Stack Overflow: Tag Prediction

1. Business Problem

Description

Stack Overflow is the largest, most trusted online community for developers to learn, share their programming knowledge, and build their careers.

Stack Overflow is something which every programmer use one way or another. Each month, over 50 million developers come to Stack Overflow to learn, share their knowledge, and build their careers. It features questions and answers on a wide range of topics in computer programming. The website serves as a platform for users to ask and answer questions, and, through membership and active participation, to vote questions and answers up or down and edit questions and answers in a fashion similar to a wiki or Digg. As of April 2014 Stack Overflow has over 4,000,000 registered users, and it exceeded 10,000,000 questions in late August 2015. Based on the type of tags assigned to questions, the top eight most discussed topics on the site are: Java, JavaScript, C#, PHP, Android, jQuery, Python and HTML.

Problem Statement

Suggest the tags based on the content that was there in the question posted on Stackoverflow.

LOAD REQUIRED LIBRARIES

```
import warnings
warnings.filterwarnings("ignore")
import pandas as pd
import sqlite3
import csv
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
from wordcloud import WordCloud
import re
import os
from sqlalchemy import create_engine # database connection
import datetime as dt
from nltk.corpus import stopwords
from nltk.tokenize import word_tokenize
from nltk.stem.snowball import SnowballStemmer
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.multiclass import OneVsRestClassifier
from sklearn.linear_model import SGDClassifier
from sklearn import metrics
from sklearn.metrics import f1_score,precision_score,recall_score
from sklearn import svm
from sklearn.linear_model import LogisticRegression
from sklearn.naive_bayes import GaussianNB
from datetime import datetime
```

CONNECT TO GOOGLE COLAB

```
from google.colab import drive

drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", for
```

LOAD THE DATA FROM CSV FILE TO TRAIN.DB

```
if not os.path.isfile('train.db'):
  start = datetime.now()
  disk_engine = create_engine('sqlite:///train.db')
  start=dt.datetime.now()
  chunksize=180000
  j=0
  index_start=1
  for df in pd.read_csv('/content/drive/My Drive/Colab Notebooks/StackOverflow Tag Predictor/Train.csv',names=['Id
    df.index +=index_start
    j+=1
    df.to_sql('data', disk_engine, if_exists='append')
    index_start = df.index[-1] + 1
  print("Time taken to run this cell :", datetime.now() - start)
```

```
Time taken to run this cell : 0:04:30.307245
```

COUNT THE TOTAL NO OF ROWS

```
if os.path.isfile('train.db'):
  start = datetime.now()
  con=sqlite3.connect('train.db')
  num_rows = pd.read_sql_query("""SELECT count(*) FROM data""",con)
  print("Number of rows in the database :","\n",num_rows['count(*)'].values[0])
  con.close()
  print("Time taken to count the number of rows :", datetime.now() - start)
else :
  print("Please download the train.db file from drive or run the above cell to genarate train.db file")
```

```
Number of rows in the database :
 6034196
Time taken to count the number of rows : 0:00:14.149502
```

CHECK FOR DUPLICATES

```
if os.path.isfile('train.db'):
  start = datetime.now()
  con=sqlite3.connect('train.db')
  df_no_duplicate=pd.read_sql_query('SELECT Title, Body, Tags, COUNT(*) as cnt_dup FROM data GROUP BY Title, Body,
  con.close()
  print("Time taken to run this cell :", datetime.now() - start)
else:
  print("Please download the train.db file from drive or run the first to genarate train.db file")
```

```
Time taken to run this cell : 0:05:11.238108
```

```
df_no_duplicate.head()
```

	Title	Body	Tags	cnt_dup
0	Implementing Boundary Value Analysis of S...	<pre><code>#include&lt;iostream&gt;\n#include&...	c++ c	1

```
print("number of duplicate questions :", num_rows['count(*)'].values[0]- df_no_duplicate.shape[0], "(",(1-((df_no_
```

```
number of duplicate questions : 1827881 ( 30.292038906260256 % )
```

2 Dynamic Datagrid Binding in Silverlight? dynamicall... columns 1

```
df_no_duplicate.cnt_dup.value_counts()
```

```
1    2656284
2    1272336
3     277575
4         90
5         25
6          5
Name: cnt_dup, dtype: int64
```

```
df_no_duplicate["Tags"].head()
```

```
0                               c++ c
1             c# silverlight data-binding
2    c# silverlight data-binding columns
3                             jsp jstl
4                            java jdbc
Name: Tags, dtype: object
```

```
start = datetime.now()
df_no_duplicate["tag_count"] = df_no_duplicate["Tags"].apply(lambda text: len(str(text).split()))
print("Time taken to run this cell :", datetime.now() - start)
df_no_duplicate.head()
```

```
Time taken to run this cell : 0:00:03.016791
```

	Title	Body	Tags	cnt_dup	tag_count
0	Implementing Boundary Value Analysis of S...	<pre><code>#include&lt;iostream&gt;\n#include&...	c++ c	1	2
1	Dynamic Datagrid Binding in Silverlight?	<p>I should do binding for datagrid dynamicall...	c# silverlight data-binding	1	3
2	Dynamic Datagrid Binding in Silverlight?	<p>I should do binding for datagrid dynamicall...	c# silverlight data-binding columns	1	4

```
df_no_duplicate.tag_count.value_counts()
```

```
3    1206157
2    1111706
4     814996
1     568298
5     505158
Name: tag_count, dtype: int64
```

```
if not os.path.isfile('train_no_dup.db'):
    disk_dup = create_engine("sqlite:///train_no_dup.db")
    no_dup = pd.DataFrame(df_no_duplicate, columns=['Title', 'Body', 'Tags'])
    no_dup.to_sql('no_dup_train',disk_dup)
```

```
if os.path.isfile('train_no_dup.db'):
    start = datetime.now()
    con = sqlite3.connect('train_no_dup.db')
    tag_data = pd.read_sql_query("""SELECT Tags FROM no_dup_train""", con)
    tag_data = pd.read_sql_query("""SELECT Tags FROM no_dup_train""", con)
    #Always remember to close the database
    con.close()

    # Let's now drop unwanted column.
    tag_data.drop(tag_data.index[0], inplace=True)
    #Printing first 5 columns from our data frame
    tag_data.head()
    print("Time taken to run this cell :", datetime.now() - start)
else:
    print("Please download the train.db file from drive or run the above cells to genarate train.db file")
```

```
Time taken to run this cell : 0:01:54.541361
```

```
tag_data.head()
```

	Tags
1	c# silverlight data-binding
2	c# silverlight data-binding columns
3	jsp jstl
4	java jdbc
5	facebook api facebook-php-sdk

```
tag_data.loc[tag_data['Tags'].isnull(),'Tags'] = ''
```

ANALYSIS OF TAGS --> COUNTVECTORIZER

```
vectorizer=CountVectorizer(tokenizer = lambda x : str(x).split())

tag_dtm=vectorizer.fit_transform(tag_data['Tags'])
```

```
print("Number of data points :", tag_dtm.shape[0])
print("Number of unique tags :", tag_dtm.shape[1])
```

```
Number of data points : 4206314
Number of unique tags : 42048
```

```
feature_tags=vectorizer.get_feature_names()

print("Some of the tags we have :", feature_tags[:10])
```

```
Some of the tags we have : ['.a', '.app', '.asp.net-mvc', '.aspxauth', '.bash-profile', '.class-file', '.cs-fil
```

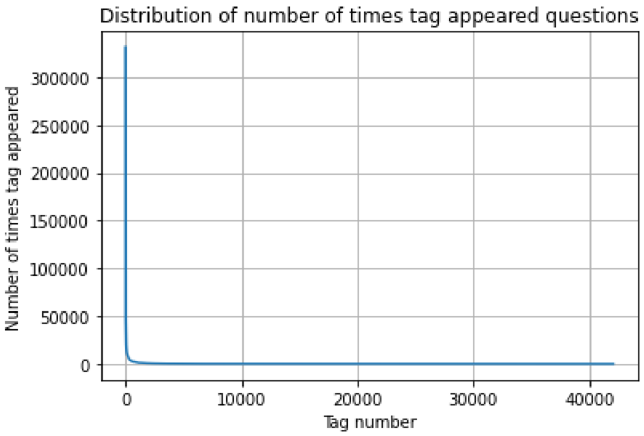
```
freqs = tag_dtm.sum(axis=0).A1
result = dict(zip(feature_tags, freqs))
```

```
if not os.path.isfile('tag_counts_dict_dtm.csv'):
    with open('tag_counts_dict_dtm.csv', 'w') as csv_file:
        writer = csv.writer(csv_file)
        for key, value in result.items():
            writer.writerow([key, value])
tag_df = pd.read_csv("tag_counts_dict_dtm.csv", names=['Tags', 'Counts'])
tag_df.head()
```

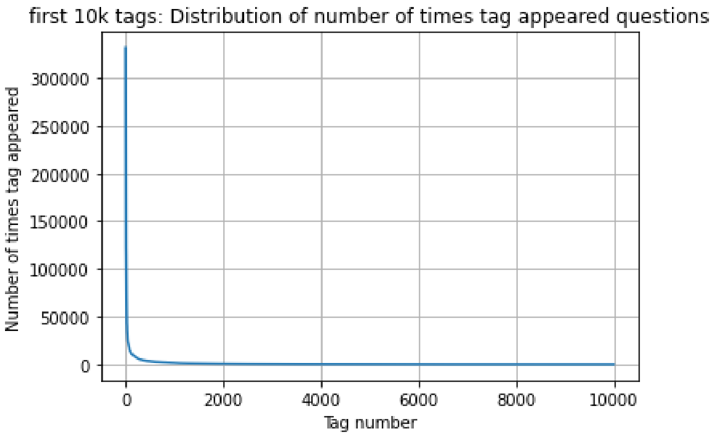
	Tags	Counts
0	.a	18
1	.app	37
2	.asp.net-mvc	1
3	.aspxauth	21

```
tag_df_sorted=tag_df.sort_values(['Counts'],ascending=False)

tag_counts=tag_df_sorted['Counts'].values
```

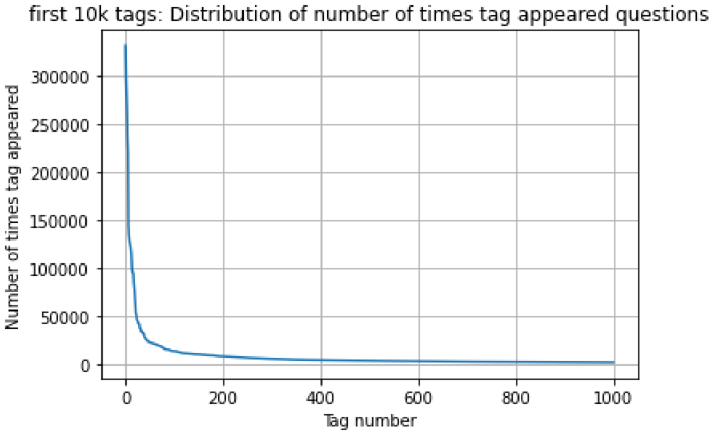
```
plt.plot(tag_counts)
plt.title("Distribution of number of times tag appeared questions")
plt.grid()
plt.xlabel("Tag number")
plt.ylabel("Number of times tag appeared")
plt.show()
```



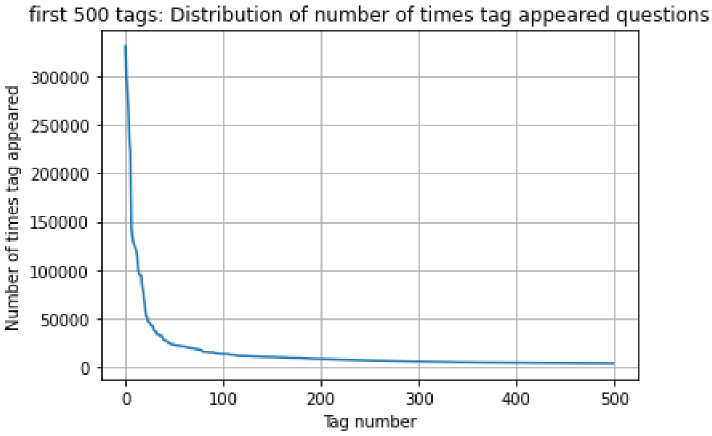
```
plt.plot(tag_counts[0:10000])
plt.title('first 10k tags: Distribution of number of times tag appeared questions')
plt.grid()
plt.xlabel("Tag number")
plt.ylabel("Number of times tag appeared")
plt.show()
```



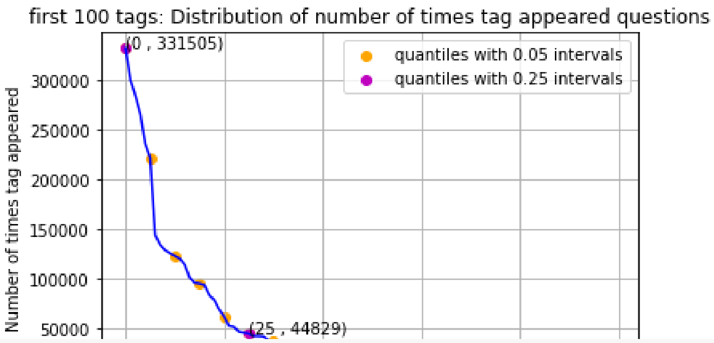
```
plt.plot(tag_counts[0:1000])
plt.title('first 10k tags: Distribution of number of times tag appeared questions')
plt.grid()
plt.xlabel("Tag number")
plt.ylabel("Number of times tag appeared")
plt.show()
```



```
plt.plot(tag_counts[0:500])
plt.title('first 500 tags: Distribution of number of times tag appeared questions')
plt.grid()
plt.xlabel("Tag number")
plt.ylabel("Number of times tag appeared")
plt.show()
```



```
plt.plot(tag_counts[0:100], c='b')
plt.scatter(x=list(range(0,100,5)), y=tag_counts[0:100:5], c='orange', label="quantiles with 0.05 intervals")
# quantiles with 0.25 difference
plt.scatter(x=list(range(0,100,25)), y=tag_counts[0:100:25], c='m', label = "quantiles with 0.25 intervals")

for x,y in zip(list(range(0,100,25)), tag_counts[0:100:25]):
    plt.annotate(s="({} , {})".format(x,y), xy=(x,y), xytext=(x-0.05, y+500))

plt.title('first 100 tags: Distribution of number of times tag appeared questions')
plt.grid()
plt.xlabel("Tag number")
plt.ylabel("Number of times tag appeared")
plt.legend()
plt.show()
print(len(tag_counts[0:100:5]), tag_counts[0:100:5])
```



```
# Store tags greater than 10K in one list
lst_tags_gt_10k = tag_df[tag_df.Counts>10000].Tags
#Print the length of the list
print ('{} Tags are used more than 10000 times'.format(len(lst_tags_gt_10k)))
# Store tags greater than 100K in one list
lst_tags_gt_100k = tag_df[tag_df.Counts>100000].Tags
#Print the length of the list.
print ('{} Tags are used more than 100000 times'.format(len(lst_tags_gt_100k)))
```

```
153 Tags are used more than 10000 times
14 Tags are used more than 100000 times
```

Observations:

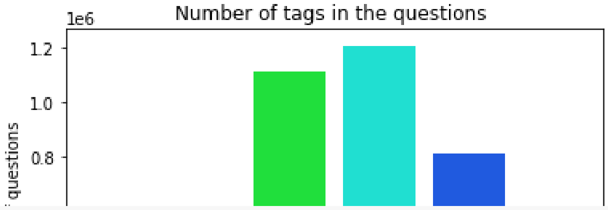
1. There are total 153 tags which are used more than 10000 times.
2. 14 tags are used more than 100000 times.
3. Most frequent tag (i.e. c#) is used 331505 times.
4. Since some tags occur much more frequenctly than others
5. Micro-averaged. F1-score is the appropriate metric for this probelm.

TAGS PER QUESTION

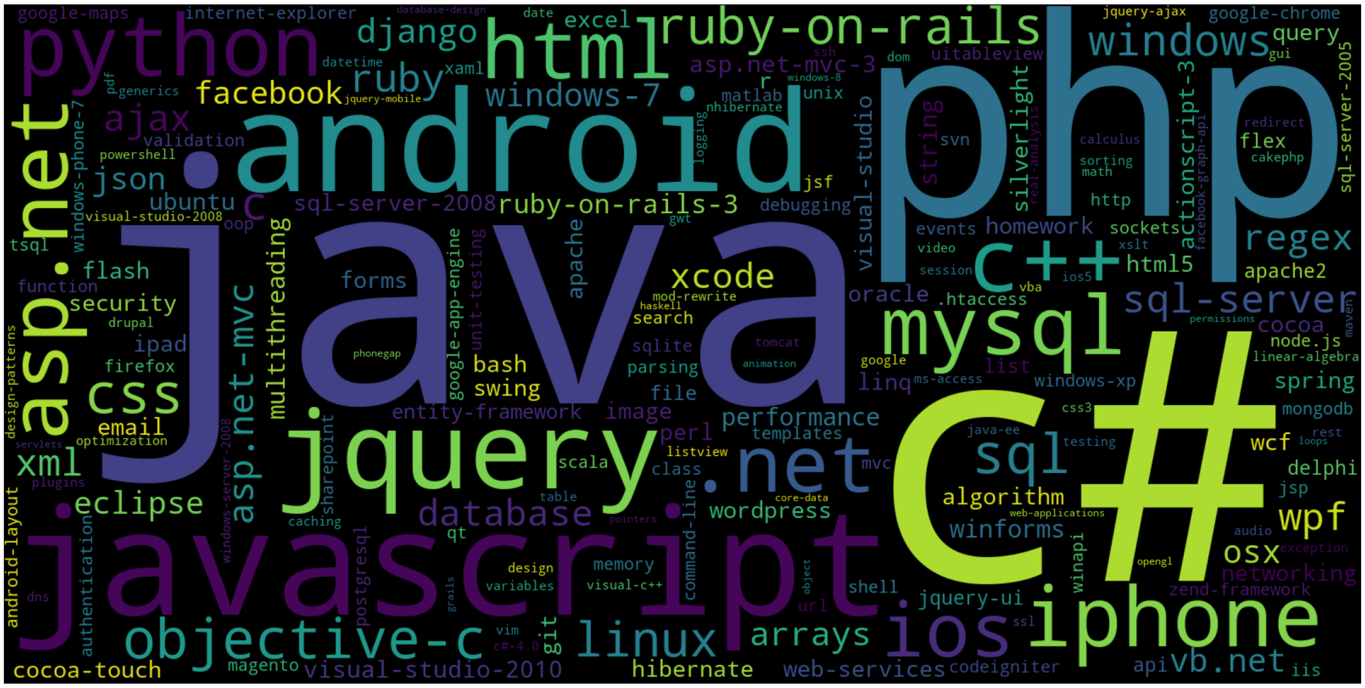
```
tag_quest_count = tag_dtm.sum(axis=1).tolist()

tag_quest_count=[int(j) for i in tag_quest_count for j in i]
print ('We have total {} datapoints.'.format(len(tag_quest_count)))

print(tag_quest_count[:5])
```

```
We have total 4206314 datapoints.
[3, 4, 2, 2, 3]
```

```
sns.countplot(tag_quest_count, palette='gist_rainbow')
plt.title("Number of tags in the questions ")
plt.xlabel("Number of Tags")
plt.ylabel("Number of questions")
plt.show()
```



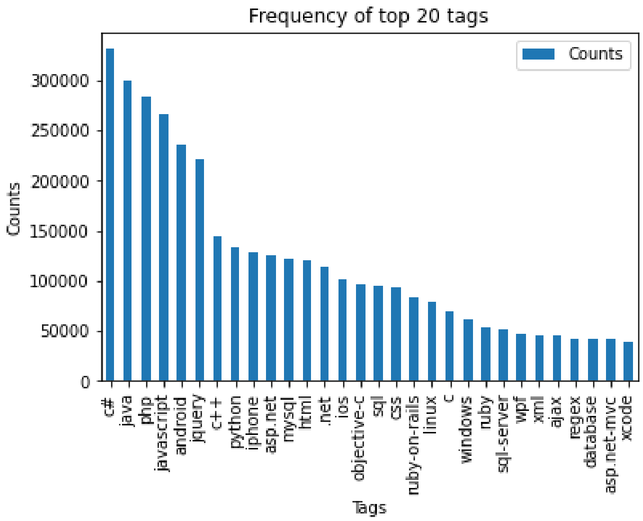
```python
start = datetime.now()

# Lets first convert the 'result' dictionary to 'list of tuples'
tup = dict(result.items())
#Initializing WordCloud using frequencies of tags.
wordcloud = WordCloud(    background_color='black',
                          width=1600,
                          height=800,
                    ).generate_from_frequencies(tup)

fig = plt.figure(figsize=(30,20))
plt.imshow(wordcloud)
plt.axis('off')
plt.tight_layout(pad=0)
fig.savefig("tag.png")
plt.show()
print("Time taken to run this cell :", datetime.now() - start)
```



```
Time taken to run this cell : 0:00:05.589744
```

Observations: A look at the word cloud shows that "c#", "java", "php", "asp.net", "javascript", "c++" are some of the most

```
i=np.arange(30)
tag_df_sorted.head(30).plot(kind='bar')
plt.title('Frequency of top 20 tags')
plt.xticks(i, tag_df_sorted['Tags'])
plt.xlabel('Tags')
plt.ylabel('Counts')
plt.show()
```



Observations:

1. Majority of the most frequent tags are programming language.
2. C# is the top most frequent programming language.
3. Android, IOS, Linux and windows are among the top most frequent operating systems.

CLEANING & PREPROCESSING OF QUESTIONS

```
import nltk
nltk.download('stopwords')
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
True
```

```
def striphtml(data):
    cleanr = re.compile('<.*?>')
    cleantext = re.sub(cleanr, ' ', str(data))
    return cleantext
stop_words = set(stopwords.words('english'))
stemmer = SnowballStemmer("english")
```

```
def create_connection(db_file):
    """ create a database connection to the SQLite database
        specified by db_file
    :param db_file: database file
    :return: Connection object or None
    """
    try:
        conn = sqlite3.connect(db_file)
        return conn
    except Error as e:
        print(e)

    return None

def create_table(conn, create_table_sql):
    """ create a table from the create_table_sql statement
    :param conn: Connection object
    :param create_table_sql: a CREATE TABLE statement
    :return:
    """
    try:
        c = conn.cursor()
        c.execute(create_table_sql)
    except Error as e:
        print(e)

def checkTableExists(dbcon):
    cursr = dbcon.cursor()
    str = "select name from sqlite_master where type='table'"
    table_names = cursr.execute(str)
    print("Tables in the databse:")
    tables =table_names.fetchall()
    print(tables[0][0])
    return(len(tables))

def create_database_table(database, query):
    conn = create_connection(database)
    if conn is not None:
        create_table(conn, query)
        checkTableExists(conn)
    else:
        print("Error! cannot create the database connection.")
    conn.close()

sql_create_table = """CREATE TABLE IF NOT EXISTS QuestionsProcessed (question text NOT NULL, code text, tags text,
create_database_table("Processed.db", sql_create_table)
```

```
Tables in the databse:
QuestionsProcessed
```

```
start = datetime.now()
read_db = 'train_no_dup.db'
write_db = 'Processed.db'
if os.path.isfile(read_db):
    conn_r = create_connection(read_db)
    if conn_r is not None:
        reader =conn_r.cursor()
        reader.execute("SELECT Title, Body, Tags From no_dup_train ORDER BY RANDOM() LIMIT 1000000;")

if os.path.isfile(write_db):
    conn_w = create_connection(write_db)
    if conn_w is not None:
        tables = checkTableExists(conn_w)
        writer =conn_w.cursor()
        if tables != 0:
            writer.execute("DELETE FROM QuestionsProcessed WHERE 1")
            print("Cleared All the rows")
print("Time taken to run this cell :", datetime.now() - start)
```

```
Tables in the databse:
QuestionsProcessed
```

```
nltk.download('punkt')
```

```
[nltk_data] Downloading package punkt to /root/nltk_data...
[nltk_data]   Unzipping tokenizers/punkt.zip.
True
```

```
start = datetime.now()
preprocessed_data_list=[]
reader.fetchone()
questions_with_code=0
len_pre=0
len_post=0
questions_proccesed = 0
for row in reader:

    is_code = 0

    title, question, tags = row[0], row[1], row[2]

    if '<code>' in question:
        questions_with_code+=1
        is_code = 1
    x = len(question)+len(title)
    len_pre+=x

    code = str(re.findall(r'<code>(.*?)</code>', question, flags=re.DOTALL))

    question=re.sub('<code>(.*?)</code>', '', question, flags=re.MULTILINE|re.DOTALL)
    question=striphtml(question.encode('utf-8'))

    title=title.encode('utf-8')

    question=str(title)+" "+str(question)
    question=re.sub(r'[^A-Za-z]+',' ',question)
    words=word_tokenize(str(question.lower()))

    #Removing all single letter and and stopwords from question exceptt for the letter 'c'
    question=' '.join(str(stemmer.stem(j)) for j in words if j not in stop_words and (len(j)!=1 or j=='c'))

    len_post+=len(question)
    tup = (question,code,tags,x,len(question),is_code)
    questions_proccesed += 1
    writer.execute("insert into QuestionsProcessed(question,code,tags,words_pre,words_post,is_code) values (?,?,?,
    if (questions_proccesed%100000==0):
        print("number of questions completed=",questions_proccesed)

no_dup_avg_len_pre=(len_pre*1.0)/questions_proccesed
no_dup_avg_len_post=(len_post*1.0)/questions_proccesed

print( "Avg. length of questions(Title+Body) before processing: %d"%no_dup_avg_len_pre)
print( "Avg. length of questions(Title+Body) after processing: %d"%no_dup_avg_len_post)
print ("Percent of questions containing code: %d"%((questions_with_code*100.0)/questions_proccesed))

print("Time taken to run this cell :", datetime.now() - start)
```

```
number of questions completed= 100000
number of questions completed= 200000
number of questions completed= 300000
number of questions completed= 400000
number of questions completed= 500000
number of questions completed= 600000
number of questions completed= 700000
```

```
conn_r.commit()
conn_w.commit()
conn_r.close()
conn_w.close()
```

```
Time taken to run this cell : 0:25:27.569922
```

```
if os.path.isfile(write_db):
    conn_r = create_connection(write_db)
    if conn_r is not None:
        reader =conn_r.cursor()
        reader.execute("SELECT question From QuestionsProcessed LIMIT 10")
        print("Questions after preprocessed")
        print('='*100)
        reader.fetchone()
        for row in reader:
            print(row)
            print('-'*100)
conn_r.commit()
conn_r.close()
```

```
Questions after preprocessed
====================================================================================================
('right wrong practic use statement foo foo true throughout short career far program mere student work internsh
----------------------------------------------------------------------------------------------------
('java anim import imag netbean hi want ask move import jpg imag left right bottom beginn java pleas help thank
----------------------------------------------------------------------------------------------------
('help sql inner join tri inner join temp tabl ni know done done complet forgot npleas advis queri tri execut f
----------------------------------------------------------------------------------------------------
('possibl pitfal use extens method base shorthand regular want access properti possibl null object use often sn
----------------------------------------------------------------------------------------------------
('chrome extens run background file function everi sec extens need synch data server everi second also backgrou
----------------------------------------------------------------------------------------------------
('iphon xcode mutablecopi still immut look place regard problem tri creat nsuser default object add mutabl arra
----------------------------------------------------------------------------------------------------
('could due servic endpoint bind use http protocol wcf servic run fine local machin put server receiv follow er
----------------------------------------------------------------------------------------------------
('gotoandstop bug reason one instanc get gotoandstop go stop second frame movi clip two frame load ad movieclip
----------------------------------------------------------------------------------------------------
('traffic shape tp ipsec vpn via account connect need abl control amount bandwidth specif user account use vpn
----------------------------------------------------------------------------------------------------
```

```
start = datetime.now()
con=sqlite3.connect('/content/drive/My Drive/Colab Notebooks/StackOverflow Tag Predictor/Processed.db')
preprocessed_data  = pd.read_sql_query("""SELECT question, Tags FROM QuestionsProcessed""",con)
con.close()
print("Time taken to count the number of rows :", datetime.now() - start)
```

```
Time taken to count the number of rows : 0:00:21.968940
```

```
preprocessed_data.head()
```

	question	tags
0	macport gcc select error tri exec appl darwin ...	macports selection gcc
1	right wrong practic use statement foo foo true ...	validation if-statement logic

MACHINE LEARNING MODELS

Converting Tags to MultiLabel Problems

```
preprocessed_data[preprocessed_data.isnull().any(axis=1)]
```

	question	tags
642062	handl nullobject done quit bit research best w...	None

```
preprocessed_data.loc[preprocessed_data['tags'].isnull(),'tags'] = ''
```

```
# binary = true  , means it will return binary vector
count_vectorizer=CountVectorizer(tokenizer = lambda x : str(x).split() , binary='true')

multilabel_y=count_vectorizer.fit_transform(preprocessed_data['tags'])
```

```
def tags_to_choose(n):
    t = multilabel_y.sum(axis=0).tolist()[0]
    sorted_tags_i = sorted(range(len(t)), key=lambda i: t[i], reverse=True)
    multilabel_yn=multilabel_y[:,sorted_tags_i[:n]]
    return multilabel_yn

def questions_explained_fn(n):
    multilabel_yn = tags_to_choose(n)
    x= multilabel_yn.sum(axis=1)
    return (np.count_nonzero(x==0))
```

```
multilabel_y.shape[1]
```

```
35388
```

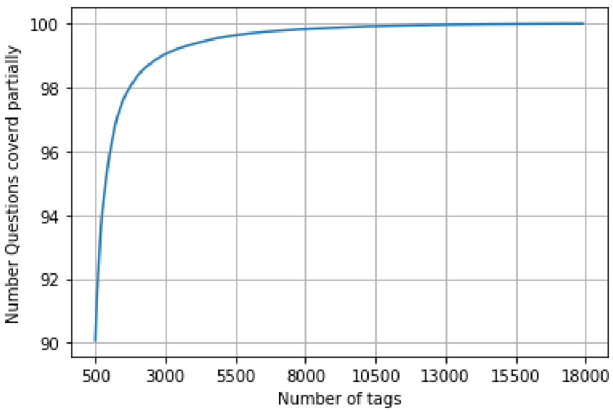
```
preprocessed_data.shape[0]
```

```
999997
```

```
questions_explained = []
total_tags=multilabel_y.shape[1]
total_qs=preprocessed_data.shape[0]
for i in range(500, total_tags, 100):
    questions_explained.append(np.round(((total_qs-questions_explained_fn(i))/total_qs)*100,3))
```

```
fig, ax = plt.subplots()
ax.plot(questions_explained)
xlabel = list(500+np.array(range(-50,450,50))*50)
ax.set_xticklabels(xlabel)
plt.xlabel("Number of tags")
plt.ylabel("Number Questions coverd partially")
plt.grid()
plt.show()
# you can choose any number of tags based on your computing power, minimun is 50(it covers 90% of the tags)
```

```
print("with ",5500,"tags we are covering ",questions_explained[50],"% of questions")
```



```
with  5500 tags we are covering  99.048 % of questions
```

```
multilabel_yx = tags_to_choose(5500)
print("number of questions that are not covered :", questions_explained_fn(5500),"out of ", total_qs)
```

```
number of questions that are not covered : 9517 out of  999997
```

```
print("Number of tags in sample :", multilabel_y.shape[1])
print("number of tags taken :", multilabel_yx.shape[1],"(",(multilabel_yx.shape[1]/multilabel_y.shape[1])*100,"%)'
```

```
Number of tags in sample : 35388
number of tags taken : 5500 ( 15.541991635582683 %)
```

Split the Data into Test & Train

```
total_size=preprocessed_data.shape[0]
train_size=int(0.80*total_size)

x_train=preprocessed_data.head(train_size)
x_test=preprocessed_data.tail(total_size - train_size)

y_train = multilabel_yx[0:train_size,:]
y_test = multilabel_yx[train_size:total_size,:]
```

```
print("Number of data points in train data :", y_train.shape)
print("Number of data points in test data :", y_test.shape)
```

```
Number of data points in train data : (799997, 5500)
Number of data points in test data : (200000, 5500)
```

Featurizing of data

TF-IDF Featurization Vector

```
start = datetime.now()
vectorizer = TfidfVectorizer(min_df=0.00009, max_features=200000, smooth_idf=True, norm="l2", \
                             tokenizer = lambda x: x.split(), sublinear_tf=False, ngram_range=(1,1))
```

```
x_train_multilabel = vectorizer.fit_transform(x_train['question'])
```

```
x_test_multilabel = vectorizer.transform(x_test['question'])
print("Time taken to run this cell :", datetime.now() - start)
```

```
Time taken to run this cell : 0:00:37.624874
```

```
print("Dimensions of train data X:",x_train_multilabel.shape, "Y :",y_train.shape)
print("Dimensions of test data X:",x_test_multilabel.shape,"Y:",y_test.shape)
```

```
Dimensions of train data X: (799997, 9366) Y : (799997, 5500)
Dimensions of test data X: (200000, 9366) Y: (200000, 5500)
```

```
classifier = OneVsRestClassifier(SGDClassifier(loss='log', alpha=0.00001, penalty='l1'), n_jobs=-1)
classifier.fit(x_train_multilabel, y_train)
predictions = classifier.predict(x_test_multilabel)

print("accuracy :",metrics.accuracy_score(y_test,predictions))
print("macro f1 score :",metrics.f1_score(y_test, predictions, average = 'macro'))
print("micro f1 scoore :",metrics.f1_score(y_test, predictions, average = 'micro'))
print("hamming loss :",metrics.hamming_loss(y_test,predictions))
print("Precision recall report :\n",metrics.classification_report(y_test, predictions))
```

```
start = datetime.now()
con=sqlite3.connect('/content/drive/My Drive/Colab Notebooks/StackOverflow Tag Predictor/Titlemoreweight.db')
preprocessed_data  = pd.read_sql_query("""SELECT question, Tags FROM QuestionsProcessed LIMIT 200000""",con)
con.close()
print("Time taken to count the number of rows :", datetime.now() - start)
```

```
Time taken to count the number of rows : 0:34:27.679654
```

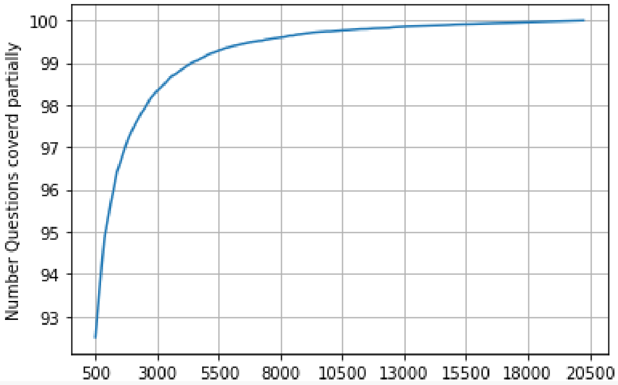
```
print("number of data points in sample :", preprocessed_data.shape[0])
print("number of dimensions :", preprocessed_data.shape[1])
```

```
number of data points in sample : 200000
number of dimensions : 2
```

```
vectorizer = CountVectorizer(tokenizer = lambda x: x.split(), binary='true')
multilabel_y = vectorizer.fit_transform(preprocessed_data['tags'])
```

```
questions_explained = []
total_tags=multilabel_y.shape[1]
total_qs=preprocessed_data.shape[0]
for i in range(500, total_tags, 100):
    questions_explained.append(np.round(((total_qs-questions_explained_fn(i))/total_qs)*100,3))
```

```
fig, ax = plt.subplots()
ax.plot(questions_explained)
xlabel = list(500+np.array(range(-50,450,50))*50)
ax.set_xticklabels(xlabel)
plt.xlabel("Number of tags")
plt.ylabel("Number Questions coverd partially")
plt.grid()
plt.show()
# you can choose any number of tags based on your computing power, minimun is 500(it covers 90% of the tags)
print("with ",5500,"tags we are covering ",questions_explained[50],"% of questions")
print("with ",500,"tags we are covering ",questions_explained[0],"% of questions")
```



```
multilabel_yx = tags_to_choose(500)
print("number of questions that are not covered :", questions_explained_fn(500),"out of ", total_qs)
```

```
number of questions that are not covered : 15045 out of  200000
```

```
train_datasize = 130000
x_train=preprocessed_data.head(train_datasize)
x_test=preprocessed_data.tail(preprocessed_data.shape[0] - 130000)

y_train = multilabel_yx[0:train_datasize,:]
y_test = multilabel_yx[train_datasize:preprocessed_data.shape[0],:]
```

```
print("Number of data points in train data :", y_train.shape)
print("Number of data points in test data :", y_test.shape)
```

```
Number of data points in train data : (130000, 500)
Number of data points in test data : (70000, 500)
```

```
start = datetime.now()
vectorizer = CountVectorizer(min_df=0.00009, max_features=200000,
                             tokenizer = lambda x: str(x).split(),ngram_range=(1,4))
x_train_multilabel_bow = vectorizer.fit_transform(x_train['question'])
x_test_multilabel_bow = vectorizer.transform(x_test['question'])
print("Time taken to run this cell :", datetime.now() - start)
```

```
Time taken to run this cell : 0:02:35.063394
```

```
print("Dimensions of train data X:",x_train_multilabel_bow.shape, "Y :",y_train.shape)
print("Dimensions of test data X:",x_test_multilabel_bow.shape,"Y:",y_test.shape)
```

```
Dimensions of train data X: (130000, 100181) Y : (130000, 500)
Dimensions of test data X: (70000, 100181) Y: (70000, 500)
```

```
start = datetime.now()
classifier = OneVsRestClassifier(SGDClassifier(loss='log', alpha=0.00001, penalty='l1'), n_jobs=1)
classifier.fit(x_train_multilabel_bow, y_train)
predictions = classifier.predict (x_test_multilabel_bow)


print("Accuracy :",metrics.accuracy_score(y_test, predictions))
print("Hamming loss ",metrics.hamming_loss(y_test,predictions))


precision = precision_score(y_test, predictions, average='micro')
recall = recall_score(y_test, predictions, average='micro')
f1 = f1_score(y_test, predictions, average='micro')

print("Micro-average quality numbers")
print("Precision: {:.4f}, Recall: {:.4f}, F1-measure: {:.4f}".format(precision, recall, f1))

precision = precision_score(y_test, predictions, average='macro')
recall = recall_score(y_test, predictions, average='macro')
f1 = f1_score(y_test, predictions, average='macro')

print("Macro-average quality numbers")
print("Precision: {:.4f}, Recall: {:.4f}, F1-measure: {:.4f}".format(precision, recall, f1))

print (metrics.classification_report(y_test, predictions))
print("Time taken to run this cell :", datetime.now() - start)
```

```
Accuracy : 0.11258571428571429
Hamming loss  0.006103285714285714
Micro-average quality numbers
Precision: 0.3424, Recall: 0.5517, F1-measure: 0.4225
Macro-average quality numbers
Precision: 0.1623, Recall: 0.3566, F1-measure: 0.2083
              precision    recall  f1-score   support

           0       0.97      0.96      0.96     42802
           1       0.25      0.32      0.28      1764
           2       0.27      0.41      0.33       942
           3       0.24      0.28      0.26      6539
           4       0.35      0.45      0.40      2540
           5       0.50      0.58      0.54      2156
           6       0.47      0.54      0.50      1990
           7       0.13      0.21      0.16       611
           8       0.20      0.33      0.25       324
           9       0.69      0.74      0.71      2335
          10       0.27      0.43      0.33       736
          11       0.23      0.38      0.29      1199
          12       0.31      0.48      0.38       842
          13       0.30      0.44      0.36       770
          14       0.40      0.63      0.49       975
          15       0.22      0.33      0.26       523
          16       0.09      0.36      0.14       143
          17       0.34      0.57      0.43       428
          18       0.39      0.60      0.47       552
          19       0.44      0.59      0.50       708
          20       0.26      0.63      0.37        89
          21       0.17      0.39      0.24       219
          22       0.29      0.29      0.29       662
          23       0.18      0.20      0.19      1965
          24       0.23      0.38      0.29      1046
          25       0.23      0.34      0.27       488
          26       0.26      0.38      0.31       458
          27       0.25      0.39      0.31      1193
          28       0.51      0.44      0.47      1492
          29       0.09      0.22      0.13       354
          30       0.10      0.47      0.17       159
          31       0.09      0.34      0.15       157
          32       0.17      0.26      0.21       740
          33       0.40      0.44      0.42      1337
          34       0.21      0.38      0.27       226
          35       0.25      0.50      0.33       535
          36       0.22      0.37      0.28       315
          37       0.12      0.28      0.17       167
          38       0.39      0.62      0.48      1074
          39       0.23      0.33      0.27       336
          40       0.13      0.45      0.21       312
          41       0.13      0.19      0.15       682
          42       0.36      0.65      0.46       265
          43       0.46      0.65      0.54       478
          44       0.22      0.42      0.29       598
          45       0.19      0.33      0.24      1054
          46       0.26      0.42      0.32       253
          47       0.14      0.21      0.17       936
          48       0.10      0.28      0.15       133
          49       0.09      0.23      0.13       152
          50       0.35      0.42      0.38       943
          51       0.10      0.18      0.13       243
          52       0.13      0.36      0.19       135
          53       0.92      0.84      0.88       969
          54       0.13      0.19      0.16       801
          55       0.13      0.72      0.22        50
          56       0.12      0.40      0.18       142
          57       0.13      0.36      0.19       125
          58       0.02      0.15      0.03        39
          59       0.10      0.50      0.16        36
          60       0.22      0.42      0.29       205
          61       0.11      0.21      0.14       354
          62       0.10      0.20      0.13       266
          63       0.17      0.54      0.26       178
```

```
         63       0.17      0.54      0.26       178
         64       0.36      0.76      0.49       163
         65       0.13      0.48      0.21        46
         66       0.13      0.25      0.17       269
         67       0.29      0.79      0.43       133
         68       0.18      0.33      0.23       577
         69       0.12      0.23      0.16       212
         70       0.31      0.70      0.43       120
         71       0.09      0.20      0.13       258
         72       0.13      0.23      0.17       354
         73       0.42      0.58      0.49       159
         74       0.07      0.31      0.11        89
         75       0.22      0.37      0.28       125
         76       0.08      0.24      0.12        94
         77       0.37      0.37      0.37       456
         78       0.20      0.31      0.24       712
         79       0.15      0.22      0.18       299
         80       0.06      0.23      0.10        53
         81       0.12      0.40      0.18       275
         82       0.21      0.40      0.28       623
         83       0.18      0.43      0.25        75
         84       0.01      0.22      0.02        27
         85       0.24      0.39      0.29       230
         86       0.26      0.42      0.32       177
         87       0.03      0.27      0.06        30
         88       0.32      0.62      0.42       655
         89       0.06      0.21      0.10       126
         90       0.31      0.30      0.31       422
         91       0.05      0.12      0.07       130
         92       0.53      0.87      0.66       451
         93       0.05      0.17      0.08        77
         94       0.04      0.12      0.06       461
         95       0.26      0.50      0.34       104
         96       0.07      0.15      0.10       454
         97       0.20      0.49      0.28       345
         98       0.17      0.49      0.26       125
         99       0.25      0.47      0.33       144
        100       0.09      0.22      0.12       279
        101       0.08      0.25      0.12        99
        102       0.34      0.53      0.42       553
        103       0.12      0.34      0.18       123
        104       0.05      0.12      0.07       542
        105       0.11      0.18      0.14       542
        106       0.07      0.18      0.10       118
        107       0.18      0.58      0.27        73
        108       0.07      0.24      0.11       191
        109       0.06      0.13      0.08       180
        110       0.10      0.30      0.15       121
        111       0.05      0.24      0.08        41
        112       0.07      0.16      0.10       254
        113       0.06      0.18      0.10       146
        114       0.38      0.41      0.39       279
        115       0.13      0.22      0.17       245
        116       0.14      0.29      0.19       102
        117       0.37      0.35      0.36       469
        118       0.08      0.10      0.09       248
        119       0.15      0.28      0.19        98
        120       0.20      0.40      0.27       105
        121       0.07      0.24      0.10       164
        122       0.12      0.42      0.19        95
        123       0.19      0.42      0.26       208
        124       0.23      0.41      0.29        85
        125       0.18      0.48      0.26        98
        126       0.03      0.27      0.05        41
        127       0.32      0.41      0.36       431
        128       0.23      0.37      0.28       111
        129       0.10      0.35      0.16        74
        130       0.10      0.27      0.15       116
        131       0.14      0.49      0.21       126
        132       0.23      0.46      0.31       270
        133       0.05      0.43      0.10        35
        134       0.07      0.30      0.11        64
        135       0.15      0.59      0.23       243
```

```
         135       0.15      0.59      0.25       245
         136       0.75      0.81      0.78       345
         137       0.12      0.25      0.16       174
         138       0.11      0.34      0.17       183
         139       0.50      0.43      0.46       454
         140       0.52      0.74      0.61       302
         141       0.16      0.40      0.23        82
         142       0.34      0.82      0.48        82
         143       0.18      0.37      0.24        98
         144       0.41      0.72      0.52       137
         145       0.22      0.32      0.26       412
         146       0.02      0.10      0.03       224
         147       0.11      0.25      0.15       153
         148       0.25      0.70      0.37        64
         149       0.17      0.51      0.26        68
         150       0.08      0.25      0.12       126
         151       0.07      0.10      0.09       202
         152       0.02      0.31      0.04        39
         153       0.09      0.39      0.15        36
         154       0.20      0.49      0.28       136
         155       0.07      0.13      0.09       212
         156       0.23      0.45      0.31        51
         157       0.17      0.45      0.25        94
         158       0.04      0.13      0.06       286
         159       0.28      0.48      0.35       350
         160       0.07      0.36      0.12        22
         161       0.05      0.20      0.07       120
         162       0.06      0.17      0.09       144
         163       0.24      0.50      0.33       119
         164       0.07      0.29      0.11        42
         165       0.66      0.83      0.73       361
         166       0.11      0.24      0.15       206
         167       0.16      0.40      0.23        87
         168       0.06      0.35      0.10       112
         169       0.15      0.27      0.20       298
         170       0.19      0.24      0.21       191
         171       0.17      0.44      0.24        91
         172       0.22      0.52      0.31       100
         173       0.04      0.14      0.07       167
         174       0.32      0.31      0.32       344
         175       0.03      0.07      0.04        76
         176       0.06      0.17      0.08       198
         177       0.09      0.27      0.13       127
         178       0.08      0.26      0.12       102
         179       0.10      0.52      0.16        31
         180       0.23      0.42      0.30       139
         181       0.17      0.51      0.25        63
         182       0.17      0.28      0.21       367
         183       0.19      0.55      0.28        67
         184       0.01      0.04      0.01        46
         185       0.46      0.16      0.24       381
         186       0.04      0.17      0.06        29
         187       0.11      0.26      0.16       111
         188       0.14      0.38      0.21       121
         189       0.01      0.02      0.02        82
         190       0.15      0.36      0.21       118
         191       0.13      0.43      0.20        77
         192       0.19      0.53      0.28       118
         193       0.05      0.15      0.07       159
         194       0.26      0.30      0.28       269
         195       0.25      0.67      0.36        81
         196       0.22      0.43      0.29       299
         197       0.04      0.11      0.06        47
         198       0.30      0.77      0.43        47
         199       0.08      0.27      0.12        62
         200       0.01      0.08      0.02        24
         201       0.18      0.42      0.25        86
         202       0.29      0.27      0.28       308
         203       0.40      0.55      0.46       321
         204       0.03      0.06      0.04        67
         205       0.06      0.25      0.09        28
         206       0.17      0.61      0.26        59
         207       0.14      0.31      0.19       245
         207       0.14      0.31      0.19       245
         208       0.25      0.68      0.37        53
         209       0.03      0.11      0.05       274
         210       0.02      0.38      0.04         8
         211       0.20      0.46      0.28        95
         212       0.18      0.37      0.24       129
         213       0.13      0.50      0.20        34
         214       0.17      0.30      0.22        89
         215       0.14      0.43      0.21        67
         216       0.07      0.36      0.12        25
         217       0.49      0.80      0.61       109
         218       0.09      0.16      0.11       134
         219       0.20      0.46      0.28        70
         220       0.14      0.42      0.21        67
         221       0.14      0.32      0.20        79
         222       0.22      0.44      0.29        50
         223       0.34      0.75      0.47        93
         224       0.13      0.35      0.19        94
         225       0.04      0.11      0.06       180
         226       0.03      0.14      0.05        79
         227       0.13      0.45      0.20        64
         228       0.03      0.10      0.05        50
         229       0.21      0.64      0.31        53
         230       0.08      0.34      0.13        44
         231       0.11      0.28      0.16        61
         232       0.11      0.59      0.19        49
         233       0.40      0.75      0.52        72
         234       0.12      0.18      0.14       233
         235       0.11      0.16      0.13       166
         236       0.21      0.60      0.31        58
         237       0.06      0.20      0.10       152
         238       0.23      0.30      0.26       302
         239       0.19      0.52      0.28        42
         240       0.25      0.52      0.34       269
         241       0.05      0.13      0.07        54
         242       0.08      0.25      0.12       162
         243       0.06      0.30      0.10        23
         244       0.24      0.44      0.31        66
         245       0.05      0.33      0.09        40
         246       0.22      0.42      0.29        73
         247       0.49      0.71      0.58        78
         248       0.08      0.18      0.11       131
         249       0.10      0.26      0.14        82
         250       0.30      0.65      0.41        57
         251       0.15      0.18      0.16       296
         252       0.13      0.24      0.17        87
         253       0.13      0.27      0.18        96
         254       0.38      0.30      0.34       280
         255       0.03      0.21      0.05        24
         256       0.10      0.24      0.14        88
         257       0.04      0.57      0.07         7
         258       0.08      0.21      0.11       136
         259       0.28      0.51      0.36        73
         260       0.42      0.19      0.26       268
         261       0.30      0.91      0.45        11
         262       0.39      0.55      0.46        82
         263       0.04      0.60      0.07         5
         264       0.13      0.32      0.18       108
         265       0.26      0.63      0.36        78
         266       0.06      0.20      0.09        69
         267       0.05      0.19      0.08        80
         268       0.13      0.43      0.20        28
         269       0.03      0.14      0.05        44
         270       0.23      0.60      0.33        42
         271       0.14      0.34      0.20       114
         272       0.08      0.17      0.11        59
         273       0.09      0.23      0.13       130
         274       0.10      0.33      0.15        48
         275       0.04      0.20      0.07       227
         276       0.30      0.73      0.43        75
         277       0.13      0.22      0.16        68
         278       0.40      0.56      0.46       143
         279       0.04      0.23      0.07        78
         279       0.04      0.25      0.07        78
         280       0.30      0.63      0.41        78
         281       0.30      0.52      0.39        61
         282       0.04      0.11      0.06        61
         283       0.08      0.27      0.12        52
         284       0.02      0.12      0.03        24
         285       0.03      0.10      0.05       125
         286       0.11      0.25      0.15       138
         287       0.11      0.25      0.15       171
         288       0.38      0.50      0.43       157
         289       0.09      0.43      0.14        30
         290       0.02      0.17      0.04        30
         291       0.21      0.47      0.29        64
         292       0.02      0.33      0.04         9
         293       0.13      0.30      0.18       123
         294       0.08      0.29      0.13        35
         295       0.01      0.05      0.01        22
         296       0.24      0.47      0.32       184
         297       0.18      0.30      0.23       140
         298       0.19      0.29      0.23       224
         299       0.19      0.46      0.27        97
         300       0.05      0.12      0.07        65
         301       0.04      0.16      0.06        44
         302       0.09      0.39      0.14        38
         303       0.22      0.30      0.26        98
         304       0.08      0.42      0.13        31
         305       0.30      0.40      0.34       235
         306       0.39      0.73      0.51       249
         307       0.13      0.10      0.11       247
         308       0.12      0.45      0.19       122
         309       0.13      0.20      0.16       230
         310       0.09      0.23      0.13       166
         311       0.05      0.28      0.09        40
         312       0.05      0.24      0.08        17
         313       0.06      0.31      0.10        36
         314       0.27      0.47      0.34       109
         315       0.00      0.01      0.01        67
         316       0.35      0.67      0.46        79
         317       0.10      0.15      0.12       197
         318       0.10      0.49      0.17        47
         319       0.47      0.39      0.43       222
         320       0.11      0.59      0.19        27
         321       0.50      0.63      0.56       207
         322       0.42      0.39      0.40       240
         323       0.20      0.15      0.18       215
         324       0.20      0.43      0.27       120
         325       0.12      0.37      0.18       130
         326       0.23      0.57      0.33        28
         327       0.07      0.16      0.10       166
         328       0.32      0.60      0.42        45
         329       0.33      0.54      0.41       180
         330       0.04      0.24      0.06        62
         331       0.10      0.24      0.14       105
         332       0.23      0.69      0.34        39
         333       0.06      1.00      0.12         4
         334       0.13      0.41      0.19       113
         335       0.13      0.47      0.20        78
         336       0.08      0.22      0.11        51
         337       0.20      0.18      0.19       147
         338       0.01      0.03      0.02       135
         339       0.04      0.15      0.07        27
         340       0.06      0.14      0.08        79
         341       0.39      0.73      0.51        30
         342       0.10      0.30      0.15        54
         343       0.26      0.31      0.28       195
         344       0.13      0.36      0.19        39
         345       0.11      0.89      0.19         9
         346       0.47      0.69      0.56        86
         347       0.05      0.16      0.08        44
         348       0.25      0.42      0.32       185
         349       0.21      0.62      0.31        66
         350       0.03      0.67      0.06         3
         351       0.10      0.40      0.15        35
         351       0.10      0.40      0.15        55
         352       0.37      0.38      0.38       216
         353       0.22      0.40      0.28        42
         354       0.04      0.50      0.08         6
         355       0.02      1.00      0.04         3
         356       0.03      0.36      0.05        14
         357       0.09      0.55      0.15        31
         358       0.11      0.33      0.16       204
         359       0.05      0.05      0.05       211
         360       0.30      0.26      0.28       184
         361       0.18      0.25      0.21       108
         362       0.02      0.06      0.03        54
         363       0.05      0.27      0.08        56
         364       0.09      0.21      0.12        97
         365       0.12      0.40      0.19        72
         366       0.02      0.17      0.03        12
         367       0.29      0.22      0.25       185
         368       0.12      0.16      0.13       193
         369       0.03      0.12      0.05        34
         370       0.18      0.34      0.23       164
         371       0.14      0.83      0.24        18
         372       0.08      0.29      0.13        65
         373       0.07      0.35      0.11        20
         374       0.01      0.03      0.01        29
         375       0.27      0.42      0.33        71
         376       0.04      0.05      0.04       164
         377       0.17      0.53      0.25       185
         378       0.05      0.21      0.08        24
         379       0.09      0.33      0.14        52
         380       0.02      0.14      0.04        57
         381       0.09      0.17      0.12        59
         382       0.11      0.29      0.16       117
         383       0.17      0.62      0.27        39
         384       0.28      0.45      0.34       125
         385       0.07      0.25      0.11       130
         386       0.26      0.61      0.37        74
         387       0.19      0.66      0.29        35
         388       0.10      0.67      0.17        21
         389       0.20      0.25      0.22       175
         390       0.07      0.11      0.09        54
         391       0.00      0.00      0.00        29
         392       0.07      0.14      0.09        63
         393       0.10      0.47      0.17        34
         394       0.20      0.66      0.31        38
         395       0.05      0.27      0.09        15
         396       0.01      0.10      0.01        10
         397       0.08      0.27      0.13        49
         398       0.24      0.31      0.27       169
         399       0.08      0.30      0.13        33
         400       0.35      0.56      0.43        84
         401       0.27      0.61      0.37        31
         402       0.10      0.54      0.17        24
         403       0.57      0.26      0.36       187
         404       0.03      0.50      0.06         6
         405       0.12      0.33      0.18        33
         406       0.02      0.18      0.04        17
         407       0.03      0.19      0.05        21
         408       0.07      0.21      0.10        62
         409       0.07      0.14      0.09        78
         410       0.46      0.47      0.46       147
         411       0.06      0.29      0.10        31
         412       0.00      0.00      0.00        14
         413       0.19      0.31      0.23       103
         414       0.42      0.75      0.53        36
         415       0.28      0.57      0.38        68
         416       0.02      0.19      0.04        43
         417       0.18      0.45      0.26        73
         418       0.51      0.56      0.54        62
         419       0.06      0.23      0.10        97
         420       0.06      0.21      0.09        42
         421       0.17      0.41      0.24        41
         422       0.01      0.05      0.02        38
         423       0.00      0.03      0.01        36
         423       0.00      0.03      0.01        30
         424       0.04      0.23      0.07        13
         425       0.06      0.33      0.10        24
         426       0.00      0.33      0.01         3
         427       0.07      0.30      0.11        94
         428       0.27      0.26      0.27       151
         429       0.34      0.71      0.46        63
         430       0.02      0.25      0.04        40
         431       0.23      0.43      0.30        49
         432       0.01      0.03      0.01        34
         433       0.27      0.78      0.40        37
         434       0.10      0.35      0.15        34
         435       0.06      1.00      0.11         1
         436       0.03      0.17      0.05        29
         437       0.06      0.18      0.09        50
         438       0.00      0.00      0.00       104
         439       0.00      0.00      0.00        29
         440       0.06      0.35      0.11        23
         441       0.03      0.09      0.04        46
         442       0.05      0.15      0.07        39
         443       0.17      0.34      0.23        56
         444       0.18      0.47      0.27        80
         445       0.03      0.10      0.05        30
         446       0.04      0.17      0.06        30
         447       0.13      0.30      0.18        37
         448       0.02      0.05      0.03        39
         449       0.07      0.16      0.10        83
         450       0.06      0.39      0.10        23
         451       0.06      0.44      0.10         9
         452       0.06      0.23      0.10        44
         453       0.25      0.17      0.20       166
         454       0.19      0.66      0.30        32
         455       0.06      0.26      0.10        53
         456       0.14      0.63      0.23        41
         457       0.05      0.12      0.07        78
         458       0.13      0.19      0.16       133
         459       0.05      0.20      0.08        25
         460       0.11      0.34      0.16       103
         461       0.10      0.21      0.14        53
         462       0.07      0.30      0.12        30
         463       0.03      0.50      0.05         4
         464       0.06      0.08      0.07        66
         465       0.03      0.28      0.05        47
         466       0.06      0.26      0.10        31
         467       0.14      0.49      0.22        35
         468       0.01      0.04      0.02        50
         469       0.34      0.35      0.34       155
         470       0.06      0.26      0.10        27
         471       0.36      0.50      0.42        58
         472       0.03      0.08      0.05       159
```

```
start = datetime.now()
classifier_2 = OneVsRestClassifier(LogisticRegression(penalty='l1',solver='liblinear'), n_jobs=1)
classifier_2.fit(x_train_multilabel_bow, y_train)
predictions_2 = classifier_2.predict(x_test_multilabel_bow)
print("Accuracy :",metrics.accuracy_score(y_test, predictions_2))
print("Hamming loss ",metrics.hamming_loss(y_test,predictions_2))


precision = precision_score(y_test, predictions_2, average='micro')
recall = recall_score(y_test, predictions_2, average='micro')
f1 = f1_score(y_test, predictions_2, average='micro')

print("Micro-average quality numbers")
print("Precision: {:.4f}, Recall: {:.4f}, F1-measure: {:.4f}".format(precision, recall, f1))

precision = precision_score(y_test, predictions_2, average='macro')
recall = recall_score(y_test, predictions_2, average='macro')
f1 = f1_score(y_test, predictions_2, average='macro')

print("Macro-average quality numbers")
print("Precision: {:.4f}, Recall: {:.4f}, F1-measure: {:.4f}".format(precision, recall, f1))

print (metrics.classification_report(y_test, predictions_2))
print("Time taken to run this cell :", datetime.now() - start)
```

```
Accuracy : 0.2359
Hamming loss  0.002942057142857143
Micro-average quality numbers
Precision: 0.6777, Recall: 0.5207, F1-measure: 0.5889
Macro-average quality numbers
Precision: 0.4122, Recall: 0.3021, F1-measure: 0.3397
              precision    recall  f1-score   support

           0       0.98      0.97      0.97     42802
           1       0.42      0.26      0.32      1764
           2       0.56      0.38      0.46       942
           3       0.34      0.19      0.25      6539
           4       0.48      0.41      0.45      2540
           5       0.65      0.54      0.59      2156
           6       0.66      0.50      0.57      1990
           7       0.31      0.17      0.22       611
           8       0.55      0.24      0.34       324
           9       0.76      0.78      0.77      2335
          10       0.48      0.40      0.44       736
          11       0.40      0.29      0.34      1199
          12       0.55      0.40      0.46       842
          13       0.54      0.36      0.43       770
          14       0.61      0.56      0.58       975
          15       0.37      0.21      0.27       523
          16       0.40      0.27      0.32       143
          17       0.71      0.56      0.62       428
          18       0.71      0.53      0.61       552
          19       0.67      0.55      0.60       708
          20       0.81      0.61      0.69        89
          21       0.48      0.25      0.33       219
          22       0.43      0.27      0.33       662
          23       0.23      0.13      0.17      1965
          24       0.50      0.28      0.36      1046
          25       0.44      0.29      0.35       488
          26       0.47      0.31      0.37       458
          27       0.52      0.38      0.44      1193
          28       0.68      0.48      0.56      1492
          29       0.23      0.16      0.19       354
          30       0.49      0.41      0.45       159
          31       0.47      0.29      0.36       157
          32       0.31      0.19      0.24       740
          33       0.53      0.40      0.46      1337
          34       0.57      0.32      0.41       226
          35       0.66      0.49      0.57       535
          36       0.46      0.28      0.35       315
          37       0.33      0.20      0.25       167
          38       0.74      0.64      0.68      1074
          39       0.44      0.26      0.33       336
          40       0.49      0.37      0.42       312
          41       0.22      0.13      0.16       682
          42       0.74      0.57      0.65       265
          43       0.77      0.61      0.68       478
          44       0.63      0.36      0.46       598
          45       0.45      0.27      0.34      1054
          46       0.51      0.30      0.38       253
          47       0.27      0.17      0.21       936
          48       0.32      0.23      0.27       133
          49       0.38      0.18      0.24       152
          50       0.43      0.37      0.40       943
          51       0.17      0.11      0.13       243
          52       0.43      0.28      0.34       135
          53       0.98      0.90      0.94       969
          54       0.24      0.13      0.17       801
          55       0.58      0.64      0.61        50
          56       0.55      0.36      0.44       142
          57       0.49      0.27      0.35       125
          58       0.24      0.13      0.17        39
          59       0.38      0.36      0.37        36
          60       0.51      0.33      0.40       205
          61       0.29      0.21      0.24       354
          62       0.28      0.20      0.24       266
          63       0.58      0.47      0.52       178
          63       0.58      0.47      0.52       178
          64       0.90      0.68      0.77       163
          65       0.53      0.46      0.49        46
          66       0.36      0.20      0.26       269
          67       0.78      0.74      0.76       133
          68       0.32      0.20      0.24       577
          69       0.23      0.09      0.13       212
          70       0.82      0.66      0.73       120
          71       0.29      0.16      0.21       258
          72       0.19      0.12      0.14       354
          73       0.72      0.58      0.64       159
          74       0.50      0.27      0.35        89
          75       0.37      0.29      0.32       125
          76       0.26      0.20      0.23        94
          77       0.52      0.36      0.43       456
          78       0.42      0.38      0.40       712
          79       0.29      0.11      0.16       299
          80       0.28      0.17      0.21        53
          81       0.43      0.32      0.37       275
          82       0.53      0.23      0.32       623
          83       0.53      0.39      0.45        75
          84       0.12      0.07      0.09        27
          85       0.62      0.34      0.44       230
          86       0.49      0.36      0.41       177
          87       0.45      0.33      0.38        30
          88       0.60      0.69      0.64       655
          89       0.14      0.10      0.12       126
          90       0.50      0.37      0.42       422
          91       0.15      0.04      0.06       130
          92       0.82      0.86      0.84       451
          93       0.29      0.06      0.11        77
          94       0.13      0.05      0.07       461
          95       0.71      0.38      0.50       104
          96       0.18      0.09      0.12       454
          97       0.39      0.37      0.38       345
          98       0.44      0.44      0.44       125
          99       0.52      0.33      0.41       144
         100       0.20      0.06      0.09       279
         101       0.49      0.18      0.26        99
         102       0.78      0.62      0.69       553
         103       0.52      0.24      0.32       123
         104       0.14      0.08      0.10       542
         105       0.21      0.14      0.17       542
         106       0.33      0.11      0.16       118
         107       0.52      0.40      0.45        73
         108       0.27      0.14      0.19       191
         109       0.29      0.12      0.17       180
         110       0.48      0.27      0.35       121
         111       0.28      0.17      0.21        41
         112       0.14      0.06      0.08       254
         113       0.19      0.13      0.15       146
         114       0.60      0.36      0.45       279
         115       0.33      0.17      0.22       245
         116       0.49      0.21      0.29       102
         117       0.56      0.39      0.46       469
         118       0.20      0.06      0.09       248
         119       0.37      0.24      0.29        98
         120       0.56      0.47      0.51       105
         121       0.23      0.11      0.15       164
         122       0.48      0.31      0.37        95
         123       0.48      0.27      0.35       208
         124       0.59      0.39      0.47        85
         125       0.60      0.53      0.57        98
         126       0.27      0.15      0.19        41
         127       0.79      0.34      0.47       431
         128       0.59      0.33      0.43       111
         129       0.39      0.22      0.28        74
         130       0.42      0.20      0.27       116
         131       0.52      0.42      0.47       126
         132       0.35      0.40      0.37       270
         133       0.36      0.29      0.32        35
         134       0.34      0.27      0.30        64
         135       0.59      0.66      0.62       243
         135       0.99      0.66      0.82       245
         136       0.96      0.79      0.87       345
         137       0.41      0.18      0.25       174
         138       0.32      0.27      0.29       183
         139       0.73      0.39      0.50       454
         140       0.81      0.72      0.76       302
         141       0.68      0.34      0.46        82
         142       0.77      0.77      0.77        82
         143       0.50      0.37      0.42        98
         144       0.86      0.74      0.79       137
         145       0.41      0.25      0.31       412
         146       0.21      0.09      0.12       224
         147       0.29      0.13      0.18       153
         148       0.60      0.62      0.61        64
         149       0.61      0.41      0.49        68
         150       0.20      0.08      0.11       126
         151       0.15      0.09      0.12       202
         152       0.26      0.28      0.27        39
         153       0.56      0.39      0.46        36
         154       0.50      0.46      0.48       136
         155       0.20      0.06      0.09       212
         156       0.49      0.39      0.43        51
         157       0.45      0.44      0.44        94
         158       0.20      0.08      0.12       286
         159       0.52      0.45      0.48       350
         160       0.45      0.41      0.43        22
         161       0.10      0.07      0.08       120
         162       0.24      0.12      0.16       144
         163       0.59      0.50      0.55       119
         164       0.37      0.26      0.31        42
         165       0.82      0.81      0.81       361
         166       0.28      0.15      0.19       206
         167       0.60      0.29      0.39        87
         168       0.29      0.29      0.29       112
         169       0.24      0.11      0.15       298
         170       0.40      0.23      0.29       191
         171       0.44      0.48      0.46        91
         172       0.67      0.49      0.57       100
         173       0.10      0.05      0.07       167
         174       0.47      0.34      0.40       344
         175       0.07      0.04      0.05        76
         176       0.17      0.09      0.12       198
         177       0.40      0.24      0.30       127
         178       0.33      0.20      0.25       102
         179       0.65      0.35      0.46        31
         180       0.51      0.46      0.48       139
         181       0.65      0.56      0.60        63
         182       0.46      0.24      0.32       367
         183       0.52      0.70      0.59        67
         184       0.00      0.00      0.00        46
         185       0.57      0.16      0.25       381
         186       0.90      0.31      0.46        29
         187       0.33      0.26      0.29       111
         188       0.26      0.17      0.20       121
         189       0.21      0.04      0.06        82
         190       0.58      0.42      0.49       118
         191       0.70      0.52      0.60        77
         192       0.59      0.53      0.56       118
         193       0.26      0.09      0.14       159
         194       0.43      0.38      0.41       269
         195       0.76      0.64      0.70        81
         196       0.41      0.31      0.35       299
         197       0.31      0.09      0.13        47
         198       0.76      0.74      0.75        47
         199       0.40      0.26      0.31        62
         200       0.31      0.17      0.22        24
         201       0.53      0.27      0.36        86
         202       0.53      0.22      0.31       308
         203       0.67      0.56      0.61       321
         204       0.08      0.03      0.04        67
         205       0.16      0.18      0.17        28
         206       0.58      0.49      0.53        59
         207       0.36      0.23      0.28       245
         207       0.30      0.25      0.28       245
         208       0.85      0.64      0.73        53
         209       0.11      0.09      0.10       274
         210       0.12      0.12      0.12         8
         211       0.48      0.26      0.34        95
         212       0.29      0.22      0.25       129
         213       0.64      0.47      0.54        34
         214       0.29      0.34      0.31        89
         215       0.55      0.36      0.43        67
         216       0.36      0.20      0.26        25
         217       0.62      0.63      0.63       109
         218       0.40      0.15      0.22       134
         219       0.62      0.49      0.54        70
         220       0.53      0.40      0.46        67
         221       0.39      0.22      0.28        79
         222       0.50      0.40      0.44        50
         223       0.72      0.71      0.71        93
         224       0.27      0.26      0.26        94
         225       0.14      0.05      0.07       180
         226       0.10      0.06      0.08        79
         227       0.31      0.36      0.33        64
         228       0.15      0.06      0.09        50
         229       0.65      0.64      0.65        53
         230       0.52      0.34      0.41        44
         231       0.24      0.21      0.23        61
         232       0.39      0.39      0.39        49
         233       0.73      0.75      0.74        72
         234       0.20      0.14      0.16       233
         235       0.33      0.10      0.16       166
         236       0.67      0.52      0.58        58
         237       0.16      0.07      0.09       152
         238       0.52      0.27      0.35       302
         239       0.49      0.55      0.52        42
         240       0.46      0.34      0.39       269
         241       0.26      0.11      0.16        54
         242       0.21      0.07      0.11       162
         243       0.50      0.39      0.44        23
         244       0.65      0.30      0.41        66
         245       0.19      0.10      0.13        40
         246       0.67      0.59      0.63        73
         247       0.83      0.62      0.71        78
         248       0.35      0.17      0.23       131
         249       0.26      0.11      0.16        82
         250       0.67      0.58      0.62        57
         251       0.19      0.06      0.09       296
         252       0.39      0.18      0.25        87
         253       0.27      0.16      0.20        96
         254       0.44      0.14      0.21       280
         255       0.25      0.21      0.23        24
         256       0.31      0.19      0.24        88
         257       0.23      0.43      0.30         7
         258       0.24      0.15      0.19       136
         259       0.72      0.56      0.63        73
         260       0.63      0.43      0.51       268
         261       1.00      0.82      0.90        11
         262       0.69      0.51      0.59        82
         263       0.50      0.80      0.62         5
         264       0.37      0.24      0.29       108
         265       0.67      0.50      0.57        78
         266       0.16      0.10      0.12        69
         267       0.34      0.12      0.18        80
         268       0.37      0.25      0.30        28
         269       0.12      0.05      0.07        44
         270       0.66      0.60      0.62        42
         271       0.47      0.25      0.32       114
         272       0.10      0.08      0.09        59
         273       0.27      0.21      0.24       130
         274       0.26      0.21      0.23        48
         275       0.17      0.11      0.13       227
         276       0.72      0.77      0.74        75
         277       0.71      0.32      0.44        68
         278       0.59      0.48      0.53       143
         279       0.16      0.15      0.16        78
         279       0.18      0.15      0.16        78
         280       0.69      0.56      0.62        78
         281       0.72      0.59      0.65        61
         282       0.06      0.02      0.03        61
         283       0.43      0.25      0.32        52
         284       0.20      0.08      0.12        24
         285       0.06      0.02      0.02       125
         286       0.35      0.19      0.24       138
         287       0.18      0.09      0.12       171
         288       0.68      0.45      0.54       157
         289       0.52      0.40      0.45        30
         290       0.18      0.10      0.13        30
         291       0.77      0.31      0.44        64
         292       0.14      0.22      0.17         9
         293       0.20      0.12      0.15       123
         294       0.45      0.29      0.35        35
         295       0.25      0.09      0.13        22
         296       0.41      0.46      0.43       184
         297       0.64      0.21      0.32       140
         298       0.38      0.19      0.25       224
         299       0.63      0.45      0.53        97
         300       0.07      0.03      0.04        65
         301       0.11      0.05      0.06        44
         302       0.43      0.26      0.33        38
         303       0.37      0.18      0.24        98
         304       0.48      0.48      0.48        31
         305       0.38      0.25      0.30       235
         306       0.98      0.93      0.95       249
         307       0.40      0.09      0.15       247
         308       0.40      0.30      0.34       122
         309       0.20      0.08      0.11       230
         310       0.37      0.16      0.22       166
         311       0.23      0.15      0.18        40
         312       0.56      0.29      0.38        17
         313       0.27      0.19      0.23        36
         314       0.55      0.33      0.41       109
         315       0.00      0.00      0.00        67
         316       0.63      0.58      0.61        79
         317       0.08      0.02      0.03       197
         318       0.27      0.53      0.36        47
         319       0.62      0.35      0.45       222
         320       0.47      0.56      0.51        27
         321       0.68      0.56      0.61       207
         322       0.69      0.38      0.49       240
         323       0.26      0.18      0.21       215
         324       0.42      0.33      0.37       120
         325       0.42      0.23      0.30       130
         326       0.68      0.54      0.60        28
         327       0.15      0.16      0.15       166
         328       0.66      0.56      0.60        45
         329       0.45      0.45      0.45       180
         330       0.17      0.08      0.11        62
         331       0.44      0.23      0.30       105
         332       0.81      0.67      0.73        39
         333       0.67      1.00      0.80         4
         334       0.54      0.28      0.37       113
         335       0.39      0.40      0.39        78
         336       0.27      0.14      0.18        51
         337       0.42      0.17      0.24       147
         338       0.07      0.02      0.03       135
         339       0.29      0.33      0.31        27
         340       0.29      0.13      0.18        79
         341       0.92      0.73      0.81        30
         342       0.26      0.15      0.19        54
         343       0.59      0.23      0.33       195
         344       0.35      0.31      0.33        39
         345       0.75      0.67      0.71         9
         346       0.75      0.78      0.77        86
         347       0.39      0.20      0.27        44
         348       0.68      0.39      0.50       185
         349       0.68      0.61      0.64        66
         350       1.00      0.67      0.80         3
         351       0.39      0.31      0.35        35
         351       0.59      0.51      0.55        55
         352       0.57      0.42      0.48       216
         353       0.41      0.38      0.40        42
         354       0.67      0.33      0.44         6
         355       0.06      0.33      0.10         3
         356       0.22      0.14      0.17        14
         357       0.34      0.35      0.35        31
         358       0.32      0.06      0.10       204
         359       0.12      0.01      0.02       211
         360       0.38      0.19      0.25       184
         361       0.29      0.20      0.24       108
         362       0.06      0.02      0.03        54
         363       0.21      0.18      0.19        56
         364       0.21      0.10      0.14        97
         365       0.29      0.21      0.24        72
         366       0.17      0.08      0.11        12
         367       0.64      0.41      0.50       185
         368       0.18      0.06      0.09       193
         369       0.27      0.12      0.16        34
         370       0.57      0.34      0.43       164
         371       0.62      0.72      0.67        18
         372       0.22      0.11      0.14        65
         373       0.60      0.30      0.40        20
         374       0.00      0.00      0.00        29
         375       0.64      0.42      0.51        71
         376       0.14      0.12      0.13       164
         377       0.37      0.34      0.35       185
         378       0.19      0.21      0.20        24
         379       0.24      0.17      0.20        52
         380       0.21      0.12      0.15        57
         381       0.20      0.07      0.10        59
         382       0.23      0.09      0.13       117
         383       0.58      0.54      0.56        39
         384       0.57      0.53      0.55       125
         385       0.35      0.14      0.20       130
         386       0.66      0.58      0.62        74
         387       0.71      0.63      0.67        35
         388       0.48      0.62      0.54        21
         389       0.35      0.24      0.28       175
         390       0.19      0.09      0.12        54
         391       0.00      0.00      0.00        29
         392       0.35      0.11      0.17        63
         393       0.28      0.32      0.30        34
         394       0.81      0.66      0.72        38
         395       0.20      0.20      0.20        15
         396       0.29      0.20      0.24        10
         397       0.33      0.18      0.24        49
         398       0.51      0.20      0.29       169
         399       0.29      0.24      0.26        33
         400       0.45      0.35      0.39        84
         401       0.72      0.58      0.64        31
         402       0.38      0.42      0.40        24
         403       0.67      0.36      0.47       187
         404       0.40      0.33      0.36         6
         405       0.50      0.30      0.38        33
         406       0.21      0.24      0.22        17
         407       0.20      0.10      0.13        21
         408       0.42      0.16      0.23        62
         409       0.20      0.06      0.10        78
         410       0.70      0.50      0.58       147
         411       0.30      0.26      0.28        31
         412       0.00      0.00      0.00        14
         413       0.41      0.12      0.18       103
         414       0.74      0.64      0.69        36
         415       0.58      0.59      0.58        68
         416       0.07      0.05      0.05        43
         417       0.45      0.38      0.41        73
         418       0.73      0.60      0.65        62
         419       0.04      0.02      0.03        97
         420       0.03      0.02      0.03        42
         421       0.63      0.46      0.54        41
         422       0.07      0.05      0.06        38
         423       0.04      0.03      0.03        36
         423       0.04      0.03      0.03        36
         424       0.14      0.08      0.10        13
         425       0.42      0.33      0.37        24
         426       0.10      0.33      0.15         3
         427       0.37      0.23      0.29        94
         428       0.38      0.22      0.28       151
         429       0.60      0.54      0.57        63
         430       0.09      0.05      0.06        40
         431       0.53      0.41      0.46        49
         432       0.00      0.00      0.00        34
         433       0.78      0.76      0.77        37
         434       0.36      0.29      0.32        34
         435       1.00      1.00      1.00         1
         436       0.13      0.07      0.09        29
         437       0.20      0.18      0.19        50
         438       0.00      0.00      0.00       104
         439       0.00      0.00      0.00        29
         440       0.33      0.22      0.26        23
         441       0.05      0.02      0.03        46
         442       0.12      0.08      0.09        39
         443       0.57      0.30      0.40        56
         444       0.54      0.49      0.51        80
         445       0.09      0.03      0.05        30
         446       0.11      0.10      0.11        30
         447       0.32      0.30      0.31        37
         448       0.19      0.10      0.13        39
         449       0.21      0.14      0.17        83
         450       0.47      0.39      0.43        23
         451       0.40      0.67      0.50         9
         452       0.38      0.20      0.26        44
         453       0.48      0.36      0.41       166
         454       0.64      0.56      0.60        32
         455       0.37      0.25      0.30        53
         456       0.52      0.59      0.55        41
         457       0.18      0.09      0.12        78
         458       0.29      0.11      0.16       133
         459       0.25      0.16      0.20        25
         460       0.51      0.37      0.43       103
         461       0.53      0.15      0.24        53
         462       0.34      0.33      0.34        30
         463       0.11      0.25      0.15         4
         464       0.11      0.06      0.08        66
```

LINEAR SVM

```
         468       0.00      0.00      0.00        50
```

```
from sklearn.model_selection import GridSearchCV
from scipy.stats import randint as sp_randint
from sklearn.model_selection import cross_val_score
from sklearn.linear_model import SGDClassifier


LinearSVM = OneVsRestClassifier(SGDClassifier(loss='hinge',penalty='l2',random_state=None, class_weight=None), n_j
LinearSVM.fit(x_train_multilabel_bow, y_train)
predictions_svm = LinearSVM.predict(x_test_multilabel_bow)
print("Accuracy :",metrics.accuracy_score(y_test, predictions_svm))
print("Hamming loss ",metrics.hamming_loss(y_test,predictions_svm))


precision = precision_score(y_test, predictions_svm, average='micro')
recall = recall_score(y_test, predictions_svm, average='micro')
f1 = f1_score(y_test, predictions_svm, average='micro')

print("Micro-average quality numbers")
print("Precision: {:.4f}, Recall: {:.4f}, F1-measure: {:.4f}".format(precision, recall, f1))

precision = precision_score(y_test, predictions_svm, average='macro')
recall = recall_score(y_test, predictions_svm, average='macro')
f1 = f1_score(y_test, predictions_svm, average='macro')
```

```

print("Macro-average quality numbers")
print("Precision: {:.4f}, Recall: {:.4f}, F1-measure: {:.4f}".format(precision, recall, f1))

print (metrics.classification_report(y_test, predictions_svm))
print("Time taken to run this cell :", datetime.now() - start)
```

```
Accuracy : 0.2384
Hamming loss  0.002897085714285714
Micro-average quality numbers
Precision: 0.7029, Recall: 0.4923, F1-measure: 0.5790
Macro-average quality numbers
Precision: 0.4318, Recall: 0.2714, F1-measure: 0.3184
              precision    recall  f1-score   support

           0       0.98      0.95      0.96     42802
           1       0.36      0.23      0.28      1764
           2       0.55      0.32      0.40       942
           3       0.36      0.17      0.23      6539
           4       0.46      0.37      0.41      2540
           5       0.64      0.53      0.58      2156
           6       0.64      0.49      0.56      1990
           7       0.29      0.18      0.22       611
           8       0.43      0.25      0.32       324
           9       0.76      0.79      0.78      2335
          10       0.44      0.38      0.41       736
          11       0.37      0.25      0.29      1199
          12       0.49      0.36      0.42       842
          13       0.52      0.30      0.38       770
          14       0.55      0.53      0.54       975
          15       0.32      0.17      0.23       523
          16       0.38      0.25      0.30       143
          17       0.64      0.54      0.59       428
          18       0.71      0.50      0.59       552
          19       0.62      0.53      0.57       708
          20       0.84      0.60      0.70        89
          21       0.47      0.18      0.26       219
          22       0.41      0.24      0.30       662
          23       0.25      0.12      0.16      1965
          24       0.49      0.27      0.35      1046
          25       0.42      0.26      0.32       488
          26       0.42      0.27      0.33       458
          27       0.53      0.38      0.45      1193
          28       0.69      0.42      0.52      1492
          29       0.24      0.13      0.17       354
          30       0.43      0.36      0.39       159
          31       0.33      0.24      0.28       157
          32       0.32      0.22      0.26       740
          33       0.55      0.40      0.46      1337
          34       0.57      0.30      0.39       226
          35       0.69      0.44      0.54       535
          36       0.48      0.18      0.27       315
          37       0.28      0.15      0.20       167
          38       0.76      0.59      0.67      1074
          39       0.39      0.21      0.28       336
          40       0.43      0.35      0.39       312
          41       0.24      0.16      0.19       682
          42       0.81      0.54      0.65       265
          43       0.76      0.63      0.68       478
          44       0.67      0.25      0.36       598
          45       0.53      0.25      0.34      1054
          46       0.49      0.28      0.36       253
          47       0.31      0.13      0.18       936
          48       0.33      0.20      0.25       133
          49       0.31      0.10      0.15       152
          50       0.45      0.24      0.31       943
          51       0.19      0.09      0.12       243
          52       0.41      0.30      0.35       135
          53       0.98      0.74      0.85       969
          54       0.23      0.04      0.07       801
          55       0.62      0.58      0.60        50
          56       0.60      0.30      0.40       142
          57       0.39      0.24      0.30       125
          58       0.12      0.08      0.09        39
          59       0.44      0.33      0.38        36
          60       0.51      0.27      0.36       205
          61       0.31      0.19      0.23       354
          62       0.27      0.15      0.19       266
          63       0.66      0.38      0.48       178
          63       0.66      0.38      0.48       178
          64       0.85      0.63      0.72       163
          65       0.54      0.43      0.48        46
          66       0.39      0.15      0.22       269
          67       0.72      0.74      0.73       133
          68       0.34      0.09      0.14       577
          69       0.15      0.04      0.06       212
          70       0.77      0.67      0.71       120
          71       0.25      0.14      0.18       258
          72       0.17      0.19      0.18       354
          73       0.72      0.57      0.63       159
          74       0.44      0.25      0.32        89
          75       0.48      0.29      0.36       125
          76       0.32      0.26      0.29        94
          77       0.56      0.28      0.37       456
          78       0.48      0.27      0.35       712
          79       0.25      0.07      0.11       299
          80       0.18      0.15      0.16        53
          81       0.54      0.27      0.36       275
          82       0.53      0.11      0.19       623
          83       0.55      0.37      0.44        75
          84       0.10      0.07      0.08        27
          85       0.63      0.39      0.48       230
          86       0.51      0.32      0.39       177
          87       0.50      0.33      0.40        30
          88       0.61      0.50      0.55       655
          89       0.18      0.12      0.14       126
          90       0.49      0.38      0.43       422
          91       0.08      0.02      0.03       130
          92       0.83      0.80      0.82       451
          93       0.19      0.05      0.08        77
          94       0.08      0.00      0.01       461
          95       0.68      0.40      0.51       104
          96       0.19      0.09      0.12       454
          97       0.39      0.41      0.40       345
          98       0.43      0.40      0.42       125
          99       0.54      0.39      0.45       144
         100       0.27      0.11      0.15       279
         101       0.47      0.09      0.15        99
         102       0.79      0.55      0.65       553
         103       0.71      0.20      0.32       123
         104       0.22      0.07      0.10       542
         105       0.17      0.05      0.08       542
         106       0.32      0.14      0.20       118
         107       0.58      0.40      0.47        73
         108       0.29      0.14      0.18       191
         109       0.30      0.12      0.17       180
         110       0.47      0.17      0.25       121
         111       0.39      0.22      0.28        41
         112       0.12      0.02      0.04       254
         113       0.17      0.10      0.13       146
         114       0.66      0.34      0.45       279
         115       0.35      0.12      0.18       245
         116       0.51      0.23      0.31       102
         117       0.57      0.36      0.44       469
         118       0.23      0.03      0.06       248
         119       0.38      0.23      0.29        98
         120       0.57      0.41      0.48       105
         121       0.18      0.05      0.08       164
         122       0.39      0.28      0.33        95
         123       0.47      0.37      0.42       208
         124       0.53      0.35      0.42        85
         125       0.65      0.51      0.57        98
         126       0.23      0.07      0.11        41
         127       0.79      0.39      0.52       431
         128       0.57      0.29      0.38       111
         129       0.41      0.27      0.33        74
         130       0.44      0.22      0.30       116
         131       0.54      0.31      0.39       126
         132       0.37      0.37      0.37       270
         133       0.35      0.20      0.25        35
         134       0.41      0.23      0.30        64
         135       0.62      0.65      0.64       243
         135       0.82      0.85      0.84       245
         136       0.93      0.75      0.83       345
         137       0.41      0.18      0.25       174
         138       0.34      0.28      0.31       183
         139       0.76      0.27      0.39       454
         140       0.86      0.64      0.73       302
         141       0.62      0.39      0.48        82
         142       0.74      0.80      0.77        82
         143       0.42      0.35      0.38        98
         144       0.87      0.64      0.73       137
         145       0.48      0.21      0.30       412
         146       0.24      0.10      0.14       224
         147       0.26      0.08      0.12       153
         148       0.62      0.64      0.63        64
         149       0.54      0.38      0.45        68
         150       0.18      0.07      0.10       126
         151       0.15      0.07      0.10       202
         152       0.21      0.15      0.18        39
         153       0.55      0.33      0.41        36
         154       0.69      0.43      0.53       136
         155       0.21      0.04      0.07       212
         156       0.50      0.43      0.46        51
         157       0.49      0.48      0.49        94
         158       0.18      0.07      0.10       286
         159       0.49      0.49      0.49       350
         160       0.41      0.32      0.36        22
         161       0.15      0.07      0.10       120
         162       0.24      0.14      0.18       144
         163       0.59      0.55      0.57       119
         164       0.50      0.19      0.28        42
         165       0.85      0.73      0.79       361
         166       0.35      0.14      0.20       206
         167       0.60      0.17      0.27        87
         168       0.39      0.26      0.31       112
         169       0.33      0.10      0.15       298
         170       0.45      0.15      0.23       191
         171       0.55      0.44      0.49        91
         172       0.88      0.50      0.64       100
         173       0.22      0.07      0.10       167
         174       0.47      0.41      0.44       344
         175       0.14      0.04      0.06        76
         176       0.25      0.09      0.13       198
         177       0.42      0.19      0.26       127
         178       0.38      0.22      0.28       102
         179       0.67      0.26      0.37        31
         180       0.57      0.47      0.52       139
         181       0.74      0.41      0.53        63
         182       0.47      0.25      0.32       367
         183       0.49      0.64      0.55        67
         184       0.00      0.00      0.00        46
         185       0.54      0.11      0.18       381
         186       0.56      0.17      0.26        29
         187       0.31      0.16      0.21       111
         188       0.22      0.12      0.15       121
         189       0.17      0.01      0.02        82
         190       0.50      0.36      0.42       118
         191       0.79      0.34      0.47        77
         192       0.61      0.53      0.57       118
         193       0.38      0.07      0.12       159
         194       0.44      0.24      0.31       269
         195       0.78      0.58      0.67        81
         196       0.44      0.20      0.27       299
         197       0.09      0.02      0.03        47
         198       0.79      0.70      0.74        47
         199       0.36      0.16      0.22        62
         200       0.00      0.00      0.00        24
         201       0.60      0.30      0.40        86
         202       0.52      0.15      0.24       308
         203       0.77      0.45      0.57       321
         204       0.00      0.00      0.00        67
         205       0.21      0.21      0.21        28
         206       0.51      0.44      0.47        59
         207       0.33      0.19      0.24       245
         207       0.55      0.15      0.24       245
         208       0.65      0.58      0.61        53
         209       0.06      0.01      0.01       274
         210       0.25      0.12      0.17         8
         211       0.53      0.38      0.44        95
         212       0.30      0.25      0.27       129
         213       0.58      0.44      0.50        34
         214       0.35      0.30      0.33        89
         215       0.51      0.37      0.43        67
         216       0.42      0.20      0.27        25
         217       0.67      0.53      0.59       109
         218       0.45      0.10      0.16       134
         219       0.60      0.47      0.53        70
         220       0.63      0.36      0.46        67
         221       0.50      0.18      0.26        79
         222       0.57      0.40      0.47        50
         223       0.75      0.71      0.73        93
         224       0.33      0.22      0.27        94
         225       0.10      0.06      0.07       180
         226       0.22      0.09      0.13        79
         227       0.35      0.38      0.36        64
         228       0.25      0.04      0.07        50
         229       0.72      0.55      0.62        53
         230       0.55      0.27      0.36        44
         231       0.18      0.26      0.21        61
         232       0.38      0.51      0.43        49
         233       0.82      0.75      0.78        72
         234       0.23      0.17      0.19       233
         235       0.34      0.06      0.10       166
         236       0.84      0.45      0.58        58
         237       0.12      0.01      0.02       152
         238       0.61      0.23      0.33       302
         239       0.49      0.48      0.48        42
         240       0.56      0.42      0.48       269
         241       0.25      0.07      0.11        54
         242       0.20      0.02      0.03       162
         243       0.53      0.39      0.45        23
         244       0.78      0.38      0.51        66
         245       0.14      0.05      0.07        40
         246       0.69      0.49      0.58        73
         247       0.86      0.55      0.67        78
         248       0.28      0.13      0.18       131
         249       0.37      0.13      0.20        82
         250       0.86      0.56      0.68        57
         251       0.21      0.01      0.03       296
         252       0.49      0.20      0.28        87
         253       0.25      0.15      0.18        96
         254       0.52      0.26      0.34       280
         255       0.36      0.17      0.23        24
         256       0.38      0.14      0.20        88
         257       0.30      0.43      0.35         7
         258       0.26      0.12      0.16       136
         259       0.76      0.47      0.58        73
         260       0.62      0.51      0.56       268
         261       0.82      0.82      0.82        11
         262       0.67      0.43      0.52        82
         263       0.33      0.40      0.36         5
         264       0.36      0.25      0.30       108
         265       0.80      0.47      0.60        78
         266       0.24      0.09      0.13        69
         267       0.41      0.11      0.18        80
         268       0.57      0.29      0.38        28
         269       0.22      0.05      0.08        44
         270       0.71      0.57      0.63        42
         271       0.41      0.29      0.34       114
         272       0.15      0.07      0.09        59
         273       0.43      0.20      0.27       130
         274       0.23      0.19      0.21        48
         275       0.28      0.10      0.14       227
         276       0.77      0.61      0.68        75
         277       0.65      0.38      0.48        68
         278       0.66      0.51      0.57       143
         279       0.26      0.15      0.19        78
         279       0.26      0.15      0.19        78
         280       0.81      0.44      0.57        78
         281       0.75      0.49      0.59        61
         282       0.00      0.00      0.00        61
         283       0.69      0.21      0.32        52
         284       0.25      0.12      0.17        24
         285       0.11      0.02      0.03       125
         286       0.35      0.17      0.23       138
         287       0.17      0.05      0.07       171
         288       0.72      0.31      0.43       157
         289       0.62      0.33      0.43        30
         290       0.17      0.07      0.10        30
         291       0.74      0.31      0.44        64
         292       0.15      0.22      0.18         9
         293       0.36      0.13      0.19       123
         294       0.55      0.34      0.42        35
         295       0.20      0.05      0.07        22
         296       0.40      0.44      0.42       184
         297       0.63      0.29      0.40       140
         298       0.39      0.10      0.16       224
         299       0.80      0.44      0.57        97
         300       0.12      0.03      0.05        65
         301       0.14      0.05      0.07        44
         302       0.50      0.32      0.39        38
         303       0.45      0.26      0.32        98
         304       0.52      0.42      0.46        31
         305       0.32      0.25      0.28       235
         306       0.99      0.76      0.86       249
         307       0.31      0.23      0.26       247
         308       0.47      0.29      0.36       122
         309       0.24      0.06      0.10       230
         310       0.40      0.13      0.19       166
         311       0.19      0.10      0.13        40
         312       0.44      0.24      0.31        17
         313       0.27      0.19      0.23        36
         314       0.53      0.39      0.44       109
         315       0.00      0.00      0.00        67
         316       0.72      0.68      0.70        79
         317       0.19      0.06      0.09       197
         318       0.16      0.47      0.23        47
         319       0.68      0.32      0.44       222
         320       0.63      0.44      0.52        27
         321       0.70      0.57      0.63       207
         322       0.74      0.29      0.41       240
         323       0.32      0.06      0.09       215
         324       0.47      0.29      0.36       120
         325       0.44      0.16      0.24       130
         326       0.82      0.64      0.72        28
         327       0.12      0.15      0.13       166
         328       0.76      0.49      0.59        45
         329       0.51      0.48      0.49       180
         330       0.23      0.11      0.15        62
         331       0.28      0.25      0.26       105
         332       0.96      0.56      0.71        39
         333       0.50      1.00      0.67         4
         334       0.61      0.40      0.48       113
         335       0.64      0.29      0.40        78
         336       0.21      0.08      0.11        51
         337       0.40      0.18      0.25       147
         338       0.00      0.00      0.00       135
         339       0.30      0.37      0.33        27
         340       0.12      0.01      0.02        79
         341       0.95      0.63      0.76        30
         342       0.25      0.06      0.09        54
         343       0.59      0.20      0.30       195
         344       0.30      0.33      0.31        39
         345       0.86      0.67      0.75         9
         346       0.78      0.65      0.71        86
         347       0.31      0.11      0.17        44
         348       0.76      0.28      0.40       185
         349       0.83      0.53      0.65        66
         350       0.33      0.33      0.33         3
         351       0.53      0.29      0.37        35
         351       0.53      0.29      0.37        55
         352       0.51      0.31      0.39       216
         353       0.52      0.33      0.41        42
         354       0.67      0.33      0.44         6
         355       0.07      0.67      0.12         3
         356       0.20      0.07      0.11        14
         357       0.42      0.35      0.39        31
         358       0.39      0.09      0.14       204
         359       0.00      0.00      0.00       211
         360       0.48      0.17      0.26       184
         361       0.29      0.18      0.22       108
         362       0.00      0.00      0.00        54
         363       0.31      0.18      0.23        56
         364       0.32      0.09      0.14        97
         365       0.41      0.17      0.24        72
         366       0.00      0.00      0.00        12
         367       0.60      0.22      0.32       185
         368       0.20      0.02      0.03       193
         369       0.17      0.06      0.09        34
         370       0.57      0.27      0.37       164
         371       0.67      0.67      0.67        18
         372       0.29      0.15      0.20        65
         373       0.42      0.25      0.31        20
         374       0.00      0.00      0.00        29
         375       0.52      0.34      0.41        71
         376       0.12      0.01      0.01       164
         377       0.53      0.14      0.22       185
         378       0.12      0.12      0.12        24
         379       0.26      0.25      0.25        52
         380       0.08      0.02      0.03        57
         381       0.29      0.03      0.06        59
         382       0.33      0.02      0.03       117
         383       0.65      0.56      0.60        39
         384       0.65      0.44      0.53       125
         385       0.27      0.12      0.16       130
         386       0.66      0.58      0.62        74
         387       0.66      0.54      0.59        35
         388       0.52      0.57      0.55        21
         389       0.49      0.13      0.20       175
         390       0.00      0.00      0.00        54
         391       0.00      0.00      0.00        29
         392       0.46      0.10      0.16        63
         393       0.33      0.38      0.36        34
         394       0.75      0.63      0.69        38
         395       0.50      0.20      0.29        15
         396       0.25      0.20      0.22        10
         397       0.33      0.12      0.18        49
         398       0.67      0.05      0.09       169
         399       0.33      0.30      0.32        33
         400       0.56      0.45      0.50        84
         401       0.80      0.52      0.63        31
         402       0.44      0.46      0.45        24
         403       0.72      0.16      0.26       187
         404       0.50      0.33      0.40         6
         405       0.58      0.33      0.42        33
         406       0.17      0.12      0.14        17
         407       0.50      0.05      0.09        21
         408       0.32      0.10      0.15        62
         409       0.19      0.04      0.06        78
         410       0.67      0.48      0.56       147
         411       0.35      0.23      0.27        31
         412       0.00      0.00      0.00        14
         413       0.69      0.19      0.30       103
         414       0.88      0.61      0.72        36
         415       0.51      0.59      0.54        68
         416       0.16      0.07      0.10        43
         417       0.44      0.37      0.40        73
         418       0.89      0.52      0.65        62
         419       0.00      0.00      0.00        97
         420       0.08      0.05      0.06        42
         421       0.73      0.39      0.51        41
         422       0.33      0.05      0.09        38
         423       0.50      0.03      0.05        36
         424       0.20      0.08      0.11        13
         425       0.33      0.12      0.18        24
         426       0.00      0.00      0.00         3
         427       0.40      0.22      0.29        94
         428       0.37      0.16      0.22       151
         429       0.73      0.59      0.65        63
         430       0.25      0.07      0.12        40
         431       0.47      0.31      0.37        49
         432       0.00      0.00      0.00        34
         433       0.87      0.70      0.78        37
         434       0.39      0.32      0.35        34
         435       1.00      1.00      1.00         1
         436       0.14      0.03      0.06        29
         437       0.17      0.14      0.15        50
         438       0.00      0.00      0.00       104
         439       0.00      0.00      0.00        29
         440       0.20      0.04      0.07        23
         441       0.00      0.00      0.00        46
         442       0.27      0.10      0.15        39
         443       0.61      0.30      0.40        56
         444       0.61      0.35      0.44        80
         445       0.14      0.07      0.09        30
         446       0.10      0.07      0.08        30
         447       0.33      0.24      0.28        37
         448       0.62      0.13      0.21        39
         449       0.19      0.10      0.13        83
         450       0.67      0.26      0.38        23
         451       0.31      0.56      0.40         9
         452       0.47      0.16      0.24        44
         453       0.55      0.10      0.17       166
         454       0.68      0.47      0.56        32
         455       0.29      0.11      0.16        53
         456       0.60      0.51      0.55        41
         457       0.14      0.08      0.10        78
         458       0.25      0.05      0.09       133
         459       0.33      0.12      0.18        25
         460       0.50      0.17      0.26       103
         461       0.62      0.09      0.16        53
         462       0.38      0.30      0.33        30
         463       1.00      0.25      0.40         4
         464       0.17      0.05      0.07        66
         465       0.25      0.11      0.15        47
         466       0.33      0.19      0.24        31
```

CONCLUSION USING PRETTY TABLE

```
         470       0.17      0.11      0.13        27
```

```
pip install -U PTable
```

```
Collecting PTable
  Downloading https://files.pythonhosted.org/packages/ab/b3/b54301811173ca94119eb474634f120a49cd370f257d1aae5a4
Building wheels for collected packages: PTable
  Building wheel for PTable (setup.py) ... done
  Created wheel for PTable: filename=PTable-0.9.2-cp36-none-any.whl size=22908 sha256=f93098ba6d1e52cdfd0e51e86
  Stored in directory: /root/.cache/pip/wheels/22/cc/2e/55980bfe86393df3e9896146a01f6802978d09d7ebcba5ea56
Successfully built PTable
Installing collected packages: PTable
Successfully installed PTable-0.9.2
```

```
from prettytable import PrettyTable
x= PrettyTable()
x.title = "TF-IDF Featurization"
x.field_names = ["Algorithm" , "Macro F1 Score Precision", "Micro F1 Score", "Hamming Loss"]
x.add_row(["Logistic Regression with OneVsRest",0.5473,0.7216,0.002708])
print(x)
y= PrettyTable()
y.add_row(["Logistic Regression with OneVsRest",0.4122,0.6777,0.002942])
y.add_row(["Linear SVM with OneVsRest",0.4318,0.7029,0.00289])
y.title = "CountVectorizer BIGRAM"
```

```
y.title = "CountVectorizer BIGRAM"
y.field_names = ["Algorithm" , "Macro F1 Score Precision", "Micro F1 Score", "Hamming Loss"]
print(y)
```

```
+-----------------------------------------------------------------------------------------------+
|                                      TF-IDF Featurization                                     |
+------------------------------------+--------------------------+----------------+--------------+
|             Algorithm              | Macro F1 Score Precision | Micro F1 Score | Hamming Loss |
+------------------------------------+--------------------------+----------------+--------------+
| Logistic Regression with OneVsRest |          0.5473          |     0.7216     |   0.002708   |
+------------------------------------+--------------------------+----------------+--------------+
+-----------------------------------------------------------------------------------------------+
|                                     CountVectorizer BIGRAM                                    |
+------------------------------------+--------------------------+----------------+--------------+
|             Algorithm              | Macro F1 Score Precision | Micro F1 Score | Hamming Loss |
+------------------------------------+--------------------------+----------------+--------------+
| Logistic Regression with OneVsRest |          0.4122          |     0.6777     |   0.002942   |
|     Linear SVM with OneVsRest      |          0.4318          |     0.7029     |   0.00289    |
+------------------------------------+--------------------------+----------------+--------------+
```

CONCLUSION : LOGISTIC REGRESSION WITH ONEVSREST HAVE GOOD PRECISION : 0.6777 AS MICRO F1 SCORE