Model Performances without Preprocessing

[Main Notebook Link]

Installs

```
#Installs
!pip install pydot --quiet
!pip install gensim==3.8.3 --quiet
!pip install tensorflow-datasets --quiet
!pip install -U tensorflow-text==2.8.2 --quiet
!pip install transformers --quiet
!pip install datasets
!pip3 install emoji==0.6.0
```

```
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 23.4/23.4 MB 63.1 MB/s eta 0:00:00
  Preparing metadata (setup.py) ... done
  Building wheel for gensim (setup.py) ... done
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 4.9/4.9 MB 39.9 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 498.1/498.1 MB 3.0 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 42.6/42.6 kB 4.5 MB/s eta 0:00:00
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     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 462.3/462.3 kB 48.2 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.4/1.4 MB 78.8 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 4.9/4.9 MB 99.1 MB/s eta 0:00:00
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Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
Collecting datasets
  Downloading datasets-2.11.0-py3-none-any.whl (468 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 468.7/468.7 kB 9.0 MB/s eta 0:00:00
Requirement already satisfied: huggingface-hub<1.0.0,>=0.11.0 in /usr/local/lib/python3.9/dist-packages (from datasets) (0.1
Requirement already satisfied: pyarrow>=8.0.0 in /usr/local/lib/python3.9/dist-packages (from datasets) (9.0.0)
Collecting multiprocess
  Downloading multiprocess-0.70.14-py39-none-any.whl (132 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 132.9/132.9 kB 19.4 MB/s eta 0:00:00
Requirement already satisfied: packaging in /usr/local/lib/python3.9/dist-packages (from datasets) (23.0)
Collecting aiohttp
  Downloading aiohttp-3.8.4-cp39-cp39-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (1.0 MB)
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Requirement already satisfied: numpy>=1.17 in /usr/local/lib/python3.9/dist-packages (from datasets) (1.22.4)
Requirement already satisfied: fsspec[http]>=2021.11.1 in /usr/local/lib/python3.9/dist-packages (from datasets) (2023.4.0)
Requirement already satisfied: pyyaml>=5.1 in /usr/local/lib/python3.9/dist-packages (from datasets) (6.0)
Collecting responses<0.19
  Downloading responses-0.18.0-py3-none-any.whl (38 kB)
Requirement already satisfied: tqdm>=4.62.1 in /usr/local/lib/python3.9/dist-packages (from datasets) (4.65.0)
Requirement already satisfied: pandas in /usr/local/lib/python3.9/dist-packages (from datasets) (1.5.3)
Requirement already satisfied: requests>=2.19.0 in /usr/local/lib/python3.9/dist-packages (from datasets) (2.27.1)
Collecting xxhash
  Downloading xxhash-3.2.0-cp39-cp39-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (212 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 212.2/212.2 kB 26.6 MB/s eta 0:00:00
Collecting dill<0.3.7,>=0.3.0
  Downloading dill-0.3.6-py3-none-any.whl (110 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 110.5/110.5 kB 15.5 MB/s eta 0:00:00
Collecting async-timeout<5.0,>=4.0.0a3
  Downloading async_timeout-4.0.2-py3-none-any.whl (5.8 kB)
Collecting frozenlist>=1.1.1
  Downloading frozenlist-1.3.3-cp39-cp39-manylinux_2_5_x86_64.manylinux1_x86_64.manylinux_2_17_x86_64.manylinux2014_x86_64.wh
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 158.8/158.8 kB 20.4 MB/s eta 0:00:00
Collecting yarl<2.0,>=1.0
  Downloading yarl-1.8.2-cp39-cp39-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (264 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 264.6/264.6 kB 28.1 MB/s eta 0:00:00
Requirement already satisfied: attrs>=17.3.0 in /usr/local/lib/python3.9/dist-packages (from aiohttp->datasets) (22.2.0)
Collecting multidict<7.0,>=4.5
  Downloading multidict-6.0.4-cp39-cp39-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (114 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 114.2/114.2 kB 4.5 MB/s eta 0:00:00
Requirement already satisfied: charset-normalizer<4.0,>=2.0 in /usr/local/lib/python3.9/dist-packages (from aiohttp->dataset
Collecting aiosignal>=1.1.2
  Downloading aiosignal-1.3.1-py3-none-any.whl (7.6 kB)
Requirement already satisfied: typing-extensions>=3.7.4.3 in /usr/local/lib/python3.9/dist-packages (from huggingface-hub<1.
Requirement already satisfied: filelock in /usr/local/lib/python3.9/dist-packages (from huggingface-hub<1.0.0,>=0.11.0->datas
```

Imports

```
import numpy as np
import tensorflow as tf
from tensorflow import keras

from tensorflow.keras.layers import Embedding, Input, Dense, Lambda
from tensorflow.keras.models import Model
import tensorflow.keras.backend as K
import tensorflow_datasets as tfds
import tensorflow_text as tf_text

from transformers import BertTokenizer, TFBertModel, AutoModel, AutoTokenizer, TFAutoModelForSequenceClassification, TFAutoModel,

import nltk
from nltk.corpus import reuters
from nltk.data import find
from nltk.tokenize import RegexpTokenizer
from nltk.tokenize import wordpunct_tokenize
from nltk.tokenize import TweetTokenizer

import sklearn as sk
import os

import matplotlib.pyplot as plt

import re

#This continues to work with gensim 3.8.3.  It doesn't yet work with 4.x.
#Make sure your pip install command specifies gensim==3.8.3
import gensim


from sklearn.metrics import classification_report
import seaborn as sns
```

DataSet Import

```
import datasets
dataset = datasets.load_dataset('ucberkeley-dlab/measuring-hate-speech', 'binary')
df = dataset['train'].to_pandas()

##Citation
##@article{kennedy2020constructing,
  #title={Constructing interval variables via faceted Rasch measurement and multitask deep learning: a hate speech application},
  #author={Kennedy, Chris J and Bacon, Geoff and Sahn, Alexander and von Vacano, Claudia},
  #journal={arXiv preprint arXiv:2009.10277},
  #year={2020}
#}
```

```
Downloading readme: 100%                                    4.03k/4.03k [00:00<00:00, 250kB/s]
Downloading and preparing dataset parquet/ucberkeley-dlab--measuring-hate-speech to /root/.cache/huggingface/datasets/ucberke
Downloading data files: 100%                                1/1 [00:01<00:00, 1.49s/it]
Downloading data: 100%                                      14.1M/14.1M [00:00<00:00, 28.1MB/s]
Extracting data files: 100%                                 1/1 [00:00<00:00, 25.07it/s]
Dataset parquet downloaded and prepared to /root/.cache/huggingface/datasets/ucberkeley-dlab___parquet/ucberkeley-dlab--measu
100%                                        1/1 [00:00<00:00, 15.64it/s]
```

```
# list of all the columns in the dataframe
for i in df.columns:
  print(i)
```

```
comment_id
annotator_id
platform
sentiment
respect
insult
```

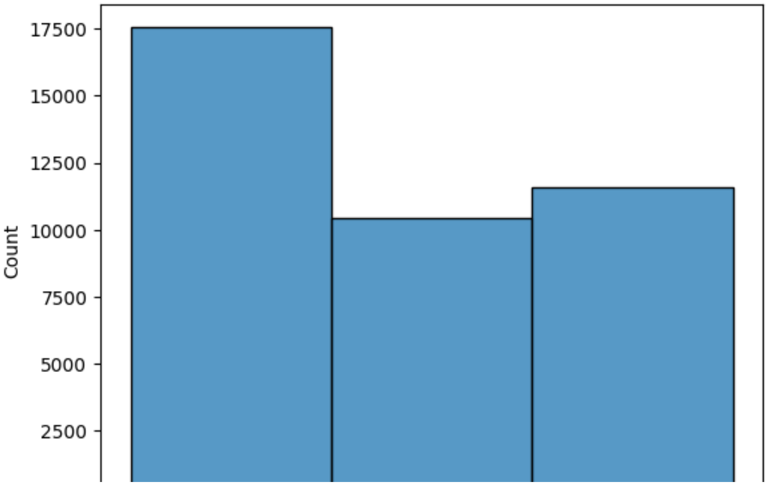
```
    humiliate
    status
    dehumanize
    violence
    genocide
    attack_defend
    hatespeech
    hate_speech_score
    text
    infitms
    outfitms
    annotator_severity
    std_err
    annotator_infitms
    annotator_outfitms
    hypothesis
    target_race_asian
    target_race_black
    target_race_latinx
    target_race_middle_eastern
    target_race_native_american
    target_race_pacific_islander
    target_race_white
    target_race_other
    target_race
    target_religion_atheist
    target_religion_buddhist
    target_religion_christian
    target_religion_hindu
    target_religion_jewish
    target_religion_mormon
    target_religion_muslim
    target_religion_other
    target_religion
    target_origin_immigrant
    target_origin_migrant_worker
    target_origin_specific_country
    target_origin_undocumented
    target_origin_other
    target_origin
    target_gender_men
    target_gender_non_binary
    target_gender_transgender_men
    target_gender_transgender_unspecified
    target_gender_transgender_women
    target_gender_women
    target_gender_other
    target_gender
    target_sexuality_bisexual
    target_sexuality_gay
    target_sexuality_lesbian
    target_sexuality_straight
```

```
# creating arrays of text column and labels column for viewing and making text columns str
df['text'].astype(str)
df = df[['text', 'hate_speech_score']].groupby('text').mean().reset_index()
text = np.array(df['text'])
labels = np.array(df['hate_speech_score'])
```

EDA

```
##EDA
import seaborn as sns
def str_labler(arr):
  new_arr = []
  for i in arr:
    if i >= .5:
      new_arr.append("Hateful")
    elif i < .5 and i > -1:
      new_arr.append("Neutral")
    else:
      new_arr.append("Supportive")
  return new_arr
labels_str = str_labler(labels)
sns.histplot(labels_str)
```

```
<Axes: ylabel='Count'>
```



```
supp_count = len([i for i in labels_str if i =="Supportive"])
hate_count = len([i for i in labels_str if i =="Hateful"])
neut_count = len([i for i in labels_str if i =="Neutral"])
total_count = len(labels_str)
print("Supportive Count: ", supp_count)
print("Supportive Prop: ", supp_count/total_count)
print("Hateful Count: ", hate_count)
print("Hateful Prop: ", hate_count/total_count)
print("Neutral Count: ", neut_count)
print("Neutral Prop: ", neut_count/total_count)
```

```
Supportive Count:  17553
Supportive Prop:  0.4436496903829142
Hateful Count:  10437
Hateful Prop:  0.2637937571085555
Neutral Count:  11575
Neutral Prop:  0.29255655250853024
```

```
supp_exs = df[df['hate_speech_score'] < -1].sort_values('hate_speech_score')
hate_exs = df[df['hate_speech_score'] > .5].sort_values('hate_speech_score', ascending = False)
neut_exs = df[df['hate_speech_score'].between(-1,.3)]
hate_neut_edge_exs = df[df['hate_speech_score'].between(.3,.7)]
```

```
supp_exs
```

hate_speech_score	text	2class_hate_speech

```
hate_exs
```

	hate_speech_score	text	2class_hate_speech
0	2	! thank u! im transmasc and generally present ...	0
22476	2	My masculine is awakening from my spiritual el...	0
22484	2	My masculine is awakening through my spiritual...	0
22483	2	My masculine is awakening my from my spiritual...	0
22482	2	My masculine is awakening from my spiritual up...	0
...	...	...	...
19468	1	Islam needs to be fucking destroyed.	1
19467	1	Islam kills gays. Nothing to do with you being...	1
12330	1	Fuck yourself bitch	1
19462	1	Islam is bullsh#t.. a butch a beating, butcher...	1
18431	1	If anything, Fox news employs very lovely wome...	1

27990 rows × 3 columns

```
neut_exs[neut_exs['hate_speech_score'].between(-.01,.01)]
```

	hate_speech_score	text	2class_hate_speech
8	0	" Fuck you niggas ion give a fuck no more nigg...	0
10	0	" I got women tryna sneak me through there doo...	0
11	0	" I wish ur crack mom aborted you" well guess ...	0
12	0	" Pray for him" ha! The filthy traitor would b...	0
15	0	" is dat so hard for yu niggas to do😕 y'all wa...	0
...	...	...	...
39543	0	😡 Vandals destroy Christian cemetery in Israel ...	0
39546	0	😭 😭 😭 so litt sus with the right bitch tho none o...	0
39553	0	🤐 shhhhh them yung buls always wanna give me t...	0
39557	0	🤣 this nigga shot out	0
39561	0	🤬 CONGRATULATIONS #MARYLAND #BALTIMORE LIBERALS...	0

11575 rows × 3 columns

```
hate_neut_edge_exs.sort_values('hate_speech_score', ascending = False)
```

hate_speech_score	text	2class_hate_speech

Pre-Processing

```
def labler(arr):
  new_arr = []
  for i in arr:
    if i >= .5:
      new_arr.append(1)
    elif i < .5 and i > -1:
      new_arr.append(0)
    else:
      new_arr.append(2)
  return new_arr
```

```
#https://www.educative.io/answers/remove-all-the-punctuation-marks-from-a-sentence-using-regex
```

```
#labels = labler(labels)
new_df = df.apply(lambda x: labler(x) if x.name == 'hate_speech_score' else x,
                axis = 0)
```

```
new_df['hate_speech_score'].value_counts()
```

```
    2    17553
    0    11575
    1    10437
    Name: hate_speech_score, dtype: int64
```

```
new_df['2class_hate_speech'] = [0 if i in [0,2] else 1 for i in new_df['hate_speech_score'].values]
```

```
new_df['2class_hate_speech'].value_counts()
```

```
    0    29128
    1    10437
    Name: 2class_hate_speech, dtype: int64
```

```
np.random.seed(6543)
grouped = new_df[['hate_speech_score', 'text', '2class_hate_speech']].groupby('hate_speech_score', as_index = False).apply(lambda
df = grouped[['hate_speech_score', 'text', '2class_hate_speech']]
df
```

```
<ipython-input-14-aefeba8d0452>:2: FutureWarning: Not prepending group keys to the result index of transform-like apply. In t
To preserve the previous behavior, use

        >>> .groupby(..., group_keys=False)

To adopt the future behavior and silence this warning, use

        >>> .groupby(..., group_keys=True)
  grouped = new_df[['hate_speech_score', 'text', '2class_hate_speech']].groupby('hate_speech_score', as_index = False).apply(
```

	hate_speech_score	text	2class_hate_speech
0	2	! thank u! im transmasc and generally present ...	0
1	1	!Go fuck yourself faggot!	1
2	2	!flair [I love women and minorities]	0
3	1	!flair [death to all niggers and gays]	1
4	2	" 'convoluted' genealogy of Jesus"; was that c...	0
...	...	...	...
39560	1	🤧 The limousine liberal Jews and WASPs who wa...	1
39561	0	🤬 CONGRATULATIONS #MARYLAND #BALTIMORE LIBERALS...	0
39562	1	🥳 another bitch will when another bitch can't	1
39563	2	🥴 🥴 next time stay your ass in the car before o...	0
39564	2	🧬 🧬 🧬 *IM SMARTER THAN SSSNIPERWOLF.I KNOW EVERY...	0

Train/Test/Val Split

[ ] ↳ *6 cells hidden*

Regular Tokenization

```
tokenizer = tf_text.WhitespaceTokenizer()
train_tokens = tokenizer.tokenize(train_examples)
val_tokens = tokenizer.tokenize(val_examples)
test_tokens = tokenizer.tokenize(test_examples)
```

```
max([len(i) for i in train_tokens.numpy()])
```

```
128
```

```
np.mean([len(i) for i in train_tokens.numpy()])
```

```
24.54015873015873
```

```
np.median([len(i) for i in train_tokens.numpy()])
```

```
19.0
```

Baseline

```
def baseline_model(lbls):
  guesses = []
  for i in range(len(lbls)):
    x = np.random.uniform(low=0, high=1)
    if x <= supp_count/total_count:
      guesses.append(2)
    elif x <= (supp_count + hate_count)/total_count and x > supp_count/total_count:
      guesses.append(1)
    elif x > (supp_count + hate_count)/total_count and x<=1:
      guesses.append(0)
  return guesses
```

```
baseline_guesses = baseline_model(test_labels)
```

```
baseline_accuracy = np.mean([1 if baseline_guesses[i] == test_labels[i] else 0 for i in range(len(test_labels))])
baseline_accuracy
```

```
    0.3486099410278012
```

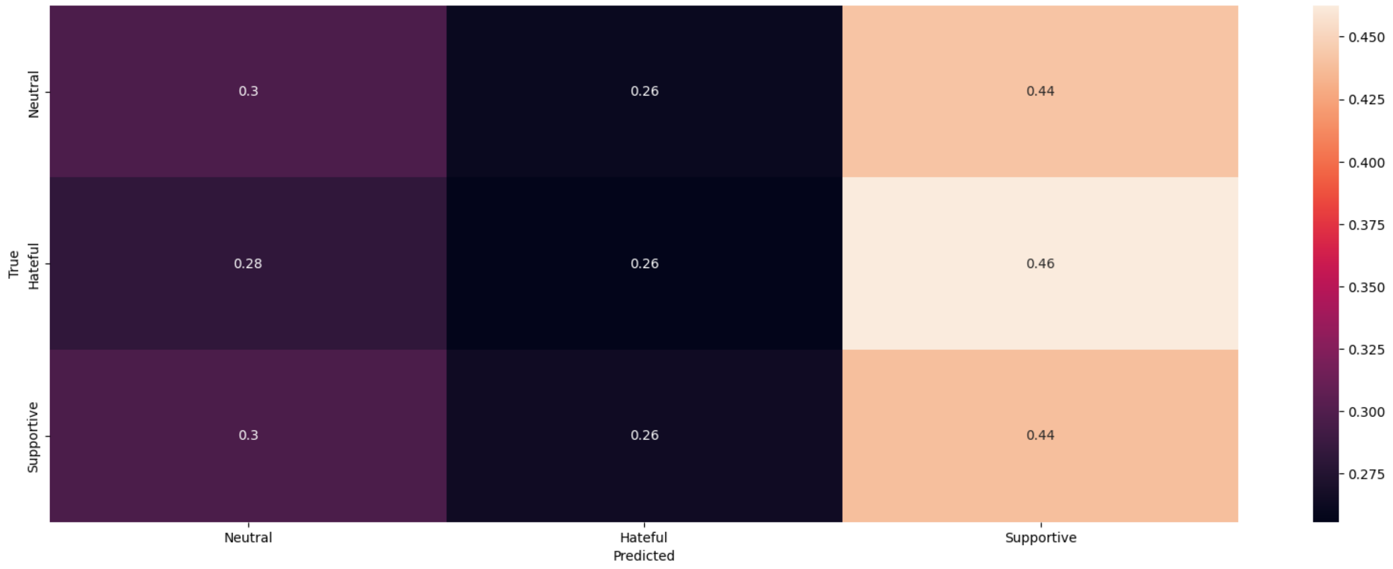
```
print(classification_report(test_labels, baseline_guesses))
```

```
                  precision    recall  f1-score   support

               0       0.30      0.30      0.30      1750
               1       0.26      0.26      0.26      1576
               2       0.43      0.44      0.44      2609

        accuracy                           0.35      5935
       macro avg       0.33      0.33      0.33      5935
    weighted avg       0.35      0.35      0.35      5935
```

```
cm = tf.math.confusion_matrix(test_labels, baseline_guesses)
cm = cm/cm.numpy().sum(axis=1)[:, tf.newaxis]
```

```
plt.figure(figsize=(20,7))
sns.heatmap(
    cm, annot=True,
    xticklabels=["Neutral", "Hateful", "Supportive"],
    yticklabels=["Neutral", "Hateful", "Supportive"])
plt.xlabel("Predicted")
plt.ylabel("True")
```

```
    Text(220.72222222222223, 0.5, 'True')
```



Bert Tokenization

```
#Train and Test for Bert Based Models
bert_tokenizer = BertTokenizer.from_pretrained('bert-base-cased')
bert_model = TFBertModel.from_pretrained('bert-base-cased')

MAX_SEQUENCE_LENGTH = 128

bert_train_tokenized = bert_tokenizer(list(train_examples),
              max_length=MAX_SEQUENCE_LENGTH,
              truncation=True,
              padding='max_length',
              return_tensors='tf')
bert_train_inputs = [bert_train_tokenized.input_ids,
                     bert_train_tokenized.token_type_ids,
                     bert_train_tokenized.attention_mask]
bert_train_labels = np.array(train_labels)

bert_val_tokenized = bert_tokenizer(list(val_examples),
              max_length=MAX_SEQUENCE_LENGTH,
              truncation=True,
              padding='max_length',
              return_tensors='tf')
bert_val_inputs = [bert_val_tokenized.input_ids,
                     bert_val_tokenized.token_type_ids,
                     bert_val_tokenized.attention_mask]
bert_val_labels = np.array(val_labels)

bert_test_tokenized = bert_tokenizer(list(test_examples),
              max_length=MAX_SEQUENCE_LENGTH,
              truncation=True,
              padding='max_length',
              return_tensors='tf')
bert_test_inputs = [bert_test_tokenized.input_ids,
                     bert_test_tokenized.token_type_ids,
                     bert_test_tokenized.attention_mask]
bert_test_labels = np.array(test_labels)
```

```
Downloading (…)solve/main/vocab.txt: 100%                       213k/213k [00:00<00:00, 3.94MB/s]

Downloading (…)okenizer_config.json: 100%                       29.0/29.0 [00:00<00:00, 1.35kB/s]

Downloading (…)lve/main/config.json: 100%                       570/570 [00:00<00:00, 25.4kB/s]

Downloading tf_model.h5: 100%                           527M/527M [00:07<00:00, 79.4MB/s]
Some layers from the model checkpoint at bert-base-cased were not used when initializing TFBertModel: ['nsp___cls', 'mlm___cl
- This IS expected if you are initializing TFBertModel from the checkpoint of a model trained on another task or with anothe
- This IS NOT expected if you are initializing TFBertModel from the checkpoint of a model that you expect to be exactly iden
All the layers of TFBertModel were initialized from the model checkpoint at bert-base-cased.
If your task is similar to the task the model of the checkpoint was trained on, you can already use TFBertModel for predicti
```

```
#max(len(x) for x in bert_train_inputs)
np.unique(bert_train_labels[:5000], return_counts =True)
```

```
(array([0, 1, 2]), array([1434, 1340, 2226]))
```

BERT CLS

```
#BERT Base Case
def create_bert_cls_classification_model(max_sequence_length=MAX_SEQUENCE_LENGTH,
                          dropout = 0.3,
                          hidden_size = 100,
                          learning_rate=0.00001):
    """
    Build a  classification model with BERT, where you apply CNN layers  to the BERT output
    """


    bert_model.trainable = True
    max_length = MAX_SEQUENCE_LENGTH
    input_ids = tf.keras.layers.Input(shape=(max_length,), dtype=tf.int64, name='input_ids_layer')
    token_type_ids = tf.keras.layers.Input(shape=(max_length,), dtype=tf.int64, name='token_type_ids_layer')
    attention_mask = tf.keras.layers.Input(shape=(max_length,), dtype=tf.int64, name='attention_mask_layer')

    bert_inputs = {'input_ids': input_ids,
                   'token_type_ids': token_type_ids,
                   'attention_mask': attention_mask}

    bert_out = bert_model(bert_inputs)

    cls_token = bert_out[0][:, 0, :]

    hidden = tf.keras.layers.Dense(hidden_size, activation='relu', name='hidden_layer')(cls_token)

    hidden = tf.keras.layers.Dropout(dropout)(hidden)

    classification = tf.keras.layers.Dense(3, activation='softmax',name='classification_layer', kernel_regularizer='l1')(hidden)
    classification_model = tf.keras.Model(inputs=[input_ids, token_type_ids, attention_mask], outputs=[classification])

    classification_model.compile(optimizer=tf.keras.optimizers.Adam(learning_rate=learning_rate),
                                 loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=False),
                                 metrics='accuracy')

    return classification_model


bert_cls_classification_model = create_bert_cls_classification_model()
bert_cls_classification_model.summary()
#confirm all layers are frozen
bert_cls_classification_model_history = bert_cls_classification_model.fit(
    [bert_train_inputs[0], bert_train_inputs[1], bert_train_inputs[2]],
    bert_train_labels,
    validation_data=([bert_val_inputs[0], bert_val_inputs[1], bert_val_inputs[2]], bert_val_labels),
    batch_size=8,
    epochs=2)
```

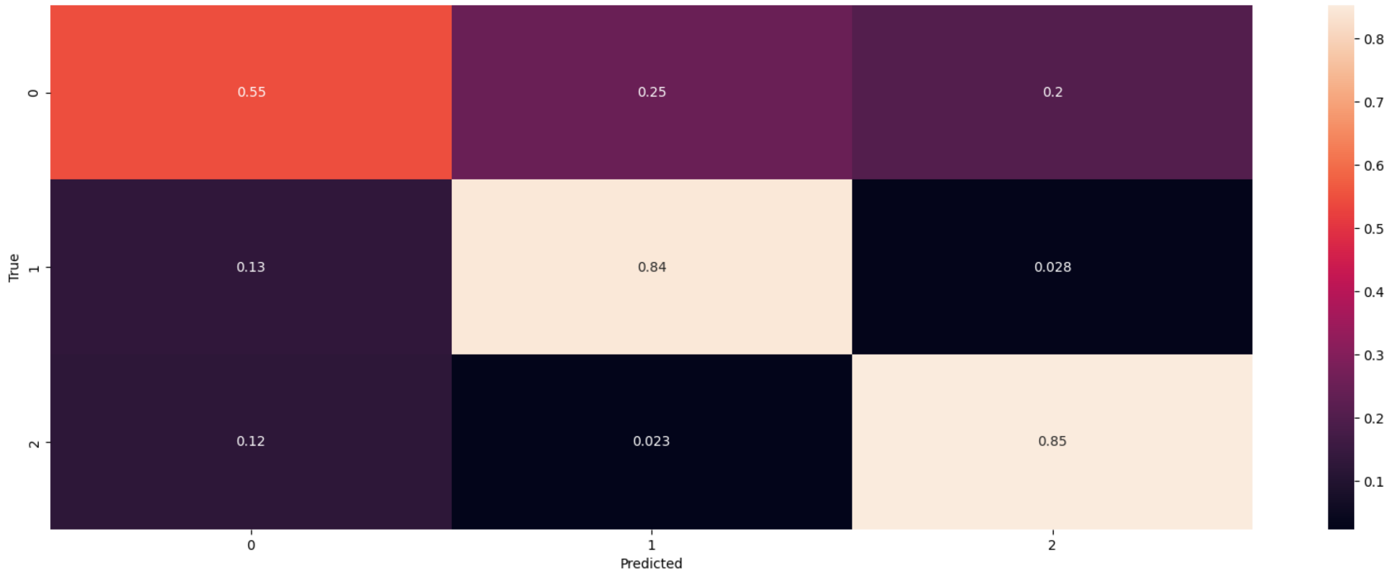
```
Model: "model"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 attention_mask_layer (InputLay  [(None, 128)]       0           []
 er)

 input_ids_layer (InputLayer)   [(None, 128)]        0           []

 token_type_ids_layer (InputLay  [(None, 128)]       0           []
 er)

 tf_bert_model (TFBertModel)    TFBaseModelOutputWi  108310272   ['attention_mask_layer[0][0]',
                                thPoolingAndCrossAt               'input_ids_layer[0][0]',
                                tentions(last_hidde               'token_type_ids_layer[0][0]']
                                n_state=(None, 128,
                                 768),
                                 pooler_output=(Non
                                e, 768),
                                 past_key_values=No
                                ne, hidden_states=N
                                one, attentions=Non
                                e, cross_attentions
                                =None)

 tf.__operators__.getitem (Slic  (None, 768)         0           ['tf_bert_model[0][0]']
 ingOpLambda)

 hidden_layer (Dense)           (None, 100)          76900       ['tf.__operators__.getitem[0][0]'
                                                                 ]

 dropout_37 (Dropout)           (None, 100)          0           ['hidden_layer[0][0]']

 classification_layer (Dense)   (None, 3)            303         ['dropout_37[0][0]']

==================================================================================================
Total params: 108,387,475
Trainable params: 108,387,475
Non-trainable params: 0
__________________________________________________________________________________________________
Epoch 1/2
WARNING:tensorflow:Gradients do not exist for variables ['tf_bert_model/bert/pooler/dense/kernel:0', 'tf_bert_model/bert/pool
WARNING:tensorflow:Gradients do not exist for variables ['tf_bert_model/bert/pooler/dense/kernel:0', 'tf_bert_model/bert/pool
3462/3462 [==============================] - 825s 235ms/step - loss: 1.1745 - accuracy: 0.6077 - val_loss: 1.0605 - val_accu
Epoch 2/2
3462/3462 [==============================] - 813s 235ms/step - loss: 0.9898 - accuracy: 0.6909 - val_loss: 1.0136 - val_accu
```

```
cls_predictions = bert_cls_classification_model.predict([bert_test_inputs[0], bert_test_inputs[1], bert_test_inputs[2]])
cls_predictions = tf.argmax(cls_predictions, axis=-1)


print(classification_report(bert_test_labels, cls_predictions))#, target_names=["Neutral", "Hateful", "Supportive"]))
```

```
              precision    recall  f1-score   support

           0       0.65      0.55      0.59      1750
           1       0.73      0.84      0.78      1576
           2       0.85      0.85      0.85      2609

    accuracy                           0.76      5935
   macro avg       0.74      0.75      0.74      5935
weighted avg       0.76      0.76      0.76      5935
```

```
cm = tf.math.confusion_matrix(bert_test_labels, cls_predictions)
cm = cm/cm.numpy().sum(axis=1)[:, tf.newaxis]
plt.figure(figsize=(20,7))
sns.heatmap(
    cm, annot=True)
plt.xlabel("Predicted")
plt.ylabel("True")
```

```
Text(220.72222222222223, 0.5, 'True')
```



Bert CNN

[ ] ↳ *8 cells hidden*

Combined Roberta Model

```
from transformers import RobertaConfig, TFRobertaModel
```

```
#Roberta Model, Tokenizer, and Train and Test Sets

roberta_tokenizer = AutoTokenizer.from_pretrained("roberta-base")
roberta_model = TFRobertaModel.from_pretrained("roberta-base")

MAX_SEQUENCE_LENGTH = 128
roberta_train_tokenized = roberta_tokenizer(list(train_examples),
              max_length=MAX_SEQUENCE_LENGTH,
              truncation=True,
              padding='max_length',
              add_special_tokens=True,
              return_tensors='tf')
print(roberta_train_tokenized)
roberta_train_inputs = [roberta_train_tokenized.input_ids,
                     roberta_train_tokenized.attention_mask]
roberta_train_labels = np.array(train_labels)

roberta_val_tokenized = roberta_tokenizer(list(val_examples),
              max_length=MAX_SEQUENCE_LENGTH,
              truncation=True,
              padding='max_length',
              return_tensors='tf')
roberta_val_inputs = [roberta_val_tokenized.input_ids,
                     roberta_val_tokenized.attention_mask]
roberta_val_labels = np.array(val_labels)

roberta_test_tokenized = roberta_tokenizer(list(test_examples),
              max_length=MAX_SEQUENCE_LENGTH,
              truncation=True,
              padding='max_length',
              return_tensors='tf')
roberta_test_inputs = [roberta_test_tokenized.input_ids,
                     #roberta_test_tokenized.token_type_ids,
                     roberta_test_tokenized.attention_mask]
roberta_test_labels = np.array(test_labels)
```

```
Downloading (…)lve/main/config.json: 100%                                   481/481 [00:00<00:00, 9.33kB/s]

Downloading (…)olve/main/vocab.json: 100%                                   899k/899k [00:00<00:00, 6.22MB/s]

Downloading (…)olve/main/merges.txt: 100%                                   456k/456k [00:00<00:00, 3.60MB/s]

Downloading (…)/main/tokenizer.json: 100%                                   1.36M/1.36M [00:00<00:00, 8.04MB/s]

Downloading tf_model.h5: 100%                                   657M/657M [00:08<00:00, 96.1MB/s]

Some layers from the model checkpoint at roberta-base were not used when initializing TFRobertaModel: ['lm_head']
- This IS expected if you are initializing TFRobertaModel from the checkpoint of a model trained on another task or with anot
- This IS NOT expected if you are initializing TFRobertaModel from the checkpoint of a model that you expect to be exactly ic
All the layers of TFRobertaModel were initialized from the model checkpoint at roberta-base.
If your task is similar to the task the model of the checkpoint was trained on, you can already use TFRobertaModel for predic
{'input_ids': <tf.Tensor: shape=(27696, 128), dtype=int32, numpy=
array([[    0,  1039,  6785, ...,     1,     1,     1],
       [    0,  1039,   298, ...,     1,     1,     1],
       [    0, 20328,    47, ...,     1,     1,     1],
       ...,
       [    0,   597, 24029, ...,     1,     1,     1],
       [    0, 15698,   286, ...,     1,     1,     1],
       [    0, 37294,   219, ...,     1,     1,     1]], dtype=int32)>, 'attention_mask': <tf.Tensor: shape=(27696, 128), dty
array([[1, 1, 1, ..., 0, 0, 0],
       [1, 1, 1, ..., 0, 0, 0],
       [1, 1, 1, ..., 0, 0, 0],
       ...,
       [1, 1, 1, ..., 0, 0, 0],
       [1, 1, 1, ..., 0, 0, 0],
       [1, 1, 1, ..., 0, 0, 0]], dtype=int32)>}
```

```
def create_roberta1_classification_model(max_sequence_length=MAX_SEQUENCE_LENGTH,
                          num_filters = [100, 100, 50, 25],
                          kernel_sizes = [2, 3, 4, 5],
                          dropout = 0.3,
                          hidden_size = 100,
                          learning_rate=.00001):
    """
    Build a  classification model with BERT, where you apply CNN layers  to the BERT output
    """



    roberta_model.trainable = True
    #max_length = 100
    input_ids = tf.keras.layers.Input(shape=(max_sequence_length,), dtype=tf.int64, name='input_ids_layer')
   # token_type_ids = tf.keras.layers.Input(shape=(max_sequence_length,), dtype=tf.int64, name='token_type_ids_layer')
    attention_mask = tf.keras.layers.Input(shape=(max_sequence_length,), dtype=tf.int64, name='attention_mask_layer')

    roberta_inputs = {'input_ids': input_ids,
                   'attention_mask': attention_mask}

    roberta_out = roberta_model(roberta_inputs)

    pooler_token = roberta_out[1]
    print(pooler_token)
    hidden = tf.keras.layers.Dense(hidden_size, activation='relu', name='hidden_layer')(pooler_token)

    hidden = tf.keras.layers.Dropout(dropout)(hidden)

    classification = tf.keras.layers.Dense(3, activation='softmax',name='classification_layer')(hidden)

    classification_model = tf.keras.Model(inputs=[input_ids, attention_mask], outputs=[classification])

    classification_model.compile(optimizer=tf.keras.optimizers.Adam(learning_rate=learning_rate),
                                 loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=False),
                                 metrics='accuracy')
    return classification_model


roberta1_classification_model = create_roberta1_classification_model()
roberta1_classification_model.summary()
#confirm all layers are frozen
roberta1_classification_model_history = roberta1_classification_model.fit(
    [roberta_train_inputs[0], roberta_train_inputs[1]],
    roberta_train_labels,
    validation_data=([roberta_test_inputs[0], roberta_test_inputs[1]], roberta_test_labels),
    batch_size=8,
    epochs=2)
```

```
KerasTensor(type_spec=TensorSpec(shape=(None, 768), dtype=tf.float32, name=None), name='tf_roberta_model/roberta/pooler/dense
Model: "model"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 attention_mask_layer (InputLay  [(None, 128)]       0           []
 er)

 input_ids_layer (InputLayer)   [(None, 128)]        0           []

 tf_roberta_model (TFRobertaMod  TFBaseModelOutputWi  124645632  ['attention_mask_layer[0][0]',
 el)                            thPoolingAndCrossAt               'input_ids_layer[0][0]']
                                tentions(last_hidde
                                n_state=(None, 128,
                                 768),
                                 pooler_output=(Non
                                e, 768),
                                 past_key_values=No
                                ne, hidden_states=N
                                one, attentions=Non
                                e, cross_attentions
                                =None)

 hidden_layer (Dense)           (None, 100)          76900       ['tf_roberta_model[0][1]']

 dropout_37 (Dropout)           (None, 100)          0           ['hidden_layer[0][0]']

 classification_layer (Dense)   (None, 3)            303         ['dropout_37[0][0]']

==================================================================================================
Total params: 124,722,835
Trainable params: 124,722,835
Non-trainable params: 0
__________________________________________________________________________________________________
Epoch 1/2
3462/3462 [==============================] - 861s 246ms/step - loss: 0.7949 - accuracy: 0.6232 - val_loss: 0.6932 - val_accu
Epoch 2/2
3462/3462 [==============================] - 851s 246ms/step - loss: 0.6859 - accuracy: 0.6833 - val_loss: 0.5965 - val_accu
```

```
predictions1 = roberta1_classification_model.predict([roberta_test_inputs[0], roberta_test_inputs[1]])
```

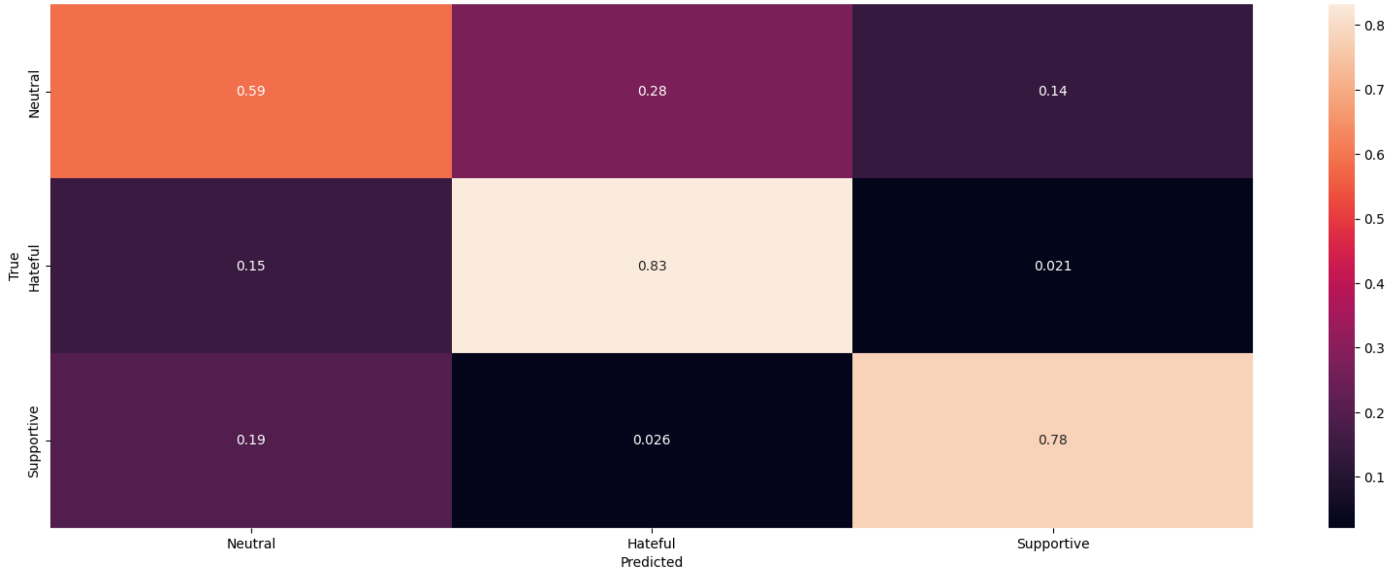
```
predictions1 = tf.argmax(predictions1, axis=-1)
```

```
from sklearn.metrics import classification_report
print(classification_report(roberta_test_labels, predictions1))#, target_names=["Neutral", "Hateful", "Supportive"]))
```

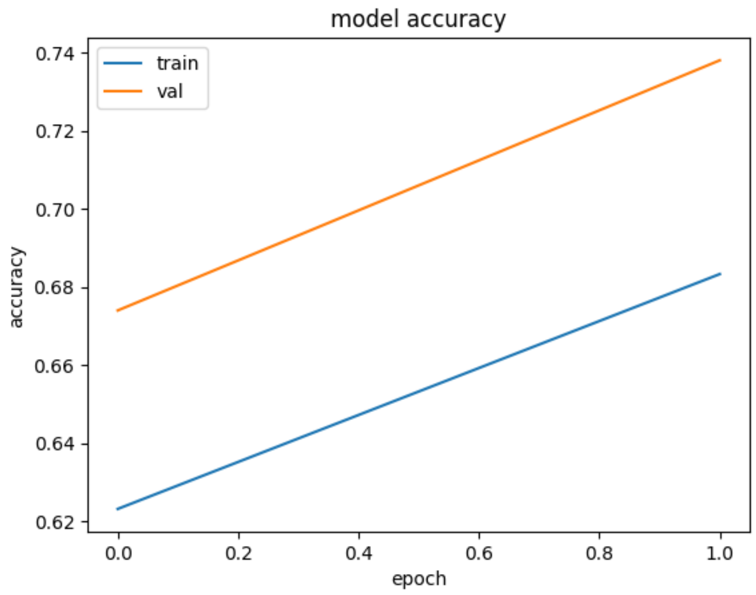
```
              precision    recall  f1-score   support

           0       0.58      0.59      0.59      1750
           1       0.70      0.83      0.76      1576
           2       0.88      0.78      0.83      2609

    accuracy                           0.74      5935
   macro avg       0.72      0.73      0.73      5935
weighted avg       0.75      0.74      0.74      5935
```

```
cm = tf.math.confusion_matrix(roberta_test_labels, predictions1)
cm = cm/cm.numpy().sum(axis=1)[:, tf.newaxis]
```

```
plt.figure(figsize=(20,7))
sns.heatmap(
    cm, annot=True,
    xticklabels=["Neutral", "Hateful", "Supportive"],
    yticklabels=["Neutral", "Hateful", "Supportive"])
plt.xlabel("Predicted")
plt.ylabel("True")
     Text(220.72222222222223, 0.5, 'True')
```



```
from matplotlib import pyplot as plt
plt.plot(roberta1_classification_model_history.history['accuracy'])
plt.plot(roberta1_classification_model_history.history['val_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'val'], loc='upper left')
plt.show()
```



```
MAX_SEQUENCE_LENGTH = 128
binary_roberta_train_tokenized = roberta_tokenizer(list(binary_train_examples),
              max_length=MAX_SEQUENCE_LENGTH,
              truncation=True,
              padding='max_length',
              return_tensors='tf')
binary_roberta_train_inputs = [binary_roberta_train_tokenized.input_ids,
                     binary_roberta_train_tokenized.attention_mask]
```

```
binary_roberta_train_labels = np.array(binary_train_labels)

binary_roberta_val_tokenized = roberta_tokenizer(list(binary_val_examples),
              max_length=MAX_SEQUENCE_LENGTH,
              truncation=True,
              padding='max_length',
              return_tensors='tf')
binary_roberta_val_inputs = [binary_roberta_val_tokenized.input_ids,
                     binary_roberta_val_tokenized.attention_mask]
binary_roberta_val_labels = np.array(binary_val_labels)

binary_roberta_test_tokenized = roberta_tokenizer(list(binary_test_examples),
              max_length=MAX_SEQUENCE_LENGTH,
              truncation=True,
              padding='max_length',
              return_tensors='tf')
binary_roberta_test_inputs = [binary_roberta_test_tokenized.input_ids,
                     binary_roberta_test_tokenized.attention_mask]
binary_roberta_test_labels = np.array(binary_test_labels)


def create_roberta2_classification_model(max_sequence_length=MAX_SEQUENCE_LENGTH,
                          num_classes = 1,
                          dropout = 0.3,
                          hidden_size = 100,
                          learning_rate=0.00001):
    """
    Build a  classification model with BERT, where you apply CNN layers  to the BERT output
    """



    roberta_model.trainable = True
    #max_length = 100
    input_ids = tf.keras.layers.Input(shape=(max_sequence_length,), dtype=tf.int64, name='input_ids_layer')
   # token_type_ids = tf.keras.layers.Input(shape=(max_sequence_length,), dtype=tf.int64, name='token_type_ids_layer')
    attention_mask = tf.keras.layers.Input(shape=(max_sequence_length,), dtype=tf.int64, name='attention_mask_layer')

    roberta_inputs = {'input_ids': input_ids,
                   'attention_mask': attention_mask}

    roberta_out = roberta_model(roberta_inputs)

    cls_token = roberta_out[1]

    hidden = tf.keras.layers.Dense(hidden_size, activation='relu', name='hidden_layer')(cls_token)

    hidden = tf.keras.layers.Dropout(dropout)(hidden)

    classification = tf.keras.layers.Dense(num_classes, activation='sigmoid',name='classification_layer')(hidden)

    classification_model = tf.keras.Model(inputs=[input_ids, attention_mask], outputs=[classification])

    classification_model.compile(optimizer=tf.keras.optimizers.Adam(learning_rate=learning_rate),
                                 loss=tf.keras.losses.BinaryCrossentropy(from_logits=False),
                                 metrics='accuracy')

    return classification_model


binary_roberta2_classification_model = create_roberta2_classification_model()
binary_roberta2_classification_model.summary()
#confirm all layers are frozen
binary_roberta2_classification_model_history = binary_roberta2_classification_model.fit(
    [binary_roberta_train_inputs[0], binary_roberta_train_inputs[1]],
    binary_roberta_train_labels,
    validation_data=([binary_roberta_val_inputs[0], binary_roberta_val_inputs[1]], binary_roberta_val_labels),
    batch_size=8,
    epochs=2)
```

```
Model: "model_2"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 attention_mask_layer (InputLay  [(None, 128)]       0           []
 er)

 input_ids_layer (InputLayer)   [(None, 128)]        0           []

 tf_roberta_model (TFRobertaMod  TFBaseModelOutputWi  124645632  ['attention_mask_layer[0][0]',
 el)                            thPoolingAndCrossAt              'input_ids_layer[0][0]'
                                tentions(last_hidde
                                n_state=(None, 128,
                                 768),
                                 pooler_output=(Non
                                e, 768),
                                 past_key_values=No
                                ne, hidden_states=N
                                one, attentions=Non
                                e, cross_attentions
                                =None)

 hidden_layer (Dense)           (None, 100)          76900       ['tf_roberta_model[2][1]']

 dropout_39 (Dropout)           (None, 100)          0           ['hidden_layer[0][0]']

 classification_layer (Dense)   (None, 1)            101         ['dropout_39[0][0]']

==================================================================================================
Total params: 124,722,633
Trainable params: 124,722,633
Non-trainable params: 0
__________________________________________________________________________________________________
Epoch 1/2
3462/3462 [==============================] - 878s 246ms/step - loss: 0.2316 - accuracy: 0.9032 - val_loss: 0.4643 - val_accu
Epoch 2/2
3462/3462 [==============================] - 849s 245ms/step - loss: 0.1745 - accuracy: 0.9280 - val_loss: 0.5233 - val_accu
```

```
binary_predictions2 = binary_roberta2_classification_model.predict([binary_roberta_test_inputs[0], binary_roberta_test_inputs[1]])
```

```
binary_predictions2 = [1 if i[0] > .5 else 0 for i in binary_predictions2]
```

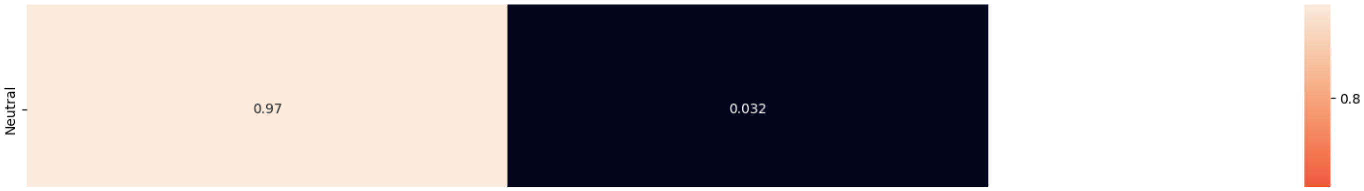
```
print(classification_report(binary_roberta_test_labels, binary_predictions2))#, target_names=["Neutral", "Hateful", "Supportive"])
```

```
              precision    recall  f1-score   support

           0       0.95      0.97      0.96      4359
           1       0.91      0.85      0.88      1576

    accuracy                           0.94      5935
   macro avg       0.93      0.91      0.92      5935
weighted avg       0.94      0.94      0.94      5935
```

```
cm = tf.math.confusion_matrix(binary_roberta_test_labels, binary_predictions2)
cm = cm/cm.numpy().sum(axis=1)[:, tf.newaxis]
```

```
plt.figure(figsize=(20,7))
sns.heatmap(
    cm, annot=True,
    xticklabels=["Neutral", "Hateful", "Supportive"],
    yticklabels=["Neutral", "Hateful", "Supportive"])
plt.xlabel("Predicted")
plt.ylabel("True")
```

```
    Text(220.72222222222223, 0.5, 'True')
```



```
combined_preds = []
for i in range(len(predictions1)):
  if predictions1[i] == 0 and binary_predictions2[i] == 1:
    combined_preds.append(binary_predictions2[i])
  else:
    combined_preds.append(predictions1[i])
combined_preds = np.array(combined_preds)
```

```
print(len(predictions1))
print(len(binary_predictions2))
```

```
    5935
    5935
```

```
print(classification_report(roberta_test_labels, combined_preds))
```

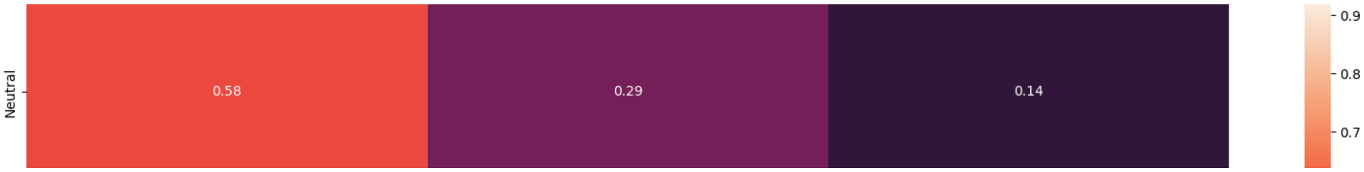
```
                  precision    recall  f1-score   support

               0       0.63      0.58      0.60      1750
               1       0.72      0.92      0.81      1576
               2       0.88      0.78      0.83      2609

        accuracy                           0.76      5935
       macro avg       0.74      0.76      0.75      5935
    weighted avg       0.76      0.76      0.76      5935
```

```
plt.figure(figsize=(20,7))
cm = tf.math.confusion_matrix(roberta_test_labels, combined_preds)
cm = cm/cm.numpy().sum(axis=1)[:, tf.newaxis]
```

```
    <Figure size 2000x700 with 0 Axes>
```

```
plt.figure(figsize=(20,7))
sns.heatmap(
    cm, annot=True,
    xticklabels=["Neutral", "Hateful", "Supportive"],
    yticklabels=["Neutral", "Hateful", "Supportive"])
plt.xlabel("Predicted")
plt.ylabel("True")
```

```
Text(220.72222222222223, 0.5, 'True')
```



```
incorrects = []
for i in range(len(combined_preds)):
  if combined_preds[i] != roberta_test_labels[i]:
    prediction=combined_preds[i]
    label=roberta_test_labels[i]
    example = list(test_examples)[i]
    incorrects.append([prediction,label, example])
```

```
for i in range(10):
  print(f'Text {i}: ' , incorrects[i][2])
  print(f'Predicted Label {i}: ' , incorrects[i][0])
  print(f'True Label {i}: ' , incorrects[i][1])
```

```
Text 0:  It was used during beatings, rapes, and murders of black people
Predicted Label 0:  0
True Label 0:  2
Text 1:  It's not a shit hole because that's where the white people live. That kid wasn't white.
Predicted Label 1:  2
True Label 1:  0
Text 2:  Let me fuck you as your sucking your own pulsating cock
Predicted Label 2:  2
True Label 2:  0
Text 3:  @TylerTrollbane @penelope7usa Liberals: White genocide NOW! "Conservatives": Hold on! We need a phase-in so we can
Predicted Label 3:  0
True Label 3:  1
Text 4:  After recent performance of India in icc tournament ( S.a smiles from a distance )  C H O K E R S
Predicted Label 4:  2
True Label 4:  0
Text 5:  The concept of "gendered brains" is demonstrably false through the very science that those mainstream atheists clai
Predicted Label 5:  0
True Label 5:  2
Text 6:  i really hate girls that are stuck up for no reason like damn sis.
Predicted Label 6:  0
True Label 6:  2
Text 7:  I Love to wear my tiny #Cage and #locked my Small #dick  #me #bottom #lockedboy #gayfaggot #faggot #TeamLocked URL
Predicted Label 7:  1
True Label 7:  0
Text 8:  I need my fat light ass fucked by a big black nigger dick 😈✨  URL
Predicted Label 8:  0
True Label 8:  2
Text 9:  Evangelicals are angry with Trump for using God's name to swear. God is angry that Evangelicals for using God's nam
Predicted Label 9:  0
True Label 9:  2
```