NLP on Research Articles (Multi-Label Classification)

Introduction

In this coursework,multi-label classifier is building through various steps like data preprocessing, text featurisation, dataset splitting, build the model, train the model, testing, also ploting bar charts to interpret the dataset, ploting confusion matrix etc. In this section, implementing 4 different experiment setup by making variations in these steps.

The multilabel classification is the supervised learning problem, in which each instance can be associated with more than one class.

Importing Library Files

In [1]:

```
import pandas as pd
import numpy as np
import os
import string
from nltk.corpus import stopwords
from nltk.stem.porter import PorterStemmer
import nltk
import matplotlib.pyplot as plt
nltk.download('stopwords')
nltk.download('wordnet')
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.model_selection import train_test_split
%matplotlib inline
import warnings
warnings.filterwarnings('ignore')
import seaborn as sns
import matplotlib.pyplot as plt
```

```
[nltk_data] Downloading package stopwords to
[nltk_data]     C:\Users\Admin\AppData\Roaming\nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
[nltk_data] Downloading package wordnet to
[nltk_data]     C:\Users\Admin\AppData\Roaming\nltk_data...
[nltk_data]   Package wordnet is already up-to-date!
```

Loading Dataset

Here, the dataset has taken from the kaggle for implementing multi-label classifier. https://www.kaggle.com/vetrirah/janatahack-independence-day-2020-ml-hackathon

The dataset consists of: TITLE: Title of the research article ABSTRACT: Abstract of the research article. Analysing whether article belongs to topic computer science, Physics, Mathematics: Statistics, Quantitative Biology, Quantitative Finance.

In the dataset there are 20972 rows and 9 columns. It consists of two text columns and 6 tag columns. Here some texts in a row are related to more than one class which is set to 1, otherwise it is set to 0.

In [2]:
```python
dataset=pd.read_csv('Research_Article_train.csv')
#dataset.head(15)

dataset.head(5)
```

Out[2]:

	ID	TITLE	ABSTRACT	Computer Science	Physics	Mathematics	Statistics	Quantitative Biology	Quantitative Financ
0	1	1 .what Reconstructing Subject-Specific Effect...	Predictive models allow subject-specific inf...	1	0	0	0	0	(
1	2	Rotation Invariance Neural Network	Rotation invariance and translation invarian...	1	0	0	0	0	(
2	3	Spherical polyharmonics and Poisson kernels fo...	We introduce and develop the notion of spher...	0	0	1	0	0	(
3	4	A finite element approximation for the stochas...	The stochastic Landau--Lifshitz--Gilbert (LL...	0	0	1	0	0	(
4	5	Comparative study of Discrete Wavelet Transfor...	Fourier-transform infra-red (FTIR) spectra o...	1	0	0	1	0	(

In [3]:
```python
dataset.columns
```

Out[3]:
```
Index(['ID', 'TITLE', 'ABSTRACT', 'Computer Science', 'Physics', 'Mathematics',
       'Statistics', 'Quantitative Biology', 'Quantitative Finance'],
      dtype='object')
```

In [4]:
```python
dataset.dtypes
```

Out[4]:
```
ID                       int64
TITLE                   object
ABSTRACT                object
Computer Science         int64
Physics                  int64
Mathematics              int64
Statistics               int64
Quantitative Biology     int64
```

```
Quantitative Finance      int64
dtype: object
```

In [5]:

```
dataset['ID']=dataset['ID'].astype(float)
dataset['Computer Science']=dataset['Computer Science'].astype(float)
dataset['Physics']=dataset['Physics'].astype(float)
dataset['Mathematics']=dataset['Mathematics'].astype(float)
dataset['Statistics']=dataset['Statistics'].astype(float)
dataset['Quantitative Biology']=dataset['Quantitative Biology'].astype(float)
dataset['Quantitative Finance']=dataset['Quantitative Finance'].astype(float)
dataset.dtypes
```

Out[5]:

```
ID                       float64
TITLE                     object
ABSTRACT                  object
Computer Science         float64
Physics                  float64
Mathematics              float64
Statistics               float64
Quantitative Biology     float64
Quantitative Finance     float64
dtype: object
```

In [6]:

```
dataset.describe()
```

Out[6]:

	ID	Computer Science	Physics	Mathematics	Statistics	Quantitative Biology	Quantitativ Financ
count	20972.000000	20972.000000	20972.000000	20972.000000	20972.000000	20972.000000	20972.00000
mean	10486.500000	0.409784	0.286716	0.267881	0.248236	0.027990	0.01187
std	6054.239259	0.491806	0.452238	0.442866	0.432000	0.164947	0.10831
min	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.00000
25%	5243.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.00000
50%	10486.500000	0.000000	0.000000	0.000000	0.000000	0.000000	0.00000
75%	15729.250000	1.000000	1.000000	1.000000	0.000000	0.000000	0.00000
max	20972.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.00000

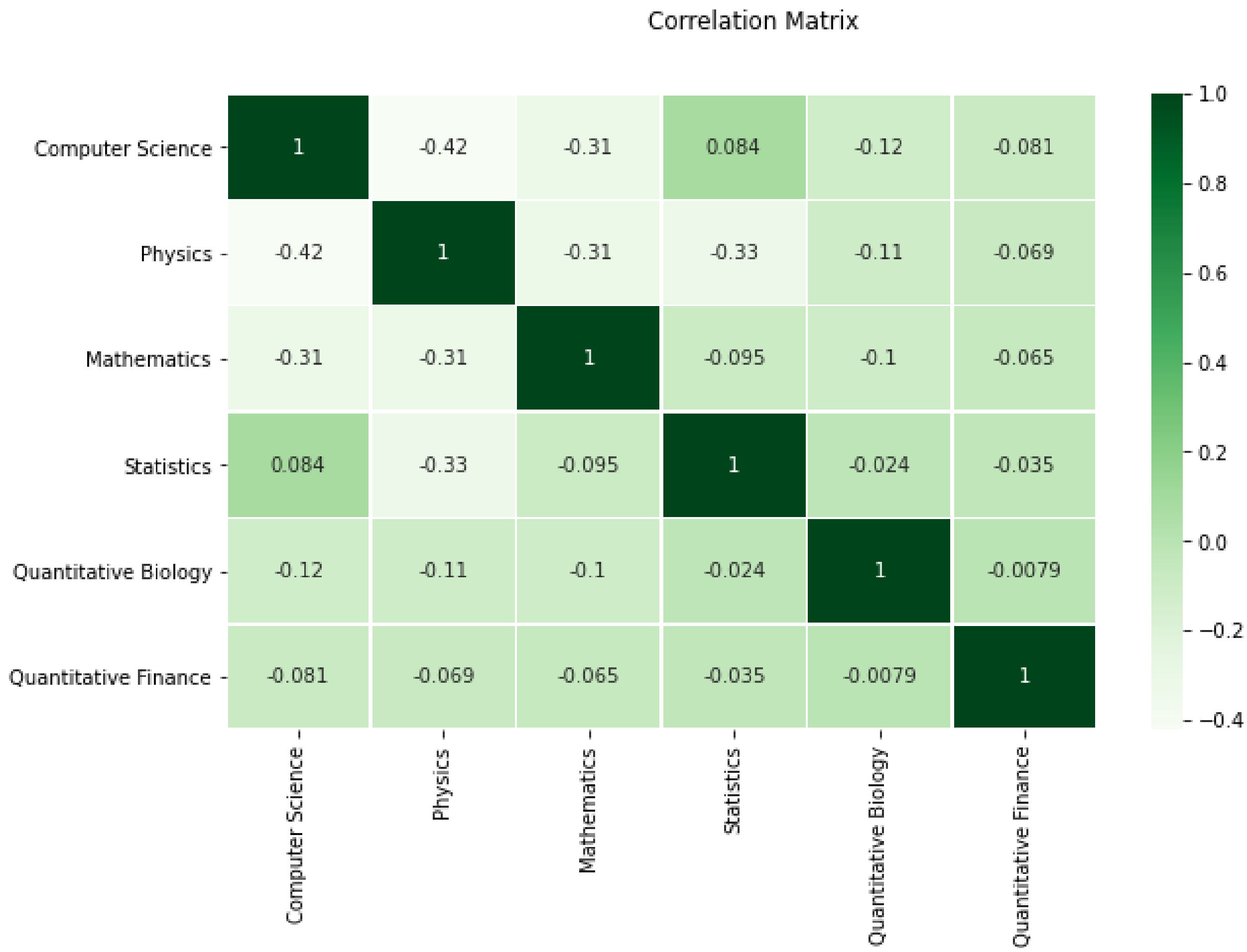
In [7]:

```
y=dataset[['Computer Science', 'Physics', 'Mathematics',
       'Statistics', 'Quantitative Biology', 'Quantitative Finance']]
```

Plotting Correlation Matrix of labels

In [8]:

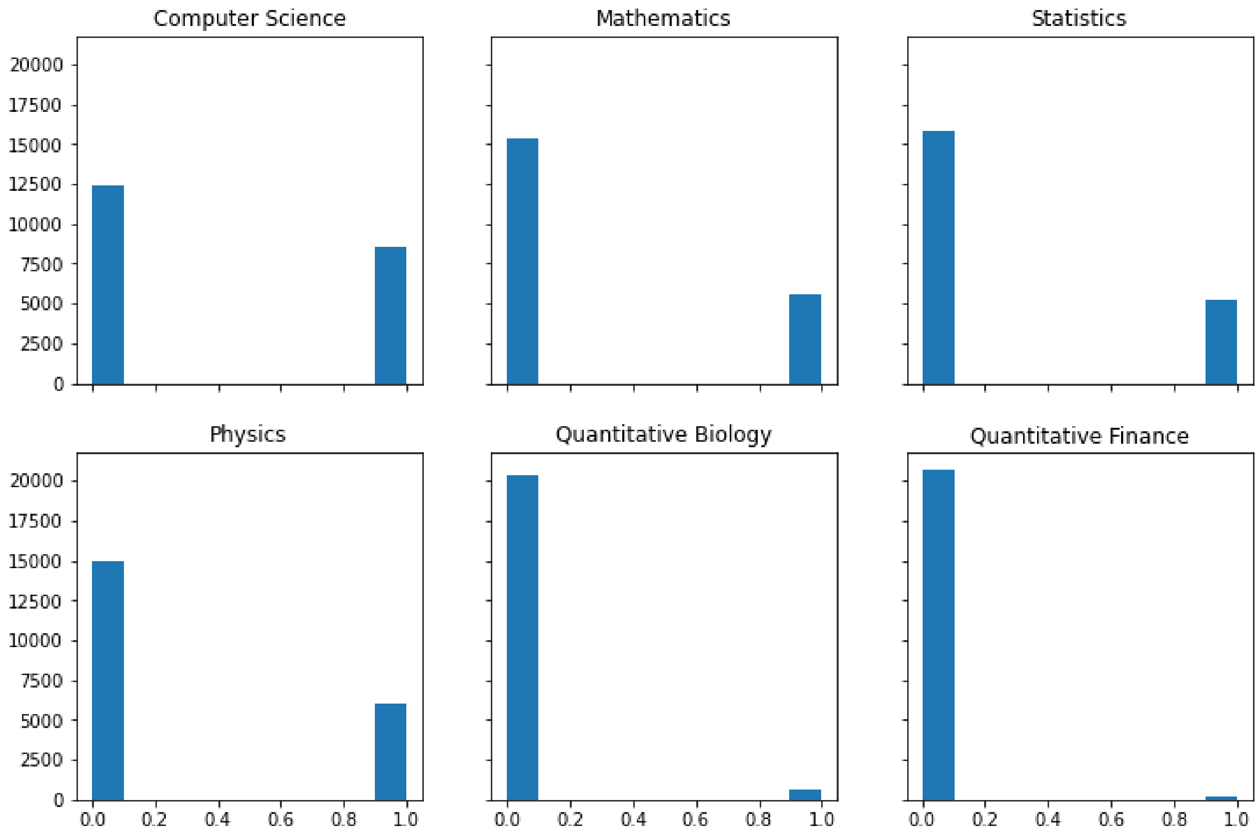
```
import seaborn as sns
fig, ax = plt.subplots(figsize=(10, 6))
fig.suptitle('Correlation Matrix')
sns.heatmap(y.corr(), annot=True, cmap="Greens", linewidths=.5, ax=ax);
```



Plotting Histogram

In [9]:

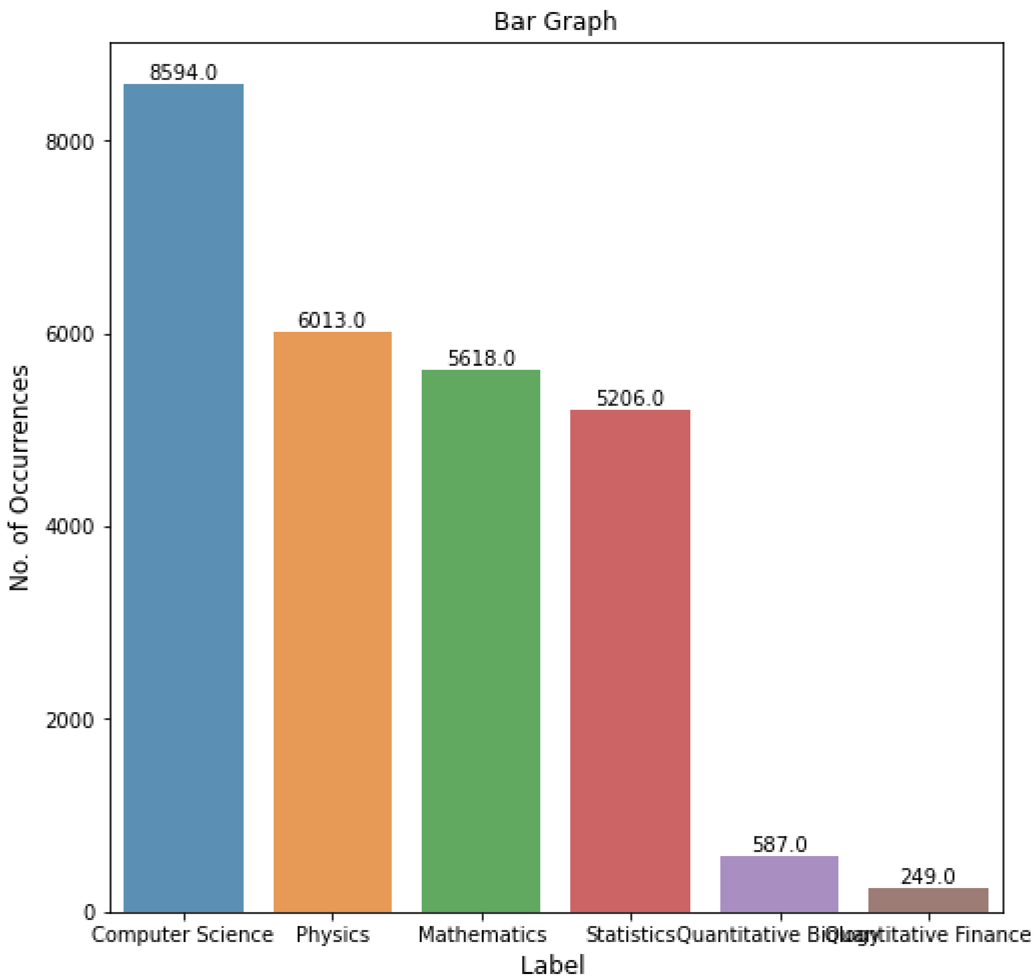
```
figure,axes=plt.subplots(2,3,sharey=True,sharex=True,figsize=(12,8))
axes[0][0].hist(dataset['Computer Science'])
axes[0][0].set_title('Computer Science')
axes[1][0].hist(dataset['Physics'])
axes[1][0].set_title('Physics')
axes[0][1].hist(dataset['Mathematics'])
axes[0][1].set_title('Mathematics')
axes[0][2].hist(dataset['Statistics'])
axes[0][2].set_title('Statistics')
axes[1][1].hist(dataset['Quantitative Biology'])
axes[1][1].set_title('Quantitative Biology')
axes[1][2].hist(dataset['Quantitative Finance'])
axes[1][2].set_title('Quantitative Finance')
plt.show()
```



Bar chart for each labels

In [10]:

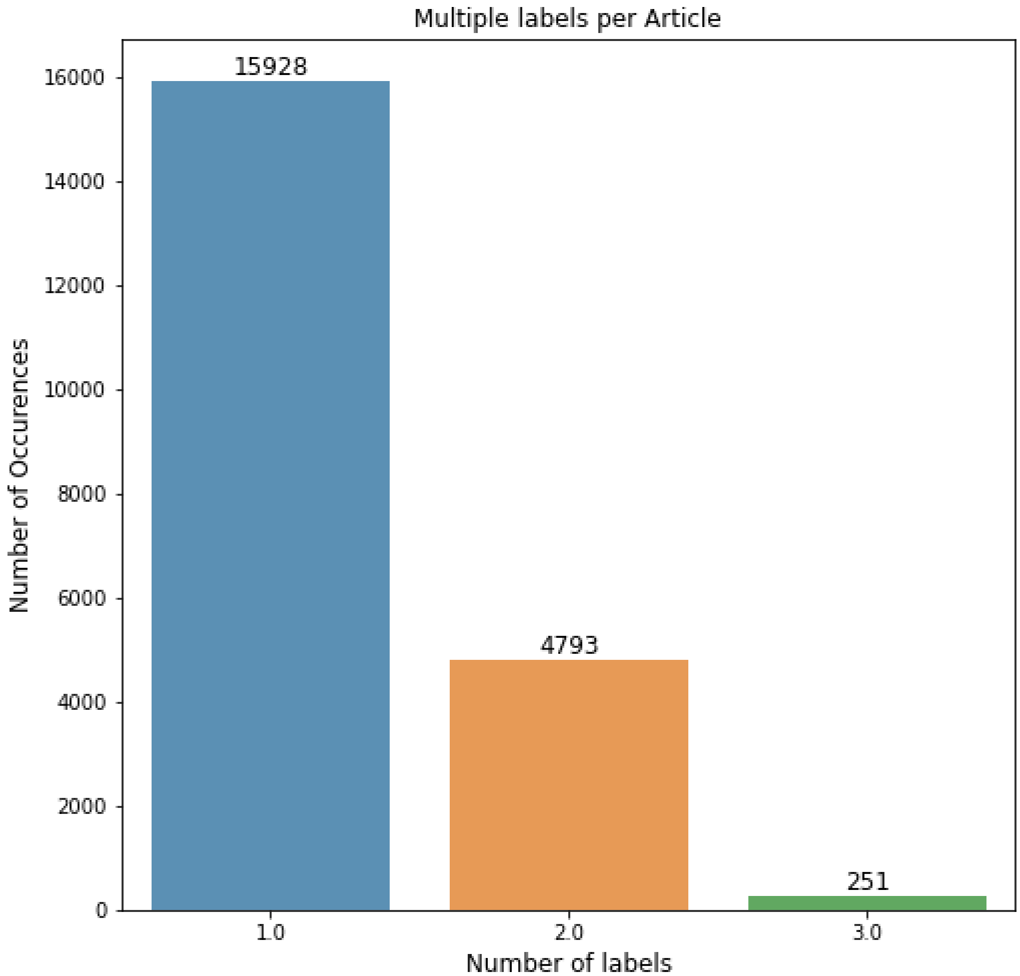
```
plt.figure(figsize=(8,8))
x=dataset.iloc[:,3:].sum()
ax= sns.barplot(x=x.index, y=x.values, alpha=0.8)
plt.title("Bar Graph")
plt.ylabel('No. of Occurrences', fontsize=12)
plt.xlabel('Label ', fontsize=12)
#adding text labels in each column labels
rects = ax.patches
labels = x.values
for rect, label in zip(rects, labels):
    height = rect.get_height()
    ax.text(rect.get_x() + rect.get_width()/2, height + 5, label, ha='center', va='bott
```



Bar chart for multiple label per article

In [11]:

```
plt.figure(figsize=(8,8))
labelSums = dataset.iloc[:,3:].sum(axis=1)
multiLabel_counts = labelSums.value_counts()
multiLabel_counts = multiLabel_counts.iloc[0:]
#print(multiLabel_counts)
ax = sns.barplot(x=multiLabel_counts.index, y=multiLabel_counts.values,alpha=0.8)
plt.title("Multiple labels per Article")
plt.ylabel('Number of Occurences', fontsize=12)
plt.xlabel('Number of labels', fontsize=12)
#determine the no of multiple labels and plot it above corresponding bar chart
rects = ax.patches
labels =multiLabel_counts.values
for rect, label in zip(rects, labels):
    height = rect.get_height()
    ax.text(rect.get_x() + rect.get_width()/2, height + 5, label, ha='center', va='bott
```



In [12]:

```
#combining 2 text columns title and abstract into one and drop columns title and abstra
dataset['Text']=dataset['TITLE']+' '+dataset['ABSTRACT']
dataset.drop(columns=['TITLE','ABSTRACT'], inplace=True)
#dataset.head(5)
```

Experiment-1

The first experiment shows the data processing variations with and without lemmatization and shows how it affects the model

Data Preprocessing without lemmatizer

In [13]:

```
remove_punc = string.punctuation
def remove_punctuation(text):
    return text.translate(str.maketrans('', '', remove_punc))
```

In [14]:

```
stopword = set(stopwords.words('english'))
def remove_stopwords(text):
    """custom function to remove the stopwords"""
    return " ".join([word for word in str(text).split() if word not in stopword])
```

In [15]:

```
from nltk.stem import PorterStemmer
```

```
stemmer = PorterStemmer()
def stem_words(text):
    return " ".join([stemmer.stem(word) for word in text.split()])
```

In [16]:

```
def preprocessing(dataset):
    #convert to string type
    dataset['Text'] = dataset['Text'].astype(str)
    #convert to the lowercase
    dataset["Text"] = dataset["Text"].str.lower()
    #remove punctuations
    dataset["Text"] = dataset["Text"].apply(lambda text: remove_punctuation(text))
    #stopwords removal
    dataset["Text"] = dataset["Text"].apply(lambda text: remove_stopwords(text))
    #stemming
    dataset["Text"] = dataset["Text"].apply(lambda text: stem_words(text))
    #Remove Numbers
    dataset['Text'] =dataset["Text"].str.replace('\d+', '')
    return dataset
```

In [17]:

```
processed_data=preprocessing(dataset)
```

In [18]:

```
clean_data=processed_data[['Text','Computer Science','Physics','Mathematics','Statistic
clean_data.head(5)
```

Out[18]:

	Text	Computer Science	Physics	Mathematics	Statistics	Quantitative Biology	Quantitative Finance
0	reconstruct subjectspecif effect map predict ...	1.0	0.0	0.0	0.0	0.0	0.0
1	rotat invari neural network rotat invari trans...	1.0	0.0	0.0	0.0	0.0	0.0
2	spheric polyharmon poisson kernel polyharmon f...	0.0	0.0	1.0	0.0	0.0	0.0
3	finit element approxim stochast maxwelllandaul...	0.0	0.0	1.0	0.0	0.0	0.0
4	compar studi discret wavelet transform wavelet...	1.0	0.0	0.0	1.0	0.0	0.0

Text Featurisation

Text featurisation means converting text into vector representation, the common text featurisation technique is tfidf vectorization, where each dimension of the vector corresponds to a word and a value corresponds to a word maps in such a way that it shows frequency or importance of words in a text chunk.

In [19]:

```
tfidf=TfidfVectorizer(analyzer='word',max_features=10000,min_df=5, max_df=0.9, token_pa
X=tfidf.fit_transform(clean_data['Text'])
```

```
X=X.toarray()
X
```

Out[19]:
```
array([[0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 0.],
       ...,
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 0.]])
```

Splitting Dataset

The dataset is divided into training dataset and testing dataset using train_test_split method. The training dataset with known output is used to train the model and the test dataset to used to make predictions. test_size=0.20 means the percentage of data that is used for testing.This is a simple and efficient method for splitting the dataset.

In [20]:
```
X_train,X_test,y_train,y_test=train_test_split(X,y,test_size=0.20,random_state=0)
```

Build the model

Machine learning algorithms are used for analysing datasets for a wide variety of tasks. Random forest is a supervised learning algorithm.It is a combination of decision trees and combined them together to get more accurate prediction. It is one of the best algorithm for analysing multiple labels in the dataset. This algorithm gives better accuracy value even without hyperparameter tuning, it is effortless to calculate relative importance on each columns. Here this algorithm is used for building multi-label classifier.

Random Forest Classifier

In [21]:
```
from sklearn.ensemble import RandomForestClassifier
```

In [22]:
```
rfclassifier=RandomForestClassifier(n_estimators=200)
```

In [23]:
```
rfclassifier.fit(X_train,y_train)
```

Out[23]:
```
RandomForestClassifier(n_estimators=200)
```

In [24]:
```
prediction=rfclassifier.predict(X_test)
prediction
```

Out[24]:
```
array([[0., 0., 1., 0., 0., 0.],
       [0., 0., 1., 0., 0., 0.],
       [0., 1., 0., 0., 0., 0.],
       ...,
       [0., 0., 1., 0., 0., 0.],
       [0., 0., 0., 0., 0., 0.],
       [1., 0., 0., 0., 0., 0.]])
```

In [25]:
```
from sklearn.metrics import accuracy_score
# View accuracy score
accuracy_score(y_test, prediction)
```

Out[25]: 0.5916567342073897

Preprocessing with lemmatizer

In [27]:
```
from nltk.stem import WordNetLemmatizer
lemmatizer = WordNetLemmatizer()
def lemmatize_words(text):
    return " ".join([lemmatizer.lemmatize(word) for word in text.split()])
```

In [29]:
```
processed_data=preprocessing(dataset)
#Lemmatisation
processed_data["Text"] = processed_data["Text"].apply(lambda text: lemmatize_words(text
```

In [30]:
```
#processed_data=preprocessing(dataset)
clean_data=processed_data[['Text','Computer Science','Physics','Mathematics','Statistic
clean_data.head(5)
```

Out[30]:

	Text	Computer Science	Physics	Mathematics	Statistics	Quantitative Biology	Quantitative Finance
0	reconstruct subjectspecif effect map predict m...	1.0	0.0	0.0	0.0	0.0	0.0
1	rotat invari neural network rotat invari trans...	1.0	0.0	0.0	0.0	0.0	0.0
2	spheric polyharmon poisson kernel polyharmon f...	0.0	0.0	1.0	0.0	0.0	0.0
3	finit element approxim stochast maxwelllandaul...	0.0	0.0	1.0	0.0	0.0	0.0
4	compar studi discret wavelet transform wavelet...	1.0	0.0	0.0	1.0	0.0	0.0

In [31]:
```
tfidf=TfidfVectorizer(analyzer='word',max_features=10000,min_df=5, max_df=0.9, token_pa
X=tfidf.fit_transform(clean_data['Text'])
X=X.toarray()
X
```

Out[31]:
```
array([[0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 0.],
       ...,
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 0.]])
```

In [32]:

```
X_train,X_test,y_train,y_test=train_test_split(X,y,test_size=0.20,random_state=0)
```

In [33]:
```
rfclassifier=RandomForestClassifier(n_estimators=200)
```

In [34]:
```
rfclassifier.fit(X_train,y_train)
```

Out[34]:
```
RandomForestClassifier(n_estimators=200)
```

In [35]:
```
prediction=rfclassifier.predict(X_test)
prediction
```

Out[35]:
```
array([[0., 0., 1., 0., 0., 0.],
       [0., 0., 1., 0., 0., 0.],
       [0., 0., 0., 0., 0., 0.],
       ...,
       [0., 0., 1., 0., 0., 0.],
       [0., 1., 0., 0., 0., 0.],
       [1., 0., 0., 0., 0., 0.]])
```

In [36]:
```
from sklearn.metrics import accuracy_score
# View accuracy score
accuracy_score(y_test, prediction)
```

Out[36]:
```
0.5928486293206198
```

There is a minute change noticed after the lemmatization has been done. The accuracy is increased by 0.001%

In [29]:
```
from sklearn.metrics import multilabel_confusion_matrix
```

In [30]:
```
print(multilabel_confusion_matrix(y_test,prediction))
```

```
[[[2070  381]
  [ 280 1464]]

 [[2942   57]
  [ 325  871]]

 [[3049   71]
  [ 361  714]]

 [[3038  131]
  [ 507  519]]

 [[4079    0]
  [ 116    0]]

 [[4145    0]
  [  50    0]]]
```

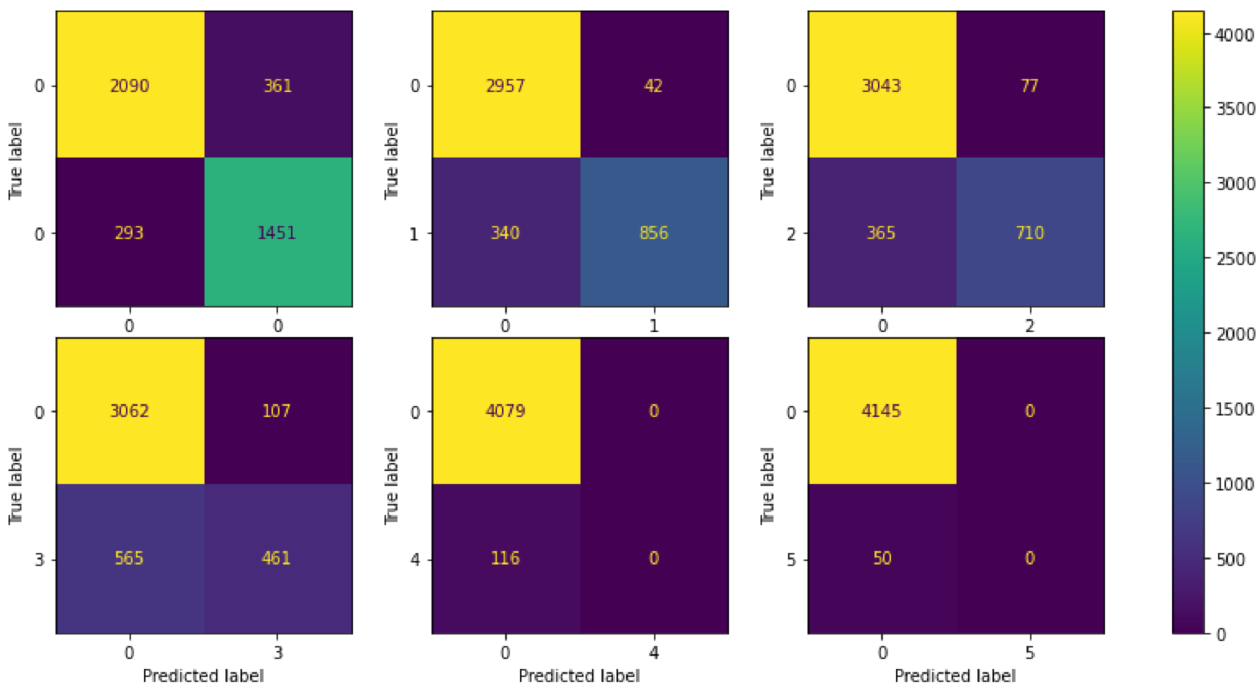
In [39]:
```
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
```

In [40]:

```
ytest=y_test.values
f, axes = plt.subplots(2, 3, figsize=(15, 7))
axes = axes.ravel()
for i in range(6):
    disp = ConfusionMatrixDisplay(confusion_matrix(ytest[:, i],prediction[:, i]),displa

    disp.plot(ax=axes[i], values_format='.4g')
    disp.im_.colorbar.remove()

plt.subplots_adjust(wspace=0.10, hspace=0.1)
f.colorbar(disp.im_, ax=axes)
plt.show()
```



In [57]:

```
from sklearn.metrics import classification_report
print(classification_report(y_test,prediction))
```

```
              precision    recall  f1-score   support

           0       0.80      0.83      0.82      1744
           1       0.95      0.72      0.82      1196
           2       0.90      0.66      0.76      1075
           3       0.81      0.45      0.58      1026
           4       0.00      0.00      0.00       116
           5       0.00      0.00      0.00        50

   micro avg       0.86      0.67      0.75      5207
   macro avg       0.58      0.44      0.50      5207
weighted avg       0.83      0.67      0.73      5207
 samples avg       0.74      0.71      0.71      5207
```