn.metrics import confusion_matrix
from datetime import datetime

# For plotting and visualization
import matplotlib.pyplot as plt
import seaborn as sns
# %matplotlib inline

### NEW #########################
# imports from Huggingface ecosystem
from transformers.modeling_outputs import SequenceClassifierOutput
from transformers import PreTrainedModel, PretrainedConfig
from transformers import TrainingArguments, Trainer
from datasets import Dataset
import evaluate

# wandb library
import wandb


# Set the base folder path using the Path class for better path handling
base_folder = Path(basepath)

# Define the data folder path by appending the relative path to the base folder
# This is where the data files will be stored
data_folder = base_folder / 'datasets'
# Define the model folder path for saving trained models
# This path points to a specific folder designated for NLP models related to the IMDb dataset
model_folder = base_folder / 'model'


model_folder.mkdir(exist_ok=True, parents = True)


model_folder
```

```
PosixPath('/content/drive/MyDrive/6342_NLP_COURSE/model')
```

Load Data

```
import pandas as pd
train_path = data_folder/'train.csv'
test_path = data_folder/'test.csv'


train_df = pd.read_csv(train_path)
test_df = pd.read_csv(test_path)


# Printing shape of dataframe
train_df.shape
```

```
(7724, 13)
```

```
train_df.head(5)
```

	ID	Tweet	anger	anticipation	disgust	fear	joy	love	optimism	pessimism	sadness	surprise	trust
0	2017-21441	“Worry is a down payment on a problem you may ...	0	1	0	0	0	0	1	0	0	0	1
1	2017-31535	Whatever you decide to do make sure it makes y...	0	0	0	0	1	1	1	0	0	0	0
2	2017-21068	@Max_Kellerman it also helps that the majorit...	1	0	1	0	1	0	1	0	0	0	0
3	2017-31436	Accept the challenges so that you can literall...	0	0	0	0	1	0	1	0	0	0	0
4	2017-22195	My roommate: it's okay that we can't spell bec...	1	0	1	0	0	0	0	0	0	0	0

Next steps: Generate code with `train_df` View recommended plots

```
test_df.head()
```

	ID	Tweet	anger	anticipation	disgust	fear	joy	love	optimism	pessimism	sadness	surprise	trust
0	2018-01559	@Adnan__786__ @AsYouNotWish Dont worry Indian ...	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
1	2018-03739	Academy of Sciences, eschews the normally sobe...	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
2	2018-00385	I blew that opportunity -__- #mad	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
3	2018-03001	This time in 2 weeks I will be 30... 😳	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
4	2018-01988	#Deppression is real. Partners w/ #depressed p...	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE

Next steps: Generate code with test_df View recommended plots

```
train_df.drop('ID', axis =1)
```

	Tweet	anger	anticipation	disgust	fear	joy	love	optimism	pessimism	sadness	surprise	trust
0	“Worry is a down payment on a problem you may ...	0	1	0	0	0	0	1	0	0	0	1
1	Whatever you decide to do make sure it makes y...	0	0	0	0	1	1	1	0	0	0	0
2	@Max_Kellerman it also helps that the majorit...	1	0	1	0	1	0	1	0	0	0	0
3	Accept the challenges so that you can literall...	0	0	0	0	1	0	1	0	0	0	0
4	My roommate: it's okay that we can't spell bec...	1	0	1	0	0	0	0	0	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...
7719	@BadHombreNPS @SecretaryPerry If this didn't m...	1	0	1	0	0	0	0	0	0	0	0
7720	Excited to watch #stateoforigin tonight! Come ...	0	0	0	0	1	0	1	0	0	0	0
7721	Blah blah blah Kyrie, IT, etc. @CJC9BOSS leavi...	1	0	1	0	0	0	0	0	1	0	0
7722	#ThingsIveLearned The wise #shepherd never tru...	0	0	0	0	0	0	0	0	0	0	0
7723	I am really flattered and happy to hear those ...	0	0	0	0	1	0	1	0	0	0	0

7724 rows × 12 columns

Cleaning the data

```
import re
```

```
def clean_text(text):
    text = re.sub('@[^\s]+','', text)
    text = re.sub(r"http\S+", "", text)
    text = ' '.join(re.findall(r'\w+', text))
    text = re.sub(r'\s+[a-zA-Z]\s+', '', text)
    text = re.sub(r'\s+', ' ', text, flags=re.I)
    return text

train_df['Tweet'] = train_df['Tweet'].apply(clean_text)
test_df['Tweet'] = test_df['Tweet'].apply(clean_text)
```

```
train_df.head()
```

	ID	Tweet	anger	anticipation	disgust	fear	joy	love	optimism	pessimism	sadness	surprise	trust
0	2017-21441	Worry isdown payment onproblem you may never h...	0	1	0	0	0	0	1	0	0	0	1
1	2017-31535	Whatever you decide to do make sure it makes y...	0	0	0	0	1	1	1	0	0	0	0
2	2017-21068	it also helps that the majority of NFL coachin...	1	0	1	0	1	0	1	0	0	0	0
3	2017-31436	Accept the challenges so that you can literall...	0	0	0	0	1	0	1	0	0	0	0
4	2017-22195	My roommate itokay that we canspell because we...	1	0	1	0	0	0	0	0	0	0	0

Next steps: Generate code with train_df View recommended plots

```
train_features = train_df['Tweet'].tolist()
train_labels = train_df.iloc[:, 2:].values.tolist()
```

```
X_test = test_df['Tweet'].tolist()
y_test = test_df.iloc[:, 2:].values.tolist()
```

Data Preprocessing

```
from sklearn.model_selection import train_test_split

X_train, X_valid, y_train, y_valid = train_test_split(train_features, train_labels,test_size = 0.3,random_state =42,shuffle = True)
```

```
type(X_train)
```

```
list
```

```
type(y_valid)
```

```
list
```

Create Huggingface Dataset

```
trainset = Dataset.from_dict({
    'texts': X_train,
    'labels': y_train
})

validset = Dataset.from_dict({
    'texts': X_valid,
    'labels': y_valid
})

testset = Dataset.from_dict({
    'texts': X_test,
    'labels': y_test
})
```

```
trainset
```

```
Dataset({
    features: ['texts', 'labels'],
    num_rows: 5406
})
```

```
validset
```

```
Dataset({
    features: ['texts', 'labels'],
    num_rows: 2318
})
```

```
trainset.features
```

```
{'texts': Value(dtype='string', id=None),
 'labels': Sequence(feature=Value(dtype='int64', id=None), length=-1, id=None)}
```

```
trainset[1]
```

```
{'texts': 'Despite my sharingNeillarticle what saddens me about the Gazza case is there seems to be more fury about the sentence than the remark',
 'labels': [1, 0, 1, 1, 0, 0, 0, 0, 1, 0, 0]}
```

Create Custom Model and Model Config Class

```
class CustomConfig(PretrainedConfig):
  def __init__(self, vocab_size=0, embedding_dim=0, hidden_dim1=0, hidden_dim2=0, num_labels=11, **kwargs):
      super().__init__()
      self.vocab_size = vocab_size
      self.embedding_dim = embedding_dim
      self.hidden_dim1 = hidden_dim1
      self.hidden_dim2 = hidden_dim2
      self.num_labels = num_labels


class CustomMLP(PreTrainedModel):
    config_class = CustomConfig

    def __init__(self, config):
        super().__init__(config)

        self.embedding_bag = nn.EmbeddingBag(config.vocab_size, config.embedding_dim)
        self.layers = nn.Sequential(
            nn.Linear(config.embedding_dim, config.hidden_dim1),
            nn.BatchNorm1d(num_features=config.hidden_dim1),
            nn.ReLU(),
            nn.Dropout(p=0.5),
            nn.Linear(config.hidden_dim1, config.hidden_dim2),
            nn.BatchNorm1d(num_features=config.hidden_dim2),
            nn.ReLU(),
            nn.Dropout(p=0.5),
            nn.Linear(config.hidden_dim2, config.num_labels)
        )

    def forward(self, input_ids, offsets, labels=None):
        embed_out = self.embedding_bag(input_ids, offsets)
        logits = self.layers(embed_out)

        loss = None
        if labels is not None:
            loss_fct = nn.BCEWithLogitsLoss()
            loss = loss_fct(logits, labels)

        return SequenceClassifierOutput(
            loss=loss,
            logits=logits
        )
```

Train Model

Collate Function

```
def get_vocab(dataset, min_freq=1):
    """
    Generate a vocabulary from a dataset.

    Args:
        dataset (Dataset): A Hugging Face Dataset object. The dataset should
                           have a key 'texts' that contains the text data.
        min_freq (int): The minimum frequency for a token to be included in
                        the vocabulary.

    Returns:
        torchtext.vocab.Vocab: Vocabulary object containing tokens from the
                               dataset that meet or exceed the specified
                               minimum frequency. It also includes a special
                               '<unk>' token for unknown words.
    """
    # Initialize a counter object to hold token frequencies
    counter = Counter()

    # Update the counter with tokens from each text in the dataset
    # Iterating through texts in the dataset
    for text in dataset['texts']:  ###### Change from previous function ####
        counter.update(str(text).split())

    # Create a vocabulary using the counter object
    # Tokens that appear fewer times than `min_freq` are excluded
    my_vocab = vocab(counter, min_freq=min_freq)

    # Insert a '<unk>' token at index 0 to represent unknown words
    my_vocab.insert_token('<unk>', 0)

    # Set the default index to 0
    # This ensures that any unknown word will be mapped to '<unk>'
    my_vocab.set_default_index(0)

    return my_vocab


# Creating a function that will be used to get the indices of words from vocab
def tokenizer(text, vocab):
    """Converts text to a list of indices using a vocabulary dictionary"""
    return [vocab[token] for token in str(text).split()]


def collate_batch(batch, my_vocab):
    """
    Prepares a batch of data by transforming texts into indices based on a vocabulary and
    converting labels into a tensor.

    Args:
        batch (list of dict): A batch of data where each element is a dictionary with keys
                              'labels' and 'texts'. 'labels' are the sentiment labels, and
                              'texts' are the corresponding texts.
        my_vocab (torchtext.vocab.Vocab): A vocabulary object that maps tokens to indices.

    Returns:
        dict: A dictionary with three keys:
              - 'input_ids': a tensor containing concatenated indices of the texts.
              - 'offsets': a tensor representing the starting index of each text in 'input_ids'.
              - 'labels': a tensor of the labels for each text in the batch.

    The function transforms each text into a list of indices based on the provided vocabulary.
    It also converts the labels into a tensor. The 'offsets' are computed to keep track of the
    start of each text within the 'input_ids' tensor, which is a flattened representation of all text indices.
    """

    # Get labels and texts from batch dict samples
    labels = [sample['labels'] for sample in batch]
    texts = [sample['texts'] for sample in batch]

    # Convert the list of labels into a tensor of dtype float32
    labels = torch.tensor(labels, dtype=torch.float32)

    # Convert the list of texts into a list of lists; each inner list contains the vocabulary indices for a text
    list_of_list_of_indices = [tokenizer(text, my_vocab) for text in texts]

    # Concatenate all text indices into a single tensor
    input_ids = torch.cat([torch.tensor(i, dtype=torch.int64) for i in list_of_list_of_indices])

    # Compute the offsets for each text in the concatenated tensor
    offsets = [0] + [len(i) for i in list_of_list_of_indices]
    offsets = torch.tensor(offsets[:-1]).cumsum(dim=0)

    return {
        'input_ids': input_ids,
        'offsets': offsets,
        'labels': labels
    }


tweet_vocab = get_vocab(trainset, min_freq=2)
collate_fn = partial(collate_batch, my_vocab=tweet_vocab)
```

Instantiate Model

```
my_config = CustomConfig(vocab_size=len(tweet_vocab),
                         embedding_dim=300,
                         hidden_dim1=200,
                         hidden_dim2=100,
                         num_labels=11)


my_config
```


```
     CustomConfig {
       "embedding_dim": 300,
       "hidden_dim1": 200,
       "hidden_dim2": 100,
       "id2label": {
         "0": "LABEL_0",
         "1": "LABEL_1",
         "2": "LABEL_2",
         "3": "LABEL_3",
```

```
        "4": "LABEL_4",
        "5": "LABEL_5",
        "6": "LABEL_6",
        "7": "LABEL_7",
        "8": "LABEL_8",
        "9": "LABEL_9",
        "10": "LABEL_10"
      },
      "label2id": {
        "LABEL_0": 0,
        "LABEL_1": 1,
        "LABEL_10": 10,
        "LABEL_2": 2,
        "LABEL_3": 3,
        "LABEL_4": 4,
        "LABEL_5": 5,
        "LABEL_6": 6,
        "LABEL_7": 7,
        "LABEL_8": 8,
        "LABEL_9": 9
      },
      "transformers_version": "4.39.3",
      "vocab_size": 5907
    }
```


```
my_config.id2label = {0: 'anger', 1: 'anticipation', 2: 'disgust', 3:'fear', 4: 'joy', 5: 'love', 6:'optimism', 7:'pessimism', 8:'sadness', 9:'surprise', 10:'trust'}


# Generating id_to_label by reversing the key-value pairs in label_to_id
my_config.label2id = {v: k for k, v in my_config.id2label .items()}


my_config
```


```
    CustomConfig {
      "embedding_dim": 300,
      "hidden_dim1": 200,
      "hidden_dim2": 100,
      "id2label": {
        "0": "anger",
        "1": "anticipation",
        "2": "disgust",
        "3": "fear",
        "4": "joy",
        "5": "love",
        "6": "optimism",
        "7": "pessimism",
        "8": "sadness",
        "9": "surprise",
        "10": "trust"
      },
      "label2id": {
        "anger": 0,
        "anticipation": 1,
        "disgust": 2,
        "fear": 3,
        "joy": 4,
        "love": 5,
        "optimism": 6,
        "pessimism": 7,
        "sadness": 8,
        "surprise": 9,
        "trust": 10
      },
      "transformers_version": "4.39.3",
      "vocab_size": 5907
    }
```


```
model = CustomMLP(config=my_config)


model
```

```
    CustomMLP(
      (embedding_bag): EmbeddingBag(5907, 300, mode='mean')
      (layers): Sequential(
        (0): Linear(in_features=300, out_features=200, bias=True)
        (1): BatchNorm1d(200, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
        (2): ReLU()
        (3): Dropout(p=0.5, inplace=False)
        (4): Linear(in_features=200, out_features=100, bias=True)
        (5): BatchNorm1d(100, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
        (6): ReLU()
        (7): Dropout(p=0.5, inplace=False)
        (8): Linear(in_features=100, out_features=11, bias=True)
      )
    )
```

compute_metrics function

```
def compute_metrics(eval_pred):
    combined_metrics = evaluate.combine([evaluate.load("accuracy"),
                                         evaluate.load("f1", average="macro")])

    logits, labels = eval_pred
    predictions = (logits>0.5).astype(int).reshape(-1)
    evaluations = combined_metrics.compute(
        predictions=predictions, references = labels.astype(int).reshape(-1),
    )
    return evaluations
```

Training Arguments

```
# Configure training parameters
training_args = TrainingArguments(

    # Training-specific configurations
    num_train_epochs=30,
    per_device_train_batch_size=128, # Number of samples per training batch
    per_device_eval_batch_size=128, # Number of samples per validation batch
    weight_decay=0.5, # weight decay (L2 regularization)
    learning_rate=0.0005, # learning arte
    optim='adamw_torch', # optimizer
    remove_unused_columns=False, # flag to retain unused columns

    # Checkpoint saving and model evaluation settings
    output_dir=str(model_folder),  # Directory to save model checkpoints
    evaluation_strategy='steps',  # Evaluate model at specified step intervals
    eval_steps=100,  # Perform evaluation every 50 training steps
    save_strategy="steps",  # Save model checkpoint at specified step intervals
    save_steps=100,  # Save a model checkpoint every 50 training steps
    load_best_model_at_end=True,  # Reload the best model at the end of training
    save_total_limit=2,  # Retain only the best and the most recent model checkpoints
    # Use 'accuracy' as the metric to determine the best model
    metric_for_best_model="accuracy",
    greater_is_better=True,  # A model is 'better' if its accuracy is higher


    # Experiment logging configurations
    logging_strategy='steps',
    logging_steps=100,
    report_to='wandb',  # Log metrics and results to Weights & Biases platform
    run_name='tweet_hf_trainer',  # Experiment name for Weights & Biases
)
```

Initialize Trainer

```
trainer = Trainer(
    model=model,
    args=training_args,
    train_dataset=trainset,
    eval_dataset = validset,
    data_collator=collate_fn,
    compute_metrics=compute_metrics,
)
```

```
    /usr/local/lib/python3.10/dist-packages/accelerate/accelerator.py:436: FutureWarning: Passing the following arguments to `Accelerator` is deprecated and will be removed in version 1.0 of Accelerate: dict_keys(['dispatch_batches', 'split_batches',
    dataloader_config = DataLoaderConfiguration(dispatch_batches=None, split_batches=False, even_batches=True, use_seedable_sampler=True)
      warnings.warn(
```

Setup WandB

```
!wandb login 613ff39916b4483921c44a083197386faebfd85b
```

```
    wandb: Appending key for api.wandb.ai to your netrc file: /root/.netrc
```

```
# specify the project name where the experiment will be logged
%env WANDB_PROJECT = nlp_course_spring_2024-sentiment-analysis-hf-trainer
```

```
env: WANDB_PROJECT=nlp_course_spring_2024-sentiment-analysis-hf-trainer
```

Training and Validation

```
trainer.train()
```

```
wandb: Currently logged in as: nxe210013 (nagalakshmi). Use `wandb login --relogin` to force relogin
Tracking run with wandb version 0.16.6
Run data is saved locally in /content/wandb/run-20240406_014201-95zp9b2z
Syncing run tweet_hf_trainer to Weights & Biases (docs)
View project at https://wandb.ai/nagalakshmi/nlp_course_spring_2024-sentiment-analysis-hf-trainer
View run at https://wandb.ai/nagalakshmi/nlp_course_spring_2024-sentiment-analysis-hf-trainer/runs/95zp9b2z
```

[1290/1290 01:47, Epoch 30/30]

Step	Training Loss	Validation Loss	Accuracy	F1
100	0.583800	0.525626	0.786571	0.004391
200	0.480100	0.480110	0.787277	0.011301
300	0.451300	0.461355	0.791670	0.067088
400	0.425500	0.442624	0.802416	0.193145
500	0.402500	0.432383	0.808103	0.261880
600	0.383500	0.424141	0.811907	0.309729
700	0.367100	0.420194	0.815280	0.361962
800	0.355300	0.416490	0.817633	0.374496
900	0.344000	0.416111	0.819123	0.394909
1000	0.339300	0.414010	0.820104	0.402812
1100	0.333100	0.413162	0.820182	0.405241
1200	0.327900	0.413253	0.820535	0.410157

```
Downloading builder script: 100%                    4.20k/4.20k [00:00<00:00, 175kB/s]
Downloading builder script: 100%                    6.77k/6.77k [00:00<00:00, 409kB/s]
TrainOutput(global_step=1290, training_loss=0.39445241292317706, metrics={'train_runtime': 122.8496, 'train_samples_per_second': 1320.15, 'train_steps_per_second': 10.501, 'total_flos': 24794210594160.0, 'train_loss': 0.39445241292317706,
'epoch': 30.0})
```

```
trainer.evaluate()
```

[19/19 00:04]

```
{'eval_loss': 0.41325318813323975,
 'eval_accuracy': 0.82053494391717,
 'eval_f1': 0.4101572570250064,
 'eval_runtime': 6.7231,
 'eval_samples_per_second': 344.779,
 'eval_steps_per_second': 2.826,
 'epoch': 30.0}
```

```
valid_output = trainer.predict(validset)
```

```
valid_output._fields
```

```
('predictions', 'label_ids', 'metrics')
```

```
valid_output.predictions
```

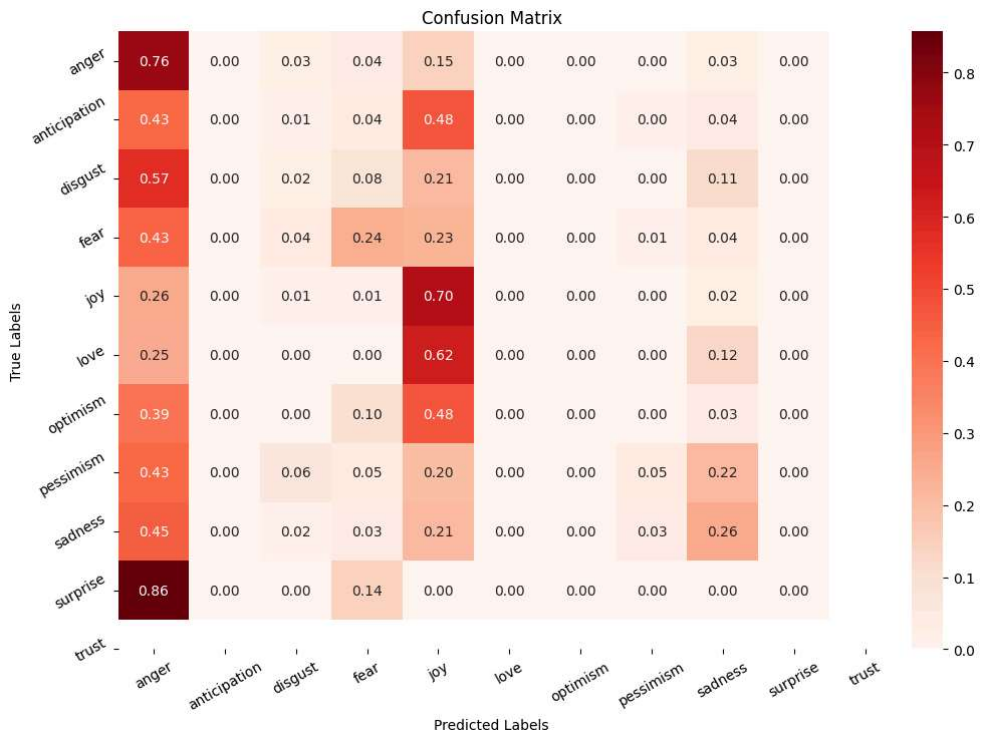
```
array([[-0.84122586, -1.0111204 , -0.80053675, ..., -1.1059527 ,
        -1.8388253 , -1.8574413 ],
       [-3.6426454 , -1.2452769 , -3.6838512 , ..., -2.7510722 ,
        -2.506678  , -1.8427474 ],
       [-0.82907677, -1.3069501 , -0.8159121 , ..., -1.2128291 ,
        -2.4301863 , -2.2177966 ],
       ...,
       [-1.7551295 , -1.1189958 , -2.037755  , ..., -2.2096174 ,
        -2.361281  , -2.1747398 ],
       [ 0.26107258, -2.1355777 ,  0.37318346, ...,  0.21714598,
        -2.3908994 , -3.1313028 ],
       [-2.2359893 , -0.77506846, -2.3692641 , ..., -1.6510063 ,
        -2.3123648 , -1.8432537 ]], dtype=float32)
```

```
valid_preds = (valid_output.predictions>0).astype(int)
valid_labels = np.array(valid_output.label_ids).astype(int)
```

```
 # Flatten the arrays to 1D for calculating confusion matrix
valid_labels_1 = valid_labels.argmax(axis=1)  # Reshape to (2318,) for comparison
valid_preds_1 = valid_preds.argmax(axis=1)  # Reshape to (2318,) for comparison
```

```
def plot_confusion_matrix(valid_labels, valid_preds, class_labels):
    """
    Plots a confusion matrix.

    Args:
        valid_labels (array-like): True labels of the validation data.
        valid_preds (array-like): Predicted labels of the validation data.
        class_labels (list): List of class names for the labels.
    """
    # Compute the confusion matrix
    cm = confusion_matrix(valid_labels_1, valid_preds_1, normalize='true')

    # Plot the confusion matrix using Seaborn
    # 'ax' represents the axes of the plot. Seaborn's heatmap is used for visualizing the confusion matrix
    # 'annot=True' displays the values in the cells, and 'fmt' specifies the string formatting for these values
    plt.figure(figsize=(12, 8))
    ax = sns.heatmap(cm, annot=True, fmt=".2f", cmap="Reds", xticklabels=class_labels, yticklabels=class_labels)

    # Rotating the tick labels for better readability
    ax.set_xticklabels(ax.get_xticklabels(), rotation=30)
    ax.set_yticklabels(ax.get_yticklabels(), rotation=30)

    # Adding labels and title to the plot
    plt.xlabel('Predicted Labels')
    plt.ylabel('True Labels')
    plt.title('Confusion Matrix')

    # Display the plot
    plt.show()
```

```
plot_confusion_matrix(valid_labels, valid_preds, class_labels=list(my_config.id2label.values()))
```

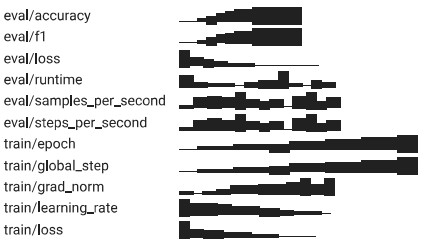


```
# After training, let us check the best checkpoint
# We need this for Inference
best_model_checkpoint_step = trainer.state.best_model_checkpoint.split('-')[-1]
print(f"The best model was saved at step {best_model_checkpoint_step}.")
```

```
The best model was saved at step 1200.
```

```
wandb.finish()
```

Run history:



Run summary:

eval/accuracy	0.82053
eval/f1	0.41016
eval/loss	0.41325
eval/runtime	6.7231
eval/samples_per_second	344.779
eval/steps_per_second	2.826
total_flos	24794210594160.0
train/epoch	30.0
train/global_step	1290
train/grad_norm	0.37696
train/learning_rate	3e-05
train/loss	0.3279
train_loss	0.39445
train_runtime	122.8496
train_samples_per_second	1320.15
train_steps_per_second	10.501

View run tweet_hf_trainer at: https://wandb.ai/nagalakshmi/nlp_course_spring_2024-sentiment-analysis-hf-trainer/runs/95zp9b2z
View project at: https://wandb.ai/nagalakshmi/nlp_course_spring_2024-sentiment-analysis-hf-trainer
Synced 5 W&B file(s), 0 media file(s), 0 artifact file(s) and 0 other file(s)
Find logs at: `./wandb/run-20240406_014201-95zp9b2z/logs`

Load Model from checkpoint

```
# Define the path to the best model checkpoint
# 'model_checkpoint' variable is constructed using the model folder path and the checkpoint step
# This step is identified as having the best model performance during training
model_checkpoint = model_folder/f'checkpoint-{best_model_checkpoint_step}'
```

```
# Instantiate the CustomMLP model with predefined configurations
# 'my_config' is an instance of the CustomConfig class, containing specific model settings like
# vocabulary size, embedding dimensions, etc.
model = CustomMLP(my_config)
```

```
model
```

```
CustomMLP(
  (embedding_bag): EmbeddingBag(5907, 300, mode='mean')
  (layers): Sequential(
    (0): Linear(in_features=300, out_features=200, bias=True)
    (1): BatchNorm1d(200, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (2): ReLU()
    (3): Dropout(p=0.5, inplace=False)
    (4): Linear(in_features=200, out_features=100, bias=True)
    (5): BatchNorm1d(100, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
    (6): ReLU()
    (7): Dropout(p=0.5, inplace=False)
    (8): Linear(in_features=100, out_features=11, bias=True)
  )
)
```

Inference

```
sample_X =  X_test
```

```
sample_X
```

```
['I LOVE conquering my fears and gaining strength and grace aerialsilks aerialarts',
 'Provide gainful employment to men and women so that they donend up joining vigilante outfits or terror squads',
 'All this great news it must be hurting some folk to be happy about this',
 'yesterday was amazing thankmtv cant wait for the interview the irony is 7 10 was also supposed to be my 7 yr anv plus6yr',
 'Creator Jack Dorsey The definition of TWitter wasshort burst of inconsequential information and chirps from birds',
 'This kind of abuse is UNBELIEVABLE and an absolute disgrace It makes me sad to see this dismayed',
 'Going to BigApple tomorrow Loving NJTransit commute Wearing khakis whiteshirt maybeblue brownshoes macys joy jealousyetusa',
 'Yeam going to go back whenget off work because thatridiculousm super pissed',
 'no offense to those who loveculturecan love it all you want bbs butjust personally want to get to know my own country s',
 'I canafford to hate peopledonhave that kind of time BobRoss TuesdayMotivation sober xa',
 'Difficult roads often lead to Beautiful destinations keepgoing keeppushing startsomewhere key start',
 'Therenothing more depressing to me than thinking about how many timeswill shave my legs in my lifetime showerthoughts writer',
 'he will haunt RM in the CL',
 'Most pathetic after service experience for Baleno servicing horrible Feelhave mademistake buying',
 'Strapless wedding dresses look awful on most people nJulianne Hough looked great',
 'Lady singing really loudly with headphones on making everyone giggle train journey smile',
 'He is very playful and can hardly stay in one spot',
 'Neverdull moment with you two',
 'Carlsbad Rouladen is one delicious hearty home style dish Stop by and let us know how you like it getdtl ldnont chaucers marienbad',
 'Everydaym stretching my elastic bands ready for practicing magic entertaining',
 'Wow there is at least 1 person who still watches CNN havenice day Clearly ur still pissedlost',
 'Really sad to hear about terror attack on pilgrims Condolences with victims family NotInMyName',
 'oh craplost 100 on poker games yesterday',
 'panas sia omgcannot',
 'Itbeen just overdecade since NickSaban quit as the head coach Good coaches donquit suckynflcoach',
 'That maybe she just lost her job in the recession and is trying outnew career path',
 'Honey you hurt me the way the sun touches my skin today burning',
 'This is what happens when blinded by raging hatred',
 'Why so sensitive Did someone put you in your place awe shutthefuckup',
 'yo where my sullen state stans',
 'The optimist sees opportunity in every barbecue the pessimist sees barbecue in every opportunity',
 'funny quote joke Hilarious joke quote of the day For more funny jokes pics and great humor quote',
 'Happy to help If there is anything we can do for you please donhesitate to ask Thanks James K',
 'gen math classnms what is the value ofin this eqn nmeis 10 tial dread and suffering isprison without escape only death',
 'Ugh Not those vile men again',
 'The excitementget whensee tipping point is on tv is rather sad',
 'There really isna more depressing feeling than coming home fromholiday',
 'Greetings Depression is anger inward Secondary feeling Its hurt needs healing Tears taken from inward to outward Eph4 19',
 'Is thatfashion to weartight pants socan seecamel toy Lol fashion girl girl pants fact',
 'Be weird Be happy Be grateful Be positive Be open mindedlove bliss success',
 'Every timefart my dog jumps in fear hahahaha yass',
 'Fuck Let us go for splendid isolation',
 'trembled the earth quaked and it becamevery great panic 2 2',
 'Looking forLyft ride 50 freeLyft Code CLEO MK mirthful LOVETOSAVEMONEY',
 'You still have hope Of being lonely apart not havingbaby dismal',
 'Going to finally start getting ready for my move',
 'Ugh hate Manarino got this game',
 'I let my anger get the best of me yesterday ampfeed in',
 'Whats more sad are the adults who continue to do it afterwards',
 'I ve lost many things but earned many more grateful',
 'you ll have to forgive mehavepersonal grudge against cnn that dates back as far as the first gulf war',
 'Game of Thrones was like The Revenant on high zombiebear GameOfThrones GOT whitewalkers terrifying TheRevenant',
 'How did you attend men',
 'My hittasshake the spot ifpoint my finger',
 'dull start',
 'This morning watchedhummingbird two cardinalsbunch of fincheslarge bunny andbaby bunny all feasting in the backyard happy',
 'Accidentally looked directly into the solar eclipse Didndie Didnget superpowers either disappointing SolarEclispe2017',
 ...]
```

```
device = 'cpu'
# Convert the list of texts into a list of lists; each inner list contains the vocabulary indices for a text
list_of_list_of_indices = [tokenizer(text, tweet_vocab) for text in sample_X]

# Compute the offsets for each text in the concatenated tensor
offsets = [0] + [len(i) for i in list_of_list_of_indices]
offsets = torch.tensor(offsets[:-1]).cumsum(dim=0)

# Concatenate all text indices into a single tensor
indices = torch.cat([torch.tensor(i, dtype=torch.int64) for i in list_of_list_of_indices])
```

```
indices
```

```
tensor([   0, 1274, 2213,  ..., 5313,   38, 1807])
```

```
offsets
```

```
tensor([    0,    14,    33,  ..., 44321, 44328, 44342])
```

```
# move model to appropriate device
model.to(device)

# put model in evaluation mode
model.eval()

# get outputs (logits) from model
outputs = model(indices, offsets)
outputs
```

```
SequenceClassifierOutput(loss=None, logits=tensor([[ 0.0485, -0.0654, -0.0754,  ..., -0.0701, -0.0968, -0.0627],
        [ 0.0769, -0.0511, -0.0910,  ..., -0.0948, -0.1199, -0.0319],
        [ 0.0914, -0.0546, -0.1356,  ..., -0.1200, -0.1075, -0.0447],
        ...,
        [ 0.0740, -0.0284, -0.1057,  ..., -0.1288, -0.1040, -0.0377],
        [ 0.0720, -0.0918, -0.0869,  ..., -0.0642, -0.0519, -0.0947],
        [ 0.0722, -0.0870, -0.1075,  ..., -0.0826, -0.1007, -0.0638]],
       grad_fn=<AddmmBackward0>), hidden_states=None, attentions=None)
```

```
outputs.logits
```

```
tensor([[ 0.0485, -0.0654, -0.0754,  ..., -0.0701, -0.0968, -0.0627],
        [ 0.0769, -0.0511, -0.0910,  ..., -0.0948, -0.1199, -0.0319],
        [ 0.0914, -0.0546, -0.1356,  ..., -0.1200, -0.1075, -0.0447],
        ...,
        [ 0.0740, -0.0284, -0.1057,  ..., -0.1288, -0.1040, -0.0377],
        [ 0.0720, -0.0918, -0.0869,  ..., -0.0642, -0.0519, -0.0947],
        [ 0.0722, -0.0870, -0.1075,  ..., -0.0826, -0.1007, -0.0638]],
       grad_fn=<AddmmBackward0>)
```

```
# get predicted labels
probabilities = torch.sigmoid(outputs.logits)
threshold = 0.5
predicted_labels = (probabilities >= threshold).int()
no_labels = predicted_labels.sum(1) == 0
predicted_labels[no_labels, torch.max(probabilities[no_labels], dim=1).indices] = 1
```

```
print(predicted_labels)
```

```
tensor([[1, 0, 0,  ..., 0, 0, 0],
        [1, 0, 0,  ..., 0, 0, 0],
        [1, 0, 0,  ..., 0, 0, 0],
        ...,
        [1, 0, 0,  ..., 0, 0, 0],
        [1, 0, 0,  ..., 0, 0, 0],
        [1, 0, 0,  ..., 0, 0, 0]], dtype=torch.int32)
```

```
binary_predictions = predicted_labels
predicted_label_names = []
for prediction in binary_predictions:
    labels = [model.config.id2label[i] for i, label in enumerate(prediction) if label == 1]
    predicted_label_names.append(labels)
```

```
tweets_data = pd.DataFrame(sample_X, columns=['tweets'])
tweets_data['predicted_label'] = predicted_label_names
```

```
tweets_data
```

	tweets	predicted_label
0	Dont worry Indian army is on its ways to dispa...	[anger, joy, love, pessimism]
1	Academy of Sciences eschews the normally sober...	[anger, love, optimism, pessimism]
2	I blew that opportunity __ mad	[anger, love, optimism, pessimism]
3	This time in 2 weekswill be 30	[anger, joy, love, optimism, pessimism]
4	Deppression is real Partnersdepressed people t...	[anger, love, optimism, pessimism]
...	...	...
3254	shaft abrasions from panties merely shifted to...	[anger, love, optimism, pessimism]
3255	heard of Remothered Indie horror game Writing ...	[anger, love, pessimism]
3256	All this fake outrageall need to stop	[anger, love, pessimism]
3257	Would be ever so grateful if you could record ...	[anger, love, optimism, pessimism]
3258	Ithe wholesome drunk that sends people memes a...	[anger, love, optimism, pessimism]

3259 rows × 2 columns

Next steps: Generate code with `tweets_data` View recommended plots

```
test_df
```

	ID	Tweet	anger	anticipation	disgust	fear	joy	love	optimism	pessimism	sadness	surprise	trust
0	2018-01559	Dont worry Indian army is on its ways to dispa...	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
1	2018-03739	Academy of Sciences eschews the normally sober...	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
2	2018-00385	I blew that opportunity __ mad	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
3	2018-03001	This time in 2 weekswill be 30	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
4	2018-01988	Deppression is real Partnersdepressed people t...	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
...	...	...	...	...	...	...	...	...	...	...	...	...	...
3254	2018-03848	shaft abrasions from panties merely shifted to...	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
3255	2018-00416	heard of Remothered Indie horror game Writing ...	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
3256	2018-03717	All this fake outrageall need to stop	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
3257	2018-03504	Would be ever so grateful if you could record ...	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
3258	2018-00115	Ithe wholesome drunk that sends people memes a...	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE

3259 rows × 13 columns

Next steps: Generate code with `test_df` View recommended plots

```
my_config.id2label.values()
```

```
dict_values(['anger', 'anticipation', 'disgust', 'fear', 'joy', 'love', 'optimism', 'pessimism', 'sadness', 'surprise', 'trust'])
```

```
print(predicted_labels.shape)
```

```
torch.Size([3259, 11])
```

```
import pandas as pd
data_sub = pd.DataFrame(predicted_labels.numpy(), columns=my_config.id2label.values())
data_sub.insert(0, 'ID', test_df['ID'])
data_sub
```

	ID	anger	anticipation	disgust	fear	joy	love	optimism	pessimism	sadness	surprise	trust
0	2018-01559	1	0	0	0	1	1	0	1	0	0	0
1	2018-03739	1	0	0	0	0	1	1	1	0	0	0
2	2018-00385	1	0	0	0	0	1	1	1	0	0	0
3	2018-03001	1	0	0	0	1	1	1	1	0	0	0
4	2018-01988	1	0	0	0	0	1	1	1	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...
3254	2018-03848	1	0	0	0	0	1	1	1	0	0	0
3255	2018-00416	1	0	0	0	0	1	0	1	0	0	0
3256	2018-03717	1	0	0	0	0	1	0	1	0	0	0
3257	2018-03504	1	0	0	0	0	1	1	1	0	0	0
3258	2018-00115	1	0	0	0	0	1	1	1	0	0	0

3259 rows × 12 columns

Next steps: Generate code with `data_sub` View recommended plots

```
data_sub.to_csv(data_folder/'submission_Final.csv', index=False)
```