Exercise source

https://medium.com/@armandj.olivares/using-bert-for-classifying-documents-with-long-texts-5c3e7b04573d

Configuration

```
#Parameters
PROJECT_NAME = 'ML1010_Weekly'
ENABLE_COLAB = True

#Root Machine Learning Directory. Projects appear underneath
GOOGLE_DRIVE_MOUNT = '/content/gdrive'
COLAB_ROOT_DIR = GOOGLE_DRIVE_MOUNT + '/MyDrive/Colab Notebooks'
COLAB_INIT_DIR = COLAB_ROOT_DIR + '/utility_files'

LOCAL_ROOT_DIR = '/home/magni/Documents/ML_Projects'
LOCAL_INIT_DIR = LOCAL_ROOT_DIR + '/utility_files'
```

Bootstrap Environment

```
#add in support for utility file directory and importing
import sys
import os

if ENABLE_COLAB:
  #Need access to drive
  from google.colab import drive
  drive.mount(GOOGLE_DRIVE_MOUNT, force_remount=True)

  #add in utility directory to syspath to import
  INIT_DIR = COLAB_INIT_DIR
  sys.path.append(os.path.abspath(INIT_DIR))

  #Config environment variables
  ROOT_DIR = COLAB_ROOT_DIR

else:
  #add in utility directory to syspath to import
  INIT_DIR = LOCAL_INIT_DIR
```

```
    sys.path.append(os.path.abspath(INIT_DIR))

    #Config environment variables
    ROOT_DIR = LOCAL_ROOT_DIR

  #Import Utility Support
  from jarvis import Jarvis
  jarvis = Jarvis(ROOT_DIR, PROJECT_NAME)

  import mv_python_utils as mvutils
```

```
Mounted at /content/gdrive
Wha...where am I?
I am awake now.

I have set your current working directory to /content/gdrive/MyDrive/Colab Notebooks/ML
The current time is 09:25
Hello sir. Extra caffeine may help.
```

Importing Necessary Libraries

```
import pandas as pd
import numpy as np
np.random.seed(1337)

%tensorflow_version 1.x
import tensorflow as tf
import tensorflow_hub as hub

from tensorflow.keras import Sequential
from tensorflow.keras.utils import Sequence
from keras.layers import LSTM, Dense, Masking
import numpy as np
import keras
from keras.utils import np_utils
from keras import optimizers
from keras.models import Sequential, Model
from keras.layers import Embedding, Dense, Input, concatenate, Layer, Lambda, Dropout, Activa
import datetime
from datetime import datetime
from keras.callbacks import ModelCheckpoint, EarlyStopping, Callback, TensorBoard
```

```
TensorFlow 1.x selected.
Using TensorFlow backend.
```

```
jarvis.getPackageVersion('tensorflow')

    tensorflow version: tensorflow 2.7.0
```

Loading The Data

```
jarvis.showProjectDataFiles()
train_raw = pd.read_csv(jarvis.DATA_DIR + '/complaints.csv.gz')
train_raw.head()
```

```
      [D] /content/gdrive/MyDrive/Colab Notebooks/data/ML1010 Weekly
mvutils.exploreDataframe(train_raw)
```

```
dataframe shape: (2355756, 18)

dataframe info:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2355756 entries, 0 to 2355755
Data columns (total 18 columns):
 #   Column                        Dtype 
---  ------                        ----- 
 0   Date received                 object
 1   Product                       object
 2   Sub-product                   object
 3   Issue                         object
 4   Sub-issue                     object
 5   Consumer complaint narrative  object
 6   Company public response       object
 7   Company                       object
 8   State                         object
 9   ZIP code                      object
 10  Tags                          object
 11  Consumer consent provided?    object
 12  Submitted via                 object
 13  Date sent to company          object
 14  Company response to consumer  object
 15  Timely response?              object
 16  Consumer disputed?            object
 17  Complaint ID                  int64 
dtypes: int64(1), object(17)
memory usage: 323.5+ MB
None

Top 5 in dataframe
```

	Date received	Product	Sub-product	Issue	Sub-issue	Consumer complaint narrative	Company public response	Com
0	2019-06-13	Credit reporting, credit repair services, or o...	Credit reporting	Incorrect information on your report	Information belongs to someone else	NaN	NaN	CAPITAL FINAN CORPORA
1	2021-11-01	Debt collection	Credit card debt	Attempts to collect debt not owed	Debt is not yours	NaN	NaN	CAPITAL FINAN CORPORA
2	2019-11-01	Vehicle loan or lease	Loan	Struggling to pay your loan	Denied request to lower payments	I contacted Ally on Friday XX/XX/XXXX after fa...	Company has responded to the consumer and the ...	FINAN
		Credit					Company	

```
#Got a different label on dataset. Renaming to match original code
train_raw.rename(columns={"Consumer complaint narrative": "consumer_complaint_narrative",
                          "Product": "product"}, inplace=True)
```

Preprocessing Data

Select non null:

```
train_raw.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2355756 entries, 0 to 2355755
Data columns (total 18 columns):
 #   Column                        Dtype
---  ------                        -----
 0   Date received                 object
 1   product                       object
 2   Sub-product                   object
 3   Issue                         object
 4   Sub-issue                     object
 5   consumer_complaint_narrative  object
 6   Company public response       object
 7   Company                       object
 8   State                         object
 9   ZIP code                      object
 10  Tags                          object
 11  Consumer consent provided?    object
 12  Submitted via                 object
 13  Date sent to company          object
 14  Company response to consumer  object
 15  Timely response?              object
 16  Consumer disputed?            object
 17  Complaint ID                  int64
dtypes: int64(1), object(17)
memory usage: 323.5+ MB
```

```
train_raw = train_raw[train_raw.consumer_complaint_narrative.notnull()]
train_raw.shape
```

```
(821617, 18)
```

```
train_raw.consumer_complaint_narrative.apply(lambda x: len(x.split())).plot(kind='hist')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f28d1b23950>
```

800000
700000
600000
500000
400000
300000
Frequency

```
train_raw['len_txt'] =train_raw.consumer_complaint_narrative.apply(lambda x: len(x.split()))
train_raw.describe()
```

	Complaint ID	len_txt
count	8.216170e+05	821617.000000
mean	3.206297e+06	190.287933
std	8.708150e+05	226.916238
min	1.290155e+06	1.000000
25%	2.654470e+06	66.000000
50%	3.246880e+06	125.000000
75%	3.855518e+06	233.000000
max	4.885060e+06	6314.000000

```
train_raw.shape
```

```
(821617, 19)
```

Select only the row with number of words greater than 250:

```
train_raw = train_raw[train_raw.len_txt >249]
train_raw.shape
```

```
(186176, 19)
```

```
train_raw = train_raw[['consumer_complaint_narrative', 'product']]
train_raw.reset_index(inplace=True, drop=True)
train_raw.head()
```

	consumer_complaint_narrative	product
0	I contacted Ally on Friday XX/XX/XXXX after fa...	Vehicle loan or lease
1	Hello This complaint is against the three cred...	Credit reporting, credit repair services, or o...

Group similar products

miss...

```
train_raw.at[train_raw['product'] == 'Credit reporting', 'product'] = 'Credit reporting, crec
train_raw.at[train_raw['product'] == 'Credit card', 'product'] = 'Credit card or prepaid carc
train_raw.at[train_raw['product'] == 'Prepaid card', 'product'] = 'Credit card or prepaid car
train_raw.at[train_raw['product'] == 'Payday loan', 'product'] = 'Payday loan, title loan, or
train_raw.at[train_raw['product'] == 'Virtual currency', 'product'] = 'Money transfer, virtua
train_raw.head()
```

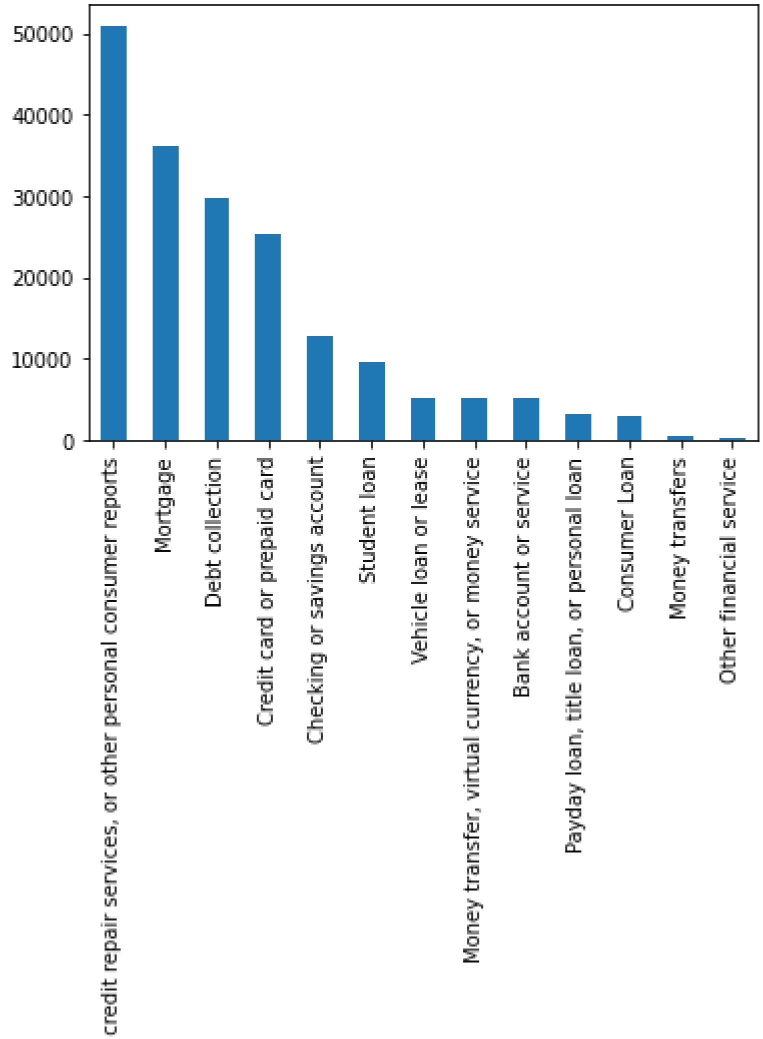
	consumer_complaint_narrative	product
0	I contacted Ally on Friday XX/XX/XXXX after fa...	Vehicle loan or lease
1	Hello This complaint is against the three cred...	Credit reporting, credit repair services, or o...
2	Although I am checking for and addressing miss...	Credit reporting, credit repair services, or o...
3	In an attempt to purchase concert tickets, I c...	Money transfer, virtual currency, or money ser...

```
for l in np.unique(train_raw['product']):
  print(l)
```

```
    Bank account or service
    Checking or savings account
    Consumer Loan
    Credit card or prepaid card
    Credit reporting, credit repair services, or other personal consumer reports
    Debt collection
    Money transfer, virtual currency, or money service
    Money transfers
    Mortgage
    Other financial service
    Payday loan, title loan, or personal loan
    Student loan
    Vehicle loan or lease
```

```
train_raw['product'].value_counts().sort_values(ascending=False).plot(kind='bar')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f28d1886410>
```



```
train_raw=train_raw.rename(columns = {'consumer_complaint_narrative':'text', 'product':'label
train_raw.head()
```

	text	label
0	I contacted Ally on Friday XX/XX/XXXX after fa...	Vehicle loan or lease
1	Hello This complaint is against the three cred...	Credit reporting, credit repair services, or o...
2	Although I am checking for and addressing miss...	Credit reporting, credit repair services, or o...
3	In an attempt to purchase concert tickets, I c...	Money transfer, virtual currency, or money ser...
4	I am attempting to sell my home and pay off my...	Mortgage

```
from sklearn.preprocessing import LabelEncoder

LE = LabelEncoder()
train_raw['label'] = LE.fit_transform(train_raw['label'])
train_raw.head()
```

	text	label
0	I contacted Ally on Friday XX/XX/XXXX after fa...	12
1	Hello This complaint is against the three cred...	4
2	Although I am checking for and addressing miss...	4
3	In an attempt to purchase concert tickets, I c...	6
4	I am attempting to sell my home and pay off my	8

```
len(np.unique(train_raw['label']))
```

```
13
```

```
train = train_raw.copy()
train = train[0:13713]
```

```
train = train.reindex(np.random.permutation(train.index))
train.head()
```

	text	label
2197	I had an old account through XXXX XXXX that wa...	4
4304	DUPLICATE XXXX ACCOUNT {$890.00}??? \n\nIm con...	5
2022	My name is XXXX XXXX, I enrolled in XXXX Unive...	5
7520	Dear Legal Department, This credit dispute is ...	4
7882	Hello. I reported many charges as fraud early ...	3

Clean the text columns

```
import re
def clean_txt(text):
  text = re.sub("'", "",text)
  text=re.sub("(\\W)+"," ",text)
  return text
```

```
train['text']  = train.text.apply(clean_txt)
train.head()
```

	text	label
2197	I had an old account through XXXX XXXX that wa...	4
4304	DUPLICATE XXXX ACCOUNT 890 00 Im confused and ...	5

```
from sklearn.model_selection import train_test_split
train, val = train_test_split(train, test_size=0.2, random_state=35)
train.head()
```

	text	label
4928	We have experienced several issues with this l...	10
5544	To Whom It May concern I am writing to dispute...	4
2633	On XX XX 2021 A Affidavit of Truth and Cease a...	5
8654	XX XX XXXX Resurgent Capital Services XXXX VAL...	5
410	Im having an issue with CitiCards When I make ...	3

```
train.reset_index(drop=True, inplace=True)
train.head(2)
```

	text	label
0	We have experienced several issues with this l...	10
1	To Whom It May concern I am writing to dispute...	4

```
val.reset_index(drop=True, inplace=True)
val.head(2)
```

	text	label
0	I am having a problem resolving an overpayment...	3
1	On XX XX XXXX I went to where I bank locally t...	1

```
val.shape, train.shape
```

```
((2743, 2), (10970, 2))
```

```
#Installing BERT module
!pip install bert-tensorflow==1.0.1
#bert-tensorflow==1.0.1
```

```
Requirement already satisfied: bert-tensorflow==1.0.1 in /usr/local/lib/python3.7/dist-
Requirement already satisfied: six in /usr/local/lib/python3.7/dist-packages (from bert
#Importing BERT modules
import bert
from bert import run_classifier
from bert import optimization
from bert import tokenization
```

Setting The Output Directory for BERT

```
# Set the output directory for saving model file
OUTPUT_DIR = '/bert_news_category'

#@markdown Whether or not to clear/delete the directory and create a new one
DO_DELETE = True #@param {type:"boolean"}

if DO_DELETE:
  try:
    tf.gfile.DeleteRecursively(OUTPUT_DIR)
  except:
    pass

tf.gfile.MakeDirs(OUTPUT_DIR)
print('***** Model output directory: {} *****'.format(OUTPUT_DIR))
```

Whether or not to clear/delete the directory and create a new one

DO_DELETE: ☑

```
     ***** Model output directory: /bert_news_category *****
```

```
print("Training Set Shape :", train.shape)
print("Validation Set Shape :", val.shape)
# print("Test Set Shape :", test.shape)
```

```
     Training Set Shape : (10970, 2)
     Validation Set Shape : (2743, 2)
```

```
DATA_COLUMN = 'text'
LABEL_COLUMN = 'label'
# The list containing all the classes (train['SECTION'].unique())
label_list = [x for x in np.unique(train.label)]
label_list
```

```
     [0, 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12]
```

Splitting the Data into smaller chunks

```
def get_split(text1):
  l_total = []
  l_parcial = []
  if len(text1.split())//150 >0:
    n = len(text1.split())//150
  else:
    n = 1
  for w in range(n):
    if w == 0:
      l_parcial = text1.split()[:200]
      l_total.append(" ".join(l_parcial))
    else:
      l_parcial = text1.split()[w*150:w*150 + 200]
      l_total.append(" ".join(l_parcial))
  return l_total

train['text_split'] = train[DATA_COLUMN].apply(get_split)
train.head()
```

	text	label	text_split
0	We have experienced several issues with this I...	10	[We have experienced several issues with this ...
1	To Whom It May concern I am writing to dispute...	4	[To Whom It May concern I am writing to disput...
2	On XX XX 2021 A Affidavit of Truth and Cease a...	5	[On XX XX 2021 A Affidavit of Truth and Cease ...
[illegible]	XX XX XXXX Resurgent Capital Services	[illegible]	[XX XX XXXX Resurgent Capital Services

```
val['text_split'] = val[DATA_COLUMN].apply(get_split)
val.head(2)
```

	text	label	text_split
0	I am having a problem resolving an overpayment...	3	[I am having a problem resolving an overpaymen...
1	On XX XX XXXX I went to where I bank	1	[On XX XX XXXX I went to where I bank

```
train_l = []
label_l = []
index_l =[]
for idx,row in train.iterrows():
  for l in row['text_split']:
    train_l.append(l)
    label_l.append(row['label'])
    index_l.append(idx)
len(train_l), len(label_l), len(index_l)
```

```
     (30322, 30322, 30322)
```

```
val_l = []
val_label_l = []
val_index_l = []
for idx,row in val.iterrows():
  for l in row['text_split']:
    val_l.append(l)
    val_label_l.append(row['label'])
    val_index_l.append(idx)
len(val_l), len(val_label_l), len(val_index_l)
```

```
(7390, 7390, 7390)
```

The final dataset for training:

```
train_df = pd.DataFrame({DATA_COLUMN:train_l, LABEL_COLUMN:label_l})
train_df.head()
```

	text	label
0	We have experienced several issues with this l...	10
1	completed some notarized papers that I have no...	10
2	To Whom It May concern I am writing to dispute...	4
3	On XX XX 2021 A Affidavit of Truth and Cease a...	5
4	1692d 1 Upon further research and discovery I ...	5

```
val_df = pd.DataFrame({DATA_COLUMN:val_l, LABEL_COLUMN:val_label_l})
val_df.head()
```

	text	label
0	I am having a problem resolving an overpayment...	3
1	On XX XX XXXX I went to where I bank locally t...	1
2	XXXX XXXX know that I was not going to stay wi...	1
3	Their customer service rep confirmed they had ...	1
4	On XXXX XXXX XXXX a collection agency operatin...	1

BERT: Data Preprocessing

Process the data for BERT

```
train_InputExamples = train_df.apply(lambda x: bert.run_classifier.InputExample(guid=None,
                                                                   text_a = x[DATA_COLUMN],
                                                                   text_b = None,
                                                                   label = x[LABEL_COLUMN]),

val_InputExamples = val_df.apply(lambda x: bert.run_classifier.InputExample(guid=None,
                                                                   text_a = x[DATA_COLUMN],
                                                                   text_b = None,
                                                                   label = x[LABEL_COLUMN]),
```

```
train_InputExamples
```

```
0        <bert.run_classifier.InputExample object at 0x...
1        <bert.run_classifier.InputExample object at 0x...
2        <bert.run_classifier.InputExample object at 0x...
3        <bert.run_classifier.InputExample object at 0x...
4        <bert.run_classifier.InputExample object at 0x...
                                ...
30317    <bert.run_classifier.InputExample object at 0x...
30318    <bert.run_classifier.InputExample object at 0x...
30319    <bert.run_classifier.InputExample object at 0x...
30320    <bert.run_classifier.InputExample object at 0x...
30321    <bert.run_classifier.InputExample object at 0x...
Length: 30322, dtype: object
```

```
print("Row 0 - guid of training set : ", train_InputExamples.iloc[0].guid)
print("\n__________\nRow 0 - text_a of training set : ", train_InputExamples.iloc[0].text_a)
print("\n__________\nRow 0 - text_b of training set : ", train_InputExamples.iloc[0].text_b)
print("\n__________\nRow 0 - label of training set : ", train_InputExamples.iloc[0].label)
```

```
Row 0 - guid of training set :  None

__________
Row 0 - text_a of training set :  We have experienced several issues with this lender m

__________
Row 0 - text_b of training set :  None

__________
Row 0 - label of training set :  10
```

BERT: Loading the pre-trained model

```
# This is a path to an uncased (all lowercase) version of BERT
BERT_MODEL_HUB = "https://tfhub.dev/google/bert_uncased_L-12_H-768_A-12/1"
```

```
def create_tokenizer_from_hub_module():
  """Get the vocab file and casing info from the Hub module."""
  with tf.Graph().as_default():
    bert_module = hub.Module(BERT_MODEL_HUB)
    tokenization_info = bert_module(signature="tokenization_info", as_dict=True)
    with tf.Session() as sess:
      vocab_file, do_lower_case = sess.run([tokenization_info["vocab_file"],
                                            tokenization_info["do_lower_case"]])

  return bert.tokenization.FullTokenizer(
      vocab_file=vocab_file, do_lower_case=do_lower_case)

tokenizer = create_tokenizer_from_hub_module()
```

```
len(tokenizer.vocab.keys())
```

```
30522
```

```
#Here is what the tokenised sample of the first training set observation looks like
print(tokenizer.tokenize(train_InputExamples.iloc[0].text_a))
```

```
['we', 'have', 'experienced', 'several', 'issues', 'with', 'this', 'lend', '##er', 'mos
```

```
MAX_SEQ_LENGTH = 200
```

```
# Convert our train and validation features to InputFeatures that BERT understands.
train_features = bert.run_classifier.convert_examples_to_features(train_InputExamples, label_

val_features = bert.run_classifier.convert_examples_to_features(val_InputExamples, label_list
```

```
#Example on first observation in the training set
print("Sentence : ", train_InputExamples.iloc[0].text_a)
print("-"*30)
print("Tokens : ", tokenizer.tokenize(train_InputExamples.iloc[0].text_a))
print("-"*30)
print("Input IDs : ", train_features[0].input_ids)
print("-"*30)
print("Input Masks : ", train_features[0].input_mask)
print("-"*30)
print("Segment IDs : ", train_features[0].segment_ids)
```

```
Sentence :  We have experienced several issues with this lender mostly with communicati
------------------------------
Tokens :  ['we', 'have', 'experienced', 'several', 'issues', 'with', 'this', 'lend', '#
------------------------------
Input IDs :  [101, 2057, 2031, 5281, 2195, 3314, 2007, 2023, 18496, 2121, 3262, 2007, 4
------------------------------
```

```
Input Masks :  [1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
------------------------------
Segment IDs :  [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
```

BERT: Creating A Multi-Class Classifier Model

```
def create_model(is_predicting, input_ids, input_mask, segment_ids, labels,
                 num_labels):

  bert_module = hub.Module(
      BERT_MODEL_HUB,
      trainable=True)
  bert_inputs = dict(
      input_ids=input_ids,
      input_mask=input_mask,
      segment_ids=segment_ids)
  bert_outputs = bert_module(
      inputs=bert_inputs,
      signature="tokens",
      as_dict=True)

  # Use "pooled_output" for classification tasks on an entire sentence.
  # Use "sequence_outputs" for token-level output.
  output_layer = bert_outputs["pooled_output"]
  # with tf.Session() as sess:
  output_layer1 = bert_outputs["pooled_output"]
  # output_layer1 = 999
  hidden_size = output_layer.shape[-1].value

  # Create our own layer to tune for politeness data.
  output_weights = tf.get_variable(
      "output_weights", [num_labels, hidden_size],
      initializer=tf.truncated_normal_initializer(stddev=0.02))

  output_bias = tf.get_variable(
      "output_bias", [num_labels], initializer=tf.zeros_initializer())

  with tf.variable_scope("loss"):

    # Dropout helps prevent overfitting
    output_layer = tf.nn.dropout(output_layer, keep_prob=0.8)

    logits = tf.matmul(output_layer, output_weights, transpose_b=True)
    logits = tf.nn.bias_add(logits, output_bias)
    log_probs = tf.nn.log_softmax(logits, axis=-1)

    # Convert labels into one-hot encoding
    one_hot_labels = tf.one_hot(labels, depth=num_labels, dtype=tf.float32)

    predicted_labels = tf.squeeze(tf.argmax(log_probs, axis=-1, output_type=tf.int32))
    # If we're predicting, we want predicted labels and the probabiltiies.
    if is_predicting:
      return (predicted_labels, log_probs, output_layer1)

    # If we're train/eval, compute loss between predicted and actual label
    per_example_loss = -tf.reduce_sum(one_hot_labels * log_probs, axis=-1)
    loss = tf.reduce_mean(per_example_loss)
    return (loss, predicted_labels, log_probs)


def model_fn_builder(num_labels, learning_rate, num_train_steps,
                     num_warmup_steps):
  """Returns `model_fn` closure for TPUEstimator."""
  def model_fn(features, labels, mode, params):  # pylint: disable=unused-argument
    """The `model_fn` for TPUEstimator."""

    input_ids = features["input_ids"]
    input_mask = features["input_mask"]
    segment_ids = features["segment_ids"]
    label_ids = features["label_ids"]

    is_predicting = (mode == tf.estimator.ModeKeys.PREDICT)

    # TRAIN and EVAL
    if not is_predicting:

      (loss, predicted_labels, log_probs) = create_model(
        is_predicting, input_ids, input_mask, segment_ids, label_ids, num_labels)

      train_op = bert.optimization.create_optimizer(
          loss, learning_rate, num_train_steps, num_warmup_steps, use_tpu=False)

      # Calculate evaluation metrics.
      def metric_fn(label_ids, predicted_labels):
        accuracy = tf.metrics.accuracy(label_ids, predicted_labels)
        true_pos = tf.metrics.true_positives(
            label_ids,
            predicted_labels)
        true_neg = tf.metrics.true_negatives(
            label_ids,
            predicted_labels)
        false_pos = tf.metrics.false_positives(
            label_ids,
            predicted_labels)
        false_neg = tf.metrics.false_negatives(
            label_ids,
            predicted_labels)

        return {
```

```
      "eval_accuracy": accuracy,
      "true_positives": true_pos,
      "true_negatives": true_neg,
      "false_positives": false_pos,
      "false_negatives": false_neg,
      }

   eval_metrics = metric_fn(label_ids, predicted_labels)

   if mode == tf.estimator.ModeKeys.TRAIN:
    return tf.estimator.EstimatorSpec(mode=mode,
     loss=loss,
     train_op=train_op)
   else:
     return tf.estimator.EstimatorSpec(mode=mode,
      loss=loss,
      eval_metric_ops=eval_metrics)
  else:
   (predicted_labels, log_probs, output_layer) = create_model(
    is_predicting, input_ids, input_mask, segment_ids, label_ids, num_labels)
   predictions = {
     'probabilities': log_probs,
     'labels': predicted_labels,
     'pooled_output': output_layer
   }
   return tf.estimator.EstimatorSpec(mode, predictions=predictions)

 # Return the actual model function in the closure
 return model_fn



BATCH_SIZE = 16
LEARNING_RATE = 2e-5
NUM_TRAIN_EPOCHS = 1.0
# Warmup is a period of time where the learning rate is small and gradually increases--usuall
WARMUP_PROPORTION = 0.1
# Model configs
SAVE_CHECKPOINTS_STEPS = 300
SAVE_SUMMARY_STEPS = 100

# Compute train and warmup steps from batch size
num_train_steps = int(len(train_features) / BATCH_SIZE * NUM_TRAIN_EPOCHS)
num_warmup_steps = int(num_train_steps * WARMUP_PROPORTION)

# Specify output directory and number of checkpoint steps to save
run_config = tf.estimator.RunConfig(
    model_dir=OUTPUT_DIR,
    save_summary_steps=SAVE_SUMMARY_STEPS,
    save_checkpoints_steps=SAVE_CHECKPOINTS_STEPS)

# Specify output directory and number of checkpoint steps to save
```

```
run_config = tf.estimator.RunConfig(
    model_dir=OUTPUT_DIR,
    save_summary_steps=SAVE_SUMMARY_STEPS,
    save_checkpoints_steps=SAVE_CHECKPOINTS_STEPS)
```

```
num_train_steps, len(label_list)
```

```
(1895, 12)
```

```
#Initializing the model and the estimator
model_fn = model_fn_builder(
  num_labels=len(label_list),
  learning_rate=LEARNING_RATE,
  num_train_steps=num_train_steps,
  num_warmup_steps=num_warmup_steps)

estimator = tf.estimator.Estimator(
  model_fn=model_fn,
  config=run_config,
  params={"batch_size": BATCH_SIZE})
```

```
# Create an input function for training. drop_remainder = True for using TPUs.
train_input_fn = bert.run_classifier.input_fn_builder(
    features=train_features,
    seq_length=MAX_SEQ_LENGTH,
    is_training=True,
    drop_remainder=False)

# Create an input function for validating. drop_remainder = True for using TPUs.
val_input_fn = run_classifier.input_fn_builder(
    features=val_features,
    seq_length=MAX_SEQ_LENGTH,
    is_training=False,
    drop_remainder=False)
```

BERT: Fine Tuning Training & Evaluating

```
#Training the model
print(f'Beginning Training!')
current_time = datetime.now()
estimator.train(input_fn=train_input_fn, max_steps=num_train_steps)
print("Training took time ", datetime.now() - current_time)
```

```
Beginning Training!
```

```
/tensorflow-1.15.2/python3.7/tensorflow_core/python/framework/indexed_slices.py:424: Us
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
Training took time  0:14:34.116648
```

The accuracy for the fine tuned BERT model

```
#Evaluating the model with Validation set
estimator.evaluate(input_fn=val_input_fn, steps=None)
```

```
/tensorflow-1.15.2/python3.7/tensorflow_core/python/framework/indexed_slices.py:424: Us
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
{'eval_accuracy': 0.79418135,
 'false_negatives': 0.0,
 'false_positives': 7.0,
 'global_step': 1895,
 'loss': 0.6375007,
 'true_negatives': 0.0,
 'true_positives': 7383.0}
```

BERT: Get The Vector Transformations from the Fine Tuned BERT

```
# A method to get predictions
def getPrediction(in_sentences, type_output = "features"):
  #A list to map the actual labels to the predictions
  labels = np.unique(train['label'])
  input_examples = [run_classifier.InputExample(guid="", text_a = x, text_b = None, label = 0
  input_features = run_classifier.convert_examples_to_features(input_examples, label_list, MA
  #Predicting the classes
  predict_input_fn = run_classifier.input_fn_builder(features=input_features, seq_length=MAX_
  predictions = estimator.predict(predict_input_fn)
  if type_output == "features":
    return [prediction['pooled_output'] for _,prediction in enumerate(predictions) ]
  else:
    return ([(sentence, prediction['probabilities'],
              prediction['labels'], labels[prediction['labels']]) for sentence, prediction in
```

```
tf.compat.v1.logging.set_verbosity(tf.logging.ERROR)
MAX_SEQ_LENGTH
```

```
200
```

```
train_df.shape, val_df.shape
```

```
((30322, 2), (7390, 2))
```

Now extracting the representations:

```
%%time
tr_emb = np.apply_along_axis(getPrediction, 0,np.array(train_df[DATA_COLUMN]))
```

```
CPU times: user 2min 31s, sys: 4.65 s, total: 2min 36s
Wall time: 6min 1s
```

```
%%time
val_emb = np.apply_along_axis(getPrediction, 0,np.array(val_df[DATA_COLUMN]))
val_emb.shape
```

```
CPU times: user 40.2 s, sys: 1.17 s, total: 41.3 s
Wall time: 1min 31s
```

```
val_emb.shape, tr_emb.shape
```

```
((7390, 768), (30322, 768))
```

and make the dataset for train and val:

```
aux = -1
len_l = 0
train_x = {}
for l, emb in zip(index_l, tr_emb):
  if l in train_x.keys():
    train_x[l]  =np.vstack([train_x[l], emb])
  else:
    train_x[l] = [emb]

len(train_x.keys())
```

```
10970
```

```
train_l_final = []
label_l_final = []
for k in train_x.keys():
  train_l_final.append(train_x[k])
  label_l_final.append(train.loc[k]['label'])

df_train = pd.DataFrame({'emb': train_l_final, 'label': label_l_final, })
df_train.head()
```

	emb	label
0	[[0.555614, -0.7043642, 0.23884456, -0.5593068...	10
1	[[0.57215804, 0.85315824, -0.3633562, -0.00601...	4
2	[[0.95516443, 0.3570898, 0.38249183, -0.696083...	5
3	[[0.8143069, 0.5722994, 0.72764134, -0.2403974...	5
4	[[0.370654, 0.9129017, 0.21963412, 0.58426046,...	3

```
aux = -1
len_l = 0
val_x = {}

for l, emb in zip(val_index_l, val_emb):
  if l in val_x.keys():
    val_x[l]  =np.vstack([val_x[l], emb])
  else:
    val_x[l] = [emb]


val_l_final = []
vlabel_l_final = []
for k in val_x.keys():
  val_l_final.append(val_x[k])
  vlabel_l_final.append(val.loc[k]['label'])

df_val = pd.DataFrame({'emb': val_l_final, 'label': vlabel_l_final})
df_val.head()
```

	emb	label
0	[[-0.031965405, 0.92160696, -0.15463464, 0.743...	3
1	[[0.44059056, -0.37587383, -0.91872317, 0.7310...	1
2	[[0.9297317, 0.09239787, -0.68322265, 0.116566...	1
3	[[-0.15868287, 0.8691171, 0.16583857, 0.785978...	3
4	[[0.14659342, 0.9458528, 0.020829953, 0.564531...	3

```
df_val, df_test = train_test_split(df_val, test_size=0.4, random_state=35)
```

LSTM: Creating the Final Model

```
from keras import layers
text_input = Input(shape=(None,768,), dtype='float32', name='text')

l_mask = layers.Masking(mask_value=-99.)(text_input)
# Which we encoded in a single vector via a LSTM
encoded_text = layers.LSTM(100,)(l_mask)
out_dense = layers.Dense(30, activation='relu')(encoded_text)
# And we add a softmax classifier on top
out = layers.Dense(len(label_list), activation='softmax')(out_dense)
# At model instantiation, we specify the input and the output:
model = Model(text_input, out)
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['acc'])
model.summary()
```

```
Model: "model_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
text (InputLayer)            (None, None, 768)         0
_________________________________________________________________
masking_2 (Masking)          (None, None, 768)         0
_________________________________________________________________
lstm_2 (LSTM)                (None, 100)               347600
_________________________________________________________________
dense_3 (Dense)              (None, 30)                3030
_________________________________________________________________
dense_4 (Dense)              (None, 12)                372
=================================================================
Total params: 351,002
Trainable params: 351,002
Non-trainable params: 0
_________________________________________________________________
```

```
df_train.shape, df_val.shape, df_test.shape
```

```
((10970, 2), (1645, 2), (1098, 2))
```

The generator functions:

```
num_sequences = len(df_train['emb'].to_list())
batch_size = 5
batches_per_epoch =  2194
assert batch_size * batches_per_epoch == num_sequences
num_features= 768
def train_generator(df):
    x_list= df['emb'].to_list()
    y_list =  df.label.to_list()
    # Generate batches
    while True:
        for b in range(batches_per_epoch):
            longest_index = (b + 1) * batch_size - 1
            timesteps = len(max(df['emb'].to_list()[:(b + 1) * batch_size][-batch_size:], key
            x_train = np.full((batch_size, timesteps, num_features), -99.)
            y_train = np.zeros((batch_size,  1))
            for i in range(batch_size):
                li = b * batch_size + i
                x_train[i, 0:len(x_list[li]), :] = x_list[li]
                y_train[i] = y_list[li]
            yield x_train, y_train

num_sequences_val = len(df_val['emb'][:1639].to_list())
batch_size_val = 11
batches_per_epoch_val = 149
assert batch_size_val * batches_per_epoch_val == num_sequences_val
num_features= 768
def val_generator(df):
    x_list= df['emb'].to_list()
    y_list =  df.label.to_list()
    # Generate batches
    while True:
        for b in range(batches_per_epoch_val):
            longest_index = (b + 1) * batch_size_val - 1
            timesteps = len(max(df['emb'].to_list()[:(b + 1) * batch_size_val][-31:], key=len
            # print(len(df_train['emb'].to_list()[:b+batch_size][-7:]))
            x_train = np.full((batch_size_val, timesteps, num_features), -99.)
            y_train = np.zeros((batch_size_val,  1))
            for i in range(batch_size_val):
                li = b * batch_size_val + i
                # print("li", li)
                # print(x_train[i, 0:len(x_list[li]), :].shape, len(x_list[li]))
                x_train[i, 0:len(x_list[li]), :] = x_list[li]
                y_train[i] = y_list[li]
            yield x_train, y_train
```

LSTM Final Model: Training

```
from keras.callbacks import ReduceLROnPlateau
call_reduce = ReduceLROnPlateau(monitor='val_acc', factor=0.95, patience=3, verbose=2,
                                mode='auto', min_delta=0.01, cooldown=0, min_lr=0)
```

```
model.fit_generator(train_generator(df_train), steps_per_epoch=batches_per_epoch, epochs=10,
                    validation_data=val_generator(df_val), validation_steps=batches_per_epoch
```

```
Epoch 1/10
2194/2194 [==============================] - 16s 7ms/step - loss: nan - acc: 7.2926e-04
Epoch 2/10
2194/2194 [==============================] - 15s 7ms/step - loss: nan - acc: 3.6463e-04
```

```
Epoch 3/10
2194/2194 [==============================] - 15s 7ms/step - loss: nan - acc: 3.6463e-04
Epoch 4/10
2194/2194 [==============================] - 15s 7ms/step - loss: nan - acc: 3.6463e-04

Epoch 00004: ReduceLROnPlateau reducing learning rate to 0.0009500000451225787.
Epoch 5/10
2194/2194 [==============================] - 15s 7ms/step - loss: nan - acc: 3.6463e-04
Epoch 6/10
2194/2194 [==============================] - 15s 7ms/step - loss: nan - acc: 3.6463e-04
Epoch 7/10
2194/2194 [==============================] - 15s 7ms/step - loss: nan - acc: 3.6463e-04

Epoch 00007: ReduceLROnPlateau reducing learning rate to 0.0009025000152178108.
Epoch 8/10
2194/2194 [==============================] - 15s 7ms/step - loss: nan - acc: 3.6463e-04
Epoch 9/10
2194/2194 [==============================] - 15s 7ms/step - loss: nan - acc: 3.6463e-04
Epoch 10/10
2194/2194 [==============================] - 15s 7ms/step - loss: nan - acc: 3.6463e-04

Epoch 00010: ReduceLROnPlateau reducing learning rate to 0.0008573750033974647.
<keras.callbacks.callbacks.History at 0x7f25d1fbc450>
```

LSTM Final Model: Evaluation

```
num_sequences_val = len(df_test['emb'].to_list())
batch_size_val = 6
batches_per_epoch_val = 183
assert batch_size_val * batches_per_epoch_val == num_sequences_val
num_features= 768
model.evaluate_generator(val_generator(df_test), steps= batches_per_epoch_val)
```

```
[nan, 0.0]
```