Assignment : 14

In [0]:

```
from keras.utils import np_utils
from keras.datasets import mnist
import seaborn as sns
from keras.initializers import RandomNormal
from keras.initializers import he_normal
from keras.layers.normalization import BatchNormalization
from keras.layers import Dropout
import matplotlib.pyplot as plt
import numpy as np
import time
import pandas as pd
from sklearn.model_selection import train_test_split
from keras.utils import to_categorical
from keras.preprocessing.text import Tokenizer
from collections import Counter
from keras.preprocessing.sequence import pad_sequences
from sklearn.feature_extraction.text import CountVectorizer
from sklearn import preprocessing
import pickle
from keras.layers import Input
from keras.layers.embeddings import Embedding
from keras.models import Sequential
from keras.layers import Dense, Input
from keras.layers import Flatten
from keras.layers import concatenate
from keras.layers import LSTM
from keras.layers import Conv1D
from keras.regularizers import l2
from keras.models import Model
from tensorboardcolab import TensorBoardColab, TensorBoardColabCallback
from keras.callbacks import ModelCheckpoint, ReduceLROnPlateau, EarlyStopping
import tensorflow as tf
from sklearn.metrics import roc_auc_score
from keras.models import load_model
from sklearn.feature_extraction.text import TfidfVectorizer
from IPython.display import Image
from tqdm import tqdm_notebook
from keras import optimizers
from keras.layers import LeakyReLU
from collections import Counter
from scipy.sparse import hstack
```

In [0]:

```
# https://gist.github.com/greydanus/f6eee59eaf1d90fcb3b534a25362cea4
# https://stackoverflow.com/a/14434334
# this function is used to update the plots for each epoch and error
def plt_dynamic(x, vy, ty, ax, colors=['b']):
    ax.plot(x, vy, 'b', label="Validation Loss")
    ax.plot(x, ty, 'r', label="Train Loss")
    plt.legend()
    plt.grid()
    fig.canvas.draw()
```

In [96]:

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

```
Drive already mounted at /content/gdrive; to attempt to forcibly remou
nt, call drive.mount("/content/gdrive", force_remount=True).
```

In [97]:

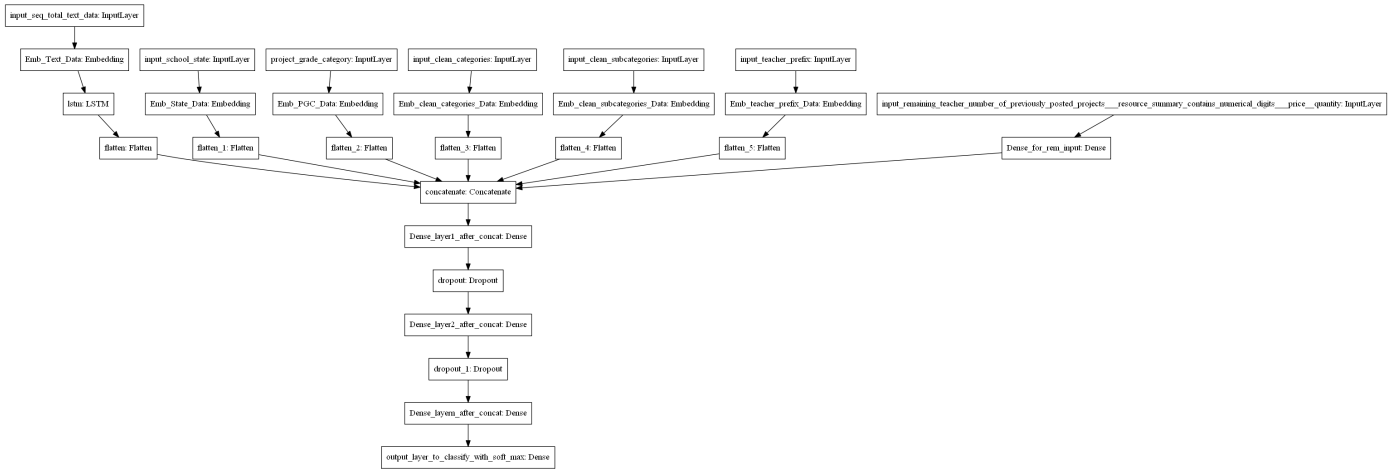
```
root_path = '/content/gdrive/My Drive/LSTM Assignment/'
!ls '/content/gdrive/My Drive/LSTM Assignment'
working_dir = '/content/gdrive/My Drive/model-weights-lstm/'
!ls '/content/gdrive/My Drive/model-weights-lstm/'
```

```
 1_Reference_EDA.ipynb            'LSTM - Assignment.ipynb'   train_da
ta.csv
 2_Reference_Preprocessing.ipynb   preprocessed_data.csv
 glove_vectors                     resources.csv
best_model_1.h5   test-essay-imp.pkl
best_model.h5     train-essay-imp.pkl
cv-essay-imp.pkl  weights-improvement-01-0.61.hdf5
hello             weights-improvement-01-0.64.hdf5
model1.png        weights-improvement-02-0.65.hdf5
model2.png        weights-improvement-02-0.67.hdf5
tb_1.png
```

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



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

- **Input_seq_total_text_data** --- You have to give Total text data columns. After this use the Embedding layer to get word vectors. Use given predefined glove word vectors, don't train any word vectors. After this use LSTM and get the LSTM output and Flatten that output.
- **Input_school_state** --- Give 'school_state' column as input to embedding layer and Train the Keras Embedding layer.
- **Project_grade_category** --- Give 'project_grade_category' column as input to embedding layer and Train the Keras Embedding layer.
- **Input_clean_categories** --- Give 'input_clean_categories' column as input to embedding layer and Train the Keras Embedding layer.
- **Input_clean_subcategories** --- Give 'input_clean_subcategories' column as input to embedding layer and Train the Keras Embedding layer.
- **Input_clean_subcategories** --- Give 'input_teacher_prefix' column as input to embedding layer and Train the Keras Embedding layer.
- **Input_remaining_teacher_number_of_previously_posted_projects._resource_summary_contains_nu** ---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 [98]:

```
df = pd.read_csv(root_path+'preprocessed_data.csv')
print(df.shape)
```

```
(109248, 9)
```

In [99]:

```
df.head()
```

Out[99]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_pı
0	ca	mrs	grades_prek_2	
1	ut	ms	grades_3_5	
2	ca	mrs	grades_prek_2	
3	ga	mrs	grades_prek_2	
4	wa	mrs	grades_3_5	

Splitting data into Train and Test

In [0]:

```
Y = df['project_is_approved'].values
df.drop(['project_is_approved'],axis=1,inplace=True)
```

In [101]:

```
X_train, X_test, Y_train, Y_test = train_test_split(df,Y,stratify=Y,test_size=0.20)
X_train, X_cv, Y_train, Y_cv = train_test_split(X_train,Y_train,stratify=Y_train,te

print("Size of X_train: ",X_train.shape)
print("Size of Y_train: ",Y_train.shape)

print("Size of X_cv: ",X_cv.shape)
print("Size of Y_cv: ",Y_cv.shape)

print("Size of X_test: ",X_test.shape)
print("Size of Y_test: ",Y_test.shape)
```

```
Size of X_train:  (69918, 8)
Size of Y_train:  (69918,)
Size of X_cv:  (17480, 8)
Size of Y_cv:  (17480,)
Size of X_test:  (21850, 8)
Size of Y_test:  (21850,)
```

Convert Y label to binary class matrix

In [102]:

```
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)
print("Shape of Y_train: ", Y_train.shape)
print("Shape of Y_cv: ", Y_cv.shape)
print("Shape of Y_test: ",Y_test.shape)
```

```
Shape of Y_train:  (69918, 2)
Shape of Y_cv:  (17480, 2)
Shape of Y_test:  (21850, 2)
```

Encoding text data as integers

- Keras offers an Embedding layer that can be used for neural networks on text data.
- It requires that the input data be integer encoded, so that each word is represented by a unique integer.

In [103]:

```
# prepare tokenizer
t = Tokenizer()
t.fit_on_texts(X_train['essay'])
vocab_size = len(t.word_index) + 1
print("Vocabulary Size: ",vocab_size)
```

```
Vocabulary Size:  47336
```

In [104]:

```
# # integer encode the documents
encoded_train_essay = t.texts_to_sequences(X_train['essay'])
encoded_cv_essay = t.texts_to_sequences(X_cv['essay'])
encoded_test_essay = t.texts_to_sequences(X_test['essay'])
print(encoded_train_essay[0])
```

```
[719, 1, 437, 764, 23, 719, 1, 493, 35, 1076, 3764, 71, 1061, 218, 22
6, 30363, 71, 317, 9555, 59, 176, 421, 3, 30, 2, 34, 1, 1171, 19, 5, 8
41, 220, 1, 94, 194, 2568, 329, 196, 3429, 1961, 117, 37, 539, 1, 492,
464, 195, 9, 437, 48, 110, 495, 238, 488, 9, 34, 290, 48, 592, 2, 50,
231, 209, 418, 2, 20, 82, 1, 418, 2, 34, 33, 35, 9, 15, 75, 152, 705,
10, 705, 2, 19, 1, 20, 159, 705, 450, 267, 719, 375, 27, 159, 71, 627,
1930, 1, 294, 687, 3, 5, 27, 15, 4, 1, 687, 364, 9, 34, 159, 118, 475,
188, 535, 3, 1198, 11637, 231, 78, 719, 60, 26, 499, 130, 719, 60, 8,
800, 897, 3957, 331, 499, 261, 349, 86, 6, 2, 34, 1, 20, 10, 475, 326,
337, 57, 2, 235, 394, 1, 75, 159, 327, 3, 101, 69, 250, 57, 2, 19, 18,
3310, 8378, 23, 1, 285, 138, 159, 297, 1348, 1165, 1492, 1, 28, 18, 2
6, 56, 968, 194, 460, 26, 153, 2, 34, 1, 100, 724, 259, 124, 719, 1, 2
38, 336, 12, 312, 8, 102, 2524, 15198, 170, 8, 18, 15198, 252, 774, 2,
34, 1237, 19, 5, 719, 1, 365, 3, 268, 772, 203, 6, 2, 49, 1180, 1, 41
8, 7, 232, 252, 1, 159, 383, 5, 13]
```

Analysing Essay lengths to find the padding size

In [0]:

```
len_of_essays = []
for essay in encoded_train_essay:
    len_of_essays.append(len(essay))

uniq_len = list(set(len_of_essays))
freq = []
for c in uniq_len:
    freq.append(len_of_essays.count(c))
```

In [106]:

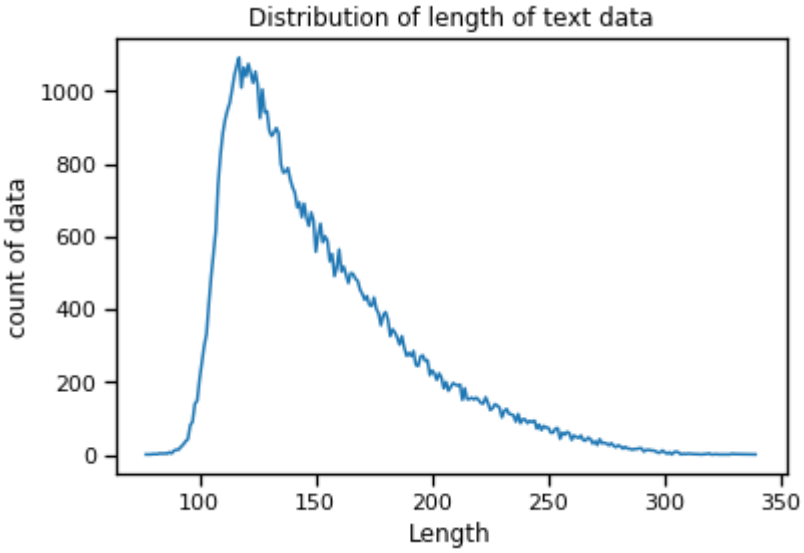
```
print("Mean Length of Essays = ", sum(len_of_essays)/len(len_of_essays))
```

```
Mean Length of Essays =  151.39409021997196
```

Plotting distribution of essay length

In [107]:

```
%matplotlib inline
sns.set_context('notebook')
plt.plot(uniq_len,freq)
plt.xlabel('Length')
plt.ylabel('count of data')
plt.title('Distribution of length of text data')
plt.show()
```



Conclusion

- As observed from the distribution a essay lenth of **300** covers most of the data points.

In [108]:

```
max_length = 300
padded_train_essay = pad_sequences(encoded_train_essay, maxlen=max_length, padding=
padded_cv_essay = pad_sequences(encoded_cv_essay, maxlen=max_length, padding='post'
padded_test_essay = pad_sequences(encoded_test_essay, maxlen=max_length, padding='p
print("After padding train essay",padded_train_essay[0])
print("After padding cv essay",padded_cv_essay[0])
print("After padding test essay",padded_test_essay[0])
```

```
After padding train essay [  719     1   437   764    23   719     1
493    35  1076  3764    71
  1061   218   226 30363    71   317  9555    59   176   421     3
30
     2    34     1  1171    19     5   841   220     1    94   194
2568
   329   196  3429  1961   117    37   539     1   492   464   195
9
   437    48   110   495   238   488     9    34   290    48   592
2
    50   231   209   418     2    20    82     1   418     2    34
33
    35     9    15    75   152   705    10   705     2    19     1
20
   159   705   450   267   719   375    27   159    71   627  1930
1
   294   687     3     5    27    15     4     1   687   364     9
34
   159   118   475   188   535     3  1198 11637   231    78   719
60
    26   499   130   719    60     8   800   897  3957   331   499
261
   349    86     6     2    34     1    20    10   475   326   337
57
     2   235   394     1    75   159   327     3   101    69   250
57
     2    19    18  3310  8378    23     1   285   138   159   297
1348
  1165  1492     1    28    18    26    56   968   194   460    26
153
     2    34     1   100   724   259   124   719     1   238   336
12
   312     8   102  2524 15198   170     8    18 15198   252   774
2
    34  1237    19     5   719     1   365     3   268   772   203
6
     2    49  1180     1   418     7   232   252     1   159   383
5
    13     0     0     0     0     0     0     0     0     0     0
0
     0     0     0     0     0     0     0     0     0     0     0
0
     0     0     0     0     0     0     0     0     0     0     0
0
     0     0     0     0     0     0     0     0     0     0     0
0
     0     0     0     0     0     0     0     0     0     0     0
0
     0     0     0     0     0     0     0     0     0     0     0
0]
After padding cv essay [ 107  112   37 2831 2118    3 3294    1  958
```

```
133 1053  199   24    8
  102  321  237   44   21   94   10  107  103   60   76  264    3
26
   37  130  111 1488  905  360 1054  409    1 1191  963 1650  632
2
  525   18  230  944  285   72   63   75  208  316  143  407  841
26
   51  218    5  178 2162  188 2168 1882  842  481   51    2 2906  1
03
   60    1    7   51  932  256 2280 1121  619  166   30   72   85
97
   26  392    7  619 1111   41   65  218   28 1515 1120  400  657
24
  252 1090 3704 1276  619  274 1972    3 1072 3999    1  374  794
3
   30   13    0    0    0    0    0    0    0    0    0    0    0
0
    0    0    0    0    0    0    0    0    0    0    0    0    0
0
    0    0    0    0    0    0    0    0    0    0    0    0    0
0
    0    0    0    0    0    0    0    0    0    0    0    0    0
0
    0    0    0    0    0    0    0    0    0    0    0    0    0
0
    0    0    0    0    0    0    0    0    0    0    0    0    0
0
    0    0    0    0    0    0    0    0    0    0    0    0    0
0
    0    0    0    0    0    0    0    0    0    0    0    0    0
0
    0    0    0    0    0    0    0    0    0    0    0    0    0
0
    0    0    0    0    0    0    0    0    0    0    0    0    0
0
    0    0    0    0    0    0    0    0    0    0    0    0    0
0
    0    0    0    0    0    0    0    0    0    0    0    0    0
0
    0    0    0    0    0    0]
After padding test essay [ 1288   782  5770  2672  2759  1581    12
1   430     8    46  2416
  2759     4     1  4698   315   922  1949    50  3988  3699     4
2043
     1  2027  1127    57     9   737   895   183    12     1    23
1648
     5   220  3971   267  1041   200   353   130   136  1396    46
1066
  3322    68   573     4    45   733  1183   456   848   362   982
6768
    30  7900     1   101   976   183    25     3   120   844    17
29
    83    61   200   218     1    17   219    44    21     1   131
2671
   205  1177    46  1059    35  1015    17   844    17   337    17
25
     3    52   227    92    57   303     1    46  1059    35  4705
793
   764    46  1059    76  1083  4948    17  1370  5195     1   194
```

```
265
 13081   326    50  1498  1462    38    31    46    46  2741   312
29
    51    47     1   761   118  5770  2672  2759    96    46  1059
35
     1    46  2759    50   614    10   130    69   186  2416   315
12
     1   300  1394   315  1138   162   187   496    17   128    38
31
  6387  1494   105  2454     1   205     0     0     0     0     0
0
     0     0     0     0     0     0     0     0     0     0     0
0
     0     0     0     0     0     0     0     0     0     0     0
0
     0     0     0     0     0     0     0     0     0     0     0
0
     0     0     0     0     0     0     0     0     0     0     0
0
     0     0     0     0     0     0     0     0     0     0     0
0
     0     0     0     0     0     0     0     0     0     0     0
0
     0     0     0     0     0     0     0     0     0     0     0
0
     0     0     0     0     0     0     0     0     0     0     0
0
     0     0     0     0     0     0     0     0     0     0     0
0
     0     0     0     0     0     0     0     0     0     0     0
0]
```

Using Glove Embedding for essays

In [0]:

```
def get_embedding_matrix(tokenizer,vocab_size):
  '''
  Takes input a tokenizer trained on the training set and vocabulary size

  Returns glove vector encoding for each word in the vocabulary (300 dim)
  as embedding_matrix.
  '''

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

  embedding_matrix = np.zeros((vocab_size, 300))
  cnt=0
  for word, i in tokenizer.word_index.items():
    if word in glove_words:
      embedding_matrix[i] = model[word]
  return embedding_matrix
```

In [110]:

```
embedding_matrix_train = get_embedding_matrix(t,vocab_size)
print(embedding_matrix_train.shape)
```

```
(47336, 300)
```

Make Data Model Ready: encoding numerical, categorical features

Encoding Categorical Features

In [0]:

```
from sklearn.preprocessing import LabelEncoder
import numpy as np
#credits: https://stackoverflow.com/questions/21057621/sklearn-labelencoder-with-ne
class LabelEncoderExt(object):
    def __init__(self):
        """
        It differs from LabelEncoder by handling new classes and providing a value
        Unknown will be added in fit and transform will take care of new item. It g
        """
        self.label_encoder = LabelEncoder()
        # self.classes_ = self.label_encoder.classes_

    def fit(self, data_list):
        """
        This will fit the encoder for all the unique values and introduce unknown v
        :param data_list: A list of string
        :return: self
        """
        self.label_encoder = self.label_encoder.fit(list(data_list) + ['Unknown'])
        self.classes_ = self.label_encoder.classes_

        return self

    def transform(self, data_list):
        """
        This will transform the data_list to id list where the new values get assig
        :param data_list:
        :return:
        """
        new_data_list = list(data_list)
        for unique_item in np.unique(data_list):
            if unique_item not in self.label_encoder.classes_:
                new_data_list = ['Unknown' if x==unique_item else x for x in new_da

        return self.label_encoder.transform(new_data_list)
```

Integer Encoding: clean_categories

In [112]:

```
category_encoder = LabelEncoderExt()

category_encoder.fit(list(X_train['clean_categories']))
print(category_encoder.classes_) # you can see new class called Unknown
#total number of unique category classes
category_vocab_size = len(category_encoder.classes_)
print("Category size: ", category_vocab_size)

category_encoded_train =  category_encoder.transform(X_train['clean_categories'])
category_encoded_cv =  category_encoder.transform(X_cv['clean_categories'])
category_encoded_test =  category_encoder.transform(X_test['clean_categories'])
category_embd_size = min(50,category_vocab_size//2+1)

print(category_encoded_train)
print(category_encoded_cv)
print(category_encoded_test)
print(category_embd_size)
```

```
['Unknown' 'appliedlearning' 'appliedlearning health_sports'
 'appliedlearning history_civics' 'appliedlearning literacy_language'
 'appliedlearning math_science' 'appliedlearning music_arts'
 'appliedlearning specialneeds' 'appliedlearning warmth care_hunger'
 'health_sports' 'health_sports appliedlearning'
 'health_sports history_civics' 'health_sports literacy_language'
 'health_sports math_science' 'health_sports music_arts'
 'health_sports specialneeds' 'health_sports warmth care_hunger'
 'history_civics' 'history_civics appliedlearning'
 'history_civics health_sports' 'history_civics literacy_language'
 'history_civics math_science' 'history_civics music_arts'
 'history_civics specialneeds' 'history_civics warmth care_hunger'
 'literacy_language' 'literacy_language appliedlearning'
 'literacy_language health_sports' 'literacy_language history_civics'
 'literacy_language math_science' 'literacy_language music_arts'
 'literacy_language specialneeds' 'literacy_language warmth care_hunge
r'
 'math_science' 'math_science appliedlearning'
 'math_science health_sports' 'math_science history_civics'
 'math_science literacy_language' 'math_science music_arts'
 'math_science specialneeds' 'math_science warmth care_hunger'
 'music_arts' 'music_arts appliedlearning' 'music_arts health_sports'
 'music_arts history_civics' 'music_arts specialneeds'
 'music_arts warmth care_hunger' 'specialneeds'
 'specialneeds health_sports' 'specialneeds music_arts'
 'specialneeds warmth care_hunger' 'warmth care_hunger']
Category size:  52
[47 38  9 ... 29 34 39]
[33 41  9 ... 25 33  9]
[25 41 38 ... 38 31 25]
27
```

Integer Encoding: clean_subcategories

In [113]:

```
subcategory_encoder = LabelEncoderExt()

subcategory_encoder.fit(list(X_train['clean_subcategories']))
print(subcategory_encoder.classes_) # you can see new class called Unknown
#total number of unique category classes
subcategory_vocab_size = len(subcategory_encoder.classes_)
print("subcategory size: ", subcategory_vocab_size)

subcategory_encoded_train =  subcategory_encoder.transform(X_train['clean_subcatego
subcategory_encoded_cv =  subcategory_encoder.transform(X_cv['clean_subcategories']
subcategory_encoded_test =  subcategory_encoder.transform(X_test['clean_subcategori
subcategory_embd_size = min(50,subcategory_vocab_size//2+1)


print(subcategory_encoded_train)
print(subcategory_encoded_test)
print(subcategory_encoded_cv)
print(subcategory_embd_size)
```

```
['Unknown' 'appliedsciences' 'appliedsciences charactereducation'
 'appliedsciences civics_government' 'appliedsciences college_career
prep'
 'appliedsciences communityservice' 'appliedsciences earlydevelopmen
t'
 'appliedsciences economics' 'appliedsciences environmentalscience'
 'appliedsciences esl' 'appliedsciences extracurricular'
 'appliedsciences financialliteracy' 'appliedsciences foreignlanguag
es'
 'appliedsciences gym_fitness' 'appliedsciences health_lifescience'
 'appliedsciences health_wellness' 'appliedsciences history_geograph
y'
 'appliedsciences literacy' 'appliedsciences literature_writing'
 'appliedsciences mathematics' 'appliedsciences music'
 'appliedsciences nutritioneducation' 'appliedsciences other'
 'appliedsciences parentinvolvement' 'appliedsciences performingart
s'
 'appliedsciences socialsciences' 'appliedsciences specialneeds'
 'appliedsciences teamsports' 'appliedsciences visualarts'
```

Integer Encoding: school_state

In [114]:

```
school_state_encoder = LabelEncoderExt()

school_state_encoder.fit(list(X_train['school_state']))
print(school_state_encoder.classes_) # you can see new class called Unknown
#total number of unique school_state classes
school_state_vocab_size = len(school_state_encoder.classes_)
print("school_state_vocab_size: ", school_state_vocab_size)

school_state_encoded_train =  school_state_encoder.transform(X_train['school_state'
school_state_encoded_cv =  school_state_encoder.transform(X_cv['school_state'])
school_state_encoded_test =  school_state_encoder.transform(X_test['school_state'])
school_state_embd_size = min(50,school_state_vocab_size//2+1)
print(school_state_encoded_train)
print(school_state_encoded_cv)
print(school_state_encoded_test)
print(school_state_embd_size)
```

```
['Unknown' 'ak' 'al' 'ar' 'az' 'ca' 'co' 'ct' 'dc' 'de' 'fl' 'ga' 'hi'
 'ia' 'id' 'il' 'in' 'ks' 'ky' 'la' 'ma' 'md' 'me' 'mi' 'mn' 'mo' 'ms'
 'mt' 'nc' 'nd' 'ne' 'nh' 'nj' 'nm' 'nv' 'ny' 'oh' 'ok' 'or' 'pa' 'ri'
 'sc' 'sd' 'tn' 'tx' 'ut' 'va' 'vt' 'wa' 'wi' 'wv' 'wy']
school_state_vocab_size:  52
[ 2  4  5 ... 29  5 11]
[44 18  7 ... 16 34 11]
[ 5  5  5 ... 10 35 10]
27
```

Integer Encoding: teacher_prefix

In [115]:

```
teacher_prefix_encoder = LabelEncoderExt()

teacher_prefix_encoder.fit(list(X_train['teacher_prefix']))
print(teacher_prefix_encoder.classes_) # you can see new class called Unknown
#total number of unique techer_prefix classes
teacher_prefix_vocab_size = len(teacher_prefix_encoder.classes_)
print("techer_prefix_vocab_size: ", teacher_prefix_vocab_size)

teacher_prefix_encoded_train =  teacher_prefix_encoder.transform(X_train['teacher_p
teacher_prefix_encoded_cv =  teacher_prefix_encoder.transform(X_cv['teacher_prefix'
teacher_prefix_encoded_test =  teacher_prefix_encoder.transform(X_test['teacher_pre

teacher_prefix_embd_size = min(50,teacher_prefix_vocab_size//2+1)

print(teacher_prefix_encoded_train)
print(teacher_prefix_encoded_cv)
print(teacher_prefix_encoded_test)
print(teacher_prefix_embd_size)
```

```
['Unknown' 'dr' 'mr' 'mrs' 'ms' 'teacher']
techer_prefix_vocab_size:  6
[3 3 3 ... 3 4 3]
[2 2 2 ... 3 2 3]
[4 4 4 ... 4 3 3]
4
```

Integer Encoding: project_grade_category

In [116]:

```
project_grade_cat_encoder = LabelEncoderExt()

project_grade_cat_encoder.fit(list(X_train['project_grade_category']))
print(project_grade_cat_encoder.classes_) # you can see new class called Unknown
project_grade_cat_size = len(project_grade_cat_encoder.classes_)
print("project_grade_cat_size: ", project_grade_cat_size)

project_grade_cat_encoded_train =  project_grade_cat_encoder.transform(X_train['pro
project_grade_cat_encoded_cv =  project_grade_cat_encoder.transform(X_cv['project_g
project_grade_cat_encoded_test =  project_grade_cat_encoder.transform(X_test['proje
project_grade_cat_embd_size = min(50,project_grade_cat_size//2+1)

print(project_grade_cat_encoded_train)
print(project_grade_cat_encoded_train)
print(project_grade_cat_encoded_test)
print(project_grade_cat_embd_size)
```

```
['Unknown' 'grades_3_5' 'grades_6_8' 'grades_9_12' 'grades_prek_2']
project_grade_cat_size:  5
[1 1 1 ... 1 4 4]
[1 1 1 ... 1 4 4]
[4 4 4 ... 4 2 4]
3
```

##Encoding Numerical features

Normalizing Price

In [117]:

```
price_vectorizer = preprocessing.Normalizer().fit(X_train['price'].values.reshape(1
X_train_price_normalized = price_vectorizer.transform(X_train['price'].values.resha
X_cv_price_normalized = price_vectorizer.transform(X_cv['price'].values.reshape(1,-
X_test_price_normalized = price_vectorizer.transform(X_test['price'].values.reshape


X_train_price_normalized = X_train_price_normalized.reshape(-1,1)
X_cv_price_normalized = X_cv_price_normalized.reshape(-1,1)
X_test_price_normalized = X_test_price_normalized.reshape(-1,1)

print(X_train_price_normalized.shape)
print(X_cv_price_normalized.shape)
print(X_test_price_normalized.shape)
```

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

Normalize teacher_number_of_previously_posted_projects

In [0]:

```
project_vectorizer = preprocessing.Normalizer().fit(X_train['teacher_number_of_prev
X_train_normal_previous_project = project_vectorizer.transform(X_train['teacher_num
X_cv_normal_previous_project = project_vectorizer.transform(X_cv['teacher_number_of
X_test_normal_previous_project = project_vectorizer.transform(X_test['teacher_numbe
```

In [119]:

```
X_train_normal_previous_project = X_train_normal_previous_project.reshape(-1,1)
X_cv_normal_previous_project = X_cv_normal_previous_project.reshape(-1,1)
X_test_normal_previous_project = X_test_normal_previous_project.reshape(-1,1)
print(X_train_normal_previous_project.shape)
print(X_cv_normal_previous_project.shape)
print(X_test_normal_previous_project.shape)
```

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

In [120]:

```
remaining_train = np.hstack((X_train_price_normalized,X_train_normal_previous_proje
remaining_cv = np.hstack((X_cv_price_normalized,X_cv_normal_previous_project))
remaining_test = np.hstack((X_test_price_normalized,X_test_normal_previous_project)
print(remaining_train.shape,Y_train.shape)
print(remaining_cv.shape,Y_cv.shape)
print(remaining_test.shape, Y_test.shape)
```

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

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.

Creating Model 1

In [0]:

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

#First Input : Essays
essay_input = Input(shape=(300,), name='essay_input')
embedding = Embedding(input_dim=vocab_size,output_dim=300,weights=[embedding_matrix
lstm_output = LSTM(units=150,dropout=0.5,return_sequences=True)(embedding)
flatten_1 = Flatten()(lstm_output)

#Second Input: school state

state_input = Input(shape=(1,),name='school_state')
state_embedding = Embedding(input_dim=school_state_vocab_size,output_dim=school_sta
flatten_2 = Flatten()(state_embedding)

#Third Input: project grade category
project_grade_cat_input = Input(shape=(1,),name='project_grade_category')
proj_gr_cat_embd = Embedding(input_dim=project_grade_cat_size,output_dim=project_gr
flatten_3 = Flatten()(proj_gr_cat_embd)

#Fourth Input: Project Category
project_cat_input = Input(shape=(1,), name='project_category')
proj_cat_embd = Embedding(input_dim=project_grade_cat_size,output_dim=project_grade
flatten_4 = Flatten()(proj_cat_embd)

#Fifth Input: Teacher Prefix
teacher_pre_input = Input(shape=(1,),name='teacher_prefix')
teacher_pr_embd = Embedding(input_dim=teacher_prefix_vocab_size,output_dim=teacher_
flatten_5 = Flatten()(teacher_pr_embd)

#Sixth Input: Project Subucategories
subcat_input = Input(shape=(1,),name='project_subcategory')
subcat_embd = Embedding(input_dim=subcategory_vocab_size,output_dim=subcategory_voc
flatten_6 = Flatten()(subcat_embd)

#Remaining Input: Price, Number of previously posted project
remaining_input = Input(shape=(2,),name='remaining_input')
dense_1 = Dense(5, activation='relu',kernel_initializer="he_normal",kernel_regulari

#concatenating all inputs together
cacatenated_inputs = concatenate([flatten_1,flatten_2,flatten_3,flatten_4,flatten_5

x = Dense(256, activation='relu',kernel_initializer="he_normal",kernel_regularizer=
x = Dropout(0.5)(x)
x = Dense(128, activation='relu',kernel_initializer="he_normal",kernel_regularizer=
x = Dropout(0.6)(x)
x = BatchNormalization()(x)

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

model_1 = Model(inputs=[essay_input, state_input, project_grade_cat_input, project_
print(model_1.summary())
```

```
WARNING:tensorflow:Large dropout rate: 0.6 (>0.5). In TensorFlow 2.x,
dropout() uses dropout rate instead of keep_prob. Please ensure that t
his is intended.
Model: "model_3"

__________________________________________________________________
```

```
__________________________
Layer (type)                 Output Shape         Param #     Conne
cted to
==================================================================
==========================
essay_input (InputLayer)     (None, 300)          0
__________________________________________________________________
__________________________
embedding_13 (Embedding)     (None, 300, 300)     14203500    essay
_input[0][0]
__________________________________________________________________
__________________________
school_state (InputLayer)    (None, 1)            0
__________________________________________________________________
__________________________
project_grade_category (InputLa (None, 1)            0
__________________________________________________________________
__________________________
project_category (InputLayer)   (None, 1)            0
__________________________________________________________________
__________________________
teacher_prefix (InputLayer)  (None, 1)            0
__________________________________________________________________
__________________________
project_subcategory (InputLayer (None, 1)            0
__________________________________________________________________
__________________________
lstm_3 (LSTM)                (None, 300, 150)     270600      embed
ding_13[0][0]
__________________________________________________________________
__________________________
embedding_14 (Embedding)     (None, 1, 27)        1404        schoo
l_state[0][0]
__________________________________________________________________
__________________________
embedding_15 (Embedding)     (None, 1, 3)         15          proje
ct_grade_category[0][0]
__________________________________________________________________
__________________________
embedding_16 (Embedding)     (None, 1, 3)         15          proje
ct_category[0][0]
__________________________________________________________________
__________________________
embedding_17 (Embedding)     (None, 1, 4)         24          teach
er_prefix[0][0]
__________________________________________________________________
__________________________
embedding_18 (Embedding)     (None, 1, 385)       148225      proje
ct_subcategory[0][0]
__________________________________________________________________
__________________________
remaining_input (InputLayer)    (None, 2)            0
__________________________________________________________________
__________________________
flatten_13 (Flatten)         (None, 45000)        0           lstm_
3[0][0]
__________________________________________________________________
__________________________
flatten_14 (Flatten)         (None, 27)           0           embed
ding_14[0][0]
__________________________________________________________________
```

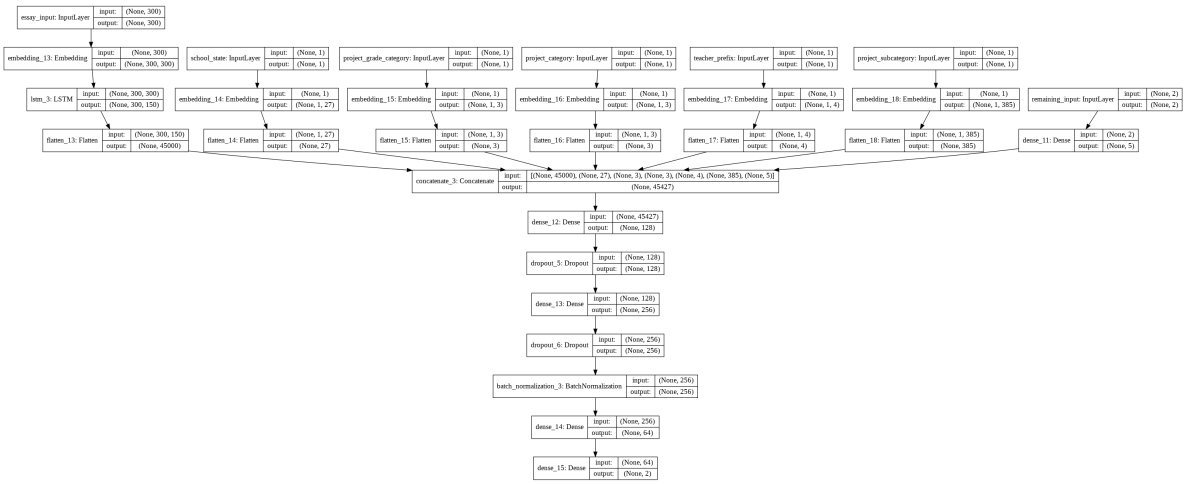
```
__________________________
flatten_15 (Flatten)            (None, 3)            0           embed
ding_15[0][0]

__________________________________________________________________________
__________________________
flatten_16 (Flatten)            (None, 3)            0           embed
ding_16[0][0]

__________________________________________________________________________
__________________________
flatten_17 (Flatten)            (None, 4)            0           embed
ding_17[0][0]

__________________________________________________________________________
__________________________
flatten_18 (Flatten)            (None, 385)          0           embed
ding_18[0][0]

__________________________________________________________________________
__________________________
dense_11 (Dense)                (None, 5)            15          remai
ning_input[0][0]

__________________________________________________________________________
__________________________
concatenate_3 (Concatenate)     (None, 45427)        0           flatt
en_13[0][0]
                                                                 flatt
en_14[0][0]
                                                                 flatt
en_15[0][0]
                                                                 flatt
en_16[0][0]
                                                                 flatt
en_17[0][0]
                                                                 flatt
en_18[0][0]
                                                                 dense
_11[0][0]

__________________________________________________________________________
__________________________
dense_12 (Dense)                (None, 128)          5814784     conca
tenate_3[0][0]

__________________________________________________________________________
__________________________
dropout_5 (Dropout)             (None, 128)          0           dense
_12[0][0]

__________________________________________________________________________
__________________________
dense_13 (Dense)                (None, 256)          33024       dropo
ut_5[0][0]

__________________________________________________________________________
__________________________
dropout_6 (Dropout)             (None, 256)          0           dense
_13[0][0]

__________________________________________________________________________
__________________________
batch_normalization_3 (BatchNor (None, 256)          1024        dropo
ut_6[0][0]

__________________________________________________________________________
__________________________
dense_14 (Dense)                (None, 64)           16448       batch
_normalization_3[0][0]

__________________________________________________________________________
__________________________
```

```
dense_15 (Dense)                (None, 2)            130         dense
_14[0][0]
==================================================================================
==============================
Total params: 20,489,208
Trainable params: 20,488,696
Non-trainable params: 512

__________________________________________________________________________________
____________________________
None
```

In [0]:

```
#https://machinelearningmastery.com/visualize-deep-learning-neural-network-model-ke
from keras.utils.vis_utils import plot_model
plot_model(model_1, to_file=working_dir+'model1.png', show_shapes=True, show_layer_
```

Out[81]:



In [0]:

```
# checkpoint
file_path=working_dir+"weights-improvement-{epoch:02d}-{val_auroc:.2f}.hdf5"
checkpoint_1 = ModelCheckpoint(filepath=file_path,
                               monitor="val_auroc",
                               mode="max",
                               save_best_only = True,
                               verbose=1)

earlystop_1 = EarlyStopping(monitor='val_loss', patience=2, verbose=1)

reduce_lr_1 = ReduceLROnPlateau(monitor='val_loss', factor=0.2, patience=1, min_lr=

tbc=TensorBoardColab()

callbacks_list = [checkpoint_1,earlystop_1,earlystop_1,TensorBoardColabCallback(tbc
```

```
Wait for 8 seconds...
TensorBoard link:
https://4f618caf.ngrok.io (https://4f618caf.ngrok.io)
```

In [0]:

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

In [0]:

```
train_1 = [padded_train_essay,
           school_state_encoded_train,
           project_grade_cat_encoded_train,
           category_encoded_train,
           teacher_prefix_encoded_train,
           subcategory_encoded_train,
           remaining_train]


cv1 = [padded_cv_essay,
           school_state_encoded_cv,
           project_grade_cat_encoded_cv,
           category_encoded_cv,
           teacher_prefix_encoded_cv,
           subcategory_encoded_cv,
           remaining_cv]

test_1 = [padded_test_essay,
           school_state_encoded_test,
           project_grade_cat_encoded_test,
           category_encoded_test,
           teacher_prefix_encoded_test,
           subcategory_encoded_test,
           remaining_test]
```

In [0]:

```
model_1.compile(optimizer='adam', loss='categorical_crossentropy', metrics=[auroc])
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/o
ptimizers.py:793: The name tf.train.Optimizer is deprecated. Please us
e tf.compat.v1.train.Optimizer instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/b
ackend/tensorflow_backend.py:3576: The name tf.log is deprecated. Plea
se use tf.math.log instead.

WARNING:tensorflow:From <ipython-input-31-5611ee7c481f>:8: py_func (fr
om tensorflow.python.ops.script_ops) is deprecated and will be removed
in a future version.
Instructions for updating:
tf.py_func is deprecated in TF V2. Instead, there are two
    options available in V2.
    - tf.py_function takes a python function which manipulates tf eage
r
    tensors instead of numpy arrays. It's easy to convert a tf eager t
ensor to
    an ndarray (just call tensor.numpy()) but having access to eager t
ensors
    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.p
y_func
    (it is not differentiable, and manipulates numpy arrays). It drops
the
    stateful argument making all functions stateful.
```

In [0]:

```
history_1 = model_1.fit(train_1, Y_train, validation_data=(cv1,Y_cv),batch_size=512
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tenso
rflow_core/python/ops/math_grad.py:1424: where (from tensorflow.pyth
on.ops.array_ops) is deprecated and will be removed in a future vers
ion.
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/kera
s/backend/tensorflow_backend.py:1033: The name tf.assign_add is depr
ecated. Please use tf.compat.v1.assign_add instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/kera
s/backend/tensorflow_backend.py:1020: The name tf.assign is deprecat
ed. Please use tf.compat.v1.assign instead.

Train on 69918 samples, validate on 17480 samples
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tenso
rboardcolab/core.py:49: The name tf.summary.FileWriter is deprecate
d. Please use tf.compat.v1.summary.FileWriter instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/kera
s/callbacks.py:1122: The name tf.summary.merge_all is deprecated. Pl
ease use tf.compat.v1.summary.merge_all instead.

Epoch 1/20
69918/69918 [==============================] - 73s 1ms/step - loss:
1.1789 - auroc: 0.5142 - val_loss: 0.9379 - val_auroc: 0.4245

Epoch 00001: val_auroc improved from -inf to 0.42447, saving model t
o /content/gdrive/My Drive/model-weights-lstm/weights-improvement-01
-0.42.hdf5
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tenso
rboardcolab/callbacks.py:51: The name tf.Summary is deprecated. Plea
se use tf.compat.v1.Summary instead.

Epoch 2/20
69918/69918 [==============================] - 72s 1ms/step - loss:
0.7811 - auroc: 0.5191 - val_loss: 0.7143 - val_auroc: 0.6072

Epoch 00002: val_auroc improved from 0.42447 to 0.60718, saving mode
l to /content/gdrive/My Drive/model-weights-lstm/weights-improvement
-02-0.61.hdf5
Epoch 3/20
69918/69918 [==============================] - 72s 1ms/step - loss:
0.6417 - auroc: 0.5088 - val_loss: 0.5913 - val_auroc: 0.5163

Epoch 00003: val_auroc did not improve from 0.60718
Epoch 4/20
69918/69918 [==============================] - 71s 1ms/step - loss:
0.5613 - auroc: 0.5830 - val_loss: 0.5884 - val_auroc: 0.6963

Epoch 00004: val_auroc improved from 0.60718 to 0.69633, saving mode
l to /content/gdrive/My Drive/model-weights-lstm/weights-improvement
-04-0.70.hdf5
Epoch 5/20
69918/69918 [==============================] - 71s 1ms/step - loss:
0.4960 - auroc: 0.7093 - val_loss: 0.5497 - val_auroc: 0.7387
```

```
Epoch 00005: val_auroc improved from 0.69633 to 0.73872, saving mode
l to /content/gdrive/My Drive/model-weights-lstm/weights-improvement
-05-0.74.hdf5
Epoch 6/20
69918/69918 [==============================] - 72s 1ms/step - loss:
0.4482 - auroc: 0.7532 - val_loss: 0.4781 - val_auroc: 0.7411

Epoch 00006: val_auroc improved from 0.73872 to 0.74109, saving mode
l to /content/gdrive/My Drive/model-weights-lstm/weights-improvement
-06-0.74.hdf5
Epoch 7/20
69918/69918 [==============================] - 71s 1ms/step - loss:
0.4188 - auroc: 0.7717 - val_loss: 0.4305 - val_auroc: 0.7433

Epoch 00007: val_auroc improved from 0.74109 to 0.74329, saving mode
l to /content/gdrive/My Drive/model-weights-lstm/weights-improvement
-07-0.74.hdf5
Epoch 8/20
69918/69918 [==============================] - 71s 1ms/step - loss:
0.3936 - auroc: 0.7926 - val_loss: 0.4562 - val_auroc: 0.7465

Epoch 00008: val_auroc improved from 0.74329 to 0.74653, saving mode
l to /content/gdrive/My Drive/model-weights-lstm/weights-improvement
-08-0.75.hdf5
Epoch 00008: early stopping
Epoch 00008: early stopping
```

In [0]:

```
#https://stackoverflow.com/posts/54978213/revisions
custom_objects = {"auroc":auroc}
from keras.models import load_model
best_model_1 = load_model('/content/gdrive/My Drive/model-weights-lstm/weights-impr
```

```
WARNING:tensorflow:Large dropout rate: 0.6 (>0.5). In TensorFlow 2.x,
dropout() uses dropout rate instead of keep_prob. Please ensure that t
his is intended.
```

In [0]:

```
result = best_model_1.evaluate(x=test_1, y=Y_test, batch_size=512)
```

```
21850/21850 [==============================] - 8s 365us/step
```

In [0]:

```
print("{} of test data {}". format(best_model_1.metrics_names[0],result[0]))
print("{} of test data {}". format(best_model_1.metrics_names[1],result[1]))
```

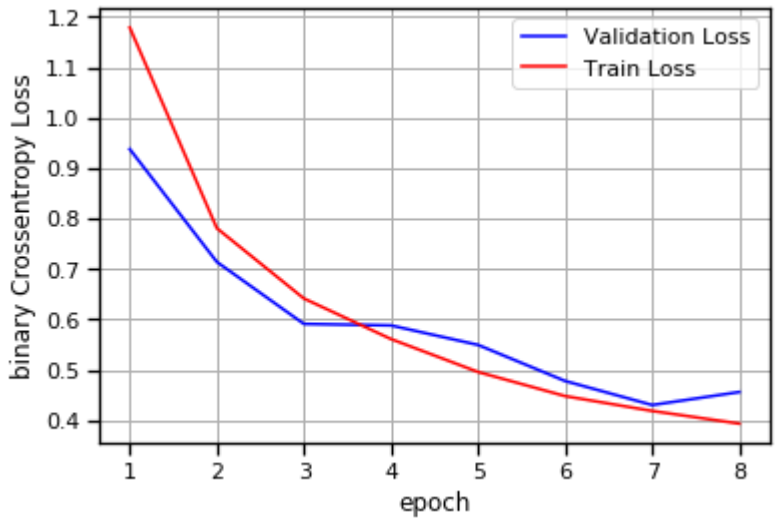
```
loss of test data 0.45637781578288744
auroc of test data 0.7424118391000872
```

In [0]:

```
best_model_1.save(working_dir+"best_model_1.h5")
```

In [0]:

```
fig,ax = plt.subplots(1,1)
ax.set_xlabel('epoch') ; ax.set_ylabel('binary Crossentropy Loss')

# list of epoch numbers
x = list(range(1,8+1))

# print(history.history.keys())
# dict_keys(['val_loss', 'val_acc', 'loss', 'acc'])
# history = model_drop.fit(X_train, Y_train, batch_size=batch_size, epochs=nb_epoch

# we will get val_loss and val_acc only when you pass the paramter validation_data
# val_loss : validation loss
# val_acc : validation accuracy

# loss : training loss
# acc : train accuracy
# for each key in histrory.histrory we will have a list of length equal to number o


vy = history_1.history['val_loss']
ty = history_1.history['loss']
plt_dynamic(x, vy, ty, ax)
```

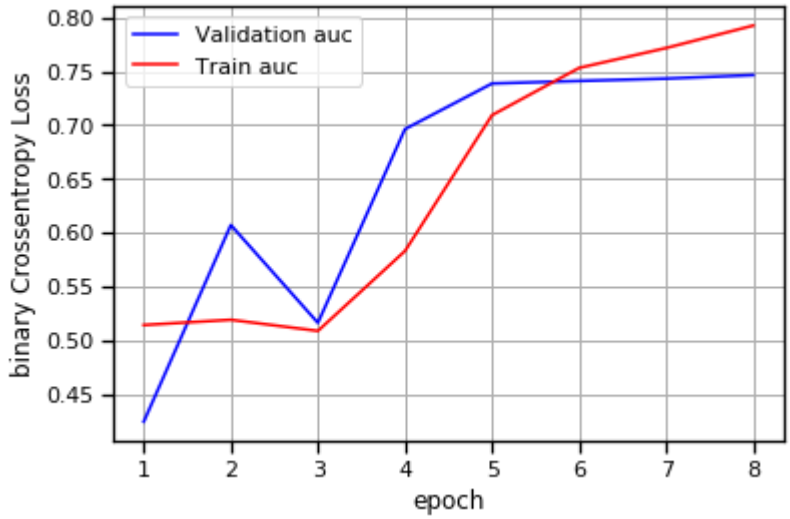


In [0]:

```
def plt_dynamic_auc(x, vy, ty, ax, colors=['b']):
    ax.plot(x, vy, 'b', label="Validation auc")
    ax.plot(x, ty, 'r', label="Train auc")
    plt.legend()
    plt.grid()
    fig.canvas.draw()
```

In [0]:

```
ig,ax = plt.subplots(1,1)
ax.set_xlabel('epoch') ; ax.set_ylabel('binary Crossentropy Loss')

# list of epoch numbers
x = list(range(1,8+1))

# print(history.history.keys())
# dict_keys(['val_loss', 'val_acc', 'loss', 'acc'])
# history = model_drop.fit(X_train, Y_train, batch_size=batch_size, epochs=nb_epoch

# we will get val_loss and val_acc only when you pass the paramter validation_data
# val_loss : validation loss
# val_acc : validation accuracy

# loss : training loss
# acc : train accuracy
# for each key in histrory.histrory we will have a list of length equal to number o


vy = history_1.history['val_auroc']
ty = history_1.history['auroc']
plt_dynamic_auc(x, vy, ty, ax)
```

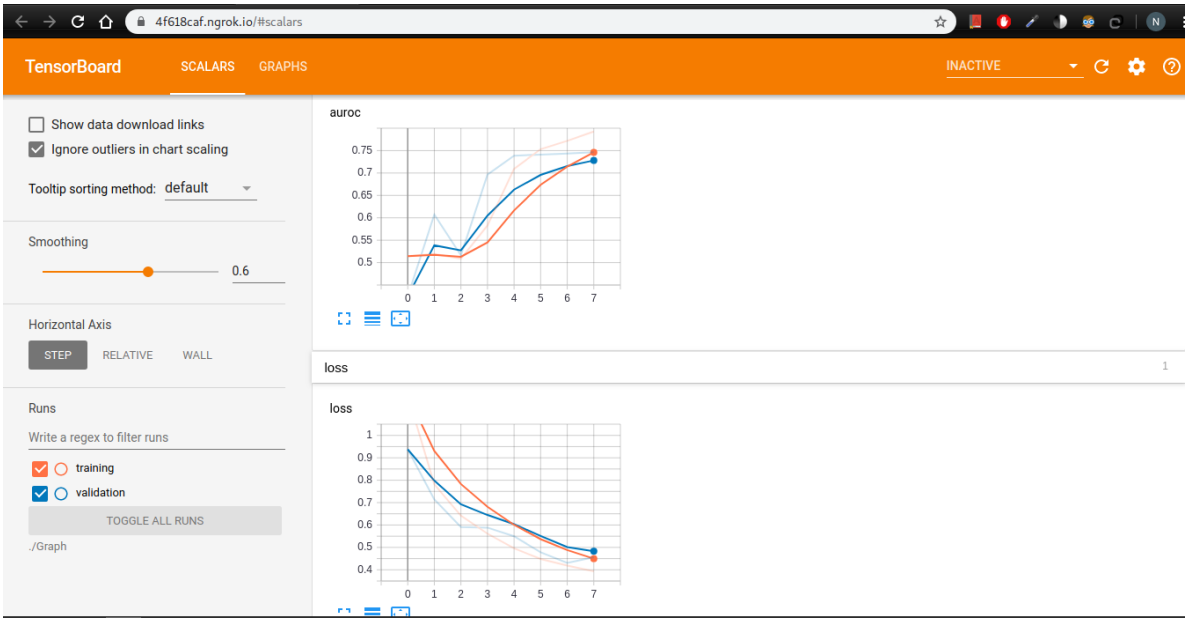


#Tensorboard Screenshot

In [0]:

```
Image(retina=True, filename=working_dir+'tb_1.png')
```

Out[43]:



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

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

#TF-idf vectorizer

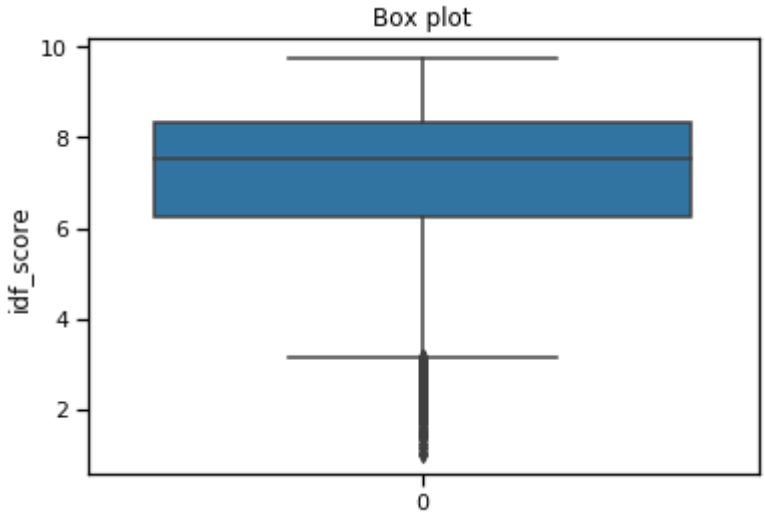
In [0]:

```
vectorizer = TfidfVectorizer(min_df=10, max_features=10000)
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
(69918, 10000) (69918, 2)
```

In [0]:

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



In [0]:

```
# getting all words
feature_names = np.asarray(vectorizer.get_feature_names())

index = []
for i in range(0,len(idf_score)):
    if idf_score[i] >= 4 and idf_score[i] <=10:
        index.append(i)

important_words = []
for i in index:
    important_words.append(feature_names[i])

print('Total words = ', len(feature_names))
print('Important words = ',len(important_words))
```

```
Total words =  10000
Important words =  9549
```

In [0]:

```
# train_data
x_train_essay_new = []
for sentence in tqdm_notebook(X_train['essay']):
    sen = []
    for word in sentence.split():
        if word in important_words:
            sen.append(word)
    x_train_essay_new.append(' '.join(sen))
```

HBox(children=(IntProgress(value=0, max=69918), HTML(value='')))

In [0]:

```
# cv_data
x_cv_essay_new = []
for sentence in tqdm_notebook(X_cv['essay']):
    sen = []
    for word in sentence.split():
        if word in important_words:
            sen.append(word)
    x_cv_essay_new.append(' '.join(sen))

#test_data
x_test_essay_new = []
for sentence in tqdm_notebook(X_test['essay']):
    sen = []
    for word in sentence.split():
        if word in important_words:
            sen.append(word)
    x_test_essay_new.append(' '.join(sen))
```

HBox(children=(IntProgress(value=0, max=17480), HTML(value='')))

HBox(children=(IntProgress(value=0, max=21850), HTML(value='')))

In [0]:

```
import pickle

with open(working_dir+'train-essay-imp.pkl', 'wb') as f:
  pickle.dump(x_train_essay_new, f)

with open(working_dir+'cv-essay-imp.pkl', 'wb') as f:
  pickle.dump(x_cv_essay_new, f)

with open(working_dir+'test-essay-imp.pkl', 'wb') as f:
  pickle.dump(x_test_essay_new, f)
```

In [0]:

```
print(len(x_train_essay_new))
print(len(x_cv_essay_new))
print(len(x_test_essay_new))
```

```
69918
17480
21850
```

In [0]:

```
text_essay = Tokenizer()
text_essay.fit_on_texts(x_train_essay_new)
vocab_size = len(text_essay.word_index) + 1
print('Total unique words in the x_train_essay_new',vocab_size)
encoded_train_new = text_essay.texts_to_sequences(x_train_essay_new)
encoded_cv_new = text_essay.texts_to_sequences(x_cv_essay_new)
encoded_test_new = text_essay.texts_to_sequences(x_test_essay_new)
```

```
Total unique words in the x_train_essay_new 9550
```

In [0]:

```
max_length = 300
padded_train_essay_new = pad_sequences(encoded_train_new, maxlen=max_length, paddin
padded_cv_essay_new = pad_sequences(encoded_cv_new, maxlen=max_length, padding='pos
padded_test_essay_new = pad_sequences(encoded_test_new, maxlen=max_length, padding=
print("length of padded_train_new data",len(padded_train_essay_new))
print("length of padded_cv_new data",len(padded_cv_essay_new))
print("length of padded_test_new data",len(padded_test_essay_new))
```

```
length of padded_train_new data 69918
length of padded_cv_new data 17480
length of padded_test_new data 21850
```

Using Glove embedding for essays

In [0]:

```
def get_embedding_matrix(tokenizer,vocab_size):
  '''
  Takes input a tokenizer trained on the training set and vocabulary size

  Returns glove vector encoding for each word in the vocabulary (300 dim)
  as embedding_matrix.
  '''

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

  embedding_matrix = np.zeros((vocab_size, 300))
  cnt=0
  for word, i in tokenizer.word_index.items():
    if word in glove_words:
      embedding_matrix[i] = model[word]
  return embedding_matrix
```

In [0]:

```
embedding_matrix_train_2 = get_embedding_matrix(text_essay,vocab_size)
print(embedding_matrix_train_2.shape)
```

```
(9550, 300)
```

In [0]:

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

#First Input : Essays
essay_input = Input(shape=(300,), name='essay_input')
embedding = Embedding(input_dim=vocab_size,output_dim=300,weights=[embedding_matrix
lstm_output = LSTM(units=150,dropout=0.5,return_sequences=True)(embedding)
flatten_1 = Flatten()(lstm_output)

#Second Input: school state

state_input = Input(shape=(1,),name='school_state')
state_embedding = Embedding(input_dim=school_state_vocab_size,output_dim=school_sta
flatten_2 = Flatten()(state_embedding)

#Third Input: project grade category
project_grade_cat_input = Input(shape=(1,),name='project_grade_category')
proj_gr_cat_embd = Embedding(input_dim=project_grade_cat_size,output_dim=project_gr
flatten_3 = Flatten()(proj_gr_cat_embd)

#Fourth Input: Project Category
project_cat_input = Input(shape=(1,), name='project_category')
proj_cat_embd = Embedding(input_dim=project_grade_cat_size,output_dim=project_grade
flatten_4 = Flatten()(proj_cat_embd)

#Fifth Input: Teacher Prefix
teacher_pre_input = Input(shape=(1,),name='teacher_prefix')
teacher_pr_embd = Embedding(input_dim=teacher_prefix_vocab_size,output_dim=teacher_
flatten_5 = Flatten()(teacher_pr_embd)

#Sixth Input: Project Subucategories
subcat_input = Input(shape=(1,),name='project_subcategory')
subcat_embd = Embedding(input_dim=subcategory_vocab_size,output_dim=subcategory_voc
flatten_6 = Flatten()(subcat_embd)

#Remaining Input: Price, Number of previously posted project
remaining_input = Input(shape=(2,),name='remaining_input')
dense_1 = Dense(1, activation='relu',kernel_initializer="he_normal",kernel_regulari

#concatenating all inputs together
cacatenated_inputs = concatenate([flatten_1,flatten_2,flatten_3,flatten_4,flatten_5
# x = Dense(256,kernel_initializer="glorot_normal",kernel_regularizer=l2(0.001))(x)
# x = LeakyReLU(alpha=0.3)(x)
# x = Dropout(0.6)(x)
# # x = BatchNormalization()(x)

# x = Dense(128,kernel_initializer="glorot_normal",kernel_regularizer=l2(0.001))(x)
# x = LeakyReLU(alpha=0.3)(x)
# x = Dropout(0.5)(x)
# # x = BatchNormalization()(x)
# x = Dense(64,kernel_initializer="glorot_normal",kernel_regularizer=l2(0.001))(x)
# x = LeakyReLU(alpha=0.3)(x)
# x = Dropout(0.5)(x)
# x = Dense(32,kernel_initializer="glorot_normal",kernel_regularizer=l2(0.001))(x)
# x = LeakyReLU(alpha=0.3)(x)
# x = Dropout(0.5)(x)
# x = Dense(16, kernel_initializer="glorot_normal",kernel_regularizer=l2(0.001))(x)
# x = LeakyReLU(alpha=0.3)(x)
```

```
x = Dense(256, activation='relu',kernel_initializer="he_normal",kernel_regularizer=
x = Dropout(.5)(x)
x = Dense(128, activation='relu',kernel_initializer="he_normal",kernel_regularizer=
x = Dropout(.5)(x)
x = BatchNormalization()(x)

x = Dense(64, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l


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

model_2 = Model(inputs=[essay_input, state_input, project_grade_cat_input, project_
print(model_2.summary())
```

```
Model: "model_2"
__________________________________________________________________________
_____________________________
Layer (type)                    Output Shape         Param #     Con
nected to
==========================================================================
==============================
essay_input (InputLayer)        (None, 300)          0
__________________________________________________________________________
_____________________________
embedding_7 (Embedding)         (None, 300, 300)     2865000     ess
ay_input[0][0]
__________________________________________________________________________
_____________________________
school_state (InputLayer)       (None, 1)            0
__________________________________________________________________________
_____________________________
project_grade_category (InputLa (None, 1)            0
__________________________________________________________________________
_____________________________
project_category (InputLayer)   (None, 1)            0
__________________________________________________________________________
_____________________________
teacher_prefix (InputLayer)     (None, 1)            0
__________________________________________________________________________
_____________________________
project_subcategory (InputLayer (None, 1)            0
__________________________________________________________________________
_____________________________
lstm_2 (LSTM)                   (None, 300, 150)     270600      emb
edding_7[0][0]
__________________________________________________________________________
_____________________________
embedding_8 (Embedding)         (None, 1, 27)        1404        sch
ool_state[0][0]
__________________________________________________________________________
_____________________________
embedding_9 (Embedding)         (None, 1, 3)         15          pro
ject_grade_category[0][0]
__________________________________________________________________________
_____________________________
embedding_10 (Embedding)        (None, 1, 3)         15          pro
ject_category[0][0]
__________________________________________________________________________
_____________________________
```

```
embedding_11 (Embedding)        (None, 1, 4)          24          tea
cher_prefix[0][0]
__________________________________________________________________
_____________________________
embedding_12 (Embedding)        (None, 1, 388)        150544      pro
ject_subcategory[0][0]
__________________________________________________________________
_____________________________
remaining_input (InputLayer)    (None, 2)             0
__________________________________________________________________
_____________________________
flatten_7 (Flatten)             (None, 45000)         0           lst
m_2[0][0]
__________________________________________________________________
_____________________________
flatten_8 (Flatten)             (None, 27)            0           emb
edding_8[0][0]
__________________________________________________________________
_____________________________
flatten_9 (Flatten)             (None, 3)             0           emb
edding_9[0][0]
__________________________________________________________________
_____________________________
flatten_10 (Flatten)            (None, 3)             0           emb
edding_10[0][0]
__________________________________________________________________
_____________________________
flatten_11 (Flatten)            (None, 4)             0           emb
edding_11[0][0]
__________________________________________________________________
_____________________________
flatten_12 (Flatten)            (None, 388)           0           emb
edding_12[0][0]
__________________________________________________________________
_____________________________
dense_6 (Dense)                 (None, 1)             3           rem
aining_input[0][0]
__________________________________________________________________
_____________________________
concatenate_2 (Concatenate)     (None, 45426)         0           fla
tten_7[0][0]
                                                                  fla
tten_8[0][0]
                                                                  fla
tten_9[0][0]
                                                                  fla
tten_10[0][0]
                                                                  fla
tten_11[0][0]
                                                                  fla
tten_12[0][0]
                                                                  den
se_6[0][0]
__________________________________________________________________
_____________________________
dense_7 (Dense)                 (None, 256)           11629312    con
catenate_2[0][0]
__________________________________________________________________
_____________________________
dropout_3 (Dropout)             (None, 256)           0           den
se_7[0][0]
```

```
__________________________________________________________________________
_______________________________
dense_8 (Dense)                 (None, 128)          32896       dro
pout_3[0][0]
__________________________________________________________________________
_______________________________
dropout_4 (Dropout)             (None, 128)          0           den
se_8[0][0]
__________________________________________________________________________
_______________________________
batch_normalization_2 (BatchNor (None, 128)          512         dro
pout_4[0][0]
__________________________________________________________________________
_______________________________
dense_9 (Dense)                 (None, 64)           8256        bat
ch_normalization_2[0][0]
__________________________________________________________________________
_______________________________
dense_10 (Dense)                (None, 2)            130         den
se_9[0][0]
==========================================================================
==============================
Total params: 14,958,711
Trainable params: 12,093,455
Non-trainable params: 2,865,256
__________________________________________________________________________
_______________________________
None
```

In [0]:

```
# checkpoint
file_path=working_dir+"weights-improvement-{epoch:02d}-{val_auroc:.2f}.hdf5"
checkpoint_2 = ModelCheckpoint(filepath=file_path,
                               monitor="val_auroc",
                               mode="max",
                               save_best_only = True,
                               verbose=1)

# earlystop_2 = EarlyStopping(monitor='val_loss', patience=2, verbose=1)

# reduce_lr_2 = ReduceLROnPlateau(monitor='val_loss', factor=0.2, patience=1, min_l
# earlystop_2 = EarlyStopping(monitor = 'val_auroc',
#                             mode="max",
#                             min_delta = 0,
#                             patience = 3,
#                             verbose = 1,)
# reduce_lr_2 = ReduceLROnPlateau(monitor = 'val_loss', factor = 0.2, patience = 2,

tbc_2=TensorBoardColab()
```

```
Wait for 8 seconds...
TensorBoard link:
https://6f9e244c.ngrok.io (https://6f9e244c.ngrok.io)
```

In [0]:

```
callbacks_list = [checkpoint_2, TensorBoardColabCallback(tbc_2)]

train_2 = [padded_train_essay_new,
           school_state_encoded_train,
           project_grade_cat_encoded_train,
           category_encoded_train,
           teacher_prefix_encoded_train,
           subcategory_encoded_train,
           remaining_train]


cv_2 = [padded_cv_essay_new,
           school_state_encoded_cv,
           project_grade_cat_encoded_cv,
           category_encoded_cv,
           teacher_prefix_encoded_cv,
           subcategory_encoded_cv,
           remaining_cv]

test_2 = [padded_test_essay_new,
           school_state_encoded_test,
           project_grade_cat_encoded_test,
           category_encoded_test,
           teacher_prefix_encoded_test,
           subcategory_encoded_test,
           remaining_test]
```

In [0]:

```
# model_2.compile(optimizer='adam', loss='categorical_crossentropy', metrics=[auroc
model_2.compile(loss='categorical_crossentropy', optimizer=optimizers.Adam(lr=0.000
history_2 = model_2.fit(train_2,Y_train,validation_data=(cv_2,Y_cv),epochs=50,batch
```

```
Train on 69918 samples, validate on 17480 samples
Epoch 1/50
69918/69918 [==============================] - 118s 2ms/step - loss:
0.9592 - auroc: 0.5416 - val_loss: 0.7789 - val_auroc: 0.5906

Epoch 00001: val_auroc improved from -inf to 0.59057, saving model t
o /content/gdrive/My Drive/model-weights-lstm/weights-improvement-01
-0.59.hdf5
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tenso
rboardcolab/callbacks.py:51: The name tf.Summary is deprecated. Plea
se use tf.compat.v1.Summary instead.

Epoch 2/50
69918/69918 [==============================] - 120s 2ms/step - loss:
0.7046 - auroc: 0.6163 - val_loss: 0.6525 - val_auroc: 0.6492

Epoch 00002: val_auroc improved from 0.59057 to 0.64923, saving mode
l to /content/gdrive/My Drive/model-weights-lstm/weights-improvement
-02-0.65.hdf5
Epoch 3/50
```

In [0]:

```
#https://stackoverflow.com/posts/54978213/revisions
custom_objects = {"auroc":auroc}
from keras.models import load_model
best_model_2 = load_model('/content/gdrive/My Drive/model-weights-lstm/weights-impr
```

In [0]:

```
result = best_model_2.evaluate(x=test_2, y=Y_test, batch_size=512)
print("{} of test data {}". format(best_model_2.metrics_names[0],result[0]))
print("{} of test data {}". format(best_model_2.metrics_names[1],result[1]))
```

```
21850/21850 [==============================] - 15s 673us/step
loss of test data 0.405921457484876
auroc of test data 0.7163328799352613
```

In [0]:

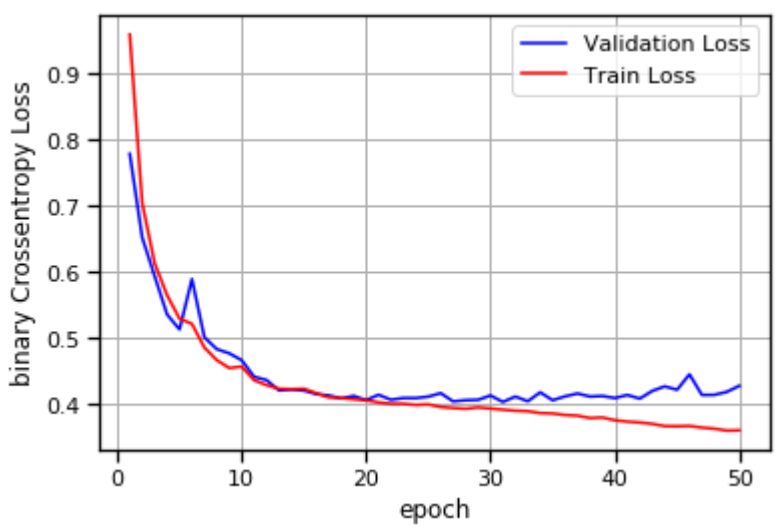
```
from sklearn.metrics import roc_auc_score
roc_auc_score(Y_test,best_model_2.predict(test_2,batch_size=512))
```

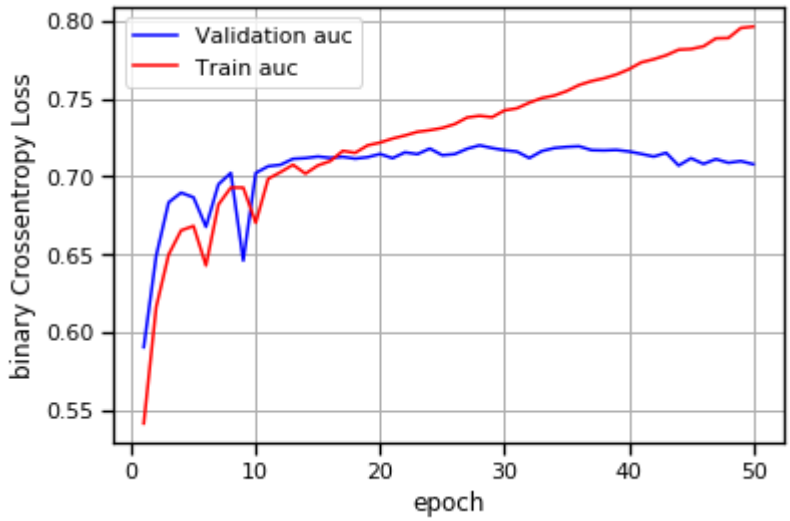
Out[52]:

```
0.7158541673812986
```

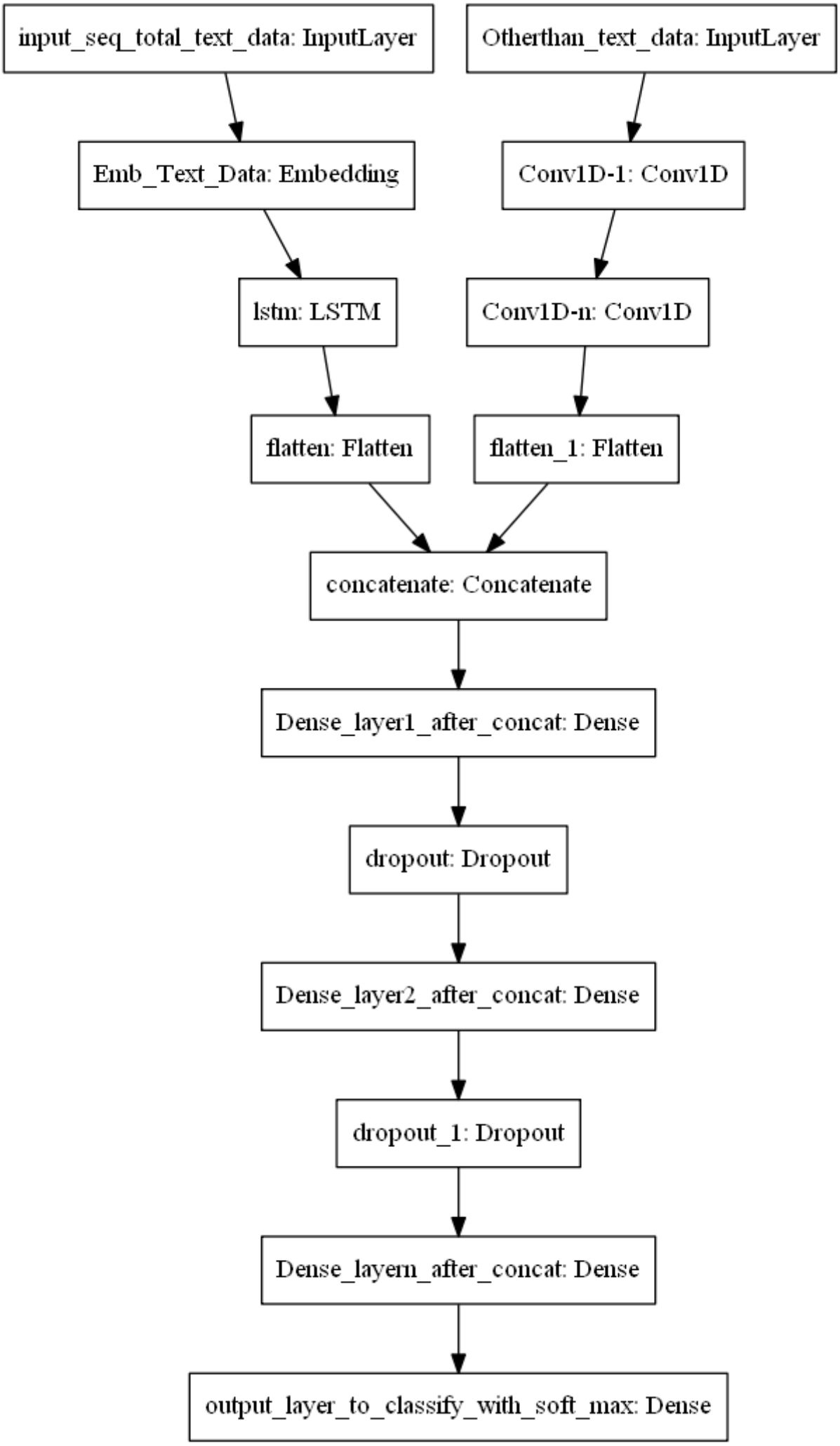
In [0]:

```
best_model_2.save(working_dir+"best_model_2.h5")

fig,ax = plt.subplots(1,1)
ax.set_xlabel('epoch') ; ax.set_ylabel('binary Crossentropy Loss')

# list of epoch numbers
x = list(range(1,50+1))

# print(history.history.keys())
# dict_keys(['val_loss', 'val_acc', 'loss', 'acc'])
# history = model_drop.fit(X_train, Y_train, batch_size=batch_size, epochs=nb_epoch

# we will get val_loss and val_acc only when you pass the paramter validation_data
# val_loss : validation loss
# val_acc : validation accuracy

# loss : training loss
# acc : train accuracy
# for each key in histrory.histrory we will have a list of length equal to number o


vy = history_2.history['val_loss']
ty = history_2.history['loss']
plt_dynamic(x, vy, ty, ax)


def plt_dynamic_auc(x, vy, ty, ax, colors=['b']):
    ax.plot(x, vy, 'b', label="Validation auc")
    ax.plot(x, ty, 'r', label="Train auc")
    plt.legend()
    plt.grid()
    fig.canvas.draw()


ig,ax = plt.subplots(1,1)
ax.set_xlabel('epoch') ; ax.set_ylabel('binary Crossentropy Loss')

# list of epoch numbers
x = list(range(1,50+1))

# print(history.history.keys())
# dict_keys(['val_loss', 'val_acc', 'loss', 'acc'])
# history = model_drop.fit(X_train, Y_train, batch_size=batch_size, epochs=nb_epoch

# we will get val_loss and val_acc only when you pass the paramter validation_data
# val_loss : validation loss
# val_acc : validation accuracy

# loss : training loss
# acc : train accuracy
# for each key in histrory.histrory we will have a list of length equal to number o


vy = history_2.history['val_auroc']
ty = history_2.history['auroc']
plt_dynamic_auc(x, vy, ty, ax)
```


Validation Loss
Train Loss
binary Crossentropy Loss
epoch
0.9
0.8
0.7
0.6
0.5
0.4
0
10
20
30
40
50


Validation auc
Train auc
binary Crossentropy Loss
epoch
0.80
0.75
0.70
0.65
0.60
0.55
0
10
20
30
40
50

Model-3


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

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

- **input_seq_total_text_data**:

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

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

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

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

- **Other_than_text_data**:

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

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

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

#Encoding Categorical Features

One hot encoding: clean_categories

In [0]:

```
my_counter = Counter()
for word in X_train['clean_categories'].values:
    my_counter.update(word.split())

cat_dict = dict(my_counter)
sorted_cat_dict = dict(sorted(cat_dict.items(), key=lambda kv: kv[1]))
```

In [123]:

```
# we use count vectorizer to convert the values into one
vectorizer_category = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowe
vectorizer_category.fit(X_train['clean_categories'].values)

X_train_category_ohe = vectorizer_category.transform(X_train['clean_categories'].va
X_cv_category_ohe = vectorizer_category.transform(X_cv['clean_categories'].values)
X_test_category_ohe = vectorizer_category.transform(X_test['clean_categories'].valu

print(vectorizer_category.get_feature_names())
print("Shape of X_train after one hot encodig ",X_train_category_ohe.shape)
print("Shape of X_cv after one hot encodig ",X_cv_category_ohe.shape)
print("Shape of X_test after one hot encodig ",X_test_category_ohe.shape)
print("Print some random encoded categories: ")
print(X_train_category_ohe[0].toarray())
print(X_cv_category_ohe[0].toarray())
print(X_test_category_ohe[15].toarray())
```

```
['warmth', 'care_hunger', 'history_civics', 'music_arts', 'appliedlear
ning', 'specialneeds', 'health_sports', 'math_science', 'literacy_lang
uage']
Shape of X_train after one hot encodig  (69918, 9)
Shape of X_cv after one hot encodig  (17480, 9)
Shape of X_test after one hot encodig  (21850, 9)
Print some random encoded categories:
[[0 0 0 0 0 1 0 0 0]]
[[0 0 0 0 0 0 0 1 0]]
[[0 0 0 0 0 0 1 0 0]]
```

One hot encoding: clean_subcategories

In [124]:

```
# count of all the words in corpus python: https://stackoverflow.com/a/22898595/408
my_counter = Counter()
for word in X_train['clean_subcategories'].values:
    my_counter.update(word.split())

sub_cat_dict = dict(my_counter)
sorted_sub_cat_dict = dict(sorted(sub_cat_dict.items(), key=lambda kv: kv[1]))

# we use count vectorizer to convert the values into one
vectorizer_subcategory = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()
vectorizer_subcategory.fit(X_train['clean_subcategories'].values)

X_train_subcategory_ohe = vectorizer_subcategory.transform(X_train['clean_subcatego
X_cv_subcategory_ohe = vectorizer_subcategory.transform(X_cv['clean_subcategories']
X_test_subcategory_ohe = vectorizer_subcategory.transform(X_test['clean_subcategori

print(vectorizer_subcategory.get_feature_names())
print("Shape of X_train subcategory after one hot encoding ",X_train_subcategory_oh
print("Shape of X_cv subcategory after one hot encoding ",X_cv_subcategory_ohe.shap
print("Shape of X_test subcategory after one hot encoding ",X_test_subcategory_ohe.
print("Print some random encoded categories: ")

print(X_train_subcategory_ohe[0].toarray())
print(X_cv_subcategory_ohe[0].toarray())
print(X_test_subcategory_ohe[10].toarray())
```

```
['economics', 'communityservice', 'financialliteracy', 'parentinvolvem
ent', 'civics_government', 'extracurricular', 'foreignlanguages', 'nut
ritioneducation', 'warmth', 'care_hunger', 'performingarts', 'socialsc
iences', 'charactereducation', 'teamsports', 'other', 'college_careerp
rep', 'music', 'history_geography', 'health_lifescience', 'earlydevelo
pment', 'esl', 'gym_fitness', 'environmentalscience', 'visualarts', 'h
ealth_wellness', 'appliedsciences', 'specialneeds', 'literature_writin
g', 'mathematics', 'literacy']
Shape of X_train subcategory after one hot encoding  (69918, 30)
Shape of X_cv subcategory after one hot encoding  (17480, 30)
Shape of X_test subcategory after one hot encoding  (21850, 30)
Print some random encoded categories:
[[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0]]
[[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0]]
[[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0]]
```

One hot encoding: school_state

In [125]:

```
# create a vocabulary for states
unique_states = np.unique(X_train['school_state'].values)

vectorizer_state = CountVectorizer(vocabulary=unique_states,lowercase=False,binary=
vectorizer_state.fit(X_train['school_state'].values)

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

print(vectorizer_state.get_feature_names())
print("Shape of X_train school_state after one hot encodig ",X_train_school_state_o
print("Shape of X_cv school_state after one hot encodig ",X_cv_school_state_ohe.sha
print("Shape of X_test school_state after one hot encodig ",X_test_school_state_ohe
print("Print some random encoded school_state: ")
print(X_train_school_state_ohe[0].toarray())
print(X_cv_school_state_ohe[0].toarray())
print(X_test_school_state_ohe[15].toarray())
```

```
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'h
i', 'ia', 'id', 'il', 'in', 'ks', 'ky', 'la', 'ma', 'md', 'me', 'mi',
'mn', 'mo', 'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', 'n
y', 'oh', 'ok', 'or', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va',
'vt', 'wa', 'wi', 'wv', 'wy']
Shape of X_train school_state after one hot encodig  (69918, 51)
Shape of X_cv school_state after one hot encodig  (17480, 51)
Shape of X_test school_state after one hot encodig  (21850, 51)
Print some random encoded school_state:
[[0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]]
[[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0
  0 0 0 0 0 0 0 1 0 0 0 0 0 0 0]]
[[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0
  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]]
```

One hot encoding: teacher_prefix

In [126]:

```
unique_teacher_prefix = np.unique(X_train['teacher_prefix'])

vectorizer_teacher_prefix = CountVectorizer(vocabulary=unique_teacher_prefix,lowerc
vectorizer_teacher_prefix.fit(X_train['teacher_prefix'].values)

X_train_teacher_prefix_ohe = vectorizer_teacher_prefix.transform(X_train['teacher_p
X_cv_teacher_prefix_ohe = vectorizer_teacher_prefix.transform(X_cv['teacher_prefix'
X_test_teacher_prefix_ohe = vectorizer_teacher_prefix.transform(X_test['teacher_pre

print(vectorizer_teacher_prefix.get_feature_names())
print("Shape of X_train clean_teacher_prefix after one hot encodig ",X_train_teache
print("Shape of X_cv clean_teacher_prefix after one hot encodig ",X_cv_teacher_pref
print("Shape of X_test clean_teacher_prefix after one hot encodig ",X_test_teacher_
print("Print some random encoded clean_teacher_prefix: ")
print(X_train_teacher_prefix_ohe[0].toarray())
print(X_cv_teacher_prefix_ohe[0].toarray())
print(X_test_teacher_prefix_ohe[15].toarray())
```

```
['dr', 'mr', 'mrs', 'ms', 'teacher']
Shape of X_train clean_teacher_prefix after one hot encodig  (69918,
5)
Shape of X_cv clean_teacher_prefix after one hot encodig  (17480, 5)
Shape of X_test clean_teacher_prefix after one hot encodig  (21850, 5)
Print some random encoded clean_teacher_prefix:
[[0 0 1 0 0]]
[[0 1 0 0 0]]
[[0 0 0 1 0]]
```

One hot encoding: project_grade_category

In [127]:

```
unique_grades = np.unique(X_train['project_grade_category'])

vectorizer_grade = CountVectorizer(vocabulary=unique_grades,lowercase=False,binary=
vectorizer_grade.fit(X_train['project_grade_category'].values)


X_train_grade_category_ohe = vectorizer_grade.transform(X_train['project_grade_cate
X_cv_grade_category_ohe = vectorizer_grade.transform(X_cv['project_grade_category']
X_test_grade_category_ohe = vectorizer_grade.transform(X_test['project_grade_catego

print(vectorizer_grade.get_feature_names())
print("Shape of X_train clean_grade_category after one hot encodig ",X_train_grade_
print("Shape of X_cv clean_grade_category after one hot encodig ",X_cv_grade_catego
print("Shape of X_test clean_grade_category after one hot encodig ",X_test_grade_ca
print("Print some random encoded clean_grade_category: ")
print(X_train_grade_category_ohe[0].toarray())
print(X_cv_grade_category_ohe[0].toarray())
print(X_test_grade_category_ohe[15].toarray())
```

```
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
Shape of X_train clean_grade_category after one hot encodig  (69918,
4)
Shape of X_cv clean_grade_category after one hot encodig  (17480, 4)
Shape of X_test clean_grade_category after one hot encodig  (21850, 4)
Print some random encoded clean_grade_category:
[[1 0 0 0]]
[[1 0 0 0]]
[[0 1 0 0]]
```

In [128]:

```
print(X_train_category_ohe.shape)
print(X_train_subcategory_ohe.shape)
print(X_train_school_state_ohe.shape)
print(X_train_grade_category_ohe.shape)
print(X_train_teacher_prefix_ohe.shape)
print(X_train_normal_previous_project.shape)
print(X_train_price_normalized.shape)
```

```
(69918, 9)
(69918, 30)
(69918, 51)
(69918, 4)
(69918, 5)
(69918, 1)
(69918, 1)
```

In [0]:

```
f1 = X_train_school_state_ohe
f2 = X_train_category_ohe
f3 = X_train_subcategory_ohe
f4 = X_train_grade_category_ohe
f5 = X_train_teacher_prefix_ohe
f6 = np.array(X_train_price_normalized)
f7 = np.array(X_train_normal_previous_project)
remaining_xtrain = hstack((f1,f2,f3,f4,f5,f6,f7))
```

In [0]:

```
remaining_xtrain = np.array(remaining_xtrain.todense())
remaining_xtrain = np.expand_dims(remaining_xtrain,2)#remaining_xtrain.reshape(rema
```

In [131]:

```
remaining_xtrain.shape
```

Out[131]:

```
(69918, 101, 1)
```

In [132]:

```
f1 = X_cv_school_state_ohe
f2 = X_cv_category_ohe
f3 = X_cv_subcategory_ohe
f4 = X_cv_grade_category_ohe
f5 = X_cv_teacher_prefix_ohe
f6 = np.array(X_cv_price_normalized)
f7 = np.array(X_cv_normal_previous_project)
remaining_xcv = hstack((f1,f2,f3,f4,f5,f6,f7))
print(remaining_xcv.shape)
```

```
(17480, 101)
```

In [133]:

```
remaining_xcv  = np.array(remaining_xcv.todense())
remaining_xcv = np.expand_dims(remaining_xcv,2)
remaining_xcv.shape
```

Out[133]:

```
(17480, 101, 1)
```

In [134]:

```
f1 = X_test_school_state_ohe
f2 = X_test_category_ohe
f3 = X_test_subcategory_ohe
f4 = X_test_grade_category_ohe
f5 = X_test_teacher_prefix_ohe
f6 = np.array(X_test_price_normalized)
f7 = np.array(X_test_normal_previous_project)
remaining_xtest = hstack((f1,f2,f3,f4,f5,f6,f7))
print(remaining_xtest.shape)
```

```
(21850, 101)
```

In [135]:

```
remaining_xtest  = np.array(remaining_xtest.todense())
remaining_xtest = np.expand_dims(remaining_xtest,2)
remaining_xtest.shape
```

Out[135]:

```
(21850, 101, 1)
```

In [137]:

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

#First Input : Essays
essay_input = Input(shape=(300,), name='essay_input')
embedding = Embedding(input_dim=vocab_size,output_dim=300,weights=[embedding_matrix
lstm_output = LSTM(units=150,dropout=0.5,return_sequences=True)(embedding)
flatten_1 = Flatten()(lstm_output)

#Remaining Input
remaining_input = Input(shape=(101,1),name='remaining_input')

x = Conv1D(filters=128, kernel_size = 3, padding='valid', activation='relu', kernel
x = Conv1D(filters=128, kernel_size = 3, padding='valid', activation='relu', kernel
x = Flatten()(x)

#concatenating all inputs together
cacatenated_inputs = concatenate([flatten_1, x])

x = Dense(256, activation='relu',kernel_initializer="he_normal",kernel_regularizer=
x = Dropout(.5)(x)
x = Dense(128, activation='relu',kernel_initializer="he_normal",kernel_regularizer=
x = Dropout(.5)(x)
x = BatchNormalization()(x)
x = Dense(64, activation='relu',kernel_initializer="he_normal",kernel_regularizer=l
final_output = Dense(2, activation='softmax')(x)

model_3 = Model(inputs=[essay_input, remaining_input], outputs=[final_output])
print(model_3.summary())
```

```
Model: "model_5"
__________________________________________________________________________
_____________________________
Layer (type)                    Output Shape         Param #     Conne
cted to
==========================================================================
============================
essay_input (InputLayer)        (None, 300)          0
__________________________________________________________________________
_____________________________
remaining_input (InputLayer)    (None, 101, 1)       0
__________________________________________________________________________
_____________________________
embedding_7 (Embedding)         (None, 300, 300)     14200800    essay
_input[0][0]
__________________________________________________________________________
_____________________________
conv1d_12 (Conv1D)              (None, 99, 128)      512         remai
ning_input[0][0]
__________________________________________________________________________
_____________________________
lstm_7 (LSTM)                   (None, 300, 150)     270600      embed
ding_7[0][0]
__________________________________________________________________________
_____________________________
conv1d_13 (Conv1D)              (None, 97, 128)      49280       conv1
d_12[0][0]
__________________________________________________________________________
_____________________________
```

```
flatten_12 (Flatten)            (None, 45000)        0           lstm_
7[0][0]
__________________________________________________________________________
_____________________________
flatten_13 (Flatten)            (None, 12416)        0           conv1
d_13[0][0]
__________________________________________________________________________
_____________________________
concatenate_5 (Concatenate)     (None, 57416)        0           flatt
en_12[0][0]
                                                                 flatt
en_13[0][0]
__________________________________________________________________________
_____________________________
dense_17 (Dense)                (None, 256)          14698752    conca
tenate_5[0][0]
__________________________________________________________________________
_____________________________
dropout_9 (Dropout)             (None, 256)          0           dense
_17[0][0]
__________________________________________________________________________
_____________________________
dense_18 (Dense)                (None, 128)          32896       dropo
ut_9[0][0]
__________________________________________________________________________
_____________________________
dropout_10 (Dropout)            (None, 128)          0           dense
_18[0][0]
__________________________________________________________________________
_____________________________
batch_normalization_5 (BatchNor (None, 128)          512         dropo
ut_10[0][0]
__________________________________________________________________________
_____________________________
dense_19 (Dense)                (None, 64)           8256        batch
_normalization_5[0][0]
__________________________________________________________________________
_____________________________
dense_20 (Dense)                (None, 2)            130         dense
_19[0][0]
==========================================================================
============================
Total params: 29,261,738
Trainable params: 15,060,682
Non-trainable params: 14,201,056
__________________________________________________________________________
_____________________________
None
```

In [138]:

```
# checkpoint
file_path=working_dir+"weights-improvement-{epoch:02d}-{val_auroc:.2f}.hdf5"
checkpoint_3 = ModelCheckpoint(filepath=file_path,
                               monitor="val_auroc",
                               mode="max",
                               save_best_only = True,
                               verbose=1)
tbc_3 = TensorBoardColab()
```

```
Wait for 8 seconds...
TensorBoard link:
https://970ea298.ngrok.io (https://970ea298.ngrok.io)
```

In [0]:

```
callbacks_list = [checkpoint_3, TensorBoardColabCallback(tbc_3)]

train_3 = [padded_train_essay, remaining_xtrain]

cv_3 = [padded_cv_essay,remaining_xcv]

test_3 = [padded_test_essay,remaining_xtest]
```

In [140]:

```
model_3.compile(loss='categorical_crossentropy', optimizer=optimizers.Adam(lr=0.000
history_3 = model_3.fit(train_3,Y_train,validation_data=(cv_3,Y_cv),epochs=50,batch
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tenso
rflow_core/python/ops/math_grad.py:1424: where (from tensorflow.pyth
on.ops.array_ops) is deprecated and will be removed in a future vers
ion.
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/kera
s/backend/tensorflow_backend.py:1033: The name tf.assign_add is depr
ecated. Please use tf.compat.v1.assign_add instead.

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/kera
s/backend/tensorflow_backend.py:1020: The name tf.assign is deprecat
ed. Please use tf.compat.v1.assign instead.

Train on 69918 samples, validate on 17480 samples
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tenso
rboardcolab/core.py:49: The name tf.summary.FileWriter is deprecate
d. Please use tf.compat.v1.summary.FileWriter instead.
```

In [0]:

```
#https://stackoverflow.com/posts/54978213/revisions
custom_objects = {"auroc":auroc}
from keras.models import load_model
best_model_3 = load_model('/content/gdrive/My Drive/model-weights-lstm/weights-impr
```

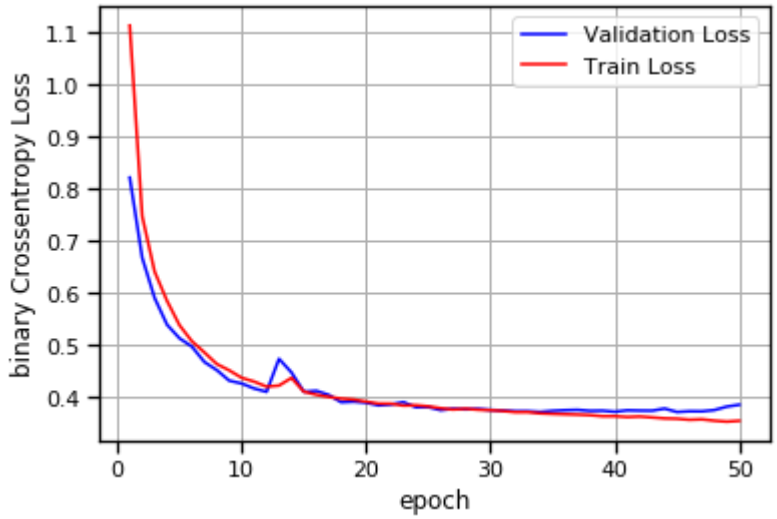
In [142]:

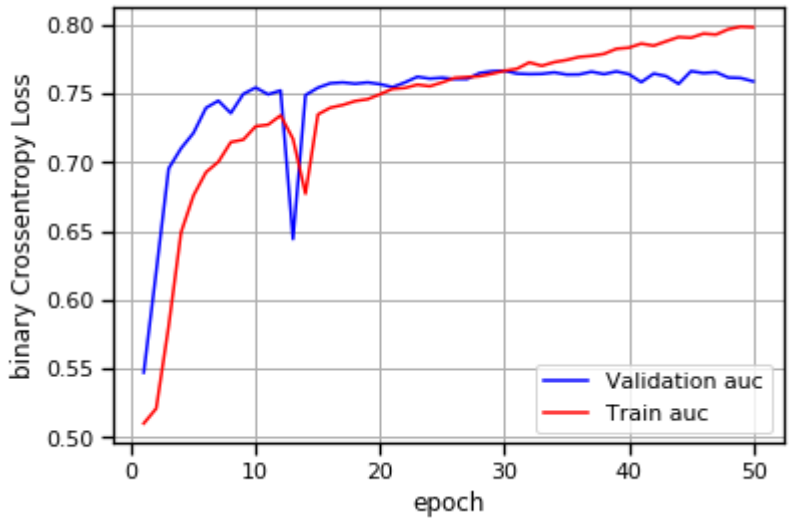
```
result = best_model_3.evaluate(x=test_3, y=Y_test, batch_size=512)
print("{} of test data {}". format(best_model_3.metrics_names[0],result[0]))
print("{} of test data {}". format(best_model_3.metrics_names[1],result[1]))
```

```
21850/21850 [==============================] - 9s 392us/step
loss of test data 0.3775796339277272
auroc of test data 0.7668925418496343
```

In [143]:

```
best_model_3.save(working_dir+"best_model_3.h5")

fig,ax = plt.subplots(1,1)
ax.set_xlabel('epoch') ; ax.set_ylabel('binary Crossentropy Loss')

# list of epoch numbers
x = list(range(1,50+1))

# print(history.history.keys())
# dict_keys(['val_loss', 'val_acc', 'loss', 'acc'])
# history = model_drop.fit(X_train, Y_train, batch_size=batch_size, epochs=nb_epoch

# we will get val_loss and val_acc only when you pass the paramter validation_data
# val_loss : validation loss
# val_acc : validation accuracy

# loss : training loss
# acc : train accuracy
# for each key in histrory.histrory we will have a list of length equal to number o


vy = history_3.history['val_loss']
ty = history_3.history['loss']
plt_dynamic(x, vy, ty, ax)


def plt_dynamic_auc(x, vy, ty, ax, colors=['b']):
    ax.plot(x, vy, 'b', label="Validation auc")
    ax.plot(x, ty, 'r', label="Train auc")
    plt.legend()
    plt.grid()
    fig.canvas.draw()


ig,ax = plt.subplots(1,1)
ax.set_xlabel('epoch') ; ax.set_ylabel('binary Crossentropy Loss')

# list of epoch numbers
x = list(range(1,50+1))

# print(history.history.keys())
# dict_keys(['val_loss', 'val_acc', 'loss', 'acc'])
# history = model_drop.fit(X_train, Y_train, batch_size=batch_size, epochs=nb_epoch

# we will get val_loss and val_acc only when you pass the paramter validation_data
# val_loss : validation loss
# val_acc : validation accuracy

# loss : training loss
# acc : train accuracy
# for each key in histrory.histrory we will have a list of length equal to number o


vy = history_3.history['val_auroc']
ty = history_3.history['auroc']
plt_dynamic_auc(x, vy, ty, ax)
```

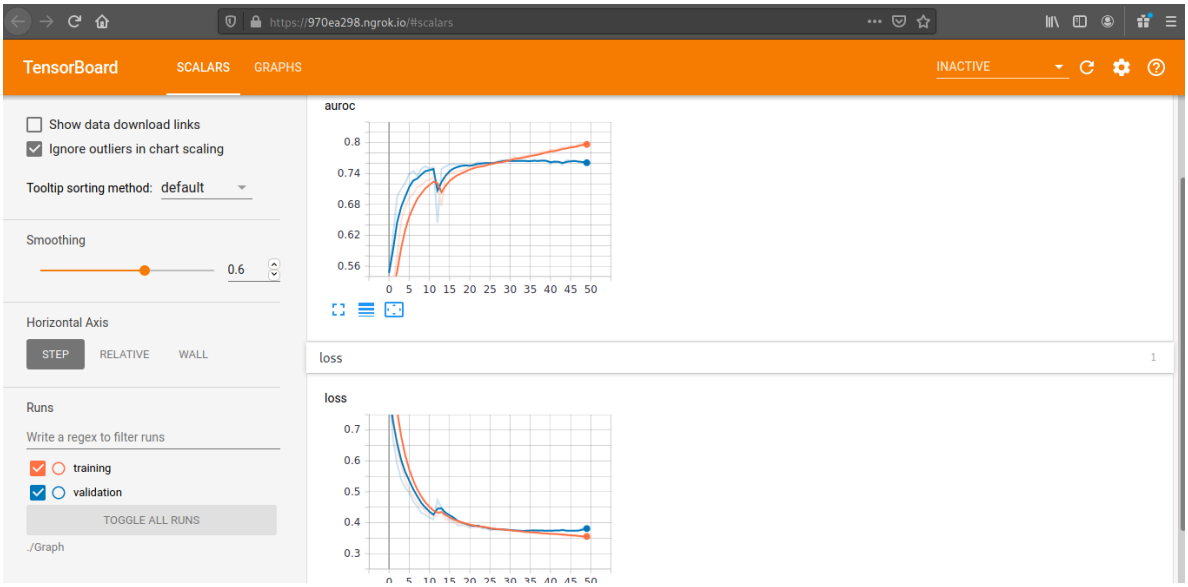




In [145]:

```
Image(retina=True, filename=working_dir+'tb3.png')
```

Out[145]:



Conclusion

In [147]:

```
from prettytable import PrettyTable
x = PrettyTable()

x.field_names = ["Model", "train_auc", "val_auc", "test_auc","val_loss","test_loss"

x.add_row(["Model_1", 0.7926,0.7465,0.7424,0.4562,0.4563])
x.add_row(["Model_2", 0.7962, 0.7079,0.7163,0.4282,0.4034])
x.add_row(["Model_3", 0.7666,0.7558,0.7668,0.3680,0.37757])

print(x)
```

```
+---------+-----------+---------+----------+----------+-----------+
|  Model  | train_auc | val_auc | test_auc | val_loss | test_loss |
+---------+-----------+---------+----------+----------+-----------+
| Model_1 |   0.7926  |  0.7465 |  0.7424  |  0.4562  |   0.4563  |
| Model_2 |   0.7962  |  0.7079 |  0.7163  |  0.4282  |   0.4034  |
| Model_3 |   0.7666  |  0.7558 |  0.7668  |  0.368   |  0.37757  |
+---------+-----------+---------+----------+----------+-----------+
```