Week8_5_NLP_text_classification

May 31, 2021

NLP: Text classification

Import Libraries

```
[1]: import numpy as np
     import pandas as pd
     import glob
     import matplotlib.pyplot as plt
     import seaborn as sns


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

Load and display Dataset

```
[2]: df=pd.read_json("/home/jayanthikishore/Downloads/news_category_dataset.json",␣
      ↪lines=True)
     df
```

```
[2]:                                         short_description  \
     0       She left her husband. He killed their children…
     1                                  Of course it has a song.
     2       The actor and his longtime girlfriend Anna Ebe…
     3       The actor gives Dems an ass-kicking for not fi…
     4       The "Dietland" actress said using the bags is …
     …                                                    …
     124984
     124985  I often hear people describe cooking for one a…
     124986
     124987
     124988  Our thoughts and feelings are powerful, but ma…

                                                     headline       date  \
     0       There Were 2 Mass Shootings In Texas Last Week… 2018-05-26
     1       Will Smith Joins Diplo And Nicky Jam For The 2… 2018-05-26
     2         Hugh Grant Marries For The First Time At Age 57 2018-05-26
     3       Jim Carrey Blasts 'Castrato' Adam Schiff And D… 2018-05-26
     4       Julianna Margulies Uses Donald Trump Poop Bags… 2018-05-26
```

```
…                                                      …         …
124984             Why I Thought I'd Never Live To See 33 2014-04-18
124985                      Five Tips For Cooking For One 2014-04-18
124986   Police Want your Home Video Surveillance Footage 2014-04-18
124987                             Ouch, Natalie Morales 2014-04-18
124988                           Reasons Not to Be Happy 2014-04-18

                                                     link  \
0       https://www.huffingtonpost.com/entry/texas-ama…
1       https://www.huffingtonpost.com/entry/will-smit…
2       https://www.huffingtonpost.com/entry/hugh-gran…
3       https://www.huffingtonpost.com/entry/jim-carre…
4       https://www.huffingtonpost.com/entry/julianna-…
…                                                      …
124984  https://www.huffingtonpost.com/entry/a-black-g…
124985  https://www.huffingtonpost.com/entry/five-tips…
124986  https://www.huffingtonpost.com/entry/police-wa…
124987  https://www.huffingtonpost.com/entry/natalie-m…
124988  https://www.huffingtonpost.com/entry/happiness…

                                                  authors       category
0                                         Melissa Jeltsen          CRIME
1                                           Andy McDonald  ENTERTAINMENT
2                                              Ron Dicker  ENTERTAINMENT
3                                              Ron Dicker  ENTERTAINMENT
4                                              Ron Dicker  ENTERTAINMENT
…                                                      …              …
124984                                                             WOMEN
124985         Food Riot, ContributorPlay with your food.          TASTE
124986  Robert Siciliano, ContributorPersonal Security…          CRIME
124987                                     Katherine Fung          MEDIA
124988  Mindy Utay, Contributor"Calming Life's Conflicts"  HEALTHY LIVING

[124989 rows x 6 columns]
```

[3]:
```
df.columns
```

[3]:
```
Index(['short_description', 'headline', 'date', 'link', 'authors', 'category'],
dtype='object')
```

[4]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 124989 entries, 0 to 124988
Data columns (total 6 columns):
 #   Column             Non-Null Count   Dtype
---  ------             --------------   -----
```

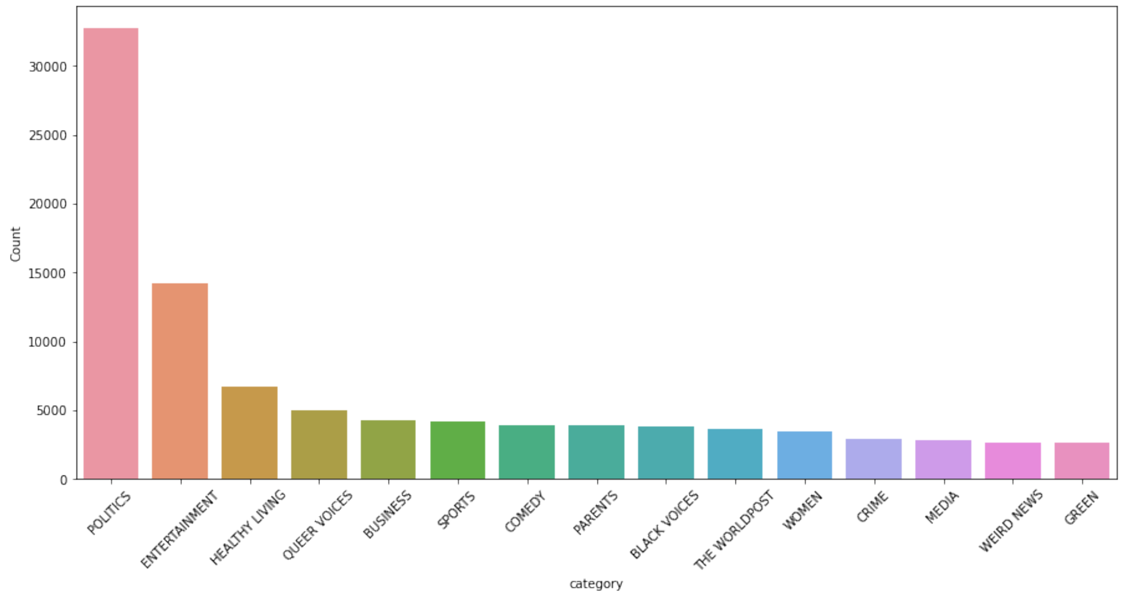
```
 0   short_description  124989 non-null  object
 1   headline           124989 non-null  object
 2   date               124989 non-null  datetime64[ns]
 3   link               124989 non-null  object
 4   authors            124989 non-null  object
 5   category           124989 non-null  object
dtypes: datetime64[ns](1), object(5)
memory usage: 5.7+ MB
```

Number of categories

```
[5]: len(set(df['category'].values))
```

```
[5]: 31
```

```
[6]: import matplotlib.pyplot as plt
     import pandas as pd
     location = df['category']
     location = pd.DataFrame(location)
     location['Count'] = 1
     location = location.groupby('category').sum().sort_values(by = 'Count',␣
      ↪ascending = False).nlargest(15,['Count'])
     location = location.reset_index()

     plt.figure(figsize=(15,7))
     sns.barplot(x = 'category',y = 'Count', data=location)
     plt.xticks(rotation=45)

     plt.show()
```



[7]:
```
location
```

[7]:
```
           category  Count
0          POLITICS  32739
1     ENTERTAINMENT  14257
2    HEALTHY LIVING   6694
3      QUEER VOICES   4995
4          BUSINESS   4254
5            SPORTS   4167
6            COMEDY   3971
7           PARENTS   3955
8      BLACK VOICES   3858
9     THE WORLDPOST   3664
10            WOMEN   3490
11            CRIME   2893
12            MEDIA   2815
13       WEIRD NEWS   2670
14            GREEN   2622
```

[8]:
```
time = df.date
time = pd.DataFrame(time)
Min = time.date.min()
Max = time.date.max()
print(f'The date range of the data is between {Min} and {Max}')
time
```

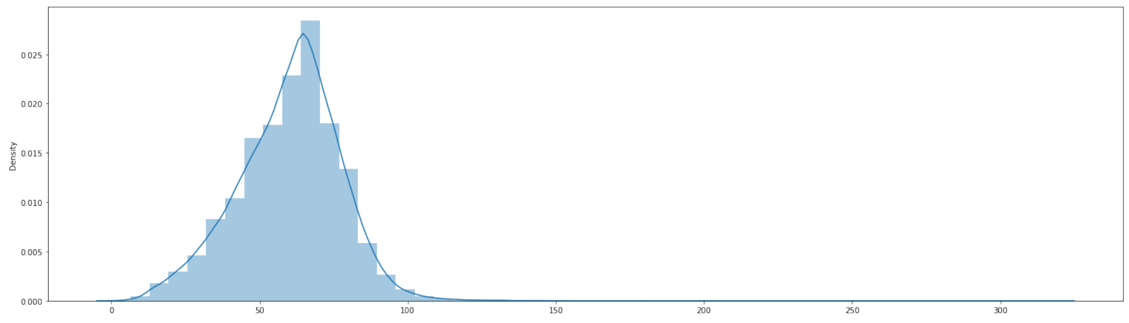
```
The date range of the data is between 2014-04-18 00:00:00 and 2018-05-26
00:00:00
```

[8]:
```
              date
0       2018-05-26
1       2018-05-26
2       2018-05-26
3       2018-05-26
4       2018-05-26
…              …
124984 2014-04-18
124985 2014-04-18
124986 2014-04-18
124987 2014-04-18
124988 2014-04-18

[124989 rows x 1 columns]
```

[9]:
```
length_tweets = pd.DataFrame(df.headline)
length_measured = []
```

```
for i in length_tweets.headline:
 length_measured.append(len(i))

plt.figure(figsize=(25,7))
sns.distplot(length_measured)
```

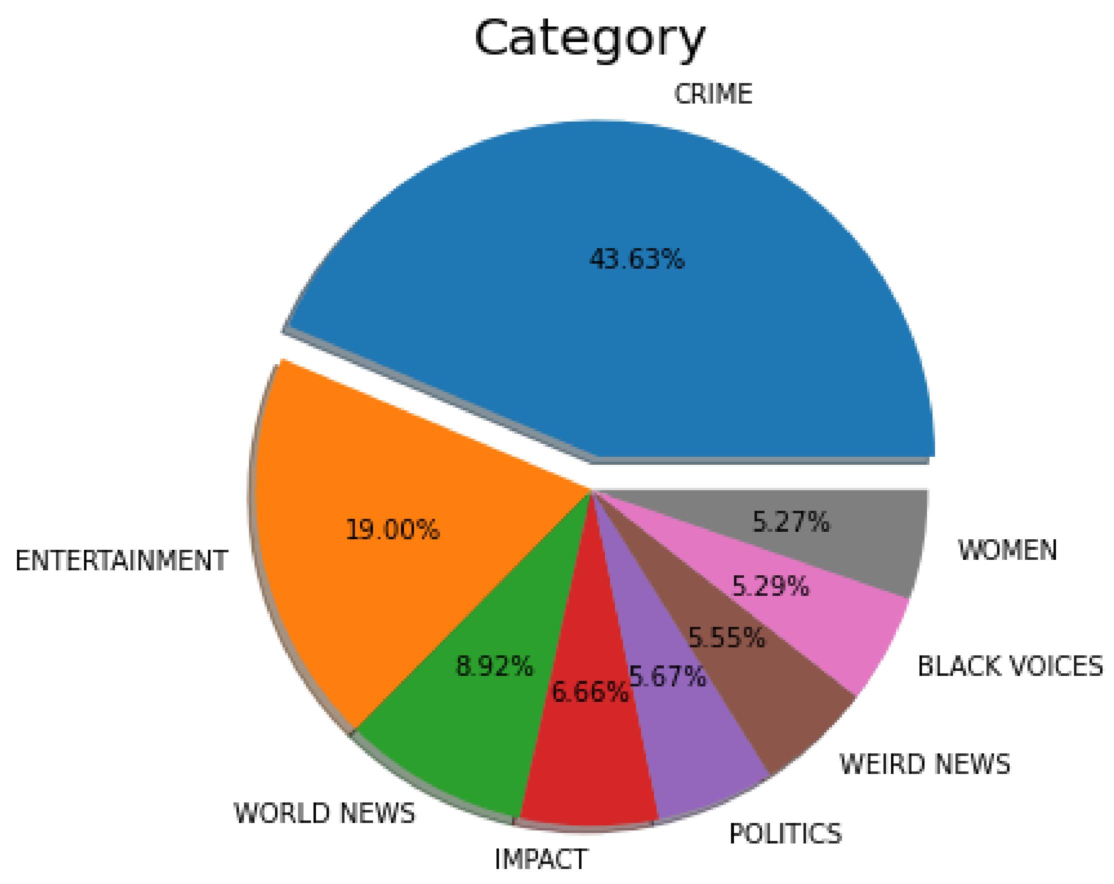
```
[9]: <matplotlib.axes._subplots.AxesSubplot at 0x7fdfb1bdafd0>
```



```
[10]: df.category.unique()
```

```
[10]: array(['CRIME', 'ENTERTAINMENT', 'WORLD NEWS', 'IMPACT', 'POLITICS',
             'WEIRD NEWS', 'BLACK VOICES', 'WOMEN', 'COMEDY', 'QUEER VOICES',
             'SPORTS', 'BUSINESS', 'TRAVEL', 'MEDIA', 'TECH', 'RELIGION',
             'SCIENCE', 'LATINO VOICES', 'EDUCATION', 'COLLEGE', 'PARENTS',
             'ARTS & CULTURE', 'STYLE', 'GREEN', 'TASTE', 'HEALTHY LIVING',
             'THE WORLDPOST', 'GOOD NEWS', 'WORLDPOST', 'FIFTY', 'ARTS'],
            dtype=object)
```

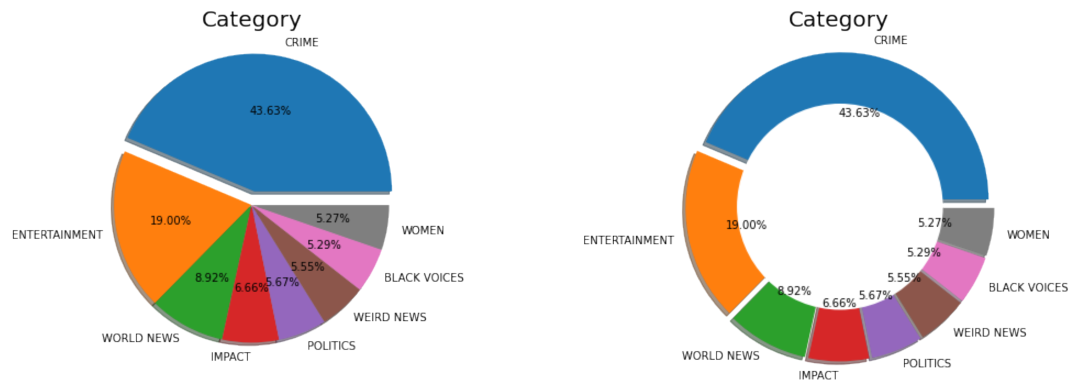
```
[11]: labls = ['CRIME', 'ENTERTAINMENT', 'WORLD NEWS', 'IMPACT', 'POLITICS','WEIRD␣
       ↪NEWS', 'BLACK VOICES', 'WOMEN']
      size1 = df['category'].value_counts()
      size=size1[0:8]
      explode = [0.1,0,0,0,0,0,0,0]

      plt.rcParams['figure.figsize'] = (6, 6)
      plt.pie(size, explode = explode, labels = labls, shadow = True, autopct = '%.
       ↪2f%%')
      plt.title('Category', fontsize = 20)
      plt.axis('off')
      # plt.legend()
      plt.show()

      size
```



[11]:
```
POLITICS          32739
ENTERTAINMENT     14257
HEALTHY LIVING     6694
QUEER VOICES       4995
BUSINESS           4254
SPORTS             4167
COMEDY             3971
PARENTS            3955
Name: category, dtype: int64
```

[12]:
```
f, (ax1,ax2) = plt.subplots(ncols=2, figsize=(15, 5))

#first plot
labls = ['CRIME', 'ENTERTAINMENT', 'WORLD NEWS', 'IMPACT', 'POLITICS','WEIRD␣
 ↪NEWS', 'BLACK VOICES', 'WOMEN']
size1 = df['category'].value_counts()
size=size1[0:8]
explode = [0.1,0,0,0,0,0,0,0]
```

```
ax1.pie(size, explode = explode, labels = labls, shadow = True, autopct = '%.
 ↪2f%%')
ax1.set_title('Category', fontsize = 20)
plt.axis('off')

#second plot
explode1 = [0.05,0.05,0.05,0.05,0.05,0.05,0.05,0.05]

ax2.pie(size, explode = explode1, labels = labls, shadow = True, autopct = '%.
 ↪2f%%')
ax2.set_title('Category', fontsize = 20)
#draw circle
centre_circle = plt.Circle((0,0),0.70,fc='white')
fig=plt.gcf()
fig.gca().add_artist(centre_circle)

#equal aspect ratio ensures that pie is drawn as a circle
plt.axis('equal')
plt.tight_layout()
plt.show()
```



Texts for Classification

- We create 3 different versions of classification

[16]:
```
import re

def tokenize_url(url:str):
    url=url.replace("https://www.huffingtonpost.com/entry/","")
    url=re.sub("(\W|_)+"," ",url)
    return url

df['tokenized_url']=df['link'].apply(lambda x:tokenize_url(x))
```

```python
#just the description
df['text_desc'] = df['short_description']

#description + headline
df['text_desc_headline'] = df['short_description'] + ' '+ df['headline']

#description + headline + tokenized url
df['text_desc_headline_url'] = df['short_description'] + ' '+ df['headline']+"␣
↪" + df['tokenized_url']

df.head(3)
```

[16]:

```
                                   short_description  \
0  She left her husband. He killed their children…
1                           Of course it has a song.
2  The actor and his longtime girlfriend Anna Ebe…

                                            headline       date  \
0  There Were 2 Mass Shootings In Texas Last Week… 2018-05-26
1  Will Smith Joins Diplo And Nicky Jam For The 2… 2018-05-26
2    Hugh Grant Marries For The First Time At Age 57 2018-05-26

                                                link          authors  \
0  https://www.huffingtonpost.com/entry/texas-ama…  Melissa Jeltsen
1  https://www.huffingtonpost.com/entry/will-smit…    Andy McDonald
2  https://www.huffingtonpost.com/entry/hugh-gran…       Ron Dicker

        category                                     tokenized_url  \
0          CRIME  texas amanda painter mass shooting us 5b081ab4…
1  ENTERTAINMENT  will smith joins diplo and nicky jam for the o…
2  ENTERTAINMENT     hugh grant marries us 5b09212ce4b0568a880b9a8c

                                           text_desc  \
0  She left her husband. He killed their children…
1                           Of course it has a song.
2  The actor and his longtime girlfriend Anna Ebe…

                                  text_desc_headline  \
0  She left her husband. He killed their children…
1  Of course it has a song. Will Smith Joins Dipl…
2  The actor and his longtime girlfriend Anna Ebe…

                              text_desc_headline_url
0  She left her husband. He killed their children…
1  Of course it has a song. Will Smith Joins Dipl…
2  The actor and his longtime girlfriend Anna Ebe…
```

[18]:
```python
def _reciprocal_rank(true_labels: list, machine_preds: list):
    """Compute the reciprocal rank at cutoff k"""

    # add index to list only if machine predicted label exists in true labels
    tp_pos_list = [(idx + 1) for idx, r in enumerate(machine_preds) if r in␣
 ↪true_labels]

    rr = 0
    if len(tp_pos_list) > 0:
        # for RR we need position of first correct item
        first_pos_list = tp_pos_list[0]

        # rr = 1/rank
        rr = 1 / float(first_pos_list)

    return rr

def compute_mrr_at_k(items:list):
    """Compute the MRR (average RR) at cutoff k"""
    rr_total = 0

    for item in items:
        rr_at_k = _reciprocal_rank(item[0],item[1])
        rr_total = rr_total + rr_at_k
        mrr = rr_total / 1/float(len(items))

    return mrr

def collect_preds(Y_test,Y_preds):
    """Collect all predictions and ground truth"""

    pred_gold_list=[[[Y_test[idx]],pred] for idx,pred in enumerate(Y_preds)]
    return pred_gold_list

def compute_accuracy(eval_items:list):
    correct=0
    total=0

    for item in eval_items:
        true_pred=item[0]
        machine_pred=set(item[1])

        for cat in true_pred:
            if cat in machine_pred:
                correct+=1
                break
    accuracy=correct/float(len(eval_items))
    return accuracy
```

[19]:
```
from sklearn.metrics import precision_recall_fscore_support
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.feature_extraction.text import CountVectorizer,TfidfVectorizer

import numpy as np
import logging

logging.basicConfig(format='%(asctime)s : %(levelname)s : %(message)s',␣
 ↪level=logging.INFO)

def extract_features(df,field,training_data,testing_data,type="binary"):
    """Extract features using different methods"""

    logging.info("Extracting features and creating vocabulary...")

    if "binary" in type:

        # BINARY FEATURE REPRESENTATION
        cv= CountVectorizer(binary=True, max_df=0.95)
        cv.fit_transform(training_data[field].values)

        train_feature_set=cv.transform(training_data[field].values)
        test_feature_set=cv.transform(testing_data[field].values)

        return train_feature_set,test_feature_set,cv

    elif "counts" in type:

        # COUNT BASED FEATURE REPRESENTATION
        cv= CountVectorizer(binary=False, max_df=0.95)
        cv.fit_transform(training_data[field].values)

        train_feature_set=cv.transform(training_data[field].values)
        test_feature_set=cv.transform(testing_data[field].values)

        return train_feature_set,test_feature_set,cv

    else:

        # TF-IDF BASED FEATURE REPRESENTATION
        tfidf_vectorizer=TfidfVectorizer(use_idf=True, max_df=0.95)
        tfidf_vectorizer.fit_transform(training_data[field].values)
        train_feature_set=tfidf_vectorizer.transform(training_data[field].
 ↪values)
        test_feature_set=tfidf_vectorizer.transform(testing_data[field].values)

        return train_feature_set,test_feature_set,tfidf_vectorizer

def get_top_k_predictions(model,X_test,k):

    # get probabilities instead of predicted labels, since we want to collect␣
 ↪top 3
    probs = model.predict_proba(X_test)

    # GET TOP K PREDICTIONS BY PROB - note these are just index
    best_n = np.argsort(probs, axis=1)[:,-k:]

    # GET CATEGORY OF PREDICTIONS
    preds=[[model.classes_[predicted_cat] for predicted_cat in prediction] for␣
 ↪prediction in best_n]

    preds=[ item[::-1] for item in preds]

    return preds


def train_model(df,field="text_desc",feature_rep="binary",top_k=3):

    logging.info("Starting model training...")

    # GET A TRAIN TEST SPLIT (set seed for consistent results)
    training_data, testing_data = train_test_split(df,random_state = 2000,)

    # GET LABELS
    Y_train=training_data['category'].values
    Y_test=testing_data['category'].values

    # GET FEATURES
  ␣
 ↪X_train,X_test,feature_transformer=extract_features(df,field,training_data,testing_data,typ

    # INIT LOGISTIC REGRESSION CLASSIFIER
    logging.info("Training a Logistic Regression Model...")
    scikit_log_reg = LogisticRegression(verbose=1,␣
 ↪solver='liblinear',random_state=0, C=5, penalty='l2',max_iter=1000)
    model=scikit_log_reg.fit(X_train,Y_train)

    # GET TOP K PREDICTIONS
    preds=get_top_k_predictions(model,X_test,top_k)

    # GET PREDICTED VALUES AND GROUND TRUTH INTO A LIST OF LISTS - for ease of␣
↪evaluation
    eval_items=collect_preds(Y_test,preds)

    # GET EVALUATION NUMBERS ON TEST SET -- HOW DID WE DO?
    logging.info("Starting evaluation...")
    accuracy=compute_accuracy(eval_items)
    mrr_at_k=compute_mrr_at_k(eval_items)

    logging.info("Done training and evaluation.")

    return model,feature_transformer,accuracy,mrr_at_k
```

Train a Single Model

- Model - 1 (binary features with description only)

[20]:
```
field='text_desc'
feature_rep='binary'
top_k=3

model,transformer,accuracy,mrr_at_k=train_model(df,field=field,feature_rep=feature_rep,top_k=t
print("\nAccuracy={0}; MRR={1}".format(accuracy,mrr_at_k))
```

```
2021-05-27 18:40:12,024 : INFO : Starting model training…
2021-05-27 18:40:12,166 : INFO : Extracting features and creating vocabulary…
2021-05-27 18:40:14,864 : INFO : Training a Logistic Regression Model…
```

```
[LibLinear]
```

```
2021-05-27 18:43:22,776 : INFO : Starting evaluation…
2021-05-27 18:43:22,840 : INFO : Done training and evaluation.
```

```

Accuracy=0.5981182795698925; MRR=0.4804787506400565
```

Model - 2 (tfidf features with description only)

[21]:
```
field='text_desc'
feature_rep='tfidf'
top_k=3

model,transformer,accuracy,mrr_at_k=train_model(df,field=field,feature_rep=feature_rep,top_k=t
print("\nAccuracy={0}; MRR={1}".format(accuracy,mrr_at_k))
```

```
2021-05-27 18:46:08,048 : INFO : Starting model training…
2021-05-27 18:46:08,116 : INFO : Extracting features and creating vocabulary…
2021-05-27 18:46:10,935 : INFO : Training a Logistic Regression Model…
```

```
[LibLinear]

2021-05-27 18:47:00,655 : INFO : Starting evaluation…
2021-05-27 18:47:00,723 : INFO : Done training and evaluation.


Accuracy=0.6306963645673324; MRR=0.5108380269670775
```

Model - 3 (tfidf features with description, headline, url)

```
[22]: field='text_desc_headline_url'
      feature_rep='tfidf'
      top_k=3

      model,transformer,accuracy,mrr_at_k=train_model(df,field=field,feature_rep=feature_rep,top_k=t
      print("\nAccuracy={0}; MRR={1}".format(accuracy,mrr_at_k))
```

```
2021-05-27 18:47:00,766 : INFO : Starting model training…
2021-05-27 18:47:00,851 : INFO : Extracting features and creating vocabulary…
2021-05-27 18:47:06,762 : INFO : Training a Logistic Regression Model…

[LibLinear]

2021-05-27 18:48:20,766 : INFO : Starting evaluation…
2021-05-27 18:48:20,828 : INFO : Done training and evaluation.


Accuracy=0.8672875064004096; MRR=0.7511680747567727
```

Check Predictions on Unseen Articles from CNN (not HuffPost our training data)

```
[23]: # https://www.cnn.com/2019/07/19/politics/george-nader-child-porn-sex-charges/
       ↪index.html
      test_features=transformer.transform(["George Aref Nader, who was a key witness␣
       ↪in special counsel Robert Mueller's Russia investigation, faces new charges␣
       ↪of transporting a minor with intent to engage in criminal sexual activity␣
       ↪and child pornography"])
      get_top_k_predictions(model,test_features,2)
```

```
[23]: [['POLITICS', 'CRIME']]
```

```
[24]: # https://www.cnn.com/2019/07/18/entertainment/
       ↪khloe-kardashian-true-thompson-video-trnd/index.html
      test_features=transformer.transform(["True Thompson makes an adorable cameo in␣
       ↪Khloe Kardashian's new makeup tutorial video"])
      model.predict(test_features)
      get_top_k_predictions(model,test_features,2)
```

```
[24]: [['ENTERTAINMENT', 'STYLE']]
```

[25]:
```
# https://www.cnn.com/2019/07/12/entertainment/heidi-klum-tom-kaulitz/
test_features=transformer.transform(["Heidi Klum is apparently the latest celeb␣
↪to get married and not tell us"])
get_top_k_predictions(model,test_features,2)
```

[25]:
```
[['ENTERTAINMENT', 'STYLE']]
```

[26]:
```
# https://www.cnn.com/2019/07/19/investing/dow-stock-market-today/index.html
test_features=transformer.transform(["Stocks end lower as geopolitical fears␣
↪rise. The Dow and US markets closed lower on Friday, as geopolitical worries␣
↪overshadowed the hopes of interest rate cuts by the Federal Reserve."])
get_top_k_predictions(model,test_features,2)
```

[26]:
```
[['BUSINESS', 'POLITICS']]
```

[27]:
```
# https://www.cnn.com/2019/07/19/health/astronaut-exercise-iv-faint-scn/index.
↪html
test_features=transformer.transform(["Exercise in space keeps astronauts from␣
↪fainting when they return to Earth, study says. "])
get_top_k_predictions(model,test_features,2)
```

[27]:
```
[['SCIENCE', 'HEALTHY LIVING']]
```

Train Different Types of Models

[28]:
```
feature_reps=['binary','counts','tfidf']
fields=['text_desc','text_desc_headline','text_desc_headline_url']
top_ks=[3]

results=[]
for field in fields:
    for feature_rep in feature_reps:
        for top_k in top_ks:
            ␣
↪model,transformer,acc,mrr_at_k=train_model(df,field=field,feature_rep=feature_rep,top_k=top
            results.append([field,feature_rep,top_k,acc,mrr_at_k])
```

```
2021-05-27 18:55:41,990 : INFO : Starting model training…
2021-05-27 18:55:42,059 : INFO : Extracting features and creating vocabulary…
2021-05-27 18:55:44,954 : INFO : Training a Logistic Regression Model…
```

```
[LibLinear]
```

```
2021-05-27 18:58:19,526 : INFO : Starting evaluation…
2021-05-27 18:58:19,586 : INFO : Done training and evaluation.
2021-05-27 18:58:19,628 : INFO : Starting model training…
2021-05-27 18:58:19,689 : INFO : Extracting features and creating vocabulary…
2021-05-27 18:58:22,458 : INFO : Training a Logistic Regression Model…
```

```
[LibLinear]

2021-05-27 19:02:28,986 : INFO : Starting evaluation…
2021-05-27 19:02:29,046 : INFO : Done training and evaluation.
2021-05-27 19:02:29,079 : INFO : Starting model training…
2021-05-27 19:02:29,145 : INFO : Extracting features and creating vocabulary…
2021-05-27 19:02:32,020 : INFO : Training a Logistic Regression Model…

[LibLinear]

2021-05-27 19:03:17,266 : INFO : Starting evaluation…
2021-05-27 19:03:17,329 : INFO : Done training and evaluation.
2021-05-27 19:03:17,362 : INFO : Starting model training…
2021-05-27 19:03:17,429 : INFO : Extracting features and creating vocabulary…
2021-05-27 19:03:21,625 : INFO : Training a Logistic Regression Model…

[LibLinear]

2021-05-27 19:07:03,592 : INFO : Starting evaluation…
2021-05-27 19:07:03,654 : INFO : Done training and evaluation.
2021-05-27 19:07:03,689 : INFO : Starting model training…
2021-05-27 19:07:03,762 : INFO : Extracting features and creating vocabulary…
2021-05-27 19:07:08,367 : INFO : Training a Logistic Regression Model…

[LibLinear]

2021-05-27 19:12:43,203 : INFO : Starting evaluation…
2021-05-27 19:12:43,267 : INFO : Done training and evaluation.
2021-05-27 19:12:43,304 : INFO : Starting model training…
2021-05-27 19:12:43,370 : INFO : Extracting features and creating vocabulary…
2021-05-27 19:12:47,888 : INFO : Training a Logistic Regression Model…

[LibLinear]

2021-05-27 19:13:50,490 : INFO : Starting evaluation…
2021-05-27 19:13:50,556 : INFO : Done training and evaluation.
2021-05-27 19:13:50,606 : INFO : Starting model training…
2021-05-27 19:13:50,685 : INFO : Extracting features and creating vocabulary…
2021-05-27 19:13:56,175 : INFO : Training a Logistic Regression Model…

[LibLinear]

2021-05-27 19:17:25,941 : INFO : Starting evaluation…
2021-05-27 19:17:26,002 : INFO : Done training and evaluation.
2021-05-27 19:17:26,037 : INFO : Starting model training…
2021-05-27 19:17:26,101 : INFO : Extracting features and creating vocabulary…
2021-05-27 19:17:31,567 : INFO : Training a Logistic Regression Model…

[LibLinear]

2021-05-27 19:22:55,773 : INFO : Starting evaluation…
2021-05-27 19:22:55,836 : INFO : Done training and evaluation.
2021-05-27 19:22:55,878 : INFO : Starting model training…
```

```
2021-05-27 19:22:55,941 : INFO : Extracting features and creating vocabulary…
2021-05-27 19:23:01,302 : INFO : Training a Logistic Regression Model…
```

```
[LibLinear]
```

```
2021-05-27 19:24:06,098 : INFO : Starting evaluation…
2021-05-27 19:24:06,160 : INFO : Done training and evaluation.
```

- Results of Various Models

[29]:
```
df_results=pd.
 ↪DataFrame(results,columns=['text_fields','feature_representation','top_k','accuracy','mrr_a
df_results.sort_values(by=['text_fields','accuracy'],ascending=False)
```

[29]:
```
              text_fields feature_representation  top_k  accuracy  mrr_at_k
8  text_desc_headline_url                  tfidf      3  0.867288  0.751168
6  text_desc_headline_url                 binary      3  0.830101  0.715576
7  text_desc_headline_url                 counts      3  0.829653  0.718126
5      text_desc_headline                  tfidf      3  0.835893  0.717177
3      text_desc_headline                 binary      3  0.794579  0.679158
4      text_desc_headline                 counts      3  0.792147  0.677921
2               text_desc                  tfidf      3  0.630696  0.510838
0               text_desc                 binary      3  0.598118  0.480479
1               text_desc                 counts      3  0.595654  0.478479
```

Save Model for Future Use

[32]:
```
import pickle

model_path="/home/jayanthikishore/Downloads/models/model.pkl"
transformer_path="/home/jayanthikishore/Downloads/models/transformer.pkl"

# we need to save both the transformer -> to encode a document and the model␣
 ↪itself to make predictions based on the weight vectors
pickle.dump(model,open(model_path, 'wb'))
pickle.dump(transformer,open(transformer_path,'wb'))
```

Use Loaded Model

[33]:
```
loaded_model = pickle.load(open(model_path, 'rb'))
loaded_transformer = pickle.load(open(transformer_path, 'rb'))


test_features=loaded_transformer.transform(["President Trump AND THE␣
 ↪impeachment story !!!"])
get_top_k_predictions(loaded_model,test_features,2)
```

[33]:
```
[['POLITICS', 'THE WORLDPOST']]
```

[ ]:
```

```