term_term_pr_distr_and_inference-multinomial-min_df-3-size-150-max

December 8, 2020

autoreload modules and utilities

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

import all neceesary libraries/packages

[32]:
```
import numpy as np
import pandas as pd

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

from sklearn.pipeline import Pipeline
from sklearn.pipeline import FeatureUnion
from sklearn.datasets import fetch_20newsgroups
from sklearn.naive_bayes import MultinomialNB, GaussianNB
from sklearn.feature_extraction.text import CountVectorizer, TfidfVectorizer

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

Utility functions

[3]:
```
## 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 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)

def plot_bars(df, ylabel, ymin=0.77):
    xlabels = ["count_model", "count_sw_model", "tfidf_model", "tfidf_sw_model"]
    accuracy_means = df[["count_model", "count_sw_model", "tfidf_model",␣
↪"tfidf_sw_model"]].loc["mean"]
    t2pi_accuracy_means = df[["t2pi_count_model", "t2pi_count_sw_model",␣
↪"t2pi_tfidf_model", "t2pi_tfidf_sw_model"]].loc["mean"]
```

```
    xvalues = np.arange(len(xlabels))  # the label locations
    width = 0.35  # the width of the bars

    fig, ax = plt.subplots()
    rects1 = ax.bar(xvalues - width/2, accuracy_means, width, label='Baseline')
    rects2 = ax.bar(xvalues + width/2, t2pi_accuracy_means, width, label='T2PI')

    # Add some text for labels, title and custom x-axis tick labels, etc.
    ax.set_ylabel(ylabel.capitalize())
    ax.set_title(f'{ylabel.capitalize()} of Baseline and T2PI')
    ax.set_ylim(ymin=ymin)
    ax.set_xticks(xvalues)
    ax.set_xticklabels(xlabels)
    ax.legend()
    plt.show()

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):
        pbar.update(1)
        return (word_word_pr.T * x).max(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)

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

        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

[4]:
```
# 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
```

[5]:
```
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

[6]:
```
data = pd.DataFrame(
    data={
        "text":all_docs.data,
        "label":all_docs.target
    }
)

data.head()
```

[6]:

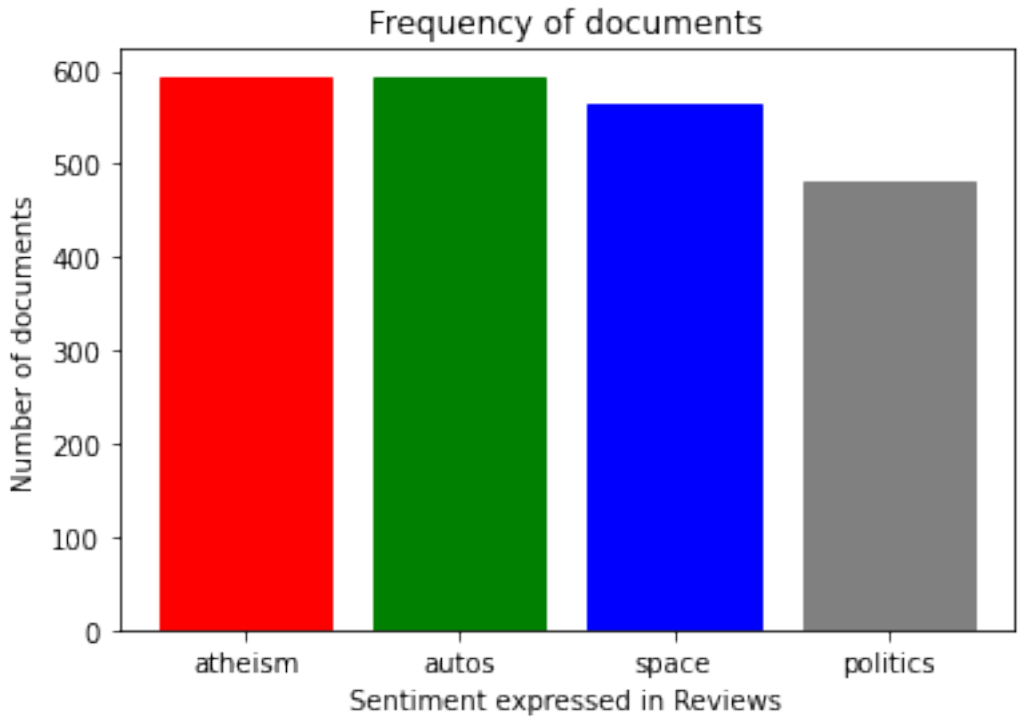
	text	label
0	\n\nI think that domestication will change beh…	0
1	\nI don't like this comment about "Typical" th…	3
2	\n<apparently you're not a woman - my husband …	1
3	While not exactly a service incident, I had a …	1
4	\n\nI think I can. Largely as a result of effo…	2

1.0.2 Label Frequency

[7]:
```
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

[15]:
```
min_df = 3
stop_words = "english"

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

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

2 Select Valid Data

[16]:
```
max_size_per_class = 150

# remove long text
```

```
indices = data["text"].apply(data_isvalid, args=(lambda x: clean_text(x,␣
 ↪get_lemmatizer()), 128, 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()
```

[16]:

	text	label
0	\n\nI think that domestication will change beh…	0
19	\n\n\tI agree, we spend too much energy on the…	0
30	\n[rest deleted…]\n\nYou were a liberal arts…	0
36	\nWorse? Maybe not, but it is definately a vi…	0
50	\n\n Could you explain what any of the above p…	0

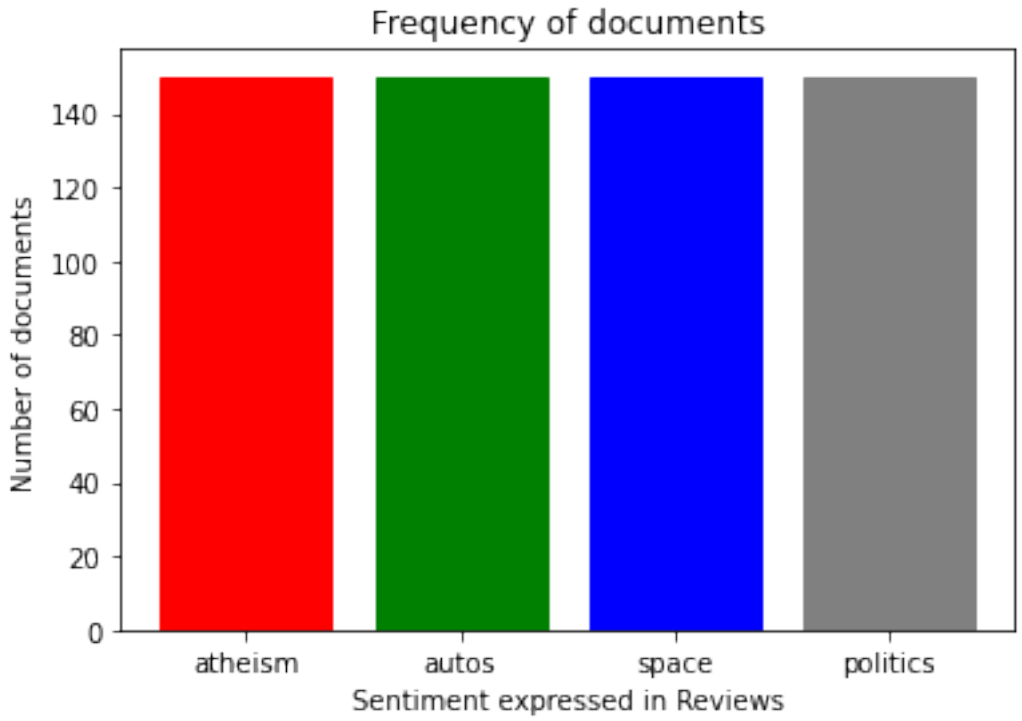
[17]:
```
print(data.iloc[0]["text"])
```

```
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.
```

[18]:
```
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    150
2    150
1    150
0    150
Name: label, dtype: int64
```



2.0.1 initialize input and output

[39]:
```
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

[40]:
```
# initialize model
t2pi_model = get_pipeline("count", get_classifier(), use_t2pi=True,␣
 ↪min_df=min_df, stop_words=None, lemmatizer = get_lemmatizer())
t2pi_model
```

[40]:
```
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())])
```

[41]:
```
# 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=1136.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=450.0),␣
 ↪HTML(value='')))
```

[41]:
```
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())])
```

[42]:
```
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=150.0),␣
 ↪HTML(value='')))
```

```
              precision    recall  f1-score   support

           0       0.71      0.67      0.69        45
           1       0.76      0.78      0.77        37
           2       0.75      0.56      0.64        32
           3       0.63      0.81      0.71        36

    accuracy                           0.71       150
   macro avg       0.71      0.70      0.70       150
weighted avg       0.71      0.71      0.70       150
```

[43]:
```
print(confusion_matrix(y_test, y_pred))
```

```
[[30  2  2 11]
 [ 3 29  3  2]
 [ 3  7 18  4]
 [ 6  0  1 29]]
```

2.0.3 Initialize models

[23]:
```
# 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

[24]:
```
split_size = 7
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=1273.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))


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

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1059.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))
```

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

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1273.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))


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

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1059.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))


-> 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=1275.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))


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

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1056.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))


-> 2. t2pi_tfidf_model
```

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

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1275.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))


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

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1056.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))


-> 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=1274.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))


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

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1057.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))


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

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

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1274.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))
```

```
-> 3. t2pi_tfidf_sw_model
================================================================================
====================
```

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

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1057.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))
```

```
-> 4. count_model
================================================================================
====================
```

```
-> 4. count_sw_model
================================================================================
====================
```

```
-> 4. tfidf_model
================================================================================
====================
```

```
-> 4. tfidf_sw_model
================================================================================
====================

-> 4. t2pi_count_model
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1274.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))


-> 4. t2pi_count_sw_model
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1057.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))


-> 4. t2pi_tfidf_model
================================================================================
====================

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

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1274.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))


-> 4. t2pi_tfidf_sw_model
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1057.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))


-> 5. count_model
================================================================================
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-> 5. count_sw_model
================================================================================
====================

-> 5. tfidf_model
================================================================================
====================

-> 5. tfidf_sw_model
================================================================================
====================
```

```
-> 5. t2pi_count_model
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1264.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))


-> 5. t2pi_count_sw_model
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1044.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))


-> 5. t2pi_tfidf_model
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1264.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))
```

```
-> 5. t2pi_tfidf_sw_model
================================================================================
====================
```

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

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1044.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=514.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=86.0),␣
 ↪HTML(value='')))
```

```
-> 6. count_model
================================================================================
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```

```
-> 6. count_sw_model
================================================================================
====================
```

```
-> 6. tfidf_model
================================================================================
====================
```

```
-> 6. tfidf_sw_model
================================================================================
====================
```

```
-> 6. t2pi_count_model
```

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

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1292.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=515.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=85.0),␣
 ↪HTML(value='')))


-> 6. t2pi_count_sw_model
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1073.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=515.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=85.0),␣
 ↪HTML(value='')))


-> 6. t2pi_tfidf_model
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1292.0),␣
 ↪HTML(value='')))


transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=515.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=85.0),␣
 ↪HTML(value='')))


-> 6. t2pi_tfidf_sw_model
================================================================================
====================

creating term-term co-occurence pr matrix

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1073.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=515.0),␣
 ↪HTML(value='')))


transforming …

HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=85.0),␣
 ↪HTML(value='')))


-> 7. count_model
================================================================================
====================

-> 7. count_sw_model
================================================================================
====================

-> 7. tfidf_model
================================================================================
====================

-> 7. tfidf_sw_model
================================================================================
====================

-> 7. t2pi_count_model
================================================================================
====================
```

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

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1287.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=515.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=85.0),␣
 ↪HTML(value='')))
```

```
-> 7. t2pi_count_sw_model
================================================================================
====================
```

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

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1069.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=515.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=85.0),␣
 ↪HTML(value='')))
```

```
-> 7. t2pi_tfidf_model
================================================================================
====================
```

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

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1287.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=515.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=85.0),␣
 ↪HTML(value='')))
```

```
-> 7. t2pi_tfidf_sw_model
================================================================================
====================
```

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

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=1069.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=515.0),␣
 ↪HTML(value='')))
```

```
transforming …
```

```
HBox(children=(HTML(value=''), FloatProgress(value=0.0, max=85.0),␣
 ↪HTML(value='')))
```

[25]:
```
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)
```

[26]:
```
accuracy.head(split_size+1)
```

[26]:

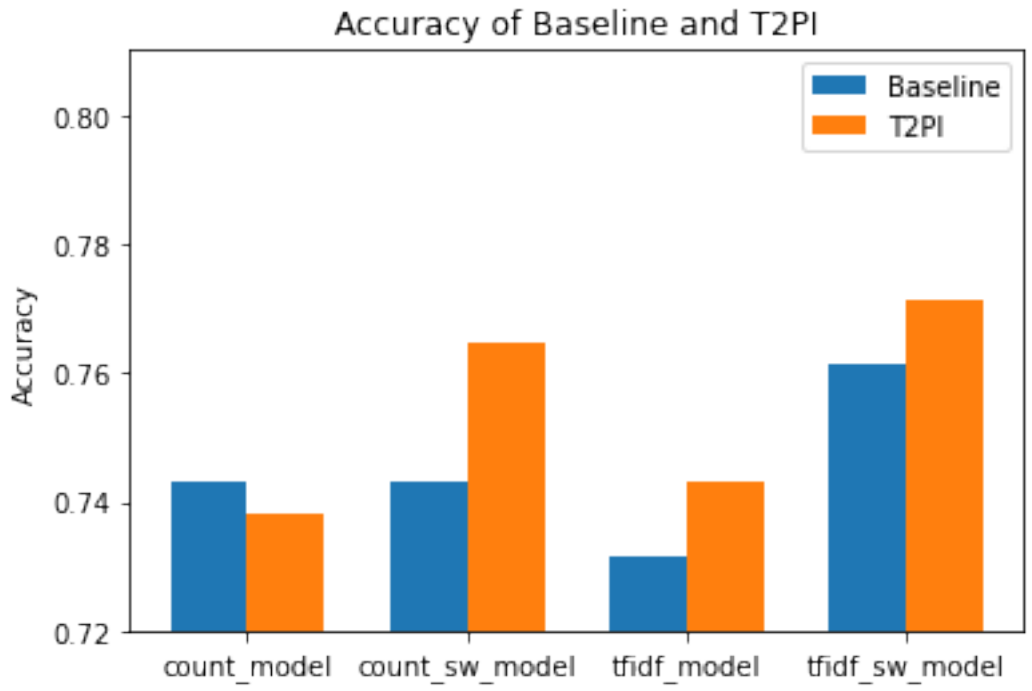
	count_model	count_sw_model	tfidf_model	tfidf_sw_model	\
0	0.790698	0.790698	0.790698	0.813953	
1	0.848837	0.848837	0.790698	0.813953	
2	0.767442	0.767442	0.720930	0.779070	
3	0.755814	0.755814	0.744186	0.744186	
4	0.639535	0.639535	0.651163	0.755814	
5	0.705882	0.705882	0.717647	0.729412	

```
6         0.694118         0.694118      0.705882         0.694118
mean      0.743189         0.743189      0.731601         0.761501

      t2pi_count_model  t2pi_count_sw_model  t2pi_tfidf_model  \
0             0.779070             0.837209          0.790698
1             0.848837             0.860465          0.837209
2             0.755814             0.767442          0.755814
3             0.744186             0.732558          0.732558
4             0.639535             0.732558          0.662791
5             0.729412             0.729412          0.729412
6             0.670588             0.694118          0.694118
mean          0.738206             0.764823          0.743228

      t2pi_tfidf_sw_model
0                0.825581
1                0.848837
2                0.790698
3                0.720930
4                0.744186
5                0.764706
6                0.705882
mean             0.771546
```

[34]:
```
plot_bars(accuracy, ylabel="accuracy", ymin=0.72)
```



[35]:
```
weighted_f1_score.head(split_size+1)
```

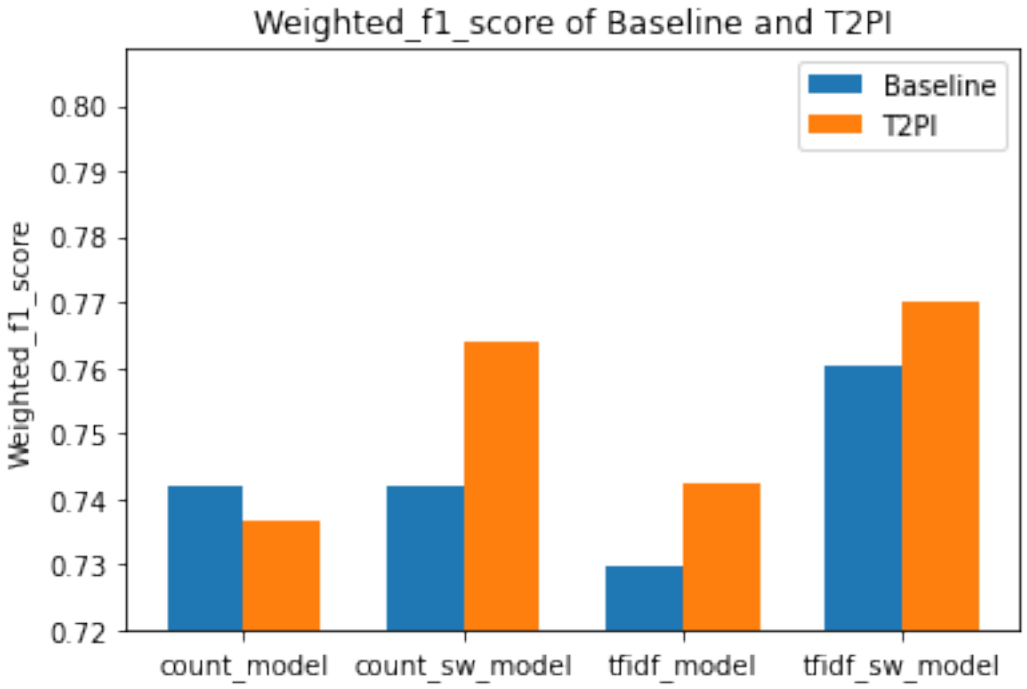
[35]:

	count_model	count_sw_model	tfidf_model	tfidf_sw_model
0	0.793588	0.793588	0.792005	0.813405
1	0.848491	0.848491	0.791508	0.813069
2	0.765940	0.765940	0.717751	0.775940
3	0.755232	0.755232	0.742546	0.744384
4	0.633116	0.633116	0.644383	0.751040
5	0.703328	0.703328	0.715738	0.730247
6	0.693308	0.693308	0.704881	0.693997
mean	0.741857	0.741857	0.729830	0.760297

	t2pi_count_model	t2pi_count_sw_model	t2pi_tfidf_model
0	0.780646	0.838026	0.790735
1	0.848610	0.860938	0.837316
2	0.752918	0.762584	0.752351
3	0.744013	0.731442	0.733177
4	0.633116	0.731213	0.660776
5	0.727592	0.729392	0.727805
6	0.669074	0.694041	0.694385
mean	0.736567	0.763948	0.742363

	t2pi_tfidf_sw_model
0	0.825307
1	0.848837
2	0.787803
3	0.717978
4	0.739650
5	0.765708
6	0.705617
mean	0.770129

[36]:
```
plot_bars(weighted_f1_score, ylabel="weighted_f1_score", ymin=0.72)
```



[37]:
```
macro_f1_score.head(split_size+1)
```

[37]:

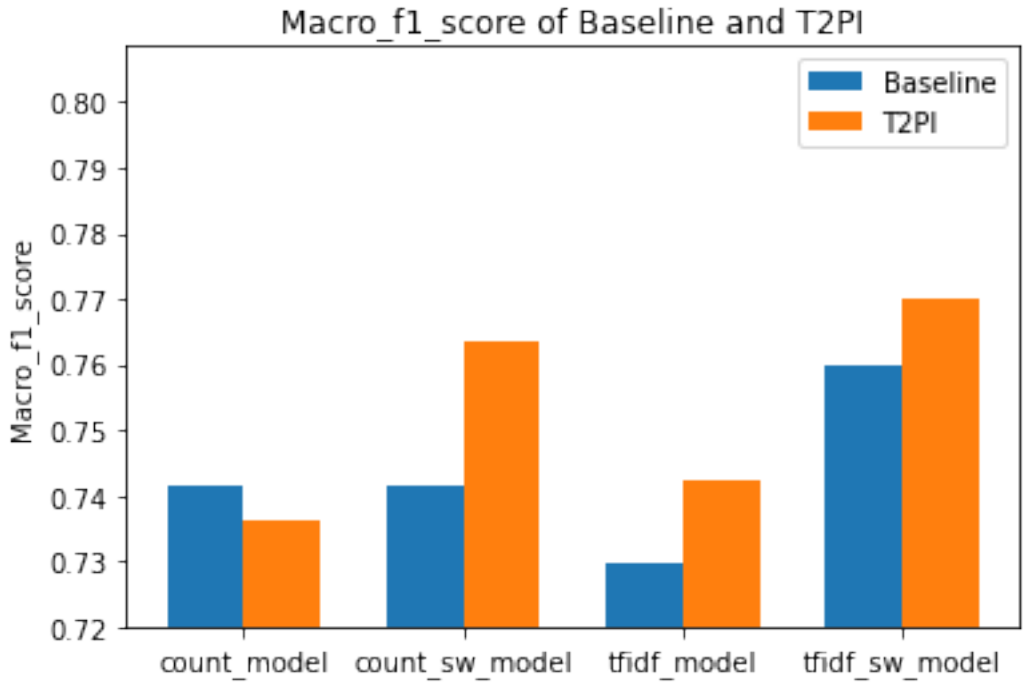
	count_model	count_sw_model	tfidf_model	tfidf_sw_model
0	0.793105	0.793105	0.791674	0.813710
1	0.848370	0.848370	0.791588	0.812626
2	0.766720	0.766720	0.718401	0.775478
3	0.754968	0.754968	0.742405	0.743709
4	0.632754	0.632754	0.643963	0.751143
5	0.702384	0.702384	0.714735	0.730082
6	0.693096	0.693096	0.704661	0.693601
mean	0.741628	0.741628	0.729632	0.760050

	t2pi_count_model	t2pi_count_sw_model	t2pi_tfidf_model
0	0.780392	0.838588	0.791070
1	0.848722	0.860613	0.837459
2	0.753387	0.762010	0.752624
3	0.743818	0.730341	0.733305
4	0.632754	0.731071	0.660436
5	0.726937	0.729081	0.726503
6	0.669103	0.693838	0.694186
mean	0.736445	0.763649	0.742226

	t2pi_tfidf_sw_model
0	0.825896

```
1               0.848787
2               0.787701
3               0.716959
4               0.739606
5               0.765829
6               0.705514
mean            0.770042
```

[38]:
```
plot_bars(macro_f1_score, ylabel="macro_f1_score", ymin=0.72)
```



[ ]:
```

```