DCLSTM

October 11, 2020

1 DonorsChoose

DonorsChoose.org receives hundreds of thousands of project proposals each year for classroom projects in need of funding. Right now, a large number of volunteers is needed to manually screen each submission before it's approved to be posted on the DonorsChoose.org website.

```
Next year, DonorsChoose.org expects to receive close to 500,000 project proposals. As a result

How to scale current manual processes and resources to screen 500,000 projects so that they ca
<li>How to increase the consistency of project vetting across different volunteers to improve 
<li>How to focus volunteer time on the applications that need the most assistance</li>
</ul>
```

The goal of the competition is to predict whether or not a DonorsChoose.org project proposal submitted by a teacher will be approved, using the text of project descriptions as well as additional metadata about the project, teacher, and school. DonorsChoose.org can then use this information to identify projects most likely to need further review before approval.

1.1 About the DonorsChoose Data Set

The `train.csv` data set provided by DonorsChoose contains the following features:

Feature	Description
`project_id`	A unique identifier for the proposed project. **Example:** `p036502`

`project_title` | Title of the project. **Examples:**
Art Will Make You Happy!
First Grade Fun
`project_grade_category` | Grade level of students for which the project is targeted. One of the following enumerated values:
Grades PreK-2
Grades 3-5
Grades 6-8
Grades 9-12
`project_subject_categories` | One or more (comma-separated) subject categories for the project from the following enumerated list of values:
Applied Learning

Care & Hunger
Health & Sports
History & Civics
Literacy & Language
Math & Science
Music & The Arts
Special Needs
Warmth
Examples:
Music & The Arts
Literacy & Language, Math & Science

`school_state` | State where school is located (Two-letter U.S. postal code). **Example:** `WY`
`project_subject_subcategories` | One or more (comma-separated) subject subcategories for the project. **Examples:**
Literacy
Literature & Writing, Social Sciences

`project_resource_summary` | An explanation of the resources needed for the project. **Example:**
My students need hands on literacy materials to manage sensory needs!

`project_essay_1` | First application essay
`project_essay_2` | Second application essay `project_essay_3` | Third application essay *`project_essay_4` | Fourth application essay* `project_submitted_datetime` | Datetime when project application was submitted. **Example:** `2016-04-28 12:43:56.245`
`teacher_id` | A unique identifier for the teacher of the proposed project. **Example:** `bdf8baa8fedef6bfeec7ae4ff1c15c56`
`teacher_prefix` | Teacher's title. One of the following enumerated values:
nan
Dr.
Mr.
Mrs.
Ms.
Teacher.

`teacher_number_of_previously_posted_projects` | Number of project applications previously submitted by the same teacher. **Example:** 2

* See the section Notes on the Essay Data for more details about these features.

Additionally, the `resources.csv` data set provides more data about the resources required for each project. Each line in this file represents a resource required by a project:

Feature	Description
`id`	A `project_id` value from the `train.csv` file. **Example:** `p036502`
`description`	Desciption of the resource. **Example:** `Tenor Saxophone Reeds, Box of 25`

Feature	Description
`quantity`	Quantity of the resource required. **Example:** `3`
`price`	Price of the resource required. **Example:** `9.95`

Note: Many projects require multiple resources. The `id` value corresponds to a `project_id` in train.csv, so you use it as a key to retrieve all resources needed for a project:

The data set contains the following label (the value you will attempt to predict):

Label	Description
`project_is_approved`	A binary flag indicating whether DonorsChoose approved the project. A value of `0` indicates the project was not approved, and a value of `1` indicates the project was approved.

1.1.1 Notes on the Essay Data

Prior to May 17, 2016, the prompts for the essays were as follows:

project_essay_1: "Introduce us to your classroom"

project_essay_2: "Tell us more about your students"

project_essay_3: "Describe how your students will use the materials you're requesting"

project_essay_3: "Close by sharing why your project will make a difference"

Starting on May 17, 2016, the number of essays was reduced from 4 to 2, and the prompts for the first 2 essays were changed to the following:

project_essay_1: "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."

project_essay_2: "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

For all projects with project_submitted_datetime of 2016-05-17 and later, the values of project_essay_3 and project_essay_4 will be NaN.

[1]:
```python
from google.colab import drive
drive.mount('/content/drive')
```

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

[2]:

```
import os
os.chdir("/content/drive/My Drive/DC")
!ls -l
```

```
total 589315
-rw------- 1 root root 110168504 Oct 10 08:47 bestgpu.hdf5
drwx------ 2 root root      4096 Oct 10 08:43 CLR
-r-------- 1 root root 127506004 May 29  2019 glove_vectors
drwx------ 2 root root      4096 Oct 10 08:53 logs
-rw------- 1 root root  38033424 Oct 10 16:54 model2.hdf5
-rw------- 1 root root  67721112 Oct 10 12:45 model3_1.hdf5
-rw------- 1 root root  67721112 Oct 10 11:25 model3_2.hdf5
-rw------- 1 root root  67698072 Oct 10 09:29 model3.hdf5
-rw------- 1 root root    145420 Oct 10 16:52 model.png
-r-------- 1 root root 124454659 May 29  2019 preprocessed_data.csv
```

[3]:

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

import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
from nltk.stem.porter import PorterStemmer

import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer

from gensim.models import Word2Vec
from gensim.models import KeyedVectors
import pickle
```

```
from tqdm import tqdm
import os

!pip install chart_studio

from chart_studio.plotly import plotly
import plotly.graph_objs as go

import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
from collections import Counter
```

```
Collecting chart_studio
  Downloading https://files.pythonhosted.org/packages/ca/ce/330794a6b6ca4b
9182c38fc69dd2a9cbff60fd49421cb8648ee5fee352dc/chart_studio-1.1.0-py3-none-
any.whl (64kB)
     || 71kB 3.6MB/s
Requirement already satisfied: plotly in /usr/local/lib/python3.6/dist-
packages (from chart_studio) (4.4.1)
Requirement already satisfied: retrying>=1.3.3 in /usr/local/lib/python3.6/dist-
packages (from chart_studio) (1.3.3)
Requirement already satisfied: six in /usr/local/lib/python3.6/dist-packages
(from chart_studio) (1.15.0)
Requirement already satisfied: requests in /usr/local/lib/python3.6/dist-
packages (from chart_studio) (2.23.0)
Requirement already satisfied: idna<3,>=2.5 in /usr/local/lib/python3.6/dist-
packages (from requests->chart_studio) (2.10)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.6
/dist-packages (from requests->chart_studio) (2020.6.20)
Requirement already satisfied: chardet<4,>=3.0.2 in /usr/local/lib/python3.6
/dist-packages (from requests->chart_studio) (3.0.4)
Requirement already satisfied: urllib3!=1.25.0,!=1.25.1,<1.26,>=1.21.1 in
/usr/local/lib/python3.6/dist-packages (from requests->chart_studio) (1.24.3)
Installing collected packages: chart-studio
Successfully installed chart-studio-1.1.0
```

1.2 1.1 Reading Data

[ ]:

```
project_data = pd.read_csv('train_data.csv')
resource_data = pd.read_csv('resources.csv')
```

[ ]:

```
print("Number of data points in train data", project_data.shape)
print('-'*50)
print("The attributes of data :", project_data.columns.values)
```

```
Number of data points in train data (109248, 17)
--------------------------------------------------
```

```
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' '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']
```

[ ]:

```
print("Number of data points in train data", resource_data.shape)
print(resource_data.columns.values)
resource_data.head(2)
```

```
Number of data points in train data (1541272, 4)
['id' 'description' 'quantity' 'price']
```

[ ]:

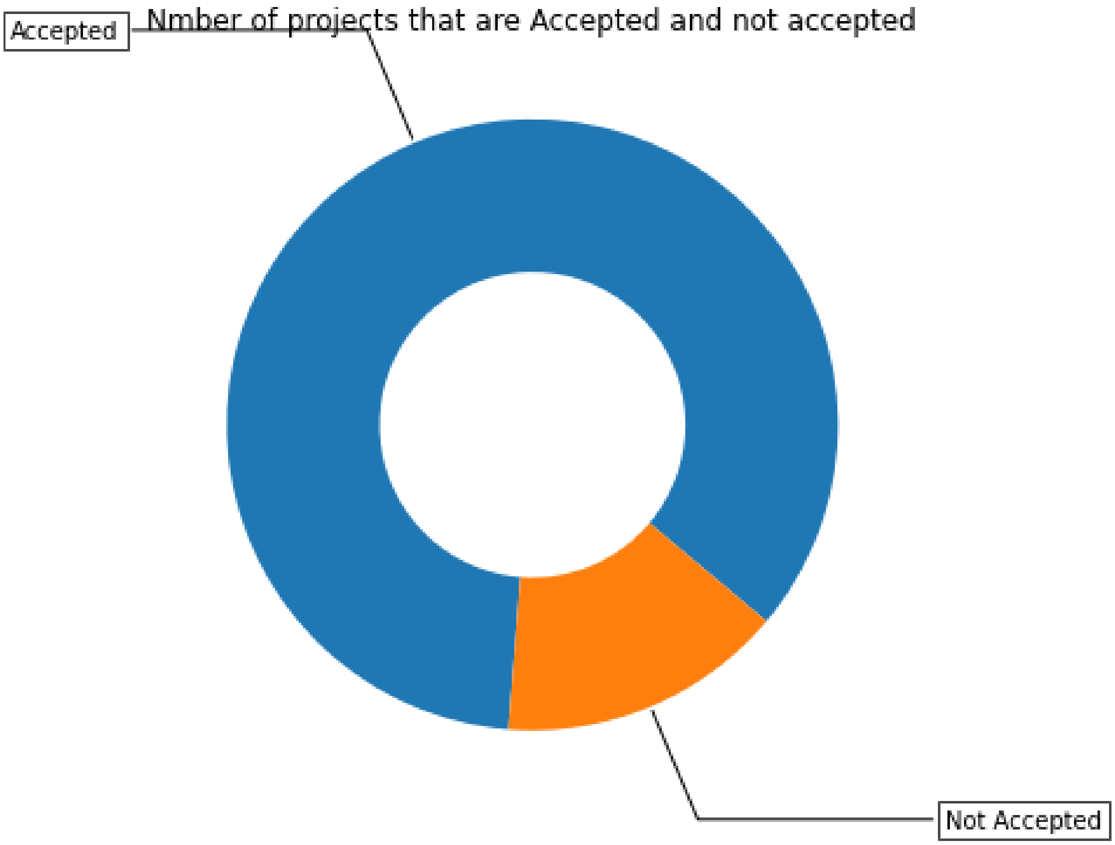
```
        id                                        description  quantity   price
0  p233245  LC652 - Lakeshore Double-Space Mobile Drying Rack         1  149.00
1  p069063        Bouncy Bands for Desks (Blue support pipes)         3   14.95
```

2 1.2 Data Analysis

[ ]:

```
# this code is taken from
# https://matplotlib.org/gallery/pie_and_polar_charts/pie_and_donut_labels.
 ↪html#sphx-glr-gallery-pie-and-polar-charts-pie-and-donut-labels-py



y_value_counts = project_data['project_is_approved'].value_counts()
print("Number of projects thar are approved for funding ", y_value_counts[1],␣
 ↪", (", (y_value_counts[1]/(y_value_counts[1]+y_value_counts[0]))*100,"%)")
print("Number of projects thar are not approved for funding ",␣
 ↪y_value_counts[0], ", (", (y_value_counts[0]/
 ↪(y_value_counts[1]+y_value_counts[0]))*100,"%)")

fig, ax = plt.subplots(figsize=(6, 6), subplot_kw=dict(aspect="equal"))
recipe = ["Accepted", "Not Accepted"]

data = [y_value_counts[1], y_value_counts[0]]

wedges, texts = ax.pie(data, wedgeprops=dict(width=0.5), startangle=-40)

bbox_props = dict(boxstyle="square,pad=0.3", fc="w", ec="k", lw=0.72)
kw = dict(xycoords='data', textcoords='data', arrowprops=dict(arrowstyle="-"),
          bbox=bbox_props, zorder=0, va="center")

for i, p in enumerate(wedges):
    ang = (p.theta2 - p.theta1)/2. + p.theta1
    y = np.sin(np.deg2rad(ang))
    x = np.cos(np.deg2rad(ang))
    horizontalalignment = {-1: "right", 1: "left"}[int(np.sign(x))]
    connectionstyle = "angle,angleA=0,angleB={}".format(ang)
    kw["arrowprops"].update({"connectionstyle": connectionstyle})
    ax.annotate(recipe[i], xy=(x, y), xytext=(1.35*np.sign(x), 1.4*y),
                horizontalalignment=horizontalalignment, **kw)

ax.set_title("Nmber of projects that are Accepted and not accepted")

plt.show()
```

```
Number of projects thar are approved for funding  92706 , ( 84.85830404217927 %)
Number of projects thar are not approved for funding  16542 , (
15.141695957820739 %)
```



2.0.1 1.2.1 Univariate Analysis: School State

[ ]:

```
# Pandas dataframe grouby count, mean: https://stackoverflow.com/a/19385591/
 ↪4084039

temp = pd.DataFrame(project_data.groupby("school_state")["project_is_approved"].
 ↪apply(np.mean)).reset_index()
# if you have data which contain only 0 and 1, then the mean = percentage␣
 ↪(think about it)
temp.columns = ['state_code', 'num_proposals']

# How to plot US state heatmap: https://datascience.stackexchange.com/a/9620

scl = [[0.0, 'rgb(242,240,247)'],[0.2, 'rgb(218,218,235)'],[0.4,␣
 ↪'rgb(188,189,220)'],\
            [0.6, 'rgb(158,154,200)'],[0.8, 'rgb(117,107,177)'],[1.0,␣
 ↪'rgb(84,39,143)']]

data = [ dict(
        type='choropleth',
        colorscale = scl,
        autocolorscale = False,
        locations = temp['state_code'],
        z = temp['num_proposals'].astype(float),
        locationmode = 'USA-states',
        text = temp['state_code'],
        marker = dict(line = dict (color = 'rgb(255,255,255)',width = 2)),
        colorbar = dict(title = "% of pro")
    ) ]

layout = dict(
        title = 'Project Proposals % of Acceptance Rate by US States',
        geo = dict(
            scope='usa',
            projection=dict( type='albers usa' ),
            showlakes = True,
            lakecolor = 'rgb(255, 255, 255)',
        ),
    )

fig = go.Figure(data=data, layout=layout)
iplot(fig, filename='us-map-heat-map')
```

[ ]:

```
# https://www.csi.cuny.edu/sites/default/files/pdf/administration/ops/
 ↪2letterstabbrev.pdf
temp.sort_values(by=['num_proposals'], inplace=True)
print("States with lowest % approvals")
print(temp.head(5))
print('='*50)
print("States with highest % approvals")
print(temp.tail(5))
```

```
States with lowest % approvals
   state_code  num_proposals
46         VT       0.800000
7          DC       0.802326
43         TX       0.813142
26         MT       0.816327
18         LA       0.831245
==================================================
States with highest % approvals
   state_code  num_proposals
30         NH       0.873563
35         OH       0.875152
47         WA       0.876178
28         ND       0.888112
8          DE       0.897959
```

[ ]:

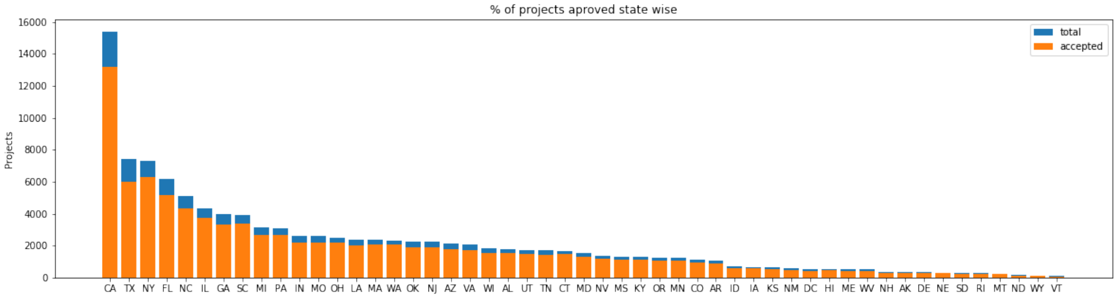
```
#stacked bar plots matplotlib: https://matplotlib.org/gallery/
 ↪lines_bars_and_markers/bar_stacked.html
def stack_plot(data, xtick, col2='project_is_approved', col3='total'):
    ind = np.arange(data.shape[0])

    plt.figure(figsize=(20,5))
    p1 = plt.bar(ind, data[col3].values)
    p2 = plt.bar(ind, data[col2].values)

    plt.ylabel('Projects')
    plt.title('% of projects aproved state wise')
    plt.xticks(ind, list(data[xtick].values))
    plt.legend((p1[0], p2[0]), ('total', 'accepted'))
    plt.show()
```

[ ]:

```
def univariate_barplots(data, col1, col2='project_is_approved', top=False):
    # Count number of zeros in dataframe python: https://stackoverflow.com/a/
 ↪51540521/4084039
    temp = pd.DataFrame(project_data.groupby(col1)[col2].agg(lambda x: x.eq(1).
 ↪sum())).reset_index()

    # Pandas dataframe grouby count: https://stackoverflow.com/a/19385591/
 ↪4084039
    temp['total'] = pd.DataFrame(project_data.groupby(col1)[col2].
 ↪agg(total='count')).reset_index()['total']
```

```
    temp['Avg'] = pd.DataFrame(project_data.groupby(col1)[col2].
↪agg(Avg='mean')).reset_index()['Avg']

    temp.sort_values(by=['total'],inplace=True, ascending=False)

    if top:
        temp = temp[0:top]

    stack_plot(temp, xtick=col1, col2=col2, col3='total')
    print(temp.head(5))
    print("="*50)
    print(temp.tail(5))
```

[ ]:
```
univariate_barplots(project_data, 'school_state', 'project_is_approved', False)
```

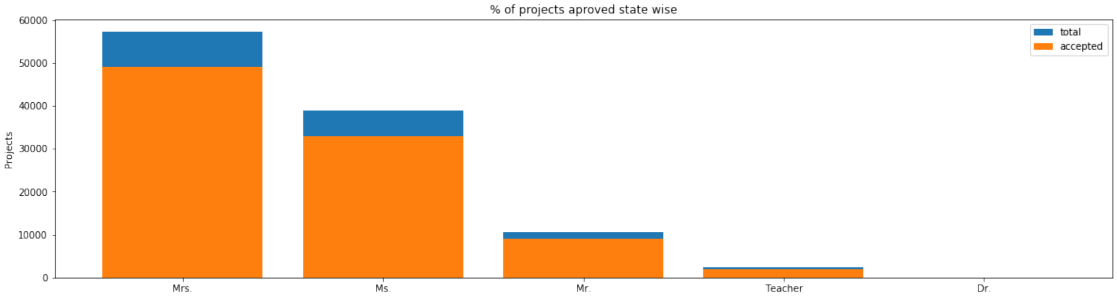


```
   school_state  project_is_approved  total       Avg
4            CA                13205  15388  0.858136
43           TX                 6014   7396  0.813142
34           NY                 6291   7318  0.859661
9            FL                 5144   6185  0.831690
27           NC                 4353   5091  0.855038
==================================================
   school_state  project_is_approved  total       Avg
39           RI                  243    285  0.852632
26           MT                  200    245  0.816327
28           ND                  127    143  0.888112
50           WY                   82     98  0.836735
46           VT                   64     80  0.800000
```

Every state is having more than 80% success rate in approval

2.0.2 1.2.2 Univariate Analysis: teacher_prefix

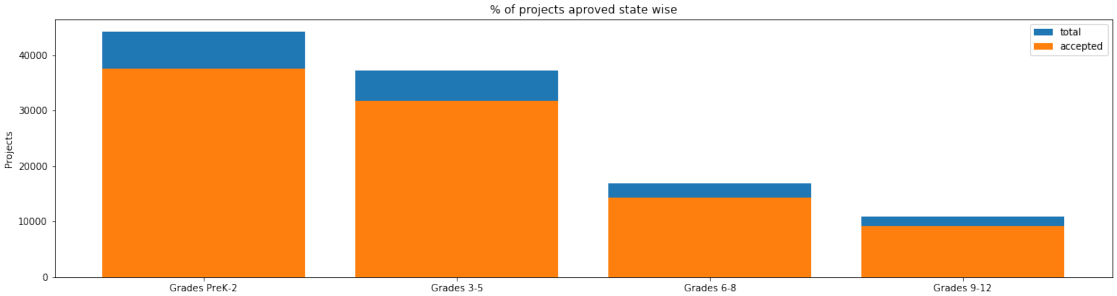
[ ]:
```
univariate_barplots(project_data, 'teacher_prefix', 'project_is_approved' ,␣
↪top=False)
```



```
  teacher_prefix  project_is_approved  total       Avg
2           Mrs.                48997  57269  0.855559
3            Ms.                32860  38955  0.843537
1            Mr.                 8960  10648  0.841473
4        Teacher                 1877   2360  0.795339
0            Dr.                    9     13  0.692308
==================================================
  teacher_prefix  project_is_approved  total       Avg
2           Mrs.                48997  57269  0.855559
3            Ms.                32860  38955  0.843537
1            Mr.                 8960  10648  0.841473
4        Teacher                 1877   2360  0.795339
0            Dr.                    9     13  0.692308
```

2.0.3 1.2.3 Univariate Analysis: project_grade_category

[ ]:
```
univariate_barplots(project_data, 'project_grade_category',␣
↪'project_is_approved', top=False)
```



```
  project_grade_category  project_is_approved  total       Avg
3          Grades PreK-2                37536  44225  0.848751
0             Grades 3-5                31729  37137  0.854377
1             Grades 6-8                14258  16923  0.842522
2            Grades 9-12                 9183  10963  0.837636
==================================================
  project_grade_category  project_is_approved  total       Avg
3          Grades PreK-2                37536  44225  0.848751
0             Grades 3-5                31729  37137  0.854377
1             Grades 6-8                14258  16923  0.842522
2            Grades 9-12                 9183  10963  0.837636
```

2.0.4 1.2.4 Univariate Analysis: project_subject_categories

[ ]:

```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.
 ↪com/a/47301924/4084039

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/
 ↪how-to-strip-a-specific-word-from-a-string
# https://stackoverflow.com/questions/8270092/
 ↪remove-all-whitespace-in-a-string-in-python
cat_list = []
for i in catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science",␣
 ↪"Warmth", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on␣
 ↪space "Math & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to␣
 ↪replace it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with␣
 ↪''(empty) ex:"Math & Science"=>"Math&Science"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the␣
 ↪trailing spaces
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())
```

[ ]:

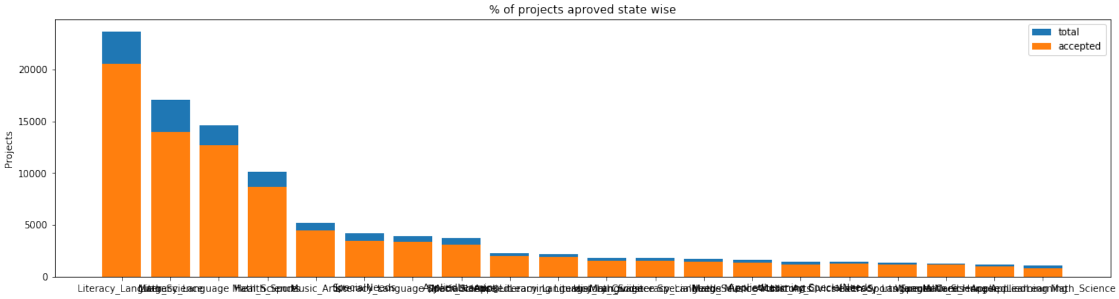
```
project_data['clean_categories'] = cat_list
project_data.drop(['project_subject_categories'], axis=1, inplace=True)
project_data.head(2)
```

[ ]:

```
   Unnamed: 0       id                        teacher_id teacher_prefix  \
0      160221  p253737  c90749f5d961ff158d4b4d1e7dc665fc           Mrs.
1      140945  p258326  897464ce9ddc600bced1151f324dd63a            Mr.
```

```
  school_state project_submitted_datetime project_grade_category  \
0           IN        2016-12-05 13:43:57          Grades PreK-2
1           FL        2016-10-25 09:22:10             Grades 6-8

      project_subject_subcategories  \
0                      ESL, Literacy
1  Civics & Government, Team Sports

                                    project_title  \
0  Educational Support for English Learners at Home
1             Wanted: Projector for Hungry Learners

                                   project_essay_1  \
0  My students are English learners that are work...
1  Our students arrive to our school eager to lea...

                                   project_essay_2 project_essay_3  \
0  \"The limits of your language are the limits o...             NaN
1  The projector we need for our school is very c...             NaN

  project_essay_4                           project_resource_summary  \
0             NaN  My students need opportunities to practice beg...
1             NaN  My students need a projector to help with view...

   teacher_number_of_previously_posted_projects  project_is_approved  \
0                                             0                    0
1                                             7                    1

             clean_categories
0            Literacy_Language
1  History_Civics Health_Sports
```

```
[ ]: univariate_barplots(project_data, 'clean_categories', 'project_is_approved',␣
     ↪top=20)
```



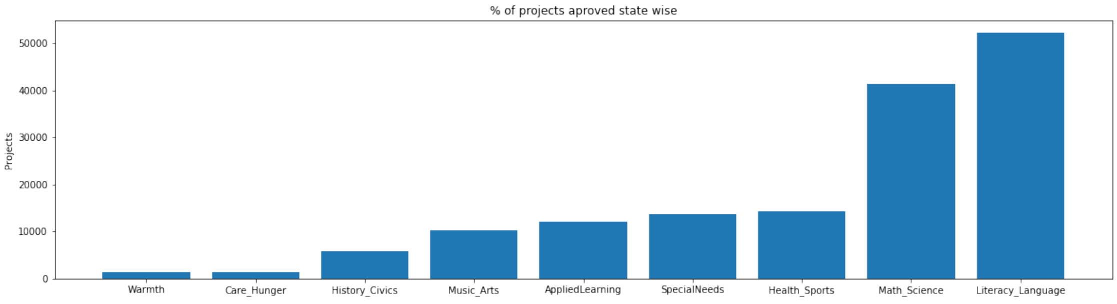
```
                  clean_categories  project_is_approved  total       Avg
24               Literacy_Language                20520  23655  0.867470
32                    Math_Science                13991  17072  0.819529
28  Literacy_Language Math_Science                12725  14636  0.869432
8                    Health_Sports                 8640  10177  0.848973
40                      Music_Arts                 4429   5180  0.855019
==================================================
                    clean_categories  project_is_approved  total       Avg
19  History_Civics Literacy_Language                 1271   1421  0.894441
14        Health_Sports SpecialNeeds                 1215   1391  0.873472
50                Warmth Care_Hunger                 1212   1309  0.925898
33      Math_Science AppliedLearning                 1019   1220  0.835246
4       AppliedLearning Math_Science                  855   1052  0.812738
```

[ ]:

```
# count of all the words in corpus python: https://stackoverflow.com/a/22898595/
 ↪4084039
from collections import Counter
my_counter = Counter()
for word in project_data['clean_categories'].values:
    my_counter.update(word.split())
```

[ ]:

```
# dict sort by value python: https://stackoverflow.com/a/613218/4084039
cat_dict = dict(my_counter)
sorted_cat_dict = dict(sorted(cat_dict.items(), key=lambda kv: kv[1]))


ind = np.arange(len(sorted_cat_dict))
plt.figure(figsize=(20,5))
p1 = plt.bar(ind, list(sorted_cat_dict.values()))

plt.ylabel('Projects')
plt.title('% of projects aproved state wise')
plt.xticks(ind, list(sorted_cat_dict.keys()))
plt.show()
```



[ ]:

```
for i, j in sorted_cat_dict.items():
    print("{:20} :{:10}".format(i,j))
```

```
Warmth                 :      1388
Care_Hunger            :      1388
History_Civics         :      5914
Music_Arts             :     10293
AppliedLearning        :     12135
SpecialNeeds           :     13642
Health_Sports          :     14223
Math_Science           :     41421
Literacy_Language      :     52239
```

2.0.5 1.2.5 Univariate Analysis: project_subject_subcategories

[ ]:

```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.
 ↪com/a/47301924/4084039

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/
 ↪how-to-strip-a-specific-word-from-a-string
# https://stackoverflow.com/questions/8270092/
 ↪remove-all-whitespace-in-a-string-in-python

sub_cat_list = []
for i in sub_catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science",␣
 ↪"Warmth", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on␣
 ↪space "Math & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to␣
 ↪replace it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with␣
 ↪''(empty) ex:"Math & Science"=>"Math&Science"
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the␣
 ↪trailing spaces
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())
```

[ ]:

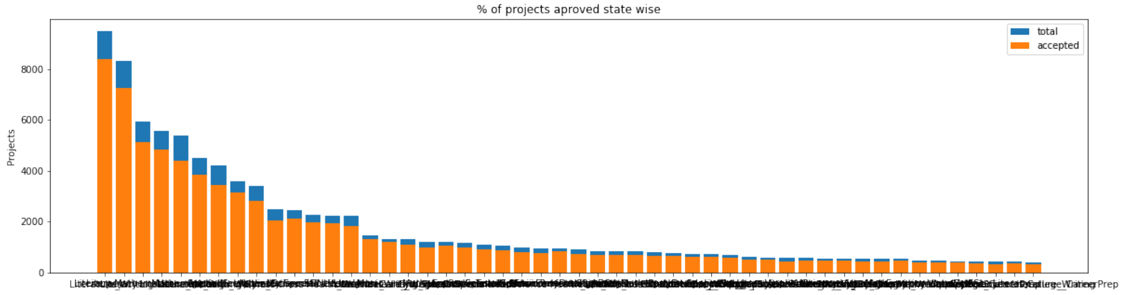
```
project_data['clean_subcategories'] = sub_cat_list
project_data.drop(['project_subject_subcategories'], axis=1, inplace=True)
project_data.head(2)
```

[ ]:

```
   Unnamed: 0       id                        teacher_id teacher_prefix  \
0      160221  p253737  c90749f5d961ff158d4b4d1e7dc665fc           Mrs.
1      140945  p258326  897464ce9ddc600bced1151f324dd63a            Mr.
```

```
  school_state project_submitted_datetime project_grade_category  \
0           IN        2016-12-05 13:43:57          Grades PreK-2   
1           FL        2016-10-25 09:22:10             Grades 6-8   

                                    project_title  \
0  Educational Support for English Learners at Home   
1             Wanted: Projector for Hungry Learners   

                                     project_essay_1  \
0  My students are English learners that are work...   
1  Our students arrive to our school eager to lea...   

                                     project_essay_2 project_essay_3  \
0  \"The limits of your language are the limits o...             NaN   
1  The projector we need for our school is very c...             NaN   

  project_essay_4                           project_resource_summary  \
0             NaN  My students need opportunities to practice beg...   
1             NaN  My students need a projector to help with view...   

   teacher_number_of_previously_posted_projects  project_is_approved  \
0                                             0                    0   
1                                             7                    1   

              clean_categories           clean_subcategories  
0            Literacy_Language                  ESL Literacy  
1  History_Civics Health_Sports  Civics_Government TeamSports  
```

[ ]:
```
univariate_barplots(project_data, 'clean_subcategories', 'project_is_approved',␣
↪top=50)
```

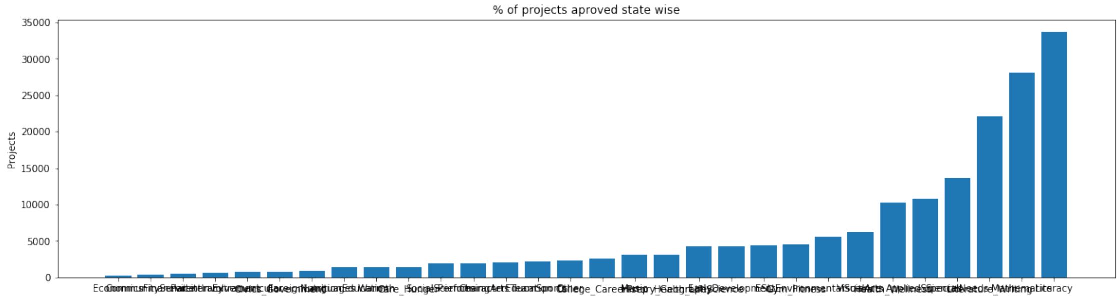


```
                clean_subcategories  project_is_approved  total       Avg
317                        Literacy                 8371   9486  0.882458
319            Literacy Mathematics                 7260   8325  0.872072
331  Literature_Writing Mathematics                 5140   5923  0.867803
318     Literacy Literature_Writing                 4823   5571  0.865733
```

```
342                          Mathematics                  4385   5379  0.815207
==================================================
                   clean_subcategories  project_is_approved  total       Avg
196        EnvironmentalScience Literacy                  389    444  0.876126
127                                  ESL                  349    421  0.828979
79                    College_CareerPrep                  343    421  0.814727
17   AppliedSciences Literature_Writing                  361    420  0.859524
3    AppliedSciences College_CareerPrep                  330    405  0.814815
```

```
[ ]: # count of all the words in corpus python: https://stackoverflow.com/a/22898595/
      ↪4084039
     from collections import Counter
     my_counter = Counter()
     for word in project_data['clean_subcategories'].values:
         my_counter.update(word.split())
```

```
[ ]: # dict sort by value python: https://stackoverflow.com/a/613218/4084039
     sub_cat_dict = dict(my_counter)
     sorted_sub_cat_dict = dict(sorted(sub_cat_dict.items(), key=lambda kv: kv[1]))


     ind = np.arange(len(sorted_sub_cat_dict))
     plt.figure(figsize=(20,5))
     p1 = plt.bar(ind, list(sorted_sub_cat_dict.values()))

     plt.ylabel('Projects')
     plt.title('% of projects aproved state wise')
     plt.xticks(ind, list(sorted_sub_cat_dict.keys()))
     plt.show()
```



```
[ ]: for i, j in sorted_sub_cat_dict.items():
         print("{:20} :{:10}".format(i,j))
```

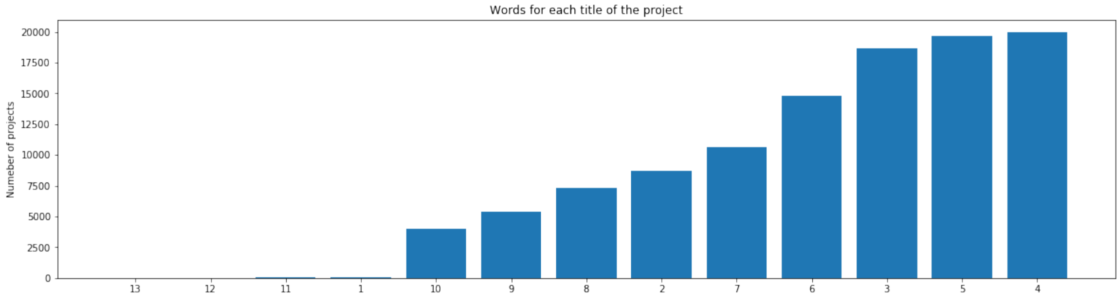
```
Economics            :       269
CommunityService     :       441
FinancialLiteracy    :       568
```

```
ParentInvolvement    :       677
Extracurricular      :       810
Civics_Government    :       815
ForeignLanguages     :       890
NutritionEducation   :      1355
Warmth               :      1388
Care_Hunger          :      1388
SocialSciences       :      1920
PerformingArts       :      1961
CharacterEducation   :      2065
TeamSports           :      2192
Other                :      2372
College_CareerPrep   :      2568
Music                :      3145
History_Geography    :      3171
Health_LifeScience   :      4235
EarlyDevelopment     :      4254
ESL                  :      4367
Gym_Fitness          :      4509
EnvironmentalScience :      5591
VisualArts           :      6278
Health_Wellness      :     10234
AppliedSciences      :     10816
SpecialNeeds         :     13642
Literature_Writing   :     22179
Mathematics          :     28074
Literacy             :     33700
```

2.0.6 1.2.6 Univariate Analysis: Text features (Title)

[ ]:

```
#How to calculate number of words in a string in DataFrame: https://
 ↪stackoverflow.com/a/37483537/4084039
word_count = project_data['project_title'].str.split().apply(len).value_counts()
word_dict = dict(word_count)
word_dict = dict(sorted(word_dict.items(), key=lambda kv: kv[1]))


ind = np.arange(len(word_dict))
plt.figure(figsize=(20,5))
p1 = plt.bar(ind, list(word_dict.values()))

plt.ylabel('Numeber of projects')
plt.title('Words for each title of the project')
plt.xticks(ind, list(word_dict.keys()))
plt.show()
```

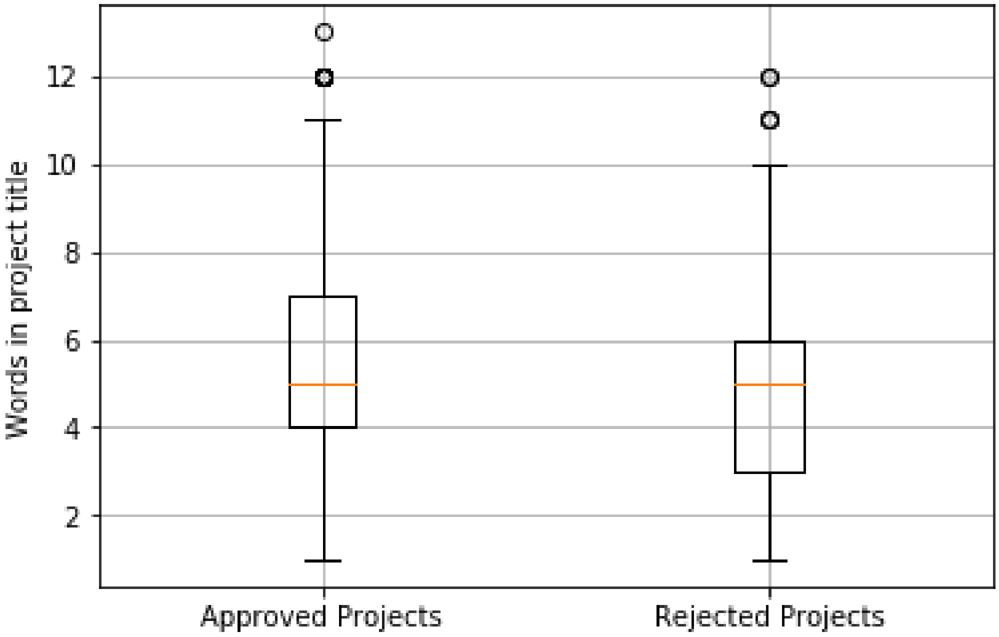


[ ]:

```
approved_word_count = project_data[project_data['project_is_approved']==1]['project_title'].str.split().apply(len)
approved_word_count = approved_word_count.values

rejected_word_count = project_data[project_data['project_is_approved']==0]['project_title'].str.split().apply(len)
rejected_word_count = rejected_word_count.values
```

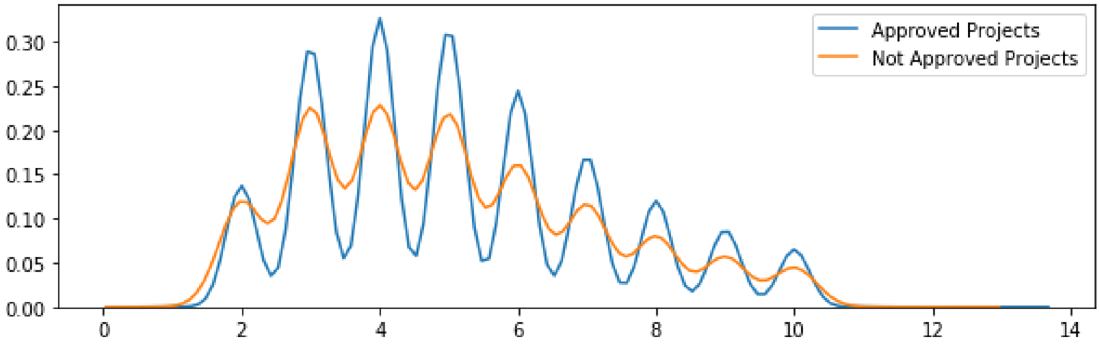
[ ]:

```
# https://glowingpython.blogspot.com/2012/09/boxplot-with-matplotlib.html
plt.boxplot([approved_word_count, rejected_word_count])
plt.xticks([1,2],('Approved Projects','Rejected Projects'))
plt.ylabel('Words in project title')
plt.grid()
plt.show()
```



[ ]:

```
plt.figure(figsize=(10,3))
sns.distplot(approved_word_count, hist=False, label="Approved Projects")
sns.distplot(rejected_word_count, hist=False, label="Not Approved Projects")
plt.legend()
plt.show()
```



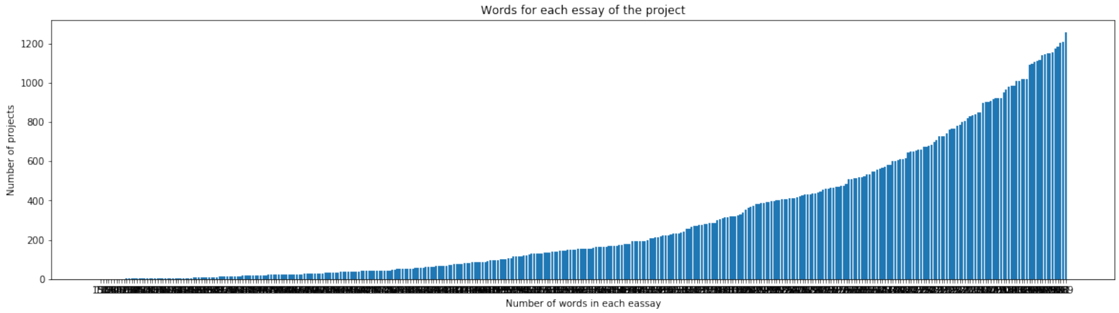
2.0.7 1.2.7 Univariate Analysis: Text features (Project Essay's)

[ ]:

```
# merge two column text dataframe:
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)
```

[ ]:

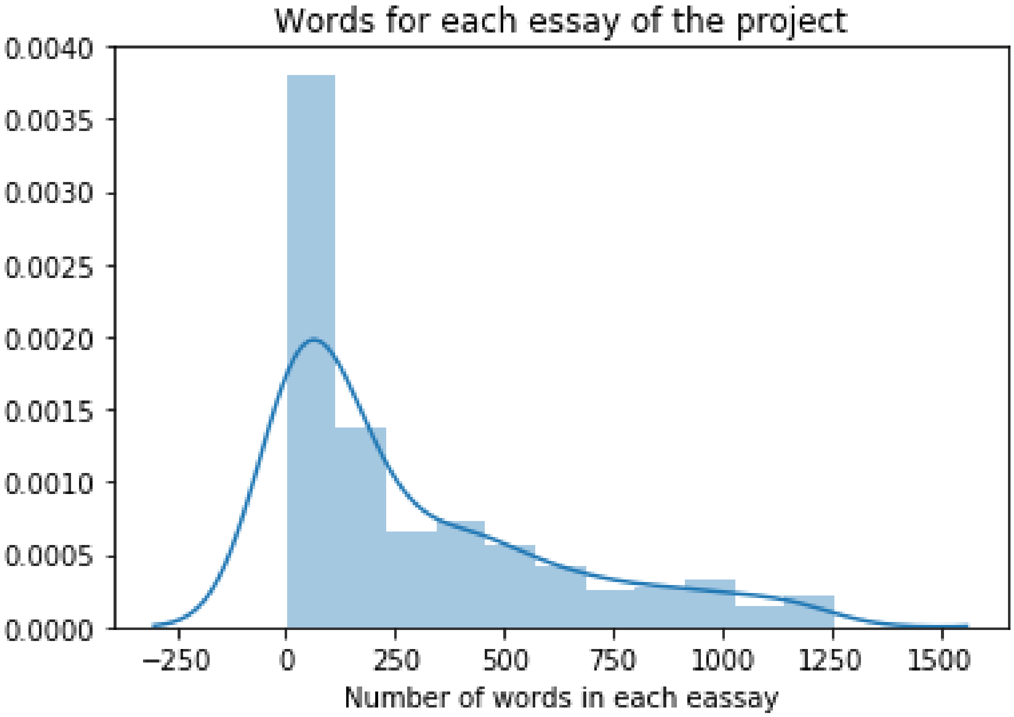
```
#How to calculate number of words in a string in DataFrame: https://
 ↪stackoverflow.com/a/37483537/4084039
word_count = project_data['essay'].str.split().apply(len).value_counts()
word_dict = dict(word_count)
word_dict = dict(sorted(word_dict.items(), key=lambda kv: kv[1]))


ind = np.arange(len(word_dict))
plt.figure(figsize=(20,5))
p1 = plt.bar(ind, list(word_dict.values()))

plt.ylabel('Number of projects')
plt.xlabel('Number of words in each eassay')
plt.title('Words for each essay of the project')
plt.xticks(ind, list(word_dict.keys()))
plt.show()
```



[ ]:

```
sns.distplot(word_count.values)
plt.title('Words for each essay of the project')
plt.xlabel('Number of words in each eassay')
plt.show()
```

```
D:\installed\Anaconda3\lib\site-packages\matplotlib\axes\_axes.py:6571:
UserWarning:

The 'normed' kwarg is deprecated, and has been replaced by the 'density' kwarg.
```

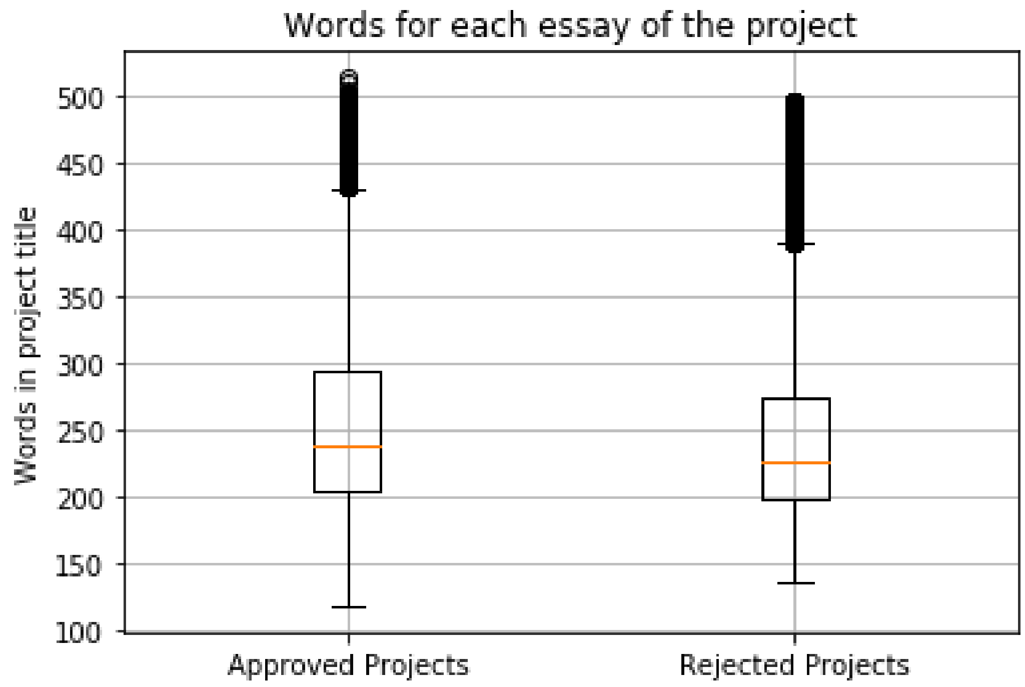


[ ]:

```
approved_word_count =␣
 ↪project_data[project_data['project_is_approved']==1]['essay'].str.split().
 ↪apply(len)
approved_word_count = approved_word_count.values

rejected_word_count =␣
 ↪project_data[project_data['project_is_approved']==0]['essay'].str.split().
 ↪apply(len)
rejected_word_count = rejected_word_count.values
```

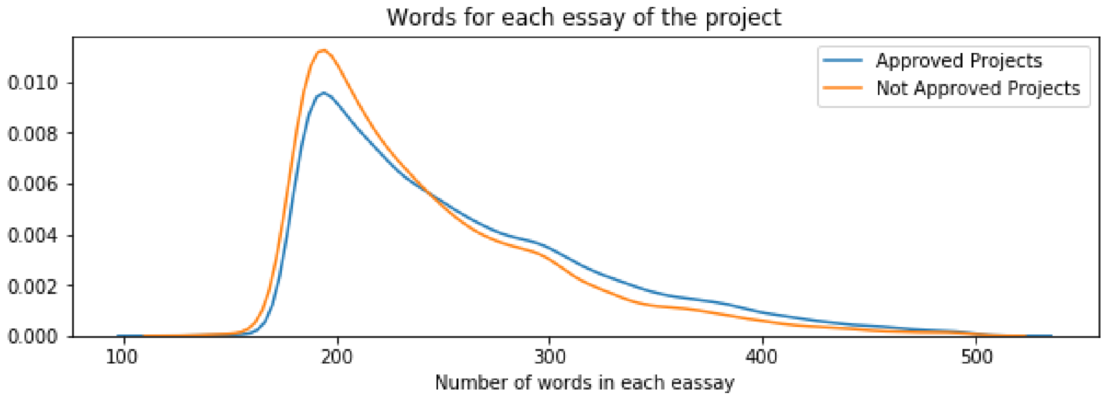
[ ]:

```
# https://glowingpython.blogspot.com/2012/09/boxplot-with-matplotlib.html
plt.boxplot([approved_word_count, rejected_word_count])
plt.title('Words for each essay of the project')
plt.xticks([1,2],('Approved Projects','Rejected Projects'))
plt.ylabel('Words in project title')
plt.grid()
plt.show()
```



[ ]:

```
plt.figure(figsize=(10,3))
sns.distplot(approved_word_count, hist=False, label="Approved Projects")
sns.distplot(rejected_word_count, hist=False, label="Not Approved Projects")
plt.title('Words for each essay of the project')
plt.xlabel('Number of words in each eassay')
plt.legend()
plt.show()
```



2.0.8 1.2.8 Univariate Analysis: Cost per project

[ ]:
```
# we get the cost of the project using resource.csv file
resource_data.head(2)
```

[ ]:
```
        id                                      description  quantity  \
0  p233245  LC652 - Lakeshore Double-Space Mobile Drying Rack         1
1  p069063        Bouncy Bands for Desks (Blue support pipes)         3

    price
0  149.00
1   14.95
```

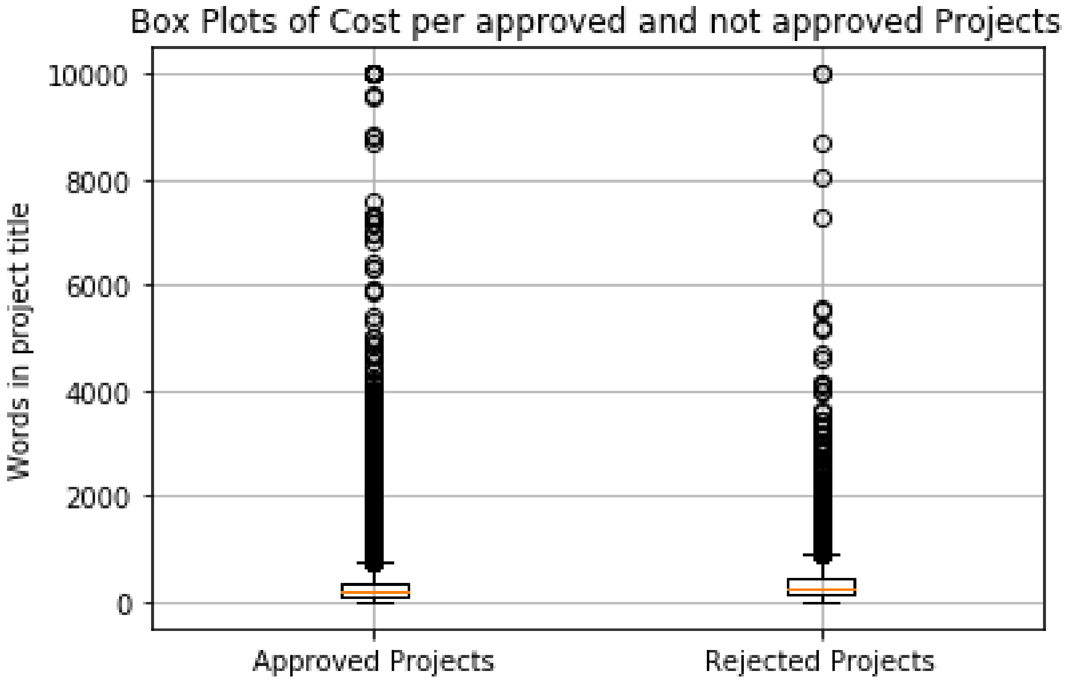
[ ]:
```
# https://stackoverflow.com/questions/22407798/
 ↪how-to-reset-a-dataframes-indexes-for-all-groups-in-one-step
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).
 ↪reset_index()
price_data.head(2)
```

[ ]:
```
        id   price  quantity
0  p000001  459.56         7
1  p000002  515.89        21
```

[ ]:
```
# join two dataframes in python:
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

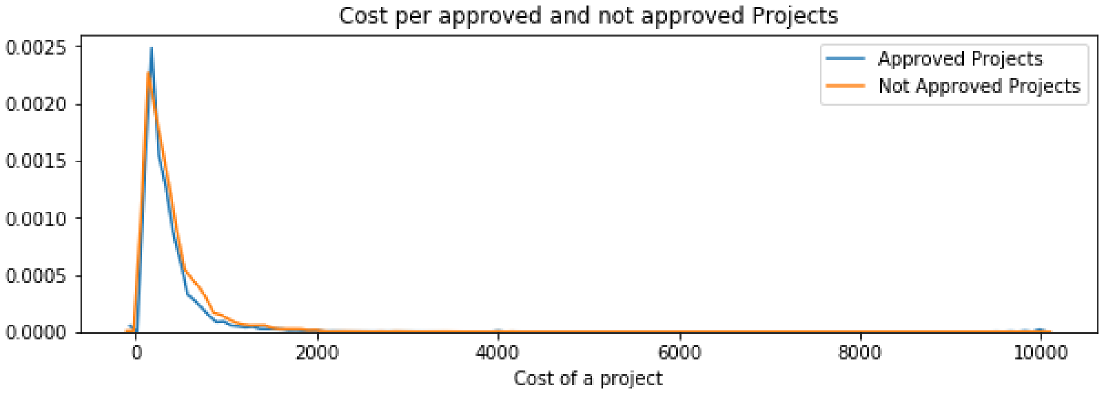
[ ]:
```
approved_price = project_data[project_data['project_is_approved']==1]['price'].
 ↪values

rejected_price = project_data[project_data['project_is_approved']==0]['price'].
 ↪values
```

[ ]:
```
# https://glowingpython.blogspot.com/2012/09/boxplot-with-matplotlib.html
plt.boxplot([approved_price, rejected_price])
plt.title('Box Plots of Cost per approved and not approved Projects')
plt.xticks([1,2],('Approved Projects','Rejected Projects'))
plt.ylabel('Words in project title')
plt.grid()
plt.show()
```



[ ]:

```
plt.figure(figsize=(10,3))
sns.distplot(approved_price, hist=False, label="Approved Projects")
sns.distplot(rejected_price, hist=False, label="Not Approved Projects")
plt.title('Cost per approved and not approved Projects')
plt.xlabel('Cost of a project')
plt.legend()
plt.show()
```



[ ]:
```
# http://zetcode.com/python/prettytable/
from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ["Percentile", "Approved Projects", "Not Approved Projects"]

for i in range(0,101,5):
    x.add_row([i,np.round(np.percentile(approved_price,i), 3), np.round(np.
 ↪percentile(rejected_price,i), 3)])
print(x)
```

```
+------------+-------------------+-----------------------+
| Percentile | Approved Projects | Not Approved Projects |
+------------+-------------------+-----------------------+
|     0      |        0.66       |          1.97         |
|     5      |       13.59       |          41.9         |
|     10     |       33.88       |         73.67         |
|     15     |        58.0       |         99.109        |
|     20     |       77.38       |         118.56        |
|     25     |       99.95       |        140.892        |
|     30     |       116.68      |         162.23        |
|     35     |      137.232      |        184.014        |
|     40     |       157.0       |        208.632        |
|     45     |      178.265      |        235.106        |
|     50     |       198.99      |        263.145        |
|     55     |       223.99      |         292.61        |
|     60     |       255.63      |        325.144        |
|     65     |      285.412      |         362.39        |
|     70     |      321.225      |         399.99        |
|     75     |      366.075      |        449.945        |
|     80     |       411.67      |        519.282        |
|     85     |       479.0       |        618.276        |
|     90     |       593.11      |        739.356        |
|     95     |      801.598      |        992.486        |
|    100     |       9999.0      |         9999.0        |
+------------+-------------------+-----------------------+
```

2.0.9 1.2.9 Univariate Analysis: teacher_number_of_previously_posted_projects

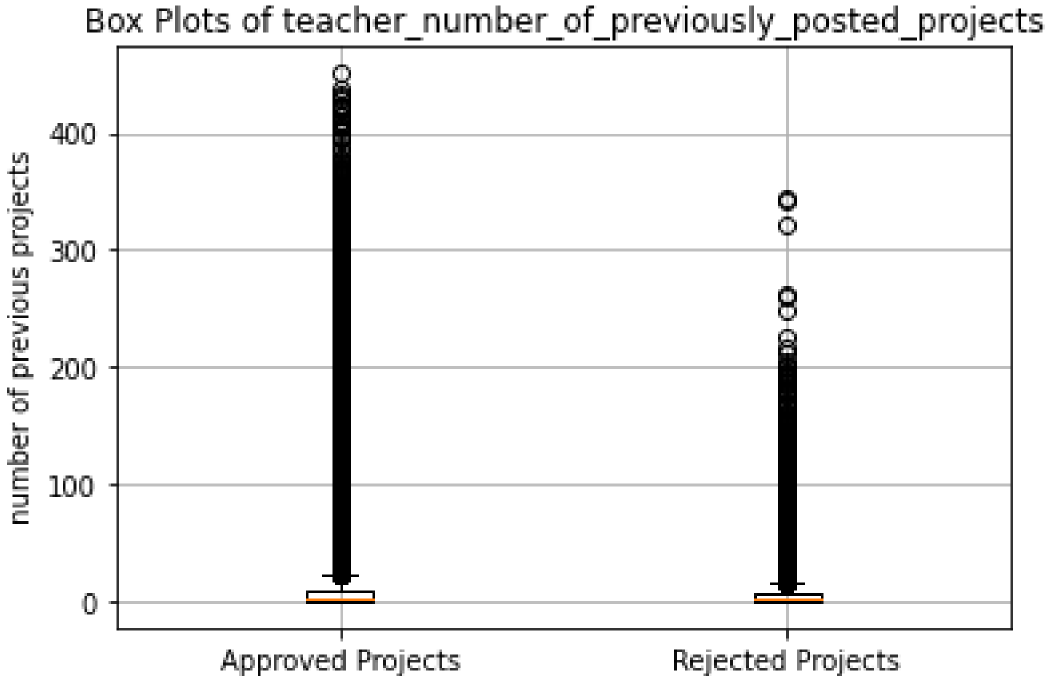
Please do this by yourself
    observe the data analysis that was done in the above cells

[ ]:
```
accepted_count =␣
 ↪project_data[project_data['project_is_approved']==1]['teacher_number_of_previously_posted_p
 ↪values
```

```
rejected_count =␣
 ↪project_data[project_data['project_is_approved']==0]['teacher_number_of_previously_posted_p
 ↪values
```

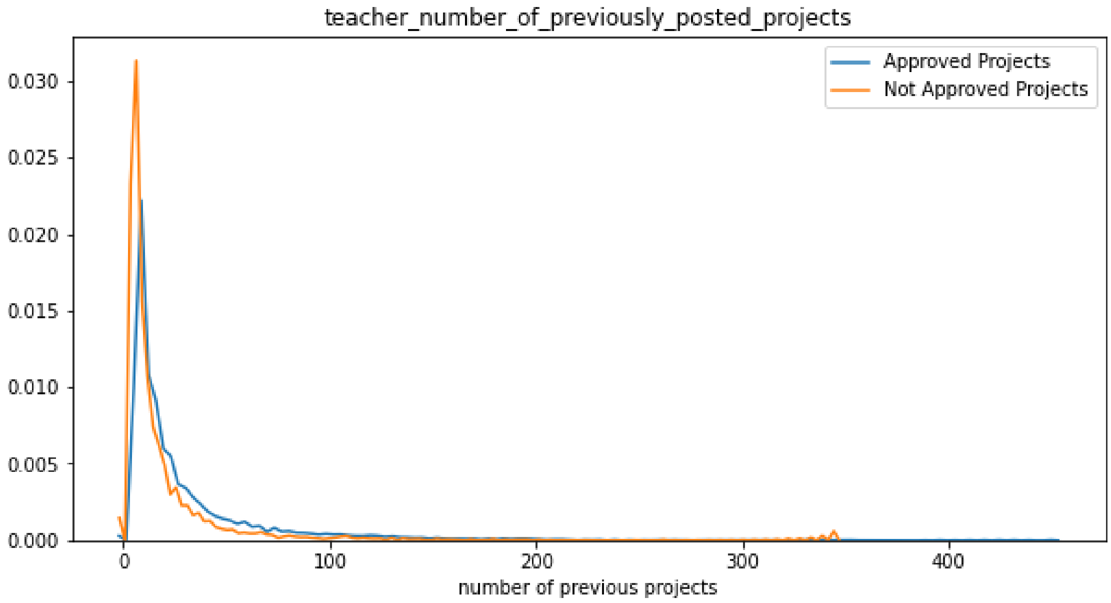
[ ]:

```
# https://glowingpython.blogspot.com/2012/09/boxplot-with-matplotlib.html
plt.boxplot([accepted_count, rejected_count])
plt.title('Box Plots of teacher_number_of_previously_posted_projects')
plt.xticks([1,2],('Approved Projects','Rejected Projects'))
plt.ylabel(' number of previous projects')
plt.grid()
plt.show()
```



[ ]:

```
plt.figure(figsize=(10,5))
sns.distplot(accepted_count, hist=False, label="Approved Projects")
sns.distplot(rejected_count, hist=False, label="Not Approved Projects")
plt.title('teacher_number_of_previously_posted_projects')
plt.xlabel(' number of previous projects ')
plt.legend()
plt.show()
```



[ ]:
```
# http://zetcode.com/python/prettytable/
from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ["Percentile", "Approved Projects", "Not Approved Projects"]

for i in range(0,101,5):
    x.add_row([i,np.round(np.percentile(accepted_count,i), 3), np.round(np.
 ↪percentile(rejected_count,i), 3)])
print(x)
```

```
+------------+-------------------+-----------------------+
| Percentile | Approved Projects | Not Approved Projects |
+------------+-------------------+-----------------------+
|     0      |        0.0        |          0.0          |
|     5      |        0.0        |          0.0          |
|     10     |        0.0        |          0.0          |
|     15     |        0.0        |          0.0          |
|     20     |        0.0        |          0.0          |
|     25     |        0.0        |          0.0          |
|     30     |        1.0        |          0.0          |
|     35     |        1.0        |          1.0          |
|     40     |        1.0        |          1.0          |
|     45     |        2.0        |          1.0          |
|     50     |        2.0        |          2.0          |
|     55     |        3.0        |          2.0          |
|     60     |        4.0        |          3.0          |
|     65     |        5.0        |          3.0          |
|     70     |        7.0        |          4.0          |
|     75     |        9.0        |          6.0          |
|     80     |        13.0       |          8.0          |
|     85     |        19.0       |          11.0         |
|     90     |        30.0       |          17.0         |
|     95     |        57.0       |          31.0         |
|    100     |       451.0       |         345.0         |
+------------+-------------------+-----------------------+
```

2.0.10 1.2.10 Univariate Analysis: project_resource_summary

Please do this by yourself

check the `presence of the numerical digits` in the `project_resource_summary` effects the acceptance of the project

if you feel like it will helpfull in the classification, please include in the further process or you can ignore it.

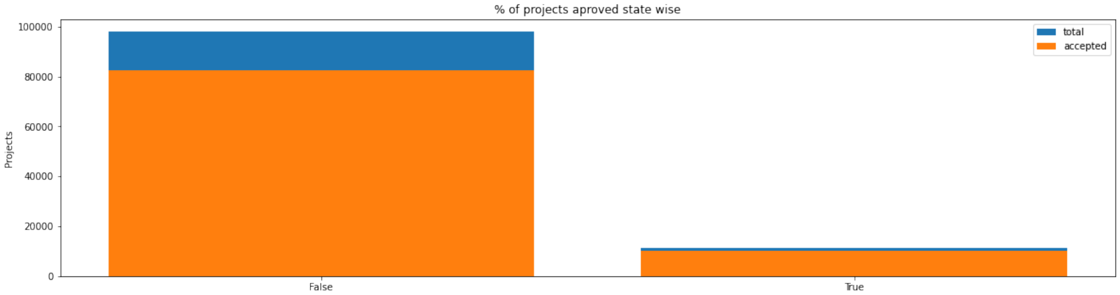
Making new column summary_contain_num which has value 0 if there is no digit in project_resource_summary else it contains 1 i.e. there is some digit

```
[ ]: project_data['summary_contain_num'] = project_data.apply(lambda row: any(y.
     ↪isdigit() for  y in row['project_resource_summary'].split()), axis = 1)
```

```
[ ]: project_data[project_data['summary_contain_num']== 1]['summary_contain_num'].
     ↪apply('count')
```

```
[ ]: 11237
```

```
[ ]: univariate_barplots(project_data, 'summary_contain_num', 'project_is_approved'␣
     ↪, top=False)
```



```
   summary_contain_num  project_is_approved  total       Avg
0                False                82562  98011  0.842375
1                 True                10144  11237  0.902732
==================================================
```

```
   summary_contain_num  project_is_approved  total       Avg
0                False                82562  98011  0.842375
1                 True                10144  11237  0.902732
```

3 2. Preprocessing Categorical Features: project_grade_category

[ ]:

```
project_data['project_grade_category'].value_counts()
```

[ ]:

```
Grades PreK-2    44225
Grades 3-5       37137
Grades 6-8       16923
Grades 9-12      10963
Name: project_grade_category, dtype: int64
```

we need to remove the spaces, replace the '-' with '_' and convert all the letters to small

[ ]:

```
# https://stackoverflow.com/questions/36383821/
 ↪pandas-dataframe-apply-function-to-column-strings-based-on-other-column-value
project_data['project_grade_category'] = project_data['project_grade_category'].
 ↪str.replace(' ','_')
project_data['project_grade_category'] = project_data['project_grade_category'].
 ↪str.replace('-','_')
project_data['project_grade_category'] = project_data['project_grade_category'].
 ↪str.lower()
project_data['project_grade_category'].value_counts()
```

[ ]:

```
grades_prek_2    44225
grades_3_5       37137
grades_6_8       16923
grades_9_12      10963
Name: project_grade_category, dtype: int64
```

4 3. Preprocessing Categorical Features: project_subject_categories

[ ]:

```
project_data['project_subject_categories'].value_counts()
```

[ ]:

```
Literacy & Language                           23655
Math & Science                                17072
Literacy & Language, Math & Science           14636
Health & Sports                               10177
Music & The Arts                               5180
Special Needs                                  4226
Literacy & Language, Special Needs             3961
Applied Learning                               3771
Math & Science, Literacy & Language            2289
Applied Learning, Literacy & Language          2191
History & Civics                               1851
Math & Science, Special Needs                  1840
Literacy & Language, Music & The Arts          1757
Math & Science, Music & The Arts               1642
Applied Learning, Special Needs                1467
History & Civics, Literacy & Language          1421
```

```
Health & Sports, Special Needs                 1391
Warmth, Care & Hunger                          1309
Math & Science, Applied Learning               1220
Applied Learning, Math & Science               1052
Literacy & Language, History & Civics           809
Health & Sports, Literacy & Language            803
Applied Learning, Music & The Arts              758
Math & Science, History & Civics                652
Literacy & Language, Applied Learning           636
Applied Learning, Health & Sports               608
Math & Science, Health & Sports                 414
History & Civics, Math & Science                322
History & Civics, Music & The Arts              312
Special Needs, Music & The Arts                 302
Health & Sports, Math & Science                 271
History & Civics, Special Needs                 252
Health & Sports, Applied Learning               192
Applied Learning, History & Civics              178
Health & Sports, Music & The Arts               155
Music & The Arts, Special Needs                 138
Literacy & Language, Health & Sports             72
Health & Sports, History & Civics                43
Special Needs, Health & Sports                   42
History & Civics, Applied Learning               42
Health & Sports, Warmth, Care & Hunger           23
Special Needs, Warmth, Care & Hunger             23
Music & The Arts, Health & Sports                19
Music & The Arts, History & Civics               18
History & Civics, Health & Sports                13
Math & Science, Warmth, Care & Hunger            11
Applied Learning, Warmth, Care & Hunger          10
Music & The Arts, Applied Learning               10
Literacy & Language, Warmth, Care & Hunger        9
Music & The Arts, Warmth, Care & Hunger           2
History & Civics, Warmth, Care & Hunger           1
Name: project_subject_categories, dtype: int64
```

remove spaces, ’the’ replace ’&’ with ’_’, and ’,’ with ’_’

[ ]:

```
project_data['project_subject_categories'] =␣
 ↪project_data['project_subject_categories'].str.replace(' The ','')
project_data['project_subject_categories'] =␣
 ↪project_data['project_subject_categories'].str.replace(' ','')
project_data['project_subject_categories'] =␣
 ↪project_data['project_subject_categories'].str.replace('&','_')
project_data['project_subject_categories'] =␣
 ↪project_data['project_subject_categories'].str.replace(',','_')
```

```
project_data['project_subject_categories'] =␣
 ↪project_data['project_subject_categories'].str.lower()
project_data['project_subject_categories'].value_counts()
```

```
[ ]: literacy_language                       23655
     math_science                            17072
     literacy_language_math_science          14636
     health_sports                           10177
     music_arts                               5180
     specialneeds                             4226
     literacy_language_specialneeds           3961
     appliedlearning                          3771
     math_science_literacy_language           2289
     appliedlearning_literacy_language        2191
     history_civics                           1851
     math_science_specialneeds                1840
     literacy_language_music_arts             1757
     math_science_music_arts                  1642
     appliedlearning_specialneeds             1467
     history_civics_literacy_language         1421
     health_sports_specialneeds               1391
     warmth_care_hunger                       1309
     math_science_appliedlearning             1220
     appliedlearning_math_science             1052
     literacy_language_history_civics          809
     health_sports_literacy_language           803
     appliedlearning_music_arts                758
     math_science_history_civics               652
     literacy_language_appliedlearning         636
     appliedlearning_health_sports             608
     math_science_health_sports                414
     history_civics_math_science               322
     history_civics_music_arts                 312
     specialneeds_music_arts                   302
     health_sports_math_science                271
     history_civics_specialneeds               252
     health_sports_appliedlearning             192
     appliedlearning_history_civics            178
     health_sports_music_arts                  155
     music_arts_specialneeds                   138
     literacy_language_health_sports            72
     health_sports_history_civics               43
     specialneeds_health_sports                 42
     history_civics_appliedlearning             42
     specialneeds_warmth_care_hunger            23
     health_sports_warmth_care_hunger           23
     music_arts_health_sports                   19
```

```
music_arts_history_civics                   18
history_civics_health_sports                13
math_science_warmth_care_hunger             11
appliedlearning_warmth_care_hunger          10
music_arts_appliedlearning                  10
literacy_language_warmth_care_hunger         9
music_arts_warmth_care_hunger                2
history_civics_warmth_care_hunger            1
Name: project_subject_categories, dtype: int64
```

5 4. Preprocessing Categorical Features: teacher_prefix

[ ]:
```
project_data['teacher_prefix'].value_counts()
```

[ ]:
```
Mrs.       57269
Ms.        38955
Mr.        10648
Teacher     2360
Dr.           13
Name: teacher_prefix, dtype: int64
```

[ ]:
```
# check if we have any nan values are there
print(project_data['teacher_prefix'].isnull().values.any())
print("number of nan values",project_data['teacher_prefix'].isnull().values.
 ↪sum())
```

```
True
number of nan values 3
```

numebr of missing values are very less in number, we can replace it with Mrs. as most of the projects are submitted by Mrs.

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

[ ]:
```
project_data['teacher_prefix'].value_counts()
```

[ ]:
```
Mrs.       57272
Ms.        38955
Mr.        10648
Teacher     2360
Dr.           13
Name: teacher_prefix, dtype: int64
```

Remove '.' convert all the chars to small

[ ]:
```
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.replace('.
 ↪','')
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.lower()
```

```
project_data['teacher_prefix'].value_counts()
```

```
[ ]: mrs        57272
     ms         38955
     mr         10648
     teacher     2360
     dr            13
     Name: teacher_prefix, dtype: int64
```

6 5. Preprocessing Categorical Features: project_subject_subcategories

```
[ ]: project_data['project_subject_subcategories'].value_counts()
```

```
[ ]: Literacy                                    9486
     Literacy, Mathematics                       8325
     Literature & Writing, Mathematics           5923
     Literacy, Literature & Writing              5571
     Mathematics                                 5379
                                                 ...
     Civics & Government, Parent Involvement        1
     Community Service, Financial Literacy          1
     Parent Involvement, Team Sports                1
     Civics & Government, Nutrition Education       1
     Economics, Other                               1
     Name: project_subject_subcategories, Length: 401, dtype: int64
```

same process we did in project_subject_categories

```
[ ]: project_data['project_subject_subcategories'] =␣
      ↪project_data['project_subject_subcategories'].str.replace(' The ','')
     project_data['project_subject_subcategories'] =␣
      ↪project_data['project_subject_subcategories'].str.replace(' ','')
     project_data['project_subject_subcategories'] =␣
      ↪project_data['project_subject_subcategories'].str.replace('&','_')
     project_data['project_subject_subcategories'] =␣
      ↪project_data['project_subject_subcategories'].str.replace(',','_')
     project_data['project_subject_subcategories'] =␣
      ↪project_data['project_subject_subcategories'].str.lower()
     project_data['project_subject_subcategories'].value_counts()
```

```
[ ]: literacy                                 9486
     literacy_mathematics                     8325
     literature_writing_mathematics           5923
     literacy_literature_writing              5571
     mathematics                              5379
                                              ...
     civics_government_nutritioneducation        1
```

```
gym_fitness_parentinvolvement               1
financialliteracy_performingarts            1
college_careerprep_warmth_care_hunger       1
economics_music                             1
Name: project_subject_subcategories, Length: 401, dtype: int64
```

7 6. Preprocessing Categorical Features: school_state

[ ]:
```
project_data['school_state'].value_counts()
```

[ ]:
```
CA    15388
TX     7396
NY     7318
FL     6185
NC     5091
IL     4350
GA     3963
SC     3936
MI     3161
PA     3109
IN     2620
MO     2576
OH     2467
LA     2394
MA     2389
WA     2334
OK     2276
NJ     2237
AZ     2147
VA     2045
WI     1827
AL     1762
UT     1731
TN     1688
CT     1663
MD     1514
NV     1367
MS     1323
KY     1304
OR     1242
MN     1208
CO     1111
AR     1049
ID      693
IA      666
KS      634
```

```
NM      557
DC      516
HI      507
ME      505
WV      503
NH      348
AK      345
DE      343
NE      309
SD      300
RI      285
MT      245
ND      143
WY       98
VT       80
Name: school_state, dtype: int64
```

convert all of them into small letters

[ ]:

```
project_data['school_state'] = project_data['school_state'].str.lower()
project_data['school_state'].value_counts()
```

[ ]:

```
ca    15388
tx     7396
ny     7318
fl     6185
nc     5091
il     4350
ga     3963
sc     3936
mi     3161
pa     3109
in     2620
mo     2576
oh     2467
la     2394
ma     2389
wa     2334
ok     2276
nj     2237
az     2147
va     2045
wi     1827
al     1762
ut     1731
tn     1688
ct     1663
md     1514
```

```
nv     1367
ms     1323
ky     1304
or     1242
mn     1208
co     1111
ar     1049
id      693
ia      666
ks      634
nm      557
dc      516
hi      507
me      505
wv      503
nh      348
ak      345
de      343
ne      309
sd      300
ri      285
mt      245
nd      143
wy       98
vt       80
Name: school_state, dtype: int64
```

8 7. Preprocessing Categorical Features: project_title

[ ]:

```python
# https://stackoverflow.com/a/47091490/4084039
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)

    # general
    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
```

[ ]:

```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
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', 'himself', \
            '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', 'while', '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"]
```

[ ]:

```
project_data['project_title'].head(5)
```

[ ]:

```
0      Educational Support for English Learners at Home
1                 Wanted: Projector for Hungry Learners
2     Soccer Equipment for AWESOME Middle School Stu...
3                               Techie Kindergarteners
4                               Interactive Math Tools
Name: project_title, dtype: object
```

[ ]:

```
print("printing some random reviews")
print(9, project_data['project_title'].values[9])
print(34, project_data['project_title'].values[34])
print(147, project_data['project_title'].values[147])
```

```
printing some random reviews
9 Just For the Love of Reading--\r\nPure Pleasure
34 \"Have A Ball!!!\"
147 Who needs a Chromebook?\r\nWE DO!!
```

[ ]:

```
# Combining all the above Statements

def preprocess_text(text_data):
    preprocessed_text = []
    # tqdm is for printing the status bar
    for sentance in tqdm(text_data):
        sent = decontracted(sentance)
        sent = sent.replace('\\r', ' ')
        sent = sent.replace('\\n', ' ')
        sent = sent.replace('\\"', ' ')
        sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
        # https://gist.github.com/sebleier/554280
        sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
        preprocessed_text.append(sent.lower().strip())
    return preprocessed_text
```

[ ]:

```
preprocessed_titles = preprocess_text(project_data['project_title'].values)
```

```
100%|| 109248/109248 [00:02<00:00, 42193.61it/s]
```

[ ]:

```
print("printing some random reviews")
print(9, preprocessed_titles[9])
print(34, preprocessed_titles[34])
print(147, preprocessed_titles[147])
```

```
printing some random reviews
9 love reading pure pleasure
34 ball
147 needs chromebook
```

[ ]:

```
project_data['project_title'] = preprocessed_titles
```

9 8. Preprocessing Categorical Features: essay

[ ]:

```
# merge two column text dataframe:
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)
```

[ ]:
```
print("printing some random essay")
print(9, project_data['essay'].values[9])
print('-'*50)
print(34, project_data['essay'].values[34])
print('-'*50)
print(147, project_data['essay'].values[147])
```

```
printing some random essay
9 Over 95% of my students are on free or reduced lunch.  I have a few who are
homeless, but despite that, they come to school with an eagerness to learn.  My
students are inquisitive eager learners who  embrace the challenge of not having
great books and other resources  every day.  Many of them are not afforded the
opportunity to engage with these big colorful pages of a book on a regular basis
at home and they don't travel to the public library.  \r\nIt is my duty as a
teacher to do all I can to provide each student an opportunity to succeed in
every aspect of life. \r\nReading is Fundamental! My students will read these
books over and over again while boosting their comprehension skills. These books
will be used for read alouds, partner reading and for Independent reading.
\r\nThey will engage in reading to build their \"Love for Reading\" by reading
for pure enjoyment. They will be introduced to some new authors as well as some
old favorites. I want my students to be ready for the 21st Century and know the
pleasure of holding a good hard back book in hand. There's nothing like a good
book to read!  \r\nMy students will soar in Reading, and more because of your
consideration and generous funding contribution. This will help build stamina
and prepare for 3rd grade. Thank you so much for reading our proposal!nannan
--------------------------------------------------
34 My students mainly come from extremely low-income families, and the majority
of them come from homes where both parents work full time. Most of my students
are at school from 7:30 am to 6:00 pm (2:30 to 6:00 pm in the after-school
program), and they all receive free and reduced meals for breakfast and lunch.
\r\n\r\n\r\nI want my students to feel  as comfortable in my classroom as they
do at home. Many of my students take on multiple roles both at home as well as
in school. They are sometimes the caretakers of younger siblings, cooks,
babysitters, academics, friends, and most of all, they are developing who they
are going to become as adults.  I consider it an essential part of my job to
model helping others gain knowledge in a positive manner. As a result, I have a
community of students who love helping each other in and outside of the
classroom. They consistently look for opportunities to support each other's
learning in a kind and helpful way.I am excited to be experimenting with
alternative seating in my classroom this school year. Studies have shown that
giving students the option of where they sit in a classroom increases focus as
well as motivation.  \r\n\r\nBy allowing students choice in the classroom, they
are able to explore and create in a welcoming environment. Alternative classroom
seating has been experimented with more frequently in recent years. I believe
(along with many others), that every child learns differently. This does not
only apply to how multiplication is memorized, or a paper is written, but
applies to the space in which they are asked to work. I have had students in the
```

```
past ask \"Can I work in the library? Can I work on the carpet?\" My answer was
always, \"As long as you're learning, you can work wherever you want!\"
\r\n\r\nWith the yoga balls and the lap-desks, I will be able to increase the
options for seating in my classroom and expand its imaginable space.nannan
--------------------------------------------------
147 My students are eager to learn and make their mark on the world.\r\n\r\nThey
come from a Title 1 school and need extra love.\r\n\r\nMy fourth grade students
are in a high poverty area and still come to school every day to get their
education. I am trying to make it fun and educational for them so they can get
the most out of their schooling. I created a caring environment for the students
to bloom! They deserve the best.\r\nThank you!\r\nI am requesting 1 Chromebook
to access online interventions, differentiate instruction, and get extra
practice. The Chromebook will be used to supplement ELA and math instruction.
Students will play ELA and math games that are engaging and fun, as well as
participate in assignments online. This in turn will help my students improve
their skills. Having a Chromebook in the classroom would not only allow students
to use the programs at their own pace, but would ensure more students are
getting adequate time to use the programs. The online programs have been
especially beneficial to my students with special needs. They are able to work
at their level as well as be challenged with some different materials. This is
making these students more confident in their abilities.\r\n\r\nThe Chromebook
would allow my students to have daily access to computers and increase their
computing skills.\r\nThis will change their lives for the better as they become
more successful in school. Having access to technology in the classroom would
help bridge the achievement gap.nannan
```

[ ]:
```python
preprocessed_essays = preprocess_text(project_data['essay'].values)
```

```
100%|| 109248/109248 [00:58<00:00, 1878.86it/s]
```

[ ]:
```python
print("printing some random essay")
print(9, preprocessed_essays[9])
print('-'*50)
print(34, preprocessed_essays[34])
print('-'*50)
print(147, preprocessed_essays[147])
```

```
printing some random essay
9 95 students free reduced lunch homeless despite come school eagerness learn
students inquisitive eager learners embrace challenge not great books resources
every day many not afforded opportunity engage big colorful pages book regular
basis home not travel public library duty teacher provide student opportunity
succeed every aspect life reading fundamental students read books boosting
comprehension skills books used read alouds partner reading independent reading
engage reading build love reading reading pure enjoyment introduced new authors
well old favorites want students ready 21st century know pleasure holding good
hard back book hand nothing like good book read students soar reading
```

```
consideration generous funding contribution help build stamina prepare 3rd grade
thank much reading proposal nannan
--------------------------------------------------
34 students mainly come extremely low income families majority come homes
parents work full time students school 7 30 6 00 pm 2 30 6 00 pm school program
receive free reduced meals breakfast lunch want students feel comfortable
classroom home many students take multiple roles home well school sometimes
caretakers younger siblings cooks babysitters academics friends developing going
become adults consider essential part job model helping others gain knowledge
positive manner result community students love helping outside classroom
consistently look opportunities support learning kind helpful way excited
experimenting alternative seating classroom school year studies shown giving
students option sit classroom increases focus well motivation allowing students
choice classroom able explore create welcoming environment alternative classroom
seating experimented frequently recent years believe along many others every
child learns differently not apply multiplication memorized paper written
applies space asked work students past ask work library work carpet answer
always long learning work wherever want yoga balls lap desks able increase
options seating classroom expand imaginable space nannan
--------------------------------------------------
147 students eager learn make mark world come title 1 school need extra love
fourth grade students high poverty area still come school every day get
education trying make fun educational get schooling created caring environment
students bloom deserve best thank requesting 1 chromebook access online
interventions differentiate instruction get extra practice chromebook used
supplement ela math instruction students play ela math games engaging fun well
participate assignments online turn help students improve skills chromebook
classroom would not allow students use programs pace would ensure students
getting adequate time use programs online programs especially beneficial
students special needs able work level well challenged different materials
making students confident abilities chromebook would allow students daily access
computers increase computing skills change lives better become successful school
access technology classroom would help bridge achievement gap nannan
```

[ ]:
```
project_data['essay'] = preprocessed_essays
```

10 8. Preprocessing Numerical Values: price

[ ]:
```
# https://stackoverflow.com/questions/22407798/
 ↪how-to-reset-a-dataframes-indexes-for-all-groups-in-one-step
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).
 ↪reset_index()
price_data.head(2)
```

[ ]:
```
        id   price  quantity
0  p000001  459.56         7
```

```
1  p000002  515.89        21
```

[ ]:
```
# join two dataframes in python:
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

[ ]:
```
project_data['price'].head()
```

[ ]:
```
0    154.60
1    299.00
2    516.85
3    232.90
4     67.98
Name: price, dtype: float64
```

[ ]:
```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
scaler.fit(project_data['price'].values.reshape(-1, 1))
project_data['std_price']=scaler.transform(project_data['price'].values.
 ↪reshape(-1, 1) )
```

[ ]:
```
project_data['std_price'].head()
```

[ ]:
```
0   -0.390533
1    0.002396
2    0.595191
3   -0.177469
4   -0.626236
Name: std_price, dtype: float64
```

[ ]:
```
from sklearn.preprocessing import MinMaxScaler

scaler = MinMaxScaler()
scaler.fit(project_data['price'].values.reshape(-1, 1))
project_data['nrm_price']=scaler.transform(project_data['price'].values.
 ↪reshape(-1, 1))
```

[ ]:
```
project_data['nrm_price'].head()
```

[ ]:
```
0    0.015397
1    0.029839
2    0.051628
3    0.023228
4    0.006733
Name: nrm_price, dtype: float64
```

[ ]:
```
from colab import
```

11 Assignment : 14

11.0.1 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_numer ---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.

[4]:
```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer
from numpy import random
from sklearn.model_selection import train_test_split

from sklearn.preprocessing import StandardScaler

from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc, roc_auc_score
from nltk.stem.porter import PorterStemmer

from bs4 import BeautifulSoup
```

```python
import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer

from gensim.models import Word2Vec
from gensim.models import KeyedVectors
import pickle

from tqdm import tqdm
import os

from sklearn.metrics import roc_curve,accuracy_score
from sklearn.metrics import precision_score, recall_score
from sklearn.metrics import f1_score, confusion_matrix

import warnings
warnings.filterwarnings("ignore")
```

[5]:

```python
from tensorflow.keras.preprocessing.text import Tokenizer
from keras.preprocessing.sequence import pad_sequences
import pickle
```

[6]:

```python
import tensorflow as tf
from tensorflow.keras.layers import Dense,Dropout,LSTM
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Embedding

tf.compat.v1.disable_eager_execution()
```

[7]:

```python
def concat(list):
    from tqdm.notebook import tqdm
    op= ' '
    print("making a Bag of words")
    for ele in tqdm(list):
        op = op + ' '+ str(ele)
    return op.split(' ')
```

[8]:

```python
def fit(lst,top_word=0):
  from tqdm.notebook import tqdm
  import itertools
  corpus=[]
  dic={}
  corpus=concat(lst)
  print('generating word frequency dictionry')
  for p in tqdm(corpus):
    freq=0
    if p in dic.keys():
      pass
    else:
      freq=(corpus.count(p))
      dic[p]=freq
  sort_orders = dict(sorted(dic.items(), key=lambda x: x[1], reverse=True))
  print('dictionary sorted')

  if top_word :

    sort_orders = dict(itertools.islice(sort_orders.items(), top_word))
    print('top {} words extracted'.format(top_word))

  arr = list(sort_orders.keys())
  print('returnig dataframe')
  return np.array(arr)
```

[9]:

```
def transform(lst,fit):
  doc=[]
  from tqdm.notebook import tqdm
  fit=fit.tolist()
  print('generating document list containing sentance list in vetor form')
  for sent in tqdm(lst):
    sent_vect=[]
    for word in sent.split(' '):
      try:
            idx = fit.index(str(word))+2
      except:
            idx = 1
      sent_vect.append(idx)
    doc.append(sent_vect)
  return doc
```

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/

11.0.2 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.

[10]:

```
data = pd.read_csv('preprocessed_data.csv')
```

[11]:

```
data.columns
```

[11]:
```
Index(['school_state', 'teacher_prefix', 'project_grade_category',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay', 'price'],
      dtype='object')
```

[12]:
```
y = data['project_is_approved'].values
```

[13]:
```
data.drop(['project_is_approved'], axis=1, inplace=True)
```

[14]:
```
data['remaining_input'] = data['teacher_number_of_previously_posted_projects']␣
 ↪+ data['price']
```

[15]:
```
data.replace(to_replace=np.NaN, value= str('nan'),inplace=True)
```

[16]:
```
data.columns
```

[16]:
```
Index(['school_state', 'teacher_prefix', 'project_grade_category',
       'teacher_number_of_previously_posted_projects', 'clean_categories',
       'clean_subcategories', 'essay', 'price', 'remaining_input'],
      dtype='object')
```

[17]:
```
col = ['teacher_prefix', 'school_state', 'project_grade_category',
       'clean_categories', 'clean_subcategories','essay',
       'remaining_input']
data = data[col]
```

[18]:
```
data.columns
```

[18]:
```
Index(['teacher_prefix', 'school_state', 'project_grade_category',
       'clean_categories', 'clean_subcategories', 'essay', 'remaining_input'],
      dtype='object')
```

[19]:
```
data.head()
```

[19]:
```
  teacher_prefix  ... remaining_input
0            mrs  ...          778.05
1             ms  ...          217.03
2            mrs  ...          339.00
3            mrs  ...          483.04
4            mrs  ...           19.74

[5 rows x 7 columns]
```

Encoding categorial features

[20]:
```
vocab_dict={}
```

[21]:
```
print(data['teacher_prefix'].describe())
vocab_dict['teacher_prefix'] = data['teacher_prefix'].describe()['unique']
data['teacher_prefix'] = transform(data['teacher_prefix'].values,␣
 ↪fit(data['teacher_prefix'].values))
```

```
count     109248
unique         5
top          mrs
freq       57272
Name: teacher_prefix, dtype: object
making a Bag of words

HBox(children=(FloatProgress(value=0.0, max=109248.0), HTML(value='')))



generating word frequency dictionry

HBox(children=(FloatProgress(value=0.0, max=109250.0), HTML(value='')))



dictionary sorted
returnig dataframe
generating document list containing sentance list in vetor form

HBox(children=(FloatProgress(value=0.0, max=109248.0), HTML(value='')))
```

[22]:

```
print(data['school_state'].describe())
vocab_dict['school_state'] = data['school_state'].describe()['unique']
data['school_state'] = transform(data['school_state'].values,␣
 ↪fit(data['school_state'].values))
```

```
count     109248
unique        51
top           ca
freq       15388
Name: school_state, dtype: object
making a Bag of words

HBox(children=(FloatProgress(value=0.0, max=109248.0), HTML(value='')))



generating word frequency dictionry

HBox(children=(FloatProgress(value=0.0, max=109250.0), HTML(value='')))



dictionary sorted
returnig dataframe
generating document list containing sentance list in vetor form
```

```
HBox(children=(FloatProgress(value=0.0, max=109248.0), HTML(value='')))
```

[23]:
```
print(data['project_grade_category'].describe())
vocab_dict['project_grade_category'] = data['project_grade_category'].
 ↪describe()['unique']
data['project_grade_category'] = transform(data['project_grade_category'].
 ↪values, fit(data['project_grade_category'].values))
```

```
count              109248
unique                  4
top         grades_prek_2
freq                44225
Name: project_grade_category, dtype: object
making a Bag of words

HBox(children=(FloatProgress(value=0.0, max=109248.0), HTML(value='')))



generating word frequency dictionry

HBox(children=(FloatProgress(value=0.0, max=109250.0), HTML(value='')))



dictionary sorted
returnig dataframe
generating document list containing sentance list in vetor form

HBox(children=(FloatProgress(value=0.0, max=109248.0), HTML(value='')))
```

[24]:
```
print(data['clean_categories'].describe())
vocab_dict['clean_categories'] = data['clean_categories'].describe()['unique']
data['clean_categories'] = transform(data['clean_categories'].values,␣
 ↪fit(data['clean_categories'].values))
```

```
count                  109248
unique                     51
top         literacy_language
freq                    23655
Name: clean_categories, dtype: object
making a Bag of words
```

```
HBox(children=(FloatProgress(value=0.0, max=109248.0), HTML(value='')))
```

```
generating word frequency dictionry
```

```
HBox(children=(FloatProgress(value=0.0, max=152645.0), HTML(value='')))
```

```
dictionary sorted
returnig dataframe
generating document list containing sentance list in vetor form
```

```
HBox(children=(FloatProgress(value=0.0, max=109248.0), HTML(value='')))
```

[25]:
```
print(data['clean_subcategories'].describe())
vocab_dict['clean_subcategories'] = data['clean_subcategories'].
 ↪describe()['unique']
data['clean_subcategories'] = transform(data['clean_subcategories'].values,␣
 ↪fit(data['clean_subcategories'].values))
```

```
count       109248
unique         401
top       literacy
freq          9486
Name: clean_subcategories, dtype: object
making a Bag of words
```

```
HBox(children=(FloatProgress(value=0.0, max=109248.0), HTML(value='')))
```

```
generating word frequency dictionry
```

```
HBox(children=(FloatProgress(value=0.0, max=175876.0), HTML(value='')))
```

```
dictionary sorted
returnig dataframe
generating document list containing sentance list in vetor form
```

```
HBox(children=(FloatProgress(value=0.0, max=109248.0), HTML(value='')))
```

[26]:
```
data.head()
```

[26]:
```
  teacher_prefix  ... remaining_input
0            [2]  ...          778.05
1            [3]  ...          217.03
2            [2]  ...          339.00
3            [2]  ...          483.04
4            [2]  ...           19.74

[5 rows x 7 columns]
```

[27]:
```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(data, y ,test_size=0.
 ↪3,random_state=0, stratify = y)
```

[28]:
```
from keras.utils import to_categorical

y_train = to_categorical(y_train)
y_test = to_categorical(y_test)
```

[29]:
```
y_train.shape
```

[29]:
```
(76473, 2)
```

Encoding the Essay Texts

[30]:
```
#https://machinelearningmastery.com/
 ↪use-word-embedding-layers-deep-learning-keras/



t = Tokenizer()
t.fit_on_texts(X_train['essay'])
vocab_size = len(t.word_index) + 1
# integer encode the documents
X_train_essay = t.texts_to_sequences(X_train['essay'])
X_test_essay = t.texts_to_sequences(X_test['essay'])

print(X_train_essay)



# pad documents to a max length of 4 words
max_length = 500
X_tr_essay = pad_sequences(X_train_essay, maxlen=max_length, padding='post')
X_ts_essay = pad_sequences(X_test_essay, maxlen=max_length, padding='post')

print(X_tr_essay)
```

```
IOPub data rate exceeded.
```

```
The notebook server will temporarily stop sending output
to the client in order to avoid crashing it.
To change this limit, set the config variable
`--NotebookApp.iopub_data_rate_limit`.

Current values:
NotebookApp.iopub_data_rate_limit=1000000.0 (bytes/sec)
NotebookApp.rate_limit_window=3.0 (secs)


[[   4    1   22 ...    0    0    0]
 [   4    1 1071 ...    0    0    0]
 [ 169  677  852 ...    0    0    0]
 ...
 [   2  325    1 ...    0    0    0]
 [  14   64  149 ...    0    0    0]
 [  14   82    3 ...    0    0    0]]
```

[31]:

```
# load the whole embedding into memory

embeddings_index = dict()
fr = open('glove_vectors','rb')
f = pickle.load(fr)
# for line in f:
#         values = line.split()
#         word = values[0]
#         coefs = np.asarray(values[1:], dtype='float32')
#         embeddings_index[word] = coefs
# print('Loaded %s word vectors.' % len(embeddings_index))




# # create a weight matrix for words in training docs
# embedding_matrix = np.zeros((vocab_size, 300))
# for word, i in t.word_index.items():
#         embedding_vector = embeddings_index.get(word)
#         if embedding_vector is not None:
#                 embedding_matrix[i] = embedding_vector


def embedding_mat(word_index,embedding_dim = 300):
        embedding_matrix = np.zeros((len(word_index) + 1, embedding_dim))
        for word, i in word_index.items():
                        embedding_vector =f.get(word)
                        if embedding_vector is not None:
                                        embedding_matrix[i] = embedding_vector
        return embedding_matrix
```

```
embedding_matrix = embedding_mat(t.word_index)
```

[32]:

```
#https://stackoverflow.com/questions/50339065/
 ↪how-to-get-maximum-length-of-each-column-in-the-data-frame-using-pandas-python

len_dict = dict(
    [
        (v, X_train[v].apply(lambda r: len(str(r)) if r!=None else 0).max())
            for v in X_train.columns.values
    ])
```

[33]:

```
len_dict
```

[33]:

```
{'clean_categories': 10,
 'clean_subcategories': 12,
 'essay': 2657,
 'project_grade_category': 3,
 'remaining_input': 18,
 'school_state': 4,
 'teacher_prefix': 3}
```

[34]:

```
vocab_dict
```

[34]:

```
{'clean_categories': 51,
 'clean_subcategories': 401,
 'project_grade_category': 4,
 'school_state': 51,
 'teacher_prefix': 5}
```

Padding

[35]:

```
max_review_length = 3

X_tr_teacher_prefix = pad_sequences(X_train['teacher_prefix'],␣
 ↪maxlen=max_review_length)  #padding zeros at the begining of each review to␣
 ↪make max len as 200
X_ts_teacher_prefix = pad_sequences(X_test['teacher_prefix'],␣
 ↪maxlen=max_review_length)
```

[36]:

```
# max_review_length = len_dict['school_state']

X_tr_school_state = pad_sequences(X_train['school_state'],␣
 ↪maxlen=max_review_length)  #padding zeros at the begining of each review to␣
 ↪make max len as 200
X_ts_school_state = pad_sequences(X_test['school_state'],␣
 ↪maxlen=max_review_length)
```

[37]:

```
# max_review_length = len_dict['clean_categories']
```

```
X_tr_clean_categories = pad_sequences(X_train['clean_categories'],␣
 ↪maxlen=max_review_length)  #padding zeros at the begining of each review to␣
 ↪make max len as 200
X_ts_clean_categories = pad_sequences(X_test['clean_categories'],␣
 ↪maxlen=max_review_length)
```

[38]:
```
# max_review_length = len_dict['clean_subcategories']

X_tr_clean_subcategories = pad_sequences(X_train['clean_subcategories'],␣
 ↪maxlen=max_review_length)  #padding zeros at the begining of each review to␣
 ↪make max len as 200
X_ts_clean_subcategories = pad_sequences(X_test['clean_subcategories'],␣
 ↪maxlen=max_review_length)
```

[39]:
```
# max_review_length = len_dict['project_grade_category']

X_tr_project_grade_category = pad_sequences(X_train['project_grade_category'],␣
 ↪maxlen=max_review_length)  #padding zeros at the begining of each review to␣
 ↪make max len as 200
X_ts_project_grade_category = pad_sequences(X_test['project_grade_category'],␣
 ↪maxlen=max_review_length)
```

[40]:
```
tr=[X_tr_essay,X_tr_teacher_prefix,X_tr_school_state,X_tr_clean_categories,X_tr_clean_subcateg

ts=[X_ts_essay,X_ts_teacher_prefix,X_ts_school_state,X_ts_clean_categories,X_ts_clean_subcateg
```

Model defining

[41]:
```
#AUC score
def auc( y_true, y_pred ) :
        return tf.py_function(roc_auc_score, (y_true, y_pred), tf.double)



def step_decay(epoch):
    import math
    initial_lrate = 0.0001
    drop = 1e-6
    epochs_drop = 1
    lrate = initial_lrate * math.pow(drop, math.floor((1+epoch)/epochs_drop))
    return lrate
```

[42]:
```
# !git clone https://github.com/bckenstler/CLR
```

[43]:
```
from tensorflow.keras.preprocessing.text import Tokenizer
from keras.preprocessing.sequence import pad_sequences
import pickle

import tensorflow as tf
```

```
from tensorflow.keras import Input, Model
from tensorflow.keras.layers import Dense,SpatialDropout1D,LSTM,Flatten
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Embedding,BatchNormalization,concatenate
from tensorflow.keras.regularizers import L1,L2
from tensorflow.keras.models import load_model
from time import time
from tensorflow.python.keras.callbacks import TensorBoard
from tensorflow.keras.callbacks import ModelCheckpoint, EarlyStopping,␣
 ↪LearningRateScheduler
from CLR import clr_callback
tf.compat.v1.disable_eager_execution()
```

[ ]:

```
len_dict
```

[ ]:

```
{'clean_categories': 10,
 'clean_subcategories': 12,
 'essay': 2657,
 'project_grade_category': 3,
 'remaining_input': 18,
 'school_state': 4,
 'teacher_prefix': 3}
```

[ ]:

```
vocab_dict
```

[ ]:

```
{'clean_categories': 51,
 'clean_subcategories': 401,
 'project_grade_category': 4,
 'school_state': 51,
 'teacher_prefix': 5}
```

[ ]:

```
tf.keras.backend.clear_session()


#input 1
input1 = Input(shape=(500,))
x1 = Embedding(input_dim=vocab_size,output_dim=␣
 ↪300,weights=[embedding_matrix],trainable=False)(input1)
x1 = LSTM(32,return_sequences=True)(x1)
x1 = Dropout(0.3)(x1)
x1 = BatchNormalization()(x1)
x1 = LSTM(128,return_sequences=True,)(x1)
x1 = Dropout(0.5)(x1)
x1 = BatchNormalization()(x1)
# x1 = LSTM(128,return_sequences=True,recurrent_activation="sigmoid")(x1)
# x1 = Dropout(0.7)(x1)


x1 = Flatten()(x1)
```

```
#input 2
input2 = Input(shape=(max_review_length,))
x2 = Embedding(input_dim= vocab_dict['teacher_prefix']+2,output_dim= 2)(input2)
x2 = Flatten()(x2)

#input 3
input3 = Input(shape=(max_review_length,))
x3 = Embedding(input_dim= vocab_dict['school_state']+2,output_dim= 2)(input3)
x3 = Flatten()(x3)

#input 4
input4 = Input(shape=(max_review_length,))
x4 = Embedding(input_dim=vocab_dict['clean_categories']+2,output_dim= 2)(input4)
x4 = Flatten()(x4)

#input 5
input5 = Input(shape=(max_review_length,))
x5 = Embedding(input_dim= vocab_dict['clean_subcategories']+2,output_dim=␣
 ↪10)(input5)
x5 = Flatten()(x5)

#input 6
input6 = Input(shape=(max_review_length,))
x6 = Embedding(input_dim= vocab_dict['project_grade_category']+2,output_dim=␣
 ↪2)(input6)
x6 = Flatten()(x6)

#input 7
input7 = Input(shape=(1,))
x7 =␣
 ↪Dense(16,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L1(0.
 ↪01))(input7)

#merging all the inputs
Concat = concatenate([x1,x2,x3,x4,x5,x6,x7])
#x = BatchNormalization()(concat)

x =␣
 ↪Dense(64,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(Concat)
x = Dropout(0.5)(x)
x = BatchNormalization()(x)
x =␣
 ↪Dense(32,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(x)
x = Dropout(0.3)(x)
```

```
x = BatchNormalization()(x)
x =␣
 ↪Dense(16,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(x)
x = Dropout(0.1)(x)
output = Dense(2, activation = 'softmax')(x)

# create model with seven inputs
model = Model([input1,input2,input3,input4,input5,input6,input7], output)
print(model.summary())
```

```
WARNING:tensorflow:Layer lstm will not use cuDNN kernel since it doesn't meet
the cuDNN kernel criteria. It will use generic GPU kernel as fallback when
running on GPU
WARNING:tensorflow:Layer lstm_1 will not use cuDNN kernel since it doesn't meet
the cuDNN kernel criteria. It will use generic GPU kernel as fallback when
running on GPU
Model: "functional_1"
--------------------------------------------------------------------------------
------------------
Layer (type)                    Output Shape         Param #     Connected to
================================================================================
==================
input_1 (InputLayer)            [(None, 500)]        0
--------------------------------------------------------------------------------
------------------
embedding (Embedding)           (None, 500, 300)     14799000    input_1[0][0]
--------------------------------------------------------------------------------
------------------
lstm (LSTM)                     (None, 500, 32)      42624       embedding[0][0]
--------------------------------------------------------------------------------
------------------
dropout (Dropout)               (None, 500, 32)      0           lstm[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization (BatchNorma (None, 500, 32)      128         dropout[0][0]
--------------------------------------------------------------------------------
------------------
lstm_1 (LSTM)                   (None, 500, 128)     82432
batch_normalization[0][0]
--------------------------------------------------------------------------------
------------------
dropout_1 (Dropout)             (None, 500, 128)     0           lstm_1[0][0]
--------------------------------------------------------------------------------
------------------
input_2 (InputLayer)            [(None, 3)]          0
--------------------------------------------------------------------------------
```

```
------------------
input_3 (InputLayer)            [(None, 3)]          0
--------------------------------------------------------------------------------
------------------
input_4 (InputLayer)            [(None, 3)]          0
--------------------------------------------------------------------------------
------------------
input_5 (InputLayer)            [(None, 3)]          0
--------------------------------------------------------------------------------
------------------
input_6 (InputLayer)            [(None, 3)]          0
--------------------------------------------------------------------------------
------------------
batch_normalization_1 (BatchNor (None, 500, 128)     512         dropout_1[0][0]
--------------------------------------------------------------------------------
------------------
embedding_1 (Embedding)         (None, 3, 2)         14          input_2[0][0]
--------------------------------------------------------------------------------
------------------
embedding_2 (Embedding)         (None, 3, 2)         106         input_3[0][0]
--------------------------------------------------------------------------------
------------------
embedding_3 (Embedding)         (None, 3, 2)         106         input_4[0][0]
--------------------------------------------------------------------------------
------------------
embedding_4 (Embedding)         (None, 3, 10)        4030        input_5[0][0]
--------------------------------------------------------------------------------
------------------
embedding_5 (Embedding)         (None, 3, 2)         12          input_6[0][0]
--------------------------------------------------------------------------------
------------------
input_7 (InputLayer)            [(None, 1)]          0
--------------------------------------------------------------------------------
------------------
flatten (Flatten)               (None, 64000)        0
batch_normalization_1[0][0]
--------------------------------------------------------------------------------
------------------
flatten_1 (Flatten)             (None, 6)            0
embedding_1[0][0]
--------------------------------------------------------------------------------
------------------
flatten_2 (Flatten)             (None, 6)            0
embedding_2[0][0]
--------------------------------------------------------------------------------
------------------
flatten_3 (Flatten)             (None, 6)            0
embedding_3[0][0]
```

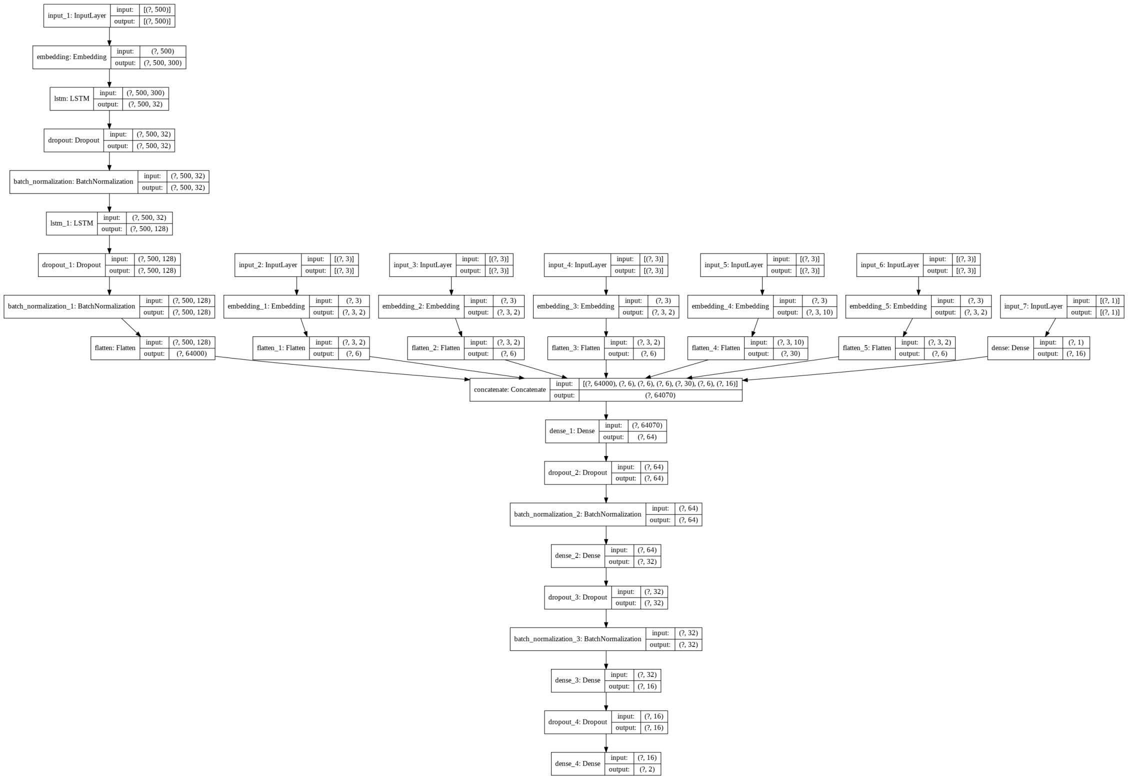
```
--------------------------------------------------------------------------------
------------------
flatten_4 (Flatten)             (None, 30)           0
embedding_4[0][0]

--------------------------------------------------------------------------------
------------------
flatten_5 (Flatten)             (None, 6)            0
embedding_5[0][0]

--------------------------------------------------------------------------------
------------------
dense (Dense)                   (None, 16)           32          input_7[0][0]

--------------------------------------------------------------------------------
------------------
concatenate (Concatenate)       (None, 64070)        0           flatten[0][0]
                                                                 flatten_1[0][0]
                                                                 flatten_2[0][0]
                                                                 flatten_3[0][0]
                                                                 flatten_4[0][0]
                                                                 flatten_5[0][0]
                                                                 dense[0][0]

--------------------------------------------------------------------------------
------------------
dense_1 (Dense)                 (None, 64)           4100544
concatenate[0][0]

--------------------------------------------------------------------------------
------------------
dropout_2 (Dropout)             (None, 64)           0           dense_1[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_2 (BatchNor (None, 64)           256         dropout_2[0][0]

--------------------------------------------------------------------------------
------------------
dense_2 (Dense)                 (None, 32)           2080
batch_normalization_2[0][0]

--------------------------------------------------------------------------------
------------------
dropout_3 (Dropout)             (None, 32)           0           dense_2[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_3 (BatchNor (None, 32)           128         dropout_3[0][0]

--------------------------------------------------------------------------------
------------------
dense_3 (Dense)                 (None, 16)           528
batch_normalization_3[0][0]

--------------------------------------------------------------------------------
------------------
dropout_4 (Dropout)             (None, 16)           0           dense_3[0][0]

--------------------------------------------------------------------------------
```

```
------------------
dense_4 (Dense)                 (None, 2)            34          dropout_4[0][0]
================================================================================
==================
Total params: 19,032,566
Trainable params: 4,233,054
Non-trainable params: 14,799,512
--------------------------------------------------------------------------------
------------------
None
```

[ ]:

```python
from keras.utils.vis_utils import plot_model
plot_model(model, show_shapes=True, show_layer_names=True)
```

[ ]:



[ ]:

```python
filepath="bestgpu.hdf5"

checkpoint = ModelCheckpoint(filepath, monitor='val_auc', verbose=1,␣
 ↪save_best_only=True, mode='max')
earlystopping = EarlyStopping(monitor='val_auc',min_delta=0.0001, patience=10,␣
 ↪verbose=1)
tensorboard = TensorBoard(log_dir='fit/{}'.format(time()))
lr = LearningRateScheduler(step_decay)
clr_triangular = CyclicLR(mode='triangular')
```

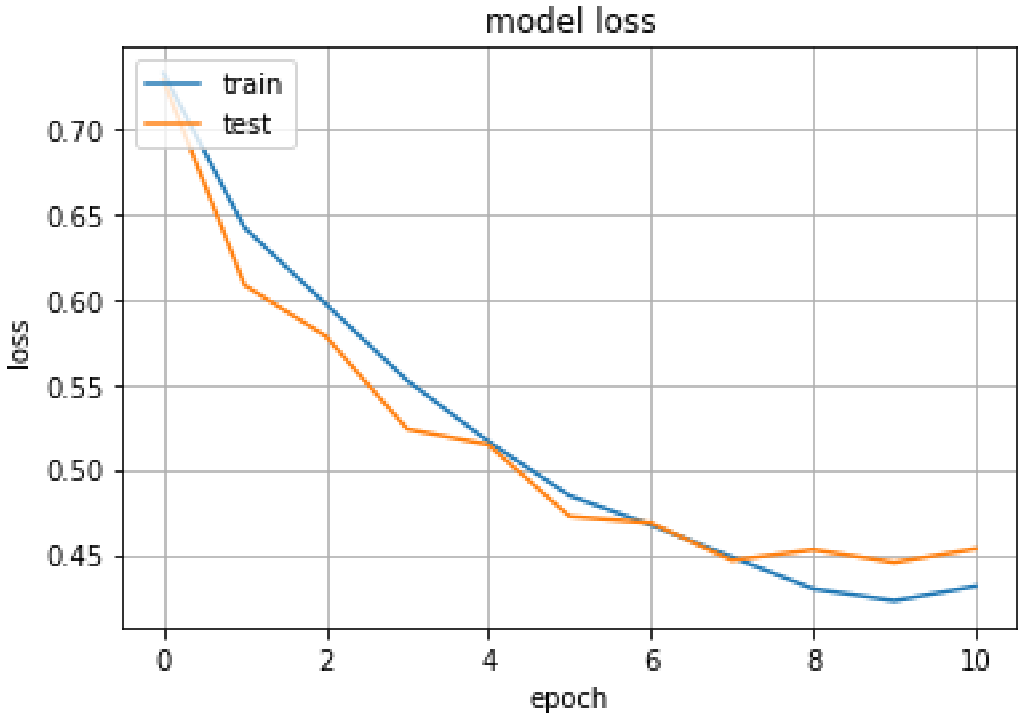
```
callbacks_list = [checkpoint,lr,earlystopping,tensorboard,clr_triangular]

model.compile(loss='categorical_crossentropy', optimizer=tf.keras.optimizers.
 ↪Adam(lr=0.0001,decay = 1e-4),metrics=[auc])


history = model.fit(tr, y_train, validation_split = 0.3, epochs=50, verbose=1,␣
 ↪batch_size=512, callbacks = callbacks_list)
```

```
Train on 53531 samples, validate on 22942 samples
Epoch 1/50
 1024/53531 [...] - ETA: 5:09 - loss: 0.9541 - auc:
0.5113WARNING:tensorflow:Callbacks method `on_train_batch_end` is slow compared
to the batch time (batch time: 1.9272s vs `on_train_batch_end` time: 4.1055s).
Check your callbacks.
53531/53531 [==============================] - ETA: 0s - loss: 0.7325 - auc:
0.5414
Epoch 00001: val_auc improved from -inf to 0.55632, saving model to bestgpu.hdf5
53531/53531 [==============================] - 165s 3ms/sample - loss: 0.7325 -
auc: 0.5414 - val_loss: 0.7282 - val_auc: 0.5563
Epoch 2/50
53531/53531 [==============================] - ETA: 0s - loss: 0.6417 - auc:
0.6047
Epoch 00002: val_auc improved from 0.55632 to 0.68314, saving model to
bestgpu.hdf5
53531/53531 [==============================] - 162s 3ms/sample - loss: 0.6417 -
auc: 0.6047 - val_loss: 0.6082 - val_auc: 0.6831
Epoch 3/50
53531/53531 [==============================] - ETA: 0s - loss: 0.5972 - auc:
0.6739
Epoch 00003: val_auc improved from 0.68314 to 0.71618, saving model to
bestgpu.hdf5
53531/53531 [==============================] - 160s 3ms/sample - loss: 0.5972 -
auc: 0.6739 - val_loss: 0.5782 - val_auc: 0.7162
Epoch 4/50
53531/53531 [==============================] - ETA: 0s - loss: 0.5521 - auc:
0.7080
Epoch 00004: val_auc improved from 0.71618 to 0.73928, saving model to
bestgpu.hdf5
53531/53531 [==============================] - 161s 3ms/sample - loss: 0.5521 -
auc: 0.7080 - val_loss: 0.5236 - val_auc: 0.7393
Epoch 5/50
53531/53531 [==============================] - ETA: 0s - loss: 0.5163 - auc:
0.7246
Epoch 00005: val_auc improved from 0.73928 to 0.74828, saving model to
bestgpu.hdf5
```

```
53531/53531 [==============================] - 160s 3ms/sample - loss: 0.5163 -
auc: 0.7246 - val_loss: 0.5144 - val_auc: 0.7483
Epoch 6/50
53531/53531 [==============================] - ETA: 0s - loss: 0.4845 - auc:
0.7400
Epoch 00006: val_auc improved from 0.74828 to 0.74919, saving model to
bestgpu.hdf5
53531/53531 [==============================] - 160s 3ms/sample - loss: 0.4845 -
auc: 0.7400 - val_loss: 0.4723 - val_auc: 0.7492
Epoch 7/50
53531/53531 [==============================] - ETA: 0s - loss: 0.4673 - auc:
0.7458
Epoch 00007: val_auc improved from 0.74919 to 0.75565, saving model to
bestgpu.hdf5
53531/53531 [==============================] - 160s 3ms/sample - loss: 0.4673 -
auc: 0.7458 - val_loss: 0.4685 - val_auc: 0.7557
Epoch 8/50
53531/53531 [==============================] - ETA: 0s - loss: 0.4485 - auc:
0.7554
Epoch 00008: val_auc did not improve from 0.75565
53531/53531 [==============================] - 158s 3ms/sample - loss: 0.4485 -
auc: 0.7554 - val_loss: 0.4464 - val_auc: 0.7532
Epoch 9/50
53531/53531 [==============================] - ETA: 0s - loss: 0.4298 - auc:
0.7645
Epoch 00009: val_auc improved from 0.75565 to 0.75790, saving model to
bestgpu.hdf5
53531/53531 [==============================] - 160s 3ms/sample - loss: 0.4298 -
auc: 0.7645 - val_loss: 0.4528 - val_auc: 0.7579
Epoch 10/50
53531/53531 [==============================] - ETA: 0s - loss: 0.4227 - auc:
0.7674
Epoch 00010: val_auc improved from 0.75790 to 0.75948, saving model to
bestgpu.hdf5
53531/53531 [==============================] - 161s 3ms/sample - loss: 0.4227 -
auc: 0.7674 - val_loss: 0.4452 - val_auc: 0.7595
Epoch 11/50
53531/53531 [==============================] - ETA: 0s - loss: 0.4313 - auc:
0.7720
Epoch 00011: val_auc did not improve from 0.75948
53531/53531 [==============================] - 159s 3ms/sample - loss: 0.4313 -
auc: 0.7720 - val_loss: 0.4534 - val_auc: 0.7584
Epoch 00011: early stopping
```

[ ]:

```python
import matplotlib.pyplot as plt
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.grid()
plt.show()
```



[ ]:

```
tf.keras.backend.clear_session()


#input 1
input1 = Input(shape=(500,))
x1 = Embedding(input_dim=vocab_size,output_dim=␣
 ↪300,weights=[embedding_matrix],trainable=False)(input1)
x1 = LSTM(32,return_sequences=True)(x1)
x1 = Dropout(0.3)(x1)
x1 = BatchNormalization()(x1)
x1 = LSTM(128,return_sequences=True,)(x1)
x1 = Dropout(0.5)(x1)
x1 = BatchNormalization()(x1)
# x1 = LSTM(128,return_sequences=True,recurrent_activation="sigmoid")(x1)
# x1 = Dropout(0.7)(x1)
```

```
x1 = Flatten()(x1)

#input 2
input2 = Input(shape=(max_review_length,))
x2 = Embedding(input_dim= vocab_dict['teacher_prefix']+2,output_dim= 2)(input2)
x2 = Flatten()(x2)

#input 3
input3 = Input(shape=(max_review_length,))
x3 = Embedding(input_dim= vocab_dict['school_state']+2,output_dim= 2)(input3)
x3 = Flatten()(x3)

#input 4
input4 = Input(shape=(max_review_length,))
x4 = Embedding(input_dim=vocab_dict['clean_categories']+2,output_dim= 2)(input4)
x4 = Flatten()(x4)

#input 5
input5 = Input(shape=(max_review_length,))
x5 = Embedding(input_dim= vocab_dict['clean_subcategories']+2,output_dim=␣
 ↪10)(input5)
x5 = Flatten()(x5)

#input 6
input6 = Input(shape=(max_review_length,))
x6 = Embedding(input_dim= vocab_dict['project_grade_category']+2,output_dim=␣
 ↪2)(input6)
x6 = Flatten()(x6)

#input 7
input7 = Input(shape=(1,))
x7 =␣
 ↪Dense(16,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L1(0.
 ↪01))(input7)

#merging all the inputs
Concat = concatenate([x1,x2,x3,x4,x5,x6,x7])
#x = BatchNormalization()(concat)

x =␣
 ↪Dense(64,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(Concat)
x = Dropout(0.5)(x)
x = BatchNormalization()(x)
x =␣
 ↪Dense(32,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(x)
```

```
x = Dropout(0.3)(x)
x = BatchNormalization()(x)
x =␣
 ↪Dense(16,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(x)
x = Dropout(0.1)(x)
output = Dense(2, activation = 'softmax')(x)

# create model with seven inputs
model = Model([input1,input2,input3,input4,input5,input6,input7], output)
model.load_weights('bestgpu.hdf5')
```

```
WARNING:tensorflow:Layer lstm will not use cuDNN kernel since it doesn't meet
the cuDNN kernel criteria. It will use generic GPU kernel as fallback when
running on GPU
WARNING:tensorflow:Layer lstm_1 will not use cuDNN kernel since it doesn't meet
the cuDNN kernel criteria. It will use generic GPU kernel as fallback when
running on GPU
```

Train AUC

[ ]:

```
roc_auc_score(y_train,model.predict(tr))
```

[ ]:

```
0.7850252836667377
```

Test AUC

[ ]:

```
roc_auc_score(y_test,model.predict(ts))
```

[ ]:

```
0.760770265186021
```

11.0.3 Model-2

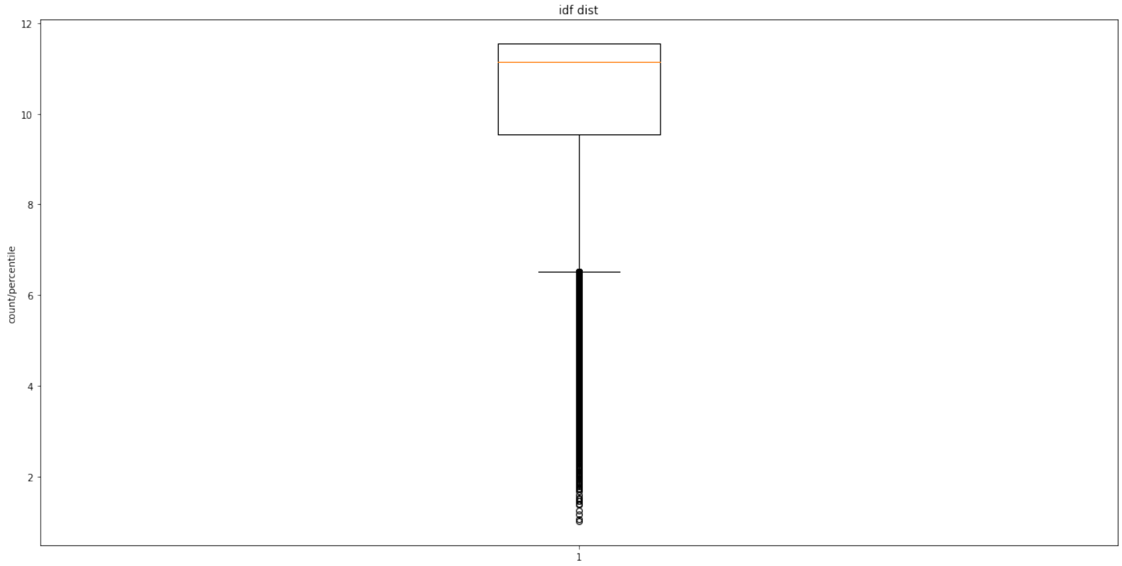
Use the same model as above but for 'input_seq_total_text_data' give only some words in the sentance not all the words. Filter the words as below.

[108]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
tf_vec = TfidfVectorizer()
tf_vec.fit(X_train['essay'])
idf = tf_vec.idf_
```

[109]:

```
plt.figure(figsize=(20,10))
plt.boxplot(idf)
plt.title('idf dist')
plt.ylabel('count/percentile')
plt.show()
```



[110]:

```
for i in range(0,101,2):
  print(f' {i}th percentile value percentile {np.percentile(idf,[i])}')
```

```
0th percentile value percentile [1.00800855]
2th percentile value percentile [4.93930297]
4th percentile value percentile [5.85111534]
6th percentile value percentile [6.56453348]
8th percentile value percentile [7.08565079]
10th percentile value percentile [7.51731827]
12th percentile value percentile [7.86267946]
14th percentile value percentile [8.16716865]
16th percentile value percentile [8.46051646]
18th percentile value percentile [8.74819853]
20th percentile value percentile [8.98660955]
22th percentile value percentile [9.20018366]
24th percentile value percentile [9.41149275]
26th percentile value percentile [9.60564876]
28th percentile value percentile [9.75979944]
30th percentile value percentile [9.942121]
32th percentile value percentile [10.04748152]
34th percentile value percentile [10.16526455]
36th percentile value percentile [10.29879594]
38th percentile value percentile [10.45294662]
40th percentile value percentile [10.63526818]
42th percentile value percentile [10.63526818]
44th percentile value percentile [10.85841173]
46th percentile value percentile [10.85841173]
48th percentile value percentile [10.85841173]
50th percentile value percentile [11.1460938]
```

```
52th percentile value percentile [11.1460938]
54th percentile value percentile [11.1460938]
56th percentile value percentile [11.1460938]
58th percentile value percentile [11.1460938]
60th percentile value percentile [11.1460938]
62th percentile value percentile [11.55155891]
64th percentile value percentile [11.55155891]
66th percentile value percentile [11.55155891]
68th percentile value percentile [11.55155891]
70th percentile value percentile [11.55155891]
72th percentile value percentile [11.55155891]
74th percentile value percentile [11.55155891]
76th percentile value percentile [11.55155891]
78th percentile value percentile [11.55155891]
80th percentile value percentile [11.55155891]
82th percentile value percentile [11.55155891]
84th percentile value percentile [11.55155891]
86th percentile value percentile [11.55155891]
88th percentile value percentile [11.55155891]
90th percentile value percentile [11.55155891]
92th percentile value percentile [11.55155891]
94th percentile value percentile [11.55155891]
96th percentile value percentile [11.55155891]
98th percentile value percentile [11.55155891]
100th percentile value percentile [11.55155891]
```

[111]:

```
for i in range(0,101,25):
  print(f' {i}th percentile value percentile {np.percentile(idf,[i])}')
```

```
0th percentile value percentile [1.00800855]
25th percentile value percentile [9.53665589]
50th percentile value percentile [11.1460938]
75th percentile value percentile [11.55155891]
100th percentile value percentile [11.55155891]
```

[141]:

```
rm_feat = []
a=np.percentile(idf,1)
b=np.percentile(idf,75)
for x,y in zip(tf_vec.get_feature_names(),idf):

    if y < a or y > b:
        rm_feat.append(x)
```

[127]:

```
from tqdm.notebook import tqdm
def trim_text(essay_text,feat_name):

  preprocessed_text = []
  for sent in tqdm(essay_text):
    words = sent.split()
    final_sent = ''
    for word in words:
      if word in feat_name:
        pass
      else:

        final_sent += ' ' + word

    preprocessed_text.append(final_sent)

  return preprocessed_text
```

[128]:

```
%%time
i=254
z=trim_text([X_train['essay'][i]],rm_feat)
```

```
HBox(children=(FloatProgress(value=0.0, max=1.0), HTML(value='')))



CPU times: user 33.9 ms, sys: 1.92 ms, total: 35.8 ms
Wall time: 38 ms
```

[129]:

```
print([X_train['essay'][i]])
print(z)
```

```
['every year first day school students always ask exact question will dissecting
frogs it always number one experience incredibly eager project give opportunity
my students 7th graders excited hands opportunities science curious world around
think gross things awesome they lots questions incredible imaginations they
talkative like move around learn best get things since start school itching get
hands frog specimens i not sure desire stems whether memory parent sibling scene
movie dissecting frog top middle school bucket list our school not many
resources as neighborhood school struggle get bare minimum providing funds
dissection unfortunately not within school means my students wrapping learning
human body systems primarily digestive circulatory respiratory musculoskeletal
systems the frog dissection enable hands experience systems students working
teams dissect frog identify structures studied review functions compare contrast
structures found human body in addition seeing firsthand systems interconnected
practicing skills teamwork hand eye coordination also learning ethics dissection
the owl pellets provide students insight digestive system functions help
students gain understanding certain materials indigestible this project give
students excitement science provide undoubtedly inspire continue pursue
interests field they lifelong memories able pass siblings even children most
importantly show no matter zip code still entitled learning experiences millions
students around country enjoy']
```

```
[' exact question will dissecting frogs incredibly 7th gross awesome lots
incredible imaginations talkative itching frog specimens i stems whether memory
sibling scene movie dissecting frog top bucket list bare minimum funds
dissection wrapping human body systems primarily digestive circulatory
respiratory musculoskeletal systems frog dissection enable systems teams dissect
frog identify structures studied review functions compare contrast structures
found human body seeing firsthand systems interconnected practicing teamwork eye
coordination ethics dissection owl pellets insight digestive system functions
gain certain indigestible undoubtedly pursue interests field lifelong memories
pass siblings importantly matter zip code entitled millions country']
```

[130]:

```
X_train_idf_essay = trim_text(X_train['essay'],rm_feat)
```

```
HBox(children=(FloatProgress(value=0.0, max=76473.0), HTML(value='')))
```

[131]:

```
X_test_idf_essay = trim_text(X_test['essay'],rm_feat)
```

```
HBox(children=(FloatProgress(value=0.0, max=32775.0), HTML(value='')))
```

[132]:

```
#https://machinelearningmastery.com/
 ↪use-word-embedding-layers-deep-learning-keras/

t = Tokenizer()
t.fit_on_texts(X_train_idf_essay)
vocab_size = len(t.word_index) + 1
# integer encode the documents
X_train_essay = t.texts_to_sequences(X_train_idf_essay)
X_test_essay = t.texts_to_sequences(X_test_idf_essay)



# pad documents to a max length of 4 words
max_length = 300
X_tr_essay = pad_sequences(X_train_essay, maxlen=max_length, padding='post')
X_ts_essay = pad_sequences(X_test_essay, maxlen=max_length, padding='post')
```

[133]:

```
# load the whole embedding into memory

embeddings_index = dict()
fr = open('glove_vectors','rb')
f = pickle.load(fr)
```

```
def embedding_mat(word_index,embedding_dim = 300):
        embedding_matrix = np.zeros((len(word_index) + 1, embedding_dim))
        for word, i in word_index.items():
                        embedding_vector =f.get(word)
                        if embedding_vector is not None:
                                        embedding_matrix[i] = embedding_vector
        return embedding_matrix

embedding_matrix = embedding_mat(t.word_index)
```

[134]:
```
tr=[X_tr_essay,X_tr_teacher_prefix,X_tr_school_state,X_tr_clean_categories,X_tr_clean_subcateg

ts=[X_ts_essay,X_ts_teacher_prefix,X_ts_school_state,X_ts_clean_categories,X_ts_clean_subcateg
```

[135]:
```
from tensorflow.keras.preprocessing.text import Tokenizer
from keras.preprocessing.sequence import pad_sequences
import pickle

import tensorflow as tf
from tensorflow.keras import Input, Model
from tensorflow.keras.layers import␣
 ↪Dense,SpatialDropout1D,LSTM,Flatten,Conv1D,GlobalAveragePooling1D
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Embedding,BatchNormalization,concatenate
from tensorflow.keras.regularizers import L1,L2
from tensorflow.keras.models import load_model
from time import time
from tensorflow.python.keras.callbacks import TensorBoard
from tensorflow.keras.callbacks import ModelCheckpoint, EarlyStopping,␣
 ↪LearningRateScheduler
from CLR.clr_callback import *
tf.compat.v1.disable_eager_execution()
```

[136]:
```
print(vocab_size)
```

```
48837
```

[142]:
```
tf.keras.backend.clear_session()


#input 1
input1 = Input(shape=(300,))
x1 = Embedding(input_dim=vocab_size,output_dim=␣
 ↪300,weights=[embedding_matrix],trainable=False)(input1)
x1 = LSTM(32,return_sequences=True)(x1)
x1 = Dropout(0.3)(x1)
x1 = BatchNormalization()(x1)
```

```
x1 = LSTM(128,return_sequences=True,)(x1)
x1 = Dropout(0.5)(x1)
x1 = BatchNormalization()(x1)
# x1 = LSTM(128,return_sequences=True,recurrent_activation="sigmoid")(x1)
# x1 = Dropout(0.7)(x1)


x1 = Flatten()(x1)

#input 2
input2 = Input(shape=(max_review_length,))
x2 = Embedding(input_dim= vocab_dict['teacher_prefix']+2,output_dim= 2)(input2)
x2 = Flatten()(x2)

#input 3
input3 = Input(shape=(max_review_length,))
x3 = Embedding(input_dim= vocab_dict['school_state']+2,output_dim= 2)(input3)
x3 = Flatten()(x3)

#input 4
input4 = Input(shape=(max_review_length,))
x4 = Embedding(input_dim=vocab_dict['clean_categories']+2,output_dim= 2)(input4)
x4 = Flatten()(x4)

#input 5
input5 = Input(shape=(max_review_length,))
x5 = Embedding(input_dim= vocab_dict['clean_subcategories']+2,output_dim=␣
 ↪10)(input5)
x5 = Flatten()(x5)

#input 6
input6 = Input(shape=(max_review_length,))
x6 = Embedding(input_dim= vocab_dict['project_grade_category']+2,output_dim=␣
 ↪2)(input6)
x6 = Flatten()(x6)

#input 7
input7 = Input(shape=(1,))
x7 =␣
 ↪Dense(16,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L1(0.
 ↪01))(input7)

#merging all the inputs
Concat = concatenate([x1,x2,x3,x4,x5,x6,x7])
#x = BatchNormalization()(concat)
```

```
x =␣
 ↪Dense(64,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(Concat)
x = Dropout(0.5)(x)
x = BatchNormalization()(x)
x =␣
 ↪Dense(32,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(x)
x = Dropout(0.3)(x)
x = BatchNormalization()(x)
x =␣
 ↪Dense(16,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(x)
x = Dropout(0.1)(x)
output = Dense(2, activation = 'softmax')(x)

# create model with seven inputs
model = Model([input1,input2,input3,input4,input5,input6,input7], output)

print(model.summary())
```

```
WARNING:tensorflow:Layer lstm will not use cuDNN kernel since it doesn't meet
the cuDNN kernel criteria. It will use generic GPU kernel as fallback when
running on GPU
WARNING:tensorflow:Layer lstm_1 will not use cuDNN kernel since it doesn't meet
the cuDNN kernel criteria. It will use generic GPU kernel as fallback when
running on GPU
Model: "functional_1"
--------------------------------------------------------------------------------
------------------
Layer (type)                    Output Shape         Param #     Connected to
================================================================================
==================
input_1 (InputLayer)            [(None, 300)]        0

--------------------------------------------------------------------------------
------------------
embedding (Embedding)           (None, 300, 300)     14651100    input_1[0][0]

--------------------------------------------------------------------------------
------------------
lstm (LSTM)                     (None, 300, 32)      42624       embedding[0][0]

--------------------------------------------------------------------------------
------------------
dropout (Dropout)               (None, 300, 32)      0           lstm[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization (BatchNorma (None, 300, 32)      128         dropout[0][0]

--------------------------------------------------------------------------------
```

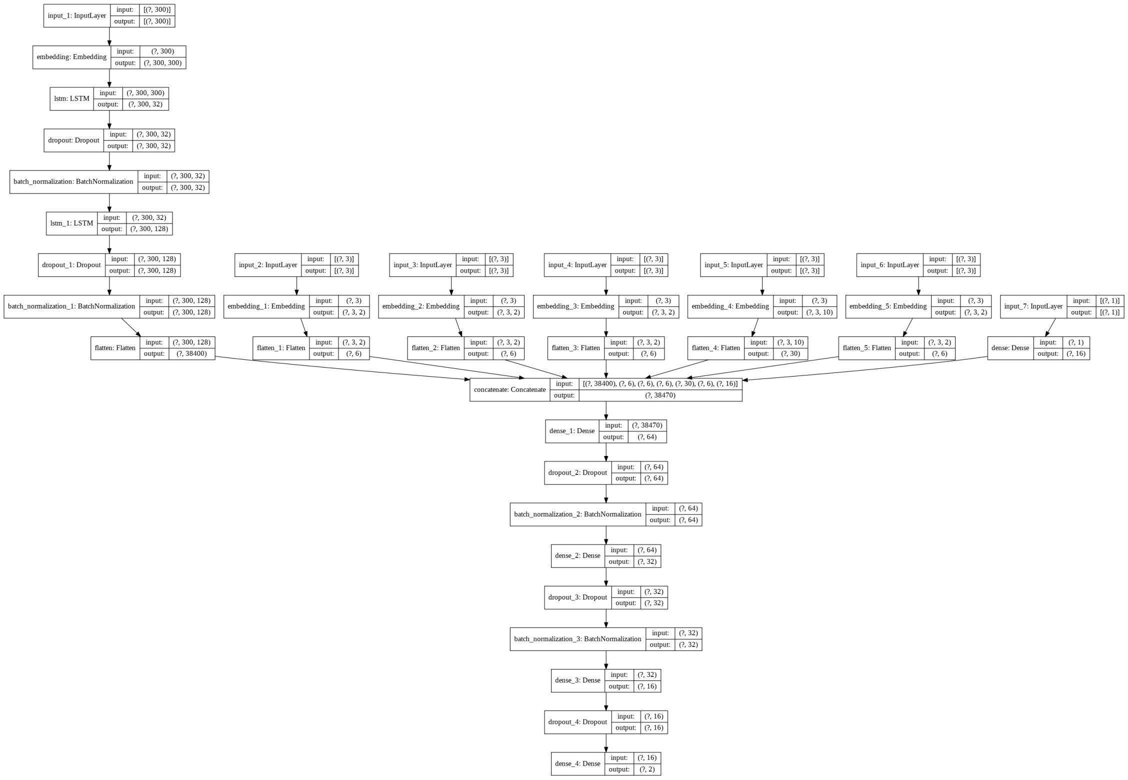
```
------------------
lstm_1 (LSTM)                   (None, 300, 128)     82432
batch_normalization[0][0]

--------------------------------------------------------------------------------
------------------
dropout_1 (Dropout)             (None, 300, 128)     0          lstm_1[0][0]

--------------------------------------------------------------------------------
------------------
input_2 (InputLayer)            [(None, 3)]          0

--------------------------------------------------------------------------------
------------------
input_3 (InputLayer)            [(None, 3)]          0

--------------------------------------------------------------------------------
------------------
input_4 (InputLayer)            [(None, 3)]          0

--------------------------------------------------------------------------------
------------------
input_5 (InputLayer)            [(None, 3)]          0

--------------------------------------------------------------------------------
------------------
input_6 (InputLayer)            [(None, 3)]          0

--------------------------------------------------------------------------------
------------------
batch_normalization_1 (BatchNor (None, 300, 128)     512        dropout_1[0][0]

--------------------------------------------------------------------------------
------------------
embedding_1 (Embedding)         (None, 3, 2)         14         input_2[0][0]

--------------------------------------------------------------------------------
------------------
embedding_2 (Embedding)         (None, 3, 2)         106        input_3[0][0]

--------------------------------------------------------------------------------
------------------
embedding_3 (Embedding)         (None, 3, 2)         106        input_4[0][0]

--------------------------------------------------------------------------------
------------------
embedding_4 (Embedding)         (None, 3, 10)        4030       input_5[0][0]

--------------------------------------------------------------------------------
------------------
embedding_5 (Embedding)         (None, 3, 2)         12         input_6[0][0]

--------------------------------------------------------------------------------
------------------
input_7 (InputLayer)            [(None, 1)]          0

--------------------------------------------------------------------------------
------------------
flatten (Flatten)               (None, 38400)        0
batch_normalization_1[0][0]

--------------------------------------------------------------------------------
------------------
```

```
flatten_1 (Flatten)             (None, 6)            0
embedding_1[0][0]
--------------------------------------------------------------------------------
------------------
flatten_2 (Flatten)             (None, 6)            0
embedding_2[0][0]
--------------------------------------------------------------------------------
------------------
flatten_3 (Flatten)             (None, 6)            0
embedding_3[0][0]
--------------------------------------------------------------------------------
------------------
flatten_4 (Flatten)             (None, 30)           0
embedding_4[0][0]
--------------------------------------------------------------------------------
------------------
flatten_5 (Flatten)             (None, 6)            0
embedding_5[0][0]
--------------------------------------------------------------------------------
------------------
dense (Dense)                   (None, 16)           32          input_7[0][0]
--------------------------------------------------------------------------------
------------------
concatenate (Concatenate)       (None, 38470)        0           flatten[0][0]
                                                                 flatten_1[0][0]
                                                                 flatten_2[0][0]
                                                                 flatten_3[0][0]
                                                                 flatten_4[0][0]
                                                                 flatten_5[0][0]
                                                                 dense[0][0]
--------------------------------------------------------------------------------
------------------
dense_1 (Dense)                 (None, 64)           2462144
concatenate[0][0]
--------------------------------------------------------------------------------
------------------
dropout_2 (Dropout)             (None, 64)           0           dense_1[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_2 (BatchNor (None, 64)           256         dropout_2[0][0]
--------------------------------------------------------------------------------
------------------
dense_2 (Dense)                 (None, 32)           2080
batch_normalization_2[0][0]
--------------------------------------------------------------------------------
------------------
dropout_3 (Dropout)             (None, 32)           0           dense_2[0][0]
--------------------------------------------------------------------------------
```

```
------------------
batch_normalization_3 (BatchNor (None, 32)           128         dropout_3[0][0]

--------------------------------------------------------------------------------
------------------
dense_3 (Dense)                 (None, 16)           528
batch_normalization_3[0][0]

--------------------------------------------------------------------------------
------------------
dropout_4 (Dropout)             (None, 16)           0           dense_3[0][0]

--------------------------------------------------------------------------------
------------------
dense_4 (Dense)                 (None, 2)            34          dropout_4[0][0]
================================================================================
==================
Total params: 17,246,266
Trainable params: 2,594,654
Non-trainable params: 14,651,612

--------------------------------------------------------------------------------
------------------
None
```

[143]:
```python
from keras.utils.vis_utils import plot_model
plot_model(model, show_shapes=True, show_layer_names=True)
```

[143]:


input_1: InputLayer | input: [(?, 300)] | output: [(?, 300)]
embedding: Embedding | input: (?, 300) | output: (?, 300, 300)
lstm: LSTM | input: (?, 300, 300) | output: (?, 300, 32)
dropout: Dropout | input: (?, 300, 32) | output: (?, 300, 32)
batch_normalization: BatchNormalization | input: (?, 300, 32) | output: (?, 300, 32)
lstm_1: LSTM | input: (?, 300, 32) | output: (?, 300, 128)
dropout_1: Dropout | input: (?, 300, 128) | output: (?, 300, 128)
batch_normalization_1: BatchNormalization | input: (?, 300, 128) | output: (?, 300, 128)
flatten: Flatten | input: (?, 300, 128) | output: (?, 38400)
input_2: InputLayer | input: [(?, 3)] | output: [(?, 3)]
embedding_1: Embedding | input: (?, 3) | output: (?, 3, 2)
flatten_1: Flatten | input: (?, 3, 2) | output: (?, 6)
input_3: InputLayer | input: [(?, 3)] | output: [(?, 3)]
embedding_2: Embedding | input: (?, 3) | output: (?, 3, 2)
flatten_2: Flatten | input: (?, 3, 2) | output: (?, 6)
input_4: InputLayer | input: [(?, 3)] | output: [(?, 3)]
embedding_3: Embedding | input: (?, 3) | output: (?, 3, 2)
flatten_3: Flatten | input: (?, 3, 2) | output: (?, 6)
input_5: InputLayer | input: [(?, 3)] | output: [(?, 3)]
embedding_4: Embedding | input: (?, 3) | output: (?, 3, 10)
flatten_4: Flatten | input: (?, 3, 10) | output: (?, 30)
input_6: InputLayer | input: [(?, 3)] | output: [(?, 3)]
embedding_5: Embedding | input: (?, 3) | output: (?, 3, 2)
flatten_5: Flatten | input: (?, 3, 2) | output: (?, 6)
input_7: InputLayer | input: [(?, 1)] | output: [(?, 1)]
dense: Dense | input: (?, 1) | output: (?, 16)
concatenate: Concatenate | input: [(?, 38400), (?, 6), (?, 6), (?, 6), (?, 30), (?, 6), (?, 16)] | output: (?, 38470)
dense_1: Dense | input: (?, 38470) | output: (?, 64)
dropout_2: Dropout | input: (?, 64) | output: (?, 64)
batch_normalization_2: BatchNormalization | input: (?, 64) | output: (?, 64)
dense_2: Dense | input: (?, 64) | output: (?, 32)
dropout_3: Dropout | input: (?, 32) | output: (?, 32)
batch_normalization_3: BatchNormalization | input: (?, 32) | output: (?, 32)
dense_3: Dense | input: (?, 32) | output: (?, 16)
dropout_4: Dropout | input: (?, 16) | output: (?, 16)
dense_4: Dense | input: (?, 16) | output: (?, 2)

[144]:

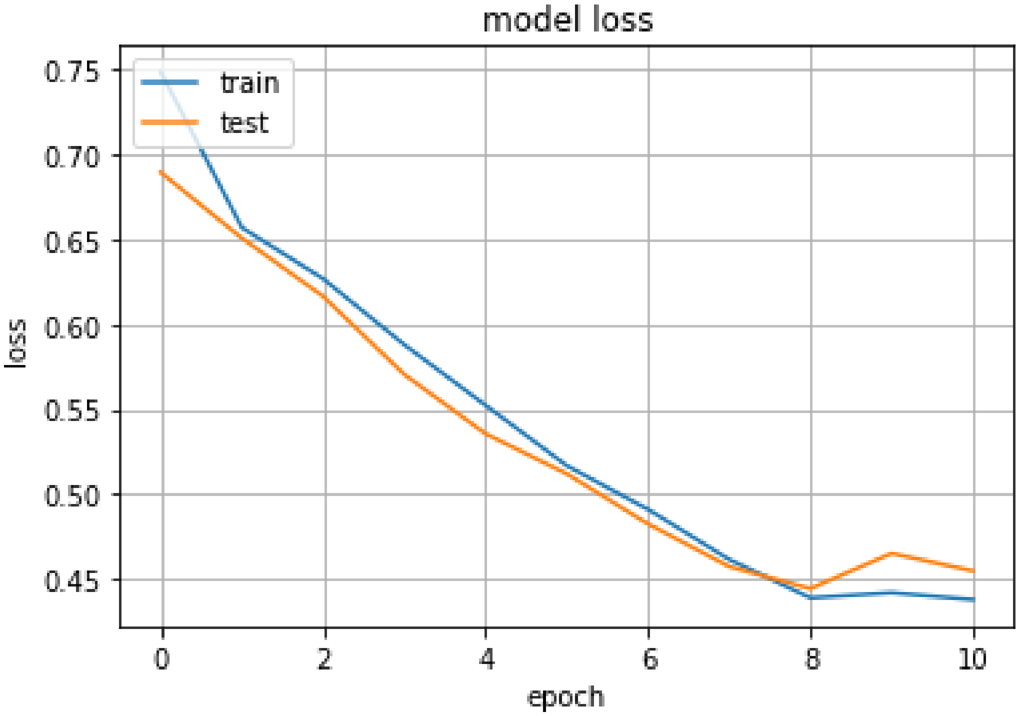
```
filepath="model2_1.hdf5"

checkpoint = ModelCheckpoint(filepath, monitor='val_auc', verbose=1,␣
 ↪save_best_only=True, mode='max')
earlystopping = EarlyStopping(monitor='val_auc',min_delta=0.00001, patience=10,␣
 ↪verbose=1)
lr = LearningRateScheduler(step_decay)
clr_triangular = CyclicLR(mode='triangular')

callbacks_list = [checkpoint,lr,earlystopping,clr_triangular]

model.compile(loss='categorical_crossentropy', optimizer=tf.keras.optimizers.
 ↪Adam(lr=0.0001,decay = 1e-4),metrics=[auc])


history = model.fit(tr, y_train, validation_split = 0.3, epochs=30, verbose=1,␣
 ↪batch_size=512, callbacks = callbacks_list)
```

```
Train on 53531 samples, validate on 22942 samples
Epoch 1/30
53531/53531 [==============================] - ETA: 0s - loss: 0.7487 - auc:
0.5330
Epoch 00001: val_auc improved from -inf to 0.49013, saving model to
model2_1.hdf5
53531/53531 [==============================] - 57s 1ms/sample - loss: 0.7487 -
auc: 0.5330 - val_loss: 0.6896 - val_auc: 0.4901
Epoch 2/30
53531/53531 [==============================] - ETA: 0s - loss: 0.6570 - auc:
0.5921
Epoch 00002: val_auc improved from 0.49013 to 0.60218, saving model to
model2_1.hdf5
53531/53531 [==============================] - 56s 1ms/sample - loss: 0.6570 -
auc: 0.5921 - val_loss: 0.6508 - val_auc: 0.6022
Epoch 3/30
53531/53531 [==============================] - ETA: 0s - loss: 0.6270 - auc:
0.6207
Epoch 00003: val_auc improved from 0.60218 to 0.64935, saving model to
model2_1.hdf5
53531/53531 [==============================] - 57s 1ms/sample - loss: 0.6270 -
auc: 0.6207 - val_loss: 0.6166 - val_auc: 0.6494
Epoch 4/30
53531/53531 [==============================] - ETA: 0s - loss: 0.5880 - auc:
0.6526
Epoch 00004: val_auc improved from 0.64935 to 0.66805, saving model to
model2_1.hdf5
53531/53531 [==============================] - 56s 1ms/sample - loss: 0.5880 -
auc: 0.6526 - val_loss: 0.5704 - val_auc: 0.6681
```

```
Epoch 5/30
53531/53531 [==============================] - ETA: 0s - loss: 0.5523 - auc:
0.6697
Epoch 00005: val_auc improved from 0.66805 to 0.68826, saving model to
model2_1.hdf5
53531/53531 [==============================] - 56s 1ms/sample - loss: 0.5523 -
auc: 0.6697 - val_loss: 0.5355 - val_auc: 0.6883
Epoch 6/30
53531/53531 [==============================] - ETA: 0s - loss: 0.5168 - auc:
0.6898
Epoch 00006: val_auc improved from 0.68826 to 0.69562, saving model to
model2_1.hdf5
53531/53531 [==============================] - 56s 1ms/sample - loss: 0.5168 -
auc: 0.6898 - val_loss: 0.5120 - val_auc: 0.6956
Epoch 7/30
53531/53531 [==============================] - ETA: 0s - loss: 0.4910 - auc:
0.6974
Epoch 00007: val_auc improved from 0.69562 to 0.70838, saving model to
model2_1.hdf5
53531/53531 [==============================] - 56s 1ms/sample - loss: 0.4910 -
auc: 0.6974 - val_loss: 0.4824 - val_auc: 0.7084
Epoch 8/30
53531/53531 [==============================] - ETA: 0s - loss: 0.4614 - auc:
0.7135
Epoch 00008: val_auc improved from 0.70838 to 0.71134, saving model to
model2_1.hdf5
53531/53531 [==============================] - 56s 1ms/sample - loss: 0.4614 -
auc: 0.7135 - val_loss: 0.4572 - val_auc: 0.7113
Epoch 9/30
53531/53531 [==============================] - ETA: 0s - loss: 0.4388 - auc:
0.7225
Epoch 00009: val_auc did not improve from 0.71134
53531/53531 [==============================] - 56s 1ms/sample - loss: 0.4388 -
auc: 0.7225 - val_loss: 0.4443 - val_auc: 0.7086
Epoch 10/30
53531/53531 [==============================] - ETA: 0s - loss: 0.4418 - auc:
0.7259
Epoch 00010: val_auc improved from 0.71134 to 0.71187, saving model to
model2_1.hdf5
53531/53531 [==============================] - 56s 1ms/sample - loss: 0.4418 -
auc: 0.7259 - val_loss: 0.4650 - val_auc: 0.7119
Epoch 11/30
53531/53531 [==============================] - ETA: 0s - loss: 0.4377 - auc:
0.7388
Epoch 00011: val_auc did not improve from 0.71187
53531/53531 [==============================] - 56s 1ms/sample - loss: 0.4377 -
auc: 0.7388 - val_loss: 0.4547 - val_auc: 0.7117
Epoch 00011: early stopping
```

[145]:

```
import matplotlib.pyplot as plt
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.grid()
plt.show()
```



[147]:

```
tf.keras.backend.clear_session()


#input 1
input1 = Input(shape=(300,))
x1 = Embedding(input_dim=vocab_size,output_dim=␣
 ↪300,weights=[embedding_matrix],trainable=False)(input1)
x1 = LSTM(32,return_sequences=True)(x1)
x1 = Dropout(0.3)(x1)
x1 = BatchNormalization()(x1)
x1 = LSTM(128,return_sequences=True,)(x1)
x1 = Dropout(0.5)(x1)
x1 = BatchNormalization()(x1)
# x1 = LSTM(128,return_sequences=True,recurrent_activation="sigmoid")(x1)
# x1 = Dropout(0.7)(x1)


x1 = Flatten()(x1)

#input 2
input2 = Input(shape=(max_review_length,))
x2 = Embedding(input_dim= vocab_dict['teacher_prefix']+2,output_dim= 2)(input2)
x2 = Flatten()(x2)

#input 3
input3 = Input(shape=(max_review_length,))
x3 = Embedding(input_dim= vocab_dict['school_state']+2,output_dim= 2)(input3)
x3 = Flatten()(x3)

#input 4
input4 = Input(shape=(max_review_length,))
x4 = Embedding(input_dim=vocab_dict['clean_categories']+2,output_dim= 2)(input4)
x4 = Flatten()(x4)

#input 5
input5 = Input(shape=(max_review_length,))
x5 = Embedding(input_dim= vocab_dict['clean_subcategories']+2,output_dim=␣
 ↪10)(input5)
x5 = Flatten()(x5)

#input 6
input6 = Input(shape=(max_review_length,))
x6 = Embedding(input_dim= vocab_dict['project_grade_category']+2,output_dim=␣
 ↪2)(input6)
x6 = Flatten()(x6)

#input 7
input7 = Input(shape=(1,))
x7 =␣
 ↪Dense(16,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L1(0.
 ↪01))(input7)

#merging all the inputs
Concat = concatenate([x1,x2,x3,x4,x5,x6,x7])
#x = BatchNormalization()(concat)

x =␣
 ↪Dense(64,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(Concat)
x = Dropout(0.5)(x)
x = BatchNormalization()(x)
```

```
x =␣
 ↪Dense(32,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(x)
x = Dropout(0.3)(x)
x = BatchNormalization()(x)
x =␣
 ↪Dense(16,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(x)
x = Dropout(0.1)(x)
output = Dense(2, activation = 'softmax')(x)

# create model with seven inputs
model = Model([input1,input2,input3,input4,input5,input6,input7], output)
model.load_weights('model2_1.hdf5')
```

```
WARNING:tensorflow:Layer lstm will not use cuDNN kernel since it doesn't meet
the cuDNN kernel criteria. It will use generic GPU kernel as fallback when
running on GPU
WARNING:tensorflow:Layer lstm_1 will not use cuDNN kernel since it doesn't meet
the cuDNN kernel criteria. It will use generic GPU kernel as fallback when
running on GPU
```

[148]:
```
roc_auc_score(y_train,model.predict(tr))
```

[148]:
```
0.7395961117115412
```

[149]:
```
roc_auc_score(y_test,model.predict(ts))
```

[149]:
```
0.7149390188241542
```

11.0.4 Model-3 Without CountVectorizer

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

- **input_seq_total_text_data**:
- **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.

[ ]:
```
#https://machinelearningmastery.com/
 ↪use-word-embedding-layers-deep-learning-keras/


t = Tokenizer()
t.fit_on_texts(X_train['essay'])
vocab_size = len(t.word_index) + 1
# integer encode the documents
```

```python
X_train_essay = t.texts_to_sequences(X_train['essay'])
X_test_essay = t.texts_to_sequences(X_test['essay'])

print(X_train_essay)



# pad documents to a max length of 4 words
max_length = 500
X_tr_essay = pad_sequences(X_train_essay, maxlen=max_length, padding='post')
X_ts_essay = pad_sequences(X_test_essay, maxlen=max_length, padding='post')

print(X_tr_essay)


# load the whole embedding into memory
embeddings_index = dict()
fr = open('glove_vectors','rb')
f = pickle.load(fr)


def embedding_mat(word_index,embedding_dim = 300):
        embedding_matrix = np.zeros((len(word_index) + 1, embedding_dim))
        for word, i in word_index.items():
                        embedding_vector =f.get(word)
                        if embedding_vector is not None:
                                        embedding_matrix[i] = embedding_vector
        return embedding_matrix

embedding_matrix = embedding_mat(t.word_index)
```

```
IOPub data rate exceeded.
The notebook server will temporarily stop sending output
to the client in order to avoid crashing it.
To change this limit, set the config variable
`--NotebookApp.iopub_data_rate_limit`.

Current values:
NotebookApp.iopub_data_rate_limit=1000000.0 (bytes/sec)
NotebookApp.rate_limit_window=3.0 (secs)


[[   4    1   22 ...    0    0    0]
 [   4    1 1071 ...    0    0    0]
 [ 169  677  852 ...    0    0    0]
 ...
 [   2  325    1 ...    0    0    0]
 [  14   64  149 ...    0    0    0]
 [  14   82    3 ...    0    0    0]]
```

[ ]:

```
import scipy
from numpy import hstack




tr1=hstack([X_tr_teacher_prefix,X_tr_school_state])
tr1=hstack((tr1,X_tr_clean_categories,X_tr_clean_subcategories))
tr=hstack((tr1,X_tr_project_grade_category,X_train['remaining_input'].values.
 ↪reshape(X_tr_school_state.shape[0],-1)))

ts1=hstack((X_ts_teacher_prefix,X_ts_school_state))
ts1=hstack((ts1,X_ts_clean_categories,X_ts_clean_subcategories))
ts=hstack((ts1,X_ts_project_grade_category,X_test['remaining_input'].values.
 ↪reshape(X_ts_school_state.shape[0],-1)))







tr=[X_tr_essay,tr.reshape(76473, 16,1)]

ts=[X_ts_essay,ts.reshape(32775, 16,1)]
```

[ ]:

```
tf.keras.backend.clear_session()

#input 1
input1 = Input(shape=(500,))
x1 = Embedding(input_dim=vocab_size,output_dim=␣
 ↪300,weights=[embedding_matrix],trainable=False)(input1)
x1 = SpatialDropout1D(0.3)(x1)
x1 = LSTM(32,return_sequences=True)(x1)
x1 = BatchNormalization()(x1)
x1 = Dropout(0.3)(x1)
x1 = LSTM(16,return_sequences=True)(x1)
x1 = BatchNormalization()(x1)
x1 = Dropout(0.3)(x1)
x1 = Flatten()(x1)

# input 2
input2 = Input(shape=(16,1))
x2 = Conv1D(32,3,strides=1)(input2)
x2 = Conv1D(16,1,strides=1)(x2)
x2 = Conv1D(8,3,strides=1)(x2)
x2 = Flatten()(x2)
```

```
# merging both the inputs
concat = concatenate([x1,x2])
x =␣
 ↪Dense(80,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(concat)
x = Dropout(0.5)(x)
x =␣
 ↪Dense(40,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(x)
x = Dropout(0.3)(x)
x = BatchNormalization()(x)
x =␣
 ↪Dense(16,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(x)
x = Dropout(0.2)(x)
output = Dense(2, activation = 'softmax')(x)

# create model with two inputs
model = Model([input1,input2], output)
model.eager = True
print(model.summary())
```

```
WARNING:tensorflow:Layer lstm will not use cuDNN kernel since it doesn't meet
the cuDNN kernel criteria. It will use generic GPU kernel as fallback when
running on GPU
WARNING:tensorflow:Layer lstm_1 will not use cuDNN kernel since it doesn't meet
the cuDNN kernel criteria. It will use generic GPU kernel as fallback when
running on GPU
Model: "functional_1"
________________________________________________________________________________
__________________
Layer (type)                    Output Shape         Param #     Connected to
================================================================================
==================
input_1 (InputLayer)            [(None, 500)]        0

________________________________________________________________________________
__________________
embedding (Embedding)           (None, 500, 300)     14799000    input_1[0][0]

________________________________________________________________________________
__________________
spatial_dropout1d (SpatialDropo (None, 500, 300)     0           embedding[0][0]

________________________________________________________________________________
__________________
lstm (LSTM)                     (None, 500, 32)      42624
spatial_dropout1d[0][0]

________________________________________________________________________________
```

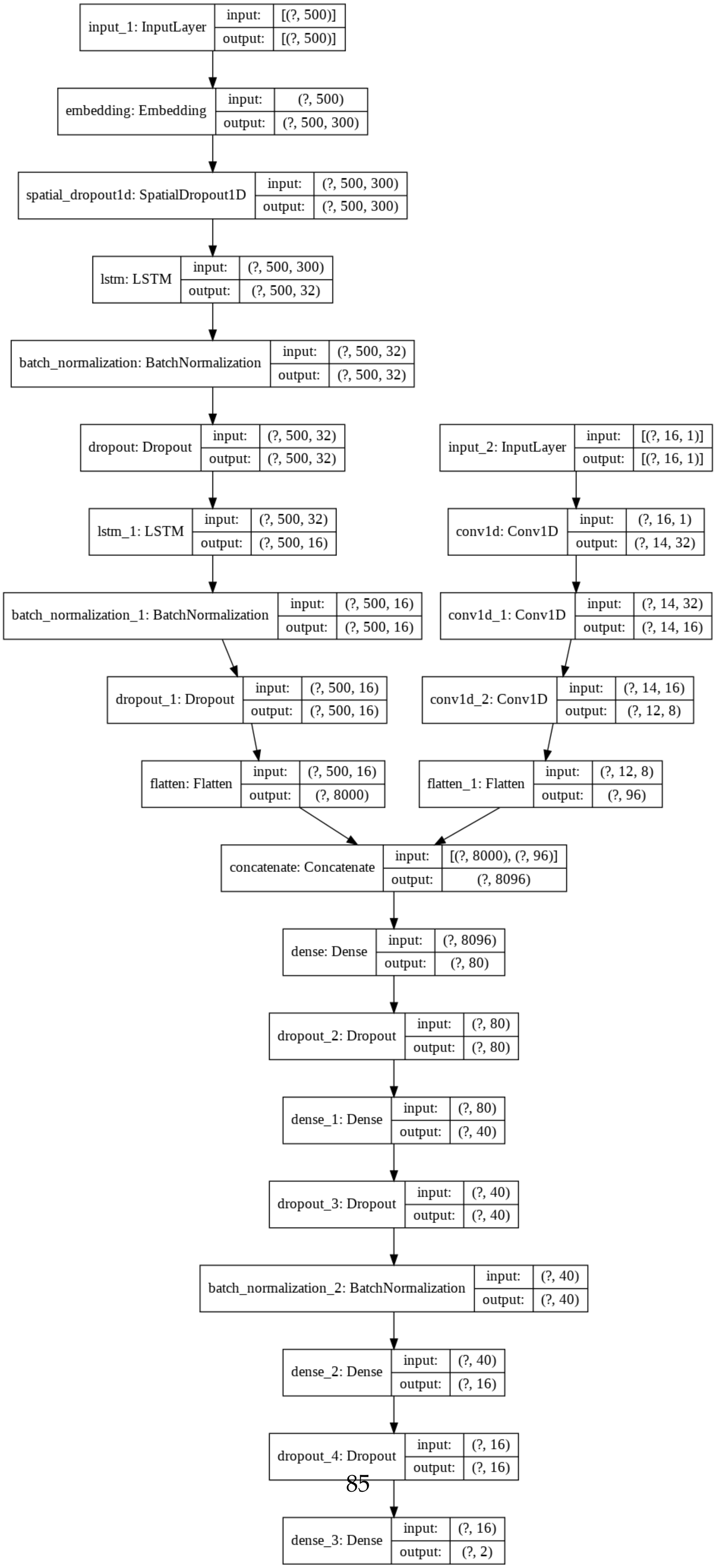
```
------------------
batch_normalization (BatchNorma (None, 500, 32)      128         lstm[0][0]

--------------------------------------------------------------------------------
------------------
dropout (Dropout)               (None, 500, 32)      0
batch_normalization[0][0]

--------------------------------------------------------------------------------
------------------
input_2 (InputLayer)            [(None, 16, 1)]      0

--------------------------------------------------------------------------------
------------------
lstm_1 (LSTM)                   (None, 500, 16)      3136        dropout[0][0]

--------------------------------------------------------------------------------
------------------
conv1d (Conv1D)                 (None, 14, 32)       128         input_2[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_1 (BatchNor (None, 500, 16)      64          lstm_1[0][0]

--------------------------------------------------------------------------------
------------------
conv1d_1 (Conv1D)               (None, 14, 16)       528         conv1d[0][0]

--------------------------------------------------------------------------------
------------------
dropout_1 (Dropout)             (None, 500, 16)      0
batch_normalization_1[0][0]

--------------------------------------------------------------------------------
------------------
conv1d_2 (Conv1D)               (None, 12, 8)        392         conv1d_1[0][0]

--------------------------------------------------------------------------------
------------------
flatten (Flatten)               (None, 8000)         0           dropout_1[0][0]

--------------------------------------------------------------------------------
------------------
flatten_1 (Flatten)             (None, 96)           0           conv1d_2[0][0]

--------------------------------------------------------------------------------
------------------
concatenate (Concatenate)       (None, 8096)         0           flatten[0][0]
                                                                 flatten_1[0][0]

--------------------------------------------------------------------------------
------------------
dense (Dense)                   (None, 80)           647760
concatenate[0][0]

--------------------------------------------------------------------------------
------------------
dropout_2 (Dropout)             (None, 80)           0           dense[0][0]

--------------------------------------------------------------------------------
------------------
dense_1 (Dense)                 (None, 40)           3240        dropout_2[0][0]
```

```
--------------------------------------------------------------------------------
------------------
dropout_3 (Dropout)             (None, 40)           0           dense_1[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_2 (BatchNor (None, 40)           160         dropout_3[0][0]

--------------------------------------------------------------------------------
------------------
dense_2 (Dense)                 (None, 16)           656
batch_normalization_2[0][0]

--------------------------------------------------------------------------------
------------------
dropout_4 (Dropout)             (None, 16)           0           dense_2[0][0]

--------------------------------------------------------------------------------
------------------
dense_3 (Dense)                 (None, 2)            34          dropout_4[0][0]
================================================================================
==================
Total params: 15,497,850
Trainable params: 698,674
Non-trainable params: 14,799,176

--------------------------------------------------------------------------------
------------------
None
```

[ ]:

```python
from keras.utils.vis_utils import plot_model
plot_model(model, show_shapes=True, show_layer_names=True)
```

[ ]:


input_1: InputLayer | input: | [(?, 500)] | output: | [(?, 500)]
embedding: Embedding | input: | (?, 500) | output: | (?, 500, 300)
spatial_dropout1d: SpatialDropout1D | input: | (?, 500, 300) | output: | (?, 500, 300)
lstm: LSTM | input: | (?, 500, 300) | output: | (?, 500, 32)
batch_normalization: BatchNormalization | input: | (?, 500, 32) | output: | (?, 500, 32)
dropout: Dropout | input: | (?, 500, 32) | output: | (?, 500, 32)
lstm_1: LSTM | input: | (?, 500, 32) | output: | (?, 500, 16)
batch_normalization_1: BatchNormalization | input: | (?, 500, 16) | output: | (?, 500, 16)
dropout_1: Dropout | input: | (?, 500, 16) | output: | (?, 500, 16)
flatten: Flatten | input: | (?, 500, 16) | output: | (?, 8000)
input_2: InputLayer | input: | [(?, 16, 1)] | output: | [(?, 16, 1)]
conv1d: Conv1D | input: | (?, 16, 1) | output: | (?, 14, 32)
conv1d_1: Conv1D | input: | (?, 14, 32) | output: | (?, 14, 16)
conv1d_2: Conv1D | input: | (?, 14, 16) | output: | (?, 12, 8)
flatten_1: Flatten | input: | (?, 12, 8) | output: | (?, 96)
concatenate: Concatenate | input: | [(?, 8000), (?, 96)] | output: | (?, 8096)
dense: Dense | input: | (?, 8096) | output: | (?, 80)
dropout_2: Dropout | input: | (?, 80) | output: | (?, 80)
dense_1: Dense | input: | (?, 80) | output: | (?, 40)
dropout_3: Dropout | input: | (?, 40) | output: | (?, 40)
batch_normalization_2: BatchNormalization | input: | (?, 40) | output: | (?, 40)
dense_2: Dense | input: | (?, 40) | output: | (?, 16)
dropout_4: Dropout | input: | (?, 16) | output: | (?, 16)
dense_3: Dense | input: | (?, 16) | output: | (?, 2)

[ ]:

```
filepath="model3_1.hdf5"

checkpoint = ModelCheckpoint(filepath, monitor='val_auc', verbose=1,␣
 ↪save_best_only=True, mode='max')
earlystopping = EarlyStopping(monitor='val_auc',min_delta=0.00001, patience=10,␣
 ↪verbose=1)
lr = LearningRateScheduler(step_decay)
clr_triangular = CyclicLR(mode='triangular')

callbacks_list = [checkpoint,lr,earlystopping,clr_triangular]

model.compile(loss='categorical_crossentropy', optimizer=tf.keras.optimizers.
 ↪Adam(lr=0.0001,decay = 1e-4),metrics=[auc])


history = model.fit(tr, y_train, validation_split = 0.3, epochs=20, verbose=1,␣
 ↪batch_size=512, callbacks = callbacks_list)
```

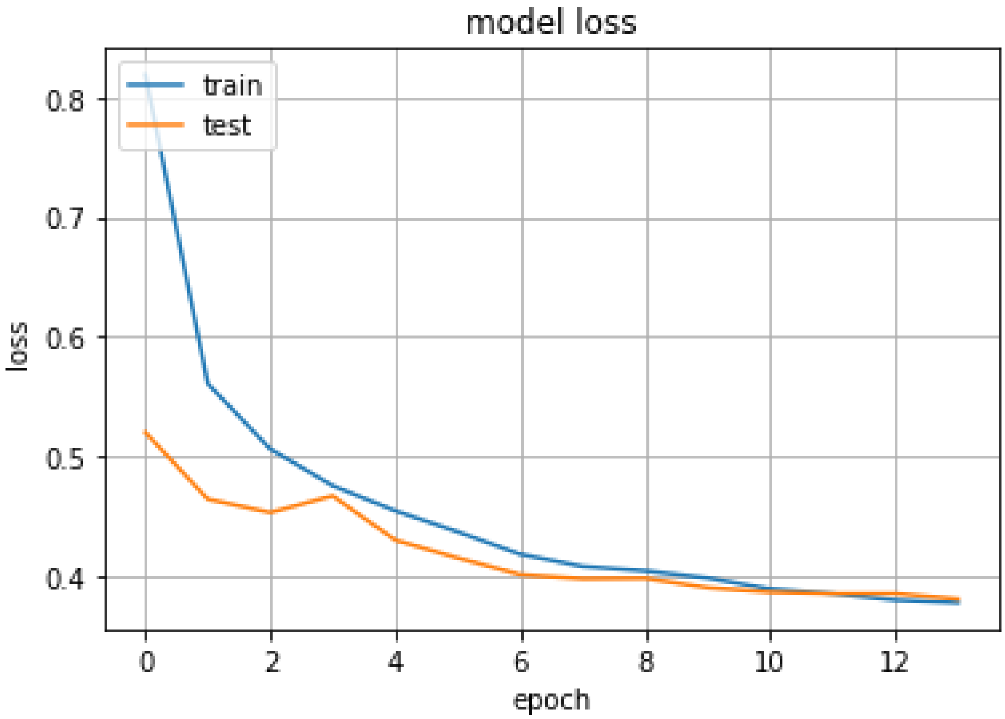
```
Train on 53531 samples, validate on 22942 samples
Epoch 1/20
53531/53531 [==============================] - ETA: 0s - loss: 0.8188 - auc:
0.5119
Epoch 00001: val_auc improved from -inf to 0.53347, saving model to
model3_1.hdf5
53531/53531 [==============================] - 111s 2ms/sample - loss: 0.8188 -
auc: 0.5119 - val_loss: 0.5202 - val_auc: 0.5335
Epoch 2/20
53531/53531 [==============================] - ETA: 0s - loss: 0.5609 - auc:
0.5149
Epoch 00002: val_auc improved from 0.53347 to 0.56900, saving model to
model3_1.hdf5
53531/53531 [==============================] - 110s 2ms/sample - loss: 0.5609 -
auc: 0.5149 - val_loss: 0.4644 - val_auc: 0.5690
Epoch 3/20
53531/53531 [==============================] - ETA: 0s - loss: 0.5062 - auc:
0.5218
Epoch 00003: val_auc improved from 0.56900 to 0.59858, saving model to
model3_1.hdf5
53531/53531 [==============================] - 111s 2ms/sample - loss: 0.5062 -
auc: 0.5218 - val_loss: 0.4533 - val_auc: 0.5986
Epoch 4/20
53531/53531 [==============================] - ETA: 0s - loss: 0.4757 - auc:
0.5367
Epoch 00004: val_auc did not improve from 0.59858
53531/53531 [==============================] - 111s 2ms/sample - loss: 0.4757 -
```

```
auc: 0.5367 - val_loss: 0.4672 - val_auc: 0.5307
Epoch 5/20
53531/53531 [==============================] - ETA: 0s - loss: 0.4546 - auc:
0.5821
Epoch 00005: val_auc improved from 0.59858 to 0.68240, saving model to
model3_1.hdf5
53531/53531 [==============================] - 109s 2ms/sample - loss: 0.4546 -
auc: 0.5821 - val_loss: 0.4301 - val_auc: 0.6824
Epoch 6/20
53531/53531 [==============================] - ETA: 0s - loss: 0.4370 - auc:
0.6428
Epoch 00006: val_auc improved from 0.68240 to 0.71582, saving model to
model3_1.hdf5
53531/53531 [==============================] - 110s 2ms/sample - loss: 0.4370 -
auc: 0.6428 - val_loss: 0.4152 - val_auc: 0.7158
Epoch 7/20
53531/53531 [==============================] - ETA: 0s - loss: 0.4184 - auc:
0.6859
Epoch 00007: val_auc improved from 0.71582 to 0.73740, saving model to
model3_1.hdf5
53531/53531 [==============================] - 109s 2ms/sample - loss: 0.4184 -
auc: 0.6859 - val_loss: 0.4014 - val_auc: 0.7374
Epoch 8/20
53531/53531 [==============================] - ETA: 0s - loss: 0.4081 - auc:
0.7048
Epoch 00008: val_auc improved from 0.73740 to 0.74247, saving model to
model3_1.hdf5
53531/53531 [==============================] - 110s 2ms/sample - loss: 0.4081 -
auc: 0.7048 - val_loss: 0.3980 - val_auc: 0.7425
Epoch 9/20
53531/53531 [==============================] - ETA: 0s - loss: 0.4045 - auc:
0.7123
Epoch 00009: val_auc improved from 0.74247 to 0.74590, saving model to
model3_1.hdf5
53531/53531 [==============================] - 111s 2ms/sample - loss: 0.4045 -
auc: 0.7123 - val_loss: 0.3983 - val_auc: 0.7459
Epoch 10/20
53531/53531 [==============================] - ETA: 0s - loss: 0.3986 - auc:
0.7210
Epoch 00010: val_auc improved from 0.74590 to 0.75251, saving model to
model3_1.hdf5
53531/53531 [==============================] - 109s 2ms/sample - loss: 0.3986 -
auc: 0.7210 - val_loss: 0.3905 - val_auc: 0.7525
Epoch 11/20
53531/53531 [==============================] - ETA: 0s - loss: 0.3895 - auc:
0.7363
Epoch 00011: val_auc improved from 0.75251 to 0.75789, saving model to
model3_1.hdf5
```

```
53531/53531 [==============================] - 110s 2ms/sample - loss: 0.3895 -
auc: 0.7363 - val_loss: 0.3869 - val_auc: 0.7579
Epoch 12/20
53531/53531 [==============================] - ETA: 0s - loss: 0.3855 - auc:
0.7376
Epoch 00012: val_auc did not improve from 0.75789
53531/53531 [==============================] - 108s 2ms/sample - loss: 0.3855 -
auc: 0.7376 - val_loss: 0.3855 - val_auc: 0.7558
Epoch 13/20
53531/53531 [==============================] - ETA: 0s - loss: 0.3803 - auc:
0.7460
Epoch 00013: val_auc did not improve from 0.75789
53531/53531 [==============================] - 109s 2ms/sample - loss: 0.3803 -
auc: 0.7460 - val_loss: 0.3856 - val_auc: 0.7573
Epoch 14/20
53531/53531 [==============================] - ETA: 0s - loss: 0.3781 - auc:
0.7510
Epoch 00014: val_auc improved from 0.75789 to 0.76236, saving model to
model3_1.hdf5
53531/53531 [==============================] - 110s 2ms/sample - loss: 0.3781 -
auc: 0.7510 - val_loss: 0.3811 - val_auc: 0.7624
Epoch 00014: early stopping
```

[ ]:

```python
import matplotlib.pyplot as plt
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.grid()
plt.show()
```



[ ]:

```
tf.keras.backend.clear_session()

#input 1
input1 = Input(shape=(500,))
x1 = Embedding(input_dim=vocab_size,output_dim=␣
 ↪300,weights=[embedding_matrix],trainable=False)(input1)
x1 = SpatialDropout1D(0.3)(x1)
x1 = LSTM(32,return_sequences=True)(x1)
x1 = BatchNormalization()(x1)
x1 = Dropout(0.3)(x1)
x1 = LSTM(16,return_sequences=True)(x1)
x1 = BatchNormalization()(x1)
x1 = Dropout(0.3)(x1)
x1 = Flatten()(x1)

# input 2
input2 = Input(shape=(16,1))
x2 = Conv1D(32,3,strides=1)(input2)
x2 = Conv1D(16,1,strides=1)(x2)
x2 = Conv1D(8,3,strides=1)(x2)
x2 = Flatten()(x2)

# merging both the inputs
concat = concatenate([x1,x2])
```

```
x =␣
 ↪Dense(80,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(concat)
x = Dropout(0.5)(x)
x =␣
 ↪Dense(40,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(x)
x = Dropout(0.3)(x)
x = BatchNormalization()(x)
x =␣
 ↪Dense(16,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(x)
x = Dropout(0.2)(x)
output = Dense(2, activation = 'softmax')(x)

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

model.load_weights('model3_1.hdf5')
```

```
WARNING:tensorflow:Layer lstm will not use cuDNN kernel since it doesn't meet
the cuDNN kernel criteria. It will use generic GPU kernel as fallback when
running on GPU
WARNING:tensorflow:Layer lstm_1 will not use cuDNN kernel since it doesn't meet
the cuDNN kernel criteria. It will use generic GPU kernel as fallback when
running on GPU
```

[ ]:
```
roc_auc_score(y_train,model.predict(tr))
```

[ ]:
```
0.7783138552416022
```

[ ]:
```
roc_auc_score(y_test,model.predict(ts))
```

[ ]:
```
0.764596551805379
```

11.0.5 Model 3 with countvectorizer

[ ]:
```
from sklearn.feature_extraction.text import CountVectorizer
```

[ ]:
```
vect = CountVectorizer()
```

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


data = pd.read_csv('preprocessed_data.csv')

data['remaining_input'] = data['teacher_number_of_previously_posted_projects']␣
 ↪+ data['price']
```

```
data.replace(to_replace=np.NaN, value= str('nan'),inplace=True)
y = data['project_is_approved'].values

col = ['teacher_prefix', 'school_state', 'project_grade_category',
       'clean_categories', 'clean_subcategories','essay',
       'remaining_input']

data = data[col]


X_train, X_test, y_train, y_test = train_test_split(data, y ,test_size=0.
 ↪3,random_state=0, stratify = y)
```

[ ]:

```
x_tr_project_grade_category = vect.
 ↪fit_transform(X_train['project_grade_category'].values)
x_ts_project_grade_category = vect.fit(X_train['project_grade_category'].values)

print(x_tr_project_grade_category.shape)
```

```
(76473, 4)
```

[ ]:

```
x_tr_clean_subcategories = vect.fit_transform(X_train['clean_subcategories'].
 ↪values)
x_ts_clean_subcategories = vect.fit(X_train['clean_subcategories'].values)

print(x_tr_clean_subcategories.shape)
```

```
(76473, 30)
```

[ ]:

```
x_tr_clean_categories = vect.fit_transform(X_train['clean_categories'].values)
x_ts_clean_categories = vect.fit(X_train['clean_categories'].values)

print(x_tr_clean_categories.shape)
```

```
(76473, 9)
```

[ ]:

```
x_tr_teacher_prefix = vect.fit_transform(X_train['teacher_prefix'].values)
x_ts_teacher_prefix = vect.fit(X_train['teacher_prefix'].values)

print(x_tr_teacher_prefix.shape)
```

```
(76473, 5)
```

[ ]:

```
x_tr_school_state = vect.fit_transform(X_train['school_state'].values)
x_ts_school_state = vect.fit(X_train['school_state'].values)
```

```
print(x_tr_school_state.shape)
```

```
(76473, 51)
```

[ ]:
```
cols= x_tr_school_state.shape[1]+x_tr_teacher_prefix.
 ↪shape[1]+x_tr_clean_categories.shape[1]+x_tr_clean_subcategories.
 ↪shape[1]+x_tr_project_grade_category.shape[1]
print(cols)
```

```
99
```

[ ]:
```
#https://machinelearningmastery.com/
 ↪use-word-embedding-layers-deep-learning-keras/


t = Tokenizer()
t.fit_on_texts(X_train['essay'])
vocab_size = len(t.word_index) + 1
# integer encode the documents
X_train_essay = t.texts_to_sequences(X_train['essay'])
X_test_essay = t.texts_to_sequences(X_test['essay'])

print(X_train_essay)



# pad documents to a max length of 4 words
max_length = 500
X_tr_essay = pad_sequences(X_train_essay, maxlen=max_length, padding='post')
X_ts_essay = pad_sequences(X_test_essay, maxlen=max_length, padding='post')

print(X_tr_essay)


# load the whole embedding into memory
embeddings_index = dict()
fr = open('glove_vectors','rb')
f = pickle.load(fr)


def embedding_mat(word_index,embedding_dim = 300):
        embedding_matrix = np.zeros((len(word_index) + 1, embedding_dim))
        for word, i in word_index.items():
                        embedding_vector =f.get(word)
                        if embedding_vector is not None:
                                        embedding_matrix[i] = embedding_vector
        return embedding_matrix
```

```
embedding_matrix = embedding_mat(t.word_index)
```

```
IOPub data rate exceeded.
The notebook server will temporarily stop sending output
to the client in order to avoid crashing it.
To change this limit, set the config variable
`--NotebookApp.iopub_data_rate_limit`.

Current values:
NotebookApp.iopub_data_rate_limit=1000000.0 (bytes/sec)
NotebookApp.rate_limit_window=3.0 (secs)


[[   4    1   22 ...    0    0    0]
 [   4    1 1071 ...    0    0    0]
 [ 169  677  852 ...    0    0    0]
 ...
 [   2  325    1 ...    0    0    0]
 [  14   64  149 ...    0    0    0]
 [  14   82    3 ...    0    0    0]]
```

[ ]:

```
import scipy
from numpy import hstack

tr=hstack((X_tr_teacher_prefix, X_tr_school_state, X_tr_clean_categories,
           X_tr_clean_subcategories, X_tr_project_grade_category,␣
 ↪X_train['remaining_input'].values.reshape(X_tr_school_state.shape[0],-1)))

tr=hstack((X_ts_teacher_prefix, X_ts_school_state, X_ts_clean_categories,
           X_ts_clean_subcategories, X_ts_project_grade_category,␣
 ↪X_test['remaining_input'].values.reshape(X_ts_school_state.shape[0],-1)))







tr=[X_tr_essay,tr]

ts=[X_ts_essay,ts]
```

[ ]:

```
tf.keras.backend.clear_session()

#input 1
input1 = Input(shape=(500,))
x1 = Embedding(input_dim=vocab_size,output_dim=␣
 ↪300,weights=[embedding_matrix],trainable=False)(input1)
```

```python
x1 = SpatialDropout1D(0.3)(x1)
x1 = LSTM(32,return_sequences=True)(x1)
x1 = BatchNormalization()(x1)
x1 = Dropout(0.3)(x1)
x1 = LSTM(16,return_sequences=True)(x1)
x1 = BatchNormalization()(x1)
x1 = Dropout(0.3)(x1)
x1 = Flatten()(x1)

# input 2
input2 = Input(shape=(13,1))
x2 = Conv1D(32,3,strides=1)(input2)
x2 = Conv1D(16,1,strides=1)(x2)
x2 = Conv1D(8,3,strides=1)(x2)
x2 = Flatten()(x2)

# merging both the inputs
concat = concatenate([x1,x2])
x = Dense(80,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.0001))(concat)
x = Dropout(0.5)(x)
x = Dense(40,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.0001))(x)
x = Dropout(0.3)(x)
x = BatchNormalization()(x)
x = Dense(16,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.0001))(x)
x = Dropout(0.2)(x)
output = Dense(2, activation = 'softmax')(x)

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

print(model.summary())
```

```
WARNING:tensorflow:Layer lstm will not use cuDNN kernel since it doesn't meet
the cuDNN kernel criteria. It will use generic GPU kernel as fallback when
running on GPU
WARNING:tensorflow:Layer lstm_1 will not use cuDNN kernel since it doesn't meet
the cuDNN kernel criteria. It will use generic GPU kernel as fallback when
running on GPU
Model: "functional_1"
--------------------------------------------------------------------------------
-----------------
```

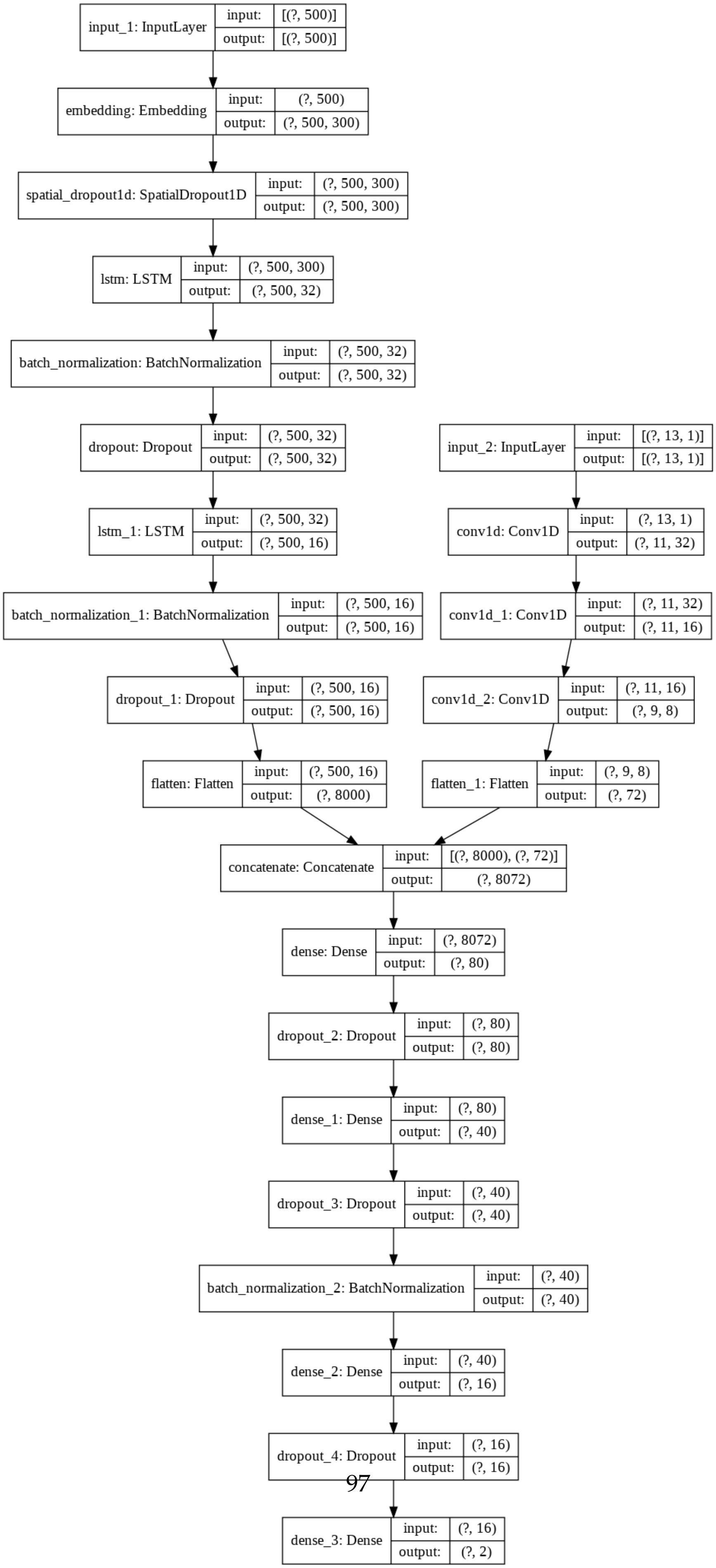
```
Layer (type)                    Output Shape         Param #     Connected to
================================================================================
==================
input_1 (InputLayer)            [(None, 500)]        0

--------------------------------------------------------------------------------
------------------
embedding (Embedding)           (None, 500, 300)     14799000    input_1[0][0]

--------------------------------------------------------------------------------
------------------
spatial_dropout1d (SpatialDropo (None, 500, 300)     0           embedding[0][0]

--------------------------------------------------------------------------------
------------------
lstm (LSTM)                     (None, 500, 32)      42624
spatial_dropout1d[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization (BatchNorma (None, 500, 32)      128         lstm[0][0]

--------------------------------------------------------------------------------
------------------
dropout (Dropout)               (None, 500, 32)      0
batch_normalization[0][0]

--------------------------------------------------------------------------------
------------------
input_2 (InputLayer)            [(None, 13, 1)]      0

--------------------------------------------------------------------------------
------------------
lstm_1 (LSTM)                   (None, 500, 16)      3136        dropout[0][0]

--------------------------------------------------------------------------------
------------------
conv1d (Conv1D)                 (None, 11, 32)       128         input_2[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_1 (BatchNor (None, 500, 16)      64          lstm_1[0][0]

--------------------------------------------------------------------------------
------------------
conv1d_1 (Conv1D)               (None, 11, 16)       528         conv1d[0][0]

--------------------------------------------------------------------------------
------------------
dropout_1 (Dropout)             (None, 500, 16)      0
batch_normalization_1[0][0]

--------------------------------------------------------------------------------
------------------
conv1d_2 (Conv1D)               (None, 9, 8)         392         conv1d_1[0][0]

--------------------------------------------------------------------------------
------------------
flatten (Flatten)               (None, 8000)         0           dropout_1[0][0]

--------------------------------------------------------------------------------
------------------
```

```
flatten_1 (Flatten)             (None, 72)            0          conv1d_2[0][0]

--------------------------------------------------------------------------------
------------------
concatenate (Concatenate)       (None, 8072)          0          flatten[0][0]
                                                                 flatten_1[0][0]

--------------------------------------------------------------------------------
------------------
dense (Dense)                   (None, 80)            645840
concatenate[0][0]

--------------------------------------------------------------------------------
------------------
dropout_2 (Dropout)             (None, 80)            0          dense[0][0]

--------------------------------------------------------------------------------
------------------
dense_1 (Dense)                 (None, 40)            3240       dropout_2[0][0]

--------------------------------------------------------------------------------
------------------
dropout_3 (Dropout)             (None, 40)            0          dense_1[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_2 (BatchNor (None, 40)            160        dropout_3[0][0]

--------------------------------------------------------------------------------
------------------
dense_2 (Dense)                 (None, 16)            656
batch_normalization_2[0][0]

--------------------------------------------------------------------------------
------------------
dropout_4 (Dropout)             (None, 16)            0          dense_2[0][0]

--------------------------------------------------------------------------------
------------------
dense_3 (Dense)                 (None, 2)             34         dropout_4[0][0]
================================================================================
==================
Total params: 15,495,930
Trainable params: 696,754
Non-trainable params: 14,799,176

--------------------------------------------------------------------------------
------------------
None
```

[ ]:

```
from keras.utils.vis_utils import plot_model
plot_model(model, show_shapes=True, show_layer_names=True)
```

[ ]:


input_1: InputLayer | input: [(?, 500)] | output: [(?, 500)]
embedding: Embedding | input: (?, 500) | output: (?, 500, 300)
spatial_dropout1d: SpatialDropout1D | input: (?, 500, 300) | output: (?, 500, 300)
lstm: LSTM | input: (?, 500, 300) | output: (?, 500, 32)
batch_normalization: BatchNormalization | input: (?, 500, 32) | output: (?, 500, 32)
dropout: Dropout | input: (?, 500, 32) | output: (?, 500, 32)
lstm_1: LSTM | input: (?, 500, 32) | output: (?, 500, 16)
batch_normalization_1: BatchNormalization | input: (?, 500, 16) | output: (?, 500, 16)
dropout_1: Dropout | input: (?, 500, 16) | output: (?, 500, 16)
flatten: Flatten | input: (?, 500, 16) | output: (?, 8000)
input_2: InputLayer | input: [(?, 13, 1)] | output: [(?, 13, 1)]
conv1d: Conv1D | input: (?, 13, 1) | output: (?, 11, 32)
conv1d_1: Conv1D | input: (?, 11, 32) | output: (?, 11, 16)
conv1d_2: Conv1D | input: (?, 11, 16) | output: (?, 9, 8)
flatten_1: Flatten | input: (?, 9, 8) | output: (?, 72)
concatenate: Concatenate | input: [(?, 8000), (?, 72)] | output: (?, 8072)
dense: Dense | input: (?, 8072) | output: (?, 80)
dropout_2: Dropout | input: (?, 80) | output: (?, 80)
dense_1: Dense | input: (?, 80) | output: (?, 40)
dropout_3: Dropout | input: (?, 40) | output: (?, 40)
batch_normalization_2: BatchNormalization | input: (?, 40) | output: (?, 40)
dense_2: Dense | input: (?, 40) | output: (?, 16)
dropout_4: Dropout | input: (?, 16) | output: (?, 16)
dense_3: Dense | input: (?, 16) | output: (?, 2)

[ ]:

```python
filepath="model3_2.hdf5"

checkpoint = ModelCheckpoint(filepath, monitor='val_auc', verbose=1,␣
 ↪save_best_only=True, mode='max')
earlystopping = EarlyStopping(monitor='val_auc',min_delta=0.00001, patience=10,␣
 ↪verbose=1,mode = 'max')
lr = LearningRateScheduler(step_decay)
clr_triangular = CyclicLR(mode='triangular')

callbacks_list = [checkpoint,lr,earlystopping,clr_triangular]

model.compile(loss='categorical_crossentropy', optimizer=tf.keras.optimizers.
 ↪Adam(lr=0.0001,decay = 1e-4),metrics=[auc])


history = model.fit(tr, y_train, validation_split = 0.3, epochs=30, verbose=1,␣
 ↪batch_size=512, callbacks = callbacks_list)
```

```
Train on 53531 samples, validate on 22942 samples
Epoch 1/30
 1024/53531 [...] - ETA: 4:22 - loss: 0.6118 - auc:
0.4875WARNING:tensorflow:Callbacks method `on_train_batch_end` is slow compared
to the batch time (batch time: 1.3200s vs `on_train_batch_end` time: 3.8029s).
Check your callbacks.
53531/53531 [==============================] - ETA: 0s - loss: 0.5080 - auc:
0.5221
Epoch 00001: val_auc improved from -inf to 0.55309, saving model to
model3_2.hdf5
53531/53531 [==============================] - 114s 2ms/sample - loss: 0.5080 -
auc: 0.5221 - val_loss: 0.5162 - val_auc: 0.5531
Epoch 2/30
53531/53531 [==============================] - ETA: 0s - loss: 0.4599 - auc:
0.5757
Epoch 00002: val_auc improved from 0.55309 to 0.63388, saving model to
model3_2.hdf5
53531/53531 [==============================] - 108s 2ms/sample - loss: 0.4599 -
auc: 0.5757 - val_loss: 0.4696 - val_auc: 0.6339
Epoch 3/30
53531/53531 [==============================] - ETA: 0s - loss: 0.4290 - auc:
0.6647
Epoch 00003: val_auc improved from 0.63388 to 0.71986, saving model to
model3_2.hdf5
53531/53531 [==============================] - 108s 2ms/sample - loss: 0.4290 -
auc: 0.6647 - val_loss: 0.4118 - val_auc: 0.7199
Epoch 4/30
```

```
53531/53531 [==============================] - ETA: 0s - loss: 0.4144 - auc:
0.6962
Epoch 00004: val_auc improved from 0.71986 to 0.73197, saving model to
model3_2.hdf5
53531/53531 [==============================] - 107s 2ms/sample - loss: 0.4144 -
auc: 0.6962 - val_loss: 0.4026 - val_auc: 0.7320
Epoch 5/30
53531/53531 [==============================] - ETA: 0s - loss: 0.4035 - auc:
0.7124
Epoch 00005: val_auc improved from 0.73197 to 0.74342, saving model to
model3_2.hdf5
53531/53531 [==============================] - 108s 2ms/sample - loss: 0.4035 -
auc: 0.7124 - val_loss: 0.4000 - val_auc: 0.7434
Epoch 6/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3976 - auc:
0.7227
Epoch 00006: val_auc improved from 0.74342 to 0.74890, saving model to
model3_2.hdf5
53531/53531 [==============================] - 109s 2ms/sample - loss: 0.3976 -
auc: 0.7227 - val_loss: 0.3938 - val_auc: 0.7489
Epoch 7/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3915 - auc:
0.7332
Epoch 00007: val_auc improved from 0.74890 to 0.75356, saving model to
model3_2.hdf5
53531/53531 [==============================] - 107s 2ms/sample - loss: 0.3915 -
auc: 0.7332 - val_loss: 0.3891 - val_auc: 0.7536
Epoch 8/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3888 - auc:
0.7374
Epoch 00008: val_auc did not improve from 0.75356
53531/53531 [==============================] - 109s 2ms/sample - loss: 0.3888 -
auc: 0.7374 - val_loss: 0.3876 - val_auc: 0.7528
Epoch 9/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3843 - auc:
0.7439
Epoch 00009: val_auc improved from 0.75356 to 0.75586, saving model to
model3_2.hdf5
53531/53531 [==============================] - 107s 2ms/sample - loss: 0.3843 -
auc: 0.7439 - val_loss: 0.3867 - val_auc: 0.7559
Epoch 10/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3827 - auc:
0.7470
Epoch 00010: val_auc did not improve from 0.75586
53531/53531 [==============================] - 108s 2ms/sample - loss: 0.3827 -
auc: 0.7470 - val_loss: 0.3859 - val_auc: 0.7544
Epoch 11/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3805 - auc:
```

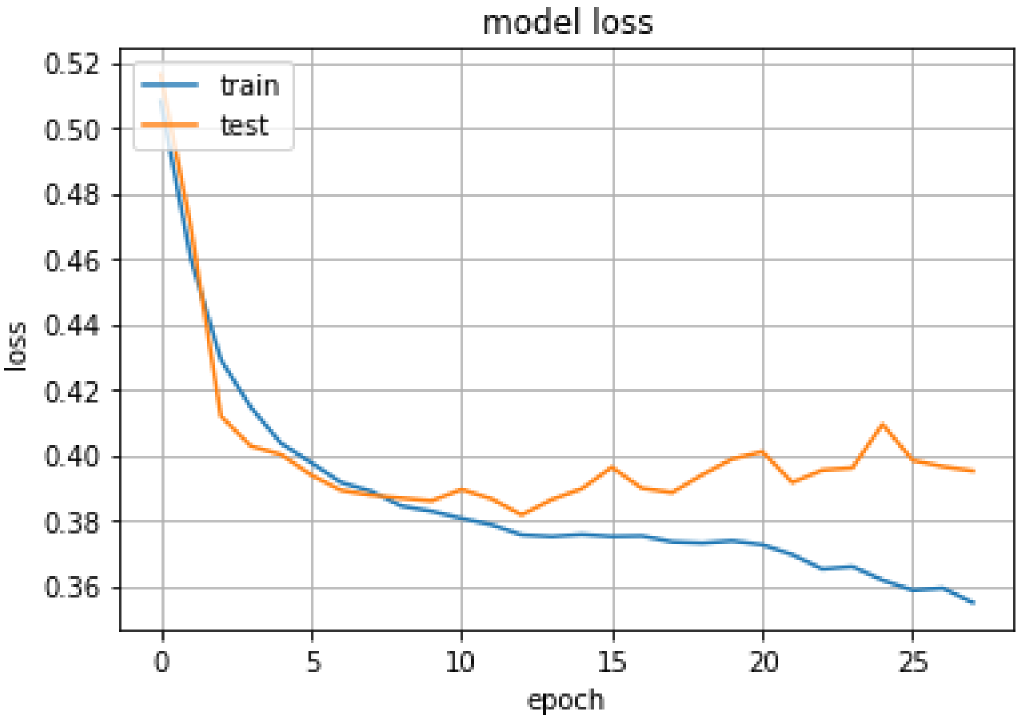
```
0.7536
Epoch 00011: val_auc improved from 0.75586 to 0.75714, saving model to
model3_2.hdf5
53531/53531 [==============================] - 107s 2ms/sample - loss: 0.3805 -
auc: 0.7536 - val_loss: 0.3894 - val_auc: 0.7571
Epoch 12/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3786 - auc:
0.7569
Epoch 00012: val_auc did not improve from 0.75714
53531/53531 [==============================] - 110s 2ms/sample - loss: 0.3786 -
auc: 0.7569 - val_loss: 0.3865 - val_auc: 0.7570
Epoch 13/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3755 - auc:
0.7622
Epoch 00013: val_auc improved from 0.75714 to 0.75832, saving model to
model3_2.hdf5
53531/53531 [==============================] - 109s 2ms/sample - loss: 0.3755 -
auc: 0.7622 - val_loss: 0.3816 - val_auc: 0.7583
Epoch 14/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3750 - auc:
0.7638
Epoch 00014: val_auc improved from 0.75832 to 0.75857, saving model to
model3_2.hdf5
53531/53531 [==============================] - 109s 2ms/sample - loss: 0.3750 -
auc: 0.7638 - val_loss: 0.3863 - val_auc: 0.7586
Epoch 15/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3756 - auc:
0.7642
Epoch 00015: val_auc improved from 0.75857 to 0.75956, saving model to
model3_2.hdf5
53531/53531 [==============================] - 110s 2ms/sample - loss: 0.3756 -
auc: 0.7642 - val_loss: 0.3896 - val_auc: 0.7596
Epoch 16/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3750 - auc:
0.7694
Epoch 00016: val_auc did not improve from 0.75956
53531/53531 [==============================] - 108s 2ms/sample - loss: 0.3750 -
auc: 0.7694 - val_loss: 0.3962 - val_auc: 0.7548
Epoch 17/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3751 - auc:
0.7724
Epoch 00017: val_auc improved from 0.75956 to 0.76055, saving model to
model3_2.hdf5
53531/53531 [==============================] - 109s 2ms/sample - loss: 0.3751 -
auc: 0.7724 - val_loss: 0.3897 - val_auc: 0.7605
Epoch 18/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3734 - auc:
0.7768
```

```
Epoch 00018: val_auc improved from 0.76055 to 0.76153, saving model to
model3_2.hdf5
53531/53531 [==============================] - 107s 2ms/sample - loss: 0.3734 -
auc: 0.7768 - val_loss: 0.3884 - val_auc: 0.7615
Epoch 19/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3730 - auc:
0.7782
Epoch 00019: val_auc did not improve from 0.76153
53531/53531 [==============================] - 108s 2ms/sample - loss: 0.3730 -
auc: 0.7782 - val_loss: 0.3939 - val_auc: 0.7561
Epoch 20/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3737 - auc:
0.7810
Epoch 00020: val_auc did not improve from 0.76153
53531/53531 [==============================] - 109s 2ms/sample - loss: 0.3737 -
auc: 0.7810 - val_loss: 0.3987 - val_auc: 0.7578
Epoch 21/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3725 - auc:
0.7802
Epoch 00021: val_auc did not improve from 0.76153
53531/53531 [==============================] - 109s 2ms/sample - loss: 0.3725 -
auc: 0.7802 - val_loss: 0.4009 - val_auc: 0.7573
Epoch 22/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3694 - auc:
0.7861
Epoch 00022: val_auc did not improve from 0.76153
53531/53531 [==============================] - 110s 2ms/sample - loss: 0.3694 -
auc: 0.7861 - val_loss: 0.3915 - val_auc: 0.7593
Epoch 23/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3650 - auc:
0.7922
Epoch 00023: val_auc did not improve from 0.76153
53531/53531 [==============================] - 109s 2ms/sample - loss: 0.3650 -
auc: 0.7922 - val_loss: 0.3953 - val_auc: 0.7584
Epoch 24/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3658 - auc:
0.7958
Epoch 00024: val_auc did not improve from 0.76153
53531/53531 [==============================] - 106s 2ms/sample - loss: 0.3658 -
auc: 0.7958 - val_loss: 0.3960 - val_auc: 0.7588
Epoch 25/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3617 - auc:
0.8008
Epoch 00025: val_auc did not improve from 0.76153
53531/53531 [==============================] - 109s 2ms/sample - loss: 0.3617 -
auc: 0.8008 - val_loss: 0.4093 - val_auc: 0.7572
Epoch 26/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3586 - auc:
```

```
0.8040
Epoch 00026: val_auc did not improve from 0.76153
53531/53531 [==============================] - 110s 2ms/sample - loss: 0.3586 -
auc: 0.8040 - val_loss: 0.3982 - val_auc: 0.7541
Epoch 27/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3592 - auc:
0.8026
Epoch 00027: val_auc did not improve from 0.76153
53531/53531 [==============================] - 108s 2ms/sample - loss: 0.3592 -
auc: 0.8026 - val_loss: 0.3964 - val_auc: 0.7560
Epoch 28/30
53531/53531 [==============================] - ETA: 0s - loss: 0.3548 - auc:
0.8089
Epoch 00028: val_auc did not improve from 0.76153
53531/53531 [==============================] - 109s 2ms/sample - loss: 0.3548 -
auc: 0.8089 - val_loss: 0.3951 - val_auc: 0.7542
Epoch 00028: early stopping
```

[ ]:

```python
import matplotlib.pyplot as plt
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.grid()
plt.show()
```



[ ]:

```
tf.keras.backend.clear_session()

#input 1
input1 = Input(shape=(500,))
x1 = Embedding(input_dim=vocab_size,output_dim=␣
 ↪300,weights=[embedding_matrix],trainable=False)(input1)
x1 = SpatialDropout1D(0.3)(x1)
x1 = LSTM(32,return_sequences=True)(x1)
x1 = BatchNormalization()(x1)
x1 = Dropout(0.3)(x1)
x1 = LSTM(16,return_sequences=True)(x1)
x1 = BatchNormalization()(x1)
x1 = Dropout(0.3)(x1)
x1 = Flatten()(x1)

# input 2
input2 = Input(shape=(16,1))
x2 = Conv1D(32,3,strides=1)(input2)
x2 = Conv1D(16,1,strides=1)(x2)
x2 = Conv1D(8,3,strides=1)(x2)
x2 = Flatten()(x2)

# merging both the inputs
concat = concatenate([x1,x2])
```

```
x =␣
 ↪Dense(80,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(concat)
x = Dropout(0.5)(x)
x =␣
 ↪Dense(40,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(x)
x = Dropout(0.3)(x)
x = BatchNormalization()(x)
x =␣
 ↪Dense(16,activation='relu',kernel_initializer='he_normal',kernel_regularizer=L2(0.
 ↪0001))(x)
x = Dropout(0.2)(x)
output = Dense(2, activation = 'softmax')(x)

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

model.load_weights('model3_2.hdf5')
```

```
WARNING:tensorflow:Layer lstm will not use cuDNN kernel since it doesn't meet
the cuDNN kernel criteria. It will use generic GPU kernel as fallback when
running on GPU
WARNING:tensorflow:Layer lstm_1 will not use cuDNN kernel since it doesn't meet
the cuDNN kernel criteria. It will use generic GPU kernel as fallback when
running on GPU
```

[ ]:
```
roc_auc_score(y_train,model.predict(tr))
```

[ ]:
```
0.7960845575714186
```

[ ]:
```
roc_auc_score(y_test,model.predict(ts))
```

[ ]:
```
0.7663776884947461
```

11.0.6 Conclusion

[150]:
```
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ["S.NO.", "architecture", "Test AUC"]
x.add_row(["1", "model1", "0.7607"])
x.add_row(["2", "model2","0.7149"])
x.add_row(["3", "model3 without countvectorizer","0.7634"])
x.add_row(["4", "model3 with countvectorizer","0.7663"])


print(x)
```

```
+-------+--------------------------------+----------+
| S.NO. |          architecture          | Test AUC |
+-------+--------------------------------+----------+
|   1   |             model1             |  0.7607  |
|   2   |             model2             |  0.7149  |
|   3   | model3 without countvectorizer |  0.7634  |
|   4   |  model3 with countvectorizer   |  0.7663  |
+-------+--------------------------------+----------+
```