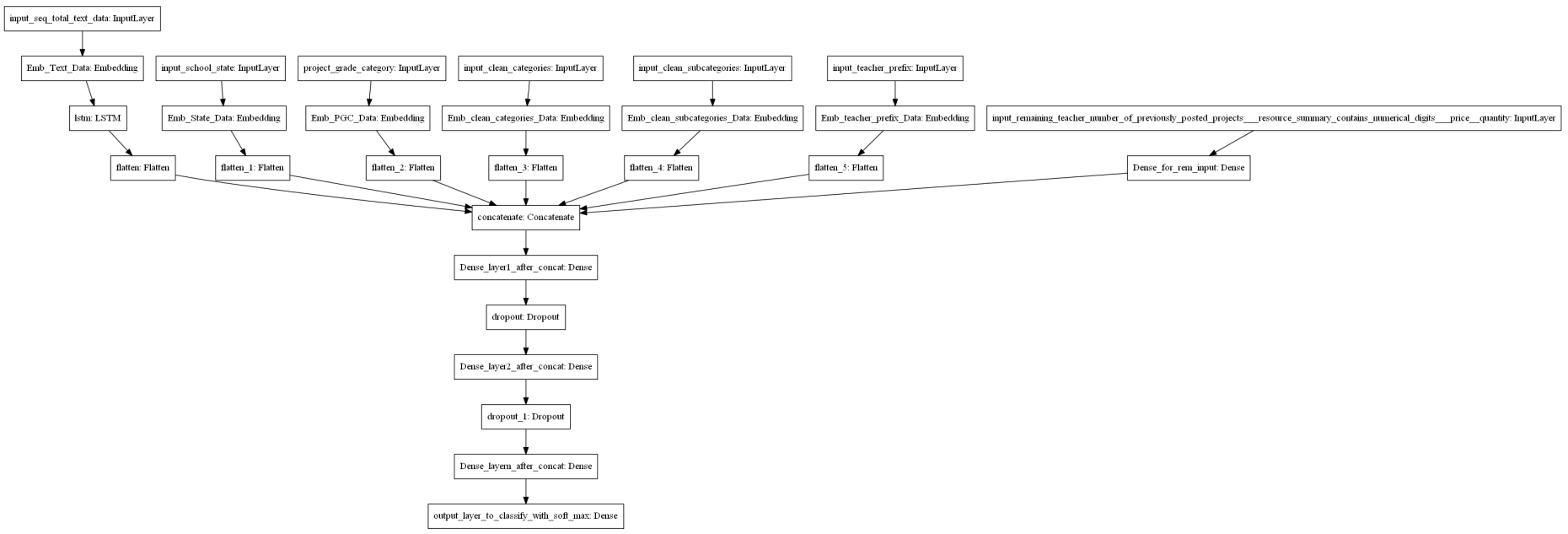
Assignment : 14

1. Preprocess all the Data we have in DonorsChoose Dataset (https://drive.google.com/drive/folders/1MIwK7BQMev8f5CbDDVNLPaFGB32pFN60) use train.csv
2. Combine 4 essay's into one column named - 'preprocessed_essays'.
3. After step 2 you have to train 3 types of models as discussed below.
4. For all the model use 'auc' (https://scikit-learn.org/stable/modules/model_evaluation.html#roc-metrics) as a metric. check this (https://datascience.stackexchange.com/a/20192) for using auc as a metric
5. You are free to choose any number of layers/hiddden units but you have to use same type of architectures shown below.
6. You can use any one of the optimizers and choice of Learning rate and momentum, resources: cs231n class notes (http://cs231n.github.io/neural-networks-3/), cs231n class video (https://www.youtube.com/watch?v=hd_KFJ5ktUc).
7. For all the model's use TensorBoard (https://www.youtube.com/watch?v=2U6Jl7oqRkM) and plot the Metric value and Loss with epoch. While submitting, take a screenshot of plots and include those images in .ipynb notebook and PDF.
8. Use Categorical Cross Entropy as Loss to minimize.

Model-1

Build and Train deep neural network as shown below



ref: https://i.imgur.com/w395Yk9.png

- **Input_seq_total_text_data** --- You have to give Total text data columns. After this use the Embedding layer to get word vectors. Use given predefined glove word vectors, don't train any word vectors. After this use LSTM and get the LSTM output and Flatten that output.
- **Input_school_state** --- Give 'school_state' column as input to embedding layer and Train the Keras Embedding layer.
- **Project_grade_category** --- Give 'project_grade_category' column as input to embedding layer and Train the Keras Embedding layer.
- **Input_clean_categories** --- Give 'input_clean_categories' column as input to embedding layer and Train the Keras Embedding layer.
- **Input_clean_subcategories** --- Give 'input_clean_subcategories' column as input to embedding layer and Train the Keras Embedding layer.
- **Input_clean_subcategories** --- Give 'input_teacher_prefix' column as input to embedding layer and Train the Keras Embedding layer.
- **Input_remaining_teacher_number_of_previously_posted_projects._resource_summary_contains_numerical_digits._price._quant** ---concatenate remaining columns and add a Dense layer after that.

- For LSTM, you can choose your sequence padding methods on your own or you can train your LSTM without padding, there is no restriction on that.

Below is an example of embedding layer for a categorical columns. In below code all are dummy values, we gave only for referance.

In [ ]:
```
# https://stats.stackexchange.com/questions/270546/how-does-keras-embedding-layer-work
# input_layer = Input(shape=(n,))
# embedding = Embedding(no_1, no_2, input_length=n)(input_layer)
# flatten = Flatten()(embedding)
```

1. Go through this blog, if you have any doubt on using predefined Embedding values in Embedding layer - https://machinelearningmastery.com/use-word-embedding-layers-deep-learning-keras/ (https://machinelearningmastery.com/use-word-embedding-layers-deep-learning-keras/)

2. Please go through this link https://keras.io/getting-started/functional-api-guide/ (https://keras.io/getting-started/functional-api-guide/) and check the 'Multi-input and multi-output models' then you will get to know how to give multiple inputs.

Make sure the test auc for all the three models is more than 0.70 and atleast 1 models test auc should be greater than 0.75

In [1]:
```
import pickle
import pandas as pd
from sklearn.feature_extraction.text import CountVectorizer
from keras.preprocessing.text import Tokenizer
from keras.preprocessing.sequence import pad_sequences
import numpy as np
from sklearn.utils import compute_class_weight
import tensorflow as tf
from sklearn.metrics import roc_auc_score

from keras.layers import LeakyReLU
from keras.layers import SpatialDropout1D, LSTM, BatchNormalization,concatenate,Flatten,Embedding,Dense,
from keras import Input, Model
from keras.regularizers import l2
from keras.initializers import he_normal
from tensorflow.keras.callbacks import TensorBoard
from time import time
from keras.optimizers import Adam
from keras.callbacks import EarlyStopping, ModelCheckpoint
```

In [2]:
```
!pip install --upgrade keras
```

```
Requirement already up-to-date: keras in /usr/local/lib/python3.7/dist-packages (2.4.3)
Requirement already satisfied, skipping upgrade: scipy>=0.14 in /usr/local/lib/python3.7/dist-packages
(from keras) (1.4.1)
Requirement already satisfied, skipping upgrade: h5py in /usr/local/lib/python3.7/dist-packages (from k
eras) (2.10.0)
Requirement already satisfied, skipping upgrade: numpy>=1.9.1 in /usr/local/lib/python3.7/dist-packages
(from keras) (1.19.5)
Requirement already satisfied, skipping upgrade: pyyaml in /usr/local/lib/python3.7/dist-packages (from
keras) (3.13)
Requirement already satisfied, skipping upgrade: six in /usr/local/lib/python3.7/dist-packages (from h5
py->keras) (1.15.0)
```

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

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

In [4]:
```
!ls '/content/drive/My Drive/LSTM_Assignment/'
```

```
data                    glove_vectors  modelcheckpoint
glove.6B.300d.txt.zip   logs           preprocessed_data.csv
```

In [5]:
```
glovevectorfile = open('/content/drive/My Drive/LSTM_Assignment/glove_vectors', 'rb')
glovevector = pickle.load(glovevectorfile)
```

In [6]:
```
glovevector['humongous'].shape
```

Out[6]:
```
(300,)
```

In [7]:
```
processed_data = pd.read_csv('/content/drive/My Drive/LSTM_Assignment/preprocessed_data.csv')
processed_data.shape
```

Out[7]:
```
(109248, 9)
```

In [8]:
```
# processed_data['remaining_input'] = processed_data['teacher_number_of_previously_posted_projects'] + p
```

In [9]:
```
processed_data.columns
```

Out[9]:
```
Index(['school_state', 'teacher_prefix', 'project_grade_category',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay', 'price'],
      dtype='object')
```

In [10]:
```
processed_data.head()
```

Out[10]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved	clean_categories
0	ca	mrs	grades_prek_2	53	1	math_science
1	ut	ms	grades_3_5	4	1	specialneeds
2	ca	mrs	grades_prek_2	10	1	literacy_language
3	ga	mrs	grades_prek_2	2	1	appliedlearning
4	wa	mrs	grades_3_5	2	1	literacy_language

In [11]:
```
Y = processed_data['project_is_approved'].values
processed_data.drop(['project_is_approved'], axis=1, inplace=True)
X = processed_data
processed_data.shape
```

Out[11]:
```
(109248, 8)
```

Splitting the data into train and test

In [12]:
```
from sklearn.model_selection import train_test_split

X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.2, stratify=Y)
X_train, X_cv, Y_train, Y_cv = train_test_split(X_train, Y_train, test_size=0.2, stratify=Y_train)

print('Train data : ', X_train.shape, Y_train.shape)
print('Cv data : ', X_cv.shape, Y_cv.shape)
print('Test data : ', X_test.shape, Y_test.shape)
```

```
Train data :  (69918, 8) (69918,)
Cv data :  (17480, 8) (17480,)
Test data :  (21850, 8) (21850,)
```

In [13]:
```
X_train_original = X_train
Y_train_original = Y_train
X_cv_original = X_cv
Y_cv_original = Y_cv
X_test_original = X_test
Y_test_original = Y_test
```

In [14]:
```
from numpy import savetxt

X_train_original.to_csv('/content/drive/My Drive/LSTM_Assignment/data/X_train.csv')
Y_train_df = pd.DataFrame(Y_train_original)
Y_train_df.to_csv('/content/drive/My Drive/LSTM_Assignment/data/Y_train.csv',index=False)

X_cv_original.to_csv('/content/drive/My Drive/LSTM_Assignment/data/X_cv.csv')
Y_cv_df = pd.DataFrame(Y_cv_original)
Y_cv_df.to_csv('/content/drive/My Drive/LSTM_Assignment/data/Y_cv.csv',index=False)

X_test_original.to_csv('/content/drive/My Drive/LSTM_Assignment/data/X_test.csv')
Y_test_df = pd.DataFrame(Y_test_original)
Y_test_df.to_csv('/content/drive/My Drive/LSTM_Assignment/data/Y_test.csv',index=False)
```

Categorical Featurization

In [15]:
```
corpus = [
    'The phone is very fast',
    'The phone is not bad',
    'I have good phone',
]

words_dict = {}

for sent in corpus:
    words = sent.split()
    for word in words:
        if(word in words_dict):
            words_dict[word] += 1
        else:
            words_dict[word] = 1

print(words_dict)

sortedList = sorted(words_dict.items(), key = lambda x:x[1], reverse=True)
print(sortedList)

rank = 1
final_dict = {}

for item in sortedList:
    item = list(item)
    final_dict[item[0]] = rank
    rank += 1

print(final_dict)

tokenize_list = []
for sent in corpus:
    words = sent.split()
    tokenize_sublist = []
    for word in words:
        if word in final_dict:
            tokenize_sublist.append(final_dict[word])

    tokenize_list.append(tokenize_sublist)

print(tokenize_list)
```

```
{'The': 2, 'phone': 3, 'is': 2, 'very': 1, 'fast': 1, 'not': 1, 'bad': 1, 'I': 1, 'have': 1, 'good': 1}
[('phone', 3), ('The', 2), ('is', 2), ('very', 1), ('fast', 1), ('not', 1), ('bad', 1), ('I', 1), ('hav
e', 1), ('good', 1)]
{'phone': 1, 'The': 2, 'is': 3, 'very': 4, 'fast': 5, 'not': 6, 'bad': 7, 'I': 8, 'have': 9, 'good': 10
}
[[2, 1, 3, 4, 5], [2, 1, 3, 6, 7], [8, 9, 10, 1]]
```

In [16]:
```
def fit_transform_train_data(train_data):
    bag_of_words = CountVectorizer(lowercase = False)
    bow_words = bag_of_words.fit_transform(train_data)

    freq = bow_words.sum(axis=0).A1
    index = freq.argsort()
    words = bag_of_words.get_feature_names()

    rank_dict = {}
    rank = 1
    for item in index[::-1]:
        feature_name = words[item]
        rank_dict[feature_name] = rank
        rank += 1

    return [words, rank_dict]

def transform_data(data, rank_dict):
    token_list = []
    for sent in data:
        words = sent.split()
        token_sublist = []
        for word in words:
            if word in words:
                token_sublist.append(rank_dict[word])
        token_list.append(token_sublist)

    return token_list
```

In [17]:
```
features, rank_dict = fit_transform_train_data(processed_data['school_state'])
print(features, rank_dict)

tokenized_data = transform_data(processed_data['school_state'], rank_dict)
print(processed_data['school_state'][5])
print(tokenized_data[5])
print(len(features))
```

```
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia', 'id', 'il', 'in', 'ks',
'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'mo', 'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', '
ny', 'oh', 'ok', 'or', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv', 'wy'] {'
ca': 1, 'tx': 2, 'ny': 3, 'fl': 4, 'nc': 5, 'il': 6, 'ga': 7, 'sc': 8, 'mi': 9, 'pa': 10, 'in': 11, 'mo
': 12, 'oh': 13, 'la': 14, 'ma': 15, 'wa': 16, 'ok': 17, 'nj': 18, 'az': 19, 'va': 20, 'wi': 21, 'al':
22, 'ut': 23, 'tn': 24, 'ct': 25, 'md': 26, 'nv': 27, 'ms': 28, 'ky': 29, 'or': 30, 'mn': 31, 'co': 32,
'ar': 33, 'id': 34, 'ia': 35, 'ks': 36, 'nm': 37, 'dc': 38, 'hi': 39, 'me': 40, 'wv': 41, 'nh': 42, 'ak
': 43, 'de': 44, 'ne': 45, 'sd': 46, 'ri': 47, 'mt': 48, 'nd': 49, 'wy': 50, 'vt': 51}
ca
[1]
51
```

One Hot Encoding of Categorical Features

In [18]:
```
(school_state_feat, rank_dict) = fit_transform_train_data(X_train['school_state'].values)

X_train_school_state_ohe = transform_data(X_train['school_state'].values, rank_dict)
X_cv_school_state_ohe = transform_data(X_cv['school_state'].values, rank_dict)
X_test_school_state_ohe = transform_data(X_test['school_state'].values, rank_dict)

print(len(X_train_school_state_ohe), Y_train.shape)
print(len(X_cv_school_state_ohe), Y_cv.shape)
print(len(X_test_school_state_ohe), Y_test.shape)
print(school_state_feat)
print(len(school_state_feat))
```

```
69918 (69918,)
17480 (17480,)
21850 (21850,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia', 'id', 'il', 'in', 'ks',
'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'mo', 'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', '
ny', 'oh', 'ok', 'or', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv', 'wy']
51
```

In [19]:
```
(project_grade_category_feat, rank_dict) = fit_transform_train_data(X_train['project_grade_category'].va

X_train_project_grade_category_ohe = transform_data(X_train['project_grade_category'].values, rank_dict)
X_cv_project_grade_category_ohe = transform_data(X_cv['project_grade_category'].values, rank_dict)
X_test_project_grade_category_ohe = transform_data(X_test['project_grade_category'].values, rank_dict)

print(len(X_train_project_grade_category_ohe), Y_train.shape)
print(len(X_cv_project_grade_category_ohe), Y_cv.shape)
print(len(X_test_project_grade_category_ohe), Y_test.shape)
print(project_grade_category_feat)
print(len(project_grade_category_feat))
```

```
69918 (69918,)
17480 (17480,)
21850 (21850,)
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
4
```

In [20]:
```
(clean_categories_feat, rank_dict) = fit_transform_train_data(X_train['clean_categories'].values)

X_train_clean_categories_ohe = transform_data(X_train['clean_categories'].values, rank_dict)
X_cv_clean_categories_ohe = transform_data(X_cv['clean_categories'].values, rank_dict)
X_test_clean_categories_ohe = transform_data(X_test['clean_categories'].values, rank_dict)

print(len(X_train_clean_categories_ohe), Y_train.shape)
print(len(X_cv_clean_categories_ohe), Y_cv.shape)
print(len(X_test_clean_categories_ohe), Y_test.shape)
print(clean_categories_feat)
print(len(clean_categories_feat))
```

```
69918 (69918,)
17480 (17480,)
21850 (21850,)
['appliedlearning', 'care_hunger', 'health_sports', 'history_civics', 'literacy_language', 'math_scienc
e', 'music_arts', 'specialneeds', 'warmth']
9
```

In [21]:
```
(clean_subcategories_feat, rank_dict) = fit_transform_train_data(X_train['clean_subcategories'].values)

X_train_clean_subcategories_ohe = transform_data(X_train['clean_subcategories'].values, rank_dict)
X_cv_clean_subcategories_ohe = transform_data(X_cv['clean_subcategories'].values, rank_dict)
X_test_clean_subcategories_ohe = transform_data(X_test['clean_subcategories'].values, rank_dict)

print(len(X_train_clean_subcategories_ohe), Y_train.shape)
print(len(X_cv_clean_subcategories_ohe), Y_cv.shape)
print(len(X_test_clean_subcategories_ohe), Y_test.shape)
print(clean_subcategories_feat)
print(len(clean_subcategories_feat))
```

```
69918 (69918,)
17480 (17480,)
21850 (21850,)
['appliedsciences', 'care_hunger', 'charactereducation', 'civics_government', 'college_careerprep', 'co
mmunityservice', 'earlydevelopment', 'economics', 'environmentalscience', 'esl', 'extracurricular', 'fi
nancialliteracy', 'foreignlanguages', 'gym_fitness', 'health_lifescience', 'health_wellness', 'history_
geography', 'literacy', 'literature_writing', 'mathematics', 'music', 'nutritioneducation', 'other', 'p
arentinvolvement', 'performingarts', 'socialsciences', 'specialneeds', 'teamsports', 'visualarts', 'war
mth']
30
```

In [22]:
```
(teacher_prefix_feat, rank_dict) = fit_transform_train_data(X_train['teacher_prefix'].values)

X_train_teacher_prefix_ohe = transform_data(X_train['teacher_prefix'].values, rank_dict)
X_cv_teacher_prefix_ohe = transform_data(X_cv['teacher_prefix'].values, rank_dict)
X_test_teacher_prefix_ohe = transform_data(X_test['teacher_prefix'].values, rank_dict)

print(len(X_train_teacher_prefix_ohe), Y_train.shape)
print(len(X_cv_teacher_prefix_ohe), Y_cv.shape)
print(len(X_test_teacher_prefix_ohe), Y_test.shape)
print(teacher_prefix_feat)
print(len(teacher_prefix_feat))
```

```
69918 (69918,)
17480 (17480,)
21850 (21850,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
5
```

In [23]:
```
#https://machinelearningmastery.com/use-word-embedding-layers-deep-learning-keras/
def padded(encoded_docs):
  max_length = 300
  padded_docs = pad_sequences(encoded_docs, maxlen=max_length, padding='post')
  return padded_docs
```

In [24]:
```
#https://stackoverflow.com/posts/51956230/revisions
t = Tokenizer()
t.fit_on_texts(X_train['essay'])
vocab_size = len(t.word_index) + 1
# integer encode the documents
encoded_docs = t.texts_to_sequences(X_train['essay'])
X_train_essay = padded(encoded_docs)
```

In [25]:
```
vocab_size
```

Out[25]: 47484

In [26]:
```
X_train_essay.shape
```

Out[26]: (69918, 300)

In [27]:
```
encoded_docs = t.texts_to_sequences(X_cv['essay'])
X_cv_essay = padded(encoded_docs)

encoded_docs = t.texts_to_sequences(X_test['essay'])
X_test_essay = padded(encoded_docs)
```

In [28]:
```
!unzip '/content/drive/My Drive/LSTM_Assignment/glove.6B.300d.txt.zip'
```

```
Archive:  /content/drive/My Drive/LSTM_Assignment/glove.6B.300d.txt.zip
  inflating: glove.6B.300d.txt
```

In [29]:
```
embeddings_index = dict()
f = open('/content/glove.6B.300d.txt')
for line in f:
    values = line.split()
    word = values[0]
    coefs = np.asarray(values[1:], dtype='float32')
    embeddings_index[word] = coefs
f.close()
```

In [30]:
```
len(embeddings_index)
```

Out[30]: 400000

In [31]:
```
embeddings_index['feel'].shape
```

Out[31]: (300,)

In [32]:
```
embedding_matrix = np.zeros((vocab_size, 300))
for word, i in t.word_index.items():
      embedding_vector = embeddings_index.get(word)
      if embedding_vector is not None:
            embedding_matrix[i] = embedding_vector
```

In [33]:
```
embedding_matrix.shape
```

Out[33]: (47484, 300)

In [34]:
```
from keras.utils import to_categorical

Y_train = to_categorical(Y_train)
Y_cv = to_categorical(Y_cv)
Y_test = to_categorical(Y_test)
```

In [35]:
```
Y_train
```

Out[35]:
```
array([[0., 1.],
       [0., 1.],
       [0., 1.],
       ...,
       [0., 1.],
       [0., 1.],
       [0., 1.]], dtype=float32)
```

In [36]:
```
class_weight = compute_class_weight("balanced", classes= np.unique(Y),y=Y)
```

In [37]:
```
class_weight
```

Out[37]:
```
array([3.30214001, 0.58921753])
```

In [38]:
```
max_length = 1

X_train_school_state_ohe = pad_sequences(X_train_school_state_ohe, maxlen=max_length)
X_cv_school_state_ohe = pad_sequences(X_cv_school_state_ohe, maxlen=max_length)
X_test_school_state_ohe = pad_sequences(X_test_school_state_ohe, maxlen=max_length)

print(X_train_school_state_ohe.shape)
print(X_train_school_state_ohe[0])
```

```
(69918, 1)
[3]
```

In [39]:
```
X_train_project_grade_category_ohe = pad_sequences(X_train_project_grade_category_ohe, maxlen=max_length
X_cv_project_grade_category_ohe = pad_sequences(X_cv_project_grade_category_ohe, maxlen=max_length)
X_test_project_grade_category_ohe = pad_sequences(X_test_project_grade_category_ohe, maxlen=max_length)

print(X_train_project_grade_category_ohe.shape)
print(X_train_project_grade_category_ohe[0])
```

```
(69918, 1)
[1]
```

In [40]:
```
X_train_clean_categories_ohe = pad_sequences(X_train_clean_categories_ohe, maxlen=max_length)
X_cv_clean_categories_ohe = pad_sequences(X_cv_clean_categories_ohe, maxlen=max_length)
X_test_clean_categories_ohe = pad_sequences(X_test_clean_categories_ohe, maxlen=max_length)

print(X_train_clean_categories_ohe.shape)
print(X_train_clean_categories_ohe[0])
```

```
(69918, 1)
[2]
```

In [41]:
```
X_train_clean_subcategories_ohe = pad_sequences(X_train_clean_subcategories_ohe, maxlen=max_length)
X_cv_clean_subcategories_ohe = pad_sequences(X_cv_clean_subcategories_ohe, maxlen=max_length)
X_test_clean_subcategories_ohe = pad_sequences(X_test_clean_subcategories_ohe, maxlen=max_length)

print(X_train_clean_subcategories_ohe.shape)
print(X_train_clean_subcategories_ohe[0])
```

```
(69918, 1)
[2]
```

In [42]:
```
X_train_teacher_prefix_ohe = pad_sequences(X_train_teacher_prefix_ohe, maxlen=max_length)
X_cv_teacher_prefix_ohe = pad_sequences(X_cv_teacher_prefix_ohe, maxlen=max_length)
X_test_teacher_prefix_ohe = pad_sequences(X_test_teacher_prefix_ohe, maxlen=max_length)

print(X_train_teacher_prefix_ohe.shape)
print(X_train_teacher_prefix_ohe[0])
```

```
(69918, 1)
[1]
```

In [43]:
```
def auc_func(y_true, y_pred):
    _auc = roc_auc_score(y_true, y_pred, average='micro')
    return _auc

def auc_score(y_true, y_pred):
    return tf.py_function(auc_func, (y_true, y_pred), tf.double)
```

In [44]:
```
X_train_essay_mat = embedding_matrix
```

In [45]:
```
embedding_matrix.shape
```

Out[45]:
```
(47484, 300)
```

Model 1

In [51]:
```
input1 = Input(shape=(300,))
i1 = Embedding(input_dim= embedding_matrix.shape[0], output_dim = 300, weights = [embedding_matrix], inp
i1 = LSTM(128, recurrent_dropout=0.3, kernel_regularizer=l2(0.001), return_sequences=True)(i1)
i1 = Flatten()(i1)

cat_vars = ["teacher_prefix","school_state","project_grade_category","clean_categories","clean_subcatego
cat_sizes = {}
cat_embsizes = {}

for cat in cat_vars:
    cat_sizes[cat] = X_train[cat].nunique()
    cat_embsizes[cat] = min(50, cat_sizes[cat]//2+1)

input2 = Input(shape=(1,))
i2 = Embedding(input_dim=cat_sizes['school_state']+1, output_dim=cat_embsizes['school_state'])(input2)
i2 = Flatten()(i2)

input3 = Input(shape=(1,))
i3 = Embedding(input_dim=cat_sizes['project_grade_category']+1, output_dim=cat_embsizes['project_grade_c
i3 = Flatten()(i3)

input4 = Input(shape=(1,))
i4 = Embedding(input_dim=cat_sizes['clean_categories']+1, output_dim=cat_embsizes['clean_categories'])(i
i4 = Flatten()(i4)

input5 = Input(shape=(1,))
i5 = Embedding(input_dim=cat_sizes['clean_subcategories']+1, output_dim=cat_embsizes['clean_subcategorie
i5 = Flatten()(i5)

input6 = Input(shape=(1,))
i6 = Embedding(input_dim=cat_sizes['teacher_prefix']+1, output_dim=cat_embsizes['teacher_prefix'])(input
i6 = Flatten()(i6)

input7 = Input(shape=(1,))
i7 = Dense(16, kernel_initializer = he_normal(), kernel_regularizer = l2(0.0001))(input7)

concat = concatenate([i1, i2, i3, i4, i5, i6, i7])

i = Dense(64, kernel_initializer = he_normal(), kernel_regularizer = l2(0.0001))(concat)
i = Dropout(0.5)(i)
i = LeakyReLU()(i)
i = Dense(64,kernel_initializer=he_normal(),kernel_regularizer=l2(0.0001))(i)
i = Dropout(0.5)(i)
i = BatchNormalization()(i)
i = LeakyReLU()(i)
i = Dense(32,kernel_initializer=he_normal(),kernel_regularizer=l2(0.0001))(i)
i = LeakyReLU()(i)

output = Dense(2, activation = 'softmax')(i)
model = Model([input1, input2, input3, input4, input5, input6, input7], output)
model.run_eagerly = True

adam = tf.keras.optimizers.Adam(learning_rate=0.0007, decay = 1e-4)

model.compile(loss = 'categorical_crossentropy', optimizer = 'adam', metrics = [auc_score])
print(model.summary())
```

```
WARNING:tensorflow:Layer lstm_1 will not use cuDNN kernel since it doesn't meet the cuDNN kernel criter
ia. It will use generic GPU kernel as fallback when running on GPU
Model: "model_1"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_8 (InputLayer)            [(None, 300)]        0
__________________________________________________________________________________________________
embedding_6 (Embedding)         (None, 300, 300)     14245200    input_8[0][0]
__________________________________________________________________________________________________
input_9 (InputLayer)            [(None, 1)]          0
```

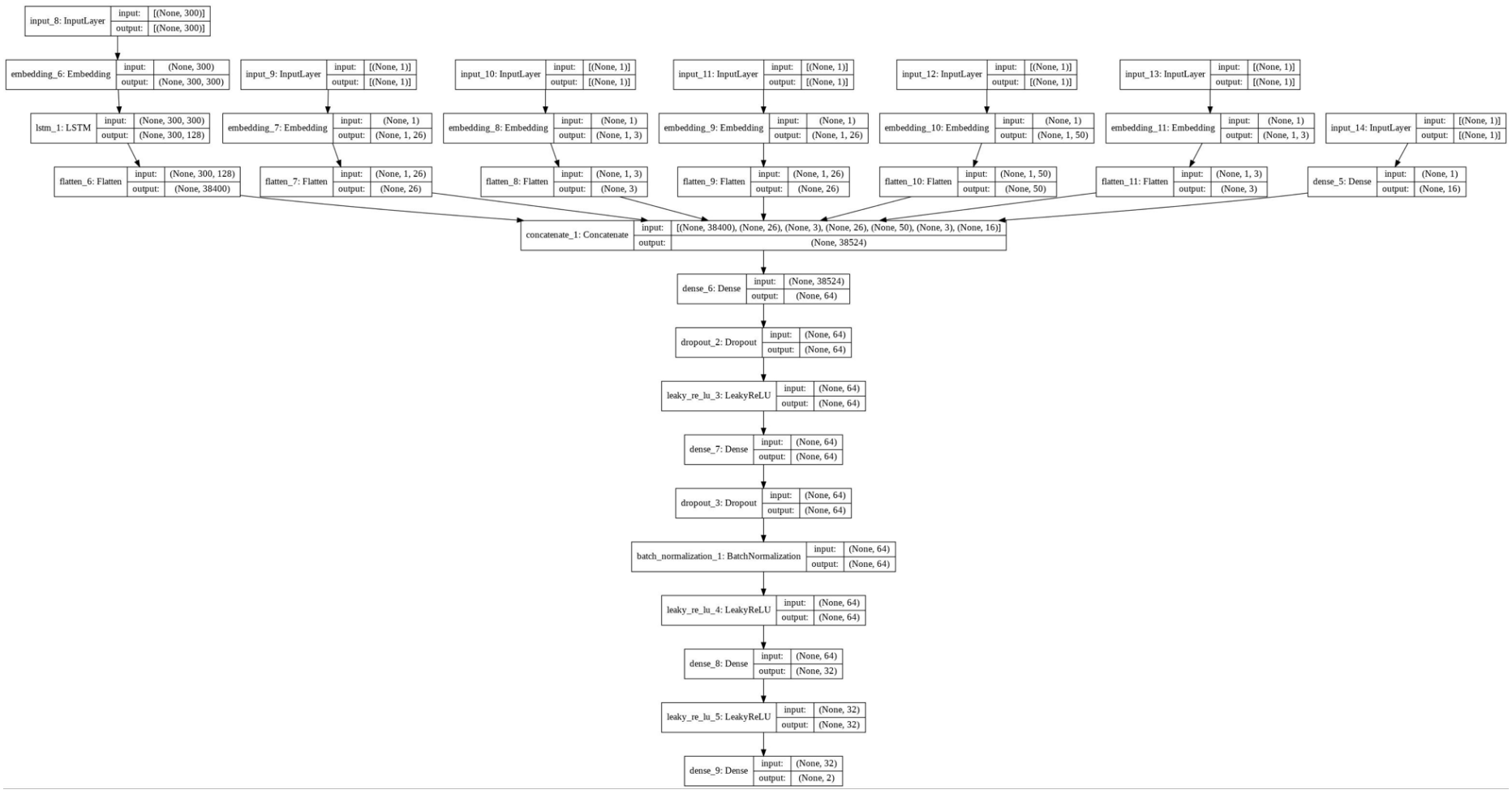
```
__________________________________________________________________________________________________
input_10 (InputLayer)           [(None, 1)]          0
__________________________________________________________________________________________________
input_11 (InputLayer)           [(None, 1)]          0
__________________________________________________________________________________________________
input_12 (InputLayer)           [(None, 1)]          0
__________________________________________________________________________________________________
input_13 (InputLayer)           [(None, 1)]          0
__________________________________________________________________________________________________
lstm_1 (LSTM)                   (None, 300, 128)     219648      embedding_6[0][0]
__________________________________________________________________________________________________
embedding_7 (Embedding)         (None, 1, 26)        1352        input_9[0][0]
__________________________________________________________________________________________________
embedding_8 (Embedding)         (None, 1, 3)         15          input_10[0][0]
__________________________________________________________________________________________________
embedding_9 (Embedding)         (None, 1, 26)        1352        input_11[0][0]
__________________________________________________________________________________________________
embedding_10 (Embedding)        (None, 1, 50)        19550       input_12[0][0]
__________________________________________________________________________________________________
embedding_11 (Embedding)        (None, 1, 3)         18          input_13[0][0]
__________________________________________________________________________________________________
input_14 (InputLayer)           [(None, 1)]          0
__________________________________________________________________________________________________
flatten_6 (Flatten)             (None, 38400)        0           lstm_1[0][0]
__________________________________________________________________________________________________
flatten_7 (Flatten)             (None, 26)           0           embedding_7[0][0]
__________________________________________________________________________________________________
flatten_8 (Flatten)             (None, 3)            0           embedding_8[0][0]
__________________________________________________________________________________________________
flatten_9 (Flatten)             (None, 26)           0           embedding_9[0][0]
__________________________________________________________________________________________________
flatten_10 (Flatten)            (None, 50)           0           embedding_10[0][0]
__________________________________________________________________________________________________
flatten_11 (Flatten)            (None, 3)            0           embedding_11[0][0]
__________________________________________________________________________________________________
dense_5 (Dense)                 (None, 16)           32          input_14[0][0]
__________________________________________________________________________________________________
concatenate_1 (Concatenate)     (None, 38524)        0           flatten_6[0][0]
                                                                 flatten_7[0][0]
                                                                 flatten_8[0][0]
                                                                 flatten_9[0][0]
                                                                 flatten_10[0][0]
                                                                 flatten_11[0][0]
                                                                 dense_5[0][0]
__________________________________________________________________________________________________
dense_6 (Dense)                 (None, 64)           2465600     concatenate_1[0][0]
__________________________________________________________________________________________________
dropout_2 (Dropout)             (None, 64)           0           dense_6[0][0]
__________________________________________________________________________________________________
leaky_re_lu_3 (LeakyReLU)       (None, 64)           0           dropout_2[0][0]
__________________________________________________________________________________________________
dense_7 (Dense)                 (None, 64)           4160        leaky_re_lu_3[0][0]
__________________________________________________________________________________________________
dropout_3 (Dropout)             (None, 64)           0           dense_7[0][0]
__________________________________________________________________________________________________
batch_normalization_1 (BatchNor (None, 64)           256         dropout_3[0][0]
__________________________________________________________________________________________________
leaky_re_lu_4 (LeakyReLU)       (None, 64)           0           batch_normalization_1[0][0]
__________________________________________________________________________________________________
dense_8 (Dense)                 (None, 32)           2080        leaky_re_lu_4[0][0]
__________________________________________________________________________________________________
leaky_re_lu_5 (LeakyReLU)       (None, 32)           0           dense_8[0][0]
__________________________________________________________________________________________________
dense_9 (Dense)                 (None, 2)            66          leaky_re_lu_5[0][0]
==================================================================================================
Total params: 16,959,329
Trainable params: 2,714,001
Non-trainable params: 14,245,328
__________________________________________________________________________________________________
None
```

In [47]:
```
X_train_essay_mat.shape
```

Out[47]:
```
(47484, 300)
```

In [52]:
```
from keras.utils.vis_utils import plot_model
plot_model(model, to_file='/content/model-1.jpg', show_shapes = True, show_layer_names=True)
```

Out[52]:



In [53]:
```
from keras.callbacks import EarlyStopping, ModelCheckpoint
import datetime

filepath = '/content/drive/My Drive/LSTM_Assignment/modelcheckpoint/weights_model1.hdf5'

checkpoint = ModelCheckpoint(filepath, monitor='val_auc_score', verbose=1, save_best_only=True, mode='ma
log_dir = "logs/fit/model1_" + datetime.datetime.now().strftime("%Y%m%d-%H%M%S")
tensorboard_callback1 = TensorBoard(log_dir=log_dir, histogram_freq=1)
callbacks = [checkpoint, tensorboard_callback1]

input_data = [X_train_essay, X_train_school_state_ohe, X_train_project_grade_category_ohe, X_train_clean
val_data = [X_cv_essay, X_cv_school_state_ohe, X_cv_project_grade_category_ohe, X_cv_clean_categories_oh

model.fit(input_data, Y_train, epochs=20, verbose=1, batch_size=512, validation_data=(val_data, Y_cv), c
```

```
137/137 [==============================] - 179s 1s/step - loss: 0.3935 - auc_score: 0.9105 - val_loss:
0.3919 - val_auc_score: 0.9105

Epoch 00012: val_auc_score improved from 0.90962 to 0.91051, saving model to /content/drive/My Drive/LS
TM_Assignment/modelcheckpoint/weights_model1.hdf5
Epoch 13/20
137/137 [==============================] - 178s 1s/step - loss: 0.3888 - auc_score: 0.9121 - val_loss:
0.4314 - val_auc_score: 0.9015

Epoch 00013: val_auc_score did not improve from 0.91051
Epoch 14/20
137/137 [==============================] - 179s 1s/step - loss: 0.3914 - auc_score: 0.9111 - val_loss:
0.3926 - val_auc_score: 0.9093

Epoch 00014: val_auc_score did not improve from 0.91051
Epoch 15/20
137/137 [==============================] - 179s 1s/step - loss: 0.3925 - auc_score: 0.9100 - val_loss:
0.3895 - val_auc_score: 0.9102

Epoch 00015: val_auc_score did not improve from 0.91051
```

In [54]:
```
X_test_data = [X_test_essay, X_test_school_state_ohe, X_test_project_grade_category_ohe, X_test_clean_ca
roc_auc_score(Y_test, model.predict(X_test_data))
```

Out[54]: 0.749788846642095

In [55]:
```
model.save("model_1.h5")
```

In [56]:
```
%load_ext tensorboard
```

In [ ]:
```
%tensorboard --logdir /content/logs/fit/model1_20210524-070152
```

Model-2

Use the same model as above but for 'input_seq_total_text_data' give only some words in the sentance not all the words. Filter the words as below.

1. Train the TF-IDF on the Train data

2. Get the idf value for each word we have in the train data.

3. Remove the low idf value and high idf value words from our data. Do some analysis on the Idf values and based on those values choose the low and high threshold value. Because very frequent words and very very rare words don't give much information. (you can plot a box plots and take only the idf scores within IQR range and corresponding words)

4. Train the LSTM after removing the Low and High idf value words. (In model-1 Train on total data but in Model-2 train on data after removing some words based on IDF values)

Type *Markdown* and LaTeX: α^2

In [ ]:
```
from sklearn.feature_extraction.text import TfidfVectorizer, CountVectorizer
vectorizer = TfidfVectorizer(min_df = 5, max_features = 10000)
tfidf = vectorizer.fit(X_train['essay'])
```

In [ ]:
```
idf = vectorizer.idf_
```

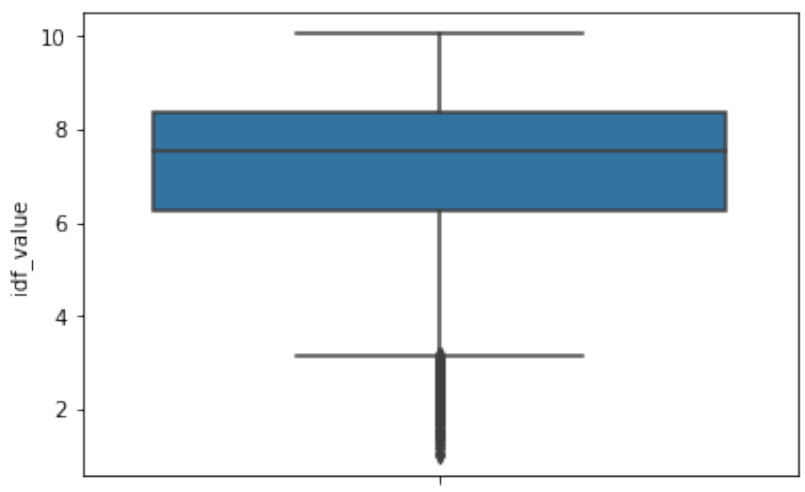
In [ ]:
```
df = pd.DataFrame(idf, columns=['idf_value'])
df.head()
```

Out[66]:

	idf_value
0	7.151146
1	5.905117
2	4.503973
3	3.811063
4	7.295280

In [ ]:
```
import seaborn as sns

sns.boxplot(y = 'idf_value', data = df)
```

Out[67]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb4bdda8190>
```



In [ ]:
```
for i in range(0, 100, 5):
    var = idf
    var = np.sort(var, axis = None)
    print(i, 'th percentile value is ', var[int(len(var)*(float(i)/100))])

print('100th percentile value is ', var[-1])
```

```
0 th percentile value is  1.0079982620655068
5 th percentile value is  4.107903145997144
10 th percentile value is  4.959905387988936
15 th percentile value is  5.461769039897696
20 th percentile value is  5.880330686925706
25 th percentile value is  6.266214749834764
30 th percentile value is  6.594411077152118
35 th percentile value is  6.871888979429657
40 th percentile value is  7.111667591248398
45 th percentile value is  7.342908352795227
50 th percentile value is  7.549922522179553
55 th percentile value is  7.724275909324332
60 th percentile value is  7.89241283112633
65 th percentile value is  8.044218843994333
70 th percentile value is  8.203848989586218
75 th percentile value is  8.348430218397326
80 th percentile value is  8.491531062038
85 th percentile value is  8.628732183551485
90 th percentile value is  8.75389532650549
95 th percentile value is  8.896996170146164
100th percentile value is  10.075651166487809
```

In [ ]:
```
feature_idf = zip(tfidf.get_feature_names(), idf)

feature_names = []

for x,y in feature_idf:
    if y >= 4 and y <= 9:
        feature_names.append(x)

print(len(feature_names))
```

```
9322
```

In [ ]:
```
from tqdm import tqdm

def get_idf_feature_text(essay):
    preprocessed_text = []

    for text in tqdm(essay):
        words = text.split()
        final_text = ''

        for word in words:
            if word in feature_names:
                final_text += ' ' + word
        preprocessed_text.append(final_text)

    return preprocessed_text
```

In [ ]:
```
print(X_train['essay'][0:2])
```

```
83805    mount carmel area school district provides fre...
69295    i kindergarten class 24 students they bright e...
Name: essay, dtype: object
```

In [ ]:
```
sample_preprocessed = get_idf_feature_text(X_train['essay'][0:2])
print(sample_preprocessed)
```

```
100%|██████████| 2/2 [00:00<00:00, 59.08it/s]

[' mount provides fresh strategies accommodate enthusiastic methods 60 12 mount national to qualify 15 2015 130 line 49 to qualify 21 annual 2015 line 11 slowly closing gap hybrid funding easily adapt assig n advanced noticed found voice online collaborative assignments soar excitement comment increases commu nicate online', ' 24 bright eyed south side los angeles qualify welcome conditions maximize engagement ribbons rulers integrating decorate journals colorful ribbons journals interesting ruler cutting ribbon s certain measurements measure inches rulers measure cut desired ribbons certain measurements journals colorful']
```

In [ ]:
```
X_train_idf_essay = get_idf_feature_text(X_train['essay'])
len(X_train_idf_essay)
```

```
100%|██████████| 69918/69918 [20:33<00:00, 56.66it/s]
```

Out[73]:
```
69918
```

In [ ]:
```
X_cv_idf_essay = get_idf_feature_text(X_cv['essay'])
len(X_cv_idf_essay)
```

```
100%|██████████| 17480/17480 [05:06<00:00, 57.05it/s]
```

Out[74]:
```
17480
```

In [ ]:
```
X_test_idf_essay = get_idf_feature_text(X_test['essay'])
len(X_test_idf_essay)
```

```
100%|██████████| 21850/21850 [06:25<00:00, 56.72it/s]
```

Out[75]:
```
21850
```

In [ ]:
```
X_train_idf_df = pd.DataFrame(X_train_idf_essay)
X_train_idf_df.to_csv('/content/drive/My Drive/LSTM_Assignment/data/X_train_idf_essay.csv',index=False)

X_cv_idf_df = pd.DataFrame(X_cv_idf_essay)
X_cv_idf_df.to_csv('/content/drive/My Drive/LSTM_Assignment/data/X_cv_idf_essay.csv',index=False)

X_test_idf_df = pd.DataFrame(X_test_idf_essay)
X_test_idf_df.to_csv('/content/drive/My Drive/LSTM_Assignment/data/X_test_idf_essay.csv',index=False)
```

In [ ]:
```
t = Tokenizer()
t.fit_on_texts(X_train_idf_essay)

vocab_size = len(t.word_index) + 1
encoded_docs = t.texts_to_sequences(X_train_idf_essay)
X_train_essay = padded(encoded_docs)
```

In [ ]:
```
X_train.shape
```

Out[78]:
```
(69918, 8)
```

In [ ]:
```
encoded_docs = t.texts_to_sequences(X_cv_idf_essay)
X_cv_essay = padded(encoded_docs)

encoded_docs = t.texts_to_sequences(X_test_idf_essay)
X_test_essay = padded(encoded_docs)
```

In [ ]:
```
embedding_matrix_2 = np.zeros((vocab_size, 300))
for word, i in t.word_index.items():
    embedding_vector = embeddings_index.get(word)
    if embedding_vector is not None:
        embedding_matrix_2[i] = embedding_vector
```

In [ ]:
```
X_train_essay_mat = embedding_matrix_2
X_train_essay_mat.shape
```

Out[81]:
```
(9323, 300)
```

In [ ]:
```
from tensorflow.keras import backend
backend.clear_session()

input1 = Input(shape=(300,))
i1 = Embedding(input_dim= embedding_matrix_2.shape[0], output_dim = 300, weights = [embedding_matrix_2],
i1 = LSTM(256, recurrent_dropout=0.3, kernel_regularizer=l2(0.0001), return_sequences=True)(i1)
i1 = Flatten()(i1)

cat_vars = ["teacher_prefix","school_state","project_grade_category","clean_categories","clean_subcatego
cat_sizes = {}
cat_embsizes = {}

for cat in cat_vars:
    cat_sizes[cat] = X_train[cat].nunique()
    cat_embsizes[cat] = min(50, cat_sizes[cat]//2+1)

input2 = Input(shape=(1,))
i2 = Embedding(input_dim=cat_sizes['school_state']+1, output_dim=cat_embsizes['school_state'])(input2)
```

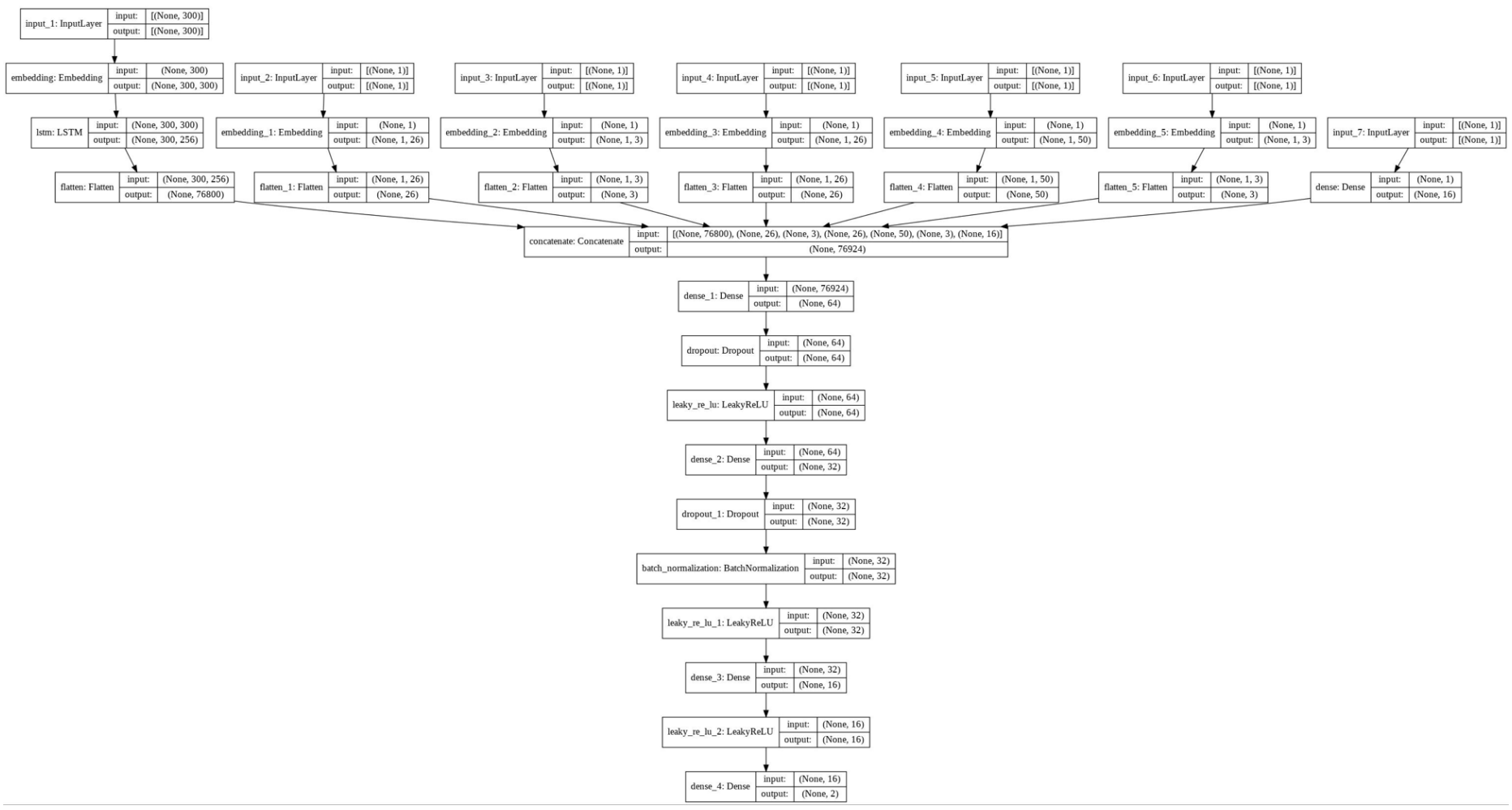
```
i2 = Flatten()(i2)

input3 = Input(shape=(1,))
i3 = Embedding(input_dim=cat_sizes['project_grade_category']+1, output_dim=cat_embsizes['project_grade_c
i3 = Flatten()(i3)

input4 = Input(shape=(1,))
i4 = Embedding(input_dim=cat_sizes['clean_categories']+1, output_dim=cat_embsizes['clean_categories'])(i
i4 = Flatten()(i4)

input5 = Input(shape=(1,))
i5 = Embedding(input_dim=cat_sizes['clean_subcategories']+1, output_dim=cat_embsizes['clean_subcategorie
i5 = Flatten()(i5)

input6 = Input(shape=(1,))
i6 = Embedding(input_dim=cat_sizes['teacher_prefix']+1, output_dim=cat_embsizes['teacher_prefix'])(input
i6 = Flatten()(i6)

input7 = Input(shape=(1,))
i7 = Dense(16, kernel_initializer = he_normal(), kernel_regularizer = l2(0.0001))(input7)

concat = concatenate([i1, i2, i3, i4, i5, i6, i7])

i = Dense(64, kernel_initializer = he_normal(), kernel_regularizer = l2(0.0001))(concat)
i = Dropout(0.5)(i)
i = LeakyReLU()(i)
i = Dense(32, kernel_initializer=he_normal(),kernel_regularizer=l2(0.0001))(i)
i = Dropout(0.5)(i)
i = BatchNormalization()(i)
i = LeakyReLU()(i)
i = Dense(16, kernel_initializer=he_normal(),kernel_regularizer=l2(0.0001))(i)
i = LeakyReLU()(i)

output = Dense(2, activation = 'softmax')(i)
model2 = Model([input1, input2, input3, input4, input5, input6, input7], output)
model2.run_eagerly = True

adam = Adam(learning_rate=0.0001, decay = 1e-4)

model2.compile(loss = 'categorical_crossentropy', optimizer = adam, metrics = [auc_score])
print(model2.summary())
```

```
WARNING:tensorflow:Layer lstm will not use cuDNN kernel since it doesn't meet the cuDNN kernel criteria
. It will use generic GPU kernel as fallback when running on GPU
Model: "model"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_1 (InputLayer)            [(None, 300)]        0
__________________________________________________________________________________________________
embedding (Embedding)           (None, 300, 300)     2796900     input_1[0][0]
__________________________________________________________________________________________________
input_2 (InputLayer)            [(None, 1)]          0
__________________________________________________________________________________________________
input_3 (InputLayer)            [(None, 1)]          0
__________________________________________________________________________________________________
input_4 (InputLayer)            [(None, 1)]          0
__________________________________________________________________________________________________
input_5 (InputLayer)            [(None, 1)]          0
__________________________________________________________________________________________________
input_6 (InputLayer)            [(None, 1)]          0
__________________________________________________________________________________________________
lstm (LSTM)                     (None, 300, 256)     570368      embedding[0][0]
__________________________________________________________________________________________________
embedding_1 (Embedding)         (None, 1, 26)        1352        input_2[0][0]
__________________________________________________________________________________________________
embedding_2 (Embedding)         (None, 1, 3)         15          input_3[0][0]
__________________________________________________________________________________________________
embedding_3 (Embedding)         (None, 1, 26)        1352        input_4[0][0]
__________________________________________________________________________________________________
embedding_4 (Embedding)         (None, 1, 50)        19600       input_5[0][0]
__________________________________________________________________________________________________
embedding_5 (Embedding)         (None, 1, 3)         18          input_6[0][0]
__________________________________________________________________________________________________
input_7 (InputLayer)            [(None, 1)]          0
__________________________________________________________________________________________________
flatten (Flatten)               (None, 76800)        0           lstm[0][0]
__________________________________________________________________________________________________
flatten_1 (Flatten)             (None, 26)           0           embedding_1[0][0]
```

```
flatten_2 (Flatten)             (None, 3)            0           embedding_2[0][0]
flatten_3 (Flatten)             (None, 26)           0           embedding_3[0][0]
flatten_4 (Flatten)             (None, 50)           0           embedding_4[0][0]
flatten_5 (Flatten)             (None, 3)            0           embedding_5[0][0]
dense (Dense)                   (None, 16)           32          input_7[0][0]
concatenate (Concatenate)       (None, 76924)        0           flatten[0][0]
                                                                 flatten_1[0][0]
                                                                 flatten_2[0][0]
                                                                 flatten_3[0][0]
                                                                 flatten_4[0][0]
                                                                 flatten_5[0][0]
                                                                 dense[0][0]
dense_1 (Dense)                 (None, 64)           4923200     concatenate[0][0]
dropout (Dropout)               (None, 64)           0           dense_1[0][0]
leaky_re_lu (LeakyReLU)         (None, 64)           0           dropout[0][0]
dense_2 (Dense)                 (None, 32)           2080        leaky_re_lu[0][0]
dropout_1 (Dropout)             (None, 32)           0           dense_2[0][0]
batch_normalization (BatchNorma (None, 32)           128         dropout_1[0][0]
leaky_re_lu_1 (LeakyReLU)       (None, 32)           0           batch_normalization[0][0]
dense_3 (Dense)                 (None, 16)           528         leaky_re_lu_1[0][0]
leaky_re_lu_2 (LeakyReLU)       (None, 16)           0           dense_3[0][0]
dense_4 (Dense)                 (None, 2)            34          leaky_re_lu_2[0][0]
==================================================================================================
Total params: 8,315,607
Trainable params: 5,518,643
Non-trainable params: 2,796,964
__________________________________________________________________________________________________
None
```

In [ ]:
```
from keras.utils.vis_utils import plot_model
plot_model(model2, to_file='/content/model-2.jpg', show_shapes = True, show_layer_names=True)
```

Out[83]:



In [ ]:
```
filepath = '/content/drive/My Drive/LSTM_Assignment/modelcheckpoint/weights_model2.hdf5'

earlyStop = EarlyStopping(monitor='val_loss', patience=2, verbose=1)
checkpoint = ModelCheckpoint(filepath, monitor='val_auc_score', verbose=1, save_best_only=True, mode='ma
```

```
log_dir = "logs/fit/model2_" + datetime.datetime.now().strftime("%Y%m%d-%H%M%S")
tensorboard_callback2 = TensorBoard(log_dir=log_dir, histogram_freq=1)
callbacks = [checkpoint, tensorboard_callback2]

input_data = [X_train_essay, X_train_school_state_ohe, X_train_project_grade_category_ohe, X_train_clean
              X_train['teacher_number_of_previously_posted_projects'] + X_train['price']]
val_data = [X_cv_essay, X_cv_school_state_ohe, X_cv_project_grade_category_ohe, X_cv_clean_categories_oh
            X_cv['teacher_number_of_previously_posted_projects'] + X_cv['price']]

model2.fit(input_data, Y_train, epochs=15, verbose=1, batch_size=400, validation_data=(val_data, Y_cv),
```

```
Epoch 1/15
175/175 [==============================] - 140s 782ms/step - loss: 0.7411 - auc_score: 0.6876 - val_los
s: 0.5451 - val_auc_score: 0.8816

Epoch 00001: val_auc_score improved from -inf to 0.88159, saving model to /content/drive/My Drive/LSTM_
Assignment/modelcheckpoint/weights_model2.hdf5
Epoch 2/15
175/175 [==============================] - 133s 761ms/step - loss: 0.5323 - auc_score: 0.8525 - val_los
s: 0.4709 - val_auc_score: 0.8911

Epoch 00002: val_auc_score improved from 0.88159 to 0.89109, saving model to /content/drive/My Drive/LS
TM_Assignment/modelcheckpoint/weights_model2.hdf5
Epoch 3/15
175/175 [==============================] - 132s 756ms/step - loss: 0.4919 - auc_score: 0.8696 - val_los
s: 0.4611 - val_auc_score: 0.8945

Epoch 00003: val_auc_score improved from 0.89109 to 0.89447, saving model to /content/drive/My Drive/LS
TM_Assignment/modelcheckpoint/weights_model2.hdf5
Epoch 4/15
175/175 [==============================] - 133s 757ms/step - loss: 0.4714 - auc_score: 0.8775 - val_los
s: 0.5019 - val_auc_score: 0.8879

Epoch 00004: val_auc_score did not improve from 0.89447
Epoch 5/15
175/175 [==============================] - 132s 756ms/step - loss: 0.4617 - auc_score: 0.8810 - val_los
s: 0.4536 - val_auc_score: 0.8960

Epoch 00005: val_auc_score improved from 0.89447 to 0.89596, saving model to /content/drive/My Drive/LS
TM_Assignment/modelcheckpoint/weights_model2.hdf5
Epoch 6/15
175/175 [==============================] - 133s 760ms/step - loss: 0.4540 - auc_score: 0.8844 - val_los
s: 0.4346 - val_auc_score: 0.8984

Epoch 00006: val_auc_score improved from 0.89596 to 0.89838, saving model to /content/drive/My Drive/LS
TM_Assignment/modelcheckpoint/weights_model2.hdf5
Epoch 7/15
175/175 [==============================] - 132s 756ms/step - loss: 0.4472 - auc_score: 0.8869 - val_los
s: 0.4326 - val_auc_score: 0.8981

Epoch 00007: val_auc_score did not improve from 0.89838
Epoch 8/15
175/175 [==============================] - 133s 758ms/step - loss: 0.4378 - auc_score: 0.8913 - val_los
s: 0.4237 - val_auc_score: 0.8995

Epoch 00008: val_auc_score improved from 0.89838 to 0.89948, saving model to /content/drive/My Drive/LS
TM_Assignment/modelcheckpoint/weights_model2.hdf5
Epoch 9/15
175/175 [==============================] - 133s 759ms/step - loss: 0.4378 - auc_score: 0.8910 - val_los
s: 0.4206 - val_auc_score: 0.8984

Epoch 00009: val_auc_score did not improve from 0.89948
Epoch 10/15
175/175 [==============================] - 134s 764ms/step - loss: 0.4301 - auc_score: 0.8938 - val_los
s: 0.4223 - val_auc_score: 0.9001

Epoch 00010: val_auc_score improved from 0.89948 to 0.90008, saving model to /content/drive/My Drive/LS
TM_Assignment/modelcheckpoint/weights_model2.hdf5
Epoch 11/15
175/175 [==============================] - 133s 761ms/step - loss: 0.4292 - auc_score: 0.8941 - val_los
s: 0.4206 - val_auc_score: 0.9005

Epoch 00011: val_auc_score improved from 0.90008 to 0.90047, saving model to /content/drive/My Drive/LS
TM_Assignment/modelcheckpoint/weights_model2.hdf5
Epoch 12/15
175/175 [==============================] - 133s 759ms/step - loss: 0.4241 - auc_score: 0.8964 - val_los
s: 0.4150 - val_auc_score: 0.9002

Epoch 00012: val_auc_score did not improve from 0.90047
Epoch 13/15
```

```
Epoch 13/15
175/175 [==============================] - 132s 756ms/step - loss: 0.4263 - auc_score: 0.8947 - val_los
s: 0.4171 - val_auc_score: 0.9014

Epoch 00013: val_auc_score improved from 0.90047 to 0.90138, saving model to /content/drive/My Drive/LS
TM_Assignment/modelcheckpoint/weights_model2.hdf5
Epoch 14/15
175/175 [==============================] - 133s 759ms/step - loss: 0.4197 - auc_score: 0.8985 - val_los
s: 0.4175 - val_auc_score: 0.9011

Epoch 00014: val_auc_score did not improve from 0.90138
Epoch 15/15
175/175 [==============================] - 132s 757ms/step - loss: 0.4164 - auc_score: 0.9003 - val_los
s: 0.4226 - val_auc_score: 0.9010


Epoch 00015: val_auc_score did not improve from 0.90138
```

Out[84]:
```
<tensorflow.python.keras.callbacks.History at 0x7fb4bebfe950>
```

In [ ]:
```
X_test_data = [X_test_essay, X_test_school_state_ohe, X_test_project_grade_category_ohe, X_test_clean_ca
roc_auc_score(Y_test, model2.predict(X_test_data))
```

Out[85]:
```
0.7042613687126467
```

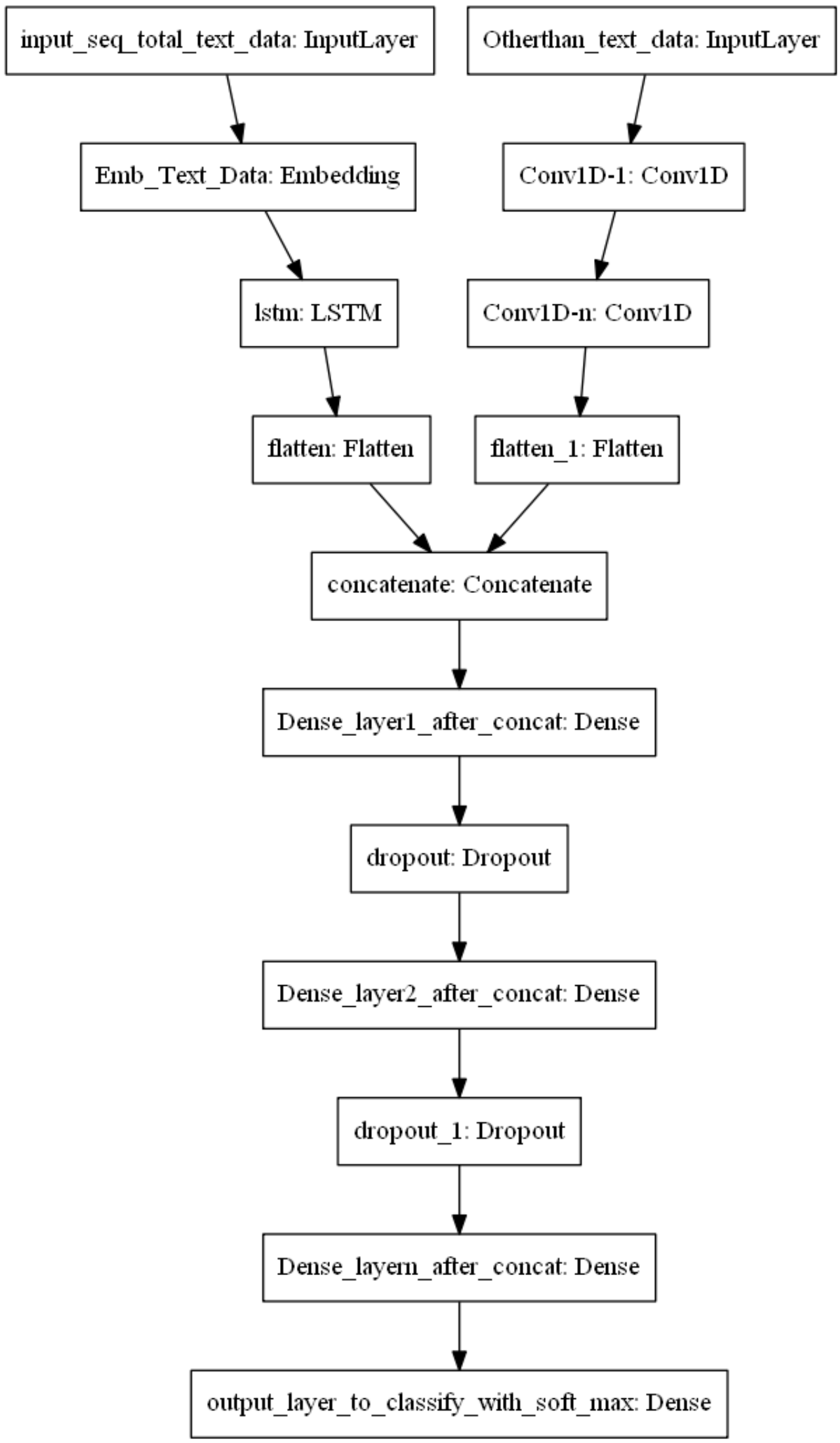
In [ ]:
```
model2.save("model_2.h5")
```

In [ ]:
```
%load_ext tensorboard
```

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

In [ ]:
```
%tensorboard --logdir /content/logs/fit/model2_20210521-190707
```

Model-3



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.

In [ ]:
```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['school_state'].values)

X_train_school_state_ohe = vectorizer.transform(X_train['school_state'].values)
X_cv_school_state_ohe = vectorizer.transform(X_cv['school_state'].values)
X_test_school_state_ohe = vectorizer.transform(X_test['school_state'].values)

school_state_features = vectorizer.get_feature_names()

print(X_train_school_state_ohe.shape, Y_train.shape)
print(X_cv_school_state_ohe.shape, Y_cv.shape)
print(X_test_school_state_ohe.shape, Y_test.shape)
```

```
(69918, 51) (69918, 2)
(17480, 51) (17480, 2)
(21850, 51) (21850, 2)
```

In [ ]:
```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_categories'].values)

X_train_clean_categories_ohe = vectorizer.transform(X_train['clean_categories'].values)
X_cv_clean_categories_ohe = vectorizer.transform(X_cv['clean_categories'].values)
X_test_clean_categories_ohe = vectorizer.transform(X_test['clean_categories'].values)

clean_categories_features = vectorizer.get_feature_names()

print(X_train_clean_categories_ohe.shape, Y_train.shape)
print(X_cv_clean_categories_ohe.shape, Y_cv.shape)
print(X_test_clean_categories_ohe.shape, Y_test.shape)
```

```
(69918, 9) (69918, 2)
(17480, 9) (17480, 2)
(21850, 9) (21850, 2)
```

In [ ]:
```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_subcategories'].values)

X_train_clean_subcategories_ohe = vectorizer.transform(X_train['clean_subcategories'].values)
X_cv_clean_subcategories_ohe = vectorizer.transform(X_cv['clean_subcategories'].values)
X_test_clean_subcategories_ohe = vectorizer.transform(X_test['clean_subcategories'].values)

clean_subcategories_features = vectorizer.get_feature_names()

print(X_train_clean_subcategories_ohe.shape, Y_train.shape)
print(X_cv_clean_subcategories_ohe.shape, Y_cv.shape)
print(X_test_clean_subcategories_ohe.shape, Y_test.shape)
```

```
(69918, 30) (69918, 2)
(17480, 30) (17480, 2)
(21850, 30) (21850, 2)
```

In [ ]:
```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['project_grade_category'].values)

X_train_project_grade_category_ohe = vectorizer.transform(X_train['project_grade_category'].values)
X_cv_project_grade_category_ohe = vectorizer.transform(X_cv['project_grade_category'].values)
X_test_project_grade_category_ohe = vectorizer.transform(X_test['project_grade_category'].values)

project_grade_category_features = vectorizer.get_feature_names()

print(X_train_project_grade_category_ohe.shape, Y_train.shape)
print(X_cv_project_grade_category_ohe.shape, Y_cv.shape)
print(X_test_project_grade_category_ohe.shape, Y_test.shape)
```

```
(69918, 4) (69918, 2)
(17480, 4) (17480, 2)
(21850, 4) (21850, 2)
```

In [ ]:
```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['teacher_prefix'].values)

X_train_teacher_prefix_ohe = vectorizer.transform(X_train['teacher_prefix'].values)
X_cv_teacher_prefix_ohe = vectorizer.transform(X_cv['teacher_prefix'].values)
X_test_teacher_prefix_ohe = vectorizer.transform(X_test['teacher_prefix'].values)

teacher_prefix_features = vectorizer.get_feature_names()

print(X_train_teacher_prefix_ohe.shape, Y_train.shape)
print(X_cv_teacher_prefix_ohe.shape, Y_cv.shape)
print(X_test_teacher_prefix_ohe.shape, Y_test.shape)
```

```
(69918, 5) (69918, 2)
(17480, 5) (17480, 2)
(21850, 5) (21850, 2)
```

In [ ]:
```
X_train_num_of_projects = X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)
X_cv_num_of_projects = X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)
X_test_num_of_projects = X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)

print(X_train_num_of_projects.shape, Y_train.shape)
print(X_cv_num_of_projects.shape, Y_cv.shape)
print(X_test_num_of_projects.shape, Y_test.shape)
```

```
(69918, 1) (69918, 2)
(17480, 1) (17480, 2)
(21850, 1) (21850, 2)
```

In [ ]:
```
X_train_price = X_train['price'].values.reshape(-1,1)
X_cv_price = X_cv['price'].values.reshape(-1,1)
X_test_price = X_test['price'].values.reshape(-1,1)

print(X_train_price.shape, Y_train.shape)
print(X_cv_price.shape, Y_cv.shape)
print(X_test_price.shape, Y_test.shape)
```

```
(69918, 1) (69918, 2)
(17480, 1) (17480, 2)
(21850, 1) (21850, 2)
```

In [ ]:
```
from scipy.sparse import hstack

X_train_orig = X_train
X_cv_orig = X_cv
X_test_orig = X_test

X_train_stacked = hstack((X_train_school_state_ohe, X_train_clean_categories_ohe, X_train_clean_subcateg
X_cv_stacked = hstack((X_cv_school_state_ohe, X_cv_clean_categories_ohe, X_cv_clean_subcategories_ohe, X
X_test_stacked = hstack((X_test_school_state_ohe, X_test_clean_categories_ohe, X_test_clean_subcategorie
```

In [ ]:
```
t = Tokenizer()
t.fit_on_texts(X_train['essay'])

vocab_size = len(t.word_index) + 1
encoded_docs = t.texts_to_sequences(X_train['essay'])
X_train_essay = padded(encoded_docs)
```

In [ ]:
```
encoded_docs = t.texts_to_sequences(X_cv['essay'])
X_cv_essay = padded(encoded_docs)

encoded_docs = t.texts_to_sequences(X_test['essay'])
X_test_essay = padded(encoded_docs)
```

In [ ]:
```
embedding_matrix_3 = np.zeros((vocab_size, 300))
for word, i in t.word_index.items():
    embedding_vector = embeddings_index.get(word)
    if embedding_vector is not None:
        embedding_matrix_3[i] = embedding_vector
```

In [ ]:
```
X_train_essay_mat = embedding_matrix_3
X_train_essay_mat.shape
print(X_train_essay_mat.shape)
```

```
(47173, 300)
```

In [ ]:
```
X_train_stacked = np.resize(X_train_stacked,new_shape=(69918,100,1))
X_cv_stacked = np.resize(X_cv_stacked,new_shape=(17480,100,1))
X_test_stacked = np.resize(X_test_stacked,new_shape=(21850,100,1))
```

In [ ]:
```
X_train_stacked.shape
```

Out[102]:
```
(69918, 100, 1)
```

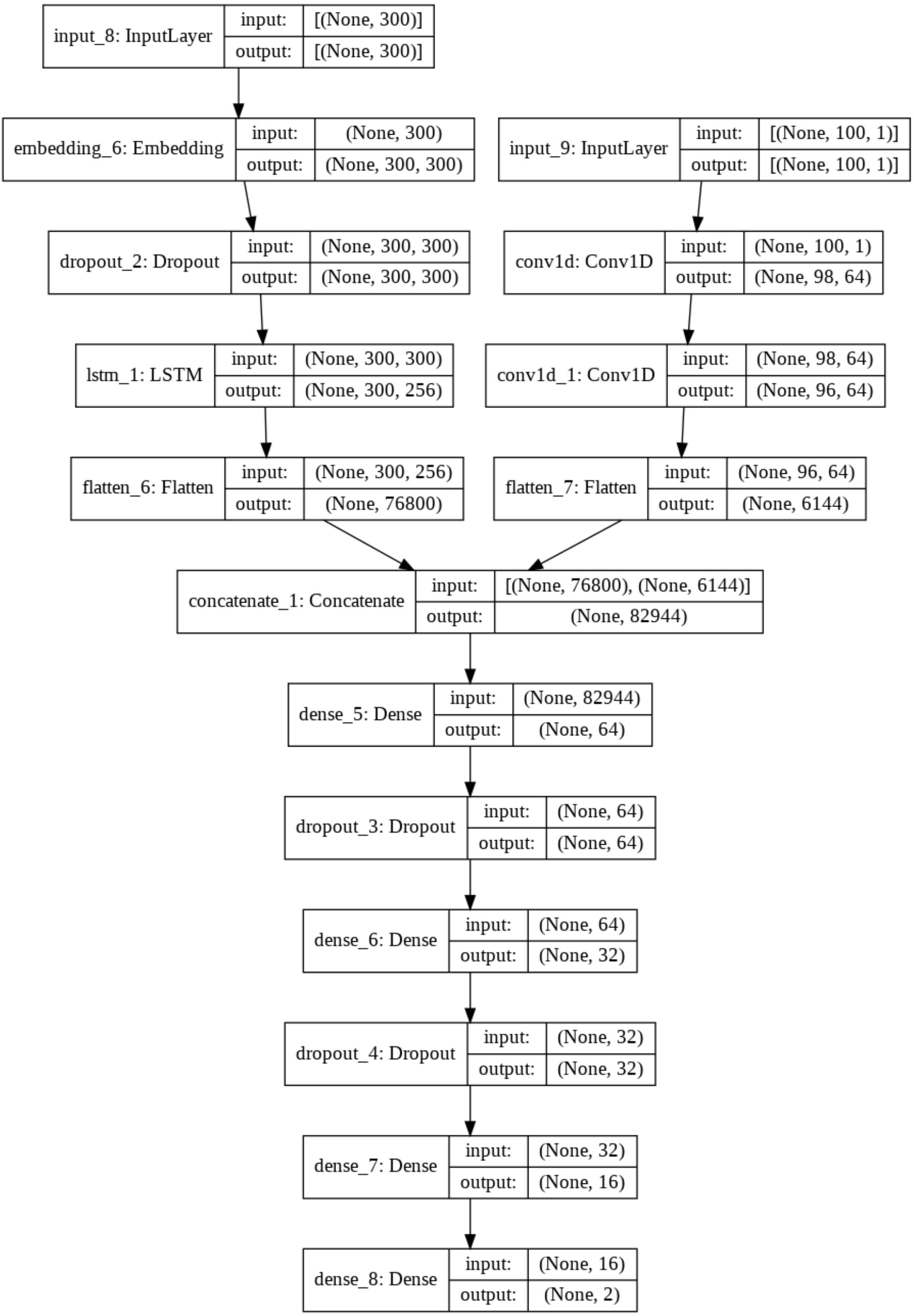
In [ ]:
```
from keras.layers.convolutional import Conv1D
from keras.layers import LeakyReLU
from keras.layers import SpatialDropout1D, LSTM, BatchNormalization,concatenate,Flatten,Embedding,Dense,
from keras import Input, Model
from keras.regularizers import l2
from keras.initializers import he_normal
from tensorflow.python.keras.callbacks import TensorBoard
from time import time
from keras.optimizers import Adam

input1 = Input(batch_shape=(None,300))
i1 = Embedding(input_dim=embedding_matrix_3.shape[0],output_dim= 300,weights=[embedding_matrix_3],traina
i1 = Dropout(0.3)(i1)
i1 = LSTM(256, recurrent_dropout=0.3, kernel_regularizer=l2(0.001), return_sequences=True)(i1)
i1 = Flatten()(i1)

# input 2
input2 = Input(shape=(100,1))
i2 = Conv1D(filters=64,kernel_size=3,strides=1)(input2)
i2 = Conv1D(filters=64,kernel_size=3,strides=1)(i2)
i2 = Flatten()(i2)

# merging both the inputs
concat = concatenate([i1,i2])
i = Dense(64,kernel_initializer=he_normal(),kernel_regularizer=l2(0.0001))(concat)
i = Dropout(0.5)(i)
i = Dense(32,kernel_initializer=he_normal(),kernel_regularizer=l2(0.0001))(i)
i = Dropout(0.5)(i)
i = Dense(16,kernel_initializer=he_normal(),kernel_regularizer=l2(0.0001))(i)
output = Dense(2, activation = 'softmax')(i)

# create model with two inputs
model3 = Model([input1,input2], output)
```

```
model3.run_eagerly = True

adam = Adam(learning_rate=0.0006, decay = 1e-4)
model3.compile(loss='categorical_crossentropy', optimizer=adam, metrics=[auc_score])
print(model3.summary())
```

```
WARNING:tensorflow:Layer lstm_1 will not use cuDNN kernel since it doesn't meet the cuDNN kernel criter
ia. It will use generic GPU kernel as fallback when running on GPU
Model: "model_1"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_8 (InputLayer)            [(None, 300)]        0
__________________________________________________________________________________________________
embedding_6 (Embedding)         (None, 300, 300)     14151900    input_8[0][0]
__________________________________________________________________________________________________
input_9 (InputLayer)            [(None, 100, 1)]     0
__________________________________________________________________________________________________
dropout_2 (Dropout)             (None, 300, 300)     0           embedding_6[0][0]
__________________________________________________________________________________________________
conv1d (Conv1D)                 (None, 98, 64)       256         input_9[0][0]
__________________________________________________________________________________________________
lstm_1 (LSTM)                   (None, 300, 256)     570368      dropout_2[0][0]
__________________________________________________________________________________________________
conv1d_1 (Conv1D)               (None, 96, 64)       12352       conv1d[0][0]
__________________________________________________________________________________________________
flatten_6 (Flatten)             (None, 76800)        0           lstm_1[0][0]
__________________________________________________________________________________________________
flatten_7 (Flatten)             (None, 6144)         0           conv1d_1[0][0]
__________________________________________________________________________________________________
concatenate_1 (Concatenate)     (None, 82944)        0           flatten_6[0][0]
                                                                 flatten_7[0][0]
__________________________________________________________________________________________________
dense_5 (Dense)                 (None, 64)           5308480     concatenate_1[0][0]
__________________________________________________________________________________________________
dropout_3 (Dropout)             (None, 64)           0           dense_5[0][0]
__________________________________________________________________________________________________
dense_6 (Dense)                 (None, 32)           2080        dropout_3[0][0]
__________________________________________________________________________________________________
dropout_4 (Dropout)             (None, 32)           0           dense_6[0][0]
__________________________________________________________________________________________________
dense_7 (Dense)                 (None, 16)           528         dropout_4[0][0]
__________________________________________________________________________________________________
dense_8 (Dense)                 (None, 2)            34          dense_7[0][0]
==================================================================================================
Total params: 20,045,998
Trainable params: 5,894,098
Non-trainable params: 14,151,900
__________________________________________________________________________________________________
None
```

In [ ]:
```
from keras.utils.vis_utils import plot_model
plot_model(model3, to_file='/content/model_3.png', show_shapes=True, show_layer_names=True)
```

Out[104]:



In [ ]:
```
from keras.callbacks import EarlyStopping, ModelCheckpoint

filepath = '/content/drive/My Drive/LSTM_Assignment/modelcheckpoint/weights_model3.hdf5'

checkpoint = ModelCheckpoint(filepath, monitor='val_auc_score', verbose=1, save_best_only=True, mode='ma
log_dir = "logs/fit/model3_" + datetime.datetime.now().strftime("%Y%m%d-%H%M%S")
tensorboard_callback3 = TensorBoard(log_dir=log_dir, histogram_freq=1)
callbacks = [checkpoint, tensorboard_callback3]

model3.fit([X_train_essay, X_train_stacked], Y_train, epochs=20, verbose=1, batch_size=512, validation_d
```

```
Epoch 1/20
137/137 [==============================] - 140s 812ms/step - loss: 3.1839 - auc_score: 0.7974 - val_los
s: 0.6236 - val_auc_score: 0.8970

Epoch 00001: val_auc_score improved from -inf to 0.89701, saving model to /content/drive/My Drive/LSTM_
Assignment/modelcheckpoint/weights_model3.hdf5
Epoch 2/20
137/137 [==============================] - 107s 779ms/step - loss: 0.6375 - auc_score: 0.8827 - val_los
s: 0.5497 - val_auc_score: 0.8942

Epoch 00002: val_auc_score did not improve from 0.89701
Epoch 3/20
137/137 [==============================] - 106s 776ms/step - loss: 0.5691 - auc_score: 0.8874 - val_los
s: 0.5182 - val_auc_score: 0.8975

Epoch 00003: val_auc_score improved from 0.89701 to 0.89748, saving model to /content/drive/My Drive/LS
TM_Assignment/modelcheckpoint/weights_model3.hdf5
Epoch 4/20
137/137 [==============================] - 106s 775ms/step - loss: 0.5228 - auc_score: 0.8946 - val_los
```

In [ ]:
```
X_test_data = [X_test_essay, X_test_stacked]
roc_auc_score(Y_test, model3.predict(X_test_data))
```

Out[106]:
```
0.7073108281770057
```

In [ ]:
```
model3.save('model_3.h5')
```

In [ ]:
```
%load_ext tensorboard
```

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

In [ ]:
```
%tensorboard --logdir /content/logs/fit/model3_20210521-194416
```

In [ ]:
```

```