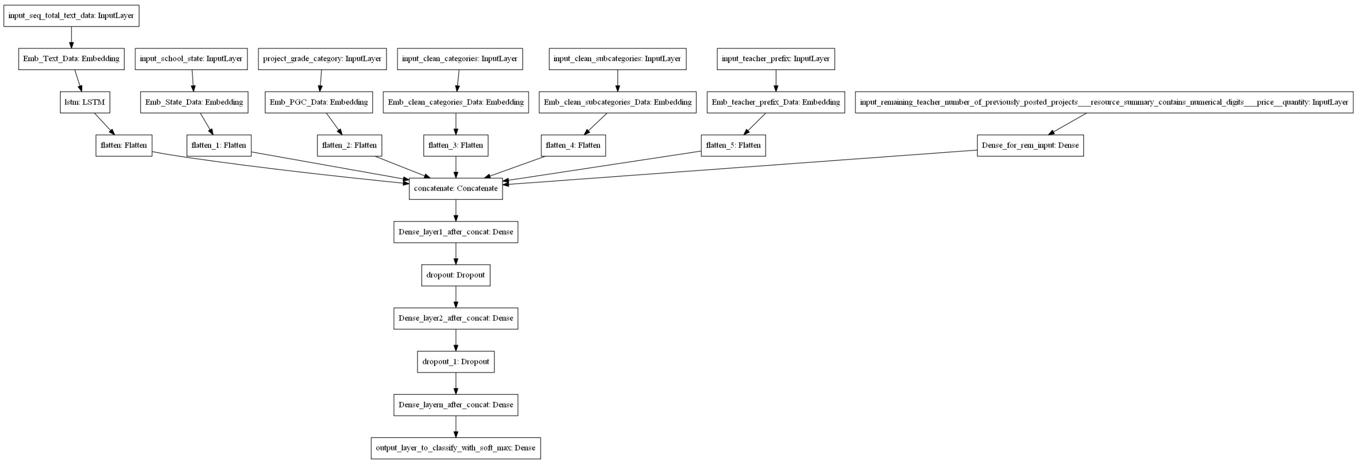
Assignment : 14

1. Download the preprocessed DonorsChoose data from here Dataset (https://drive.google.com/file/d/1GU3LIJJ3zS1xLXXe-sdItSJHtI5txjVO/view?usp=sharing)
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' (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. you need to print the AUC value for each epoch. Note: you should NOT use the tf.metric.auc
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. You should Save the best model weights.
8. 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.
9. Use Categorical Cross Entropy as Loss to minimize.
10. try to get AUC more than 0.8 for atleast one model

Model-1

Build and Train deep neural network as shown below


input_seq_total_text_data: InputLayer
Emb_Text_Data: Embedding
input_school_state: InputLayer
project_grade_category: InputLayer
input_clean_categories: InputLayer
input_clean_subcategories: InputLayer
input_teacher_prefix: InputLayer
lstm: LSTM
Emb_State_Data: Embedding
Emb_PGC_Data: Embedding
Emb_clean_categories_Data: Embedding
Emb_clean_subcategories_Data: Embedding
Emb_teacher_prefix_Data: Embedding
input_remaining_teacher_number_of_previously_posted_projects___resource_summary_contains_numerical_digits___price__quantity: InputLayer
flatten: Flatten
flatten_1: Flatten
flatten_2: Flatten
flatten_3: Flatten
flatten_4: Flatten
flatten_5: Flatten
Dense_for_rem_input: Dense
concatenate: Concatenate
Dense_layer1_after_concat: Dense
dropout: Dropout
Dense_layer2_after_concat: Dense
dropout_1: Dropout
Dense_layern_after_concat: Dense
output_layer_to_classify_with_soft_max: Dense

ref: https://i.imgur.com/w395Yk9.png (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_** ---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 [0]:

```
# 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.

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.

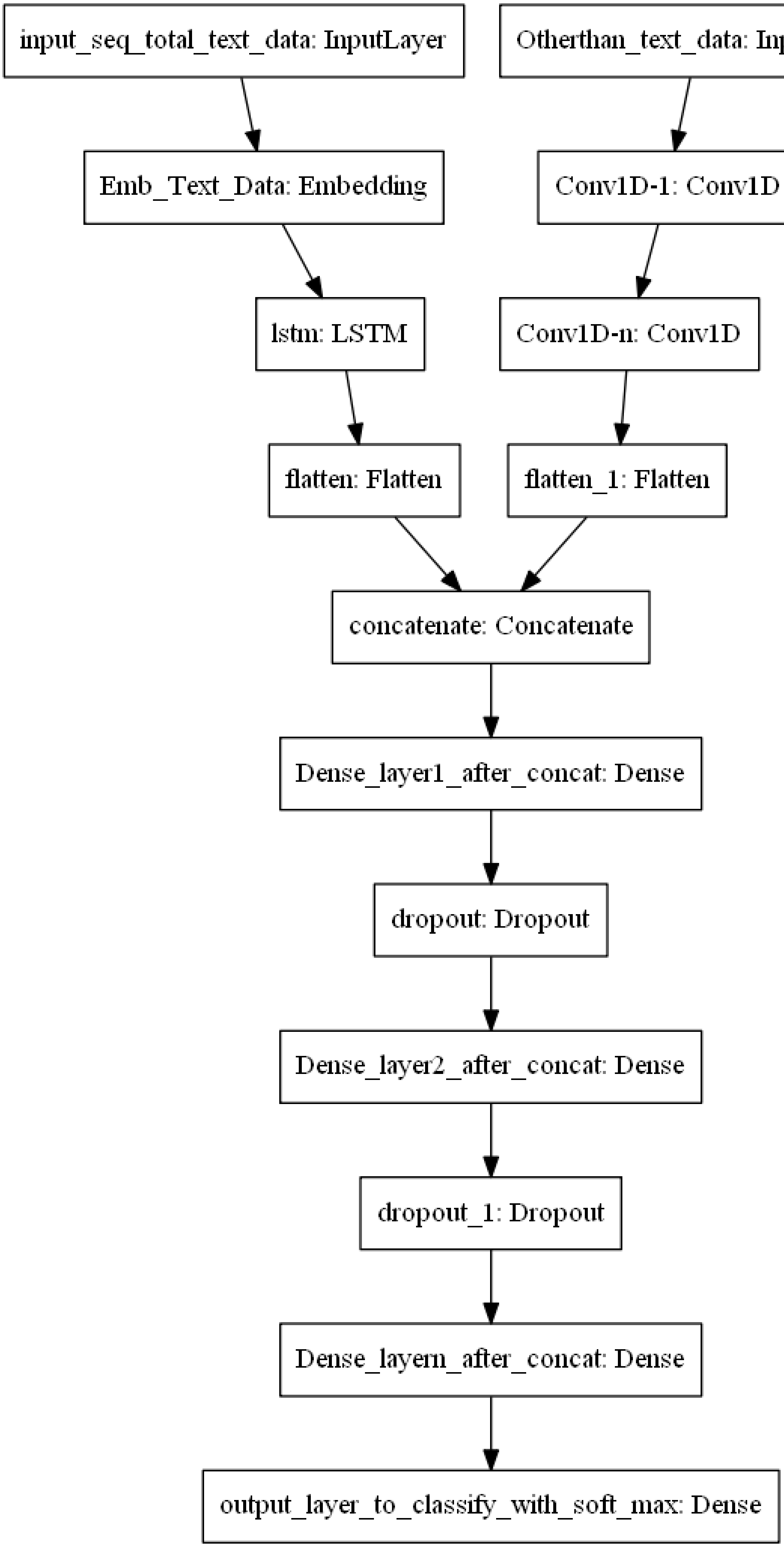
```
1. Train the TF-IDF on the Train data feature 'essay'

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 anal
ysis on the Idf values and based on those values choose the low and high thresho
ld value. Because very frequent words and very very rare words don't give much i
nformation. (you can plot a box plots and take only the idf scores within IQR ra
nge and corresponding words)

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

Model-3


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

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

- **input_seq_total_text_data**:

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

  . 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 outpu
t.

  . 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/sequen
tial-model-guide/#sequence-classification-with-1d-convolutions) as shown in
 above figure.

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

</pre>

In [1]:

```
import numpy as np
import pandas as pd
from keras.preprocessing.sequence import pad_sequences
from keras.models import Sequential
from keras.layers import Dense, Input , Dropout
from keras.layers import Flatten
from keras.layers import concatenate
from keras.layers.embeddings import Embedding
from keras.models import Model
from keras.utils import to_categorical
from sklearn.model_selection import train_test_split
from keras.preprocessing.text import Tokenizer
import matplotlib.pyplot as plt
import pickle
from keras.layers import LSTM
from keras.preprocessing.text import text_to_word_sequence
import tensorflow as tf
from keras.callbacks import ModelCheckpoint,TensorBoard,ReduceLROnPlateau, EarlyStopping
from keras.layers.normalization import BatchNormalization
from sklearn.feature_extraction.text import TfidfVectorizer
import seaborn as sns
from keras.regularizers import l2
from sklearn.metrics import roc_auc_score
from keras.models import load_model
from IPython.display import Image
from scipy.sparse import hstack
from keras.layers import Conv1D
from sklearn.feature_extraction.text import CountVectorizer
from prettytable import PrettyTable
```

```
Using TensorFlow backend.
```

The default version of TensorFlow in Colab will soon switch to TensorFlow 2.x.
We recommend you upgrade (https://www.tensorflow.org/guide/migrate) now or ensure your notebook will continue to use TensorFlow 1.x via the `%tensorflow_version 1.x` magic: more info (https://colab.research.google.com/notebooks/tensorflow_version.ipynb).

In [2]:

```
import pandas as pd
data=pd.read_csv('preprocessed_data.csv')
data.shape
```

Out[2]:

```
(109248, 9)
```

In [3]:

```
data.columns
```

Out[3]:

```
Index(['school_state', 'teacher_prefix', 'project_grade_category',
       'teacher_number_of_previously_posted_projects', 'project_is_approve
d',
       'clean_categories', 'clean_subcategories', 'essay', 'price'],
      dtype='object')
```

In [4]:

```
y=data['project_is_approved'].values
y.shape
```

Out[4]:

```
(109248,)
```

In [0]:

```
data.drop(['project_is_approved'],axis=1,inplace=True)
```

In [6]:

```
data.shape
```

Out[6]:

```
(109248, 8)
```

SPLITTING THE DATA

In [7]:

```
from sklearn.model_selection import train_test_split
X_train,X_test,y_train,y_test=train_test_split(data,y,test_size=0.30,stratify=y)
X_train,X_cv,y_train,y_cv=train_test_split(X_train,y_train,test_size=0.30,stratify=y_tr
ain)
print(X_train.shape,y_train.shape)
print(X_cv.shape,y_cv.shape)
print(X_test.shape,y_test.shape)
```

```
(53531, 8) (53531,)
(22942, 8) (22942,)
(32775, 8) (32775,)
```

In [0]:

```
y_train = to_categorical(y_train, num_classes=2)
y_cv =to_categorical(y_cv,num_classes=2)
y_test = to_categorical(y_test, num_classes=2)
```

TOKENIZING ESSAY WORDS

In [9]:

```
token = Tokenizer()
token.fit_on_texts(X_train['essay'])
vocab_size = len(token.word_index) +1
print('Total unique words in the x_train',vocab_size)
encoded_train = token.texts_to_sequences(X_train['essay'])
encoded_cv = token.texts_to_sequences(X_cv['essay'])
encoded_test = token.texts_to_sequences(X_test['essay'])
```

```
Total unique words in the x_train 42722
```

In [10]:

```
len(encoded_train)
```

Out[10]:

```
53531
```

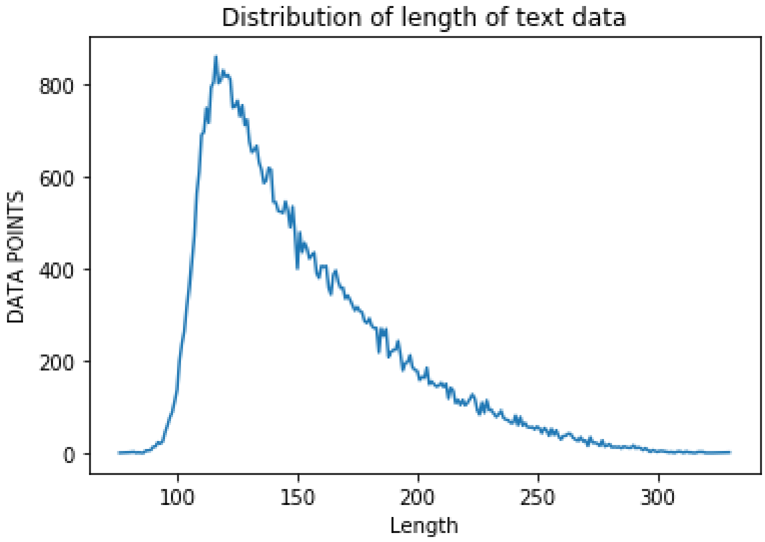
In [0]:

```
length = []
for sentence in encoded_train:
    length.append(len(sentence))

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

In [12]:

```
plt.plot(s,count)
plt.xlabel('Length')
plt.ylabel('DATA POINTS')
plt.title('Distribution of length of text data')
plt.show()
```



PADDING

In [13]:

```
max_length = 300
padded_train = pad_sequences(encoded_train, maxlen=max_length, padding='post')
padded_cv    =pad_sequences(encoded_cv,maxlen=max_length,padding='post')
padded_test = pad_sequences(encoded_test, maxlen=max_length, padding='post')
print("length of padded_train data",len(padded_train))
print("length of padded_cv data",len(padded_cv))
print("length of padded_test data",len(padded_test))
```

```
length of padded_train data 53531
length of padded_cv data 22942
length of padded_test data 32775
```

In [0]:

```

```

In [0]:

```
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
embedding_matrix_train = np.zeros((vocab_size, 300))
for word, i in token.word_index.items():
    if word in glove_words:
        embedding_vector = model[word]
        embedding_matrix_train[i] = embedding_vector
```

ENCODING CATEGORICAL VARIABLES

In [0]:

```
def label_encoder(column):
    unique = list(set(column))
    total = list(column)
    size = len(unique)
    count = []
    for category in unique:
        count.append([total.count(category),category])
    count.sort()
    rank = {}
    for i in range(1,len(count)+1):
        rank.update({count[i-1][1] : i})
    return (rank,unique,size)
```

In [17]:

```
category_rank,unique,size = label_encoder(X_train['clean_categories'])
print(category_rank)
categories_size = size
encoded_cat_train = []
encoded_cat_cv   =[]
encoded_cat_test = []
for category in X_train['clean_categories']:
    encoded_cat_train.append(category_rank[category])
for category in X_cv['clean_categories']:
    if category in unique:
        encoded_cat_cv.append(category_rank[category])
    else:
        encoded_cat_cv.append(0)

for category in X_test['clean_categories']:
    if category in unique:
        encoded_cat_test.append(category_rank[category])
    else:
        encoded_cat_test.append(0)

encoded_cat_train = np.asarray(encoded_cat_train)
encoded_cat_cv = np.asarray(encoded_cat_cv)
encoded_cat_test = np.asarray(encoded_cat_test)

print(encoded_cat_train.shape)
print(encoded_cat_cv.shape)
print(encoded_cat_test.shape)
```

```
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(53531,)
(22942,)
(32775,)
```

In [18]:

```
subcategory_rank,unique,size = label_encoder(X_train['clean_subcategories'])
print(subcategory_rank)
subcategories_size = size
encoded_subcat_train = []
encoded_subcat_cv   =[]
encoded_subcat_test = []
for category in X_train['clean_subcategories']:
    encoded_subcat_train.append(subcategory_rank[category])
for category in X_cv['clean_subcategories']:
    if category in unique:
        encoded_subcat_cv.append(subcategory_rank[category])
    else:
        encoded_subcat_cv.append(0)

for category in X_test['clean_subcategories']:
    if category in unique:
        encoded_subcat_test.append(subcategory_rank[category])
    else:
        encoded_subcat_test.append(0)

encoded_subcat_train = np.asarray(encoded_subcat_train)
encoded_subcat_cv = np.asarray(encoded_subcat_cv)
encoded_subcat_test = np.asarray(encoded_subcat_test)

print(encoded_subcat_train.shape)
print(encoded_subcat_cv.shape)
print(encoded_subcat_test.shape)
```

```
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23, 'esl environmentalscience': 224, 'parentinvolvement': 225, 'earlydevel
opment gym_fitness': 226, 'health_wellness visualarts': 227, 'characteredu
cation extracurricular': 228, 'economics': 229, 'literature_writing musi
c': 230, 'music visualarts': 231, 'health_wellness music': 232, 'extracurr
icular literacy': 233, 'health_lifescience nutritioneducation': 234, 'comm
unityservice': 235, 'financialliteracy specialneeds': 236, 'other visualar
ts': 237, 'socialsciences visualarts': 238, 'appliedsciences parentinvolve
ment': 239, 'environmentalscience health_wellness': 240, 'esl foreignlangu
ages': 241, 'gym_fitness nutritioneducation': 242, 'mathematics music': 24
```

```
3, 'extracurricular mathematics': 244, 'appliedsciences charactereducatio
n': 245, 'esl earlydevelopment': 246, 'health_lifescience history_geograph
y': 247, 'appliedsciences socialsciences': 248, 'socialsciences specialnee
ds': 249, 'health_lifescience socialsciences': 250, 'appliedsciences musi
c': 251, 'charactereducation visualarts': 252, 'earlydevelopment environme
ntalscience': 253, 'appliedsciences esl': 254, 'charactereducation communi
tyservice': 255, 'literature_writing parentinvolvement': 256, 'college_car
eerprep other': 257, 'environmentalscience socialsciences': 258, 'mathemat
ics parentinvolvement': 259, 'extracurricular visualarts': 260, 'foreignla
nguages literature_writing': 261, 'civics_government socialsciences': 262,
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y': 266, 'charactereducation mathematics': 267, 'health_lifescience visual
arts': 268, 'charactereducation other': 269, 'mathematics socialsciences':
270, 'civics_government': 271, 'mathematics other': 272, 'charactereducati
on health_wellness': 273, 'literature_writing other': 274, 'history_geogra
phy mathematics': 275, 'literature_writing performingarts': 276, 'extracur
ricular': 277, 'appliedsciences other': 278, 'history_geography specialnee
ds': 279, 'literacy performingarts': 280, 'music specialneeds': 281, 'coll
ege_careerprep specialneeds': 282, 'charactereducation college_careerpre
p': 283, 'civics_government literacy': 284, 'environmentalscience history_
geography': 285, 'charactereducation earlydevelopment': 286, 'college_care
erprep visualarts': 287, 'earlydevelopment visualarts': 288, 'financiallit
eracy mathematics': 289, 'health_lifescience specialneeds': 290, 'health_l
ifescience health_wellness': 291, 'appliedsciences extracurricular': 292,
'earlydevelopment other': 293, 'literacy music': 294, 'literacy parentinvo
lvement': 295, 'charactereducation literature_writing': 296, 'environmenta
lscience specialneeds': 297, 'financialliteracy': 298, 'gym_fitness specia
lneeds': 299, 'health_wellness other': 300, 'history_geography visualart
s': 301, 'literacy other': 302, 'charactereducation specialneeds': 303, 'e
sl specialneeds': 304, 'appliedsciences earlydevelopment': 305, 'health_li
fescience literature_writing': 306, 'environmentalscience visualarts': 30
7, 'socialsciences': 308, 'earlydevelopment literature_writing': 309, 'civ
ics_government history_geography': 310, 'health_wellness mathematics': 31
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ealth_wellness literature_writing': 316, 'nutritioneducation': 317, 'colle
ge_careerprep mathematics': 318, 'specialneeds visualarts': 319, 'earlydev
elopment health_wellness': 320, 'earlydevelopment mathematics': 321, 'hist
ory_geography socialsciences': 322, 'other specialneeds': 323, 'charactere
ducation': 324, 'college_careerprep literature_writing': 325, 'appliedscie
nces specialneeds': 326, 'charactereducation literacy': 327, 'health_lifes
cience literacy': 328, 'literature_writing socialsciences': 329, 'foreignl
anguages': 330, 'health_wellness teamsports': 331, 'performingarts': 332,
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ences': 335, 'appliedsciences literature_writing': 336, 'environmentalscie
nce literacy': 337, 'college_careerprep': 338, 'health_wellness literacy':
339, 'mathematics visualarts': 340, 'health_lifescience mathematics': 341,
'history_geography literacy': 342, 'history_geography': 343, 'appliedscien
ces health_lifescience': 344, 'appliedsciences literacy': 345, 'literacy v
isualarts': 346, 'gym_fitness teamsports': 347, 'appliedsciences visualart
s': 348, 'history_geography literature_writing': 349, 'literature_writing
visualarts': 350, 'earlydevelopment literacy': 351, 'esl literature_writin
g': 352, 'earlydevelopment specialneeds': 353, 'health_lifescience': 354,
'health_wellness nutritioneducation': 355, 'environmentalscience mathemati
cs': 356, 'other': 357, 'earlydevelopment': 358, 'music performingarts': 3
59, 'environmentalscience health_lifescience': 360, 'appliedsciences envir
onmentalscience': 361, 'environmentalscience': 362, 'teamsports': 363, 'he
alth_wellness specialneeds': 364, 'gym_fitness': 365, 'mathematics special
needs': 366, 'warmth care_hunger': 367, 'literature_writing specialneeds':
368, 'music': 369, 'visualarts': 370, 'gym_fitness health_wellness': 371,
'esl literacy': 372, 'literacy specialneeds': 373, 'appliedsciences': 374,
'appliedsciences mathematics': 375, 'health_wellness': 376, 'specialneed
s': 377, 'literature_writing': 378, 'mathematics': 379, 'literacy literatu
re_writing': 380, 'literature_writing mathematics': 381, 'literacy mathema
tics': 382, 'literacy': 383}
(53531,)
(22942,)
(32775,)
```

In [19]:

```
state_rank,unique,size =label_encoder(X_train['school_state'])
print(state_rank)
state_size = size
encoded_state_train = []
encoded_state_cv=[]
encoded_state_test = []
for state in X_train['school_state']:
    encoded_state_train.append(state_rank[state])
for state in X_cv['school_state']:
    if state in unique:
        encoded_state_cv.append(state_rank[state])
    else:
        encoded_state_cv.append(0)
for state in X_test['school_state']:
    if state in unique:
        encoded_state_test.append(state_rank[state])
    else:
        encoded_state_test.append(0)

encoded_state_train = np.asarray(encoded_state_train)
encoded_state_cv=np.asarray(encoded_state_cv)
encoded_state_test = np.asarray(encoded_state_test)

print(encoded_state_train.shape)
print(encoded_state_cv.shape)
print(encoded_state_test.shape)
```

```
{'vt': 1, 'wy': 2, 'nd': 3, 'ri': 4, 'mt': 5, 'sd': 6, 'ne': 7, 'nh': 8,
'ak': 9, 'de': 10, 'wv': 11, 'me': 12, 'hi': 13, 'dc': 14, 'nm': 15, 'ks':
16, 'id': 17, 'ia': 18, 'ar': 19, 'co': 20, 'mn': 21, 'or': 22, 'ms': 23,
'ky': 24, 'nv': 25, 'md': 26, 'ct': 27, 'ut': 28, 'tn': 29, 'al': 30, 'w
i': 31, 'va': 32, 'az': 33, 'ma': 34, 'ok': 35, 'nj': 36, 'la': 37, 'wa':
38, 'oh': 39, 'mo': 40, 'in': 41, 'pa': 42, 'mi': 43, 'sc': 44, 'ga': 45,
'il': 46, 'nc': 47, 'fl': 48, 'ny': 49, 'tx': 50, 'ca': 51}
(53531,)
(22942,)
(32775,)
```

In [20]:

```
teacher_prefix_rank, unique,size = label_encoder(X_train['teacher_prefix'])
print(teacher_prefix_rank)
teacher_prefix_size =size
encoded_prefix_train = []
encoded_prefix_cv=[]
encoded_prefix_test = []
for prefix in X_train['teacher_prefix']:
    encoded_prefix_train.append(teacher_prefix_rank[prefix])
for prefix in X_cv['teacher_prefix']:
    if prefix in unique:
        encoded_prefix_cv.append(teacher_prefix_rank[prefix])
    else:
        encoded_prefix_cv.append(0)

for prefix in X_test['teacher_prefix']:
    if prefix in unique:
        encoded_prefix_test.append(teacher_prefix_rank[prefix])
    else:
        encoded_prefix_test.append(0)

encoded_prefix_train = np.asarray(encoded_prefix_train)
encoded_prefix_cv=np.asarray(encoded_prefix_cv)
encoded_prefix_test = np.asarray(encoded_prefix_test)

print(encoded_prefix_train.shape)
print(encoded_prefix_cv.shape)
print(encoded_prefix_test.shape)
```

```
{'dr': 1, 'teacher': 2, 'mr': 3, 'ms': 4, 'mrs': 5}
(53531,)
(22942,)
(32775,)
```

In [21]:

```
project_grade_rank,unique,size =label_encoder(X_train['project_grade_category'])
print(project_grade_rank)
project_grade_categories_size = size
encoded_grade_train = []
encoded_grade_cv=[]
encoded_grade_test = []
for grade in X_train['project_grade_category']:
    encoded_grade_train.append(project_grade_rank[grade])
for grade in X_cv['project_grade_category']:
    if grade in unique:
        encoded_grade_cv.append(project_grade_rank[grade])
    else:
        encoded_grade_cv.append(0)

for grade in X_test['project_grade_category']:
    if grade in unique:
        encoded_grade_test.append(project_grade_rank[grade])
    else:
        encoded_grade_test.append(0)

encoded_grade_train = np.asarray(encoded_grade_train)
encoded_grade_cv=np.asarray(encoded_grade_cv)
encoded_grade_test = np.asarray(encoded_grade_test)

print(encoded_grade_train.shape)
print(encoded_grade_cv.shape)
print(encoded_grade_test.shape)
```

```
{'grades_9_12': 1, 'grades_6_8': 2, 'grades_3_5': 3, 'grades_prek_2': 4}
(53531,)
(22942,)
(32775,)
```

In [22]:

```
encoded_grade_train[0:5]
```

Out[22]:

```
array([2, 4, 3, 4, 2])
```

STANDARDIZING NUMERICAL FEATURES

In [23]:

```
# price

from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()

scaler.fit(X_train['price'].values.reshape(-1,1))

X_train_price_norm = scaler.transform(X_train['price'].values.reshape(-1,1))
X_cv_price_norm = scaler.transform(X_cv['price'].values.reshape(-1,1))
X_test_price_norm = scaler.transform(X_test['price'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_price_norm.shape, y_train.shape)
print(X_cv_price_norm.shape,y_cv.shape)
print(X_test_price_norm.shape, y_test.shape)
```

```
After vectorizations
(53531, 1) (53531, 2)
(22942, 1) (22942, 2)
(32775, 1) (32775, 2)
```

In [24]:

```
scaler = StandardScaler()

scaler.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1
))

X_train_projects_norm = scaler.transform(X_train['teacher_number_of_previously_posted_p
rojects'].values.reshape(-1,1))
X_cv_projects_norm = scaler.transform(X_cv['teacher_number_of_previously_posted_project
s'].values.reshape(-1,1))
X_test_projects_norm = scaler.transform(X_test['teacher_number_of_previously_posted_pro
jects'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_projects_norm.shape, y_train.shape)
print(X_cv_projects_norm.shape,y_cv.shape)
print(X_test_projects_norm.shape, y_test.shape)
```

```
After vectorizations
(53531, 1) (53531, 2)
(22942, 1) (22942, 2)
(32775, 1) (32775, 2)
```

In [0]:

```
left_input_train = np.hstack((X_train_price_norm,X_train_projects_norm))
left_input_cv = np.hstack((X_cv_price_norm,X_cv_projects_norm))
left_input_test = np.hstack((X_test_price_norm,X_test_projects_norm))
```

MODEL 1

In [0]:

```
essay_text=Input(shape=(300,),name='essay_text')
x=Embedding(vocab_size,300,weights=[embedding_matrix_train],input_length=300)(essay_text)
lstm_1=LSTM(50,recurrent_dropout=0.5,return_sequences=True)(x)
flatten_1=Flatten()(lstm_1)

state=Input(shape=(1,),name="state")
x=Embedding(state_size+1,2,input_length=1)(state)
flatten_2=Flatten()(x)

project_grade_category=Input(shape=(1,),name='project_grade_category')
x=Embedding(project_grade_categories_size+1,2,input_length=1)(project_grade_category)
flatten_3=Flatten()(x)

clean_categories=Input(shape=(1,),name='clean_categories')
x=Embedding(categories_size+1,4,input_length=1)(clean_categories)
flatten_4=Flatten()(x)

subcategory=Input(shape=(1,),name='subcategory')
x=Embedding(subcategories_size+1,4,input_length=1)(subcategory)
flatten_5=Flatten()(x)

teacher_prefix=Input(shape=(1,),name='teacher_prefix')
x=Embedding(teacher_prefix_size+1,4,input_length=1)(teacher_prefix)
flatten_6=Flatten()(x)

left_input=Input(shape=(2,),name='left_input')
dense_1 = Dense(1, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l2(0.001))(left_input)

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

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

x = Dense(64, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l2(0.001))(x)
final_output = Dense(2, activation='softmax')(x)

model = Model(inputs=[essay_text,state,project_grade_category,clean_categories,subcategory,teacher_prefix,left_input], outputs=[final_output])
print(model.summary())
```

```
Model: "model_2"
________________________________________________________________________
__________________________
Layer (type)                    Output Shape         Param #     Connect
ed to
========================================================================
==========================
essay_text (InputLayer)         (None, 300)          0
________________________________________________________________________
__________________________
embedding_7 (Embedding)         (None, 300, 300)     12768900    essay_t
ext[0][0]
________________________________________________________________________
__________________________
state (InputLayer)              (None, 1)            0
________________________________________________________________________
__________________________
project_grade_category (InputLa (None, 1)            0
________________________________________________________________________
__________________________
clean_categories (InputLayer)   (None, 1)            0
________________________________________________________________________
__________________________
subcategory (InputLayer)        (None, 1)            0
________________________________________________________________________
__________________________
teacher_prefix (InputLayer)     (None, 1)            0
________________________________________________________________________
__________________________
lstm_2 (LSTM)                   (None, 300, 50)      70200       embeddi
ng_7[0][0]
________________________________________________________________________
__________________________
embedding_8 (Embedding)         (None, 1, 2)         104         state
[0][0]
________________________________________________________________________
__________________________
embedding_9 (Embedding)         (None, 1, 2)         10          project
_grade_category[0][0]
________________________________________________________________________
__________________________
embedding_10 (Embedding)        (None, 1, 4)         204         clean_c
ategories[0][0]
________________________________________________________________________
__________________________
embedding_11 (Embedding)        (None, 1, 4)         1540        subcate
gory[0][0]
________________________________________________________________________
__________________________
embedding_12 (Embedding)        (None, 1, 4)         24          teacher
_prefix[0][0]
________________________________________________________________________
__________________________
left_input (InputLayer)         (None, 2)            0
________________________________________________________________________
__________________________
flatten_7 (Flatten)             (None, 15000)        0           lstm_2
[0][0]
________________________________________________________________________
__________________________
flatten_8 (Flatten)             (None, 2)            0           embeddi
```

```
ng_8[0][0]
________________________________________________________________________
__________________________
flatten_9 (Flatten)             (None, 2)            0           embeddi
ng_9[0][0]
________________________________________________________________________
__________________________
flatten_10 (Flatten)            (None, 4)            0           embeddi
ng_10[0][0]
________________________________________________________________________
__________________________
flatten_11 (Flatten)            (None, 4)            0           embeddi
ng_11[0][0]
________________________________________________________________________
__________________________
flatten_12 (Flatten)            (None, 4)            0           embeddi
ng_12[0][0]
________________________________________________________________________
__________________________
dense_6 (Dense)                 (None, 1)            3           left_in
put[0][0]
________________________________________________________________________
__________________________
concatenate_2 (Concatenate)     (None, 15017)        0           flatten
_7[0][0]
                                                                 flatten
_8[0][0]
                                                                 flatten
_9[0][0]
                                                                 flatten
_10[0][0]
                                                                 flatten
_11[0][0]
                                                                 flatten
_12[0][0]
                                                                 dense_6
[0][0]
________________________________________________________________________
__________________________
dense_7 (Dense)                 (None, 64)           961152      concate
nate_2[0][0]
________________________________________________________________________
__________________________
dropout_3 (Dropout)             (None, 64)           0           dense_7
[0][0]
________________________________________________________________________
__________________________
dense_8 (Dense)                 (None, 128)          8320        dropout
_3[0][0]
________________________________________________________________________
__________________________
dropout_4 (Dropout)             (None, 128)          0           dense_8
[0][0]
________________________________________________________________________
__________________________
batch_normalization_2 (BatchNor (None, 128)          512         dropout
_4[0][0]
________________________________________________________________________
__________________________
dense_9 (Dense)                 (None, 64)           8256        batch_n
ormalization_2[0][0]
```

```
________________________________________________________________________
__________________________
dense_10 (Dense)                (None, 2)            130         dense_9
[0][0]
========================================================================
==========================
Total params: 13,819,355
Trainable params: 13,819,099
Non-trainable params: 256
________________________________________________________________________
__________________________
None
```

In [0]:

```python
import tensorflow as tf
from sklearn.metrics import roc_auc_score

def auroc(y_true, y_pred):
    return tf.py_func(roc_auc_score, (y_true, y_pred), tf.double)
```

In [0]:

```python
train_data = [padded_train,encoded_state_train,encoded_grade_train,encoded_cat_train,encoded_subcat_train,encoded_prefix_train,left_input_train]
cv_data = [padded_cv,encoded_state_cv,encoded_grade_cv,encoded_cat_cv,encoded_subcat_cv,encoded_prefix_cv,left_input_cv]
test_data = [padded_test,encoded_state_test,encoded_grade_test,encoded_cat_test,encoded_subcat_test,encoded_prefix_test,left_input_test]
```

In [0]:

```python
from keras.callbacks import TensorBoard
checkpoint_1 = ModelCheckpoint("model_1.1",
                             monitor="val_auroc",
                             mode="max",
                             save_best_only = True,
                             verbose=1)
earlystop = EarlyStopping(monitor = 'val_auroc',
                            mode="max",
                            min_delta = 0,
                            patience = 2,
                            verbose = 1,)
tensorboard=TensorBoard(log_dir='lstm_1',batch_size=512)
callbacks_1=[checkpoint_1,earlystop,tensorboard]
```

In [0]:

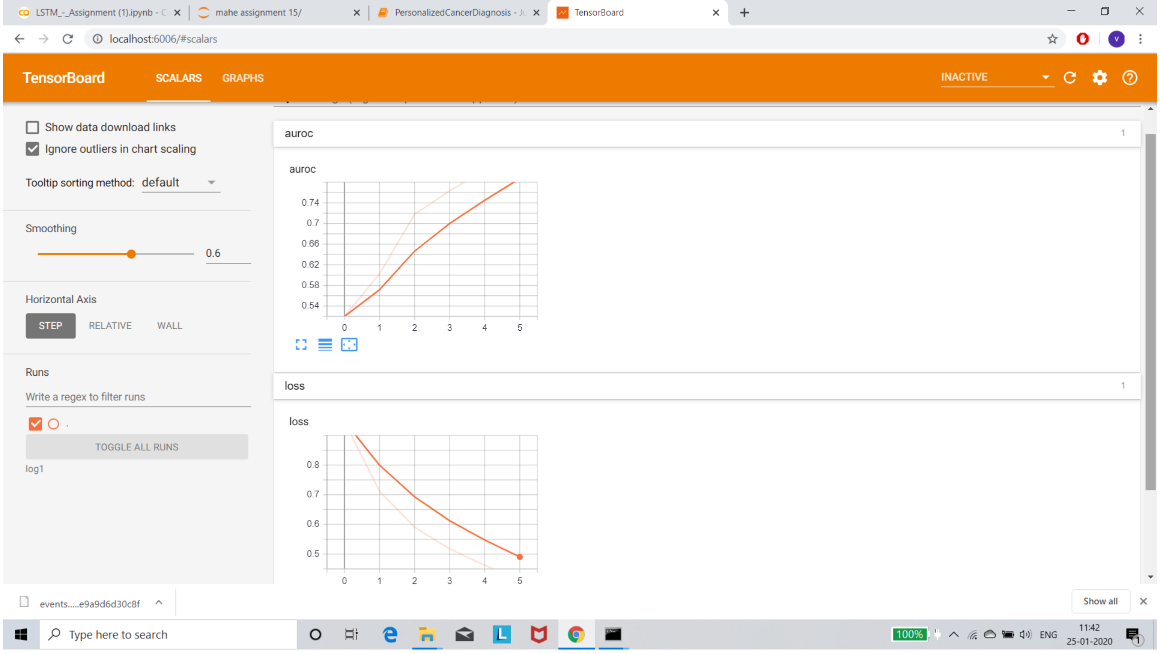
```
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=[auroc])
LSTM_1 = model.fit(train_data, y_train, batch_size=512, epochs=10, verbose=1,callbacks=
callbacks_1, validation_data=(cv_data, y_cv))
```

```
Train on 53531 samples, validate on 22942 samples
Epoch 1/10
53531/53531 [==============================] - 456s 9ms/step - loss: 0.947
4 - auroc: 0.5201 - val_loss: 0.7758 - val_auroc: 0.4897

Epoch 00001: val_auroc improved from -inf to 0.48968, saving model to mode
l_1.1
Epoch 2/10
53531/53531 [==============================] - 455s 9ms/step - loss: 0.711
2 - auroc: 0.6025 - val_loss: 0.7190 - val_auroc: 0.7081

Epoch 00002: val_auroc improved from 0.48968 to 0.70813, saving model to m
odel_1.1
Epoch 3/10
53531/53531 [==============================] - 450s 8ms/step - loss: 0.590
6 - auroc: 0.7181 - val_loss: 0.6186 - val_auroc: 0.7448

Epoch 00003: val_auroc improved from 0.70813 to 0.74482, saving model to m
odel_1.1
Epoch 4/10
53531/53531 [==============================] - 449s 8ms/step - loss: 0.517
5 - auroc: 0.7632 - val_loss: 0.5965 - val_auroc: 0.7520

Epoch 00004: val_auroc improved from 0.74482 to 0.75200, saving model to m
odel_1.1
Epoch 5/10
53531/53531 [==============================] - 448s 8ms/step - loss: 0.462
6 - auroc: 0.8038 - val_loss: 0.5980 - val_auroc: 0.7385

Epoch 00005: val_auroc did not improve from 0.75200
Epoch 6/10
53531/53531 [==============================] - 447s 8ms/step - loss: 0.411
1 - auroc: 0.8456 - val_loss: 0.5612 - val_auroc: 0.7269

Epoch 00006: val_auroc did not improve from 0.75200
Epoch 00006: early stopping
```

In [0]:

```
Image(retina=True, filename='/content/Screenshot (26).png')
```

Out[0]:



localhost:6006/#scalars

☐ Show data download links

☑ Ignore outliers in chart scaling

Tooltip sorting method: default

Smoothing 0.6

Horizontal Axis: STEP RELATIVE WALL

Runs

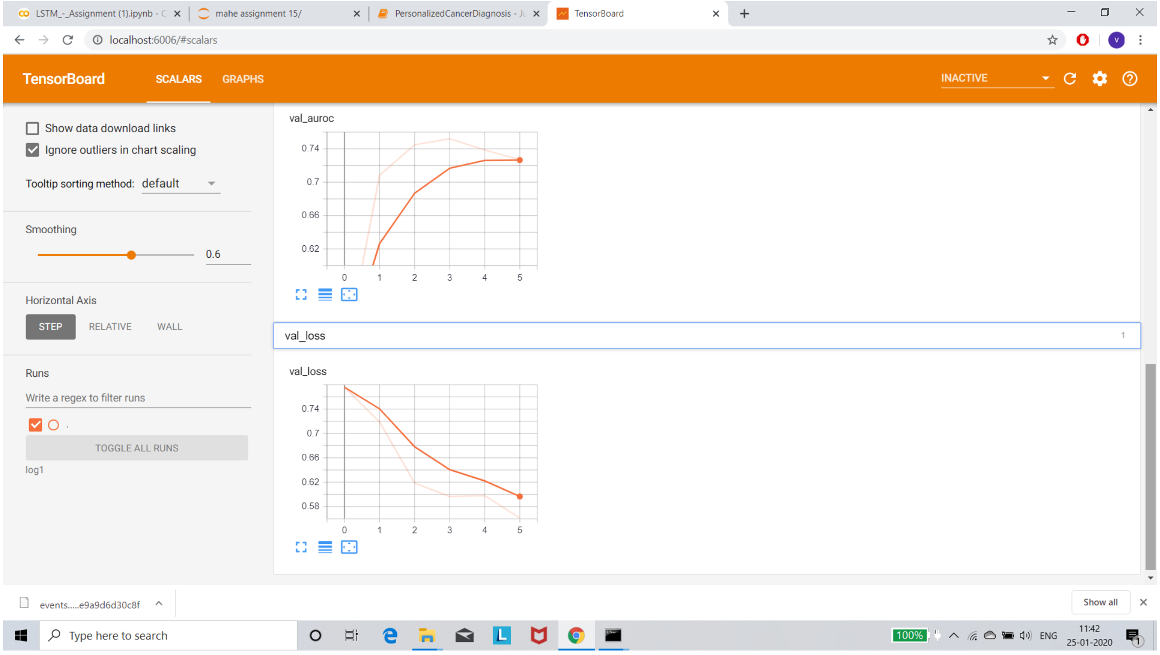
Write a regex to filter runs

log1

In [0]:

```
Image(retina=True, filename='/content/Screenshot (27).png')
```

Out[0]:



localhost:6006/#scalars

TensorBoard SCALARS GRAPHS 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
log1

val_loss

MODEL 2

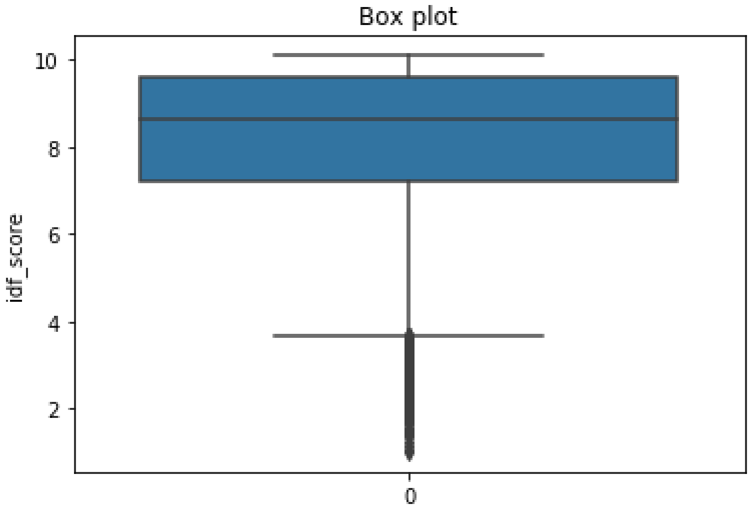
In [26]:

```
vectorizer = TfidfVectorizer(min_df=5)
X_train_essay_tfidf = vectorizer.fit_transform(X_train['essay'].values)
print("After vectorizations")
print(X_train_essay_tfidf.shape, y_train.shape)
```

```
After vectorizations
(53531, 16961) (53531, 2)
```

In [27]:

```
idf = vectorizer.idf_
sns.boxplot(data=idf)
plt.title('Box plot')
plt.ylabel('idf_score')
plt.show()
```



In [28]:

```
len(idf)
```

Out[28]:

```
16961
```

In [0]:

```
feature_names = np.asarray(vectorizer.get_feature_names())
index = []
for i in range(len(idf)):
    if idf[i] >= 2 and idf[i] <=10:
        index.append(i)
imp_words = []
for i in index:
    imp_words.append(feature_names[i])
```

In [30]:

```
print('total words=',len(feature_names))
print('important words=',len(imp_words))
```

```
total words= 16961
important words= 15665
```

In [31]:

```
# train_data
X_train_essay_imp = []
for essay in X_train['essay']:
    sentence = []
    for word in essay.split():
        if word in imp_words:
            sentence.append(word)
    X_train_essay_imp.append(' '.join(sentence))
print(len(X_train_essay_imp))
X_cv_essay_imp = []
for essay in X_cv['essay']:
    sentence = []
    for word in essay.split():
        if word in imp_words:
            sentence.append(word)
    X_cv_essay_imp.append(' '.join(sentence))
print(len(X_cv_essay_imp))
X_test_essay_imp = []
for essay in X_test['essay']:
    sentence = []
    for word in essay.split():
        if word in imp_words:
            sentence.append(word)
    X_test_essay_imp.append(' '.join(sentence))
print(len(X_test_essay_imp))
```

```
53531
22942
32775
```

In [32]:

```
 print(len(X_train_essay_imp))
print(len(X_cv_essay_imp))
print(len(X_test_essay_imp))
```

```
53531
22942
32775
```

In [33]:

```
token_2 = Tokenizer()
token_2.fit_on_texts(X_train_essay_imp)
imp_vocab = len(token_2.word_index) + 1
print('Total unique words in the important words',imp_vocab)
encoded_train_imp = token_2.texts_to_sequences(X_train_essay_imp)
encoded_cv_imp = token_2.texts_to_sequences(X_cv_essay_imp)
encoded_test_imp = token_2.texts_to_sequences(X_test_essay_imp)
print(len(encoded_train_imp))
print(len(encoded_cv_imp))
print(len(encoded_test_imp))
```

```
Total unique words in the important words 15666
53531
22942
32775
```

In [34]:

```
max_length = 300
padded_train_imp = pad_sequences(encoded_train_imp, maxlen=max_length, padding='post')
padded_cv_imp = pad_sequences(encoded_cv_imp, maxlen=max_length, padding='post')
padded_test_imp = pad_sequences(encoded_test_imp, maxlen=max_length, padding='post')
print("length of padded_train_new data",len(padded_train_imp))
print("length of padded_cv_new data",len(padded_cv_imp))
print("length of padded_test_new data",len(padded_test_imp))
```

```
length of padded_train_new data 53531
length of padded_cv_new data 22942
length of padded_test_new data 32775
```

In [0]:

```
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())

# for train
embedding_matrix_train2 = np.zeros((imp_vocab, 300))
for word, i in token_2.word_index.items():
    if word in glove_words:
        embedding_vector = model[word]
        embedding_matrix_train2[i] = embedding_vector
```

In [37]:

```
essay_text=Input(shape=(300,),name='essay_text')
x=Embedding(imp_vocab,300,weights=[embedding_matrix_train2],input_length=300)(essay_tex
t)
lstm_1=LSTM(50,recurrent_dropout=0.5,return_sequences=True)(x)
flatten_1=Flatten()(lstm_1)

state=Input(shape=(1,),name="state")
x=Embedding(state_size+1,2,input_length=1)(state)
flatten_2=Flatten()(x)

project_grade_category=Input(shape=(1,),name='project_grade_category')
x=Embedding(project_grade_categories_size+1,2,input_length=1)(project_grade_category)
flatten_3=Flatten()(x)

clean_categories=Input(shape=(1,),name='clean_categories')
x=Embedding(categories_size+1,4,input_length=1)(clean_categories)
flatten_4=Flatten()(x)

subcategory=Input(shape=(1,),name='subcategory')
x=Embedding(subcategories_size+1,4,input_length=1)(subcategory)
flatten_5=Flatten()(x)

teacher_prefix=Input(shape=(1,),name='teacher_prefix')
x=Embedding(teacher_prefix_size+1,4,input_length=1)(teacher_prefix)
flatten_6=Flatten()(x)

left_input=Input(shape=(2,),name='left_input')
dense_1 = Dense(1, activation='relu',kernel_initializer="he_normal",kernel_regularizer=
l2(0.001))(left_input)

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

x = Dense(32, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l2(0.
001))(x)
x = Dropout(.5)(x)
x = Dense(64, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l2(0.
001))(x)
x = Dropout(.5)(x)
x = BatchNormalization()(x)

x = Dense(64, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l2(0.
001))(x)
final_output = Dense(2, activation='softmax')(x)

model = Model(inputs=[essay_text,state,project_grade_category,clean_categories,subcateg
ory,teacher_prefix,left_input], outputs=[final_output])
print(model.summary())
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/bac
kend/tensorflow_backend.py:541: The name tf.placeholder is deprecated. P
lease use tf.compat.v1.placeholder instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/bac
kend/tensorflow_backend.py:66: The name tf.get_default_graph is deprecat
ed. Please use tf.compat.v1.get_default_graph instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/bac
kend/tensorflow_backend.py:4432: The name tf.random_uniform is deprecate
d. Please use tf.random.uniform instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/bac
kend/tensorflow_backend.py:190: The name tf.get_default_session is depre
cated. Please use tf.compat.v1.get_default_session instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/bac
kend/tensorflow_backend.py:197: The name tf.ConfigProto is deprecated. P
lease use tf.compat.v1.ConfigProto instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/bac
kend/tensorflow_backend.py:203: The name tf.Session is deprecated. Pleas
e use tf.compat.v1.Session instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/bac
kend/tensorflow_backend.py:207: The name tf.global_variables is deprecat
ed. Please use tf.compat.v1.global_variables instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/bac
kend/tensorflow_backend.py:216: The name tf.is_variable_initialized is d
eprecated. Please use tf.compat.v1.is_variable_initialized instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/bac
kend/tensorflow_backend.py:223: The name tf.variables_initializer is dep
recated. Please use tf.compat.v1.variables_initializer instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/bac
kend/tensorflow_backend.py:148: The name tf.placeholder_with_default is
deprecated. Please use tf.compat.v1.placeholder_with_default instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/bac
kend/tensorflow_backend.py:3733: calling dropout (from tensorflow.pytho
n.ops.nn_ops) with keep_prob is deprecated and will be removed in a futu
re version.
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/bac
kend/tensorflow_backend.py:4479: The name tf.truncated_normal is depreca
ted. Please use tf.random.truncated_normal instead.

Model: "model_1"
________________________________________________________________________
__________________________
Layer (type)                    Output Shape         Param #     Connect
ed to
========================================================================
==========================
essay_text (InputLayer)         (None, 300)          0
________________________________________________________________________
__________________________
```

```
embedding_1 (Embedding)         (None, 300, 300)     4699800     essay_t
ext[0][0]

________________________________________________________________________
__________________________
state (InputLayer)              (None, 1)            0

________________________________________________________________________
__________________________
project_grade_category (InputLa (None, 1)            0

________________________________________________________________________
__________________________
clean_categories (InputLayer)   (None, 1)            0

________________________________________________________________________
__________________________
subcategory (InputLayer)        (None, 1)            0

________________________________________________________________________
__________________________
teacher_prefix (InputLayer)     (None, 1)            0

________________________________________________________________________
__________________________
lstm_1 (LSTM)                   (None, 300, 50)      70200       embeddi
ng_1[0][0]

________________________________________________________________________
__________________________
embedding_2 (Embedding)         (None, 1, 2)         104         state
[0][0]

________________________________________________________________________
__________________________
embedding_3 (Embedding)         (None, 1, 2)         10          project
_grade_category[0][0]

________________________________________________________________________
__________________________
embedding_4 (Embedding)         (None, 1, 4)         204         clean_c
ategories[0][0]

________________________________________________________________________
__________________________
embedding_5 (Embedding)         (None, 1, 4)         1536        subcate
gory[0][0]

________________________________________________________________________
__________________________
embedding_6 (Embedding)         (None, 1, 4)         24          teacher
_prefix[0][0]

________________________________________________________________________
__________________________
left_input (InputLayer)         (None, 2)            0

________________________________________________________________________
__________________________
flatten_1 (Flatten)             (None, 15000)        0           lstm_1
[0][0]

________________________________________________________________________
__________________________
flatten_2 (Flatten)             (None, 2)            0           embeddi
ng_2[0][0]

________________________________________________________________________
__________________________
flatten_3 (Flatten)             (None, 2)            0           embeddi
ng_3[0][0]

________________________________________________________________________
__________________________
flatten_4 (Flatten)             (None, 4)            0           embeddi
ng_4[0][0]

________________________________________________________________________
```

```
__________________________
flatten_5 (Flatten)             (None, 4)            0           embeddi
ng_5[0][0]

________________________________________________________________________
__________________________
flatten_6 (Flatten)             (None, 4)            0           embeddi
ng_6[0][0]

________________________________________________________________________
__________________________
dense_1 (Dense)                 (None, 1)            3           left_in
put[0][0]

________________________________________________________________________
__________________________
concatenate_1 (Concatenate)     (None, 15017)        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, 32)           480576      concate
nate_1[0][0]

________________________________________________________________________
__________________________
dropout_1 (Dropout)             (None, 32)           0           dense_2
[0][0]

________________________________________________________________________
__________________________
dense_3 (Dense)                 (None, 64)           2112        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, 64)           4160        batch_n
ormalization_1[0][0]

________________________________________________________________________
__________________________
dense_5 (Dense)                 (None, 2)            130         dense_4
[0][0]
========================================================================
==========================
Total params: 5,259,115
Trainable params: 5,258,987
Non-trainable params: 128

________________________________________________________________________
```

```
None
```

In [0]:

```
from keras.callbacks import TensorBoard
checkpoint_2 = ModelCheckpoint("model_2.1",
                             monitor="val_auroc",
                             mode="max",
                             save_best_only = True,
                             verbose=1)
earlystop_2 = EarlyStopping(monitor = 'val_auroc',
                            mode="max",
                            min_delta = 0,
                            patience = 2,
                            verbose = 1,)
tensorboard_1=TensorBoard(log_dir='lstm_2',batch_size=512)
callbacks_2=[checkpoint_2,earlystop_2,tensorboard_1]
```

In [0]:

```
train_data_1 = [padded_train_imp,encoded_state_train,encoded_grade_train,encoded_cat_train,encoded_subcat_train,encoded_prefix_train,left_input_train]
cv_data_1 = [padded_cv_imp,encoded_state_cv,encoded_grade_cv,encoded_cat_cv,encoded_subcat_cv,encoded_prefix_cv,left_input_cv]
test_data_1 = [padded_test_imp,encoded_state_test,encoded_grade_test,encoded_cat_test,encoded_subcat_test,encoded_prefix_test,left_input_test]
```

In [42]:

```
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=[auroc])
LSTM_2 = model.fit(train_data_1, y_train, batch_size=512, epochs=10, verbose=1,callback
s=callbacks_2, validation_data=(cv_data_1, y_cv))
```

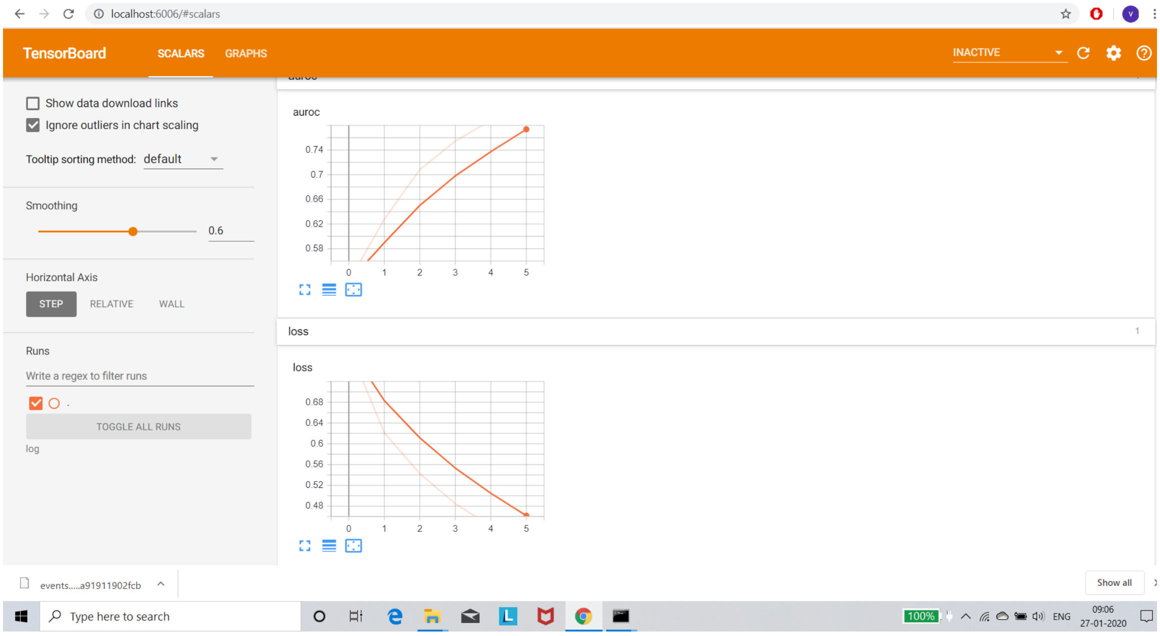
```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/optim
izers.py:793: The name tf.train.Optimizer is deprecated. Please use tf.com
pat.v1.train.Optimizer instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backe
nd/tensorflow_backend.py:3576: The name tf.log is deprecated. Please use t
f.math.log instead.

WARNING:tensorflow:From <ipython-input-41-4a25250c5bd7>:5: py_func (from t
ensorflow.python.ops.script_ops) is deprecated and will be removed in a fu
ture version.
Instructions for updating:
tf.py_func is deprecated in TF V2. Instead, there are two
    options available in V2.
    - tf.py_function takes a python function which manipulates tf eager
    tensors instead of numpy arrays. It's easy to convert a tf eager tenso
r to
    an ndarray (just call tensor.numpy()) but having access to eager tenso
rs
    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_fu
nc
    (it is not differentiable, and manipulates numpy arrays). It drops the
    stateful argument making all functions stateful.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow_
core/python/ops/math_grad.py:1424: where (from tensorflow.python.ops.array
_ops) is deprecated and will be removed in a future version.
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/backe
nd/tensorflow_backend.py:1033: The name tf.assign_add is deprecated. Pleas
e use tf.compat.v1.assign_add instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backe
nd/tensorflow_backend.py:1020: The name tf.assign is deprecated. Please us
e tf.compat.v1.assign instead.

Train on 53531 samples, validate on 22942 samples
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/callb
acks.py:1122: The name tf.summary.merge_all is deprecated. Please use tf.c
ompat.v1.summary.merge_all instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/callb
acks.py:1125: The name tf.summary.FileWriter is deprecated. Please use tf.
compat.v1.summary.FileWriter instead.

Epoch 1/10
53531/53531 [==============================] - 386s 7ms/step - loss: 0.786
5 - auroc: 0.5264 - val_loss: 0.6874 - val_auroc: 0.5568

Epoch 00001: val_auroc improved from -inf to 0.55678, saving model to mode
l_2.1
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/callb
acks.py:1265: The name tf.Summary is deprecated. Please use tf.compat.v1.S
ummary instead.

Epoch 2/10
53531/53531 [==============================] - 385s 7ms/step - loss: 0.620
9 - auroc: 0.6278 - val_loss: 0.6117 - val_auroc: 0.7106
```

```
Epoch 00002: val_auroc improved from 0.55678 to 0.71064, saving model to m
odel_2.1
Epoch 3/10
53531/53531 [==============================] - 390s 7ms/step - loss: 0.542
5 - auroc: 0.7083 - val_loss: 0.6237 - val_auroc: 0.7147

Epoch 00003: val_auroc improved from 0.71064 to 0.71470, saving model to m
odel_2.1
Epoch 4/10
53531/53531 [==============================] - 391s 7ms/step - loss: 0.484
5 - auroc: 0.7545 - val_loss: 0.5351 - val_auroc: 0.7470

Epoch 00004: val_auroc improved from 0.71470 to 0.74695, saving model to m
odel_2.1
Epoch 5/10
53531/53531 [==============================] - 390s 7ms/step - loss: 0.441
9 - auroc: 0.7884 - val_loss: 0.5426 - val_auroc: 0.7382

Epoch 00005: val_auroc did not improve from 0.74695
Epoch 6/10
53531/53531 [==============================] - 389s 7ms/step - loss: 0.401
7 - auroc: 0.8239 - val_loss: 0.5385 - val_auroc: 0.7280

Epoch 00006: val_auroc did not improve from 0.74695
Epoch 00006: early stopping
```

In [44]:

```
Image(retina=True, filename='/content/Screenshot (32).png')
```

Out[44]:



localhost:6006/#scalars

TensorBoard SCALARS GRAPHS 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

☑ ○ .

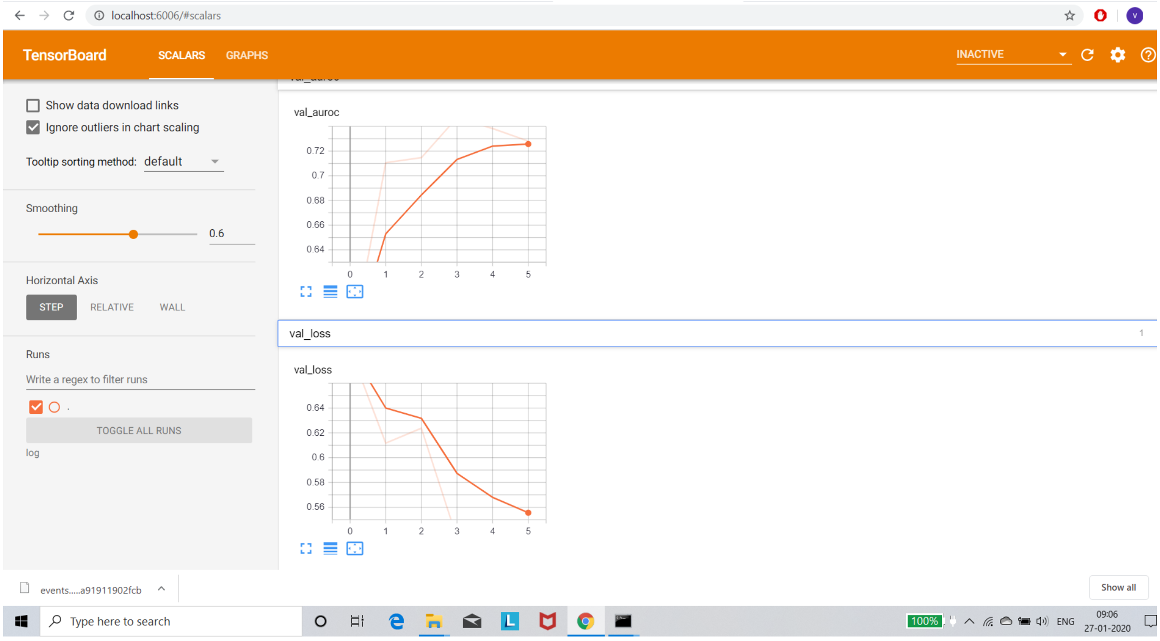
TOGGLE ALL RUNS

log

In [45]:

```
Image(retina=True, filename='/content/Screenshot (33).png')
```

Out[45]:



□ 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

In [0]:

```

```

MODEL 3

ONE HOT ENCODING OF CATEGORICAL VARIABLES

In [0]:

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

X_train_categories_one_hot = vectorizer.transform(X_train['clean_categories'].values)
X_cv_categories_one_hot = vectorizer.transform(X_cv['clean_categories'].values)
X_test_categories_one_hot = vectorizer.transform(X_test['clean_categories'].values)
print(vectorizer.get_feature_names())
print("-"*100)
print("After vectorizations")
print(X_train_categories_one_hot.shape, y_train.shape)
print(X_cv_categories_one_hot.shape, y_cv.shape)
print(X_test_categories_one_hot.shape, y_test.shape)
```

```
['appliedlearning', 'care_hunger', 'health_sports', 'history_civics', 'lit
eracy_language', 'math_science', 'music_arts', 'specialneeds', 'warmth']
--------------------------------------------------------------------------
--------------------------
After vectorizations
(53531, 9) (53531, 2)
(22942, 9) (22942, 2)
(32775, 9) (32775, 2)
```

In [0]:

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

X_train_subcategories_one_hot = vectorizer.transform(X_train['clean_subcategories'].val
ues)
X_cv_subcategories_one_hot = vectorizer.transform(X_cv['clean_subcategories'].values)
X_test_subcategories_one_hot = vectorizer.transform(X_test['clean_subcategories'].value
s)
print(vectorizer.get_feature_names())
print("-"*100)
print("After vectorizations")
print(X_train_subcategories_one_hot.shape, y_train.shape)
print(X_cv_subcategories_one_hot.shape, y_cv.shape)
print(X_test_subcategories_one_hot.shape, y_test.shape)
```

```
['appliedsciences', 'care_hunger', 'charactereducation', 'civics_governmen
t', 'college_careerprep', 'communityservice', 'earlydevelopment', 'economi
cs', 'environmentalscience', 'esl', 'extracurricular', 'financialliterac
y', 'foreignlanguages', 'gym_fitness', 'health_lifescience', 'health_welln
ess', 'history_geography', 'literacy', 'literature_writing', 'mathematic
s', 'music', 'nutritioneducation', 'other', 'parentinvolvement', 'performi
ngarts', 'socialsciences', 'specialneeds', 'teamsports', 'visualarts', 'wa
rmth']
--------------------------------------------------------------------------
--------------------------
After vectorizations
(53531, 30) (53531, 2)
(22942, 30) (22942, 2)
(32775, 30) (32775, 2)
```

In [0]:

```
X_train.columns
```

Out[0]:

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

In [0]:

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

X_train_prefix_one_hot = vectorizer.transform(X_train['teacher_prefix'].values)
X_cv_prefix_one_hot = vectorizer.transform(X_cv['teacher_prefix'].values)
X_test_prefix_one_hot = vectorizer.transform(X_test['teacher_prefix'].values)
print(vectorizer.get_feature_names())
print("-"*100)
print("After vectorizations")
print(X_train_prefix_one_hot.shape, y_train.shape)
print(X_cv_prefix_one_hot.shape, y_cv.shape)
print(X_test_prefix_one_hot.shape, y_test.shape)
```

```
['dr', 'mr', 'mrs', 'ms', 'teacher']
--------------------------------------------------------------------------
--------------------------
After vectorizations
(53531, 5) (53531, 2)
(22942, 5) (22942, 2)
(32775, 5) (32775, 2)
```

In [0]:

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

X_train_state_one_hot = vectorizer.transform(X_train['school_state'].values)
X_cv_state_one_hot = vectorizer.transform(X_cv['school_state'].values)
X_test_state_one_hot = vectorizer.transform(X_test['school_state'].values)
print(vectorizer.get_feature_names())
print("-"*100)
print("After vectorizations")
print(X_train_state_one_hot.shape, y_train.shape)
print(X_cv_state_one_hot.shape, y_cv.shape)
print(X_test_state_one_hot.shape, y_test.shape)
```

```
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi',
'ia', 'id', 'il', 'in', 'ks', 'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'm
o', 'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', 'ny', 'oh', 'o
k', 'or', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'w
i', 'wv', 'wy']
--------------------------------------------------------------------------
--------------------------
After vectorizations
(53531, 51) (53531, 2)
(22942, 51) (22942, 2)
(32775, 51) (32775, 2)
```

In [0]:

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

X_train_grade_one_hot = vectorizer.transform(X_train['project_grade_category'].values)
X_cv_grade_one_hot = vectorizer.transform(X_cv['project_grade_category'].values)
X_test_grade_one_hot = vectorizer.transform(X_test['project_grade_category'].values)
print(vectorizer.get_feature_names())
print("-"*100)
print("After vectorizations")
print(X_train_grade_one_hot.shape, y_train.shape)
print(X_cv_grade_one_hot.shape, y_cv.shape)
print(X_test_grade_one_hot.shape, y_test.shape)
```

```
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
--------------------------------------------------------------------------
--------------------------
After vectorizations
(53531, 4) (53531, 2)
(22942, 4) (22942, 2)
(32775, 4) (32775, 2)
```

CREATING INPUT DATA OTHER THAN TEXT

In [0]:

```
train_without_text=hstack((X_train_categories_one_hot,X_train_prefix_one_hot,X_train_st
ate_one_hot,X_train_subcategories_one_hot,X_train_grade_one_hot,X_train_price_norm,X_tr
ain_projects_norm)).todense()
cv_without_text=hstack((X_cv_categories_one_hot,X_cv_prefix_one_hot,X_cv_state_one_hot,
X_cv_subcategories_one_hot,X_cv_grade_one_hot,X_cv_price_norm,X_cv_projects_norm)).tode
nse()
test_without_text=hstack((X_test_categories_one_hot,X_test_prefix_one_hot,X_test_state_
one_hot,X_test_subcategories_one_hot,X_test_grade_one_hot,X_test_price_norm,X_test_proj
ects_norm)).todense()
print(train_without_text.shape)
print(cv_without_text.shape)
print(test_without_text.shape)
```

```
(53531, 101)
(22942, 101)
(32775, 101)
```

In [0]:

```
train_final = np.expand_dims(train_without_text,2)
cv_final = np.expand_dims(cv_without_text,2)
test_final=np.expand_dims(test_without_text,2)
print(train_final.shape)
print(cv_final.shape)
print(test_final.shape)
```

```
(53531, 101, 1)
(22942, 101, 1)
(32775, 101, 1)
```

MODEL 3

In [0]:

```
essay_text=Input(shape=(300,),name='essay_text')
x=Embedding(vocab_size,300,weights=[embedding_matrix_train],input_length=300)(essay_text)
lstm_1=LSTM(50,recurrent_dropout=0.5,return_sequences=True)(x)
flatten_1=Flatten()(lstm_1)

other_features=Input(shape=(101,1),name='other_features')
x = Conv1D(filters=128, kernel_size = 2, padding='valid', kernel_initializer='he_normal',)(other_features)
x = Conv1D(filters=128, kernel_size = 2, padding='valid', kernel_initializer='he_normal',)(x)
x = Flatten()(x)

con=concatenate([flatten_1,x])

x=Dense(128, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l2(0.001))(con)
x=Dropout(0.5)(x)
x=Dense(128,activation='relu',kernel_initializer="he_normal",kernel_regularizer=l2(0.001))(x)
x=Dropout(0.5)(x)
x=BatchNormalization()(x)
x=Dense(128, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l2(0.001))(x)

final_output = Dense(2, activation='softmax')(x)

model_3 = Model(inputs=[essay_text,other_features], outputs=[final_output])
print(model_3.summary())
```

```
Model: "model_3"
__________________________________________________________________________
________________________
Layer (type)                    Output Shape         Param #     Connected
to
==========================================================================
========================
essay_text (InputLayer)         (None, 300)          0
__________________________________________________________________________
________________________
other_features (InputLayer)     (None, 101, 1)       0
__________________________________________________________________________
________________________
embedding_13 (Embedding)        (None, 300, 300)     12768900    essay_tex
t[0][0]
__________________________________________________________________________
________________________
conv1d_1 (Conv1D)               (None, 100, 128)     384         other_fea
tures[0][0]
__________________________________________________________________________
________________________
lstm_3 (LSTM)                   (None, 300, 50)      70200       embedding
_13[0][0]
__________________________________________________________________________
________________________
conv1d_2 (Conv1D)               (None, 99, 128)      32896       conv1d_1
[0][0]
__________________________________________________________________________
________________________
flatten_13 (Flatten)            (None, 15000)        0           lstm_3[0]
[0]
__________________________________________________________________________
________________________
flatten_14 (Flatten)            (None, 12672)        0           conv1d_2
[0][0]
__________________________________________________________________________
________________________
concatenate_3 (Concatenate)     (None, 27672)        0           flatten_1
3[0][0]
                                                                 flatten_1
4[0][0]
__________________________________________________________________________
________________________
dense_11 (Dense)                (None, 128)          3542144     concatena
te_3[0][0]
__________________________________________________________________________
________________________
dropout_5 (Dropout)             (None, 128)          0           dense_11
[0][0]
__________________________________________________________________________
________________________
dense_12 (Dense)                (None, 128)          16512       dropout_5
[0][0]
__________________________________________________________________________
________________________
dropout_6 (Dropout)             (None, 128)          0           dense_12
[0][0]
__________________________________________________________________________
________________________
batch_normalization_3 (BatchNor (None, 128)          512         dropout_6
[0][0]
```

```
__________________________________________________________________________
________________________
dense_13 (Dense)                (None, 128)          16512       batch_nor
malization_3[0][0]
__________________________________________________________________________
________________________
dense_14 (Dense)                (None, 2)            258         dense_13
[0][0]
==========================================================================
========================
Total params: 16,448,318
Trainable params: 16,448,062
Non-trainable params: 256
__________________________________________________________________________
________________________
None
```

In [0]:

```python
from keras.callbacks import TensorBoard
checkpoint_3 = ModelCheckpoint("model_3.1",
                             monitor="val_auroc",
                             mode="max",
                             save_best_only = True,
                             verbose=1)
earlystop = EarlyStopping(monitor = 'val_auroc',
                            mode="max",
                            min_delta = 0,
                            patience = 3,
                            verbose = 1,)
tensorboard_2=TensorBoard(log_dir='lstm_3',batch_size=512)
callbacks_2=[checkpoint_3,earlystop,tensorboard_2]
```

In [0]:

```python
train_model_3=[padded_train,train_final]
cv_model_3=[padded_cv,cv_final]
test_model_3=[padded_test,test_final]
```

In [0]:

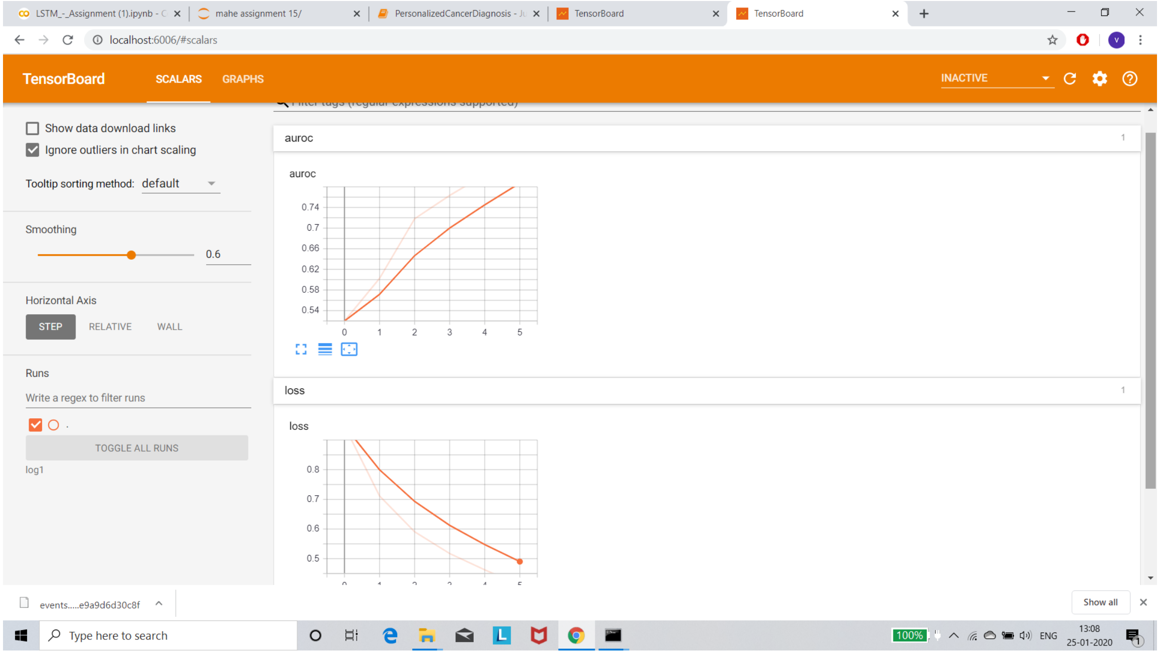
```
model_3.compile(optimizer='adam', loss='categorical_crossentropy', metrics=[auroc])
LSTM_3 = model_3.fit(train_model_3, y_train, batch_size=512, epochs=10, verbose=1,callb
acks=callbacks_2, validation_data=(cv_model_3, y_cv))
```

```
Train on 53531 samples, validate on 22942 samples
Epoch 1/10
53531/53531 [==============================] - 509s 10ms/step - loss: 1.19
05 - auroc: 0.5222 - val_loss: 0.9167 - val_auroc: 0.5946

Epoch 00001: val_auroc improved from -inf to 0.59462, saving model to mode
l_3.1
Epoch 2/10
53531/53531 [==============================] - 504s 9ms/step - loss: 0.850
1 - auroc: 0.5629 - val_loss: 0.7516 - val_auroc: 0.6469

Epoch 00002: val_auroc improved from 0.59462 to 0.64692, saving model to m
odel_3.1
Epoch 3/10
53531/53531 [==============================] - 496s 9ms/step - loss: 0.708
0 - auroc: 0.6658 - val_loss: 0.6449 - val_auroc: 0.7220

Epoch 00003: val_auroc improved from 0.64692 to 0.72202, saving model to m
odel_3.1
Epoch 4/10
53531/53531 [==============================] - 495s 9ms/step - loss: 0.609
6 - auroc: 0.7355 - val_loss: 0.6054 - val_auroc: 0.7544

Epoch 00004: val_auroc improved from 0.72202 to 0.75437, saving model to m
odel_3.1
Epoch 5/10
53531/53531 [==============================] - 495s 9ms/step - loss: 0.537
5 - auroc: 0.7747 - val_loss: 0.5510 - val_auroc: 0.7550

Epoch 00005: val_auroc improved from 0.75437 to 0.75499, saving model to m
odel_3.1
Epoch 6/10
53531/53531 [==============================] - 497s 9ms/step - loss: 0.487
6 - auroc: 0.8028 - val_loss: 0.5407 - val_auroc: 0.7480

Epoch 00006: val_auroc did not improve from 0.75499
Epoch 7/10
53531/53531 [==============================] - 492s 9ms/step - loss: 0.435
6 - auroc: 0.8382 - val_loss: 0.5047 - val_auroc: 0.7243

Epoch 00007: val_auroc did not improve from 0.75499
Epoch 8/10
53531/53531 [==============================] - 492s 9ms/step - loss: 0.383
0 - auroc: 0.8763 - val_loss: 0.5082 - val_auroc: 0.7154

Epoch 00008: val_auroc did not improve from 0.75499
Epoch 00008: early stopping
```

In [0]:

```
Image(retina=True, filename='/content/Screenshot (28).png')
```

Out[0]:

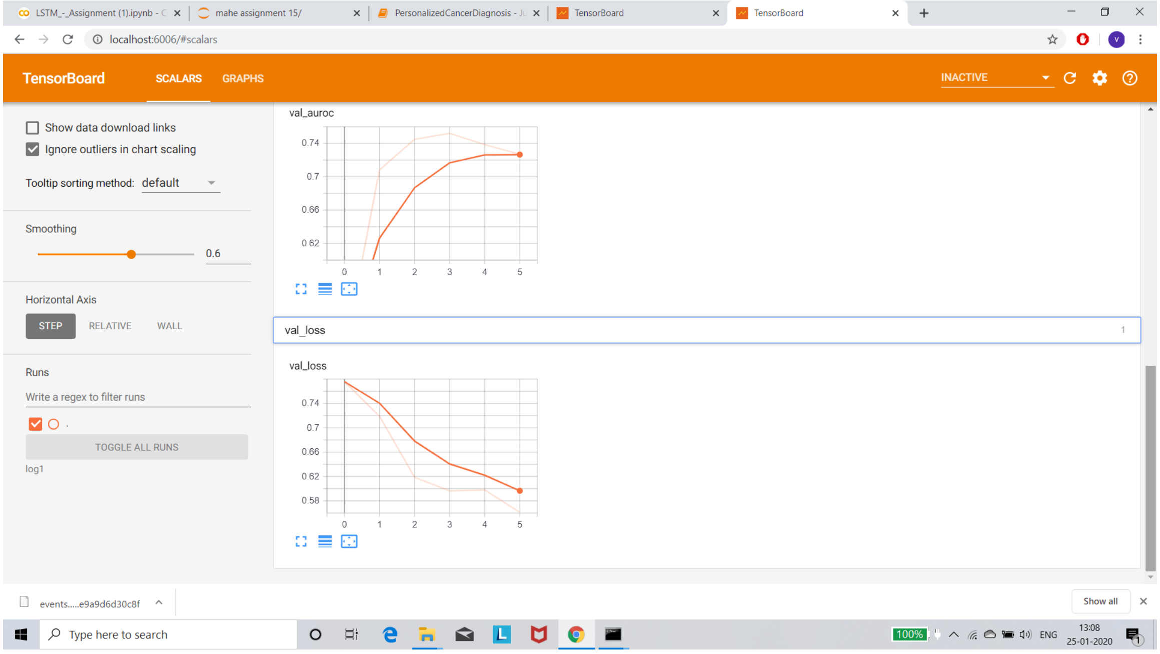


☐ Show data download links
☑ Ignore outliers in chart scaling
Tooltip sorting method: default
Smoothing 0.6
Horizontal Axis: STEP

In [0]:

```
Image(retina=True, filename='/content/Screenshot (29).png')
```

Out[0]:



☐ Show data download links
☑ Ignore outliers in chart scaling
Tooltip sorting method: default
Smoothing 0.6
Horizontal Axis: STEP

CONCLUSION

In [43]:

```
from prettytable import PrettyTable

conclusion=PrettyTable()
conclusion.field_names = ["ARCHITECTURE","EPOCHS", "TRAIN_auc", "VAL_auc",]
conclusion.add_row(["LSTM_1", 4, 0.7632,0.7520 ])
conclusion.add_row(["LSTM_2",5, 0.7545,0.7470])
conclusion.add_row(["LSTM_3", 5,0.7747,0.7550])

print(conclusion.get_string(start=0,end=7))
```

```
+--------------+--------+-----------+---------+
| ARCHITECTURE | EPOCHS | TRAIN_auc | VAL_auc |
+--------------+--------+-----------+---------+
|    LSTM_1    |   4    |   0.7632  |  0.752  |
|    LSTM_2    |   5    |   0.7545  |  0.747  |
|    LSTM_3    |   5    |   0.7747  |  0.755  |
+--------------+--------+-----------+---------+
```

In [0]:

```

```