Problem statement

- Given review, we need to classify them as positive or negative.
- For this problem we are going to get sentence embedding(review embedding) using Pretrained BERT model and then using that review vector we are going to build Neural Network model for the binary classification task...

In [2]:

```
# mounted my Google Drive in colab
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_r
emount=True).
```

In [6]:

```
#all imports
import numpy as np
import pandas as pd
import tensorflow as tf
import tensorflow_hub as hub
from tensorflow.keras.models import Model
import matplotlib.pyplot as plt
```

In [7]:

```
tf.test.gpu_device_name()
```

Out[7]:

```
'/device:GPU:0'
```

In [8]:

```
!cp -r "/content/drive/MyDrive/NLP transfer learning/Copy of Reviews.csv" "/content"
```

In [9]:

```
!cp -r "/content/drive/MyDrive/NLP transfer learning/Copy of tokenization.py" "/content"
```

Part-1: Preprocessing

In [11]:

```
#Read the dataset - Amazon fine food reviews
reviews = pd.read_csv(r"Copy of Reviews.csv")
#check the info of the dataset
reviews.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 568454 entries, 0 to 568453
Data columns (total 10 columns):
 #   Column                  Non-Null Count   Dtype
---  ------                  --------------   -----
 0   Id                      568454 non-null  int64
 1   ProductId               568454 non-null  object
 2   UserId                  568454 non-null  object
 3   ProfileName             568438 non-null  object
 4   HelpfulnessNumerator    568454 non-null  int64
 5   HelpfulnessDenominator  568454 non-null  int64
 6   Score                   568454 non-null  int64
 7   Time                    568454 non-null  int64
 8   Summary                 568427 non-null  object
 9   Text                    568454 non-null  object
dtypes: int64(5), object(5)
memory usage: 43.4+ MB
```

In [12]:

```
#get only 2 columns - Text, Score
#drop the NAN values
reviews = reviews[['Text', 'Score']]
reviews.dropna(subset=['Text', 'Score'], inplace=True)
```

In [13]:

```
#if score> 3, set score = 1
#if score<=2, set score = 0
#if score == 3, remove the rows.

# Replace values in the Score column
# Replace values in the Score column
reviews['Score'] = np.where(reviews['Score'] > 3, 1, np.where(reviews['Score'] <= 2, 0, reviews['Score']))

# Drop rows where Score is 3
reviews = reviews[reviews['Score'] != 3]
```

In [15]:

```
def get_wordlen(x):
    return len(x.split())
reviews['len'] = reviews.Text.apply(get_wordlen)
reviews = reviews[reviews.len<50]
reviews = reviews.sample(n=100000, random_state=30)
```

In [16]:

```
reviews.head(5)
```

Out[16]:

	Text	Score	len
64117	The tea was of great quality and it tasted lik...	1	30
418112	My cat loves this. The pellets are nice and s...	1	31
357829	Great product. Does not completely get rid of ...	1	41
175872	This gum is my favorite! I would advise every...	1	27
178716	I also found out about this product because of...	1	22

In [17]:

```
#remove HTML from the Text column and save in the Text column only
import re
from bs4 import BeautifulSoup

def remove_html(text):
    soup = BeautifulSoup(text, 'html.parser')
    return soup.get_text()

reviews['Text'] = reviews['Text'].apply(remove_html)
```

In [18]:

```
#print head 5
reviews.head(5)
```

Out[18]:

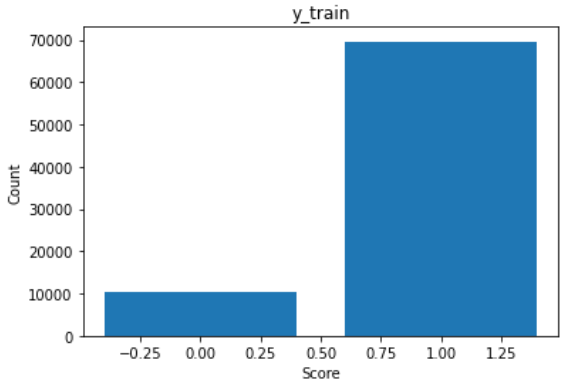
	Text	Score	len
64117	The tea was of great quality and it tasted lik...	1	30
418112	My cat loves this. The pellets are nice and s...	1	31
357829	Great product. Does not completely get rid of ...	1	41
175872	This gum is my favorite! I would advise every...	1	27
178716	I also found out about this product because of...	1	22

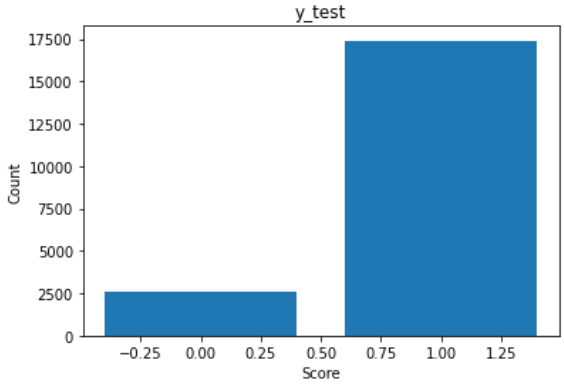
In [19]:

```
#split the data into train and test data(20%) with Stratify sampling, random state 33,
from sklearn.model_selection import train_test_split

# Split the data into train and test sets
X = reviews['Text']  # X will be the Text column
y = reviews['Score']  # y will be the Score column
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=33, stratify=y)
```

In [20]:

```
#plot bar graphs of y_train and y_test
import matplotlib.pyplot as plt

# Create a bar plot of y_train
plt.bar(y_train.value_counts().index, y_train.value_counts())
plt.xlabel('Score')
plt.ylabel('Count')
plt.title('y_train')
plt.show()

# Create a bar plot of y_test
plt.bar(y_test.value_counts().index, y_test.value_counts())
plt.xlabel('Score')
plt.ylabel('Count')
plt.title('y_test')
plt.show()
```





In [21]:

```
print(y_train.value_counts().index)
```

```
Int64Index([1, 0], dtype='int64')
```

In [22]:

```
#saving to disk. if we need, we can load preprocessed data directly.
reviews.to_csv('preprocessed.csv', index=False)
```

In [23]:

```
!cp -r "/content/preprocessed.csv"  "/content/drive/MyDrive/NLP transfer learning"
```

Part-2: Creating BERT Model

If you want to know more about BERT, You can watch live sessions on Transformers and BERt.
we will strongly recommend you to read Transformers (https://jalammar.github.io/illustrated-transformer/), BERT Paper (https://arxiv.org/abs/1810.04805) and, This blog (https://jalammar.github.io/a-visual-guide-to-using-bert-for-the-first-time/).

For this assignment, we are using BERT uncased Base model (https://tfhub.dev/tensorflow/bert_en_uncased_L-12_H-768_A-12/1).
It uses L=12 hidden layers (i.e., Transformer blocks), a hidden size of H=768, and A=12 attention heads.

In [24]:

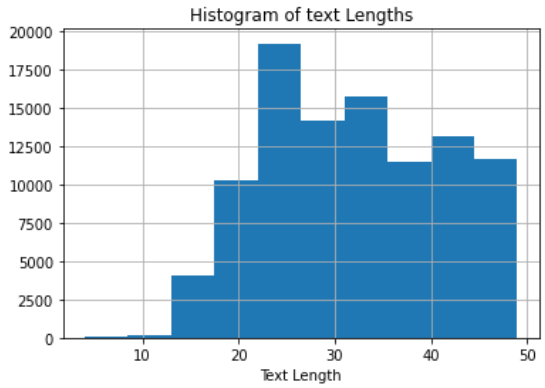
```
reviews['len']
```

Out[24]:

```
64117     30
418112    31
357829    41
175872    27
178716    22
          ..
336657    39
498034    28
357766    21
326811    23
19261     28
Name: len, Length: 100000, dtype: int64
```

In [25]:

```
# Plot the histogram
reviews['len'].hist()

# Add a title and x-axis label
plt.title('Histogram of text Lengths')
plt.xlabel('Text Length')

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



In [26]:

```
## Loading the Pretrained Model from tensorflow HUB
tf.keras.backend.clear_session()

# maximum length of a seq in the data we have, for now i am making it as 55. You can change this
max_seq_length = 55

#BERT takes 3 inputs

#this is input words. Sequence of words represented as integers
input_word_ids = tf.keras.layers.Input(shape=(max_seq_length,), dtype=tf.int32, name="input_word_ids")

#mask vector if you are padding anything
input_mask = tf.keras.layers.Input(shape=(max_seq_length,), dtype=tf.int32, name="input_mask")

#segment vectors. If you are giving only one sentence for the classification, total seg vector is 0.
#If you are giving two sentenced with [sep] token separated, first seq segment vectors are zeros and
#second seq segment vector are 1's
segment_ids = tf.keras.layers.Input(shape=(max_seq_length,), dtype=tf.int32, name="segment_ids")

#bert layer
bert_layer = hub.KerasLayer("https://tfhub.dev/tensorflow/bert_en_uncased_L-12_H-768_A-12/1", trainable=False)
pooled_output, sequence_output = bert_layer([input_word_ids, input_mask, segment_ids])

#Bert model
#We are using only pooled output(output at the CLS place) not sequence out.
#If you want to know about those, please read https://www.kaggle.com/questions-and-answers/86510
bert_model = Model(inputs=[input_word_ids, input_mask, segment_ids], outputs=pooled_output)
```

In [27]:

```
bert_model.summary()
```

```
Model: "model"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 input_word_ids (InputLayer)    [(None, 55)]         0           []

 input_mask (InputLayer)        [(None, 55)]         0           []

 segment_ids (InputLayer)       [(None, 55)]         0           []

 keras_layer (KerasLayer)       [(None, 768),        109482241   ['input_word_ids[0][0]',
                                 (None, 55, 768)]                  'input_mask[0][0]',
                                                                   'segment_ids[0][0]']

==================================================================================================
Total params: 109,482,241
Trainable params: 0
Non-trainable params: 109,482,241
__________________________________________________________________________________________________
```

In [28]:

```
bert_model.output
```

Out[28]:

```
<KerasTensor: shape=(None, 768) dtype=float32 (created by layer 'keras_layer')>
```

Part-3: Tokenization

In [29]:

```
#getting Vocab file
vocab_file = bert_layer.resolved_object.vocab_file.asset_path.numpy()
do_lower_case = bert_layer.resolved_object.do_lower_case.numpy()
```

In [30]:

```
!pip install sentencepiece
```

```
Looking in indexes: https://pypi.org/simple, (https://pypi.org/simple,) https://us-python.pkg.dev/colab-wheels/publ
ic/simple/ (https://us-python.pkg.dev/colab-wheels/public/simple/)
Requirement already satisfied: sentencepiece in /usr/local/lib/python3.8/dist-packages (0.1.97)
```

In [31]:

```
import tokenization  #We have given tokenization.py file
```

In [32]:

```
# Create tokenizer " Instantiate FullTokenizer"
# name must be "tokenizer"
# the FullTokenizer takes two parameters 1. vocab_file and 2. do_lower_case
# we have created these in the above cell ex: FullTokenizer(vocab_file, do_lower_case )
# please check the "tokenization.py" file the complete implementation
```

In [33]:

```
# if you are getting error for sentencepiece module you can install it using below command while running this cell for the first
#!pip install sentencepiece
tokenizer=tokenization.FullTokenizer(vocab_file,do_lower_case )
```

In [35]:

```
# Create train and test tokens (X_train_tokens, X_test_tokens) from (X_train, X_test) using Tokenizer and

# add '[CLS]' at start of the Tokens and '[SEP]' at the end of the tokens.

# maximum number of tokens is 55(We already given this to BERT layer above) so shape is (None, 55)

# if it is less than 55, add '[PAD]' token else truncate the tokens length.(similar to padding)

# Based on padding, create the mask for Train and Test ( 1 for real token, 0 for '[PAD]'),
# it will also same shape as input tokens (None, 55) save those in X_train_mask, X_test_mask

# Create a segment input for train and test. We are using only one sentence so all zeros. This shape will also (None, 55)

# type of all the above arrays should be numpy arrays

# after execution of this cell, you have to get
# X_train_tokens, X_train_mask, X_train_segment
# X_test_tokens, X_test_mask, X_test_segment
```

In [36]:

```
from tensorflow.keras.preprocessing.sequence import pad_sequences
```

In [37]:

```
# Create the input tokens for the train and test sets
X_train_tokens = []
X_train_mask=[]
X_train_segment=[]

X_test_tokens = []
X_test_mask=[]
X_test_segment=[]


for text in X_train:
  tokens = tokenizer.tokenize(text)
  if len(tokens)>max_seq_length-2:
    tokens=tokens[0:(max_seq_length-2)]
  tokens=['[CLS]',*tokens,'[SEP]']
  tokens = tokenizer.convert_tokens_to_ids(tokens)
  X_train_tokens.append(tokens)
  X_train_mask.append(np.array([1]*len(tokens)+[0]*(max_seq_length-len(tokens))))
  X_train_segment.append(np.array([0]*(max_seq_length)))
#X_train_tokens= X_train_tokens.numpy()



for text in X_test:
  tokens = tokenizer.tokenize(text)
  #print(len(text))
  if len(tokens)>max_seq_length-2:
    tokens=tokens[0:(max_seq_length-2)]
  tokens=['[CLS]',*tokens,'[SEP]']
  tokens = tokenizer.convert_tokens_to_ids(tokens)
  X_test_tokens.append(tokens)
  X_test_mask.append(np.array([1]*len(tokens)+[0]*(max_seq_length-len(tokens))))
  X_test_segment.append(np.array([0]*(max_seq_length)))
#X_test_tokens= X_test_tokens.numpy()


# Pad or truncate the input tokens so that they have a fixed length of max_seq_length
X_train_tokens = pad_sequences(X_train_tokens, maxlen=max_seq_length, truncating='post', padding='post')
X_test_tokens = pad_sequences(X_test_tokens, maxlen=max_seq_length, truncating='post', padding='post')
```

In [38]:

```
X_train_tokens[0]
```

Out[38]:

```
array([  101,  1045,  2018,  2196,  2699,  2023,  4435,  2077,  1010,
        2061,  1045,  2001,  5191,  2055,  1996,  3737,  1012,  2009,
       12595,  2307,  1012,  1037,  2200,  3835,  5744,  4138,  2440,
       14894,  1012,  2049,  2026,  2047,  5684,  3388,  1012,   102,
           0,     0,     0,     0,     0,     0,     0,     0,     0,
           0,     0,     0,     0,     0,     0,     0,     0,     0,
           0], dtype=int32)
```

In [39]:

```
X_train_mask=np.asarray(X_train_mask)       #converting list to numpy array
X_train_segment = np.asarray(X_train_segment)
X_test_mask=np.asarray(X_test_mask)
X_test_segment=np.asarray(X_test_segment)
```

Example

```
print("original sentance : \n", np.array(X_train.values[0].split()))
print("number of words: ", len(X_train.values[0].split()))
print('='*50)
tokens = tokenizer.tokenize(X_train.values[0])
# we need to do this "tokens = tokens[0:(max_seq_length-2)]" only when our len(tokens) is more than "max_seq_length - 2"
# we will consider only the tokens from 0 to max_seq_length-2
# if our len(tokens) are < max_seq_length-2, we don't need to do this
tokens = tokens[0:(max_seq_length-2)]
# we are doing that so that we can include the tokens [CLS] and [SEP] and make the whole sequence length == max_seq_length
tokens = ['[CLS]',*tokens,'[SEP]']
print("tokens are: \n", np.array(tokens))
print('='*50)
print("number of tokens :",len(tokens))
print("tokens replaced with the positional encoding :\n",np.array(tokenizer.convert_tokens_to_ids(tokens)))
print('='*50)
print("the mask array is : ", np.array([1]*len(tokens)+[0]*(max_seq_length-len(tokens))))
print('='*50)
print("the segment array is :",np.array([0]*max_seq_length))
print('='*50)
```

```
original sentance :
 ['I' 'had' 'never' 'tried' 'this' 'brand' 'before,' 'so' 'I' 'was'
 'worried' 'about' 'the' 'quality.' 'It' 'tasted' 'great.' 'A' 'very'
 'nice' 'smooth' 'rich' 'full' 'flavor.' 'Its' 'my' 'new' 'favoret.']
number of words:  28
==================================================
tokens are:
 ['[CLS]' 'i' 'had' 'never' 'tried' 'this' 'brand' 'before' ',' 'so' 'i'
 'was' 'worried' 'about' 'the' 'quality' '.' 'it' 'tasted' 'great' '.' 'a'
 'very' 'nice' 'smooth' 'rich' 'full' 'flavor' '.' 'its' 'my' 'new'
 'favor' '##et' '.' '[SEP]']
==================================================
number of tokens : 36
tokens replaced with the positional encoding :
 [  101  1045  2018  2196  2699  2023  4435  2077  1010  2061  1045  2001
  5191  2055  1996  3737  1012  2009 12595  2307  1012  1037  2200  3835
  5744  4138  2440 14894  1012  2049  2026  2047  5684  3388  1012   102]
==================================================
the mask array is :  [1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
==================================================
the segment array is : [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
==================================================
```

In [40]:

```
import pickle
```

In [41]:

```
##save all your results to disk so that, no need to run all again.
pickle.dump((X_train, X_train_tokens, X_train_mask, X_train_segment, y_train),open('train_data.pkl','wb'))
pickle.dump((X_test, X_test_tokens, X_test_mask, X_test_segment, y_test),open('test_data.pkl','wb'))
```

In [42]:

```
#!cp -r "/content/train_data.pkl" "/content/drive/MyDrive/NLP transfer learning"
#!cp -r "/content/test_data.pkl" "/content/drive/MyDrive/NLP transfer learning"
```

In [43]:

```
!cp -r "/content/drive/MyDrive/NLP transfer learning/train_data.pkl" "/content"
!cp -r "/content/drive/MyDrive/NLP transfer learning/test_data.pkl" "/content"
```

In [44]:

```
#you can load from disk
X_train, X_train_tokens, X_train_mask, X_train_segment, y_train = pickle.load(open("train_data.pkl", 'rb'))
X_test, X_test_tokens, X_test_mask, X_test_segment, y_test = pickle.load(open("test_data.pkl", 'rb'))
```

In [45]:

```
max_seq_length = 55
```

Part-4: Getting Embeddings from BERT Model

We already created the BERT model in the part-2 and input data in the part-3.
We will utlize those two and will get the embeddings for each sentence in the
Train and test data.

In [48]:

```
bert_model.input
```

Out[48]:

```
[<KerasTensor: shape=(None, 55) dtype=int32 (created by layer 'input_word_ids')>,
 <KerasTensor: shape=(None, 55) dtype=int32 (created by layer 'input_mask')>,
 <KerasTensor: shape=(None, 55) dtype=int32 (created by layer 'segment_ids')>]
```

In [49]:

```
bert_model.output
```

Out[49]:

```
<KerasTensor: shape=(None, 768) dtype=float32 (created by layer 'keras_layer')>
```

In [50]:

```
# get the train output, BERT model will give one output so save in
# X_train_pooled_output
#this cell will take some time to execute, make sure thay you have stable internet connection
X_train_pooled_output=bert_model.predict([X_train_tokens,X_train_mask,X_train_segment])
```

```
2500/2500 [==============================] - 307s 122ms/step
```

In [51]:

```
# get the test output, BERT model will give one output so save in
# X_test_pooled_output
X_test_pooled_output=bert_model.predict([X_test_tokens,X_test_mask,X_test_segment])
```

```
625/625 [==============================] - 78s 124ms/step
```

In [52]:

```
##save all your results to disk so that, no need to run all again.
pickle.dump((X_train_pooled_output, X_test_pooled_output),open('final_output.pkl','wb'))
```

In [53]:

```
!cp -r "/content/final_output.pkl" "/content/drive/MyDrive/NLP transfer learning"
```

In [54]:

```
#X_train_pooled_output, X_test_pooled_output= pickle.load(open('final_output.pkl', 'rb'))
```

In [55]:

```
X_test_pooled_output.shape
```

Out[55]:

```
(20000, 768)
```

Part-5: Training a NN with 768 features

Create a NN and train the NN.

1. **You have to use AUC as metric. Do not use tf.keras.metrics.AUC**
   You have to write custom code for AUC and print it at the end of each epoch
2. You can use any architecture you want.
3. You have to use tensorboard to log all your metrics and Losses. You have to send those logs.
4. Print the loss and metric at every epoch.
5. You have to submit without overfitting and underfitting.

In [57]:

```
##imports
from tensorflow.keras.layers import Input, Dense, Activation, Dropout, LSTM
from tensorflow.keras.models import Model
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers
from tensorflow.keras.callbacks import Callback
from sklearn.metrics import roc_auc_score
from keras.callbacks import Callback, EarlyStopping, ModelCheckpoint
from tensorflow.python.keras.callbacks import TensorBoard
import datetime
```

In [87]:

```
#AUC score
import tensorflow as tf
from sklearn.metrics import roc_auc_score

def auroc(y_true, y_pred):

  try:
    return tf.py_function(roc_auc_score, (y_true, y_pred), tf.double)
  except ValueError:
    pass
```

In [176]:

```
##create an Neural Network and train your model on X_train_pooled_output and y_train
# you can start as follows
input_layer=Input(shape=(X_train_pooled_output.shape[1],))
x = layers.Dense(128, activation='relu')(input_layer)
x = layers.Dropout(0.5)(x)
x = layers.Dense(128, activation='relu')(x)
x = layers.BatchNormalization()(x)
x = layers.Dropout(0.5)(x)
x = layers.Dense(128, activation='relu')(x)
x = layers.BatchNormalization()(x)
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(1, activation='sigmoid')(x)

model = keras.Model(inputs=input_layer, outputs=outputs)
```

In [62]:

```
#roc_callback(training_data=( X_train_pooled_output, y_train),validation_data=(X_test_pooled_output, y_test)),
```

In [177]:

```
logdir="/content/drive/MyDrive/NLP transfer learning/logs" + datetime.datetime.now().strftime("%Y%m%d-%H%M%S")
tensorboard = TensorBoard(log_dir=logdir)

filepath="/content/drive/MyDrive/NLP transfer learning"
checkpoint = ModelCheckpoint(filepath, monitor='val_auroc', verbose=1, save_best_only=True, mode='max')

earlystopping_1 = EarlyStopping(monitor='val_auroc', patience=10, verbose=1)

callbacks_list = [checkpoint,tensorboard,earlystopping_1]
```

In [178]:

```
# Compile the model
model.compile(optimizer='adam',
              loss='binary_crossentropy',
              metrics=[auroc])
```

In [179]:

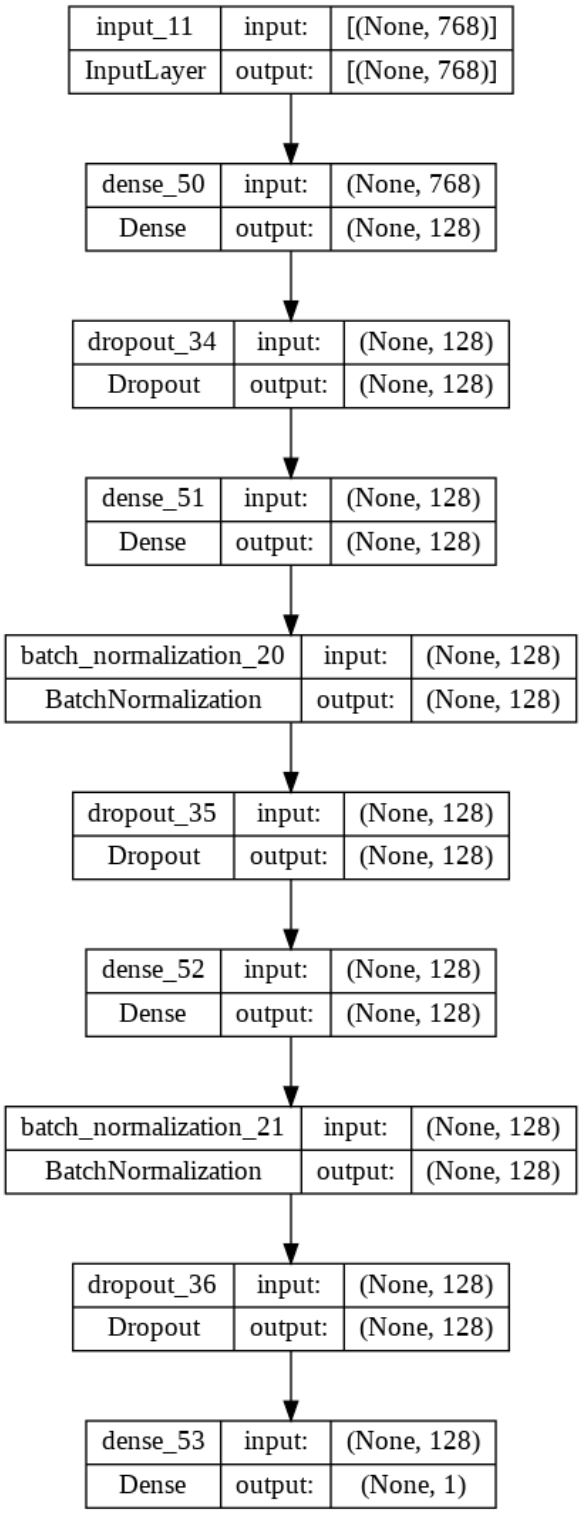
```
model.summary()
```

```
Model: "model_11"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_11 (InputLayer)       [(None, 768)]             0

 dense_50 (Dense)            (None, 128)               98432

 dropout_34 (Dropout)        (None, 128)               0

 dense_51 (Dense)            (None, 128)               16512

 batch_normalization_20 (Bat  (None, 128)              512
 chNormalization)

 dropout_35 (Dropout)        (None, 128)               0

 dense_52 (Dense)            (None, 128)               16512

 batch_normalization_21 (Bat  (None, 128)              512
 chNormalization)

 dropout_36 (Dropout)        (None, 128)               0

 dense_53 (Dense)            (None, 1)                 129

=================================================================
Total params: 132,609
Trainable params: 132,097
Non-trainable params: 512
_________________________________________________________________
```

In [180]:

```
#https://machinelearningmastery.com/visualize-deep-learning-neural-network-model-keras/
from keras.utils.vis_utils import plot_model
plot_model(model, to_file='/content/drive/MyDrive/NLP transfer learning/model.png', show_shapes=True, show_layer_names=True)
```

Out[180]:



In [181]:

```
model.fit( X_train_pooled_output, y_train.values,epochs=50, verbose=1, batch_size=128, validation_data=( X_test_pooled_output , y
```

```
Epoch 1/50
619/625 [============================>.] - ETA: 0s - loss: 0.5013 - auroc: 0.5024
Epoch 1: val_auroc improved from -inf to 0.58481, saving model to /content/drive/MyDrive/NLP transfer learning
625/625 [==============================] - 7s 10ms/step - loss: 0.5005 - auroc: 0.5027 - val_loss: 0.4000 - val_aur
oc: 0.5848
Epoch 2/50
618/625 [============================>.] - ETA: 0s - loss: 0.3985 - auroc: 0.5425
Epoch 2: val_auroc improved from 0.58481 to 0.80404, saving model to /content/drive/MyDrive/NLP transfer learning
625/625 [==============================] - 6s 10ms/step - loss: 0.3977 - auroc: 0.5438 - val_loss: 0.5350 - val_aur
oc: 0.8040
Epoch 3/50
619/625 [============================>.] - ETA: 0s - loss: 0.2969 - auroc: 0.8327
Epoch 3: val_auroc improved from 0.80404 to 0.93176, saving model to /content/drive/MyDrive/NLP transfer learning
625/625 [==============================] - 7s 11ms/step - loss: 0.2967 - auroc: 0.8330 - val_loss: 0.8022 - val_aur
oc: 0.9318
Epoch 4/50
620/625 [============================>.] - ETA: 0s - loss: 0.2563 - auroc: 0.8839
Epoch 4: val_auroc improved from 0.93176 to 0.93886, saving model to /content/drive/MyDrive/NLP transfer learning
625/625 [==============================] - 6s 10ms/step - loss: 0.2563 - auroc: 0.8840 - val_loss: 1.2042 - val_aur
oc: 0.9389
Epoch 5/50
625/625 [==============================] - ETA: 0s - loss: 0.2531 - auroc: 0.8795
Epoch 5: val_auroc improved from 0.93886 to 0.94109, saving model to /content/drive/MyDrive/NLP transfer learning
625/625 [==============================] - 7s 11ms/step - loss: 0.2531 - auroc: 0.8795 - val_loss: 0.5626 - val_aur
oc: 0.9411
Epoch 6/50
619/625 [============================>.] - ETA: 0s - loss: 0.2458 - auroc: 0.8875
Epoch 6: val_auroc improved from 0.94109 to 0.94353, saving model to /content/drive/MyDrive/NLP transfer learning
625/625 [==============================] - 6s 10ms/step - loss: 0.2456 - auroc: 0.8875 - val_loss: 0.7037 - val_aur
oc: 0.9435
Epoch 7/50
619/625 [============================>.] - ETA: 0s - loss: 0.2467 - auroc: 0.8862
Epoch 7: val_auroc improved from 0.94353 to 0.94371, saving model to /content/drive/MyDrive/NLP transfer learning
625/625 [==============================] - 6s 9ms/step - loss: 0.2464 - auroc: 0.8864 - val_loss: 1.4296 - val_auro
c: 0.9437
Epoch 8/50
618/625 [============================>.] - ETA: 0s - loss: 0.2459 - auroc: 0.8873
Epoch 8: val_auroc improved from 0.94371 to 0.94900, saving model to /content/drive/MyDrive/NLP transfer learning
625/625 [==============================] - 6s 10ms/step - loss: 0.2454 - auroc: 0.8877 - val_loss: 1.1045 - val_aur
oc: 0.9490
Epoch 9/50
621/625 [============================>.] - ETA: 0s - loss: 0.2390 - auroc: 0.8927
Epoch 9: val_auroc improved from 0.94900 to 0.94966, saving model to /content/drive/MyDrive/NLP transfer learning
625/625 [==============================] - 6s 10ms/step - loss: 0.2390 - auroc: 0.8928 - val_loss: 1.2340 - val_aur
oc: 0.9497
Epoch 10/50
625/625 [==============================] - ETA: 0s - loss: 0.2429 - auroc: 0.8886
Epoch 10: val_auroc did not improve from 0.94966
625/625 [==============================] - 4s 7ms/step - loss: 0.2429 - auroc: 0.8886 - val_loss: 1.4030 - val_auro
c: 0.9458
Epoch 11/50
623/625 [============================>.] - ETA: 0s - loss: 0.2410 - auroc: 0.8912
Epoch 11: val_auroc improved from 0.94966 to 0.95073, saving model to /content/drive/MyDrive/NLP transfer learning
625/625 [==============================] - 6s 9ms/step - loss: 0.2408 - auroc: 0.8913 - val_loss: 1.0915 - val_auro
c: 0.9507
Epoch 11: early stopping
```

Out[181]:

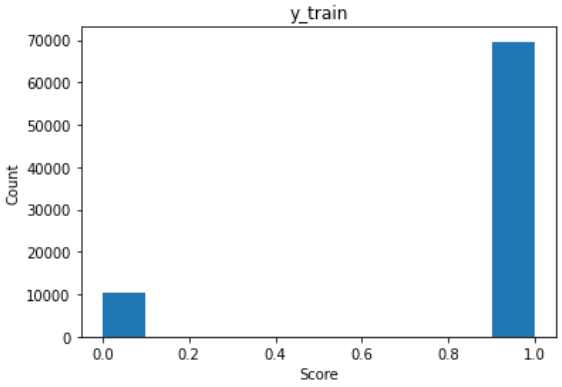
```
<keras.callbacks.History at 0x7efbdec519a0>
```

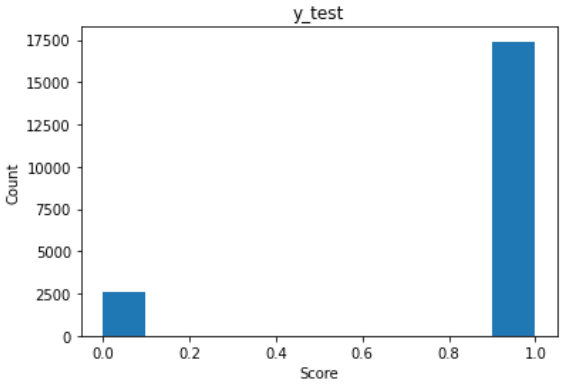
In [175]:

```
#model.reset_states()
```

In [145]:

```
import matplotlib.pyplot as plt

# Create a bar plot of y_train
plt.hist(y_train)
plt.xlabel('Score')
plt.ylabel('Count')
plt.title('y_train')
plt.show()

# Create a bar plot of y_test
plt.hist(y_test)
plt.xlabel('Score')
plt.ylabel('Count')
plt.title('y_test')
plt.show()
```





Part-6: Creating a Data pipeline for BERT Model

1. Pipeline is a way to codify and automate the workflow.
2. Download the test.csv file from here here (https://drive.google.com/file/d/1QwjqTsqTX2vdy7fTmeXjxP3dq8IAVLpo/view?usp=sharing)

In [ ]:

```
#there is an alterante way to load files from Google drive directly to your Colab session
# you can use gdown module to import the files as follows
#for example for test.csv you can write your code as !gdown --id file_id (remove the # from next line and run it)
```

In [133]:

```
from google.colab import files
uploaded = files.upload()
```

Choose Files No file chosen

Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

```
Saving test.csv to test.csv
```

In [182]:

```
#read the csv file
test_df= pd.read_csv('test.csv')
```

```
1. You have to write a function that takes the test_df,trained model and the required parameters as input.
2. Perform all the preproceesing steps inside the function.
- Remove all the html tags
- Now do tokenization [Part 3 as mentioned above]
- Create tokens,mask array and segment array
- Get Embeddings from BERT Model [Part 4 as mentioned above] , let it be X_test
- Print the shape of output(X_test.shape).You should get (352,768)
3. Predit the output of X_test with the neural network model which we trained earlier.

4. Return the occurences of class labels from the function.
The output should be the count of datapoints classified as 1 or 0.
```

In [183]:

```
test_df
```

Out[183]:

	Text
0	Just opened Greenies Joint Care (individually ...
1	This product rocks :) My mom was very happy w/...
2	The product was fine, but the cost of shipping...
3	I love this soup. It's great as part of a meal...
4	Getting ready to order again. These are great ...
...	...
347	Without a doubt this is by far the BEST beef g...
348	My 8 month old loves these. He hardly swallows...
349	the flavor palet for this coffee is deep and r...
350	This is the best granola my family has ever ha...
351	This tea and it's sister products from Numi gi...

352 rows × 1 columns

In [184]:

```
import tensorflow as tf
import pandas as pd
import numpy as np
from sklearn.preprocessing import LabelEncoder
from bs4 import BeautifulSoup
from tqdm import tqdm

def remove_html(text):
    soup = BeautifulSoup(text, 'html.parser')       #removing html tag
    return soup.get_text()



def get_class_count(test_df, model, max_seq_length=55):
  X_tests_tokens=[]
  X_tests_segment=[]
  X_tests_mask=[]

  # Preprocessing step(removing html tag)
  test_df['Text'] = test_df['Text'].apply(remove_html)

  # Tokenization
  for text in tqdm(test_df['Text']):
    tokens = tokenizer.tokenize(text)                       #tokenizing the text
    if len(tokens)>max_seq_length-2:
      tokens=tokens[0:(max_seq_length-2)]
    tokens=['[CLS]',*tokens,'[SEP]']                        #adding start and end token to the text
    tokens = tokenizer.convert_tokens_to_ids(tokens)        #converting tokens to ids
    X_tests_tokens.append(tokens)
    X_tests_mask.append(np.array([1]*len(tokens)+[0]*(max_seq_length-len(tokens))))          #creating mask for each text senten
    X_tests_segment.append(np.array([0]*(max_seq_length)))                                   #creating segment for each text sen

  X_tests_mask=np.asarray(X_tests_mask)
  X_tests_segment=np.asarray(X_tests_segment)


  # Adding padding and creating mask and segment arrays
  X_tests_tokens = pad_sequences(X_tests_tokens, maxlen=max_seq_length, truncating='post', padding='post')         #padding ids

  # Getting embeddings from BERT model
  X_tests_pooled_output = bert_model.predict([X_tests_tokens, X_tests_mask, X_tests_segment])                     #getting vecto

  # Printing shape of output
  print(X_tests_pooled_output.shape)

  # Predicting output using trained model
  y_pred = model.predict(X_tests_pooled_output)                                                                   #predicting th
  y_pred = np.where(y_pred >= 0.5, 1, 0)


  class_1_count = sum(y_pred)                                                                                     #counting the
  class_0_count = len(y_pred)- class_1_count

  return {'class_0_count': class_0_count, 'class_1_count': class_1_count}
```

In [187]:

```
result=get_class_count(test_df, model, max_seq_length=55)
```

```
100%|██████████| 352/352 [00:00<00:00, 1395.52it/s]

11/11 [==============================] - 1s 120ms/step
(352, 768)
11/11 [==============================] - 0s 3ms/step
```

In [188]:

```
result
```

Out[188]:

```
{'class_0_count': array([330]), 'class_1_count': array([22])}
```

Validation AUC of 95.07% is achieved in NN Model and for the given test.csv file we classified that 22 reviews belongs to class_1 and 330 review belongs to class_0

Summary

1)Preprocessing

- Data cleaning and preprocessing steps such as removing html tags,checking for null values were performed on the dataset.
- The dataset was split into training and testing sets.

2)Creating a BERT model from the Tensorflow HUB

- A BERT model was imported from the Tensorflow HUB and specified as the base model for the classification task.
- The model was configured with the appropriate input shape and output size.

3)Tokenization

- The BERT model was used to tokenize the text data in the dataset.
- Special tokens such as '[CLS]' and '[SEP]' were added to the tokenized data to indicate the start and end of a sequence.

4)Getting the pretrained embedding vector for a given review from the BERT

- The BERT model was used to generate the pretrained embedding vectors for each review in the dataset. The embedding vectors were generated by passing the tokenized review through the BERT model.

5)Using the embedding data to apply a NN and classify the reviews

- A neural network was trained on the embedding vectors and the corresponding labels in the dataset.
- The neural network was used to classify the reviews as positive or negative.

6)Creating a data pipeline for the BERT model

- A data pipeline was created to preprocess, tokenize, and generate embedding vectors for the reviews in the dataset.
- The data pipeline was used to feed the data into the neural network for classification