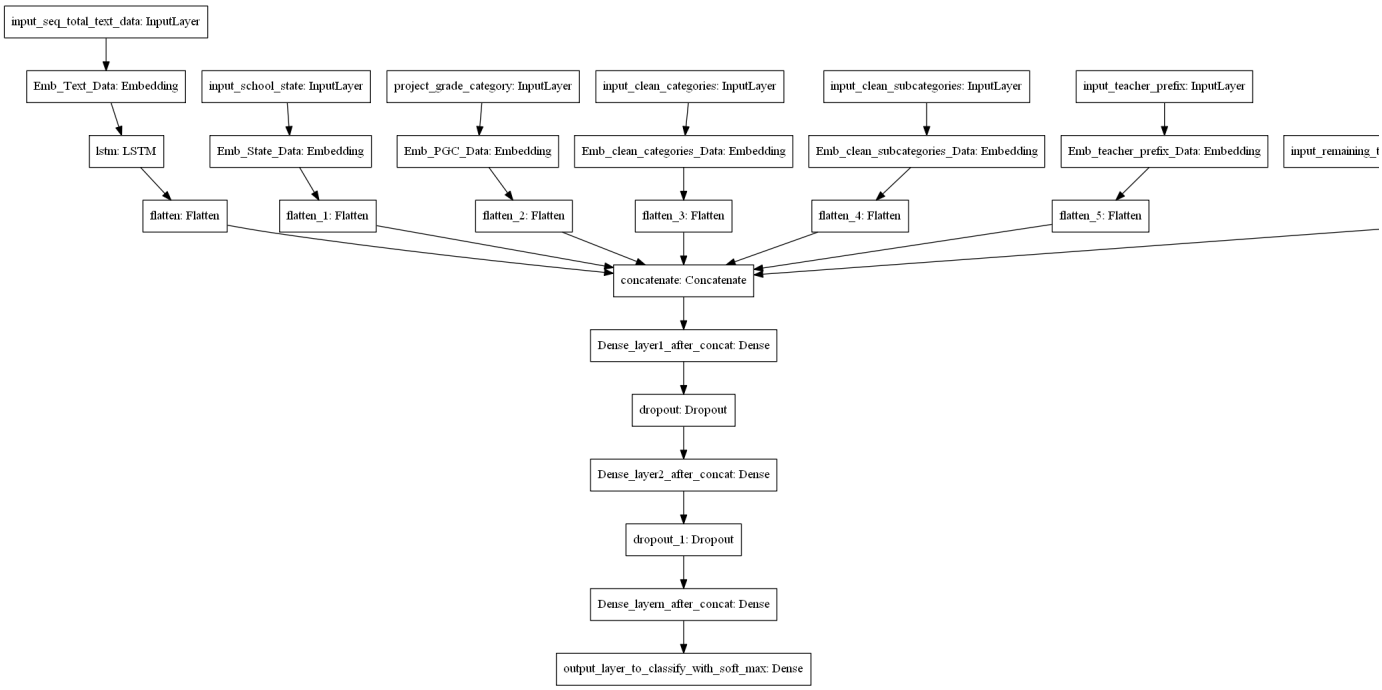
Assignment : 14

1. Download the preprocessed DonorsChoose data from here Dataset
2. Split the data into train, cv, and test
3. After step 2 you have to train 3 types of models as discussed below.
4. For all the model use 'auc' as a metric. check this for using auc as a metric. you nee
5. You are free to choose any number of layers/hiddden units but you have to use same typ
6. You can use any one of the optimizers and choice of Learning rate and momentum, resour
7. You should Save the best model weights.
8. For all the model's use TensorBoard and plot the Metric value and Loss with epoch. Whi
9. Use Categorical Cross Entropy as Loss to minimize.
10. try to get AUC more than 0.75 for atleast one model

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 Em predefined glove word vectors, don't train any word vectors. After this use LSTM and get the
- **Input_school_state** --- Give 'school_state' column as input to embedding layer and Train the k
- **Project_grade_category** --- Give 'project_grade_category' column as input to embedding laye
- **Input_clean_categories** --- Give 'input_clean_categories' column as input to embedding layer
- **Input_clean_subcategories** --- Give 'input_clean_subcategories' column as input to embeddi

- **Input_clean_subcategories** --- Give 'input_teacher_prefix' column as input to embedding laye
- **Input_remaining_teacher_number_of_previously_posted_projects._resource_summary_con** 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 yo restriction on that.

Below is an example of embedding layer for a categorical columns. In below code all are dummy

```
''''# 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)'''
```

```
"'# https://stats.stackexchange.com/questions/270546/how-does-keras-embedding-layer-w
```

1. Go through this blog, if you have any doubt on using predefined Embedding https://machinelearningmastery.com/use-word-embedding-layers-deep-learni

2. Please go through this link https://keras.io/getting-started/functional-api-gu multi-output models' then you will get to know how to give multiple inputs.

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.m
```

```
path_train="/content/drive/My Drive/Colab Notebooks/preprocessed_data.csv"
```

```
#importing all the required lib
import pandas as pd
import numpy as np
import os
import math
from collections import defaultdict
import matplotlib.pyplot as plt
from sklearn.feature_extraction.text import TfidfVectorizer,CountVectorizer
from sklearn.model_selection import train_test_split
from keras.preprocessing.text import Tokenizer
from keras.preprocessing.sequence import pad_sequences
from keras.layers import SpatialDropout1D, LSTM, BatchNormalization,concatenate,Flatten,Em
from keras.models import Sequential
from keras import Model,Input
from keras.layers.convolutional import Conv2D,Conv1D
import keras.backend as k
from sklearn.metrics import roc_auc_score
```

```
import tensorflow as tf
import keras
from sklearn.utils import compute_class_weight
from keras.initializers import he_normal,glorot_normal
from keras.regularizers import l1,l2
from keras.callbacks import Callback, EarlyStopping, ModelCheckpoint,LearningRateScheduler
from time import time
from keras.callbacks import TensorBoard

from IPython.display import SVG, display
import pickle
import warnings
warnings.filterwarnings("ignore")
```

```
Using TensorFlow backend.
```

The default version of TensorFlow in Colab will soon switch to TensorFlow 2.x.
We recommend you upgrade now or ensure your notebook will continue to use TensorFlow 1.x via the %te

```
project_data=pd.read_csv(path_train)
```

```
project_data.shape
```

```
(109248, 10)
```

```
project_data.head(1)
```

	school_state	teacher_prefix	project_grade_category	Unnamed: 3	clean_categories
0	ca	mrs	grades_prek_2	NaN	math_science

```
class_label = project_data['project_is_approved']
class_wght = compute_class_weight("balanced", classes= np.unique(class_label),y=class_labe
```

```
y_label = project_data['project_is_approved'].values
project_data.drop(['project_is_approved'],axis=1,inplace=True)
x_train, x_test, y_train, y_test = train_test_split(project_data, y_label, stratify=y_labe
```

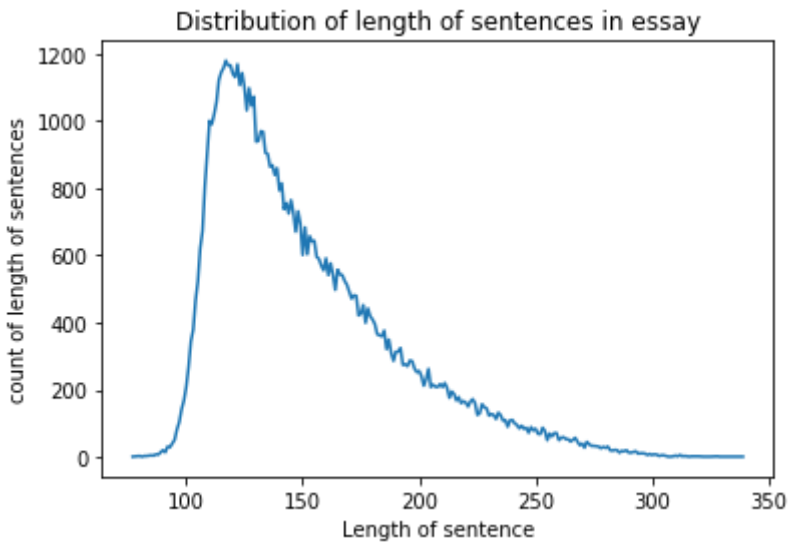
```
from keras.utils import to_categorical
y_train = to_categorical(y_train, num_classes=2)
y_test = to_categorical(y_test, num_classes=2)
```

```
token = Tokenizer()
token.fit_on_texts(x_train['essay'])
vocabulary_length = len(token.word_index) + 1
print('Total unique words in the x_train',vocabulary_length)
```

```
encoded_seq_train = token.texts_to_sequences(x_train['essay'])
encoded_seq_test = token.texts_to_sequences(x_test['essay'])
```

```
Total unique words in the x_train 49152
```

```
size = []
for sent in encoded_seq_train:
    size.append(len(sent))

s = list(set(size))
count = []
for i in s:
    count.append(size.count(i))


plt.plot(s,count)
plt.xlabel('Length of sentence')
plt.ylabel('count of length of sentences')
plt.title('Distribution of length of sentences in essay')
plt.show()
```



For padding the sequence we need to find est length which covers most of the length and we have covered within length of 300. so we can take maximum length=300 for padding. 2.We will do post

```
# This is formatted as code
```

padding the encoded sequence

```
max_size = 300
pad_train = pad_sequences(encoded_seq_train, maxlen=max_size, padding='post')
pad_test = pad_sequences(encoded_seq_test, maxlen=max_size, padding='post')


print(len(pad_train[10]))
print(len(pad_test[1000]))
```

```
300
300
```

```
len(pad_train)
```

```
76473
```

```
len(pad_test)
```

```
32775
```

```
"""essay is vectorized into 300 dimension"""
```

```
'essay is vectorized into 300 dimension'
```

```
tokenizing words using glove model
```

```
import pickle

from tqdm import tqdm
import os


import io
embeddings_index = {}
with io.open('/content/drive/My Drive/Colab Notebooks/glove_vectors','rb') as f:
  model = pickle.load(f)
  glove_words =  set(model.keys())

# for train
embedded_vector_train = np.zeros((vocabulary_length,300))
for word, i in token.word_index.items():
    if word in glove_words:
        embedded_vector = model[word]
        embedded_vector_train[i] = embedded_vector
```

```
len(embedded_vector_train[100])
```

```
300
```

tokenizing features

```
def tokenization(feature):
    all_words = list(feature)
    distinct_words = list(set(feature))
    length = len(distinct_words)
    count = []
    for cat in distinct_words:
```

```
            count.append([all_words.count(cat),cat])
        count.sort()
        rank = {}
        for i in range(1,len(count)+1):
            rank.update({count[i-1][1] : i})
        return (rank,distinct_words,length)
```

Tokenizing clean categories, clean sub categories,state,techer prefix,project grade categories,essa

```
cty_rank,distinct_words,cty_length = tokenization(x_train['clean_categories'])
print(cty_rank)
print(distinct_words)
print(cty_length)
```

```
{'music_arts warmth care_hunger': 1, 'literacy_language warmth care_hunger': 2, 'musi
['appliedlearning specialneeds', 'math_science specialneeds', 'literacy_language warm
50
```

```
enc_cty_train = []
enc_cty_test = []
clean_cat=x_train['clean_categories']
clean_cat1=x_test['clean_categories']
for cat in clean_cat:
    enc_cty_train.append(cty_rank[cat])

for cat in clean_cat1:
    if cat in distinct_words:
        enc_cty_test.append(cty_rank[cat])
    else:
        enc_cty_test.append(0)

enc_cty_train = np.asarray(enc_cty_train)
enc_cty_test = np.asarray(enc_cty_test)

print(enc_cty_train[0])
print(enc_cty_test[100])
```

```
49
46
```

```
sub_cty_rank,distinct_words,sub_cty_length = tokenization(x_train['clean_subcategories'])
print(sub_cty_rank)
print(distinct_words)
print(sub_cty_length)
enc_sub_cty_train = []
enc_sub_cty_test = []
clean_sub_cat=x_train['clean_subcategories']
clean_sub_cat1=x_test['clean_subcategories']
for cat in clean_sub_cat:
    enc_sub_cty_train.append(sub_cty_rank[cat])

for cat in clean sub cat1:
```

```
    if cat in distinct_words:
        enc_sub_cty_test.append(sub_cty_rank[cat])
    else:
        enc_sub_cty_test.append(0)

enc_sub_cty_train = np.asarray(enc_sub_cty_train)
enc_sub_cty_test = np.asarray(enc_sub_cty_test)

print(enc_sub_cty_train[0])
print(enc_sub_cty_test[100])
```

```
{'civics_government extracurricular': 1, 'civics_government foreignlanguages': 2, 'ci
['earlydevelopment mathematics', 'nutritioneducation', 'gym_fitness', 'literacy teams
390
350
376
```

```
state_rank,distinct_words,state_length = tokenization(x_train['school_state'])
print(state_rank)
print(distinct_words)
print(state_length)
enc_state_train = []
enc_state_test = []
clean_state=x_train['school_state']
clean_state1=x_test['school_state']
for cat in clean_state:
    enc_state_train.append(state_rank[cat])

for cat in clean_state1:
    if cat in distinct_words:
        enc_state_test.append(state_rank[cat])
    else:
        enc_state_test.append(0)

enc_state_train = np.asarray(enc_state_train)
enc_state_test = np.asarray(enc_state_test)

print(enc_state_train[0])
print(enc_state_test[100])
```

```
{'vt': 1, 'wy': 2, 'nd': 3, 'mt': 4, 'ne': 5, 'ri': 6, 'sd': 7, 'de': 8, 'nh': 9, 'ak
['al', 'ma', 'in', 'tn', 'me', 'dc', 'id', 'wv', 'pa', 'hi', 'wy', 'co', 'ca', 'ak',
51
19
47
```

```
teacher_rank,distinct_words,teacher_length = tokenization(x_train['teacher_prefix'])
print(teacher_rank)
print(distinct_words)
print(teacher_length)
enc_teacher_train = []
enc_teacher_test = []
```

```
clean_teacher=x_train['teacher_prefix']
clean_teacher1=x_test['teacher_prefix']
for cat in clean_teacher:
    enc_teacher_train.append(teacher_rank[cat])

for cat in clean_teacher1:
    if cat in distinct_words:
        enc_teacher_test.append(teacher_rank[cat])
    else:
        enc_teacher_test.append(0)

enc_teacher_train = np.asarray(enc_teacher_train)
enc_teacher_test = np.asarray(enc_teacher_test)

print(enc_teacher_train[0])
print(enc_teacher_test[100])
```

```
{'dr': 1, 'teacher': 2, 'mr': 3, 'ms': 4, 'mrs': 5}
['mr', 'dr', 'teacher', 'ms', 'mrs']
5
5
5
```

```
pgc_rank,distinct_words,pgc_length = tokenization(x_train['project_grade_category'])
print(pgc_rank)
print(distinct_words)
print(pgc_length)
enc_pgc_train = []
enc_pgc_test = []
clean_pgc=x_train['project_grade_category']
clean_pgc1=x_test['project_grade_category']
for cat in clean_pgc:
    enc_pgc_train.append(pgc_rank[cat])

for cat in clean_pgc1:
    if cat in distinct_words:
        enc_pgc_test.append(pgc_rank[cat])
    else:
        enc_pgc_test.append(0)

enc_pgc_train = np.asarray(enc_pgc_train)
enc_pgc_test = np.asarray(enc_pgc_test)

print(enc_pgc_train[0])
print(enc_pgc_test[100])
```

```
{'grades_9_12': 1, 'grades_6_8': 2, 'grades_3_5': 3, 'grades_prek_2': 4}
['grades_6_8', 'grades_3_5', 'grades_9_12', 'grades_prek_2']
4
4
3
```

Standardizing train and test data

```
from sklearn.preprocessing import StandardScaler
```

```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
scaler.fit(x_train['price'].values.reshape(-1,1))
x_train_price= scaler.transform(x_train['price'].values.reshape(-1,1))
x_test_price= scaler.transform(x_test['price'].values.reshape(-1,1))
print(x_train_price.shape, y_train.shape)
print(x_test_price.shape, y_test.shape)
```

```
(76473, 1) (76473, 2)
(32775, 1) (32775, 2)
```

```
scaler.fit(x_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
x_train_ppp= scaler.transform(x_train['teacher_number_of_previously_posted_projects'].valu
x_test_ppp= scaler.transform(x_test['teacher_number_of_previously_posted_projects'].values
print(x_train_ppp.shape, y_train.shape)
print(x_test_ppp.shape, y_test.shape)
```

```
(76473, 1) (76473, 2)
(32775, 1) (32775, 2)
```

```
numerical_train = np.hstack((x_train_price,x_train_ppp))
numerical_test = np.hstack((x_test_price,x_test_ppp))
```

```
'''Defining AUC'''
```

```
'Defining AUC'
```

```
def auc1(y_true, y_pred):
    if len(np.unique(y_true[:,1])) == 1:
        return 0.5
    else:
        return roc_auc_score(y_true, y_pred)

def auc(y_true, y_pred):
    return tf.py_func(auc1, (y_true, y_pred), tf.double)
```

TensorBoard installation

```
!pip install tensorboardcolab
```

```
Requirement already satisfied: tensorboardcolab in /usr/local/lib/python3.6/dist-pack
```

```
from tensorboardcolab import TensorBoardColab, TensorBoardColabCallback

tbc=TensorBoardColab()
```

```
Wait for 8 seconds...
TensorBoard link:
https://0bacd753.ngrok.io
```

LSTM MODEL 1-Architecture

```
keras.backend.clear_session()
essay = Input(shape=(300,), name='essay_input')
x1 = Embedding(vocabulary_length, 300, weights=[embedded_vector_train], input_length=300)(
lstm_out = LSTM(100,recurrent_dropout=0.5,return_sequences=True)(x1)
flatten_1 = Flatten()(lstm_out)

state = Input(shape=(1,), name='school_state')
x2 = Embedding(state_length,5, input_length=1)(state)
flatten_2 = Flatten()(x2)


pgc = Input(shape=(1,), name='project_grade_category')
x3 = Embedding(pgc_length,5, input_length=1)(pgc)
flatten_3 = Flatten()(x3)


clean_cty = Input(shape=(1,), name='clean_categories')
x4 = Embedding(cty_length,5, input_length=1)(clean_cty)
flatten_4 = Flatten()(x4)


clean_sub_cty = Input(shape=(1,), name='clean_sub_categories')
x5 = Embedding(sub_cty_length,5, input_length=1)(clean_sub_cty)
flatten_5 = Flatten()(x5)


teacher= Input(shape=(1,), name='teacher_prefix')
x6 = Embedding(teacher_length,5, input_length=1)(teacher)
flatten_6 = Flatten()(x6)


numerical_input = Input(shape=(2,), name='remaining_input')
dense_1 = Dense(16, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l2



x = concatenate([flatten_1,flatten_2,flatten_3,flatten_4,flatten_5,flatten_6,dense_1])

x = Dense(128, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l2(0.00
x = Dropout(.5)(x)
x = Dense(64, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l2(0.001
x = Dropout(.5)(x)
x = BatchNormalization()(x)

x = Dense(32, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l2(0.001
output = Dense(2, activation='softmax')(x)

model1 = Model(inputs=[essay,state,pgc,clean_cty,clean_sub_cty,teacher,numerical_input], o
model1.compile(loss='categorical_crossentropy', optimizer=keras.optimizers.Adam(lr=0.0006,
print(model1.summary())
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_prob
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/optimizers.py:79

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From <ipython-input-31-70948b21cc0e>:8: py_func (from tensorflow.p
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.

Model: "model_1"
________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
================================================================================
essay_input (InputLayer)        (None, 300)          0
________________________________________________________________________________
embedding_1 (Embedding)         (None, 300, 300)     14720100    essay_input[0][0]
________________________________________________________________________________
school_state (InputLayer)       (None, 1)            0
________________________________________________________________________________
project_grade_category (InputLa (None, 1)            0
________________________________________________________________________________
clean_categories (InputLayer)   (None, 1)            0
________________________________________________________________________________
clean_sub_categories (InputLaye (None, 1)            0
________________________________________________________________________________
teacher_prefix (InputLayer)     (None, 1)            0
```

```
lstm_1 (LSTM)                   (None, 300, 100)     160400      embedding_1[0][0]
embedding_2 (Embedding)         (None, 1, 5)         255         school_state[0][0]
embedding_3 (Embedding)         (None, 1, 5)         20          project_grade_catego
embedding_4 (Embedding)         (None, 1, 5)         250         clean_categories[0][
embedding_5 (Embedding)         (None, 1, 5)         1970        clean_sub_categories
embedding_6 (Embedding)         (None, 1, 5)         25          teacher_prefix[0][0]
remaining_input (InputLayer)    (None, 2)            0
flatten_1 (Flatten)             (None, 30000)        0           lstm_1[0][0]
flatten_2 (Flatten)             (None, 5)            0           embedding_2[0][0]
flatten_3 (Flatten)             (None, 5)            0           embedding_3[0][0]
flatten_4 (Flatten)             (None, 5)            0           embedding_4[0][0]
flatten_5 (Flatten)             (None, 5)            0           embedding_5[0][0]
flatten_6 (Flatten)             (None, 5)            0           embedding_6[0][0]
dense_1 (Dense)                 (None, 16)           48          remaining_input[0][0
concatenate_1 (Concatenate)     (None, 30041)        0           flatten_1[0][0]
                                                                 flatten_2[0][0]
                                                                 flatten_3[0][0]
                                                                 flatten_4[0][0]
                                                                 flatten_5[0][0]
                                                                 flatten_6[0][0]
                                                                 dense_1[0][0]
dense_2 (Dense)                 (None, 128)          3845376     concatenate_1[0][0]
dropout_1 (Dropout)             (None, 128)          0           dense_2[0][0]
dense_3 (Dense)                 (None, 64)           8256        dropout_1[0][0]
dropout_2 (Dropout)             (None, 64)           0           dense_3[0][0]
batch_normalization_1 (BatchNor (None, 64)           256         dropout_2[0][0]
dense_4 (Dense)                 (None, 32)           2080        batch_normalization_
dense_5 (Dense)                 (None, 2)            66          dense_4[0][0]
==================================================================================
Total params: 18,739,102
Trainable params: 18,738,974
Non-trainable params: 128
__________________________________________________________________________________
None
```

```
train_1 = [pad_train_enc_ctv, train_enc_sub_ctv, train_enc_state, train_enc_pgc, train_enc_tea
```

```
test_1 = [pad_test,enc_cty_test,enc_sub_cty_test,enc_state_test,enc_pgc_test,enc_teacher_t
```

```
print(pad_train.shape)
print(enc_cty_train.shape)
print(enc_sub_cty_train.shape)
print(enc_state_train.shape)
print(enc_pgc_train.shape)
print(enc_teacher_train.shape)
print(numerical_train.shape)
```

```
(76473, 300)
(76473,)
(76473,)
(76473,)
(76473,)
(76473,)
(76473, 2)
```

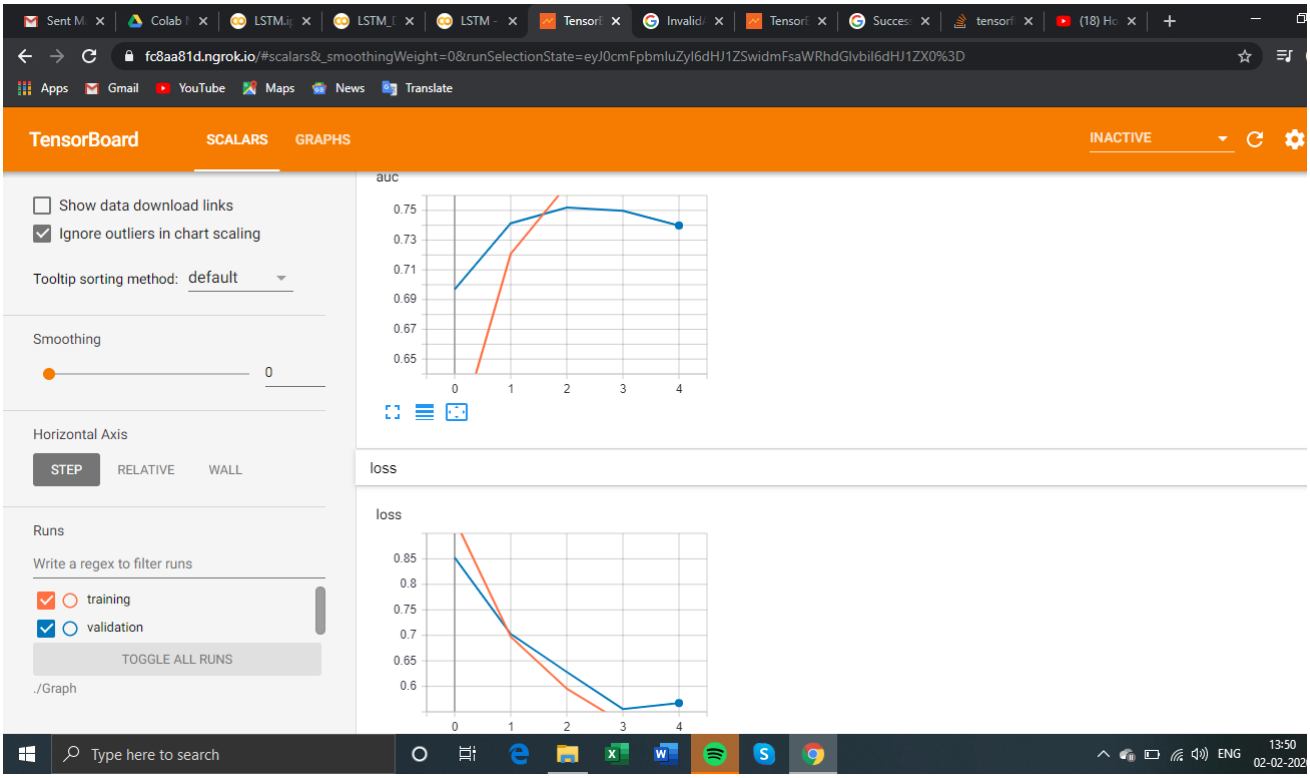
```
print(pad_test.shape)
print(enc_cty_test.shape)
print(enc_sub_cty_test.shape)
print(enc_state_test.shape)
print(enc_pgc_test.shape)
print(enc_teacher_test.shape)
print(numerical_test.shape)
```

```
(32775, 300)
(32775,)
(32775,)
(32775,)
(32775,)
(32775,)
(32775, 2)
```

```
#model fitting
#https://machinelearningmastery.com/check-point-deep-learning-models-keras/
filepath="weights_copy.best.hdf5"
checkpoint = ModelCheckpoint(filepath, monitor='val_auc', verbose=1, save_best_only=True,
callbacks_list = [checkpoint,TensorBoardColabCallback(tbc)]
model1.fit(train_1, y_train,epochs=5,verbose=1,batch_size=256,callbacks =callbacks_list,va
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow_core/python
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

Train on 76473 samples, validate on 32775 samples
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorboardcolab/core.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/callbacks.py:112

Epoch 1/5
76473/76473 [==============================] - 186s 2ms/step - loss: 0.9272 - auc: 0.

Epoch 00001: val_auc improved from -inf to 0.69684, saving model to weights_copy.best
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorboardcolab/callb

Epoch 2/5
76473/76473 [==============================] - 185s 2ms/step - loss: 0.6972 - auc: 0.

Epoch 00002: val_auc improved from 0.69684 to 0.74131, saving model to weights_copy.b
Epoch 3/5
76473/76473 [==============================] - 183s 2ms/step - loss: 0.5952 - auc: 0.

Epoch 00003: val_auc improved from 0.74131 to 0.75196, saving model to weights_copy.b
Epoch 4/5
76473/76473 [==============================] - 179s 2ms/step - loss: 0.5285 - auc: 0.

Epoch 00004: val_auc did not improve from 0.75196
Epoch 5/5
76473/76473 [==============================] - 177s 2ms/step - loss: 0.4749 - auc: 0.

Epoch 00005: val_auc did not improve from 0.75196
<keras.callbacks.History at 0x7f3e6f11cdd8>
```

```
from IPython.display import Image
Image(retina=True, filename='/content/drive/My Drive/m1.png')
```



auc graph:

Blue curve validation AUC: 0.75196

Red curve Train AUC :0.7669

Model-2

Use the same model as above but for 'input_seq_total_text_data' give only some words in the sent below.

1. Train the TF-IDF on the Train data feature 'essay'
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 t
4. Train the LSTM after removing the Low and High idf value words. (In model-1 Train on t

Performing tfid vectorization on essay data

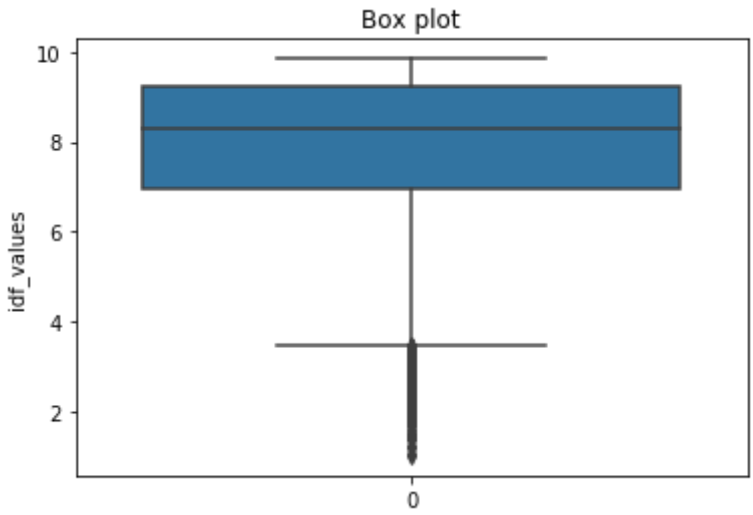
```
vectorizer = TfidfVectorizer(min_df=10)
x_tfidf_train = vectorizer.fit_transform(x_train['essay'].values)
print(x_tfidf_train.shape)
```

```
print(x_tfidf_train.shape)
```

```
(76473, 14523)
```

visualizing idf values using box plot to remove redundant and rare words

```
import seaborn as sns
idf_values = vectorizer.idf_
sns.boxplot(data=idf_values)
plt.title('Box plot')
plt.ylabel('idf_values')
plt.show()
```



Filtering words

```
features = np.asarray(vectorizer.get_feature_names())

f_i = []
for i in range(len(idf_values)):
    if idf_values[i] >= 5 and idf_values[i] <=9:
        f_i.append(i)

filtered_words = []
for i in f_i:
    filtered_words.append(features[i])


print('all words = ', len(features))
print('Filtered words = ',len(filtered_words))
```

```
all words =  14523
Filtered words =  8900
```

```
# keeping words present in filtered words in train_data
from tqdm import tqdm
x_tfidf_train_new = []
for sent in tqdm(x_train['essay']):
```

```
        line = []
        for word in sent.split():
            if word in filtered_words:
                line.append(word)
        x_tfidf_train_new.append(' '.join(line))

    #keeping words present in filtered data in test_data
    x_tfidf_test_new = []
    for sent in tqdm(x_test['essay']):
        line = []
        for word in sent.split():
            if word in filtered_words:
                line.append(word)
        x_tfidf_test_new.append(' '.join(line))

    print(len(x_tfidf_train_new))
    print(len(x_tfidf_test_new))
```

```
100%|██████████| 76473/76473 [19:46<00:00, 64.44it/s]
100%|██████████| 32775/32775 [08:21<00:00, 65.30it/s]76473
32775
```

tokenizing the idf sentences

```
token_tfidf = Tokenizer()
token_tfidf.fit_on_texts(x_tfidf_train_new)
vocabulary_length = len(token_tfidf.word_index) + 1
print('Total distinct words present in the x_tfidf_train_new',vocabulary_length)
enc_tfidf_train_new = token_tfidf.texts_to_sequences(x_tfidf_train_new)
enc_tfidf_test_new = token_tfidf.texts_to_sequences(x_tfidf_test_new)
```

```
Total distinct words present in the x_tfidf_train_new 8901
```

Padding

```
max_size = 300
pad_tfidf_train = pad_sequences(enc_tfidf_train_new, maxlen=max_size, padding='post')
pad_tfidf_test = pad_sequences(enc_tfidf_test_new, maxlen=max_size, padding='post')
print(len(pad_tfidf_train[10]))
print(len(pad_tfidf_test[1000]))
```

```
300
300
```

```
# for train
embedded_vector_train_2 = np.zeros((vocabulary_length,300))
for word, i in token_tfidf.word_index.items():
    if word in glove_words:
        embedded_vector = model[word]
        embedded_vector_train_2[i] = embedded_vector
```

```
vocabulary_length
```

```
8901
```

Model architecture 2:

```
keras.backend.clear_session()
essay = Input(shape=(300,), name='essay_input')
x1 = Embedding(vocabulary_length, 300, weights=[embedded_vector_train_2], input_length=300
lstm_out = LSTM(100,recurrent_dropout=0.5,return_sequences=True)(x1)
flatten_1 = Flatten()(lstm_out)

state = Input(shape=(1,), name='school_state')
x2 = Embedding(state_length,5, input_length=1)(state)
flatten_2 = Flatten()(x2)


pgc = Input(shape=(1,), name='project_grade_category')
x3 = Embedding(pgc_length,5, input_length=1)(pgc)
flatten_3 = Flatten()(x3)


clean_cty = Input(shape=(1,), name='clean_categories')
x4 = Embedding(cty_length,5, input_length=1)(clean_cty)
flatten_4 = Flatten()(x4)


clean_sub_cty = Input(shape=(1,), name='clean_sub_categories')
x5 = Embedding(sub_cty_length,5, input_length=1)(clean_sub_cty)
flatten_5 = Flatten()(x5)


teacher= Input(shape=(1,), name='teacher_prefix')
x6 = Embedding(teacher_length,5, input_length=1)(teacher)
flatten_6 = Flatten()(x6)


numerical_input = Input(shape=(2,), name='remaining_input')
dense_1 = Dense(16, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l2



x = concatenate([flatten_1,flatten_2,flatten_3,flatten_4,flatten_5,flatten_6,dense_1])

x = Dense(128, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l2(0.00
x = Dropout(.5)(x)
x = Dense(64, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l2(0.001
x = Dropout(.5)(x)
x = BatchNormalization()(x)

x = Dense(32, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l2(0.001
output = Dense(2, activation='softmax')(x)
```

```
model2 = Model(inputs=[essay,state,pgc,clean_cty,clean_sub_cty,teacher,numerical_input], o
tensorboard = TensorBoard(log_dir="logs".format(time()))
model2.compile(loss='categorical_crossentropy', optimizer=keras.optimizers.Adam(lr=0.0006,
print(model2.summary())
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_prob
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/optimizers.py:79

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From <ipython-input-33-70948b21cc0e>:8: py_func (from tensorflow.p
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.

Model: "model_1"
```

Layer (type)	Output Shape	Param #	Connected to
essay_input (InputLayer)	(None, 300)	0	
embedding_1 (Embedding)	(None, 300, 300)	2670300	essay_input[0][0]
school_state (InputLayer)	(None, 1)	0	
project_grade_category (InputLa	(None, 1)	0	
clean_categories (InputLayer)	(None, 1)	0	
clean_sub_categories (InputLaye	(None, 1)	0	
teacher_prefix (InputLayer)	(None, 1)	0	

lstm_1 (LSTM)	(None, 300, 100)	160400	embedding_1[0][0]
embedding_2 (Embedding)	(None, 1, 5)	255	school_state[0][0]
embedding_3 (Embedding)	(None, 1, 5)	20	project_grade_catego
embedding_4 (Embedding)	(None, 1, 5)	255	clean_categories[0][
embedding_5 (Embedding)	(None, 1, 5)	1930	clean_sub_categories
embedding_6 (Embedding)	(None, 1, 5)	25	teacher_prefix[0][0]
remaining_input (InputLayer)	(None, 2)	0	
flatten_1 (Flatten)	(None, 30000)	0	lstm_1[0][0]
flatten_2 (Flatten)	(None, 5)	0	embedding_2[0][0]
flatten_3 (Flatten)	(None, 5)	0	embedding_3[0][0]
flatten_4 (Flatten)	(None, 5)	0	embedding_4[0][0]
flatten_5 (Flatten)	(None, 5)	0	embedding_5[0][0]
flatten_6 (Flatten)	(None, 5)	0	embedding_6[0][0]
dense_1 (Dense)	(None, 16)	48	remaining_input[0][0
concatenate_1 (Concatenate)	(None, 30041)	0	flatten_1[0][0] flatten_2[0][0] flatten_3[0][0] flatten_4[0][0] flatten_5[0][0] flatten_6[0][0] dense_1[0][0]
dense_2 (Dense)	(None, 128)	3845376	concatenate_1[0][0]
dropout_1 (Dropout)	(None, 128)	0	dense_2[0][0]
dense_3 (Dense)	(None, 64)	8256	dropout_1[0][0]
dropout_2 (Dropout)	(None, 64)	0	dense_3[0][0]
batch_normalization_1 (BatchNor	(None, 64)	256	dropout_2[0][0]
dense_4 (Dense)	(None, 32)	2080	batch_normalization_
dense_5 (Dense)	(None, 2)	66	dense_4[0][0]

Total params: 6,689,267
Trainable params: 6,689,139
Non-trainable params: 128

None

```
train_2 = [pad_tfidf_train,enc_cty_train,enc_sub_cty_train,enc_state_train,enc_pgc_train,e
test_2 = [pad_tfidf_test,enc_cty_test,enc_sub_cty_test,enc_state_test,enc_pgc_test,enc_tea


print(pad_tfidf_train.shape)
print(enc_cty_train.shape)
print(enc_sub_cty_train.shape)
print(enc_state_train.shape)
print(enc_pgc_train.shape)
print(enc_teacher_train.shape)
print(numerical_train.shape)
```

```
(76473, 300)
(76473,)
(76473,)
(76473,)
(76473,)
(76473,)
(76473, 2)
```

```
print(pad_tfidf_test.shape)
print(enc_cty_test.shape)
print(enc_sub_cty_test.shape)
print(enc_state_test.shape)
print(enc_pgc_test.shape)
print(enc_teacher_test.shape)
print(numerical_test.shape)
```

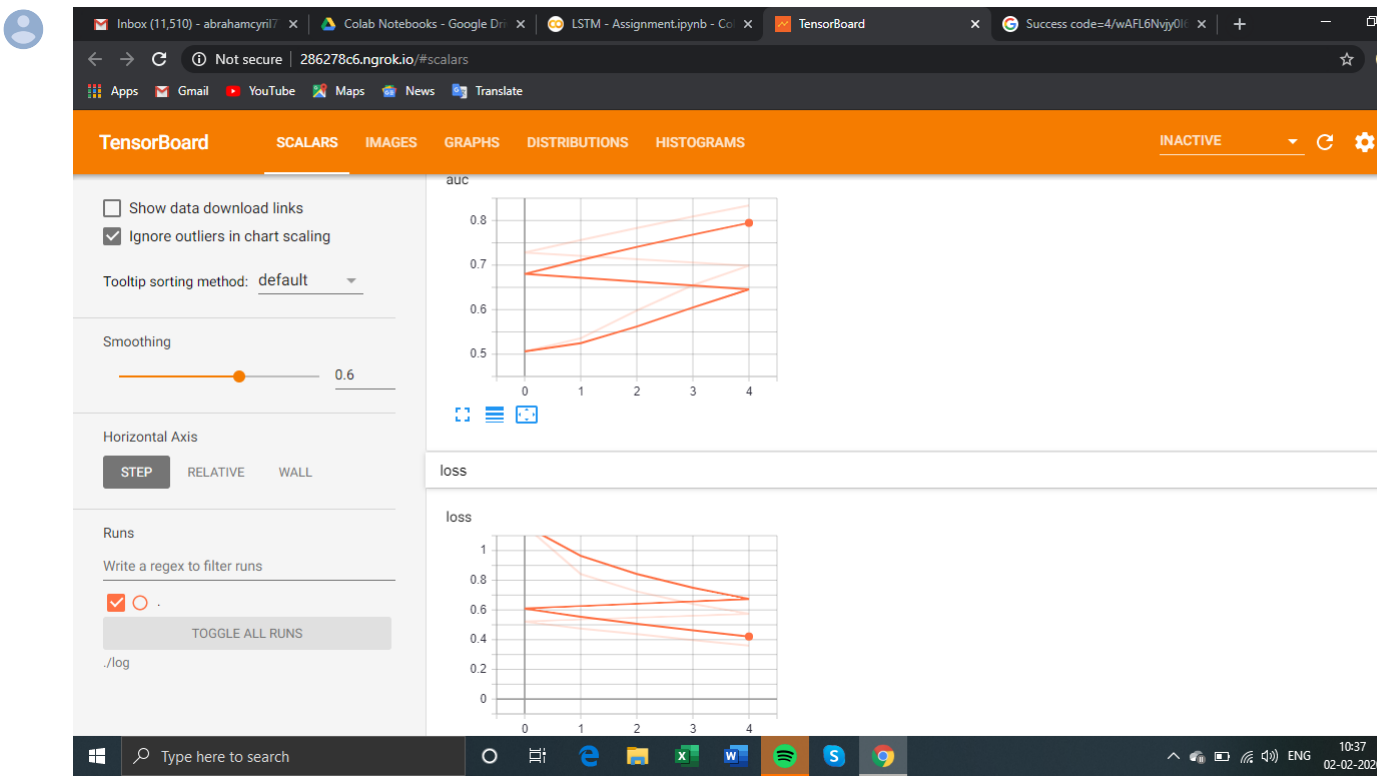
```
(32775, 300)
(32775,)
(32775,)
(32775,)
(32775,)
(32775,)
(32775, 2)
```

```
filepath="weights_copy2.best.hdf5"
checkpoint = ModelCheckpoint(filepath, monitor='val_auc', verbose=1, save_best_only=True,
callbacks_list = [checkpoint,tbCallBack]
model2.fit(train_2, y_train,epochs=5,verbose=1,batch_size=256,callbacks =callbacks_list,va
```

```
Train on 76473 samples, validate on 32775 samples
Epoch 1/5
76473/76473 [==============================] - 177s 2ms/step - loss: 0.5215 - auc: 0.

Epoch 00001: val_auc improved from -inf to 0.66984, saving model to weights_copy2.bes
Epoch 2/5
76473/76473 [==============================] - 173s 2ms/step - loss: 0.4755 - auc: 0.

Epoch 00002: val_auc improved from 0.66984 to 0.67841, saving model to weights_copy2.
Epoch 3/5
76473/76473 [==============================] - 173s 2ms/step - loss: 0.4384 - auc: 0.

Epoch 00003: val_auc did not improve from 0.67841
Epoch 4/5
76473/76473 [==============================] - 171s 2ms/step - loss: 0.3975 - auc: 0.

Epoch 00004: val_auc did not improve from 0.67841
Epoch 5/5
76473/76473 [==============================] - 172s 2ms/step - loss: 0.3594 - auc: 0.

Epoch 00005: val_auc did not improve from 0.67841
<keras.callbacks.History at 0x7f6051006cc0>
```

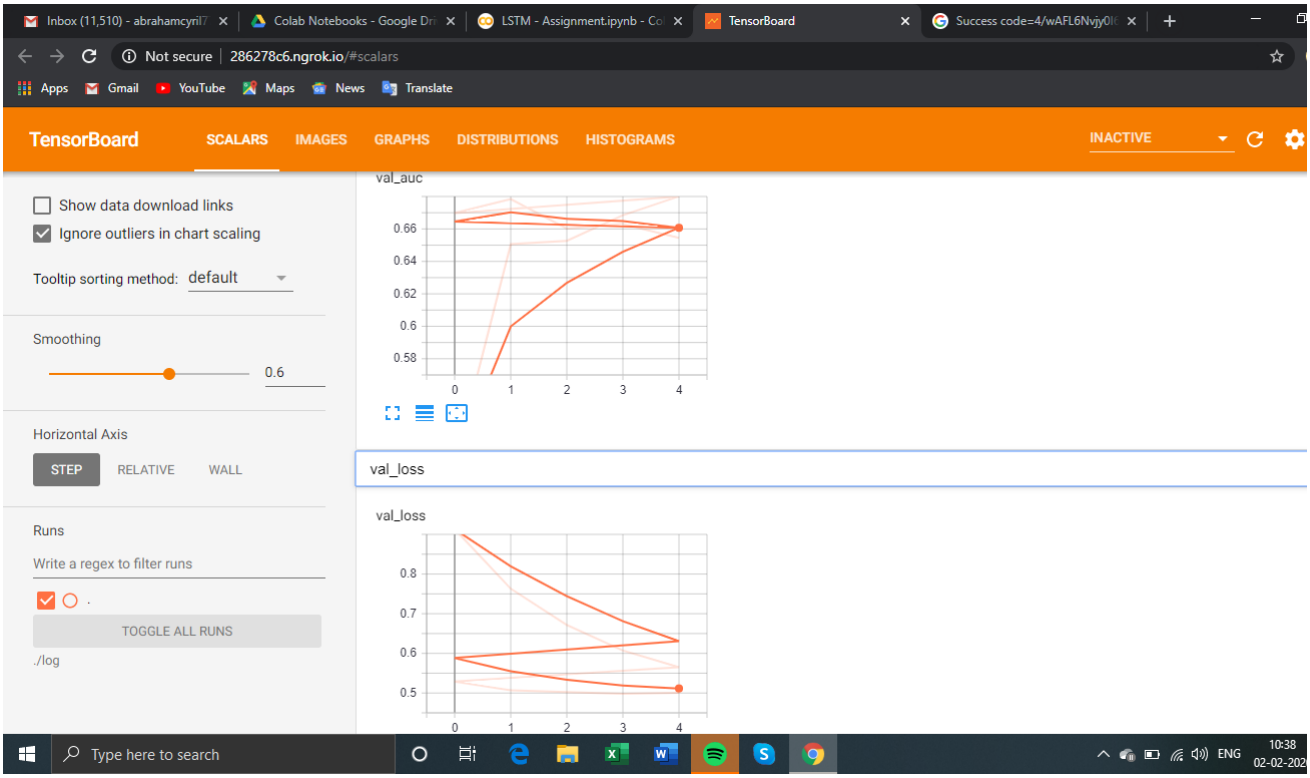
Train AUC and loss:

```
Image(retina=True, filename='/content/drive/My Drive/Colab Notebooks/train_auc_2.png')
```

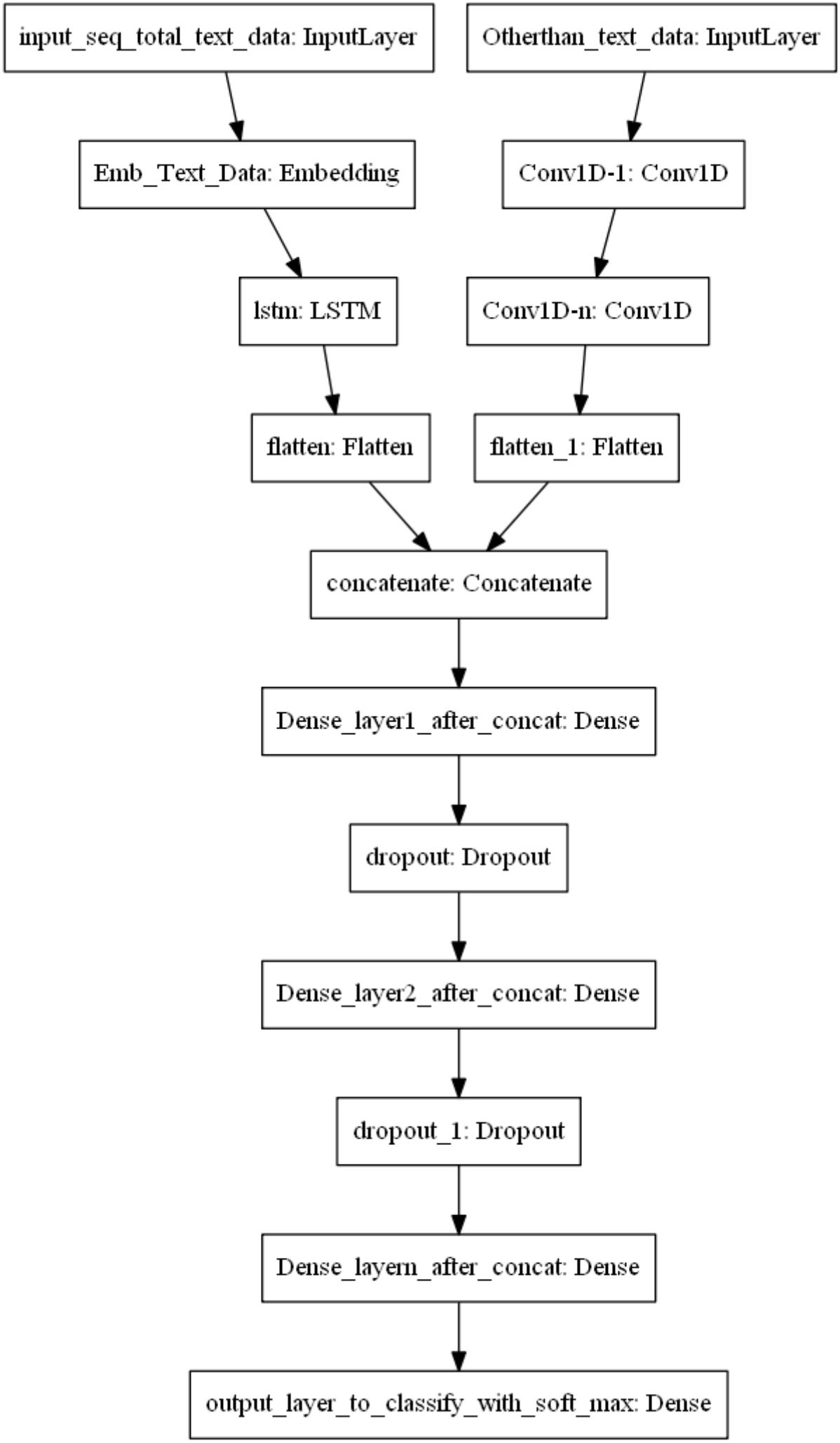


Validation AUC and loss

```
Image(retina=True, filename='/content/drive/My Drive/Colab Notebooks/val_auc_2.png')
```


Inbox (11,510) - abrahamcyril7
Colab Notebooks - Google Dri
LSTM - Assignment.ipynb - Co
TensorBoard
Success code=4/wAFL6Nvjy0I
Not secure 286278c6.ngrok.io/#scalars
Apps Gmail YouTube Maps News Translate
TensorBoard SCALARS IMAGES GRAPHS DISTRIBUTIONS HISTOGRAMS INACTIVE
Show data download links
Ignore outliers in chart scaling
Tooltip sorting method: default
Smoothing
0.6
Horizontal Axis
STEP RELATIVE WALL
Runs
Write a regex to filter runs
TOGGLE ALL RUNS
./log
val_auc
0.66
0.64
0.62
0.6
0.58
0 1 2 3 4
val_loss
val_loss
0.8
0.7
0.6
0.5
0 1 2 3 4
Type here to search
ENG
10:38
02-02-202

Model-3



ref: https://i.ii

- **input_seq_total_text_data**:

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

    . 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 ou

    . 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 concaten

    . Neumerical values and use CNN1D as shown in above figure.

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

For essay the processing is same as for we did for first model.

Tokenizing subject category,subcategory,teacher prefix,state,project grade categories using *count*

```
token_cat= CountVectorizer()

# integer encode the documents
proj_cat_train = token_cat.fit_transform(x_train['clean_categories'])
proj_cat_test = token_cat.transform(x_test['clean_categories'])


print(proj_cat_train.shape)
print(proj_cat_test.shape)
```

```
(76473, 9)
(32775, 9)
```

```
token_sub_cat = CountVectorizer()
```

```
subcat_train = token_sub_cat.fit_transform(x_train['clean_subcategories'])
subcat_test = token_sub_cat.transform(x_test['clean_subcategories'])

print(subcat_train.shape)
print(subcat_test.shape)
```

```
(76473, 30)
(32775, 30)
```

```
token_state = CountVectorizer()

# integer encode the documents
state_train = token_state.fit_transform(x_train['school_state'])
state_test = token_state.transform(x_test['school_state'])


print(state_train.shape)
print(state_test.shape)
```

```
(76473, 51)
(32775, 51)
```

```
token_pgc = CountVectorizer()

# integer encode the documents
pgc_train = token_pgc.fit_transform(x_train['project_grade_category'])
pgc_test = token_pgc.transform(x_test['project_grade_category'])


print(pgc_train.shape)
print(pgc_test.shape)
```

```
(76473, 4)
(32775, 4)
```

```
token_teacher = CountVectorizer()
# integer encode the documents
teacher_train = token_teacher.fit_transform(x_train['teacher_prefix'])
teacher_test = token_teacher.transform(x_test['teacher_prefix'])

print(teacher_train.shape)
print(teacher_test.shape)
```

```
(76473, 5)
(32775, 5)
```

```
print(pad_train.shape)
print(proj_cat_train.shape)
print(subcat_train.shape)
```

```
print(state_train.shape)
print(pgc_train.shape)
print(teacher_train.shape)
print(numerical_train.shape)
```

```
(76473, 300)
(76473, 9)
(76473, 30)
(76473, 51)
(76473, 4)
(76473, 5)
(76473, 2)
```

```
from scipy.sparse import hstack

train_3 = hstack((proj_cat_train,subcat_train,state_train,pgc_train,teacher_train,numerica
test3 = hstack((proj_cat_test,subcat_test,state_test,pgc_test,teacher_test,numerical_test)

train_3.shape
```

```
(76473, 101)
```

```
test3.shape
```

```
(32775, 101)
```

```
train_m3=train_3.todense()
test_m3 =test3.todense()


train_3 = np.resize(train_m3,new_shape=(76473,101,1))
test_3 =np.resize(test_m3,new_shape=(32775,101,1))


train_3.shape
```

```
(76473, 101, 1)
```

```
embedded_vector_train.shape[0]
```

```
49152
```

```
vocabulary_length
```

```
49152
```

defining model 3 architecture

```
essay = Input(shape=(300,), name='essay_input')#from model_1
```

```
x = Embedding(embedded_vector_train.shape[0], 300, weights=[embedded_vector_train], input_
lstm = LSTM(100,recurrent_dropout=0.5,return_sequences=True)(x)
flatten = Flatten()(lstm)


remaining_input = Input(shape=(101,1),name='rest_all')
x = Conv1D(filters=256, kernel_size = 3, padding='valid', kernel_initializer='glorot_norma
x = Conv1D(filters=256, kernel_size = 3, padding='valid', kernel_initializer='glorot_norma
flatten_1 = Flatten()(x)

#concatenate
concat = concatenate([flatten,flatten_1])

x = Dense(300, activation='relu',kernel_initializer="glorot_normal",kernel_regularizer=l2(
x = Dropout(.5)(x)
x = Dense(256, activation='relu',kernel_initializer="glorot_normal",kernel_regularizer=l2(
x = Dropout(.5)(x)
x = BatchNormalization()(x)
x = Dense(128, activation='relu',kernel_initializer="glorot_normal",kernel_regularizer=l2(
output = Dense(2, activation='softmax')(x)

model3 = Model(inputs=[essay,remaining_input], outputs=[output])
print(model3.summary())
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_prob
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

Model: "model_1"
```

Layer (type)	Output Shape	Param #	Connected to
essay_input (InputLayer)	(None, 300)	0	
rest_all (InputLayer)	(None, 101, 1)	0	
embedding_1 (Embedding)	(None, 300, 300)	14745600	essay_input[0][0]
conv1d_1 (Conv1D)	(None, 99, 128)	512	rest_all[0][0]
lstm_1 (LSTM)	(None, 300, 100)	160400	embedding_1[0][0]
conv1d_2 (Conv1D)	(None, 97, 128)	49280	conv1d_1[0][0]
flatten_1 (Flatten)	(None, 30000)	0	lstm_1[0][0]
flatten_2 (Flatten)	(None, 12416)	0	conv1d_2[0][0]
concatenate_1 (Concatenate)	(None, 42416)	0	flatten_1[0][0] flatten_2[0][0]
dense_1 (Dense)	(None, 300)	12725100	concatenate_1[0][0]
dropout_1 (Dropout)	(None, 300)	0	dense_1[0][0]
dense_2 (Dense)	(None, 256)	77056	dropout_1[0][0]
dropout_2 (Dropout)	(None, 256)	0	dense_2[0][0]
batch_normalization_1 (BatchNor	(None, 256)	1024	dropout_2[0][0]
dense_3 (Dense)	(None, 128)	32896	batch_normalization_
dense_4 (Dense)	(None, 2)	258	dense_3[0][0]

```
=================================================================================================
Total params: 27,792,126
Trainable params: 27,791,614
Non-trainable params: 512
_________________________________________________________________________________________________
None
```

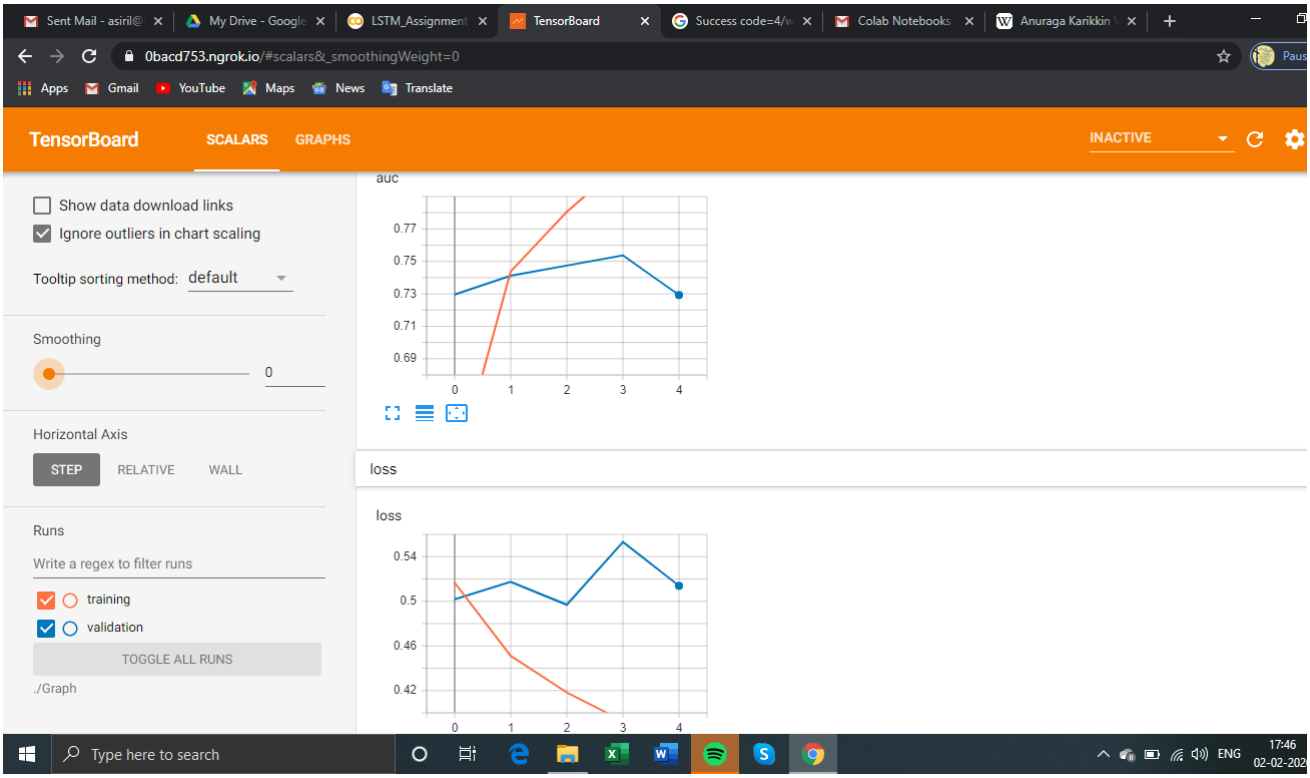
```
model3.compile(loss='categorical_crossentropy', optimizer=keras.optimizers.adam(lr=0.0006,
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/optimizers.py:79

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From <ipython-input-34-70948b21cc0e>:8: py_func (from tensorflow.p
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.
```

```
train_3_n = [pad_train,train_3]
test_3_n = [pad_test,test_3]


#model fitting
filepath="weights_3.best_copy.hdf5"
checkpoint = ModelCheckpoint(filepath,monitor='val_auc', verbose=1, save_best_only=True, m

earlystop = EarlyStopping(monitor = 'val_auroc',
                          mode="max",
                          min_delta = 0,
                          patience = 2,
                          verbose = 1,)
callbacks_list = [checkpoint,earlystop,TensorBoardColabCallback(tbc)]
model3.fit(train_3_n, y_train,epochs=5,verbose=1,batch_size=256,callbacks =callbacks_list,
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow_core/python
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorfl

Train on 76473 samples, validate on 32775 samples
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorboardcolab/core.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/callbacks.py:112

Epoch 1/5
76473/76473 [==============================] - 191s 2ms/step - loss: 0.5167 - auc: 0.

Epoch 00001: val_auc improved from -inf to 0.72956, saving model to weights_3.best_co
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorboardcolab/callb

Epoch 2/5
76473/76473 [==============================] - 181s 2ms/step - loss: 0.4511 - auc: 0.

Epoch 00002: val_auc improved from 0.72956 to 0.74119, saving model to weights_3.best
Epoch 3/5
76473/76473 [==============================] - 181s 2ms/step - loss: 0.4182 - auc: 0.

Epoch 00003: val_auc improved from 0.74119 to 0.74744, saving model to weights_3.best
Epoch 4/5
76473/76473 [==============================] - 181s 2ms/step - loss: 0.3928 - auc: 0.

Epoch 00004: val_auc improved from 0.74744 to 0.75367, saving model to weights_3.best
Epoch 5/5
76473/76473 [==============================] - 180s 2ms/step - loss: 0.3693 - auc: 0.

Epoch 00005: val_auc did not improve from 0.75367
<keras.callbacks.History at 0x7f1a3e235208>
```

```
from IPython.display import Image
Image(retina=True, filename='/content/drive/My Drive/image.png')
```




```
from prettytable import PrettyTable

x = PrettyTable()

x.field_names = ["Model", "Train AUC", "Cross validation AUC"]

x.add_row(["Model 1", 0.7992,0.7520])
x.add_row(["Model 2",0.7562,0.6784] )
x.add_row(["Model 3", 0.8106, 0.7537])


print(x)
```

```
+---------+-----------+----------------------+
|  Model  | Train AUC | Cross validation AUC |
+---------+-----------+----------------------+
| Model 1 |   0.7992  |        0.752         |
| Model 2 |   0.7562  |        0.6784        |
| Model 3 |   0.8106  |        0.7537        |
+---------+-----------+----------------------+
```

Conclusion:

We got 2 models that have cross validation AUC above 0.75