In [1]:
```
## Importing libraries
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

import pandas as pd
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
import seaborn as sns
import tensorflow as tf
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
from nltk.stem.porter import PorterStemmer

import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer

from gensim.models import Word2Vec
from gensim.models import KeyedVectors
import pickle

from tqdm import tqdm
import os

# from chart_studio.plotly import plotly
# import plotly.offline as offline
# import plotly.graph_objs as go
#offline.init_notebook_mode()
from collections import Counter
```

In [3]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

In [2]:
```
# !pip install tensorflow==1.15.0
# !pip install keras==2.3.1
# # import tensorflow
# tensorflow.__version__
```

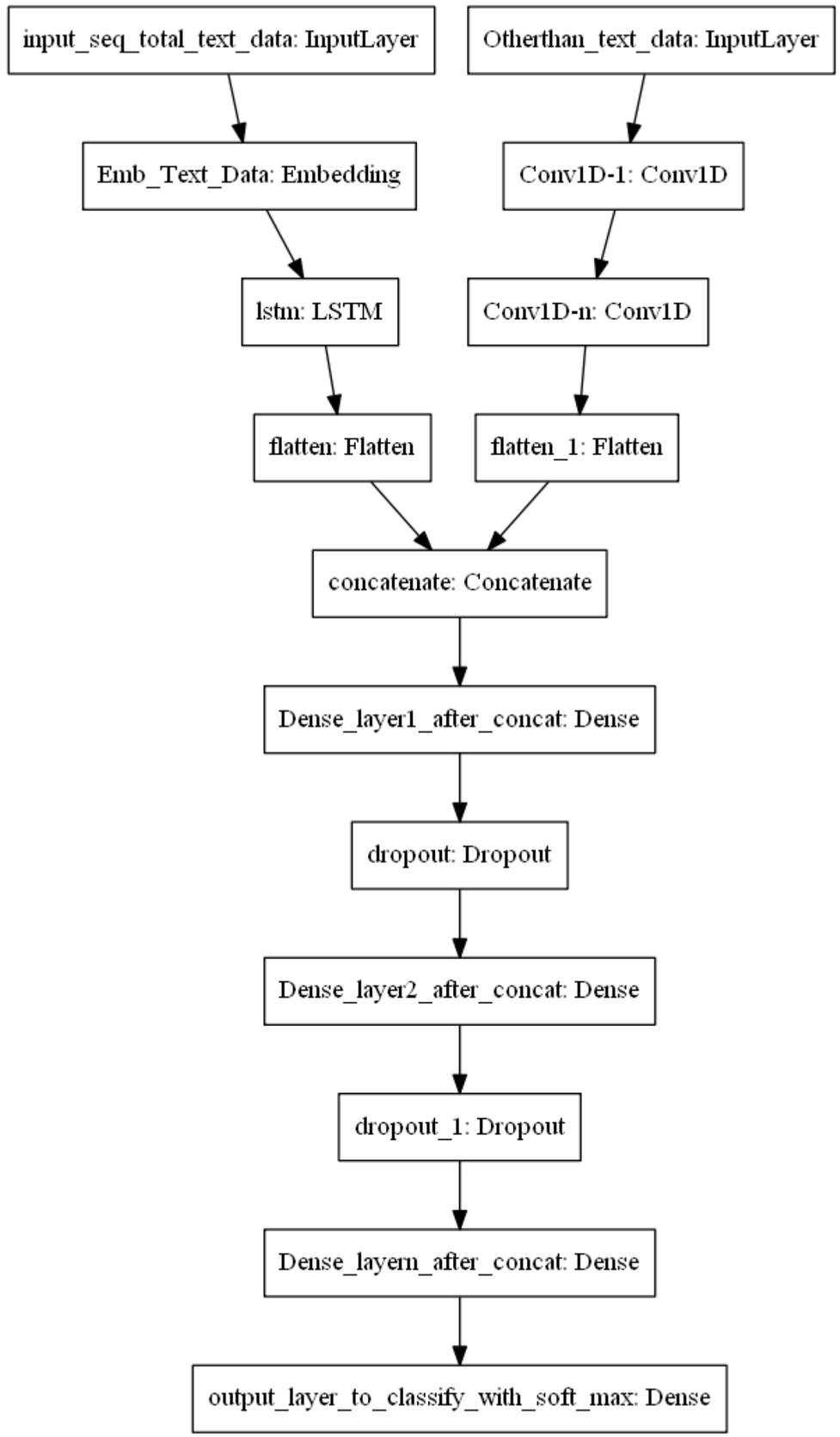
In [5]:
```
# !cp -r '/content/drive/My Drive/LSTM_preprocessed/model1/processed_data_split.h2' '/content/'
# !cp -r '/content/drive/My Drive/LSTM_preprocessed/model1/model_inputs.pkl' '/content/'
# !cp -r '/content/drive/My Drive/LSTM_preprocessed/model1/model_input_cat_lables.pkl' '/content/'
# !cp -r  '/content/drive/My Drive/_datasets/glove_vectors' '/content/'
```

In [6]:
```
## Load data after split
x_train = pd.read_hdf('processed_data_split.h2', 'x_train',mode='r')
x_test = pd.read_hdf('processed_data_split.h2', 'x_test',mode='r')
x_cv = pd.read_hdf('processed_data_split.h2', 'x_cv',mode='r')
y_train =pd.read_hdf('processed_data_split.h2', 'y_train',mode='r')
y_test =pd.read_hdf('processed_data_split.h2', 'y_test',mode='r')
y_cv =pd.read_hdf('processed_data_split.h2', 'y_cv',mode='r')
print('*'*50)
print(' Successfully loaded processed split data')
emd_i,embedding_matrix,seq_x_train,seq_x_test,seq_x_cv,padseq_x_train,sklstate_train,proj_grade_train,train_categories,train_subcategories,teacher_prefix_train,numerical_tra
print('*'*50)
print(' Successfully loaded model input variables')
y_train_cat,y_test_cat,y_cv_cat = pickle.load(open('model_input_cat_lables.pkl', 'rb'))
print('*'*50)
print('Successfully loaded split y labels')
```

```
**************************************************
 Successfully loaded processed split data
**************************************************
 Successfully loaded model input variables
**************************************************
Successfully loaded split y labels
```

In [12]:
```
vocab_size = embedding_matrix.shape[0]
```

## Model-3


input_seq_total_text_data: InputLayer
Otherthan_text_data: InputLayer
Emb_Text_Data: Embedding
Conv1D-1: Conv1D
lstm: LSTM
Conv1D-n: Conv1D
flatten: Flatten
flatten_1: Flatten
concatenate: Concatenate
Dense_layer1_after_concat: Dense
dropout: Dropout
Dense_layer2_after_concat: Dense
dropout_1: Dropout
Dense_layern_after_concat: Dense
output_layer_to_classify_with_soft_max: Dense

ref: https://i.imgur.com/fkQ8nGo.png

- **input_seq_total_text_data**:

    . Use text column('essay'), and use the Embedding layer to get word vectors.

    . Use given predefined glove word vectors, don't train any word vectors.

    . Use LSTM that is given above, get the LSTM output and Flatten that output.

    . You are free to preprocess the input text as you needed.

- **Other_than_text_data**:

    . Convert all your Categorical values to onehot coded and then concatenate all these onehot vectors

    . Neumerical values and use CNN1D (https://keras.io/getting-started/sequential-model-guide/#sequence-classification-with-1d-convolutions) as shown in above figure.

    . You are free to choose all CNN parameters like kernel sizes, stride.

## 3.1 Hyperparameter Tuning

In [8]:
```
from scipy.sparse import hstack
other_than_text_train = hstack((sklstate_train,proj_grade_train,train_categories,train_subcategories,teacher_prefix_train,numerical_train)).todense()
other_than_text_test = hstack((sklstate_test,proj_grade_test,test_categories,test_subcategories,teacher_prefix_test,numerical_test)).todense()
other_than_text_cv = hstack((sklstate_cv,proj_grade_cv,cv_categories,cv_subcategories,teacher_prefix_cv,numerical_cv)).todense()
```

In [9]:
```
other_than_text_train = np.expand_dims(other_than_text_train,2)
other_than_text_test = np.expand_dims(other_than_text_test,2)
other_than_text_cv = np.expand_dims(other_than_text_cv,2)
```

In [10]:
```
print(other_than_text_train.shape)
print(other_than_text_test.shape)
print(other_than_text_cv.shape)
```

```
(69918, 102, 1)
(21850, 102, 1)
(17480, 102, 1)
```

In [11]:

```
import tensorflow as tf
from keras.callbacks import TensorBoard,ModelCheckpoint
import keras
import datetime, os
import keras.backend as K
from keras.regularizers import l2
from tensorflow import set_random_seed
from sklearn.metrics import roc_auc_score
from keras.layers import Dropout,Input,Activation,Dense,Embedding,concatenate,LSTM,Flatten,BatchNormalization
from keras.layers import Conv1D,MaxPool1D
from keras.models import Model
# Load the TensorBoard notebook extension
%load_ext tensorboard

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

```
Using TensorFlow backend.
```

In [9]:

```
## clear the graph of the tensorflow
K.clear_session()
### defining all the Input layer
input_seq_total_text_data = Input(shape=padseq_x_train[0].shape,name='text_Input')
input_other_than_text = Input(shape=(102,1),name='other_than_text')

set_random_seed(5)
auc_scores_model3=[]
if not os.path.isfile('tuning_output_model3.pkl'):
    for k_s in [3,5,10]:
      for stride in [1,2,3]:
        for mx_p in [3,5]:
            #definig embedding layer
            embed_text_data = Embedding(vocab_size,300,weights = [embedding_matrix],trainable=False)(input_seq_total_text_data)
            #embed_other_than_text = Embedding(other_than_text_train.shape[1],other_than_text_train.shape[1]//e)(input_other_than_text)
            ##defining LSTM layer
            lstm_layer = LSTM(128,return_sequences=True)(embed_text_data)
            ##convolutional layer
            for c_i in [64,128,256]:
                conv_1 = Conv1D(c_i,kernel_size=k_s,strides=stride,padding='same',activation='relu',kernel_initializer='he_normal')(input_other_than_text)
                conv_2 = Conv1D(c_i,kernel_size=k_s,strides=stride,padding='same',activation='relu',kernel_initializer='he_normal')(conv_1)
                max_pool = MaxPool1D(pool_size=(3),padding='same')(conv_2)
                conv_3 = Conv1D(c_i,kernel_size=k_s,strides=stride,padding='same',activation='relu',kernel_initializer='he_normal')(max_pool)
                conv_4 = Conv1D(c_i,kernel_size=k_s,strides=stride,padding='same',activation='relu',kernel_initializer='he_normal')(conv_3)
                max_pool = MaxPool1D(pool_size=(3),padding='same')(conv_4)
            #max_pool = MaxPool1D(pool_size=(mx_p),padding='same')(conv_2)
            #flatten layer
            flatten_1 = Flatten()(lstm_layer)
            flatten_2 = Flatten()(max_pool)
            # concat layer
            concat_layer =  concatenate([flatten_1,flatten_2])
            #dense layers
            dense_layer_1 =  Dense(512,activation='relu',kernel_initializer='he_normal',kernel_regularizer=l2(0.0001))(concat_layer)
            regularization = BatchNormalization()(dense_layer_1)
            regularization = Dropout(0.25)(regularization)
            dense_layer_2 =  Dense(256,activation='relu',kernel_initializer='he_normal',kernel_regularizer=l2(0.0001))(regularization)
            regularization = BatchNormalization()(dense_layer_2)
            dense_layer_3 =  Dense(128,activation='relu',kernel_initializer='he_normal',kernel_regularizer=l2(0.0001))(regularization)
            regularization = BatchNormalization()(dense_layer_3)
            regularization = Dropout(0.25)(dense_layer_3)
            out_layer = Dense(2,activation='softmax',kernel_initializer='glorot_normal',kernel_regularizer=l2(0.0001))(dense_layer_3)

            model3 = Model(inputs=[input_seq_total_text_data,input_other_than_text],outputs=[out_layer])

            # https://stackoverflow.com/questions/48285129/saving-best-model-in-keras
            # Whether to restore model weights from the epoch with the best value of the monitored quantity. If False, the model weights obtained at the last step of trainin
            model3.compile(optimizer=keras.optimizers.Adam(),loss='categorical_crossentropy',metrics=['accuracy',aucroc])

            callback = tf.keras.callbacks.EarlyStopping(monitor='val_aucroc',verbose=1, patience=2,restore_best_weights=True,mode='max')

            history = model3.fit([padseq_x_train,other_than_text_train],y_train_cat,epochs=10,batch_size=1000,verbose=1,
                            validation_data=[[padseq_x_cv,other_than_text_cv],y_cv_cat],
                              callbacks=[callback])
            max_= np.argmax(history.history['val_aucroc'])
            print(''' Validation loss for LSTM_untis={0}, kernel_size={1} ,stride_size={2},max_pool={3},Conv1_units={4}
              '''.format(128,k_s,stride,mx_p,c_i),' is :' ,history.history['val_loss'][max_])

            auc_scores_model3.append((k_s,stride,mx_p,c_i,history.history['accuracy'][max_]
                            ,history.history['loss'][max_],history.history['aucroc'][max_],
                            history.history['val_accuracy'][max_],history.history['val_loss'][max_],history.history['val_aucroc'][max_]))
```

```
    df = pd.DataFrame(data=auc_scores_model3,columns=['Kernel_size','stride_size','pool_size','CNN_units',
                                                      'Train Accuracy','Train Loss','Train auc','Test Accuracy','Test Loss','Test auc'])
    best_param = df[df['Test auc'] == df['Test auc'].max()]
    with open('tuning_output_model3.pkl', 'wb') as f:
          pickle.dump([df,auc_scores_model3,best_param] , f)
else:
  df,auc_scores_model3,best_param = pickle.load(open('tuning_output_model3.pkl','rb'))
  print('----Tuning output loaded -------')
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow_core/python/ops/resource_variable_ops.py:1630: calling BaseResourceVariable.__init__ (from tensorfl
ow.python.ops.resource_variable_ops) with constraint is deprecated and will be removed in a future version.
Instructions for updating:
If using Keras pass *_constraint arguments to layers.
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backend.py:4070: The name tf.nn.max_pool is deprecated. Please use tf.nn.max_pool2d i
nstead.

WARNING:tensorflow:From <ipython-input-8-ed55f280d3db>:11: py_func (from tensorflow.python.ops.script_ops) is deprecated and will be removed in a future version.
Instructions for updating:
tf.py_func is deprecated in TF V2. Instead, there are two
    options available in V2.
    - tf.py_function takes a python function which manipulates tf eager
    tensors instead of numpy arrays. It's easy to convert a tf eager tensor to
    an ndarray (just call tensor.numpy()) but having access to eager tensors
    means `tf.py_function`s can use accelerators such as GPUs as well as
    being differentiable using a gradient tape.
    - tf.numpy_function maintains the semantics of the deprecated tf.py_func
    (it is not differentiable, and manipulates numpy arrays). It drops the
    stateful argument making all functions stateful.
```

In [14]:
```
# !cp -r   '/content/drive/My Drive/LSTM_preprocessed/model3/tuning_output_model3.pkl'  '/content/'
# df,auc_scores_model3,best_param = pickle.load(open('tuning_output_model3.pkl','rb'))
```

In [14]:
```
best_param
```

Out[14]:

| | Kernel_size | stride_size | pool_size | CNN_units | Train Accuracy | Train Loss | Train auc | Test Accuracy | Test Loss | Test auc |
|---|---|---|---|---|---|---|---|---|---|---|
| **13** | 10 | 1 | 5 | 256 | 0.854358 | 0.516614 | 0.756903 | 0.837185 | 0.597083 | 0.752001 |

### 3.1 Model Trials after hyperparameter tuning

Trail :
* Our primary task is to improve Test AUC.
* After hyperparameter tuning we found best kernel size ,stirde size ,poolsize etc. Now lets tune our dense layers without using for loops.
* lets increase layer1 units to 854 from 512

In [75]:
```
#!cp -r  '/content/model3_weights.best.hdf5'   '/content/drive/My Drive/LSTM_preprocessed/model3/'
```

In [21]:

```
# Clear any logs from previous runs
!rm -rf ./logs/

## clear the graph of the tensorflow
K.clear_session()
### defining all the Input layer
input_seq_total_text_data = Input(shape=padseq_x_train[0].shape,name='text_Input')
input_other_than_text = Input(shape=(102,1),name='other_than_text')

set_random_seed(5)
#definig embedding layer
embed_text_data = Embedding(vocab_size,300,weights = [embedding_matrix],trainable=False)(input_seq_total_text_data)
#embed_other_than_text = Embedding(other_than_text_train.shape[1],other_than_text_train.shape[1]//e)(input_other_than_text)
##defining LSTM layer
lstm_layer = LSTM(128,return_sequences=True)(embed_text_data)
##convolutional layer

conv_1 = Conv1D(int(best_param['CNN_units']),
                kernel_size=int(best_param['Kernel_size']),
                strides=int(best_param['stride_size']),
                padding='same',activation='relu',kernel_initializer='he_normal')(input_other_than_text)
conv_2 = Conv1D(int(best_param['CNN_units']),
                kernel_size=int(best_param['Kernel_size']),
                strides=int(best_param['stride_size']),
                padding='same',activation='relu',kernel_initializer='he_normal')(conv_1)
max_pool = MaxPool1D(pool_size=(int(best_param['pool_size'])),padding='same')(conv_2)
conv_3 = Conv1D(int(best_param['CNN_units']),
                kernel_size=int(best_param['Kernel_size']),
                strides=int(best_param['stride_size']),
                padding='same',activation='relu',kernel_initializer='he_normal')(max_pool)
conv_4 = Conv1D(int(best_param['CNN_units']),
                kernel_size=int(best_param['Kernel_size']),
                strides=int(best_param['stride_size']),
                padding='same',activation='relu',kernel_initializer='he_normal')(conv_3)
max_pool = MaxPool1D(pool_size=((int(best_param['pool_size']))),padding='same')(conv_4)
#max_pool = MaxPool1D(pool_size=(mx_p),padding='same')(conv_2)
#flatten layer
flatten_1 = Flatten()(lstm_layer)
flatten_2 = Flatten()(max_pool)
# concat layer
concat_layer =  concatenate([flatten_1,flatten_2])
#dense layers
dense_layer_1 =  Dense(854,activation='relu',kernel_initializer='he_normal',kernel_regularizer=l2(0.0001))(concat_layer)
regularization = BatchNormalization()(dense_layer_1)
regularization = Dropout(0.45)(regularization)
dense_layer_2 =  Dense(512,activation='relu',kernel_initializer='he_normal',kernel_regularizer=l2(0.0001))(regularization)
regularization = BatchNormalization()(dense_layer_2)
dense_layer_3 =  Dense(256,activation='relu',kernel_initializer='he_normal',kernel_regularizer=l2(0.0001))(regularization)
regularization = BatchNormalization()(dense_layer_3)
regularization = Dropout(0.25)(regularization)
out_layer = Dense(2,activation='softmax',kernel_initializer='glorot_normal',kernel_regularizer=l2(0.0001))(regularization)

model3 = Model(inputs=[input_seq_total_text_data,input_other_than_text],outputs=[out_layer])

# https://stackoverflow.com/questions/48285129/saving-best-model-in-keras
# Whether to restore model weights from the epoch with the best value of the monitored quantity. If False, the model weights obtained at the last step of training are used.
model3.compile(optimizer=keras.optimizers.Adam(),loss='categorical_crossentropy',metrics=['accuracy',aucroc])

callback = tf.keras.callbacks.EarlyStopping(monitor='val_aucroc',verbose=1, patience=2,restore_best_weights=True,mode='max')
```

```
log_dir="logs/" + datetime.datetime.now().strftime("%Y%m%d-%H%M%S")
tensorboard_callback = tf.keras.callbacks.TensorBoard(log_dir=log_dir,histogram_freq=0, write_graph=True,write_grads=True)

#https://machinelearningmastery.com/check-point-deep-learning-models-keras/
filepath="model3_weights.best.hdf5"
checkpoint = ModelCheckpoint(filepath, monitor='val_aucroc', verbose=1, save_best_only=True, mode='max')

callback_list = [callback,tensorboard_callback,checkpoint]
history = model3.fit([padseq_x_train,other_than_text_train],y_train_cat,epochs=10,batch_size=1000,verbose=1,
      validation_data=[[padseq_x_cv,other_than_text_cv],y_cv_cat],callbacks=callback_list)
```

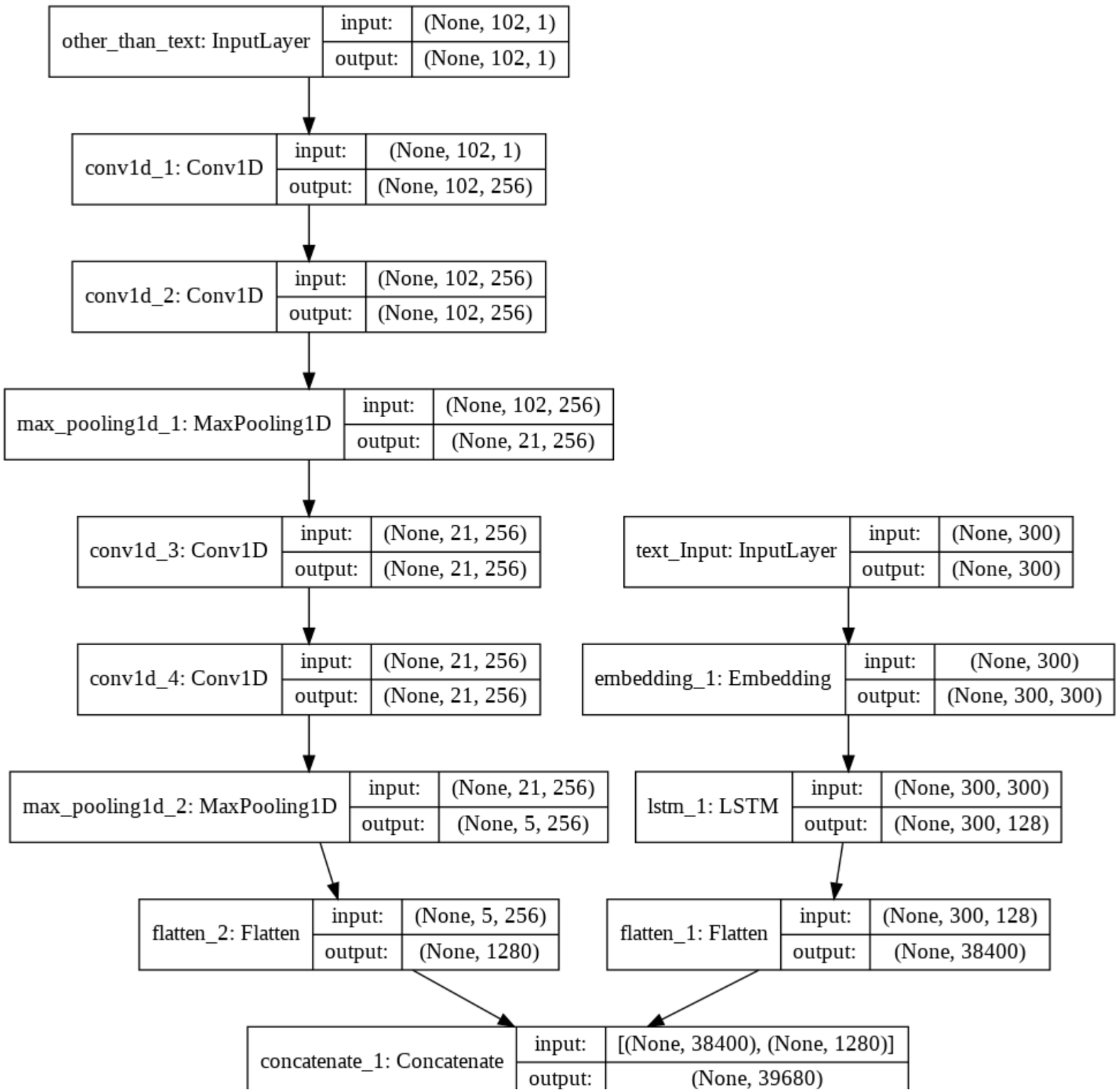
```
Train on 69918 samples, validate on 17480 samples
Epoch 1/10
69918/69918 [==============================] - 38s 550us/step - loss: 1.0177 - accuracy: 0.7194 - aucroc: 0.5127 - val_loss: 0.9752 - val_accuracy: 0.8486 - val_aucroc: 0.5377

Epoch 00001: val_aucroc improved from -inf to 0.53766, saving model to model3_weights.best.hdf5
Epoch 2/10
69918/69918 [==============================] - 37s 534us/step - loss: 0.7582 - accuracy: 0.8357 - aucroc: 0.6052 - val_loss: 0.7427 - val_accuracy: 0.8371 - val_aucroc: 0.6949

Epoch 00002: val_aucroc improved from 0.53766 to 0.69492, saving model to model3_weights.best.hdf5
Epoch 3/10
69918/69918 [==============================] - 37s 523us/step - loss: 0.6614 - accuracy: 0.8470 - aucroc: 0.7099 - val_loss: 0.7183 - val_accuracy: 0.8486 - val_aucroc: 0.7344

Epoch 00003: val_aucroc improved from 0.69492 to 0.73442, saving model to model3_weights.best.hdf5
Epoch 4/10
69918/69918 [==============================] - 37s 535us/step - loss: 0.6001 - accuracy: 0.8513 - aucroc: 0.7438 - val_loss: 0.5829 - val_accuracy: 0.8490 - val_aucroc: 0.7577

Epoch 00004: val_aucroc improved from 0.73442 to 0.75773, saving model to model3_weights.best.hdf5
Epoch 5/10
69918/69918 [==============================] - 37s 530us/step - loss: 0.5574 - accuracy: 0.8559 - aucroc: 0.7629 - val_loss: 0.6824 - val_accuracy: 0.8486 - val_aucroc: 0.7412

Epoch 00005: val_aucroc did not improve from 0.75773
Epoch 6/10
69918/69918 [==============================] - 37s 527us/step - loss: 0.5247 - accuracy: 0.8584 - aucroc: 0.7779 - val_loss: 0.8514 - val_accuracy: 0.8486 - val_aucroc: 0.7352
Restoring model weights from the end of the best epoch.

Epoch 00006: val_aucroc did not improve from 0.75773
Epoch 00006: early stopping
```

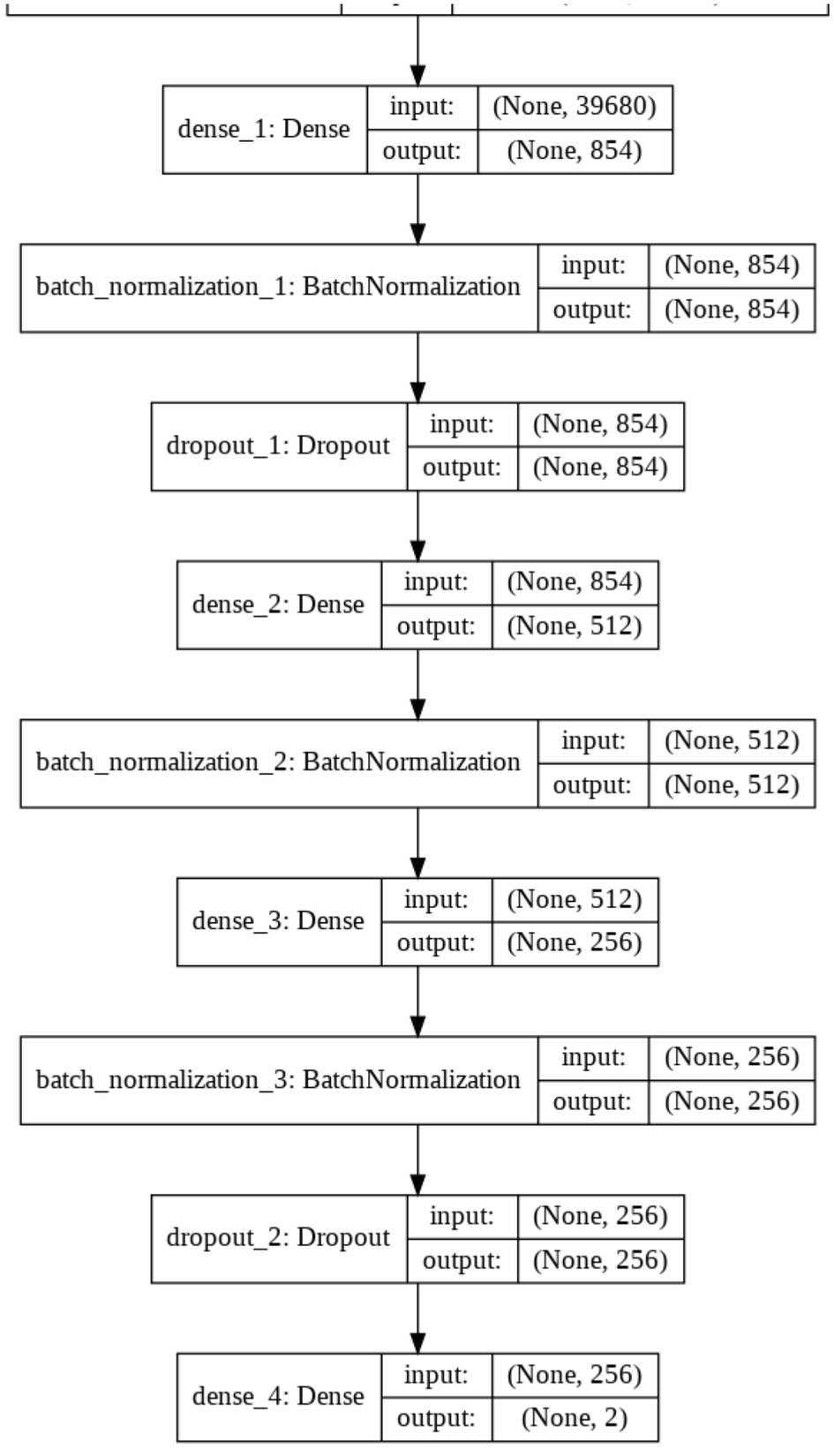
In [23]:
```
1 model3.summary()
```

```
Model: "model_1"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
other_than_text (InputLayer)    (None, 102, 1)       0
__________________________________________________________________________________________________
conv1d_1 (Conv1D)               (None, 102, 256)     2816        other_than_text[0][0]
__________________________________________________________________________________________________
conv1d_2 (Conv1D)               (None, 102, 256)     655616      conv1d_1[0][0]
__________________________________________________________________________________________________
max_pooling1d_1 (MaxPooling1D)  (None, 21, 256)      0           conv1d_2[0][0]
__________________________________________________________________________________________________
text_Input (InputLayer)         (None, 300)          0
__________________________________________________________________________________________________
conv1d_3 (Conv1D)               (None, 21, 256)      655616      max_pooling1d_1[0][0]
__________________________________________________________________________________________________
embedding_1 (Embedding)         (None, 300, 300)     14160600    text_Input[0][0]
__________________________________________________________________________________________________
conv1d_4 (Conv1D)               (None, 21, 256)      655616      conv1d_3[0][0]
__________________________________________________________________________________________________
lstm_1 (LSTM)                   (None, 300, 128)     219648      embedding_1[0][0]
__________________________________________________________________________________________________
max_pooling1d_2 (MaxPooling1D)  (None, 5, 256)       0           conv1d_4[0][0]
__________________________________________________________________________________________________
flatten_1 (Flatten)             (None, 38400)        0           lstm_1[0][0]
__________________________________________________________________________________________________
flatten_2 (Flatten)             (None, 1280)         0           max_pooling1d_2[0][0]
__________________________________________________________________________________________________
concatenate_1 (Concatenate)     (None, 39680)        0           flatten_1[0][0]
                                                                 flatten_2[0][0]
__________________________________________________________________________________________________
dense_1 (Dense)                 (None, 854)          33887574    concatenate_1[0][0]
__________________________________________________________________________________________________
batch_normalization_1 (BatchNor (None, 854)          3416        dense_1[0][0]
__________________________________________________________________________________________________
dropout_1 (Dropout)             (None, 854)          0           batch_normalization_1[0][0]
__________________________________________________________________________________________________
dense_2 (Dense)                 (None, 512)          437760      dropout_1[0][0]
__________________________________________________________________________________________________
batch_normalization_2 (BatchNor (None, 512)          2048        dense_2[0][0]
__________________________________________________________________________________________________
dense_3 (Dense)                 (None, 256)          131328      batch_normalization_2[0][0]
__________________________________________________________________________________________________
batch_normalization_3 (BatchNor (None, 256)          1024        dense_3[0][0]
__________________________________________________________________________________________________
dropout_2 (Dropout)             (None, 256)          0           batch_normalization_3[0][0]
__________________________________________________________________________________________________
dense_4 (Dense)                 (None, 2)            514         dropout_2[0][0]
==================================================================================================
Total params: 50,813,576
Trainable params: 36,649,732
Non-trainable params: 14,163,844
__________________________________________________________________________________________________
```

In [24]:
```
#https://machinelearningmastery.com/visualize-deep-learning-neural-network-model-keras/
from keras.utils.vis_utils import plot_model
plot_model(model3, to_file='/content/drive/My Drive/LSTM_preprocessed/model3/model3_t2.png', show_shapes=True, show_layer_names=True)
```

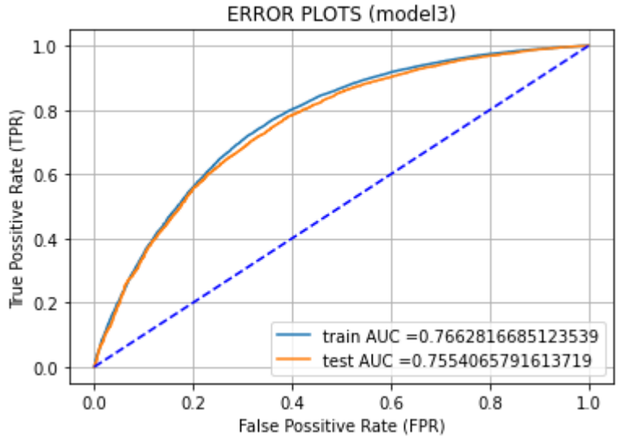
Out[24]:




dense_1: Dense
input: (None, 39680)
output: (None, 854)
batch_normalization_1: BatchNormalization
input: (None, 854)
output: (None, 854)
dropout_1: Dropout
input: (None, 854)
output: (None, 854)
dense_2: Dense
input: (None, 854)
output: (None, 512)
batch_normalization_2: BatchNormalization
input: (None, 512)
output: (None, 512)
dense_3: Dense
input: (None, 512)
output: (None, 256)
batch_normalization_3: BatchNormalization
input: (None, 256)
output: (None, 256)
dropout_2: Dropout
input: (None, 256)
output: (None, 256)
dense_4: Dense
input: (None, 256)
output: (None, 2)

In [26]:

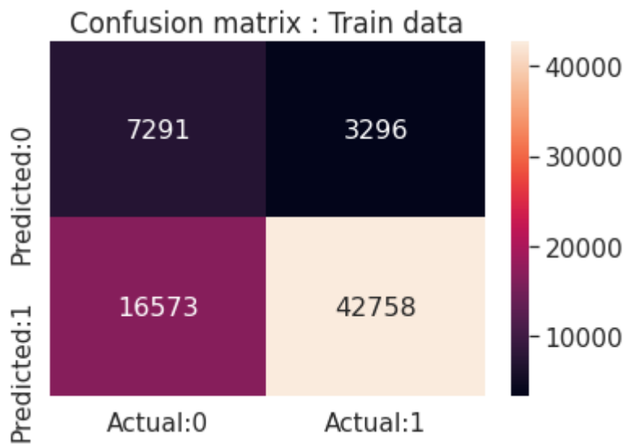
```
## Predict the test and train
from sklearn.metrics import confusion_matrix
## Finding best threshold for predictions
def best_threshold(thresholds,fpr,tpr):
    t=thresholds[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    return t

def predict_with_best_t(proba, threshold):
    predictions = []
    for i in proba:
        if i>=threshold:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions


y_test_predict = model3.predict([padseq_x_test,other_than_text_test],use_multiprocessing=True)[:,1]
y_train_predict = model3.predict([padseq_x_train,other_than_text_train],use_multiprocessing=True)[:,1]

# if  os.path.isfile('model_predictions.pkl'):
#     os.remove('model_predictions.pkl')
#     print("File model_predictions Removed!")
#     with open('model_predictions.pkl','wb') as f:
#         pickle.dump([y_train_predict,y_test_predict],f)

## Store fpr and tpr rates


train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_predict)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_predict)


#plot
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("False Possitive Rate (FPR)")
plt.ylabel("True Possitive Rate (TPR)")
plt.title("ERROR PLOTS (model3)")
plt.plot([0, 1], [0, 1],'b--')
plt.grid()
plt.show()

print("="*100)

best_t=best_threshold(tr_thresholds,train_fpr, train_tpr)

```




```
==========================================================================================================
the maximum value of tpr*(1-fpr) 0.4963064277331075 for threshold 0.811
```

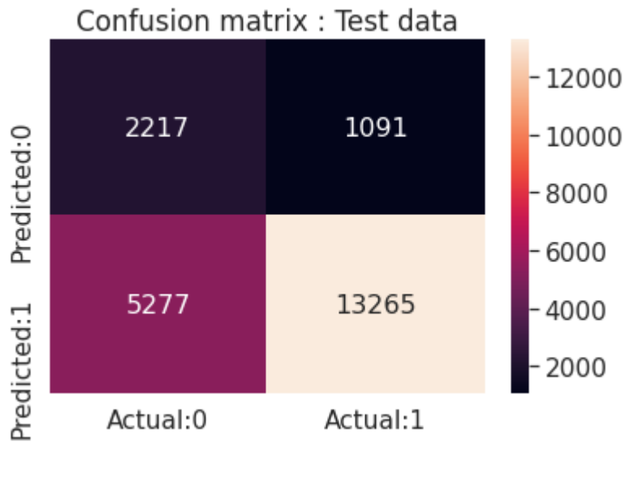
In [27]:

```
### PLOT the matrix for Train
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
# source : https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
df_cm = pd.DataFrame(confusion_matrix(y_train, predict_with_best_t(y_train_predict, best_t))
                     , range(2), range(2))
# plt.figure(figsize=(10,7))
sns.set(font_scale=1.4) # for label size
sns.heatmap(df_cm, annot=True, annot_kws={"size": 16},fmt='g',
            xticklabels=['Actual:0','Actual:1']
          ,yticklabels=['Predicted:0','Predicted:1']) # font size
plt.title('Confusion matrix : Train data')
plt.show()
```



In [28]:

```
### PLOT the matrix for Test
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
# source : https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
df_cm = pd.DataFrame(confusion_matrix(y_test, predict_with_best_t(y_test_predict, best_t))
                     , range(2), range(2))
# plt.figure(figsize=(10,7))
sns.set(font_scale=1.4) # for label size
sns.heatmap(df_cm, annot=True, annot_kws={"size": 16},fmt='g',
            xticklabels=['Actual:0','Actual:1']
           ,yticklabels=['Predicted:0','Predicted:1']) # font size
plt.title('Confusion matrix : Test data')
plt.show()
```




```
<li><b>Validation Loss,Validation aucroc,Train Loss,Train aucroc</b>
<img src='model3.jpg' width="800" height="800">


```

In [1]:
```
from prettytable import PrettyTable
pt=PrettyTable()
pt.field_names=["model","train_auc","test_auc"]
pt.add_row(["model_1","0.74","0.71"])
pt.add_row(["model_2","0.78","0.72"])
pt.add_row(["model_3","0.766","0.7554"])

print(pt)
```

```
+---------+-----------+----------+
|  model  | train_auc | test_auc |
+---------+-----------+----------+
| model_1 |    0.74   |   0.71   |
| model_2 |    0.78   |   0.72   |
| model_3 |   0.766   |  0.7554  |
+---------+-----------+----------+
```

***Observations***

* Model3 performs best among all on test data with 0.76 auc with CNN and max pooling layers as features to our dense layers.
* As the number of units in dense layer increases the model tends to overfit hence we regularize using dropouts in between layers and l2 regularizer in all the dense layers.
* using maxpool represents data in convoltional layer 1 and layer 2 in a abstracted way and avoids overfitting and reduces computational time while evaluation.
* Using filtered words in Model2 in our dataset reduced train time and produced good results.
* Model3 can be considered best fit among all as train and test AUC's are more close than Model1 and Model2 and also resulted with highest AUC.
* using early stopping we are fitting data in epoch which produced best validation auc and stop the training when there is no improvement.