term_term_pr_distr_and_inference-multinomial-sum

December 7, 2020

autoreload modules and utilities

[1]:
```
%load_ext autoreload
%autoreload 2
```

import all neceesary libraries/packages

[21]:
```
import joblib

import numpy as np
import pandas as pd

from tqdm.notebook import tqdm
import matplotlib.pyplot as plt

from scipy.stats import entropy as calculate_entropy

from sklearn.datasets import fetch_20newsgroups
from sklearn.model_selection import StratifiedShuffleSplit

from sklearn.pipeline import Pipeline
from sklearn.pipeline import FeatureUnion
from sklearn.naive_bayes import MultinomialNB, GaussianNB
from sklearn.feature_extraction.text import CountVectorizer, TfidfVectorizer

from sklearn.metrics import classification_report, accuracy_score
from sklearn.metrics import f1_score as calculate_f1_score
from sklearn.model_selection import train_test_split, StratifiedKFold
```

Utility functions

[3]:
```
z = np.random.randint(20, size=(3, 5))
z
```

[3]:
```
array([[ 3, 17,  0,  0,  9],
       [11, 11, 19, 18,  2],
       [15,  5, 14,  9, 10]])
```

[4]:
```
np.array(map(lambda x: x, [1,2,3]))
```

[4]:
```
array(<map object at 0x0000021FE46718B0>, dtype=object)
```

[28]:
```
## utilities
# from utils import clean_text

import string

from sklearn.base import TransformerMixin

import nltk
from nltk import word_tokenize
from nltk.stem import WordNetLemmatizer


nltk.download('stopwords')
nltk.download('wordnet')

def clean_text(text: str, lemmatizer = lambda x: x) -> str:
    # removes upper cases
    text = text.lower().strip()

    # removes punctuation
    for char in string.punctuation:
        text = text.replace(char, " ")

    #lematize the words and join back into string text
    text = " ".join([lemmatizer(word) for word in word_tokenize(text)])
    return text


def calculate_sparsity(matrix):
    non_zero = np.count_nonzero(matrix)
    total_val = np.product(matrix.shape)
    sparsity = (total_val - non_zero) / total_val
    return sparsity


def data_isvalid(text, analyser, min_character_size, max_character_size):
    return min_character_size <= len(analyser(text)) <= max_character_size


def get_pipeline(vectorizer_type, classifier, use_t2pi, min_df=3,␣
↪stop_words=None, lemmatizer = lambda x: x):
    vectorizer = CountVectorizer if vectorizer_type == "count" else␣
↪TfidfVectorizer
    models = [
        ('clean_text', CleanTextTransformer(lemmatizer)),
```

```
        ("vectorizers", FeatureUnion([
            ('count_binary', CountVectorizer(stop_words=stop_words,␣
↪binary=True, min_df=min_df)),
            ("count", vectorizer(stop_words=stop_words, min_df=min_df))
        ])),
    ]

    if use_t2pi:
        models.append(('t2pi_transformer', T2PITransformer()))

    models.append(('classifier', classifier))
    return Pipeline(models)


class CleanTextTransformer(TransformerMixin):
    def __init__(self, lemmatizer):
        self._lemmatizer = lemmatizer

    def fit(self, X, y=None, **fit_params):
        return self

    def transform(self, X, y=None, **fit_params):
        return np.vectorize(lambda x: clean_text(x, self._lemmatizer))(X)

    def __str__(self):
        return "CleanTextTransformer()"

    def __repr__(self):
        return self.__str__()


class T2PITransformer(TransformerMixin):
    @staticmethod
    def _max_weight(x, pbar, word_word_pr_distr_prime):
        pbar.update(1)
        return word_word_pr_distr_prime.apply(lambda y: x*y, axis=0).max(0)

    @staticmethod
    def _sum_weight(x, pbar, word_word_pr_distr_prime):
        pbar.update(1)
        return word_word_pr_distr_prime.apply(lambda y: x*y, axis=0).sum(0)

    @staticmethod
    def _weighted_mean_weight(x, pbar, word_word_pr_distr_prime):
        pbar.update(1)
        xt = word_word_pr_distr_prime.apply(lambda y: x*y, axis=0)
```

```
        return (xt * (xt / xt.sum(0))).sum(0)

    def fit(self, X, y=None, **fit_params):
        X = X[:, :int(X.shape[1]/2)].toarray()

        print("creating term-term co-occurence pr matrix")
        terms = np.arange(X.shape[1])

        X = pd.DataFrame(X, columns=terms)
        self.word_word_pr_distr = pd.DataFrame(data=0.0, columns=terms,␣
↪index=terms)

        for term in tqdm(terms):
#             self.word_word_pr_distr[term] = X[X[term] > 0].sum(0) / X.sum(0)
            self.word_word_pr_distr[term] = X[X[term] > 0].sum(0) / X[term].
↪sum()

        return self

    def transform(self, X, y=None, **fit_params):
        X = X[:, int(X.shape[1]/2):].toarray()
        X = pd.DataFrame(X, columns=self.word_word_pr_distr.columns)

        print("transforming ...")

        # new_sparsity after transform
        sparsity_before = calculate_sparsity(X)

        with tqdm(total=X.shape[0]) as pbar:
            X = X.apply(self._sum_weight, axis=1, args=(pbar, self.
↪word_word_pr_distr))

        # new_sparsity after transform
        sparsity_after = calculate_sparsity(X)

        print("sparsity(X):")
        print(f"=> before {sparsity_before:.4f}")
        print(f"=>  after {sparsity_after:.4f}")
        print()

        return X

    def __str__(self):
        return "T2PITransformer()"

    def __repr__(self):
        return self.__str__()
```

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

1 Load Data

[6]:
```
# total number of samples needed
randomize = False

# retrieve dataset
categories = ['rec.autos', 'talk.politics.mideast', 'alt.atheism', 'sci.space']

all_docs = fetch_20newsgroups(subset='train', shuffle=randomize,␣
 ↪remove=('headers', 'footers', 'quotes'), categories=categories)
categories = all_docs.target_names
```

[7]:
```
print(all_docs.data[0])
```

```
I think that domestication will change behavior to a large degree.
Domesticated animals exhibit behaviors not found in the wild.  I
don't think that they can be viewed as good representatives of the
wild animal kingdom, since they have been bred for thousands of years
to produce certain behaviors, etc.
```

1.0.1 Create Dataframe

[8]:
```
data = pd.DataFrame(
    data={
        "text":all_docs.data,
        "label":all_docs.target
    }
)

data.head()
```

[8]:

	text	label
0	\n\nI think that domestication will change beh…	0
1	\nI don't like this comment about "Typical" th…	3
2	\n<apparently you're not a woman - my husband …	1
3	While not exactly a service incident, I had a …	1
4	\n\nI think I can. Largely as a result of effo…	2

1.0.2 Label Frequency

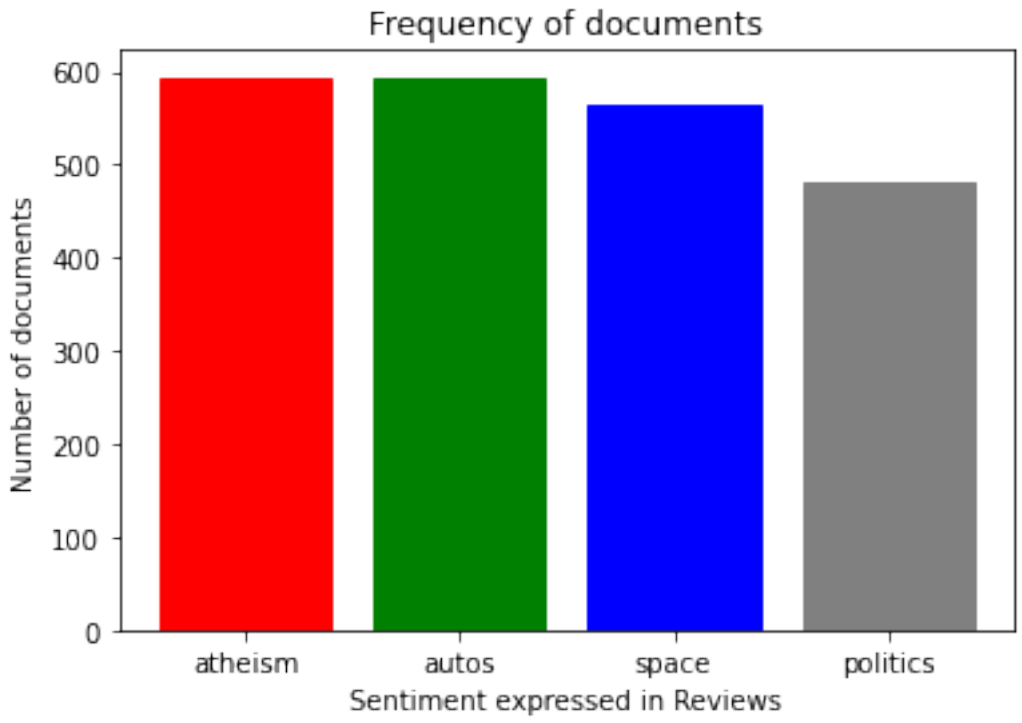
[9]:
```
print(data["label"].value_counts())
print()

barlist = plt.bar(categories, data["label"].value_counts())

plt.title("Frequency of documents")
plt.xticks(categories, list(map(lambda x: x.split(".")[1], categories)))
plt.ylabel('Number of documents')
plt.xlabel('Sentiment expressed in Reviews')

barlist[0].set_color('red')
barlist[1].set_color('green')
barlist[2].set_color('blue')
barlist[3].set_color('grey')
plt.show()
```

```
1    594
2    593
3    564
0    480
Name: label, dtype: int64
```



The Dataset labels needs to be balanced

1.0.3 Parameters

[11]:
```
min_df = 3
stop_words = "english"

def get_classifier():
#     return GaussianNB()
    return MultinomialNB()

def get_lemmatizer():
#     return WordNetLemmatizer().lemmatize
    return lambda x: x
```

2 Select Valid Data

[12]:
```
max_size_per_class = 150

# remove long text
indices = data["text"].apply(data_isvalid, args=(lambda x: clean_text(x,␣
 ↪get_lemmatizer()), 256, 512))
data = data[indices]

# make classes balanced
class_indices = []

for index in range(4):
    class_indices.append(np.where((data["label"] == index))[0])

size_per_class = min(max_size_per_class, min(map(len, class_indices)))
indices = np.concatenate([class_ids[:size_per_class] for class_ids in␣
 ↪class_indices])

data = data.iloc[indices]

data.head()
```

[12]:

	text	label
0	\n\nI think that domestication will change beh…	0
30	\n[rest deleted…]\n\nYou were a liberal arts…	0
36	\nWorse? Maybe not, but it is definately a vi…	0
63	\nCould you expand on your definition of knowi…	0
65	\nLooking at historical evidence such 'perfect…	0

[13]:
```
print(data.iloc[0]["text"])
```

I think that domestication will change behavior to a large degree. Domesticated animals exhibit behaviors not found in the wild. I don't think that they can be viewed as good representatives of the wild animal kingdom, since they have been bred for thousands of years to produce certain behaviors, etc.

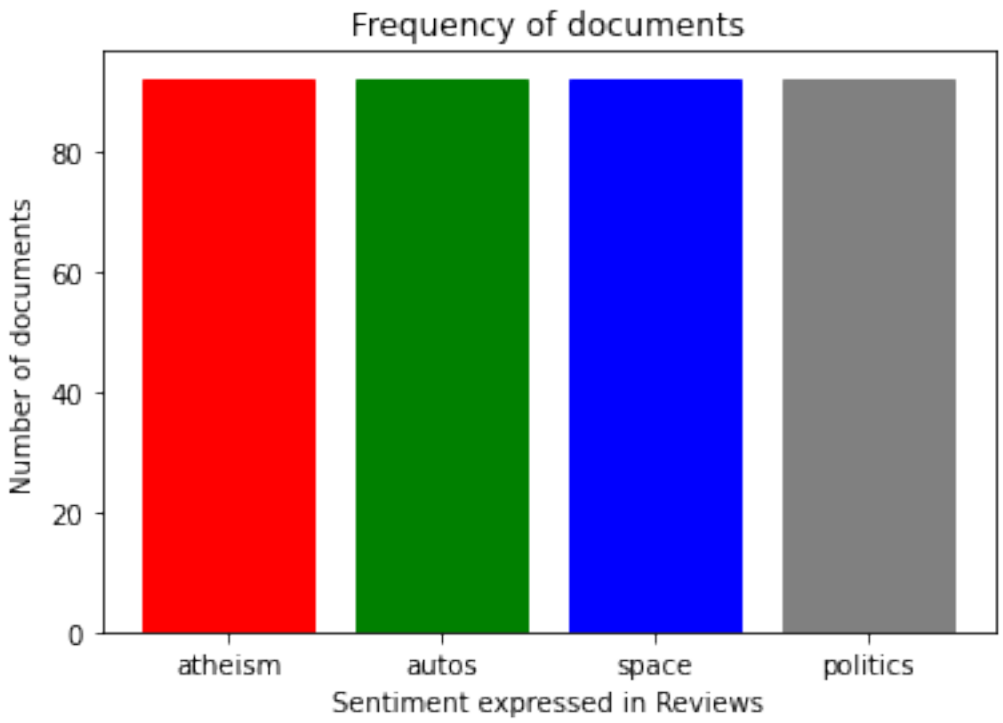
[14]:
```
print(data["label"].value_counts())
print()

barlist = plt.bar(categories, data["label"].value_counts())

plt.title("Frequency of documents")
plt.xticks(categories, list(map(lambda x: x.split(".")[1], categories)))
plt.ylabel('Number of documents')
plt.xlabel('Sentiment expressed in Reviews')

barlist[0].set_color('red')
barlist[1].set_color('green')
barlist[2].set_color('blue')
barlist[3].set_color('grey')
plt.show()
```

```
3    92
2    92
1    92
0    92
Name: label, dtype: int64
```



2.0.1 initialize input and output

[15]:
```
X = data["text"]
y = data['label']

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.25,␣
↪random_state=42)
```

2.0.2 initialize recursive word infer model

[16]:
```
# initialize model
t2pi_model = get_pipeline("count", get_classifier(), use_t2pi=True,␣
↪min_df=min_df, stop_words=None, lemmatizer = get_lemmatizer())
t2pi_model
```

[16]:
```
Pipeline(steps=[('clean_text', CleanTextTransformer()),
                ('vectorizers',
                 FeatureUnion(transformer_list=[('count_binary',
                                                 CountVectorizer(binary=True,
                                                                 min_df=3)),
                                                ('count',
                                                 CountVectorizer(min_df=3))])),
                ('t2pi_transformer', T2PITransformer()),
```

```
                  ('classifier', MultinomialNB())])
```

[17]:
```
# fit model
t2pi_model.fit(X_train, y_train)
```

```
creating term-term co-occurence pr matrix
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=864.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=276.0),␣
 ↪HTML(value='')))
```

```
sparsity(X):
=> before 0.9578
=>  after 0.0000
```

[17]:
```
Pipeline(steps=[('clean_text', CleanTextTransformer()),
                ('vectorizers',
                 FeatureUnion(transformer_list=[('count_binary',
                                                 CountVectorizer(binary=True,
                                                                 min_df=3)),
                                                ('count',
                                                 CountVectorizer(min_df=3))])),
                ('t2pi_transformer', T2PITransformer()),
                ('classifier', MultinomialNB())])
```

[18]:
```
y_pred = t2pi_model.predict(X_test) #predict testing data

print(classification_report(y_test, y_pred))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=92.0),␣
 ↪HTML(value='')))
```

```
sparsity(X):
=> before 0.9606
=>  after 0.0000
```

```
              precision    recall  f1-score   support

           0       0.79      0.73      0.76        30
           1       0.59      0.84      0.70        19
```

```
           2       0.86      0.57      0.69        21
           3       0.65      0.68      0.67        22

    accuracy                           0.71        92
   macro avg       0.72      0.71      0.70        92
weighted avg       0.73      0.71      0.71        92
```

2.0.3 Initialize models

[29]:
```
# normal model
count_model = get_pipeline("count", get_classifier(), use_t2pi=False,␣
 ↪min_df=min_df, stop_words=None, lemmatizer = get_lemmatizer())
count_sw_model = get_pipeline("count", get_classifier(), use_t2pi=False,␣
 ↪min_df=min_df, stop_words=stop_words, lemmatizer = get_lemmatizer())

tfidf_model = get_pipeline("tfidf", get_classifier(), use_t2pi=False,␣
 ↪min_df=min_df, stop_words=None, lemmatizer = get_lemmatizer())
tfidf_sw_model = get_pipeline("tfidf", get_classifier(), use_t2pi=False,␣
 ↪min_df=min_df, stop_words=stop_words, lemmatizer = get_lemmatizer())

# model
t2pi_count_model = get_pipeline("count", get_classifier(), use_t2pi=True,␣
 ↪min_df=min_df, stop_words=None, lemmatizer = get_lemmatizer())
t2pi_count_sw_model = get_pipeline("count", get_classifier(), use_t2pi=True,␣
 ↪min_df=min_df, stop_words=stop_words, lemmatizer = get_lemmatizer())

t2pi_tfidf_model = get_pipeline("tfidf", get_classifier(), use_t2pi=True,␣
 ↪min_df=min_df, stop_words=None, lemmatizer = get_lemmatizer())
t2pi_tfidf_sw_model = get_pipeline("tfidf", get_classifier(), use_t2pi=True,␣
 ↪min_df=min_df, stop_words=stop_words, lemmatizer = get_lemmatizer())

models = {
    "count_model": count_model,
    "count_sw_model": count_model,
    "tfidf_model": tfidf_model,
    "tfidf_sw_model": tfidf_sw_model,
    "t2pi_count_model": t2pi_count_model,
    "t2pi_count_sw_model": t2pi_count_sw_model,
    "t2pi_tfidf_model": t2pi_tfidf_model,
    "t2pi_tfidf_sw_model": t2pi_tfidf_sw_model
}
```

2.0.4 Running Cross validation on all Models

[30]:
```
split_size = 3
skf = StratifiedKFold(n_splits=split_size, shuffle=True, random_state=100)

index = 0
macro_f1_scores, weighted_f1_scores, accuracies = [], [], []

for train_index, test_index in skf.split(X, y):
    index += 1

    x_train_fold, x_test_fold = X.iloc[train_index], X.iloc[test_index]
    y_train_fold, y_test_fold = y.iloc[train_index], y.iloc[test_index]

    accuracies.append([])
    macro_f1_scores.append([])
    weighted_f1_scores.append([])

    for model_name, model in models.items():
        print(f'-> {index}. {model_name} \n{"="*100}\n')
        model.fit(x_train_fold, y_train_fold)
        y_pred = model.predict(x_test_fold)

        accuracy = accuracy_score(y_test_fold, y_pred)
        weighted_f1_score = calculate_f1_score(y_test_fold, y_pred,␣
↪average='weighted')
        macro_f1_score = calculate_f1_score(y_test_fold, y_pred,␣
↪average='macro')

        weighted_f1_scores[-1].append(weighted_f1_score)
        macro_f1_scores[-1].append(macro_f1_score)
        accuracies[-1].append(accuracy)
```

```
-> 1. count_model
====================================================================================
====================

-> 1. count_sw_model
====================================================================================
====================

-> 1. tfidf_model
====================================================================================
====================

-> 1. tfidf_sw_model
====================================================================================
====================
```

```
-> 1. t2pi_count_model
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=765.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=245.0),␣
 ↪HTML(value='')))


sparsity(X):
=> before 0.9539
=>  after 0.0000

transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=123.0),␣
 ↪HTML(value='')))


sparsity(X):
=> before 0.9561
=>  after 0.0000

-> 1. t2pi_count_sw_model
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=567.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=245.0),␣
 ↪HTML(value='')))


sparsity(X):
=> before 0.9769
=>  after 0.1902

transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=123.0),␣
 ↪HTML(value='')))


sparsity(X):
=> before 0.9813
=>  after 0.2021

-> 1. t2pi_tfidf_model
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=765.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=245.0),␣
 ↪HTML(value='')))


sparsity(X):
=> before 0.9539
=>  after 0.0000

transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=123.0),␣
 ↪HTML(value='')))


sparsity(X):
=> before 0.9561
=>  after 0.0000

-> 1. t2pi_tfidf_sw_model
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=567.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=245.0),␣
 ↪HTML(value='')))
```

```
sparsity(X):
=> before 0.9769
=>  after 0.1902

transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=123.0),␣
 ↪HTML(value='')))
```

```
sparsity(X):
=> before 0.9813
=>  after 0.2021

-> 2. count_model
================================================================================
====================

-> 2. count_sw_model
================================================================================
====================

-> 2. tfidf_model
================================================================================
====================

-> 2. tfidf_sw_model
================================================================================
====================

-> 2. t2pi_count_model
================================================================================
====================

creating term-term co-occurence pr matrix
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=805.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=245.0),␣
 ↪HTML(value='')))
```

```
sparsity(X):
=> before 0.9552
=>  after 0.0001
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=123.0),␣
 ↪HTML(value='')))
```

```
sparsity(X):
=> before 0.9587
=>  after 0.0000

-> 2. t2pi_count_sw_model
================================================================================
====================

creating term-term co-occurence pr matrix
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=614.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=245.0),␣
 ↪HTML(value='')))
```

```
sparsity(X):
=> before 0.9778
=>  after 0.2109

transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=123.0),␣
 ↪HTML(value='')))
```

```
sparsity(X):
=> before 0.9823
=>  after 0.2030

-> 2. t2pi_tfidf_model
================================================================================
====================

creating term-term co-occurence pr matrix
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=805.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=245.0),␣
 ↪HTML(value='')))


sparsity(X):
=> before 0.9552
=>  after 0.0001

transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=123.0),␣
 ↪HTML(value='')))


sparsity(X):
=> before 0.9587
=>  after 0.0000

-> 2. t2pi_tfidf_sw_model
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=614.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=245.0),␣
 ↪HTML(value='')))


sparsity(X):
=> before 0.9778
=>  after 0.2109

transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=123.0),␣
 ↪HTML(value='')))


sparsity(X):
=> before 0.9823
=>  after 0.2030

-> 3. count_model
================================================================================
====================
```

```
-> 3. count_sw_model
================================================================================
====================

-> 3. tfidf_model
================================================================================
====================

-> 3. tfidf_sw_model
================================================================================
====================

-> 3. t2pi_count_model
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=778.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=246.0),␣
 ↪HTML(value='')))


sparsity(X):
=> before 0.9531
=>  after 0.0000

transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=122.0),␣
 ↪HTML(value='')))


sparsity(X):
=> before 0.9590
=>  after 0.0001

-> 3. t2pi_count_sw_model
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=578.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=246.0),␣
 ↪HTML(value='')))
```

```
sparsity(X):
=> before 0.9766
=>  after 0.1672

transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=122.0),␣
 ↪HTML(value='')))
```

```
sparsity(X):
=> before 0.9823
=>  after 0.2105

-> 3. t2pi_tfidf_model
================================================================================
====================

creating term-term co-occurence pr matrix
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=778.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=246.0),␣
 ↪HTML(value='')))
```

```
sparsity(X):
=> before 0.9531
=>  after 0.0000

transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=122.0),␣
 ↪HTML(value='')))
```

```
sparsity(X):
=> before 0.9590
=>  after 0.0001

-> 3. t2pi_tfidf_sw_model
```

```
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=578.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=246.0),␣
 ↪HTML(value='')))


sparsity(X):
=> before 0.9766
=>  after 0.1672

transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=122.0),␣
 ↪HTML(value='')))


sparsity(X):
=> before 0.9823
=>  after 0.2105
```

[31]:
```
model_names = list(models.keys())

accuracy = pd.DataFrame(data=np.array(accuracies), columns=model_names)
weighted_f1_score = pd.DataFrame(data=np.array(weighted_f1_scores),␣
 ↪columns=model_names)
macro_f1_score = pd.DataFrame(data=np.array(macro_f1_scores),␣
 ↪columns=model_names)

accuracy.loc["mean"] = accuracy.mean(0)
weighted_f1_score.loc["mean"] = weighted_f1_score.mean(0)
macro_f1_score.loc["mean"] = macro_f1_score.mean(0)
```

[32]:
```
accuracy.head(split_size+1)
```

[32]:

	count_model	count_sw_model	tfidf_model	tfidf_sw_model	\
0	0.642276	0.642276	0.634146	0.682927	
1	0.780488	0.780488	0.723577	0.756098	
2	0.663934	0.663934	0.672131	0.721311	
mean	0.695566	0.695566	0.676618	0.720112	

```
      t2pi_count_model  t2pi_count_sw_model  t2pi_tfidf_model  \
0             0.430894             0.626016          0.577236
1             0.504065             0.626016          0.552846
2             0.450820             0.639344          0.549180
mean          0.461926             0.630459          0.559754

      t2pi_tfidf_sw_model
0                0.617886
1                0.650407
2                0.663934
mean             0.644076
```

[33]:
```
weighted_f1_score.head(split_size+1)
```

[33]:
```
      count_model  count_sw_model  tfidf_model  tfidf_sw_model  \
0        0.643803        0.643803     0.635956        0.686151
1        0.780400        0.780400     0.723008        0.751996
2        0.660720        0.660720     0.670429        0.719510
mean     0.694974        0.694974     0.676464        0.719219

      t2pi_count_model  t2pi_count_sw_model  t2pi_tfidf_model  \
0             0.427879             0.630670          0.574755
1             0.505092             0.622361          0.551767
2             0.445862             0.636208          0.535771
mean          0.459611             0.629746          0.554098

      t2pi_tfidf_sw_model
0                0.625293
1                0.648284
2                0.659674
mean             0.644417
```

[34]:
```
macro_f1_score.head(split_size+1)
```

[34]:
```
      count_model  count_sw_model  tfidf_model  tfidf_sw_model  \
0        0.644194        0.644194     0.636203        0.686592
1        0.780461        0.780461     0.723287        0.752383
2        0.661328        0.661328     0.670800        0.720057
mean     0.695328        0.695328     0.676764        0.719677

      t2pi_count_model  t2pi_count_sw_model  t2pi_tfidf_model  \
0             0.427258             0.631296          0.574399
1             0.504921             0.623087          0.552425
2             0.446160             0.635758          0.535888
mean          0.459446             0.630047          0.554237

      t2pi_tfidf_sw_model
```

```
0               0.625963
1               0.649074
2               0.659672
mean            0.644903
```

[ ]:

[ ]: