1. Importing the libraries.

In [3]:

```
from google.colab import drive
drive.mount('/content/drive/', force_remount=True)
```

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_id=947318989803-6bn6qk8q
dgf4n4g3pfee6491hc0brc4i.apps.googleusercontent.com&redirect_uri=urn%3Aietf%3Awg%3Aoauth%3A2.0%3Aoob&s
cope=email%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fdocs.test%20https%3A%2F%2Fwww.googleapis.com%2F
auth%2Fdrive%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fdrive.photos.readonly%20https%3A%2F%2Fwww.goo
gleapis.com%2Fauth%2Fpeopleapi.readonly&response_type=code

Enter your authorization code:
··········
Mounted at /content/drive/


Mounted at /content/drive/
```

In [1]:

```
from datetime import datetime as dt
global start
start = dt.now()

%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

import sqlite3
import pandas as pd
import numpy as np

import re
import string

from tqdm import tqdm
```

```
import os

from numpy import array
from numpy import asarray
from numpy import zeros
from keras.preprocessing.text import Tokenizer
from keras.preprocessing.sequence import pad_sequences
from keras.models import Sequential
from keras.layers import Dense
from keras.layers import Flatten
from keras.layers import Embedding
from keras.layers import Input, Embedding, LSTM, Dense, concatenate, Dropout, BatchNormalization
from keras.models import Model

from sklearn.metrics import accuracy_score
from IPython.core.display import display, HTML
display(HTML("<style>.container { width:100% !important; }</style>"))
```

```
Using TensorFlow backend.
```

2. Loading the data and displaying the initial tables.

In [0]:

```
#Load the given dataframes.
project_data = pd.read_csv('train_data.csv')
resource_data = pd.read_csv('resources.csv')
```

In [0]:

```
#Display the contents of "train_data.csv"
project_data.head(2)
```

Out[0]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_category
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Grades PreK-2

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_category
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grades 6-8

In [0]:

```
#Display the contents of "resources.csv"
resource_data.head(2)
```

Out[0]:

	id	description	quantity	price
0	p233245	LC652 - Lakeshore Double-Space Mobile Drying Rack	1	149.00
1	p069063	Bouncy Bands for Desks (Blue support pipes)	3	14.95

3. Merge the two dataframes based on ID

In [0]:

```
#Merging both the dataframes by their corresponding IDs
price_quantity_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
project_data = pd.merge(project_data, price_quantity_data, on='id', how='left')

#Remove the columns which are not needed anymore. Keeping ID for now.
project_data.drop(['Unnamed: 0', 'teacher_id', 'id'], axis=1, inplace=True)

project_data.head(3)
```

Out[0]:

	teacher_prefix	school_state	project_submitted_datetime	project_grade_category	project_subject_categories	project_subject_subcategories
0	Mrs.	IN	2016-12-05 13:43:57	Grades PreK-2	Literacy & Language	ESL, Literacy

	teacher_prefix	school_state	project_submitted_datetime	project_grade_category	project_subject_categories	project_subject_subcategories
1	Mr.	FL	2016-10-25 09:22:10	Grades 6-8	History & Civics, Health & Sports	Civics & Government, Team Sports
2	Ms.	AZ	2016-08-31 12:03:56	Grades 6-8	Health & Sports	Health & Wellness, Team Sports

4. Basic information about the dataset.

In [0]:

```
print("Number of data points we have: ", project_data.shape[0])
print("Number of initial features we have:", project_data.shape[1])
print("\nLet's look at the all columns present in the dataset: \n",project_data.columns.values)
```

```
Number of data points we have:  109248
Number of initial features we have: 16

Let's look at the all columns present in the dataset:
 ['teacher_prefix' 'school_state' 'project_submitted_datetime'
 'project_grade_category' 'project_subject_categories'
 'project_subject_subcategories' 'project_title' 'project_essay_1'
 'project_essay_2' 'project_essay_3' 'project_essay_4'
 'project_resource_summary' 'teacher_number_of_previously_posted_projects'
 'project_is_approved' 'price' 'quantity']
```

5. Data Pre-processing Section

In this section, we will pre-process all the data before using them to build Machine Learning models. The dataset has the following types of features:

Categorical variables:

1. teacher_prefix
2. school_state
3. project_grade_category
4. project_subject_categories
5. project_subject_subcategories

Text data:

1. project_essay_1
2. project_essay_2
3. project_essay_3
4. project_essay_4
5. project_title
6. project_resource_summary

Numerical Data:

1. teacher_number_of_previously_posted_projects
2. price
3. quantity

5.1 Utility functions for pre processing text datas and categories data

In [0]:

```
#Stopwords contains the list of commonly found english keywords. We will remove them from the text dat
as as part of the pre-processing of data.
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himsel
f', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them',
'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these'
, 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having',
'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'whi
le', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll', 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't","a","b","c","d","e","f","g","h","i","j","k","l","m","n","o","p","q","r","s", \
            't','u','v','w','x','y','z']

from tqdm import tqdm
def clean_subjects(input_values):
    '''This function will be used to pre process the two features -> "project_subject_categories" and
    "project_subject_subcategories"'''
    processed_list = []
    for i in tqdm(input_values):
        temp = ""
        for j in i.split(','):
            if 'The' in j.split():
                j=j.replace('The','')
            j = j.replace(' ','')
            temp +=j.strip()+" "
            temp = temp.replace('&','_')
        processed_list.append(temp.strip())
    return processed_list

import re
def decontracted(phrase):
    """This function will be used to expand the de-contracted words"""
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
    phrase = re.sub(r"\'m", " am", phrase)
    return phrase

def process_text(list_of_sentences):
    """This function will be used to pre-process the text data"""
    preprocessed_texts = []
    for sentence in tqdm(list_of_sentences):
        sent = decontracted(sentence)
        sent = sent.replace('\\r', ' ')
        sent = sent.replace('\\"', ' ')
        sent = sent.replace('\\n', ' ')
        sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
        sent = ' '.join(word.lower() for word in sent.split() if word.lower() not in stopwords) #We will keep only those words in title which has a string length greater than one
        preprocessed_texts.append(sent.lower().strip())
    return preprocessed_texts
```

5.2 Pre-Processing the 'essays' data

In [0]:

```
#Merging the essays data into one single column for ease of processing.
project_data["essay"] = project_data["project_essay_1"].map(str) + \
                        project_data["project_essay_2"].map(str) + \
                        project_data["project_essay_3"].map(str) + \
                        project_data["project_essay_4"].map(str)

preprocessed_essays = process_text(project_data["essay"].values)

#Add the pre-processed data into a new column.
project_data['clean_essays'] = preprocessed_essays
```

```
#Remove the columns which are already processed and are not needed anymore.
project_data.drop(['essay','project_essay_1','project_essay_2','project_essay_3','project_essay_4'],
                  axis=1, inplace=True)
```

```
100%|██████████| 109248/109248 [02:00<00:00, 905.36it/s]
```

5.3 Pre-Processing the 'project_resource_summary' data

In [0]:

```
preprocessed_summary = process_text(project_data['project_resource_summary'].values)
project_data['clean_project_resource_summary'] = preprocessed_summary
project_data.drop(['project_resource_summary'], axis=1, inplace=True)
```

```
100%|██████████| 109248/109248 [00:12<00:00, 8621.78it/s]
```

5.4 Pre-Processing the 'project_title' data

In [0]:

```
preprocessed_titles = process_text(project_data['project_title'].values)
project_data['clean_project_title'] = preprocessed_titles
project_data.drop(['project_title'], axis=1, inplace=True)
```

```
100%|██████████| 109248/109248 [00:05<00:00, 19912.64it/s]
```

5.5 Pre-Processing of 'project_subject_categories'

In [0]:

```
preprocessed_categories = clean_subjects(project_data['project_subject_categories'].values)

project_data['clean_categories'] = preprocessed_categories
project_data.drop(['project_subject_categories'], axis=1, inplace=True)
```

```
100%|██████████| 109248/109248 [00:00<00:00, 302094.48it/s]
```

5.6 Pre-Processing of 'project_subject_subcategories'

In [0]:

```
preprocessed_subcategories = clean_subjects(project_data['project_subject_subcategories'].values)

project_data['clean_subcategories'] = preprocessed_subcategories
project_data.drop(['project_subject_subcategories'], axis=1, inplace=True)
```

```
100%|██████████| 109248/109248 [00:00<00:00, 301790.06it/s]
```

5.7 Pre-Processing of 'project_grade_category'

In [0]:

```
project_data['project_grade_category'] = project_data['project_grade_category'].map(lambda x: x.replac
e(" ","_").replace("-","_"))
```

5.7 Designing a new feature called - Presence of numerical digits in project resources summary

In [0]:

```
def is_digit(sent):
    digits=re.findall('\d+', sent)
    if(len(digits) != 0 ):
        return 1
    else:
        return 0

project_data['presence_of_the_numerical_digits']=project_data['clean_project_resource_summary'].apply(
is_digit)
```

5.8 Combining all text features into one single feature 'total_text'

In [0]:

```
project_data['total_text'] = project_data['clean_essays'].map(str) + " " + project_data['clean_project
_resource_summary'].map(str) + " " + project_data['clean_project_title'].map(str)
project_data.drop(['clean_essays','clean_project_resource_summary','clean_project_title','project_subm
itted_datetime'], axis=1, inplace=True) #Remove not needed features
```

5.9 Replacing NAN values by empty strings

In [0]:
```
project_data['teacher_prefix'] = project_data['teacher_prefix'].fillna(' ')
```

5.10 Display the processed dataframe and save it into a pandas CSV file.

In [0]:
```
#After pre-processing, we have 13 features. We will have one feature as our target variable and the re
st of the columns as our independent features variables.
project_data.head(5)
```

Out[0]:

	teacher_prefix	school_state	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved	price	quantity
0	Mrs.	IN	Grades_PreK_2	0	0	154.60	23
1	Mr.	FL	Grades_6_8	7	1	299.00	1
2	Ms.	AZ	Grades_6_8	1	0	516.85	22
3	Mrs.	KY	Grades_PreK_2	4	1	232.90	4

	teacher_prefix	school_state	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved	price	quantity
4	Mrs.	TX	Grades_PreK_2	1	1	67.98	4

```
In [0]: DATADIR = "/content/drive/My Drive/Donors/"
```

```
In [0]: #Save the processed dataset into a pandas CSV file.
        project_data.to_csv("processed_data.csv", index=False)
```

```
In [2]: project_data = pd.read_csv("processed_data.csv")
```

6. Splitting the original data into train and test data in 80:20 ratio.

```
In [3]: #Taking the target and predictor variables into separate variables
        y = project_data["project_is_approved"] #target variables
        X = project_data.drop(['project_is_approved'], axis=1) #predictor variables

        #Split the dataset into train and val dataset
        from sklearn.model_selection import train_test_split
        X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.10, random_state=1, stratify=y)
        X_train, X_val, y_train, y_val = train_test_split(X_train, y_train, test_size=0.20, random_state=1, st
        ratify=y_train)

        #Display basic information after splitting the data
        print("Number of points in train data: ",X_train.shape[0])
        print("Number of points in validation data: ",X_val.shape[0])
        print("Number of points in test data: ",X_test.shape[0])
```

```
Number of points in train data:  78658
Number of points in validation data:  19665
Number of points in test data:  10925
```

Model-1

Build and Train deep neural network as shown below

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

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

```
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/

2. Please go through this link 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.

Total Text Data

Build train and val data

In [4]:

```
#Get the total_text values in list
docs_text_train=list(X_train.total_text.values)
docs_text_val=list(X_val.total_text.values)
docs_text_test=list(X_test.total_text.values)
labels_train=np.array(y_train)
labels_val=np.array(y_val)
labels_test=np.array(y_test)

#Initializing the keras tokenizer and fitting it on train data
tokens = Tokenizer()
tokens.fit_on_texts(docs_text_train)

#Convert the texts to sequences using the tokenizer
sequences_text_train = tokens.texts_to_sequences(docs_text_train)
sequences_text_val = tokens.texts_to_sequences(docs_text_val)
sequences_text_test = tokens.texts_to_sequences(docs_text_test)
vocab_size_text = len(tokens.word_index) + 1

#Add padding
padded_text_train = pad_sequences(sequences_text_train, maxlen=300, padding='post')
padded_text_val = pad_sequences(sequences_text_val, maxlen=300, padding='post')
padded_text_test = pad_sequences(sequences_text_test, maxlen=300, padding='post')
```

In [5]:

```
#Load the whole embedding into memory
embeddings_index = dict()
file = open('glove.6B.300d.txt')
for line in file:
    values = line.split()
    word = values[0]
    coefs = asarray(values[1:], dtype='float32')
    embeddings_index[word] = coefs
file.close()

print('Loaded %s word vectors.' % len(embeddings_index))

#Create a weight matrix for words in training docs
embedding_matrix = zeros((vocab_size_text, 300))
for word, i in tqdm(tokens.word_index.items()):
    embedding_vector = embeddings_index.get(word)
    if embedding_vector is not None:
        embedding_matrix[i] = embedding_vector

print(len(embedding_matrix[0]))
```

```
100%|██████████| 53260/53260 [00:00<00:00, 297799.89it/s]
```

```
Loaded 400000 word vectors.
300
```

In [7]:

```
#Get the flattened LSTM output for input text
input_layer_total_text = Input(shape=(300,), name = "total_text_sequence")
embedding_layer_total_text = Embedding(input_dim=vocab_size_text, output_dim=300, weights=[embedding_matrix], trainable=False)(input_layer_total_text)
lstm_total_text  = LSTM(16, activation="relu", return_sequences=True)(embedding_layer_total_text)
flatten_total_text = Flatten()(lstm_total_text)
```

Categorical data: school_state

Building train, test and validation data

In [8]:

```
#Get the school state values
docs_school_state_train=list(X_train.school_state.values)
docs_school_state_val=list(X_val.school_state.values)
```

```
docs_school_state_test=list(X_test.school_state.values)

#Initializing the keras tokenizer and fitting it on train data
tokens = Tokenizer()
tokens.fit_on_texts(docs_school_state_train)

#Convert the school_state to sequences using the tokenizer
sequences_school_train = np.array(tokens.texts_to_sequences(docs_school_state_train))
sequences_school_val = np.array(tokens.texts_to_sequences(docs_school_state_val))
sequences_school_test = np.array(tokens.texts_to_sequences(docs_school_state_test))
vocab_size_school_state = len(tokens.word_index) + 1
```

In [9]:

```
#Get the flattened output for school_state
input_layer_school_state = Input(shape=(1,), name = "encoded_school_state")
embedding_layer_school_state = Embedding(input_dim=vocab_size_school_state, output_dim=4, trainable=True)(input_layer_school_state)
flatten_school_state = Flatten()(embedding_layer_school_state)
```

Categorical data: teacher_prefix

Building train, test and validation data

In [10]:

```
#Get the teacher_prefix values
docs_teacher_prefix_train=list(X_train.teacher_prefix.values)
docs_teacher_prefix_val=list(X_val.teacher_prefix.values)
docs_teacher_prefix_test=list(X_test.teacher_prefix.values)

#Initializing the keras tokenizer and fitting it on train data
tokens = Tokenizer()
tokens.fit_on_texts(docs_teacher_prefix_train)

#Convert the school_state to sequences using the tokenizer
sequences_teacher_prefix_train = np.array(tokens.texts_to_sequences(docs_teacher_prefix_train))
sequences_teacher_prefix_val = np.array(tokens.texts_to_sequences(docs_teacher_prefix_val))
```

```
sequences_teacher_prefix_test = np.array(tokens.texts_to_sequences(docs_teacher_prefix_test))
vocab_size_teacher_prefix = len(tokens.word_index) + 1
```

In [11]:

```
#Get the flattened output for teacher_prefix
input_layer_teacher_prefix = Input(shape=(1,), name = "teacher_prefix")
embedding_layer_teacher_prefix = Embedding(input_dim=vocab_size_teacher_prefix, output_dim=4, trainable=True)(input_layer_teacher_prefix)
flatten_teacher_prefix = Flatten()(embedding_layer_teacher_prefix)
```

Categorical data: project_grade_category

Building train, test and validation data

In [12]:

```
#Get the project_grade_category values
docs_project_grade_category_train=list(X_train.project_grade_category.values)
docs_project_grade_category_val=list(X_val.project_grade_category.values)
docs_project_grade_category_test=list(X_test.project_grade_category.values)

#Initializing the keras tokenizer and fitting it on train data
tokens = Tokenizer()
tokens.fit_on_texts(docs_project_grade_category_train)

#Convert the school_state to sequences using the tokenizer
sequences_project_grade_category_train = tokens.texts_to_sequences(docs_project_grade_category_train)
sequences_project_grade_category_val = tokens.texts_to_sequences(docs_project_grade_category_val)
sequences_project_grade_category_test = tokens.texts_to_sequences(docs_project_grade_category_test)
vocab_size_project_grade_category= len(tokens.word_index) + 1

#Add padding
padded_project_grade_category_train = pad_sequences(sequences_project_grade_category_train, maxlen=3, padding='post')
padded_project_grade_category_val = pad_sequences(sequences_project_grade_category_val, maxlen=3, padding='post')
padded_project_grade_category_test = pad_sequences(sequences_project_grade_category_test, maxlen=3, padding='post')
```

In [13]:

```
#Get the flattened output for project_grade_category
input_layer_project_grade = Input(shape=(3,), name = "project_grade_category")
embedding_layer_project_grade = Embedding(input_dim=vocab_size_project_grade_category, output_dim=4, trainable=True)(input_layer_project_grade)
flatten_project_grade = Flatten()(embedding_layer_project_grade)
```

Categorical data: clean_categories

Building train, test and validation data

In [14]:

```
#Get the clean_categories values
docs_clean_categories_train=list(X_train.clean_categories.values)
docs_clean_categories_val=list(X_val.clean_categories.values)
docs_clean_categories_test=list(X_test.clean_categories.values)

#Initializing the keras tokenizer and fitting it on train data
tokens = Tokenizer()
tokens.fit_on_texts(docs_clean_categories_train)

#Convert the school_state to sequences using the tokenizer
sequences_clean_categories_train = tokens.texts_to_sequences(docs_clean_categories_train)
sequences_clean_categories_val = tokens.texts_to_sequences(docs_clean_categories_val)
sequences_clean_categories_test = tokens.texts_to_sequences(docs_clean_categories_test)
vocab_size_clean_categories = len(tokens.word_index) + 1

#Add padding
padded_clean_categories_train = pad_sequences(sequences_clean_categories_train, maxlen=3, padding='post')
padded_clean_categories_val = pad_sequences(sequences_clean_categories_val, maxlen=3, padding='post')
padded_clean_categories_test = pad_sequences(sequences_clean_categories_test, maxlen=3, padding='post')
```

In [15]:

```
#Get the flattened output for clean_categories
input_layer_clean_categories = Input(shape=(3,), name = "clean_categories")
embedding_layer_clean_categories = Embedding(input_dim=vocab_size_clean_categories, output_dim=4, trai
nable=True)(input_layer_clean_categories)
flatten_clean_categories = Flatten()(embedding_layer_clean_categories)
```

Categorical data: clean_subcategories

Building train, test and validation data

In [16]:

```
#Get the clean_subcategories values
docs_clean_subcategories_train=list(X_train.clean_subcategories.values)
docs_clean_subcategories_val=list(X_val.clean_subcategories.values)
docs_clean_subcategories_test=list(X_test.clean_subcategories.values)

#Initializing the keras tokenizer and fitting it on train data
tokens = Tokenizer()
tokens.fit_on_texts(docs_clean_subcategories_train)

#Convert the school_state to sequences using the tokenizer
sequences_clean_subcategories_train = tokens.texts_to_sequences(docs_clean_subcategories_train)
sequences_clean_subcategories_val = tokens.texts_to_sequences(docs_clean_subcategories_val)
sequences_clean_subcategories_test = tokens.texts_to_sequences(docs_clean_subcategories_test)
vocab_size_clean_subcategories = len(tokens.word_index) + 1

padded_clean_subcategories_train = pad_sequences(sequences_clean_subcategories_train, maxlen=3, paddin
g='post')
padded_clean_subcategories_val = pad_sequences(sequences_clean_subcategories_val, maxlen=3, padding='p
ost')
padded_clean_subcategories_test = pad_sequences(sequences_clean_subcategories_test, maxlen=3, padding=
'post')
```

In [17]:

```
#Get the flattened output for clean_subcategories
input_layer_clean_subcategories = Input(shape=(3,), name = "clean_subcategories")
embedding_layer_clean_subcategories = Embedding(input_dim=vocab_size_clean_subcategories, output_dim=4
, trainable=True)(input_layer_clean_subcategories)
flatten_clean_subcategories = Flatten()(embedding_layer_clean_subcategories)
```

Numerical datas

In [18]:
```
from sklearn.preprocessing import Normalizer

def normalize_vars(data):
    """This function is used to normalize all the input datas between 0 and 1"""
    normalizer = Normalizer()
    data_normalized = normalizer.fit_transform(data.reshape(1, -1))
    return data_normalized, normalizer
```

teacher_number_of_previously_posted_projects

Building train, test and validation data

In [19]:
```
previous_projects_train = X_train.teacher_number_of_previously_posted_projects.values
previous_projects_val = X_val.teacher_number_of_previously_posted_projects.values
previous_projects_test = X_test.teacher_number_of_previously_posted_projects.values

norm_previous_projects_train, normalizer = normalize_vars(previous_projects_train.reshape(1,-1))
norm_previous_projects_val = normalizer.transform(previous_projects_val.reshape(1,-1))
norm_previous_projects_test = normalizer.transform(previous_projects_test.reshape(1,-1))

norm_previous_projects_train = norm_previous_projects_train.reshape(len(X_train),1)
norm_previous_projects_val = norm_previous_projects_val.reshape(len(X_val),1)
norm_previous_projects_test = norm_previous_projects_test.reshape(len(X_test),1)
```

In [20]:
```
#Input layer for teacher_number_of_previously_posted_projects
input_layer_previous_projects = Input(shape=(1,), name = "previous_projects")
```

price

Building train, test and validation data

In [21]:
```
price_train = X_train.price.values
price_val = X_val.price.values
price_test = X_test.price.values

norm_price_train, normalizer = normalize_vars(price_train.reshape(1,-1))
norm_price_val = normalizer.transform(price_val.reshape(1,-1))
norm_price_test = normalizer.transform(price_test.reshape(1,-1))

norm_price_train = norm_price_train.reshape(len(X_train),1)
norm_price_val = norm_price_val.reshape(len(X_val),1)
norm_price_test = norm_price_test.reshape(len(X_test),1)
```

In [22]:
```
#Input layer for price
input_layer_price = Input(shape=(1,), name = "price")
```

quantity

Building train and validation data

In [23]:
```
quantity_train = X_train.quantity.values
quantity_val = X_val.quantity.values
quantity_test = X_test.quantity.values

norm_quantity_train, normalizer = normalize_vars(quantity_train.reshape(1,-1))
norm_quantity_val = normalizer.transform(quantity_val.reshape(1,-1))
norm_quantity_test = normalizer.transform(quantity_test.reshape(1,-1))

norm_quantity_train = norm_quantity_train.reshape(len(X_train),1)
norm_quantity_val = norm_quantity_val.reshape(len(X_val),1)
norm_quantity_test = norm_quantity_test.reshape(len(X_test),1)
```

In [24]:
```
#Input layer for quantity
input_layer_quantity = Input(shape=(1,), name = "quantity")
```

Concatenation of all the numerical features layers

In [25]:
```
numerical_features_layers_concat = concatenate([input_layer_previous_projects, input_layer_price, input_layer_quantity])
dense_layer_numerical = Dense(4, activation='relu',kernel_initializer='he_normal')(numerical_features_layers_concat)
```

Concatenation of all the layers and building the final model

In [26]:
```
# Merge all the layers according to the architecture diagram
x = concatenate([flatten_total_text, flatten_teacher_prefix, flatten_school_state, flatten_project_grade, flatten_clean_categories, flatten_clean_subcategories, dense_layer_numerical])
x = Dense(8, activation='relu', kernel_initializer='he_normal', name='dense_layer_1')(x)
x = Dropout(0.3, name='dropout_1')(x)
x = Dense(4, activation='relu', kernel_initializer='he_normal', name='dense_layer_2')(x)
#x = Dropout(0.3, name='dropout_2')(x)
output_layer = Dense(1, activation='sigmoid', name='output_layer')(x)

# Final model
model = Model(inputs=[input_layer_total_text,input_layer_teacher_prefix,input_layer_school_state,input_layer_project_grade,input_layer_clean_categories,
                      input_layer_clean_subcategories,input_layer_previous_projects,input_layer_price,input_layer_quantity], outputs=[output_layer])
model.summary()
```

```
WARNING:tensorflow:From /root/anaconda3/lib/python3.7/site-packages/keras/backend/tensorflow_backend.py:3445: calling dropout (from tensorflow.python.ops.nn_ops) with keep_prob is deprecated and will be removed in a future version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_prob`.
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
total_text_sequence (InputLayer (None, 300)          0
__________________________________________________________________________________________________
embedding_2 (Embedding)         (None, 300, 300)     15978300    total_text_sequence[0][0]
```

```
__________________________________________________________________________________________________
teacher_prefix (InputLayer)     (None, 1)            0
__________________________________________________________________________________________________
encoded_school_state (InputLaye (None, 1)            0
__________________________________________________________________________________________________
project_grade_category (InputLa (None, 3)            0
__________________________________________________________________________________________________
clean_categories (InputLayer)   (None, 3)            0
__________________________________________________________________________________________________
clean_subcategories (InputLayer (None, 3)            0
__________________________________________________________________________________________________
previous_projects (InputLayer)  (None, 1)            0
__________________________________________________________________________________________________
price (InputLayer)              (None, 1)            0
__________________________________________________________________________________________________
quantity (InputLayer)           (None, 1)            0
__________________________________________________________________________________________________
lstm_2 (LSTM)                   (None, 300, 16)      20288       embedding_2[0][0]
__________________________________________________________________________________________________
embedding_4 (Embedding)         (None, 1, 4)         24          teacher_prefix[0][0]
__________________________________________________________________________________________________
embedding_3 (Embedding)         (None, 1, 4)         208         encoded_school_state[0][0]
__________________________________________________________________________________________________
embedding_5 (Embedding)         (None, 3, 4)         40          project_grade_category[0][0]
__________________________________________________________________________________________________
embedding_6 (Embedding)         (None, 3, 4)         64          clean_categories[0][0]
__________________________________________________________________________________________________
embedding_7 (Embedding)         (None, 3, 4)         152         clean_subcategories[0][0]
__________________________________________________________________________________________________
concatenate_1 (Concatenate)     (None, 3)            0           previous_projects[0][0]
                                                                 price[0][0]
                                                                 quantity[0][0]
__________________________________________________________________________________________________
flatten_2 (Flatten)             (None, 4800)         0           lstm_2[0][0]
__________________________________________________________________________________________________
flatten_4 (Flatten)             (None, 4)            0           embedding_4[0][0]
__________________________________________________________________________________________________
flatten_3 (Flatten)             (None, 4)            0           embedding_3[0][0]
__________________________________________________________________________________________________
```

```
flatten_5 (Flatten)             (None, 12)           0           embedding_5[0][0]
__________________________________________________________________________________________________
flatten_6 (Flatten)             (None, 12)           0           embedding_6[0][0]
__________________________________________________________________________________________________
flatten_7 (Flatten)             (None, 12)           0           embedding_7[0][0]
__________________________________________________________________________________________________
dense_1 (Dense)                 (None, 4)            16          concatenate_1[0][0]
__________________________________________________________________________________________________
concatenate_2 (Concatenate)     (None, 4848)         0           flatten_2[0][0]
                                                                 flatten_4[0][0]
                                                                 flatten_3[0][0]
                                                                 flatten_5[0][0]
                                                                 flatten_6[0][0]
                                                                 flatten_7[0][0]
                                                                 dense_1[0][0]
__________________________________________________________________________________________________
dense_layer_1 (Dense)           (None, 8)            38792       concatenate_2[0][0]
__________________________________________________________________________________________________
dropout_1 (Dropout)             (None, 8)            0           dense_layer_1[0][0]
__________________________________________________________________________________________________
dense_layer_2 (Dense)           (None, 4)            36          dropout_1[0][0]
__________________________________________________________________________________________________
output_layer (Dense)            (None, 1)            5           dense_layer_2[0][0]
==================================================================================================
Total params: 16,037,925
Trainable params: 59,625
Non-trainable params: 15,978,300
__________________________________________________________________________________________________
```

Defining a custom metric AUC

In [27]:

```python
import tensorflow as tf
from keras import backend as K
from sklearn.metrics import roc_auc_score
#https://stackoverflow.com/questions/51922500/tf-metrics-auc-yielding-very-different-from-sklearn-metrics-roc-auc-score
def roc_auc(y_true, y_pred):
    auc = tf.py_func(roc_auc_score, (y_true, y_pred), tf.double)
    #auc = tf.metrics.auc(y_true, y_pred, num_thresholds=200)[1]
    K.get_session().run(tf.local_variables_initializer())
    return auc
```

Defining callbacks

In [28]:

```
from time import time
from tensorflow.python.keras.callbacks import TensorBoard
from keras.callbacks import ModelCheckpoint

tensorboard = TensorBoard(log_dir="logs/{}".format(time))
filepath="weights_best.hdf5"
checkpoint = ModelCheckpoint(filepath, monitor='val_roc_auc', verbose=1, save_best_only=True, mode='ma
x')
```

In [31]:

```
import gc
gc.collect()
```

Out[31]:

```
0
```

Compiling the final model

In [29]:

```
model.compile(optimizer='rmsprop', loss='binary_crossentropy', metrics=[roc_auc])
model.fit(x=[padded_text_train,sequences_teacher_prefix_train,sequences_school_train,padded_project_gr
ade_category_train,padded_clean_categories_train,padded_clean_subcategories_train,
             norm_previous_projects_train,norm_price_train,norm_quantity_train],
          y=[labels_train],
          validation_data=([padded_text_val,sequences_teacher_prefix_val,sequences_school_val,padded_p
roject_grade_category_val,padded_clean_categories_val,padded_clean_subcategories_val,
                            norm_previous_projects_val,norm_price_val,norm_quantity_val],[labels_val
]),
          epochs=7,
          batch_size=1024,
          callbacks=[tensorboard,checkpoint])
```

```
WARNING:tensorflow:From <ipython-input-27-3a8aa8280c4d>:6: py_func (from tensorflow.python.ops.script
ops) is deprecated and will be removed in a future version.
Instructions for updating:
tf.py_func is deprecated in TF V2. Instead, use
    tf.py_function, which takes a python function which manipulates tf eager
    tensors instead of numpy arrays. It's easy to convert a tf eager tensor to
    an ndarray (just call tensor.numpy()) but having access to eager tensors
    means `tf.py_function`s can use accelerators such as GPUs as well as
    being differentiable using a gradient tape.

WARNING:tensorflow:From /root/anaconda3/lib/python3.7/site-packages/tensorflow/python/ops/math_ops.py:
3066: to_int32 (from tensorflow.python.ops.math_ops) is deprecated and will be removed in a future ver
sion.
Instructions for updating:
Use tf.cast instead.
Train on 78658 samples, validate on 19665 samples
Epoch 1/7
78658/78658 [==============================] - 120s 2ms/step - loss: 0.4494 - roc_auc: 0.5880 - val_lo
ss: 0.3961 - val_roc_auc: 0.6927

Epoch 00001: val_roc_auc improved from -inf to 0.69267, saving model to weights_best.hdf5
Epoch 2/7
78658/78658 [==============================] - 119s 2ms/step - loss: 0.4177 - roc_auc: 0.6587 - val_lo
ss: 0.3893 - val_roc_auc: 0.7117

Epoch 00002: val_roc_auc improved from 0.69267 to 0.71167, saving model to weights_best.hdf5
Epoch 3/7
78658/78658 [==============================] - 116s 1ms/step - loss: 0.4037 - roc_auc: 0.6841 - val_lo
ss: 0.3875 - val_roc_auc: 0.7187

Epoch 00003: val_roc_auc improved from 0.71167 to 0.71871, saving model to weights_best.hdf5
Epoch 4/7
78658/78658 [==============================] - 115s 1ms/step - loss: 0.3928 - roc_auc: 0.7088 - val_lo
ss: 0.3833 - val_roc_auc: 0.7257

Epoch 00004: val_roc_auc improved from 0.71871 to 0.72575, saving model to weights_best.hdf5
Epoch 5/7
78658/78658 [==============================] - 117s 1ms/step - loss: 0.3845 - roc_auc: 0.7257 - val_lo
ss: 0.3988 - val_roc_auc: 0.7281
```

```
Epoch 00005: val_roc_auc improved from 0.72575 to 0.72814, saving model to weights_best.hdf5
Epoch 6/7
78658/78658 [==============================] - 120s 2ms/step - loss: 0.3788 - roc_auc: 0.7353 - val_lo
ss: 0.3820 - val_roc_auc: 0.7276

Epoch 00006: val_roc_auc did not improve from 0.72814
Epoch 7/7
78658/78658 [==============================] - 121s 2ms/step - loss: 0.3741 - roc_auc: 0.7437 - val_lo
ss: 0.3853 - val_roc_auc: 0.7304

Epoch 00007: val_roc_auc improved from 0.72814 to 0.73041, saving model to weights_best.hdf5
```

Out[29]:
```
<keras.callbacks.History at 0x7f48b3f0bf98>
```

In [30]:
```
!tensorboard --logdir=logs/
```

```
TensorBoard 1.13.1 at http://saugata:6006 (Press CTRL+C to quit)
^C
```

Prediction on unseen test data

In [31]:
```
model.load_weights("weights_best.hdf5")
test_data=[padded_text_test,sequences_teacher_prefix_test,sequences_school_test,padded_project_grade_c
ategory_test,
                  padded_clean_categories_test,padded_clean_subcategories_test,norm_previous_projects_
test,norm_price_test,norm_quantity_test]

#Test AUC
y_pred= model.predict(test_data)
print("AUC on unseen test data: ",roc_auc_score(y_test,y_pred))
```

```
AUC on unseen test data:  0.7303351116201827
```

In [32]:
```
#Save model
model.save("model1.h5")
```

Model-2

1. Train the TF-IDF on the Train data
2. Get the idf value for each word we have in the train data.
3. Remove the low idf value and high idf value words from our data. Do some analysis on the Idf values and based on those values choose the low and high threshold value. Because very frequent words and very very rare words don't give much information. (you can plot a box plots and take only the idf scores within IQR range and corresponding words)

TF-IDF Analysis

In [8]:

```
from sklearn.feature_extraction.text import TfidfVectorizer

#Fit the TFIDF vectorizer to the train data
vect = TfidfVectorizer()
vect.fit_transform(X_train['total_text'])

#Get the features names and their corresponding IDF scores
words = vect.get_feature_names()
idf_words = vect.idf_

#Map the words and their idf_ scores in a disctionary
dict_word_idf_ = dict(zip(words, idf_words))

print("Total number of unique words present originally:", len(words))
```

```
Total number of unique words present originally: 53250
```

Box-Plot Analysis

In [29]:

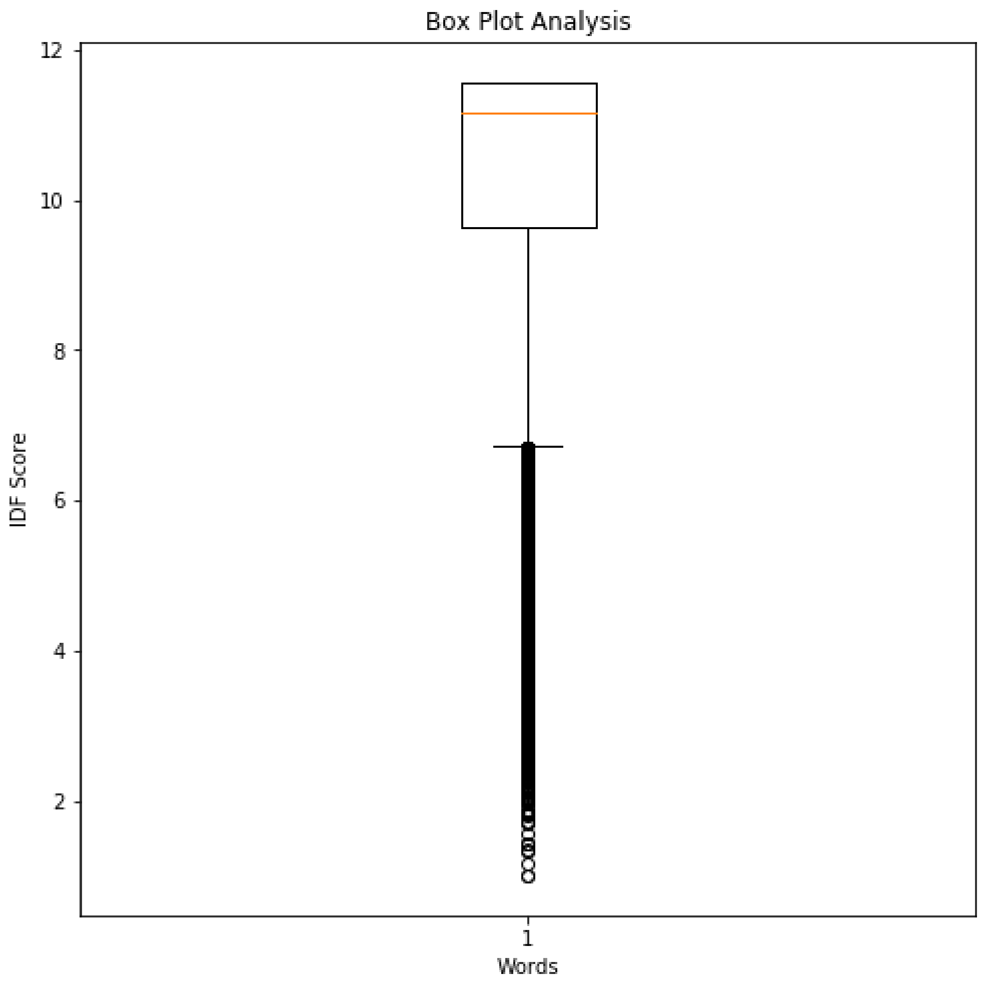
```
p_75th = np.percentile(idf_words,59.81896)
p_75th
```

Out[29]:

```
11.57892343902367
```

In [9]:

```
import matplotlib.pyplot as plt
plt.figure(figsize=(8,8))
plt.boxplot(idf_words)
plt.title('Box Plot Analysis')
plt.xlabel('Words')
plt.ylabel('IDF Score')
plt.show()

p_25th = 3
p_75th = np.percentile(idf_words,75)
#p_75th = 11.555

print("The lowest significant value of TF-IDF Scores: ",p_25th)
print("The highest significant value of TF-IDF Scores: ",p_75th)
```



```
The lowest significant value of TF-IDF Scores:  3
The highest significant value of TF-IDF Scores:  11.57973015240327
```

Create a list of words to be removed

In [10]:

```
removed_wordlist = []
for word in list(dict_word_idf_.keys()):
    if(dict_word_idf_[word] < p_25th or dict_word_idf_[word] > p_75th):
        removed_wordlist.append(word)
    else:
        continue

print("Number of words to be removed: ",len(removed_wordlist))
```

```
Number of words to be removed:  139
```

Removing words from the train and val data which falls outside the threshold range

In [11]:

```
def remove_from_text(list_of_sentences):
    """This function will be used to remove words from text data"""
    processed_text = []
    for sentence in tqdm(list_of_sentences):
        sent = ' '.join(word for word in sentence.split() if word not in removed_wordlist) #We will keep only those words in title which has a string length greater than one
        processed_text.append(sent)
    return processed_text

X_train['total_text'] = remove_from_text(X_train.total_text.values)
X_val['total_text'] = remove_from_text(X_val.total_text.values)
X_test['total_text'] = remove_from_text(X_test.total_text.values)
```

```
100%|██████████| 78658/78658 [00:34<00:00, 2295.18it/s]
100%|██████████| 19665/19665 [00:08<00:00, 2277.37it/s]
100%|██████████| 10925/10925 [00:04<00:00, 2277.97it/s]
```

In [12]:

```
X_train.to_csv("X_train_removed.csv", index=False)
X_val.to_csv("X_val_removed.csv", index=False)
X_test.to_csv("X_test_removed.csv", index=False)
```

In [13]:

```
X_train = pd.read_csv("X_train_removed.csv")
X_val = pd.read_csv("X_val_removed.csv")
X_test = pd.read_csv("X_test_removed.csv")
```

Total Text Data

Building train, test and validation data

In [14]:

```
#Get the total_text values in list
docs_text_train=list(X_train.total_text.values)
docs_text_val=list(X_val.total_text.values)
docs_text_test=list(X_test.total_text.values)
labels_train=np.array(y_train)
labels_val=np.array(y_val)
labels_test=np.array(y_test)

#Initializing the keras tokenizer and fitting it on train data
tokens = Tokenizer()
tokens.fit_on_texts(docs_text_train)

#Convert the texts to sequences using the tokenizer
sequences_text_train = tokens.texts_to_sequences(docs_text_train)
sequences_text_val = tokens.texts_to_sequences(docs_text_val)
sequences_text_test = tokens.texts_to_sequences(docs_text_test)
vocab_size_text = len(tokens.word_index) + 1

#Add padding
padded_text_train = pad_sequences(sequences_text_train, maxlen=300, padding='post')
padded_text_val = pad_sequences(sequences_text_val, maxlen=300, padding='post')
padded_text_test = pad_sequences(sequences_text_test, maxlen=300, padding='post')
```

In [15]:

```
#Load the whole embedding into memory
embeddings_index = dict()
file = open('glove.6B.300d.txt')
for line in file:
    values = line.split()
    word = values[0]
    coefs = asarray(values[1:], dtype='float32')
    embeddings_index[word] = coefs
file.close()
```

```
print('Loaded %s word vectors.' % len(embeddings_index))

#Create a weight matrix for words in training docs
embedding_matrix = zeros((vocab_size_text, 300))
for word, i in tqdm(tokens.word_index.items()):
    embedding_vector = embeddings_index.get(word)
    if embedding_vector is not None:
        embedding_matrix[i] = embedding_vector

print(len(embedding_matrix[0]))
```

```
100%|██████████| 53121/53121 [00:00<00:00, 282202.83it/s]
```

```
Loaded 400000 word vectors.
300
```

In [16]:

```
#Get the flattened LSTM output for input text
input_layer_total_text = Input(shape=(300,), name = "total_text_sequence")
embedding_layer_total_text = Embedding(input_dim=vocab_size_text, output_dim=300, weights=[embedding_matrix], trainable=False)(input_layer_total_text)
lstm_total_text  = LSTM(16, activation="relu", return_sequences=True)(embedding_layer_total_text)
flatten_total_text = Flatten()(lstm_total_text)
```

```
WARNING:tensorflow:From /root/anaconda3/lib/python3.7/site-packages/tensorflow/python/framework/op_def_library.py:263: colocate_with (from tensorflow.python.framework.ops) is deprecated and will be removed in a future version.
Instructions for updating:
Colocations handled automatically by placer.
```

Categorical data: school_state

Building train, test and validation data

In [17]:

```
#Get the school state values
docs_school_state_train=list(X_train.school_state.values)
```

```
docs_school_state_val=list(X_val.school_state.values)
docs_school_state_test=list(X_test.school_state.values)

#Initializing the keras tokenizer and fitting it on train data
tokens = Tokenizer()
tokens.fit_on_texts(docs_school_state_train)

#Convert the school_state to sequences using the tokenizer
sequences_school_train = np.array(tokens.texts_to_sequences(docs_school_state_train))
sequences_school_val = np.array(tokens.texts_to_sequences(docs_school_state_val))
sequences_school_test = np.array(tokens.texts_to_sequences(docs_school_state_test))
vocab_size_school_state = len(tokens.word_index) + 1
```

In [18]:

```
#Get the flattened output for school_state
input_layer_school_state = Input(shape=(1,), name = "encoded_school_state")
embedding_layer_school_state = Embedding(input_dim=vocab_size_school_state, output_dim=4, trainable=True)(input_layer_school_state)
flatten_school_state = Flatten()(embedding_layer_school_state)
```

Categorical data: teacher_prefix

Building train, test and validation data

In [19]:

```
#Get the teacher_prefix values
docs_teacher_prefix_train=list(X_train.teacher_prefix.values)
docs_teacher_prefix_val=list(X_val.teacher_prefix.values)
docs_teacher_prefix_test=list(X_test.teacher_prefix.values)

#Initializing the keras tokenizer and fitting it on train data
tokens = Tokenizer()
tokens.fit_on_texts(docs_teacher_prefix_train)

#Convert the school_state to sequences using the tokenizer
sequences_teacher_prefix_train = np.array(tokens.texts_to_sequences(docs_teacher_prefix_train))
sequences_teacher_prefix_val = np.array(tokens.texts_to_sequences(docs_teacher_prefix_val))
```

```
sequences_teacher_prefix_test = np.array(tokens.texts_to_sequences(docs_teacher_prefix_test))
vocab_size_teacher_prefix = len(tokens.word_index) + 1
```

In [20]:

```
#Get the flattened output for teacher_prefix
input_layer_teacher_prefix = Input(shape=(1,), name = "teacher_prefix")
embedding_layer_teacher_prefix = Embedding(input_dim=vocab_size_teacher_prefix, output_dim=4, trainabl
e=True)(input_layer_teacher_prefix)
flatten_teacher_prefix = Flatten()(embedding_layer_teacher_prefix)
```

Categorical data: project_grade_category

Building train, test and validation data

In [21]:

```
#Get the project_grade_category values
docs_project_grade_category_train=list(X_train.project_grade_category.values)
docs_project_grade_category_val=list(X_val.project_grade_category.values)
docs_project_grade_category_test=list(X_test.project_grade_category.values)

#Initializing the keras tokenizer and fitting it on train data
tokens = Tokenizer()
tokens.fit_on_texts(docs_project_grade_category_train)

#Convert the school_state to sequences using the tokenizer
sequences_project_grade_category_train = tokens.texts_to_sequences(docs_project_grade_category_train)
sequences_project_grade_category_val = tokens.texts_to_sequences(docs_project_grade_category_val)
sequences_project_grade_category_test = tokens.texts_to_sequences(docs_project_grade_category_test)
vocab_size_project_grade_category= len(tokens.word_index) + 1

#Add padding
padded_project_grade_category_train = pad_sequences(sequences_project_grade_category_train, maxlen=3,
padding='post')
padded_project_grade_category_val = pad_sequences(sequences_project_grade_category_val, maxlen=3, padd
ing='post')
padded_project_grade_category_test = pad_sequences(sequences_project_grade_category_test, maxlen=3, pa
dding='post')
```

In [22]:

```
#Get the flattened output for project_grade_category
input_layer_project_grade = Input(shape=(3,), name = "project_grade_category")
embedding_layer_project_grade = Embedding(input_dim=vocab_size_project_grade_category, output_dim=4, trainable=True)(input_layer_project_grade)
flatten_project_grade = Flatten()(embedding_layer_project_grade)
```

Categorical data: clean_categories

Building train, test and validation data

In [23]:

```
#Get the clean_categories values
docs_clean_categories_train=list(X_train.clean_categories.values)
docs_clean_categories_val=list(X_val.clean_categories.values)
docs_clean_categories_test=list(X_test.clean_categories.values)

#Initializing the keras tokenizer and fitting it on train data
tokens = Tokenizer()
tokens.fit_on_texts(docs_clean_categories_train)

#Convert the school_state to sequences using the tokenizer
sequences_clean_categories_train = tokens.texts_to_sequences(docs_clean_categories_train)
sequences_clean_categories_val = tokens.texts_to_sequences(docs_clean_categories_val)
sequences_clean_categories_test = tokens.texts_to_sequences(docs_clean_categories_test)
vocab_size_clean_categories = len(tokens.word_index) + 1

#Add padding
padded_clean_categories_train = pad_sequences(sequences_clean_categories_train, maxlen=3, padding='post')
padded_clean_categories_val = pad_sequences(sequences_clean_categories_val, maxlen=3, padding='post')
padded_clean_categories_test = pad_sequences(sequences_clean_categories_test, maxlen=3, padding='post')
```

In [24]:

```
#Get the flattened output for clean_categories
input_layer_clean_categories = Input(shape=(3,), name = "clean_categories")
embedding_layer_clean_categories = Embedding(input_dim=vocab_size_clean_categories, output_dim=4, trai
nable=True)(input_layer_clean_categories)
flatten_clean_categories = Flatten()(embedding_layer_clean_categories)
```

Categorical data: clean_subcategories

Building train, test and validation data

In [25]:

```
#Get the clean_subcategories values
docs_clean_subcategories_train=list(X_train.clean_subcategories.values)
docs_clean_subcategories_val=list(X_val.clean_subcategories.values)
docs_clean_subcategories_test=list(X_test.clean_subcategories.values)

#Initializing the keras tokenizer and fitting it on train data
tokens = Tokenizer()
tokens.fit_on_texts(docs_clean_subcategories_train)

#Convert the school_state to sequences using the tokenizer
sequences_clean_subcategories_train = tokens.texts_to_sequences(docs_clean_subcategories_train)
sequences_clean_subcategories_val = tokens.texts_to_sequences(docs_clean_subcategories_val)
sequences_clean_subcategories_test = tokens.texts_to_sequences(docs_clean_subcategories_test)
vocab_size_clean_subcategories = len(tokens.word_index) + 1

padded_clean_subcategories_train = pad_sequences(sequences_clean_subcategories_train, maxlen=3, paddin
g='post')
padded_clean_subcategories_val = pad_sequences(sequences_clean_subcategories_val, maxlen=3, padding='p
ost')
padded_clean_subcategories_test = pad_sequences(sequences_clean_subcategories_test, maxlen=3, padding=
'post')
```

In [26]:

```
#Get the flattened output for clean_subcategories
input_layer_clean_subcategories = Input(shape=(3,), name = "clean_subcategories")
embedding_layer_clean_subcategories = Embedding(input_dim=vocab_size_clean_subcategories, output_dim=4
, trainable=True)(input_layer_clean_subcategories)
flatten_clean_subcategories = Flatten()(embedding_layer_clean_subcategories)
```

teacher_number_of_previously_posted_projects

Building train, test and validation data

In [27]:

```
previous_projects_train = X_train.teacher_number_of_previously_posted_projects.values
previous_projects_val = X_val.teacher_number_of_previously_posted_projects.values
previous_projects_test = X_test.teacher_number_of_previously_posted_projects.values

norm_previous_projects_train, normalizer = normalize_vars(previous_projects_train.reshape(1,-1))
norm_previous_projects_val = normalizer.transform(previous_projects_val.reshape(1,-1))
norm_previous_projects_test = normalizer.transform(previous_projects_test.reshape(1,-1))

norm_previous_projects_train = norm_previous_projects_train.reshape(len(X_train),1)
norm_previous_projects_val = norm_previous_projects_val.reshape(len(X_val),1)
norm_previous_projects_test = norm_previous_projects_test.reshape(len(X_test),1)
```

In [28]:

```
#Input layer for teacher_number_of_previously_posted_projects
input_layer_previous_projects = Input(shape=(1,), name = "previous_projects")
```

price

Building train, test and validation data

In [29]:

```
price_train = X_train.price.values
price_val = X_val.price.values
price_test = X_test.price.values

norm_price_train, normalizer = normalize_vars(price_train.reshape(1,-1))
norm_price_val = normalizer.transform(price_val.reshape(1,-1))
norm_price_test = normalizer.transform(price_test.reshape(1,-1))

norm_price_train = norm_price_train.reshape(len(X_train),1)
```

```
norm_price_val = norm_price_val.reshape(len(X_val),1)
norm_price_test = norm_price_test.reshape(len(X_test),1)
```

In [30]:

```
#Input layer for price
input_layer_price = Input(shape=(1,), name = "price")
```

quantity

Building train and validation data

In [31]:

```
quantity_train = X_train.quantity.values
quantity_val = X_val.quantity.values
quantity_test = X_test.quantity.values

norm_quantity_train, normalizer = normalize_vars(quantity_train.reshape(1,-1))
norm_quantity_val = normalizer.transform(quantity_val.reshape(1,-1))
norm_quantity_test = normalizer.transform(quantity_test.reshape(1,-1))

norm_quantity_train = norm_quantity_train.reshape(len(X_train),1)
norm_quantity_val = norm_quantity_val.reshape(len(X_val),1)
norm_quantity_test = norm_quantity_test.reshape(len(X_test),1)
```

In [32]:

```
#Input layer for quantity
input_layer_quantity = Input(shape=(1,), name = "quantity")
```

Concatenation of the numerical layers

In [33]:

```
numerical_features_layers_concat = concatenate([input_layer_previous_projects, input_layer_price, input_layer_quantity])
dense_layer_numerical = Dense(6, activation='relu',kernel_initializer='he_normal')(numerical_features_layers_concat)
```

Concatenation of all the layers and building the final model

In [34]:
```
del( X_train, X_val, y_train, y_val, X, y, project_data, file, embeddings_index, coefs)
```

In [36]:
```
# Merge all the layers according to the architecture diagram
x = concatenate([flatten_total_text, flatten_teacher_prefix, flatten_school_state, flatten_project_gra
de, flatten_clean_categories, flatten_clean_subcategories, dense_layer_numerical])
x = Dense(10, activation='relu',kernel_initializer='he_normal',name='dense_layer_1')(x)
x = Dropout(0.3, name='dropout_1')(x)
x = Dense(10, activation='relu',kernel_initializer='he_normal',name='dense_layer_2')(x)
x = Dropout(0.3, name='dropout_2')(x)
output_layer = Dense(1, activation='sigmoid', name='output_layer')(x)

# Final model
model = Model(inputs=[input_layer_total_text,input_layer_teacher_prefix,input_layer_school_state,input
_layer_project_grade,input_layer_clean_categories,
                      input_layer_clean_subcategories,input_layer_previous_projects,input_layer_price,
input_layer_quantity], outputs=[output_layer])
model.summary()
```

```
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
total_text_sequence (InputLayer (None, 300)          0
__________________________________________________________________________________________________
embedding_1 (Embedding)         (None, 300, 300)     15936600    total_text_sequence[0][0]
__________________________________________________________________________________________________
teacher_prefix (InputLayer)     (None, 1)            0
__________________________________________________________________________________________________
encoded_school_state (InputLaye (None, 1)            0
__________________________________________________________________________________________________
project_grade_category (InputLa (None, 3)            0
__________________________________________________________________________________________________
clean_categories (InputLayer)   (None, 3)            0
__________________________________________________________________________________________________
clean_subcategories (InputLayer (None, 3)            0
__________________________________________________________________________________________________
previous_projects (InputLayer)  (None, 1)            0
__________________________________________________________________________________________________
```

```
price (InputLayer)              (None, 1)            0

quantity (InputLayer)           (None, 1)            0

lstm_1 (LSTM)                   (None, 300, 16)      20288       embedding_1[0][0]

embedding_3 (Embedding)         (None, 1, 4)         24          teacher_prefix[0][0]

embedding_2 (Embedding)         (None, 1, 4)         208         encoded_school_state[0][0]

embedding_4 (Embedding)         (None, 3, 4)         40          project_grade_category[0][0]

embedding_5 (Embedding)         (None, 3, 4)         64          clean_categories[0][0]

embedding_6 (Embedding)         (None, 3, 4)         152         clean_subcategories[0][0]

concatenate_1 (Concatenate)     (None, 3)            0           previous_projects[0][0]
                                                                 price[0][0]
                                                                 quantity[0][0]

flatten_1 (Flatten)             (None, 4800)         0           lstm_1[0][0]

flatten_3 (Flatten)             (None, 4)            0           embedding_3[0][0]

flatten_2 (Flatten)             (None, 4)            0           embedding_2[0][0]

flatten_4 (Flatten)             (None, 12)           0           embedding_4[0][0]

flatten_5 (Flatten)             (None, 12)           0           embedding_5[0][0]

flatten_6 (Flatten)             (None, 12)           0           embedding_6[0][0]

dense_1 (Dense)                 (None, 6)            24          concatenate_1[0][0]

concatenate_3 (Concatenate)     (None, 4850)         0           flatten_1[0][0]
                                                                 flatten_3[0][0]
                                                                 flatten_2[0][0]
                                                                 flatten_4[0][0]
                                                                 flatten_5[0][0]
                                                                 flatten_6[0][0]
                                                                 dense_1[0][0]
__________________________________________________________________________________________________
dense_layer_1 (Dense)           (None, 10)           48510       concatenate_3[0][0]
__________________________________________________________________________________________________
dropout_1 (Dropout)             (None, 10)           0           dense_layer_1[0][0]
__________________________________________________________________________________________________
dense_layer_2 (Dense)           (None, 10)           110         dropout_1[0][0]
__________________________________________________________________________________________________
dropout_2 (Dropout)             (None, 10)           0           dense_layer_2[0][0]
__________________________________________________________________________________________________
output_layer (Dense)            (None, 1)            11          dropout_2[0][0]
==================================================================================================
Total params: 16,006,031
Trainable params: 69,431
Non-trainable params: 15,936,600
__________________________________________________________________________________________________
```

Compiling the final model

In [37]:

```python
import gc
gc.collect()
```

Out[37]:

```
28
```

In [38]:

```python
model.compile(optimizer='adam', loss='binary_crossentropy', metrics=[roc_auc])
model.fit(x=[padded_text_train,sequences_teacher_prefix_train,sequences_school_train,padded_project_grade_category_train,padded_clean_categories_train,padded_clean_subcategories_train,
             norm_previous_projects_train,norm_price_train,norm_quantity_train],
          y=[labels_train],
          validation_data=([padded_text_val,sequences_teacher_prefix_val,sequences_school_val,padded_project_grade_category_val,padded_clean_categories_val,padded_clean_subcategories_val,
                            norm_previous_projects_val,norm_price_val,norm_quantity_val],[labels_val]),
          epochs=5,
          batch_size=1024,
          callbacks=[tensorboard])
```

```
WARNING:tensorflow:From <ipython-input-3-3a8aa8280c4d>:6: py_func (from tensorflow.python.ops.script_o
ps) is deprecated and will be removed in a future version.
Instructions for updating:
tf.py_func is deprecated in TF V2. Instead, use
    tf.py_function, which takes a python function which manipulates tf eager
    tensors instead of numpy arrays. It's easy to convert a tf eager tensor to
    an ndarray (just call tensor.numpy()) but having access to eager tensors
    means `tf.py_function`s can use accelerators such as GPUs as well as
    being differentiable using a gradient tape.

WARNING:tensorflow:From /root/anaconda3/lib/python3.7/site-packages/tensorflow/python/ops/math_ops.py:
3066: to_int32 (from tensorflow.python.ops.math_ops) is deprecated and will be removed in a future ver
sion.
Instructions for updating:
Use tf.cast instead.
Train on 78658 samples, validate on 19665 samples
Epoch 1/5
78658/78658 [==============================] - 120s 2ms/step - loss: 0.4583 - roc_auc: 0.5592 - val_lo
ss: 0.4071 - val_roc_auc: 0.6739
Epoch 2/5
78658/78658 [==============================] - 122s 2ms/step - loss: 0.4251 - roc_auc: 0.6348 - val_lo
ss: 0.3953 - val_roc_auc: 0.6977
Epoch 3/5
78658/78658 [==============================] - 121s 2ms/step - loss: 0.4139 - roc_auc: 0.6641 - val_lo
ss: 0.3929 - val_roc_auc: 0.7062
Epoch 4/5
78658/78658 [==============================] - 119s 2ms/step - loss: 0.4046 - roc_auc: 0.6869 - val_lo
ss: 0.3920 - val_roc_auc: 0.7097
Epoch 5/5
78658/78658 [==============================] - 117s 1ms/step - loss: 0.3994 - roc_auc: 0.6975 - val_lo
ss: 0.3910 - val_roc_auc: 0.7123
```

Out[38]:

```
<keras.callbacks.History at 0x7f998b0ca320>
```

In [41]:

```
!tensorboard --logdir=logs/
```

```
TensorBoard 1.13.1 at http://saugata:6006 (Press CTRL+C to quit)
^C
```

Prediction on unseen test data

In [39]:

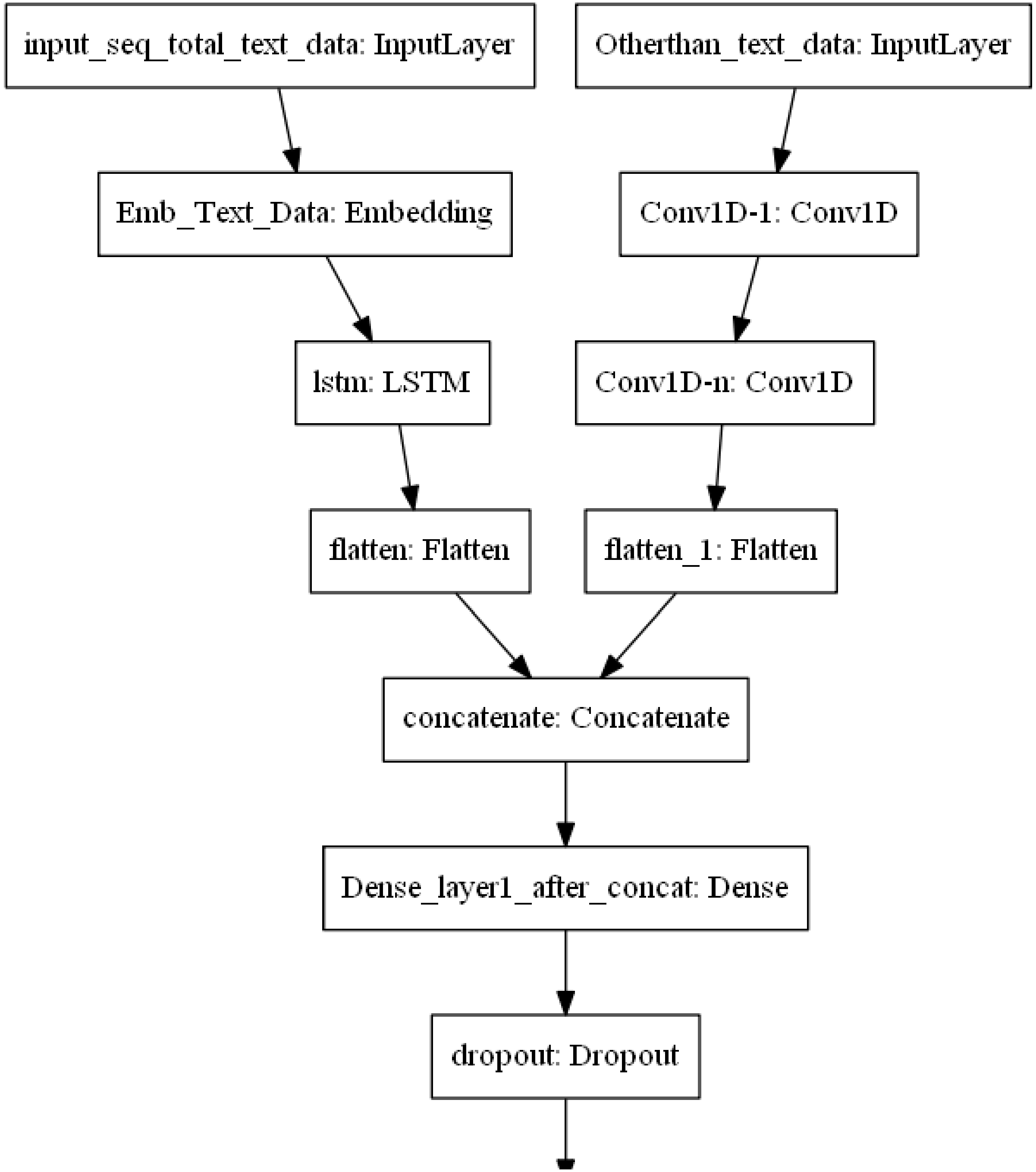
```
test_data=[padded_text_test,sequences_teacher_prefix_test,sequences_school_test,padded_project_grade_c
ategory_test,
                  padded_clean_categories_test,padded_clean_subcategories_test,norm_previous_projects_
test,norm_price_test,norm_quantity_test]

#Test AUC
y_pred= model.predict(test_data)
print("AUC on unseen test data: ",roc_auc_score(y_test,y_pred))
```

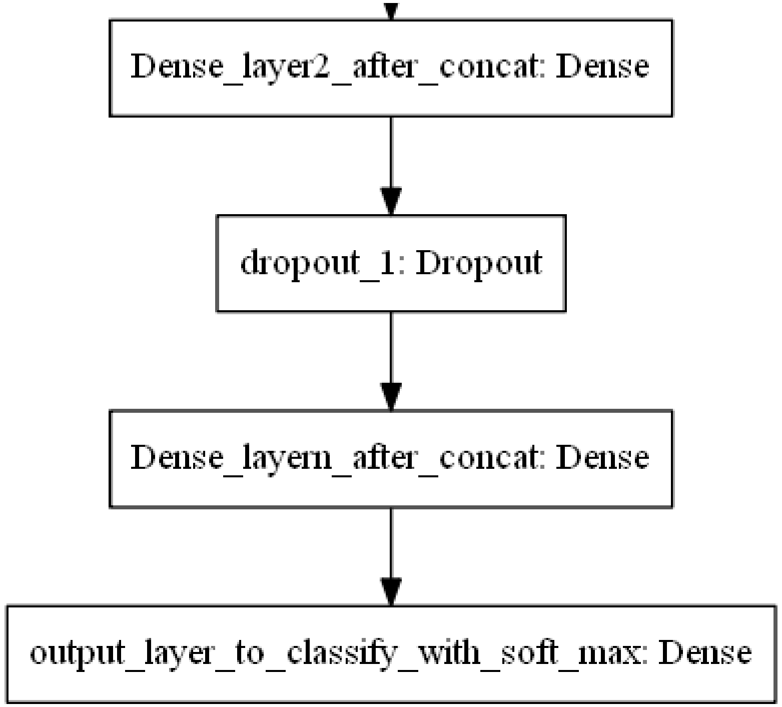
```
AUC on unseen test data:  0.7117405081988445
```

In [42]:

```
#Save model
model.save("model2.h5")
```

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 as shown in above figure.

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

</pre>

1. Load the data

In [2]:

```python
from sklearn.preprocessing import Normalizer

def normalize_vars(data):
    """This function is used to normalize all the input datas between 0 and 1"""
    normalizer = Normalizer()
    data_normalized = normalizer.fit_transform(data.reshape(1, -1))
    return data_normalized, normalizer

import tensorflow as tf
from keras import backend as K
from sklearn.metrics import roc_auc_score
#https://stackoverflow.com/questions/51922500/tf-metrics-auc-yielding-very-different-from-sklearn-metrics-roc-auc-score
def roc_auc(y_true, y_pred):
    auc = tf.py_func(roc_auc_score, (y_true, y_pred), tf.double)
    #auc = tf.metrics.auc(y_true, y_pred, num_thresholds=200)[1]
    K.get_session().run(tf.local_variables_initializer())
    return auc
```

In [3]:

```python
project_data = pd.read_csv("processed_data.csv")
```

2. Splitting the original data into train and test data in 80:20 ratio.

In [4]:

```
#Taking the target and predictor variables into separate variables
y = project_data["project_is_approved"] #target variables
X = project_data.drop(['project_is_approved'], axis=1) #predictor variables

#Split the dataset into train and val dataset
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.10, random_state=1, stratify=y)
X_train, X_val, y_train, y_val = train_test_split(X_train, y_train, test_size=0.20, random_state=1, st
ratify=y_train)

#Display basic information after splitting the data
print("Number of points in train data: ",X_train.shape[0])
print("Number of points in validation data: ",X_val.shape[0])
print("Number of points in test data: ",X_test.shape[0])
```

```
Number of points in train data:  78658
Number of points in validation data:  19665
Number of points in test data:  10925
```

3. Tokenizing Total Text Data

Building train, test and validation data

In [5]:

```
#Get the total_text values in list
docs_text_train=list(X_train.total_text.values)
docs_text_val=list(X_val.total_text.values)
docs_text_test=list(X_test.total_text.values)
labels_train=np.array(y_train)
labels_val=np.array(y_val)
labels_test=np.array(y_test)

#Initializing the keras tokenizer and fitting it on train data
tokens = Tokenizer()
tokens.fit_on_texts(docs_text_train)

#Convert the texts to sequences using the tokenizer
```

```
sequences_text_train = tokens.texts_to_sequences(docs_text_train)
sequences_text_val = tokens.texts_to_sequences(docs_text_val)
sequences_text_test = tokens.texts_to_sequences(docs_text_test)
vocab_size_text = len(tokens.word_index) + 1

#Add padding
padded_text_train = pad_sequences(sequences_text_train, maxlen=300, padding='post')
padded_text_val = pad_sequences(sequences_text_val, maxlen=300, padding='post')
padded_text_test = pad_sequences(sequences_text_test, maxlen=300, padding='post')
```

In [6]:

```
#Load the whole embedding into memory
embeddings_index = dict()
file = open('glove.6B.300d.txt')
for line in file:
    values = line.split()
    word = values[0]
    coefs = asarray(values[1:], dtype='float32')
    embeddings_index[word] = coefs
file.close()

print('Loaded %s word vectors.' % len(embeddings_index))

#Create a weight matrix for words in training docs
embedding_matrix = zeros((vocab_size_text, 300))
for word, i in tqdm(tokens.word_index.items()):
    embedding_vector = embeddings_index.get(word)
    if embedding_vector is not None:
        embedding_matrix[i] = embedding_vector #embedding_matrix.shape: (9049, 300)

print(len(embedding_matrix[0]))
```

```
100%|██████████| 53260/53260 [00:00<00:00, 296603.40it/s]
```

```
Loaded 400000 word vectors.
300
```

In [8]:

```
#Get the flattened LSTM output for input text
input_layer_total_text = Input(shape=(300,), name = "total_text_sequence")
```

```
embedding_layer_total_text = Embedding(input_dim=vocab_size_text, output_dim=300, weights=[embedding_matrix], trainable=False)(input_layer_total_text)
lstm_total_text  = LSTM(40, activation="relu", return_sequences=True)(embedding_layer_total_text)
flatten_lstm_out = Flatten()(lstm_total_text)
```

4. One hot encoding categorical features

In [9]:

```
from sklearn.preprocessing import OneHotEncoder
from sklearn.feature_extraction.text import CountVectorizer
```

In [10]:

```
#School state
encoder=OneHotEncoder().fit(X_train['school_state'].values.reshape(-1,1))
enc_school_state_train=encoder.transform(X_train['school_state'].values.reshape(-1,1))
enc_school_state_val=encoder.transform(X_val['school_state'].values.reshape(-1, 1))
enc_school_state_test=encoder.transform(X_test['school_state'].values.reshape(-1, 1))

#Teacher prefix
encoder=OneHotEncoder().fit(X_train['teacher_prefix'].values.reshape(-1,1))
enc_teacher_prefix_train=encoder.transform(X_train['teacher_prefix'].values.reshape(-1,1))
enc_teacher_prefix_val=encoder.transform(X_val['teacher_prefix'].values.reshape(-1, 1))
enc_teacher_prefix_test=encoder.transform(X_test['teacher_prefix'].values.reshape(-1, 1))

#project_grade_category
encoder=OneHotEncoder().fit(X_train['project_grade_category'].values.reshape(-1,1))
enc_project_grade_category_train=encoder.transform(X_train['project_grade_category'].values.reshape(-1,1))
enc_project_grade_category_val=encoder.transform(X_val['project_grade_category'].values.reshape(-1, 1))
enc_project_grade_category_test=encoder.transform(X_test['project_grade_category'].values.reshape(-1, 1))

#clean_categories
encoder=CountVectorizer(binary=True).fit(X_train['clean_categories'])
enc_clean_categories_category_train=encoder.transform(X_train['clean_categories'])
enc_clean_categories_category_val=encoder.transform(X_val['clean_categories'])
enc_clean_categories_category_test=encoder.transform(X_test['clean_categories'])
```

```
#clean_subcategories
encoder=CountVectorizer(binary=True).fit(X_train['clean_subcategories'])
enc_clean_subcategories_train=encoder.transform(X_train['clean_subcategories'])
enc_clean_subcategories_val=encoder.transform(X_val['clean_subcategories'])
enc_clean_subcategories_test=encoder.transform(X_test['clean_subcategories'])
```

5. Normalizing numerical data

In [11]:

```
#teacher_number_of_previously_posted_projects
previous_projects_train = X_train.teacher_number_of_previously_posted_projects.values
previous_projects_val = X_val.teacher_number_of_previously_posted_projects.values
previous_projects_test = X_test.teacher_number_of_previously_posted_projects.values

norm_previous_projects_train, normalizer = normalize_vars(previous_projects_train.reshape(1,-1))
norm_previous_projects_val = normalizer.transform(previous_projects_val.reshape(1,-1))
norm_previous_projects_test = normalizer.transform(previous_projects_test.reshape(1,-1))

norm_previous_projects_train = norm_previous_projects_train.reshape(len(X_train),1)
norm_previous_projects_val = norm_previous_projects_val.reshape(len(X_val),1)
norm_previous_projects_test = norm_previous_projects_test.reshape(len(X_test),1)

#price
price_train = X_train.price.values
price_val = X_val.price.values
price_test = X_test.price.values

norm_price_train, normalizer = normalize_vars(price_train.reshape(1,-1))
norm_price_val = normalizer.transform(price_val.reshape(1,-1))
norm_price_test = normalizer.transform(price_test.reshape(1,-1))

norm_price_train = norm_price_train.reshape(len(X_train),1)
norm_price_val = norm_price_val.reshape(len(X_val),1)
norm_price_test = norm_price_test.reshape(len(X_test),1)

#quantity
quantity_train = X_train.quantity.values
quantity_val = X_val.quantity.values
```

```
quantity_test = X_test.quantity.values

norm_quantity_train, normalizer = normalize_vars(quantity_train.reshape(1,-1))
norm_quantity_val = normalizer.transform(quantity_val.reshape(1,-1))
norm_quantity_test = normalizer.transform(quantity_test.reshape(1,-1))

norm_quantity_train = norm_quantity_train.reshape(len(X_train),1)
norm_quantity_val = norm_quantity_val.reshape(len(X_val),1)
norm_quantity_test = norm_quantity_test.reshape(len(X_test),1)
```

5. Stacking the numerical and categorical vectors

In [12]:

```
from scipy.sparse import hstack
stacked_vectors_train = hstack((enc_school_state_train,enc_teacher_prefix_train,enc_project_grade_category_train,enc_clean_categories_category_train,enc_clean_subcategories_train,
                                norm_previous_projects_train,norm_price_train,norm_quantity_train))

stacked_vectors_val = hstack((enc_school_state_val,enc_teacher_prefix_val,enc_project_grade_category_val,enc_clean_categories_category_val,enc_clean_subcategories_val,
                                norm_previous_projects_val,norm_price_val,norm_quantity_val))

stacked_vectors_test = hstack((enc_school_state_test,enc_teacher_prefix_test,enc_project_grade_category_test,enc_clean_categories_category_test,enc_clean_subcategories_test,
                                norm_previous_projects_test,norm_price_test,norm_quantity_test))
```

In [13]:

```
encoded_df_train = np.expand_dims(pd.DataFrame(stacked_vectors_train.todense()), axis=2)
encoded_df_val = np.expand_dims(pd.DataFrame(stacked_vectors_val.todense()), axis=2)
encoded_df_test = np.expand_dims(pd.DataFrame(stacked_vectors_test.todense()), axis=2)
```

6. Defining the model architecture

In [24]:

```
from keras.layers import Conv1D, MaxPooling2D, Input, Dense, Flatten
from keras.models import Model

conv_input = Input(shape=(stacked_vectors_train.shape[1],1), name="non_text_data_layer")
```

```
x = Conv1D(filters=16, kernel_size=4, activation='relu',name='conv_layer_1')(conv_input)
x = Conv1D(filters=32, kernel_size=4, activation='relu',name='conv_layer_2')(x)
x = Conv1D(filters=64, kernel_size=4, activation='relu',name='conv_layer_3')(x)
flatten_conv_output = Flatten()(x)
```

In [14]:

```
del( X_train, X_val, y_train, y_val, X, y, project_data, file, embeddings_index, coefs, stacked_vector
s_val)
```

In [25]:

```
from keras.layers import Input, Embedding, LSTM, Dense, concatenate, Dropout

x = concatenate([flatten_lstm_out, flatten_conv_output])

x = Dense(32, activation='relu',kernel_initializer='he_normal',name='dense_layer_1')(x)
x = Dropout(0.25)(x)
x = Dense(64, activation='relu',kernel_initializer='he_normal',name='dense_layer_2')(x)
x = BatchNormalization()(x)
#x = Dropout(0.25)(x)
x = Dense(128, activation='relu',kernel_initializer='he_normal',name='dense_layer_3')(x)

output = Dense(1, activation='sigmoid', name='output')(x)

model = Model(inputs=[input_layer_total_text,conv_input], outputs=[output])
model.summary()
```

```
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to                     
==================================================================================================
non_text_data_layer (InputLayer (None, 102, 1)       0                                            
__________________________________________________________________________________________________
total_text_sequence (InputLayer (None, 300)          0                                            
__________________________________________________________________________________________________
conv_layer_1 (Conv1D)           (None, 99, 16)       80          non_text_data_layer[0][0]        
__________________________________________________________________________________________________
embedding_2 (Embedding)         (None, 300, 300)     15978300    total_text_sequence[0][0]        
__________________________________________________________________________________________________
conv_layer_2 (Conv1D)           (None, 96, 32)       2080        conv_layer_1[0][0]               
__________________________________________________________________________________________________
lstm_2 (LSTM)                   (None, 300, 40)      54560       embedding_2[0][0]                
__________________________________________________________________________________________________
```

```
conv_layer_3 (Conv1D)           (None, 93, 64)       8256        conv_layer_2[0][0]
__________________________________________________________________________________________________
flatten_2 (Flatten)             (None, 12000)        0           lstm_2[0][0]
__________________________________________________________________________________________________
flatten_4 (Flatten)             (None, 5952)         0           conv_layer_3[0][0]
__________________________________________________________________________________________________
concatenate_4 (Concatenate)     (None, 17952)        0           flatten_2[0][0]
                                                                 flatten_4[0][0]
__________________________________________________________________________________________________
dense_layer_1 (Dense)           (None, 32)           574496      concatenate_4[0][0]
__________________________________________________________________________________________________
dropout_5 (Dropout)             (None, 32)           0           dense_layer_1[0][0]
__________________________________________________________________________________________________
dense_layer_2 (Dense)           (None, 64)           2112        dropout_5[0][0]
__________________________________________________________________________________________________
batch_normalization_3 (BatchNor (None, 64)           256         dense_layer_2[0][0]
__________________________________________________________________________________________________
dense_layer_3 (Dense)           (None, 128)          8320        batch_normalization_3[0][0]
__________________________________________________________________________________________________
output (Dense)                  (None, 1)            129         dense_layer_3[0][0]
==================================================================================================
Total params: 16,628,589
Trainable params: 650,161
Non-trainable params: 15,978,428
__________________________________________________________________________________________________
```

7. Compiling the final model

In [16]:

```
from time import time
from tensorflow.python.keras.callbacks import TensorBoard, EarlyStopping
from keras.callbacks import ModelCheckpoint, ReduceLROnPlateau


tensorboard = TensorBoard(log_dir="logs/{}".format(time))

filepath="weights_best.hdf5"
checkpoint = ModelCheckpoint(filepath, monitor='val_roc_auc', verbose=1, save_best_only=True, mode='ma
x')
reduce_lr = reduce_lr = ReduceLROnPlateau(monitor='val_roc_auc', mode='max', factor=0.2, patience=0)
```

In [19]:
```
model.compile(optimizer='adam', loss='binary_crossentropy', metrics=[roc_auc])
model.fit(x=[padded_text_train, encoded_df_train],
          y=[labels_train],
          epochs=6,
          batch_size=1024,
          validation_data=([padded_text_val, encoded_df_val],[labels_val]),
          callbacks=[tensorboard,checkpoint,reduce_lr])
```

```
WARNING:tensorflow:From <ipython-input-2-0d2476dd34f0>:14: py_func (from tensorflow.python.ops.script_
ops) is deprecated and will be removed in a future version.
Instructions for updating:
tf.py_func is deprecated in TF V2. Instead, use
    tf.py_function, which takes a python function which manipulates tf eager
    tensors instead of numpy arrays. It's easy to convert a tf eager tensor to
    an ndarray (just call tensor.numpy()) but having access to eager tensors
    means `tf.py_function`s can use accelerators such as GPUs as well as
    being differentiable using a gradient tape.

WARNING:tensorflow:From /root/anaconda3/lib/python3.7/site-packages/tensorflow/python/ops/math_ops.py:
3066: to_int32 (from tensorflow.python.ops.math_ops) is deprecated and will be removed in a future ver
sion.
Instructions for updating:
Use tf.cast instead.
Train on 78658 samples, validate on 19665 samples
Epoch 1/6
78658/78658 [==============================] - 226s 3ms/step - loss: 0.4238 - roc_auc: 0.6168 - val_lo
ss: 0.4026 - val_roc_auc: 0.7012

Epoch 00001: val_roc_auc improved from -inf to 0.70117, saving model to weights_best.hdf5
Epoch 2/6
78658/78658 [==============================] - 224s 3ms/step - loss: 0.3891 - roc_auc: 0.7121 - val_lo
ss: 0.4043 - val_roc_auc: 0.7225

Epoch 00002: val_roc_auc improved from 0.70117 to 0.72249, saving model to weights_best.hdf5
Epoch 3/6
78658/78658 [==============================] - 224s 3ms/step - loss: 0.3799 - roc_auc: 0.7339 - val_lo
```

```
ss: 0.4017 - val_roc_auc: 0.7319

Epoch 00003: val_roc_auc improved from 0.72249 to 0.73188, saving model to weights_best.hdf5
Epoch 4/6
78658/78658 [==============================] - 223s 3ms/step - loss: 0.3719 - roc_auc: 0.7508 - val_lo
ss: 0.3861 - val_roc_auc: 0.7365

Epoch 00004: val_roc_auc improved from 0.73188 to 0.73650, saving model to weights_best.hdf5
Epoch 5/6
78658/78658 [==============================] - 223s 3ms/step - loss: 0.3641 - roc_auc: 0.7676 - val_lo
ss: 0.3823 - val_roc_auc: 0.7379

Epoch 00005: val_roc_auc improved from 0.73650 to 0.73795, saving model to weights_best.hdf5
Epoch 6/6
78658/78658 [==============================] - 223s 3ms/step - loss: 0.3538 - roc_auc: 0.7894 - val_lo
ss: 0.3930 - val_roc_auc: 0.7361

Epoch 00006: val_roc_auc did not improve from 0.73795
```

Out[19]:

```
<keras.callbacks.History at 0x7f866755d7f0>
```

In [23]:

```
!tensorboard --logdir=logs/
```

```
TensorBoard 1.13.1 at http://saugata:6006 (Press CTRL+C to quit)
^C
```

Prediction on unseen test data

In [21]:

```
model.load_weights("weights_best.hdf5")
test_data=[padded_text_test,encoded_df_test]

#Test AUC
y_pred= model.predict(test_data)
print("AUC on unseen test data: ",roc_auc_score(y_test,y_pred))
```

```
AUC on unseen test data:  0.7413265464711182
```

In [20]:

```
#Save model
model.save("model3.h5")
```

Model comparison

In [26]:

```
from prettytable import PrettyTable

table =PrettyTable()
table.field_names = ["Model No", "Trained for Epochs", "Train ROC-AUC", "Validation ROC-AUC", "Test RO
C-AUC"]
table.add_row(["Model 1",7,0.7437,0.7304,0.7303])
table.add_row(["Model 2",5,0.6975,0.7123,0.7147])
table.add_row(["Model 3",6,0.7676,0.7379,0.7413])
print(table)
```

```
+----------+--------------------+---------------+--------------------+---------------+
| Model No | Trained for Epochs | Train ROC-AUC | Validation ROC-AUC | Test ROC-AUC |
+----------+--------------------+---------------+--------------------+---------------+
| Model 1  |         7          |     0.7437    |       0.7304       |     0.7303    |
| Model 2  |         5          |     0.6975    |       0.7123       |     0.7147    |
| Model 3  |         6          |     0.7676    |       0.7379       |     0.7413    |
+----------+--------------------+---------------+--------------------+---------------+
```

Brief Summary:

1. Amongst all the three models, the 3rd model with 1D CNN layers seems to perform the best as we have got the maximum value of ROC-AUC for it.
2. I first tried without proper weight initialization in the hidden layers, but this was resulting in a massive overfitting and the models were trained way-wardly. The test roc auc was always 7-10% more than the validation roc-auc.There was also an issue of exploding gradients after training the models for longer epochs. The problem of exploding gradients seems to have been resolved on using proper initialization techniques.

3. Using RSM Prop with proper weight initialization was also resulting in exploding gradients for Model 1. Changing the optimizer to adam has changed this problem.
4. Got the loss curves and score curve using Tensorboard.
5. Used a custome metric function for training the model with a custom roc-auc score.
6. For TFIDF analysis, I first tried with the 25 percentile threshold for tfidf scores and the model performed very poorly despiting trying my best to optimize it. The lowest threshold I have considered for this assignment is 6.5 approximately.
7. Model 3 has given us the best value of ROC-AUC - just under 0.75.
8. Used this blog as a reference for doing this assignment: https://machinelearningmastery.com/use-word-embedding-layers-deep-learning-keras/
9. For TFIDF analysis, I had previously tried with IDF score between 7 and max value, ut it resulted in huge loss of data. Hence I took IDF values which were greater than 3 and the model has improved a lot.