02_stackexchange_text_analysis

August 21, 2021

1 Project with StackOverflow posts

In this task you will deal with a dataset of post titles from StackOverflow. You are provided a split to 3 sets: *train*, *validation* and *test*. All corpora (except for *test*) contain titles of the posts and corresponding tags (100 tags are available). The *test* set is provided for Coursera's grading and doesn't contain answers. Upload the corpora using *pandas* and look at the data:

[24]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

from scipy import sparse as sp_sparse
from numpy.random import rand
```

[5]:

```
from ast import literal_eval

data_dir = "../nlp_datasets/SE_dataset/"
```

[6]:

```
def read_data(filename):
    data = pd.read_csv(filename, sep='\t')
    data['tags'] = data['tags'].apply(literal_eval)
    return data
```

[9]:

```
train = read_data(data_dir+'train.tsv')
validation = read_data(data_dir+'validation.tsv')
test = pd.read_csv(data_dir+'test.tsv', sep='\t') # test doesn't have any tags

train.head(3)
```

[9]:

```
                                               title          tags
0                 How to draw a stacked dotplot in R?            [r]
1  mysql select all records where a datetime fiel…  [php, mysql]
2             How to terminate windows phone 8.1 app          [c#]
```

[10]:

```
X_train, y_train = train['title'].values, train['tags'].values
X_val, y_val = validation['title'].values, validation['tags'].values
X_test = test['title'].values
```

```
print ('training shape:', X_train.shape, 'validation shape:', X_val.shape,␣
 ↪'test shape:', X_test.shape)
```

```
training shape: (100000,) validation shape: (30000,) test shape: (20000,)
```

1.1 Preparing the data

[11]:

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

```
[nltk_data] Downloading package stopwords to
[nltk_data]     /Users/gshyam/nltk_data…
[nltk_data]   Package stopwords is already up-to-date!
```

[12]:

```
import re

REPLACE_BY_SPACE_RE = re.compile('[/(){}\[\]\|@,;]')
BAD_SYMBOLS_RE = re.compile('[^0-9a-z #+_]')
STOPWORDS = set(stopwords.words('english'))

def text_prepare(text):
    text = text.lower() # lowercase text
    text = REPLACE_BY_SPACE_RE.sub(' ',text) # replace REPLACE_BY_SPACE_RE␣
 ↪symbols by space in text
    text = BAD_SYMBOLS_RE.sub('', text)# delete symbols which are in␣
 ↪BAD_SYMBOLS_RE from text
    text = ' '.join([word for word in text.split() if word not in STOPWORDS]) #␣
 ↪delete stopwors from text
    return text
```

[13]:

```
# test above function
examples = ["SQL Server - any equivalent of Excel's CHOOSE function?",
            "How to free c++ memory vector<int> * arr?"]
answers = ["sql server equivalent excels choose function",
           "free c++ memory vectorint arr"]
for i in range(2):
    text = examples[i]
    ans = text_prepare(text)
    ans_correct = answers[i]
    print (i)
    print ('\n answer \t \t :', ans,
           '\n correct answer \t :', ans_correct,
           '\n both are equal \t :', ans==ans_correct)
```

```
0
```

```
 answer                    : sql server equivalent excels choose function
 correct answer            : sql server equivalent excels choose function
 both are equal            : True
1

 answer                    : free c++ memory vectorint arr
 correct answer            : free c++ memory vectorint arr
 both are equal            : True
```

[14]:

```
# Prepare your data from train, test and validation set
X_train = [text_prepare(x) for x in X_train]
X_val = [text_prepare(x) for x in X_val]
X_test = [text_prepare(x) for x in X_test]
```

[15]:

```
print ( X_train[:2])
print ( X_test[:2])
print ( X_val[:2])
```

```
['draw stacked dotplot r', 'mysql select records datetime field less specified
value']
['warning mysql_query expects parameter 2 resource object given', 'get click
coordinates input typeimage via javascript']
['odbc_exec always fail', 'access base classes variable within child class']
```

[16]:

```
y_train[:2]
```

[16]:

```
array([list(['r']), list(['php', 'mysql'])], dtype=object)
```

1.2 WordsTagsCount

Find 3 most popular tags and 3 most popular words in the train data and submit the results to earn the points.

[17]:

```
from collections import Counter

# Dictionary of all tags from train corpus with their counts.
all_tags = [item for item_list in y_train for item in item_list]
tags_counts = Counter(all_tags)

# Dictionary of all words from train corpus with their counts.
#all_words = [word for line in X_train for word in line.split()]
ALL_WORDS = [word for line in X_train for word in line.split()]
words_counts = Counter(ALL_WORDS)
```

[18]:

```
# The most common items in tags and words
print ( 'The top 3 tags:', tags_counts.most_common(3) )
print ( 'The top 3 words:', words_counts.most_common(3) )
```

```
The top 3 tags: [('javascript', 19078), ('c#', 19077), ('java', 18661)]
The top 3 words: [('using', 8278), ('php', 5614), ('java', 5501)]
```

[19]:

```
# get a sorted dictionary
tags_counts_sorted  =  sorted(tags_counts.items(), key=lambda x: x[1],␣
 ↪reverse=True)
words_counts_sorted = sorted(words_counts.items(), key=lambda x: x[1],␣
 ↪reverse=True)

most_common_tags   = tags_counts_sorted[:3]
most_common_words = words_counts_sorted[:3]

print ('most_common_tags',most_common_tags)
print ('most_common_words',most_common_words)
```

```
most_common_tags [('javascript', 19078), ('c#', 19077), ('java', 18661)]
most_common_words [('using', 8278), ('php', 5614), ('java', 5501)]
```

[20]:

```
DICT_SIZE = 1000
VOCAB = words_counts.most_common(DICT_SIZE)  # already sorted
WORDS_TO_INDEX = {item[0]:ii for ii, item in enumerate(VOCAB) }
#VOCAB is already sorted hence we don't need to do the following.
#WORDS_TO_INDEX = {item[0]:ii for ii, item in enumerate( sorted(VOCAB,␣
 ↪key=lambda x: x[1], reverse=True) ) }

INDEX_TO_WORDS = {ii:word for word, ii in WORDS_TO_INDEX.items()}

#print (WORDS_TO_INDEX)
#print (INDEX_TO_WORDS)
```

[21]:

```
def my_bag_of_words(text, words_to_index, dict_size):
    result_vec = np.zeros(dict_size)
    for word in text.split():
        if word in words_to_index:
            result_vec[words_to_index[word]] +=1
    return result_vec
```

[22]:

```
# test my bag of words
mytext = ['hi how are you']
words_to_index = {'hi': 0, 'you': 1, 'me': 2, 'are': 3} # these are the most␣
 ↪common words already found
ans = [1, 1, 0, 1]

for i, text in enumerate(mytext):
    vec = my_bag_of_words(text, words_to_index, 4)
    print ('obtained vector:', vec)
    print ('correct ansswer:', ans)
    print ( 'The two are equal (T/F):',(vec==ans).any() )
```

```
obtained vector: [1. 1. 0. 1.]
correct ansswer: [1, 1, 0, 1]
The two are equal (T/F): True
```

[25]:
```
X_train_mybag = sp_sparse.vstack([ sp_sparse.csr_matrix(my_bag_of_words(text,␣
 ↪WORDS_TO_INDEX, DICT_SIZE)) for text in X_train])
X_val_mybag = sp_sparse.vstack([sp_sparse.csr_matrix(my_bag_of_words(text,␣
 ↪WORDS_TO_INDEX, DICT_SIZE)) for text in X_val])
X_test_mybag = sp_sparse.vstack([sp_sparse.csr_matrix(my_bag_of_words(text,␣
 ↪WORDS_TO_INDEX, DICT_SIZE)) for text in X_test])
print('X_train shape ', X_train_mybag.shape)
print('X_val shape ', X_val_mybag.shape)
print('X_test shape ', X_test_mybag.shape)
```

```
X_train shape  (100000, 1000)
X_val shape  (30000, 1000)
X_test shape  (20000, 1000)
```

1.3 Bag Of Words

For the 11th row in X_train_mybag find how many non-zero elements it has. In this task the answer (variable non_zero_elements_count) should be a number, e.g. 20.

[26]:
```
row = X_train_mybag[10].toarray()[0]

non_zero_elements_count = np.sum([1 for item in row if item != 0])
print (non_zero_elements_count)
```

```
4
```

1.4 TF-IDF

Convert a collection of raw documents to a matrix of TF-IDF features.

```
Implement function tfidf_features using class TfidfVectorizer from scikit-learn. Use train cor

First use TfidfVectorizer without token_pattern and see if you have 'c+' in tfidf_vocab if not
```

[27]:
```
from sklearn.feature_extraction.text import TfidfVectorizer

def tfidf_features(X_train, X_val, X_test):
    # max_df and min_df is to filter out too frequent and too rare words
    tfidf_vectorizer = TfidfVectorizer(ngram_range=(1,2),
                                       max_df=0.9, min_df=5,
                                  token_pattern='(\S+)' )

    X_train_tfidf = tfidf_vectorizer.fit_transform(X_train)
    X_val_tfidf = tfidf_vectorizer.transform(X_val)
    X_test_tfidf = tfidf_vectorizer.transform(X_test)

    return (X_train_tfidf, X_val_tfidf, X_test_tfidf, tfidf_vectorizer.
 ↪vocabulary_ )
```

[28]:
```
X_train_tfidf, X_val_tfidf, X_test_tfidf, tfidf_vocab = tfidf_features(X_train,␣
 ↪X_val, X_test)
tfidf_reversed_vocab = {i:word for word,i in tfidf_vocab.items()}
```

[29]:
```
tfidf_vocab['c#']
```

[29]:
```
1879
```

1.5 MultiLabel Classifier

[30]:
```
from sklearn.preprocessing import MultiLabelBinarizer
```

[31]:
```
mlb = MultiLabelBinarizer(classes=sorted(tags_counts.keys()))
y_train = mlb.fit_transform(y_train)
y_val = mlb.fit_transform(y_val)
```

[32]:
```
y_val
```

[32]:
```
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]])
```

[33]:
```
from sklearn.multiclass import OneVsRestClassifier
from sklearn.linear_model import LogisticRegression, RidgeClassifier
```

[34]:
```
def train_classifier(X_train, y_train):
    model = OneVsRestClassifier(LogisticRegression(penalty='l2', C=1.0,␣
 ↪max_iter=500))
    model.fit(X_train, y_train)
    return model
```

[35]:
```
classifier_mybag = train_classifier(X_train_mybag, y_train)
classifier_tfidf = train_classifier(X_train_tfidf, y_train)
```

[36]:

```
y_val_predicted_labels_mybag = classifier_mybag.predict(X_val_mybag)
y_val_predicted_scores_mybag = classifier_mybag.decision_function(X_val_mybag)

y_val_predicted_labels_tfidf = classifier_tfidf.predict(X_val_tfidf)
y_val_predicted_scores_tfidf = classifier_tfidf.decision_function(X_val_tfidf)
```

[37]:

```
y_val_pred_inversed = mlb.inverse_transform(y_val_predicted_labels_tfidf)
y_val_inversed = mlb.inverse_transform(y_val)
for i in range(3):
    print('Title:\t{}\nTrue labels:\t{}\nPredicted labels:\t{}\n\n'.format(
        X_val[i],
        ','.join(y_val_inversed[i]),
        ','.join(y_val_pred_inversed[i])
    ))
```

```
Title:  odbc_exec always fail
True labels:    php,sql
Predicted labels:



Title:  access base classes variable within child class
True labels:    javascript
Predicted labels:



Title:  contenttype application json required rails
True labels:    ruby,ruby-on-rails
Predicted labels:       json,ruby-on-rails
```

1.5.1 Evaluation

To evaluate the results we will use several classification metrics: - Accuracy - F1-score - Area under ROC-curve - Area under precision-recall curve

Make sure you are familiar with all of them. How would you expect the things work for the multi-label scenario? Read about micro/macro/weighted averaging following the sklearn links provided above.

[38]:

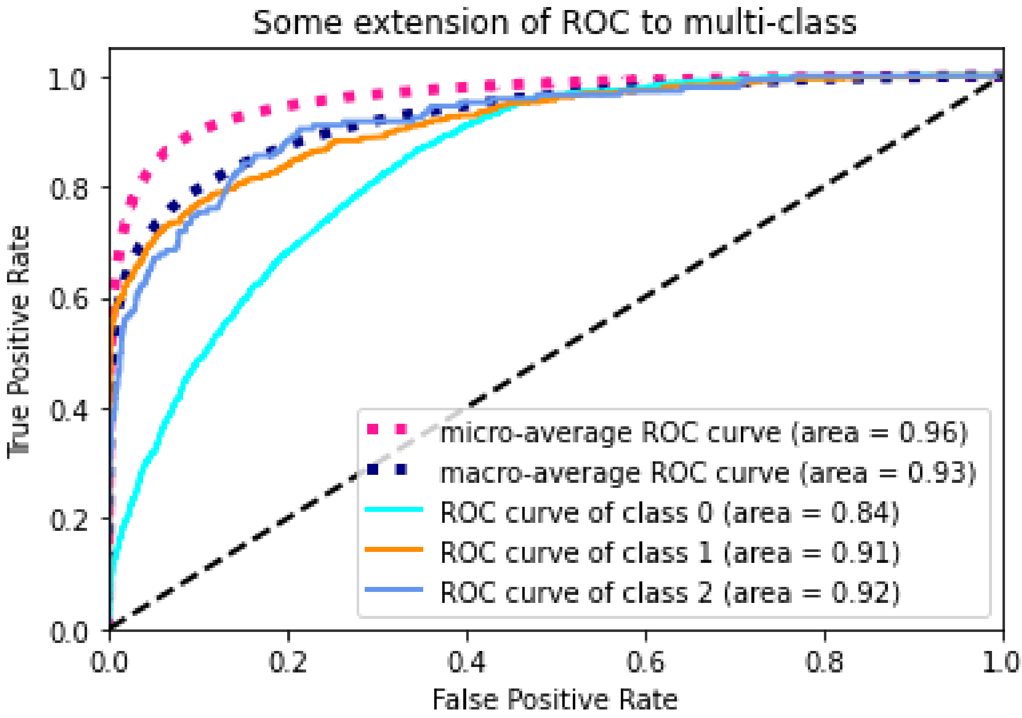
```
from sklearn.metrics import accuracy_score
from sklearn.metrics import f1_score   #  extra arguement 'average' is required␣
 ↪for multiclass/multilabel targets.
from sklearn.metrics import roc_auc_score
from sklearn.metrics import average_precision_score
from sklearn.metrics import recall_score
```

```
[39]: def print_evaluation_scores(y_val, predicted):
          print ("Accracy={}".format(accuracy_score(y_val, predicted)),
              "F1_macro={}".format(f1_score(y_val, predicted, average='macro')),
              "F1_micro={}".format(f1_score(y_val, predicted, average='micro')),
              "F1_wted={}".format(f1_score(y_val, predicted, average='weighted')),
              "Precsion_macro={}".format(average_precision_score(y_val, predicted,␣
       ↪average='macro')),
              "Precsion_micro={}".format(average_precision_score(y_val, predicted,␣
       ↪average='micro')),
              "Precsion_wted={}".format(average_precision_score(y_val, predicted,␣
       ↪average='weighted')))
```

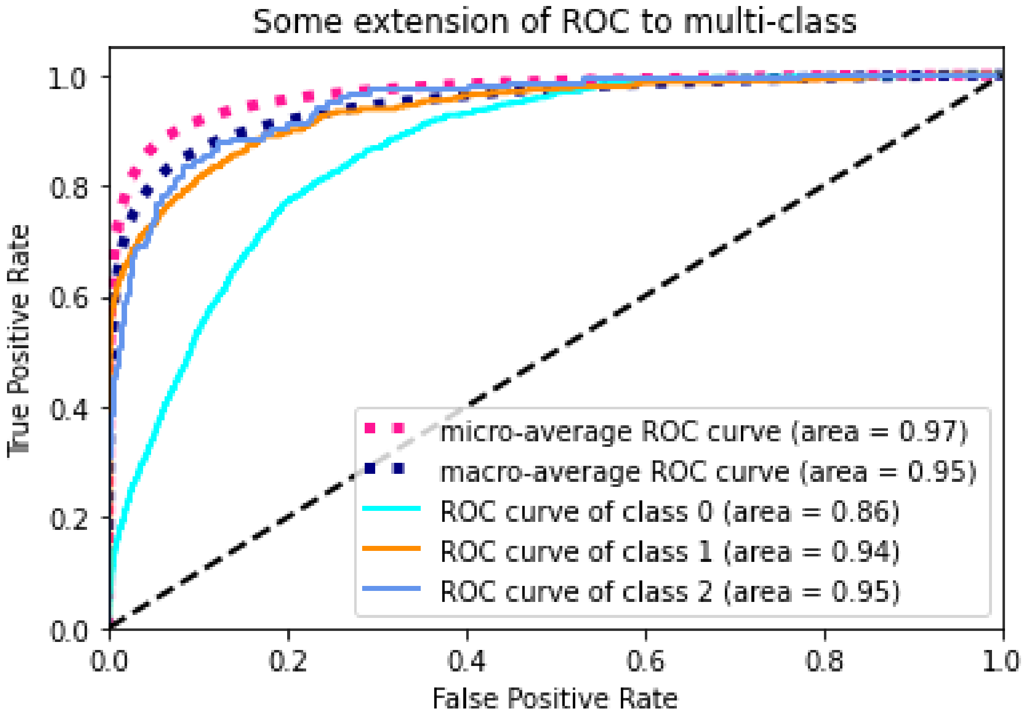
```
[40]: print('Bag-of-words')
      print_evaluation_scores(y_val, y_val_predicted_labels_mybag)
      print('Tfidf')
      print_evaluation_scores(y_val, y_val_predicted_labels_tfidf)
```

```
Bag-of-words
Accracy=0.30733333333333335 F1_macro=0.48042789607695546
F1_micro=0.6225785774040394 F1_wted=0.603181533862139
Precsion_macro=0.3235746811091482 Precsion_micro=0.42836779433666106
Precsion_wted=0.4627357127118158
Tfidf
Accracy=0.3339 F1_macro=0.4454765332377671 F1_micro=0.6417184899710957
F1_wted=0.614248024164715 Precsion_macro=0.3018168343817219
Precsion_micro=0.4568968080771187 Precsion_wted=0.48500349929335657
```

```
[41]: #from utility_metrics import roc_auc
      #from utils.wk1_utility_metrics import roc_auc
      from utils_metrics import roc_auc
      n_classes = len(tags_counts)
      roc_auc(y_val, y_val_predicted_scores_mybag, n_classes)
```



```
[42]: n_classes = len(tags_counts)
      roc_auc(y_val, y_val_predicted_scores_tfidf, n_classes)
```



1.6 MultilabelClassification

Once we have the evaluation set up, we suggest that you experiment a bit with training your classifiers. We will use F1-score weighted as an evaluation metric. Our recommendation:

compare the quality of the bag-of-words and TF-IDF approaches and chose one of them. for the chosen one, try L1 and L2-regularization techniques in Logistic Regression with different coefficients (e.g. C equal to 0.1, 1, 10, 100). You also could try other improvements of the preprocessing / model, if you want.

```
[43]: ######### YOUR CODE HERE #############
      test_predictions = classifier_tfidf.predict(X_test_tfidf)
      test_pred_inversed = mlb.inverse_transform(test_predictions)

      test_predictions_for_submission = '\n'.join('%i\t%s' % (i, ','.join(row)) for␣
       ↪i, row in enumerate(test_pred_inversed))
      #grader.submit_tag('MultilabelClassification', test_predictions_for_submission)
```

```
[44]: print (test_predictions_for_submission[:100] )
```

```
0       php
1       javascript,jquery
2
3       javascript,jquery
4       android,java
5       php,xml
6       json
7       java
8       python
9       h
```

1.7 Most Important Features

```
[45]: def print_words_for_tag(classifier, tag, tags_classes, index_to_words,␣
       ↪all_words):
          """
              classifier: trained classifier
              tag: particular tag
              tags_classes: a list of classes names from MultiLabelBinarizer
              index_to_words: index_to_words transformation
              all_words: all words in the dictionary

              return nothing, just print top 5 positive and top 5 negative words for␣
       ↪current tag
          """
```

```
    print('Tag:\t{}'.format(tag))

    # Extract an estimator from the classifier for the given tag.
    # Extract feature coefficients from the estimator.
    estimator = classifier.estimators_[tags_classes.index(tag)]
    coff = estimator.coef_[0]
    coff_idx = list(enumerate(coff))
    top_pos_words_idx = [idx for idx, wt in sorted(coff_idx, key=lambda x:␣
 ↪x[1], reverse=True)[:5]]
    top_neg_words_idx = [idx for idx, wt in sorted(coff_idx, key=lambda x:␣
 ↪x[1], reverse=False)[:5]]
    top_positive_words = [index_to_words[idx] for idx in top_pos_words_idx] #␣
 ↪top-5 words sorted by the coefficiens.
    top_negative_words = [index_to_words[idx] for idx in top_neg_words_idx] #␣
 ↪bottom-5 words  sorted by the coefficients.
    print('Top positive words:\t{}'.format(', '.join(top_positive_words)))
    print('Top negative words:\t{}\n'.format(', '.join(top_negative_words)))
```

[46]:

```
print_words_for_tag(classifier_tfidf, 'c', mlb.classes, tfidf_reversed_vocab,␣
 ↪ALL_WORDS)
print_words_for_tag(classifier_tfidf, 'c++', mlb.classes, tfidf_reversed_vocab,␣
 ↪ALL_WORDS)
print_words_for_tag(classifier_tfidf, 'linux', mlb.classes,␣
 ↪tfidf_reversed_vocab, ALL_WORDS)
```

```
Tag:    c
Top positive words:     c, malloc, scanf, printf, gcc
Top negative words:     java, php, python, javascript, c#

Tag:    c++
Top positive words:     c++, qt, boost, mfc, opencv
Top negative words:     java, php, python, javascript, c#

Tag:    linux
Top positive words:     linux, ubuntu, c, address, signal
Top negative words:     javascript, c#, jquery, array, method
```

[ ]:

```
```