Assignment - to apply KNN algo on BoW, TfIDF, W2V, TfIdf-W2V vectorizers

In [1]:
```
#importing general purpose libraries:
import psutil
import os
import sys
import datetime
import time
import warnings
import pickle
warnings.filterwarnings('ignore')
#importing EDA libraries and maths libraries
warnings.filterwarnings('ignore', 'Data with input dtype int64 was conv
erted to float64 by StandardScaler.')
import pandas as pd
import numpy as np
import scipy as sc
import math
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
#from mlxtend.plotting import plot_decision_regions #for decision surfa
ce:
```

importing performance metric libraries

In [2]:
```
#importing KNN relevant libraries:
from sklearn.neighbors import KNeighborsClassifier
from sklearn.model_selection import cross_val_score

#importing performance libraries:
from sklearn.metrics import f1_score
from sklearn.metrics import confusion_matrix
from sklearn.metrics import precision_score
```

```
from sklearn.metrics import precision_recall_curve
from sklearn.metrics import roc_curve
from sklearn.metrics import roc_auc_score
from sklearn.metrics import auc

#train test split libaries:
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
```

In [3]:
```
#checking current memory utilization:
psutil.virtual_memory()
```

Out[3]:
```
svmem(total=25285955584, available=21555621888, percent=14.8, used=3381
485568, free=20653178880, active=4049473536, inactive=346533888, buffer
s=53899264, cached=1197391872, shared=11333632, slab=68972544)
```

In [4]:
```
#importing the preprocessed file in database.
import sqlite3
con = sqlite3.connect('/home/jalesh_j/Data_Preprocessing/cleaned.sqlit
e')
df = pd.read_sql_query("""select * from cleandf""", con)
```

In [5]:
```
df.columns
```

Out[5]:
```
Index(['index', 'Score', 'Time', 'Text', 'Summary', 'cleanedtext',
       'numeric_score', 'bow_feat', 'bow_new_feat', 'tfw2v_feat'],
      dtype='object')
```

unfeatured engineering preprocessed text

In [6]:
```
#tfidf, w2v, tfidf-w2v cleaned text
print(df['Text'].head(3))

print('\n' * 2)

#bow cleaned text
print(df['cleanedtext'].head(2))
```

```
0    i have bought several of the vitality canned d...
1    product arrived labeled as jumbo salted peanut...
2    this is a confection that has been around a fe...
Name: Text, dtype: object
```

```
0    bought sever vital can dog food product found ...
1    product arriv label jumbo salt peanut peanut a...
Name: cleanedtext, dtype: object
```

In [7]:
```
len(df)
```

Out[7]:
```
364171
```

sorting the datframe based on time:

In [8]:
```
#sorting the datframe based on time:
df = df.sort_values('Time', ascending=True)
df['Time'].head(8)
```

Out[8]:
```
117924    939340800
117901    940809600
298792    944092800
169281    944438400
298791    946857600
169342    947376000
169267    948240000
63317     948672000
Name: Time, dtype: int64
```

taking 50000 samples

In [9]:
```
d = df.head(50000)
x = d['cleanedtext']
y = d['numeric_score'].apply(lambda x: 0 if int(x) < 3 else 1)
y.value_counts()
```

```
Out[9]: 1    44377
0     5623
Name: numeric_score, dtype: int64
```

1.BoW-BruteForce implementation

```
In [9]: #train test split:
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split

xt, xtest, yt, ytest = train_test_split(x, y, test_size=0.2, shuffle=Fa
lse)
xtr, xcv, ytr, ycv = train_test_split(xt, yt, test_size=0.2, shuffle=Fa
lse)
```

```
In [10]: print(ytr.value_counts())
```

```
1    28510
0     3490
Name: numeric_score, dtype: int64
```

balancing the dataset

```
In [11]: %%time

dtrain = pd.concat([xtr, ytr], axis=1)
print(dtrain.head(2))
d0 = dtrain[dtrain['numeric_score'] == 0.0]
d1 = dtrain[dtrain['numeric_score'] == 1.0]
print()
print(dtrain.head(2))
print()
print(d0.head(4))

d1_count, d0_count = ytr.value_counts()
```

```python
print(d1_count)
print(d0_count)

#oversampling of minority class:
d0_over = d0.sample(d1_count, replace=True)
print(len(d0_over))

#concatenation:
dtrain = pd.concat([d1, d0_over], axis=0)
print(len(dtrain))
```

```
                                              cleanedtext  numeric_scor
e
117924  witti littl book make son laugh loud recit car...
1
117901  rememb see show air televis year ago child sis...
1

                                              cleanedtext  numeric_scor
e
117924  witti littl book make son laugh loud recit car...
1
117901  rememb see show air televis year ago child sis...
1

                                              cleanedtext  numeric_scor
e
169267  alway enjoy movi funni entertain didn hesit pi...
0
298797  michael keaton bring distinguish characterist ...
0
169263  continu amaz shoddi treatment movi get dvd rel...
0
169266  let know movi one person favorit ghost movi sa...
0
28510
3490
28510
57020
```

```
CPU times: user 40 ms, sys: 0 ns, total: 40 ms
Wall time: 84.3 ms
```

In [12]:
```
dtrain.numeric_score.value_counts()
```

Out[12]:
```
1    28510
0    28510
Name: numeric_score, dtype: int64
```

Instantiating Bow object

In [13]:
```
%time
#importing Bow library:
from sklearn.feature_extraction.text import CountVectorizer
bow = CountVectorizer(ngram_range=(1, 1))
xtr = bow.fit_transform(dtrain['cleanedtext'])
xcv = bow.transform(xcv)
xtest = bow.transform(xtest)
```

```
CPU times: user 0 ns, sys: 0 ns, total: 0 ns
Wall time: 6.2 µs
```

Standardizing data

In [14]:
```
#standardizing the data:
sc = StandardScaler(with_mean=False)
xtr = sc.fit_transform(xtr)
xcv = sc.transform(xcv)
xtest = sc.transform(xtest)
print(xtr.shape)
print(xcv.shape)
print(xtest.shape)
```

```
(57020, 23081)
(8000, 23081)
(10000, 23081)
```

```
/home/jalesh_j/.local/lib/python3.5/site-packages/sklearn/utils/validat
ion.py:595: DataConversionWarning: Data with input dtype int64 was conv
erted to float64 by StandardScaler.
  warnings.warn(msg, DataConversionWarning)
/home/jalesh_j/.local/lib/python3.5/site-packages/sklearn/utils/validat
ion.py:595: DataConversionWarning: Data with input dtype int64 was conv
erted to float64 by StandardScaler.
  warnings.warn(msg, DataConversionWarning)
/home/jalesh_j/.local/lib/python3.5/site-packages/sklearn/utils/validat
ion.py:595: DataConversionWarning: Data with input dtype int64 was conv
erted to float64 by StandardScaler.
  warnings.warn(msg, DataConversionWarning)
/home/jalesh_j/.local/lib/python3.5/site-packages/sklearn/utils/validat
ion.py:595: DataConversionWarning: Data with input dtype int64 was conv
erted to float64 by StandardScaler.
  warnings.warn(msg, DataConversionWarning)
```

KNN on BoW

In [16]:

```
#checking memory usage:
psutil.virtual_memory()
```

Out[16]:

```
svmem(total=25286242304, available=23465373696, percent=7.2, used=14673
46944, free=22748409856, active=1385566208, inactive=940220416, buffers
=41017344, cached=1029468160, shared=19644416, slab=57643008)
```

In [17]:

```
%%time

pre_rec_tr_dict = {}
pre_rec_cv_dict = {}
auc_cv_dict = {}
auc_tr_dict = {}


for i in range(3, 50, 4):
    knn = KNeighborsClassifier(n_neighbors=i, algorithm='brute', weight
s='uniform', n_jobs=-1)
    knn.fit(xtr, dtrain['numeric_score'])
```

```
    #performance metrics for cv data:
    y_pred_cv = knn.predict_proba(xcv)
    fpr_cv, tpr_cv, thresholds_cv = roc_curve(ycv, y_pred_cv[:,1])
    auc_cv_dict[i] = auc(fpr_cv, tpr_cv)
    #pre_cv, rec_cv, threshold_cv = precision_recall_curve(ycv, y_pred_
cv[:,1])
    #pre_rec_cv_dict[i] = [pre_cv, rec_cv]

    #performance metrics for training data:
    y_pred_tr = knn.predict_proba(xtr)
    fpr_tr, tpr_tr, thresholds_tr = roc_curve(dtrain['numeric_score'],
y_pred_tr[:,1])
    auc_tr_dict[i] = auc(fpr_tr, tpr_tr)
    #pre_tr, rec_tr, threshold_tr = precision_recall_curve(ytr, y_pred_
tr[:,1])
    #pre_rec_tr_dict[i] = [pre_tr, rec_tr]
```

```
CPU times: user 15min 4s, sys: 20min 20s, total: 35min 25s
Wall time: 43min 14s
```

In [18]:
```
psutil.virtual_memory()
```

Out[18]:
```
svmem(total=25286242304, available=11378216960, percent=55.0, used=1355
3856512, free=10659201024, active=13438607360, inactive=934817792, buff
ers=41926656, cached=1031258112, shared=19709952, slab=60669952)
```

Sorting dictionaries on values(AUC score) on training and cv auc score

In [19]:
```
# print('AUC of cross validation dictionary is :\n{}'.format(auc_cv_dic
t))
# print('*' * 70)
# print('AUC score of training dataset is :\n{}'.format(auc_tr_dict))
# print('*' * 70)

#sorting dictionary wrt higest AuC Score of both training and cv data:

cv_tup = sorted(auc_cv_dict.items(), key= lambda x: x[1],reverse=True)
tr_tup = sorted(auc_tr_dict.items(), key= lambda x: x[1],reverse=True)
```

```
print(cv_tup)
print('*' * 70)
print(tr_tup)
```

```
[(47, 0.7250877621644958), (43, 0.7204434997338767), (39, 0.71651854756
60079), (35, 0.7147030281699575), (31, 0.7093259068243791), (27, 0.6984
376402497201), (23, 0.6914156663373421), (19, 0.6760919867266317), (15,
0.6584377849739597), (11, 0.6405028335928362), (7, 0.6199026467753976),
(3, 0.5748837086848861)]
**********************************************************************
[(3, 0.999909016767671), (7, 0.9920147256447029), (11, 0.96030240209364
89), (15, 0.9312283677532088), (19, 0.9131611373783693), (23, 0.9023043
16170331), (27, 0.8956959301326334), (31, 0.8910559932019397), (35, 0.8
888873017534876), (39, 0.8854622886417303), (43, 0.8829095497269324),
(47, 0.8797871078729476)]
```

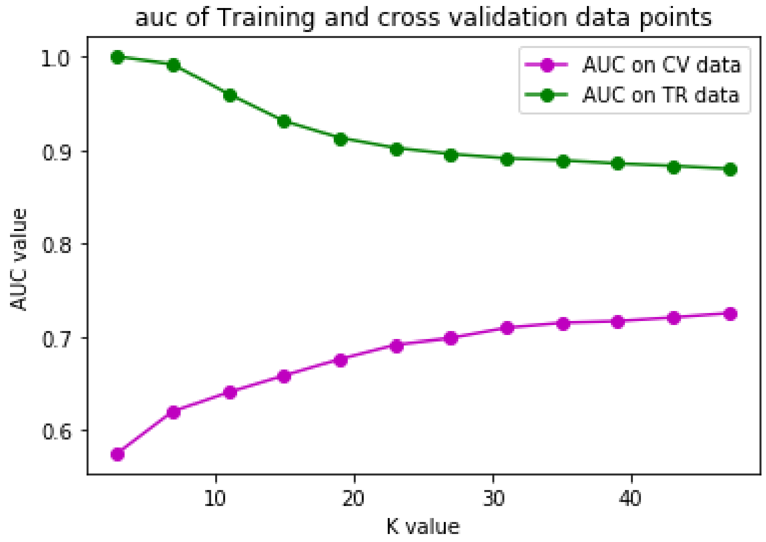
Plotting AUC Curve on training and cv data

In [20]:

```
plt.plot([x[0] for x in cv_tup], [x[1] for x in cv_tup], linestyle='-',
 color='m', marker='o',label='AUC on CV data')
plt.plot([x[0] for x in tr_tup], [x[1] for x in tr_tup], linestyle='-',
 color='g', marker='o', label='AUC on TR data')
#plt.plot([0, 1], [0, 1], linestyle='--')
plt.xlabel("K value")
plt.ylabel('AUC value')
plt.title('auc of Training and cross validation data points')
plt.legend()
```

Out[20]:

```
<matplotlib.legend.Legend at 0x7f4eb22f1a58>
```



KNN brute force algo on optimal K

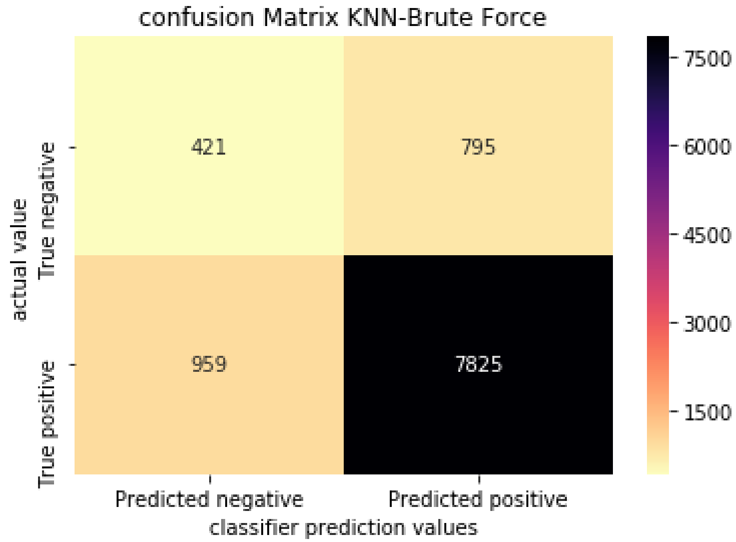
In [23]:
```
knn = KNeighborsClassifier(n_neighbors=47, algorithm='brute', weights=
'uniform', n_jobs=-1)
knn.fit(xtr, dtrain['numeric_score'])
#performance metrics for cv data:
y_pred_test = knn.predict_proba(xtest)
y_pred = knn.predict(xtest)
fpr_test, tpr_test, thresholds_test= roc_curve(ytest, y_pred_test[:,1])
auc_test = auc(fpr_test, tpr_test)
print(auc_test)

y_pred_tr = knn.predict_proba(xtr)
fpr_tr, tpr_tr, thresholds_tr = roc_curve(dtrain['numeric_score'], y_pr
ed_tr[:,1])
```

```
0.7304104708171557
```

Plotting confusion matrix

In [24]:
```
%time
#creating confusion matrix:

cf = confusion_matrix(ytest, y_pred)
labels = ['True negative', 'True positive']

df_cf = pd.DataFrame(cf, index=labels, columns=['Predicted negative',
'Predicted positive'])
sns.heatmap(df_cf, annot=True,fmt='3d', cmap='magma_r')

plt.title("confusion Matrix KNN-Brute Force")
plt.xlabel("classifier prediction values")
plt.ylabel("actual value")
plt.show()
```

```
CPU times: user 0 ns, sys: 0 ns, total: 0 ns
Wall time: 6.2 µs
```

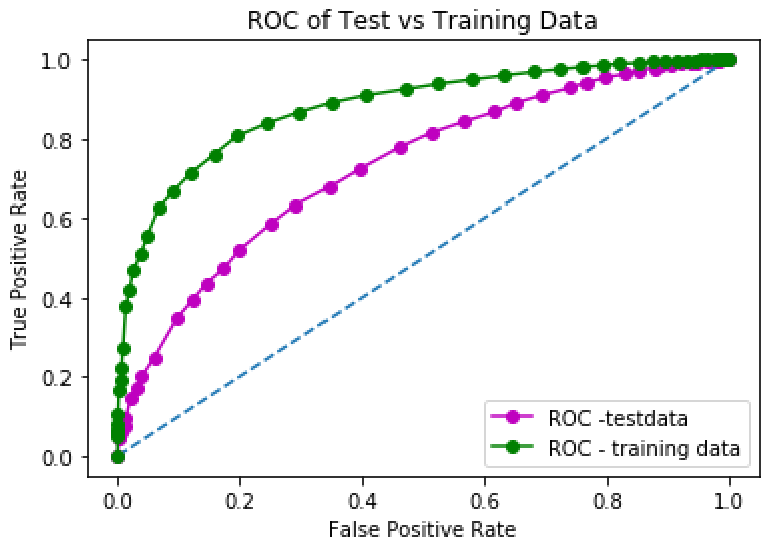


Plotting ROC of test and Training data

In [25]:
```
plt.plot(fpr_test, tpr_test, color='m', marker='o',label='ROC -testdat
```

```
a')
plt.plot([0, 1], [0, 1], linestyle='--')
plt.plot(fpr_tr, tpr_tr, linestyle='-', color='g', marker='o', label='R
OC - training data')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC of Test vs Training Data')
plt.legend()
```

Out[25]: <matplotlib.legend.Legend at 0x7f4eb5cf3d30>



BowBruteForce - optimal k = 47 , AUC = 0.73

In [26]:

```
#checking memory usage:
psutil.virtual_memory()
```

Out[26]: svmem(total=25286242304, available=16968077312, percent=32.9, used=7972675584, free=16923115520, active=7925469184, inactive=216117248, buffers=21594112, cached=368857088, shared=19709952, slab=42926080)

2. BOW - KDtree implementation

In [10]:
```
#train test split:
xt, xtest, yt, ytest = train_test_split(x, y, test_size=0.2, shuffle=Fa
lse)
xtr, xcv, ytr, ycv = train_test_split(xt, yt, test_size=0.2, shuffle=Fa
lse)

#balancing the training dataset:
dtrain = pd.concat([xtr, ytr], axis=1)
print(dtrain.head(2))
d0 = dtrain[dtrain['numeric_score'] == 0.0]
d1 = dtrain[dtrain['numeric_score'] == 1.0]

d1_count, d0_count = ytr.value_counts()
print(d1_count)
print(d0_count)

#oversampling of minority class:
d0_over = d0.sample(d1_count, replace=True)
print(len(d0_over))

#concatenation:
dtrain = pd.concat([d1, d0_over], axis=0)
print(len(dtrain))
```

```
                                              cleanedtext  numeric_scor
e
117924  witti littl book make son laugh loud recit car...
1
117901  rememb see show air televis year ago child sis...
1
28510
3490
28510
57020
```

instantiating BoW featurizer

In [12]:
```
#instantiating BoW featurizer:
from sklearn.feature_extraction.text import CountVectorizer
bow = CountVectorizer(ngram_range=(1, 1),min_df=10)
xtr = bow.fit_transform(dtrain['cleanedtext'])
xcv = bow.transform(xcv)
xtest = bow.transform(xtest)

print(xtr.shape)
print(xcv.shape)
print(xtest.shape)
```

```
(57020, 7235)
(8000, 7235)
(10000, 7235)
```

converting into dense matrix and reducing the dimesnion

In [13]:
```
from sklearn.decomposition import TruncatedSVD
tsvd = TruncatedSVD(n_components=500)

xtr = tsvd.fit_transform(xtr)
xcv = tsvd.transform(xcv)
xtest = tsvd.transform(xtest)

print(xtr.shape)
print(xcv.shape)
print(xtest.shape)
```

```
(57020, 500)
(8000, 500)
(10000, 500)
```

Standardizing data

In [15]:
```
sc = StandardScaler(with_mean=False)
```

```
xtr = sc.fit_transform(xtr)
xcv = sc.transform(xcv)
xtest = sc.transform(xtest)
```

Bow-KNN-KDtree

In [16]:
```
%%time

auc_cv_dict = {}
auc_tr_dict = {}


for i in range(3, 50, 4):
    knn = KNeighborsClassifier(n_neighbors=i, algorithm='kd_tree', weig
hts='uniform', n_jobs=-1)
    knn.fit(xtr, dtrain['numeric_score'])
    #performance metrics for cv data:
    y_pred_cv = knn.predict_proba(xcv)
    fpr_cv, tpr_cv, thresholds_cv = roc_curve(ycv, y_pred_cv[:,1])
    auc_cv_dict[i] = auc(fpr_cv, tpr_cv)


    #performance metrics for training data:
    y_pred_tr = knn.predict_proba(xtr)
    fpr_tr, tpr_tr, thresholds_tr = roc_curve(dtrain['numeric_score'],
y_pred_tr[:,1])
    auc_tr_dict[i] = auc(fpr_tr, tpr_tr)
```

```
CPU times: user 17h 37min 57s, sys: 2.57 s, total: 17h 38min
Wall time: 1h 55min 33s
```

optimal k for kd tree

In [22]:
```
# print('AUC of cross validation dictionary is :\n{}'.format(auc_cv_dic
t))
# print('*' * 70)
```

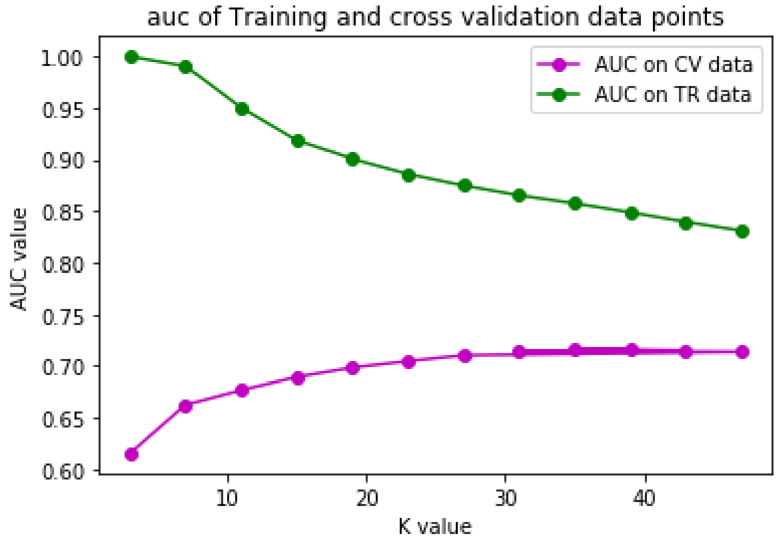
```
# print('AUC score of training dataset is :\n{}'.format(auc_tr_dict))
# print('*' * 70)

#sorting dictionary wrt higest AuC Score of both training and cv data:

cv_tup = sorted(auc_cv_dict.items(), key= lambda x: x[1],reverse=True)
tr_tup = sorted(auc_tr_dict.items(), key= lambda x: x[1],reverse=True)
print(cv_tup)
print('*' * 70)
print(tr_tup)
print()
print('optimal k for kdtree on CV data is {}'.format(cv_tup[0]))
```

```
[(39, 0.7169594176296602), (35, 0.7167301682758), (43, 0.7150396659887721), (31, 0.7147048757134404), (47, 0.7137068173276794), (27, 0.7103204240851311), (23, 0.7046516218121599), (19, 0.698454960969874), (15, 0.6893363331281019), (11, 0.6767122994510794), (7, 0.6624843670877988),
(3, 0.6154138859212721)]
**********************************************************************
[(3, 0.9999365855987076), (7, 0.9905740753704295), (11, 0.9502152432008018), (15, 0.9185605154203248), (19, 0.9006802396987967), (23, 0.886191554564165), (27, 0.8749777909035468), (31, 0.865403103343532), (35, 0.8576313270304217), (39, 0.8487867038475058), (43, 0.8396443973272807),
(47, 0.8309787405601805)]

optimal k for kdtree on CV data is (39, 0.7169594176296602)
```

Plotting training vs CV AUC plot

In [23]:
```
plt.plot([x[0] for x in cv_tup], [x[1] for x in cv_tup], linestyle='-', color='m', marker='o',label='AUC on CV data')
plt.plot([x[0] for x in tr_tup], [x[1] for x in tr_tup], linestyle='-', color='g', marker='o', label='AUC on TR data')
#plt.plot([0, 1], [0, 1], linestyle='--')
plt.xlabel("K value")
plt.ylabel('AUC value')
plt.title('auc of Training and cross validation data points')
plt.legend()
```

Out[23]: <matplotlib.legend.Legend at 0x7fc7d5c3b358>



Bow-Kdtree on optimal K=39

In [25]:

```
knn = KNeighborsClassifier(n_neighbors=39, algorithm='kd_tree', weights
='uniform', n_jobs=-1)
knn.fit(xtr, dtrain['numeric_score'])

#performance metrics for cv data:
y_pred_test = knn.predict_proba(xtest)
y_pred = knn.predict(xtest)
fpr_test, tpr_test, thresholds_test= roc_curve(ytest, y_pred_test[:,1])
auc_test = auc(fpr_test, tpr_test)
print(auc_test)

y_pred_tr = knn.predict_proba(xtr)
fpr_tr, tpr_tr, thresholds_tr = roc_curve(dtrain['numeric_score'], y_pr
ed_tr[:,1])
```

0.7091511611272889

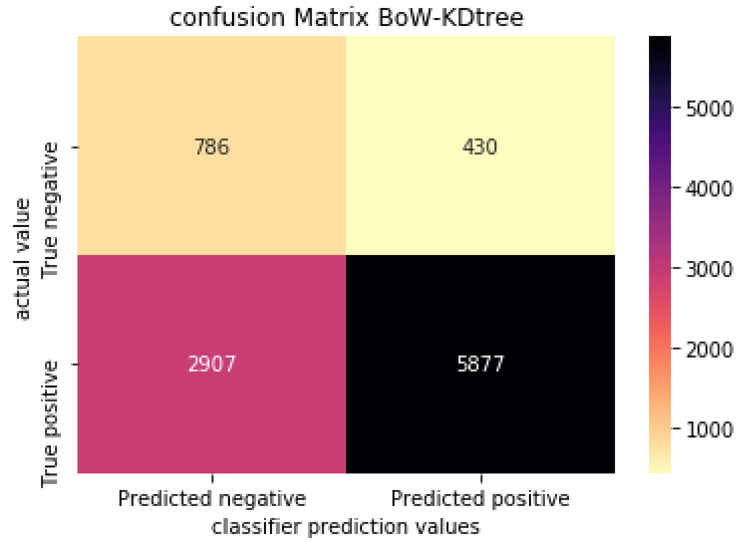
In [26]:
```
psutil.virtual_memory()
```

Out[26]:
```
svmem(total=25286234112, available=22880768000, percent=9.5, used=20402
79040, free=21856940032, active=2056912896, inactive=1131753472, buffer
s=54362112, cached=1334652928, shared=19656704, slab=81936384)
```

Plotting confusion matrix

In [27]:
```
%time
#creating confusion matrix:

cf = confusion_matrix(ytest, y_pred)
labels = ['True negative', 'True positive']

df_cf = pd.DataFrame(cf, index=labels, columns=['Predicted negative',
'Predicted positive'])
sns.heatmap(df_cf, annot=True,fmt='3d', cmap='magma_r')

plt.title("confusion Matrix BoW-KDtree")
plt.xlabel("classifier prediction values")
plt.ylabel("actual value")
plt.show()
```

```
CPU times: user 0 ns, sys: 0 ns, total: 0 ns
Wall time: 5.72 µs
```



BowKDtree - optimal k = 39 , AUC = 0.70

3. Bow-TFIDF-BruteForce implementation

1. taking preprecossed 'text' column for tfidf:
2. train-test-cv split

In [10]:
```
#sampling precossed 'text' column for tfidf:
d = df.head(50000)
x = d['Text']
y = d['numeric_score'].apply(lambda x: 0 if int(x) < 3 else 1)

#train-test split and balancing the dataset:

#train test split:
xt, xtest, yt, ytest = train_test_split(x, y, test_size=0.2, shuffle=Fa
lse)
```

```
xtr, xcv, ytr, ycv = train_test_split(xt, yt, test_size=0.2, shuffle=Fa
lse)
```

Balancing the training dataset

In [11]:
```
#balancing the training dataset:
dtrain = pd.concat([xtr, ytr], axis=1)
print(dtrain.head(2))
d0 = dtrain[dtrain['numeric_score'] == 0.0]
d1 = dtrain[dtrain['numeric_score'] == 1.0]

d1_count, d0_count = ytr.value_counts()
print(d1_count)
print(d0_count)

#oversampling of minority class:
d0_over = d0.sample(d1_count, replace=True)
print(len(d0_over))

#concatenation:
dtrain = pd.concat([d1, d0_over], axis=0)
print(len(dtrain))
```

```
                                                     Text  numeric_scor
e
117924  this witty little book makes my son laugh at l...
1
117901  i can remember seeing the show when it aired o...
1
28510
3490
28510
57020
```

instantiating TF-idf featurizer

In [12]:
```
%time
```

```
#importing Bow library:
from sklearn.feature_extraction.text import TfidfVectorizer
tfidf = TfidfVectorizer(ngram_range=(1, 1))
xtr = tfidf.fit_transform(dtrain['Text'])
xcv = tfidf.transform(xcv)
xtest = tfidf.transform(xtest)
```

```
CPU times: user 0 ns, sys: 0 ns, total: 0 ns
Wall time: 5.48 µs
```

tfidf_features storing in a list and saving it to disc

In [13]:
```
tfidf_features = tfidf.get_feature_names()
file = open('tfidf_features.pickle', 'wb')
pickle.dump(tfidf_features, file)
file.close()
tfidf_features.clear()
```

standardizing the data

In [14]:
```
#standardizing the data:
sc = StandardScaler(with_mean=False)
xtr = sc.fit_transform(xtr)
xcv = sc.transform(xcv)
xtest = sc.transform(xtest)
print(xtr.shape)
print(xcv.shape)
print(xtest.shape)
```

```
(57020, 33510)
(8000, 33510)
(10000, 33510)
```

In [15]:
```
psutil.virtual_memory()
```

Out[15]:
```
svmem(total=25285955584, available=23428489216, percent=7.3, used=15038
99648, free=22710829056, active=1405628416, inactive=940216320, buffers
```

```
=41181184, cached=1030045696, shared=19697664, slab=58449920)
```

TFIDF - BruteForce algo implementation

In [16]:
```
%%time

auc_cv_dict = {}
auc_tr_dict = {}


for i in range(3, 50, 4):
    knn = KNeighborsClassifier(n_neighbors=i, algorithm='brute', weight
s='uniform', n_jobs=-1)
    knn.fit(xtr, dtrain['numeric_score'])

    #performance metrics for cv data:
    y_pred_cv = knn.predict_proba(xcv)
    fpr_cv, tpr_cv, thresholds_cv = roc_curve(ycv, y_pred_cv[:,1])
    auc_cv_dict[i] = auc(fpr_cv, tpr_cv)


    #performance metrics for training data:
    y_pred_tr = knn.predict_proba(xtr)
    fpr_tr, tpr_tr, thresholds_tr = roc_curve(dtrain['numeric_score'],
y_pred_tr[:,1])
    auc_tr_dict[i] = auc(fpr_tr, tpr_tr)
```

```
CPU times: user 15min 28s, sys: 20min 56s, total: 36min 24s
Wall time: 44min 58s
```

In [17]:
```
psutil.virtual_memory()
```

Out[17]:
```
svmem(total=25285955584, available=8541278208, percent=66.2, used=16390
275072, free=7821647872, active=16258981888, inactive=935141376, buffer
s=42041344, cached=1031991296, shared=19771392, slab=62816256)
```

optimal K on CV data

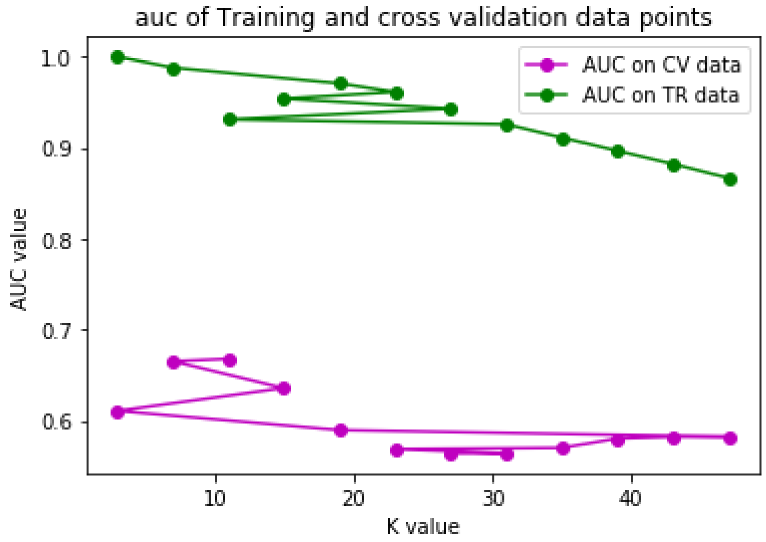
In [18]:
```
#sorting dictionary wrt higest AuC Score of both training and cv data:
cv_tup = sorted(auc_cv_dict.items(), key= lambda x: x[1],reverse=True)
tr_tup = sorted(auc_tr_dict.items(), key= lambda x: x[1],reverse=True)
print(cv_tup)
print()
print('optimal k and auc value on cv data is:\n {}'.format(cv_tup[0]))
```

```
[(11, 0.6682594800920261), (7, 0.6655519051175569), (15, 0.635969269809
2457), (3, 0.6109179658361497), (19, 0.5896835327371618), (47, 0.582382
8107017723), (43, 0.5822009816306449), (39, 0.5803842305389392), (35,
0.5701045755800017), (23, 0.5687226900356284), (31, 0.564134777681243
5), (27, 0.5640384744771876)]

optimal k and auc value on cv data is:
 (11, 0.6682594800920261)
```

training vs CV AUC plot for various k

In [19]:
```
plt.plot([x[0] for x in cv_tup], [x[1] for x in cv_tup], linestyle='-',
 color='m', marker='o',label='AUC on CV data')
plt.plot([x[0] for x in tr_tup], [x[1] for x in tr_tup], linestyle='-',
 color='g', marker='o', label='AUC on TR data')
#plt.plot([0, 1], [0, 1], linestyle='--')
plt.xlabel("K value")
plt.ylabel('AUC value')
plt.title('auc of Training and cross validation data points')
plt.legend()
```

Out[19]:
```
<matplotlib.legend.Legend at 0x7f59d9c48828>
```



TFidf brute force classifier built on optimal K

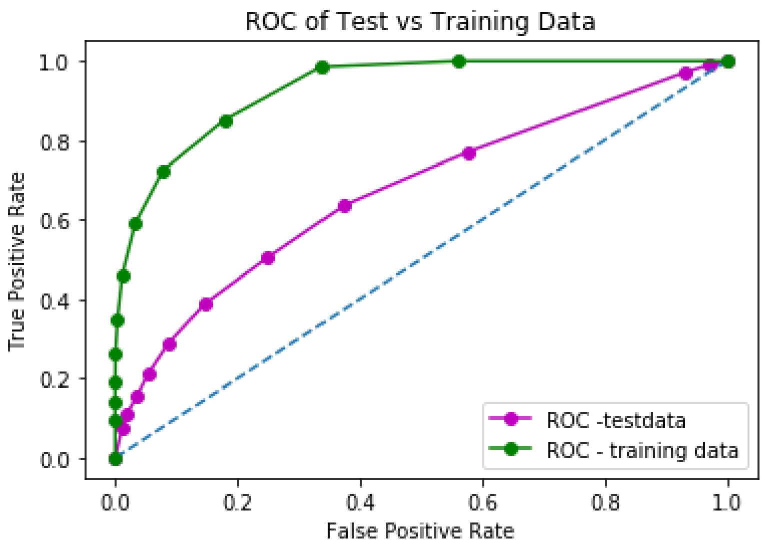
In [20]:
```
knn = KNeighborsClassifier(n_neighbors=11, algorithm='brute', weights=
'uniform', n_jobs=-1)
knn.fit(xtr, dtrain['numeric_score'])

#performance metrics for cv data:
y_pred_test = knn.predict_proba(xtest)
y_pred = knn.predict(xtest)
fpr_test, tpr_test, thresholds_test= roc_curve(ytest, y_pred_test[:,1])
auc_test = auc(fpr_test, tpr_test)
print(np.round(auc_test,2))

y_pred_tr = knn.predict_proba(xtr)
fpr_tr, tpr_tr, thresholds_tr = roc_curve(dtrain['numeric_score'], y_pr
ed_tr[:,1])
```

```
0.67
```

ROC plot on test vs training data

In [21]:
```
plt.plot(fpr_test, tpr_test, color='m', marker='o',label='ROC -testdat
a')
plt.plot([0, 1], [0, 1], linestyle='--')
plt.plot(fpr_tr, tpr_tr, linestyle='-', color='g', marker='o', label='R
OC - training data')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC of Test vs Training Data')
plt.legend()
```

Out[21]: <matplotlib.legend.Legend at 0x7f59d3516860>

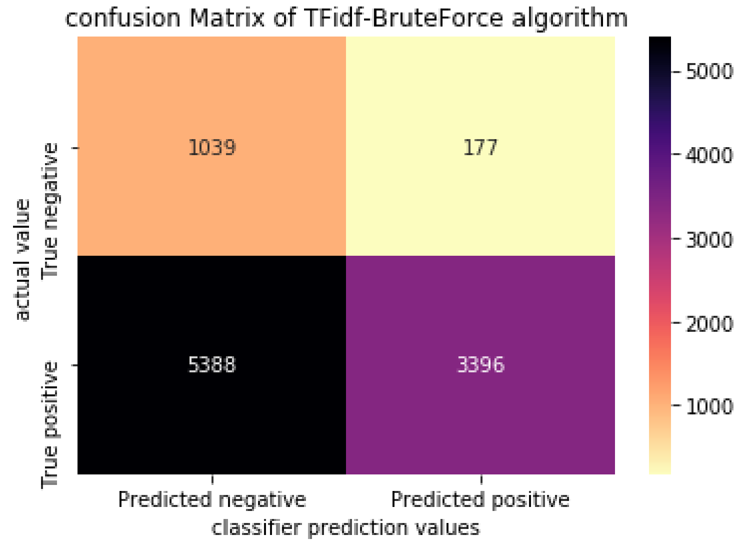


plotting confusion matrix

In [22]:
```
%time
#creating confusion matrix:

cf = confusion_matrix(ytest, y_pred)
labels = ['True negative', 'True positive']

df_cf = pd.DataFrame(cf, index=labels, columns=['Predicted negative',
```

```
'Predicted positive'])
sns.heatmap(df_cf, annot=True,fmt='3d', cmap='magma_r')

plt.title("confusion Matrix of TFidf-BruteForce algorithm")
plt.xlabel("classifier prediction values")
plt.ylabel("actual value")
plt.show()
```

```
CPU times: user 0 ns, sys: 0 ns, total: 0 ns
Wall time: 6.68 µs
```



TFidfBruteForce - optimal k = 11 , AUC = 0.67

4. TF-idf-KDtree implementation

taking sorted 10K point only as KD tree is taking soo much of time

In [7]:
```
#sampling precossed 'text' column for tfidf:
d = df.head(50000)
```

```
x = d['Text']
y = d['numeric_score'].apply(lambda x: 0 if int(x) < 3 else 1)

#train-test split and balancing the dataset:

#train test split:
xt, xtest, yt, ytest = train_test_split(x, y, test_size=0.2, shuffle=Fa
lse)
xtr, xcv, ytr, ycv = train_test_split(xt, yt, test_size=0.2, shuffle=Fa
lse)
```

In [8]:
```
psutil.virtual_memory()
```

Out[8]:
```
svmem(total=25285955584, available=23553781760, percent=6.9, used=13784
10496, free=22803169280, active=1310449664, inactive=940683264, buffers
=41291776, cached=1063084032, shared=19697664, slab=58957824)
```

Balancing training data

In [9]:
```
#balancing the training dataset:
dtrain = pd.concat([xtr, ytr], axis=1)
print(dtrain.head(2))
d0 = dtrain[dtrain['numeric_score'] == 0.0]
d1 = dtrain[dtrain['numeric_score'] == 1.0]

d1_count, d0_count = ytr.value_counts()
print(d1_count)
print(d0_count)

#oversampling of minority class:
d0_over = d0.sample(d1_count, replace=True)
print(len(d0_over))

#concatenation:
dtrain = pd.concat([d1, d0_over], axis=0)
print(len(dtrain))
```

```
                                                 Text  numeric_scor
```

```
e
117924  this witty little book makes my son laugh at l...
1
117901  i can remember seeing the show when it aired o...
1
28510
3490
28510
57020
```

initializing tfidf vectorizer

In [10]:
```
%time
#importing TFIDF library:
from sklearn.feature_extraction.text import TfidfVectorizer
tfidf = TfidfVectorizer(min_df=10, ngram_range=(1, 1))
xtr = tfidf.fit_transform(dtrain['Text'])
xcv = tfidf.transform(xcv)
xtest = tfidf.transform(xtest)

print(xtr.shape)
```

```
CPU times: user 0 ns, sys: 0 ns, total: 0 ns
Wall time: 6.2 µs
(57020, 10611)
```

sparse to dense matrix conversion with reduced features

In [11]:
```
from sklearn.decomposition import TruncatedSVD
tsvd = TruncatedSVD(n_components=500)

xtr = tsvd.fit_transform(xtr)
xcv = tsvd.transform(xcv)
xtest = tsvd.transform(xtest)

print(xtr.shape)
print(xcv.shape)
```

```
print(xtest.shape)
```

```
(57020, 500)
(8000, 500)
(10000, 500)
```

Standardizing data

In [12]:
```
#standardizing the data:
sc = StandardScaler(with_mean=False)
xtr = sc.fit_transform(xtr)
xcv = sc.transform(xcv)
xtest = sc.transform(xtest)
print(xtr.shape)
print(xcv.shape)
print(xtest.shape)
```

```
(57020, 500)
(8000, 500)
(10000, 500)
```

KNN-KDtree implementation of tfidf

In [13]:
```
psutil.virtual_memory()
```

Out[13]:
```
svmem(total=25285955584, available=23042207744, percent=8.9, used=18898
82112, free=22285123584, active=1822142464, inactive=946888704, buffers
=41414656, cached=1069535232, shared=19697664, slab=59330560)
```

In [14]:
```
%%time

auc_cv_dict = {}
auc_tr_dict = {}


for i in range(3, 50, 4):
```

```
    knn = KNeighborsClassifier(n_neighbors=i, algorithm='kd_tree', weig
hts='uniform', n_jobs=-1)
    knn.fit(xtr, dtrain['numeric_score'])

    #performance metrics for cv data:
    y_pred_cv = knn.predict_proba(xcv)
    fpr_cv, tpr_cv, thresholds_cv = roc_curve(ycv, y_pred_cv[:,1])
    auc_cv_dict[i] = auc(fpr_cv, tpr_cv)


    #performance metrics for training data:
    y_pred_tr = knn.predict_proba(xtr)
    fpr_tr, tpr_tr, thresholds_tr = roc_curve(dtrain['numeric_score'],
y_pred_tr[:,1])
    auc_tr_dict[i] = auc(fpr_tr, tpr_tr)
```

```
CPU times: user 20h 36min 39s, sys: 2.69 s, total: 20h 36min 41s
Wall time: 1h 51min 28s
```

In [15]:

```
#sorting dictionary wrt higest AuC Score of both training and cv data:
cv_tup = sorted(auc_cv_dict.items(), key= lambda x: x[1],reverse=True)
tr_tup = sorted(auc_tr_dict.items(), key= lambda x: x[1],reverse=True)
print(cv_tup)
print()
print('optimal k and auc value on cv data is:\n {}'.format(cv_tup[0]))
```

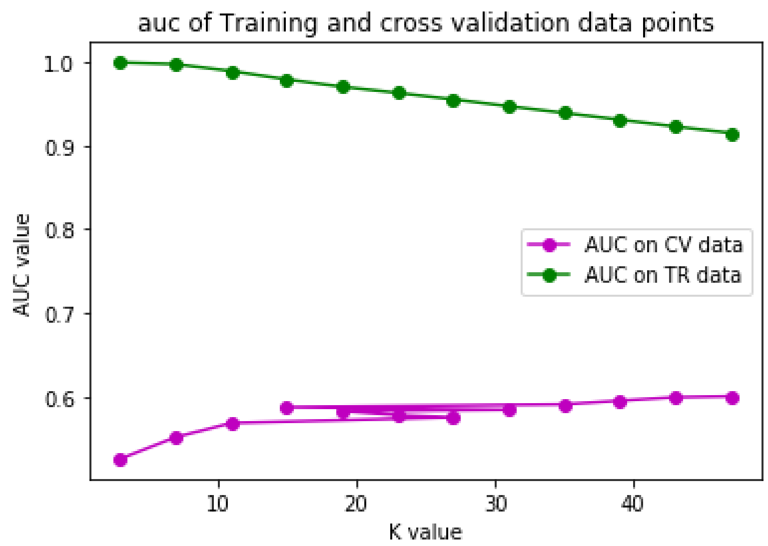
```
[(47, 0.6003175311399604), (43, 0.5991817537837305), (39, 0.59505634314
79462), (35, 0.5906984499572062), (15, 0.5873221412228365), (31, 0.5841
702320406841), (19, 0.5826308434143773), (23, 0.5777631821842615), (27,
0.5750250457613426), (11, 0.5682009129636122), (7, 0.5510578649079285),
(3, 0.5250836359840502)]

optimal k and auc value on cv data is:
 (47, 0.6003175311399604)
```

In [16]:

```
plt.plot([x[0] for x in cv_tup], [x[1] for x in cv_tup], linestyle='-',
 color='m', marker='o',label='AUC on CV data')
plt.plot([x[0] for x in tr_tup], [x[1] for x in tr_tup], linestyle='-',
 color='g', marker='o', label='AUC on TR data')
```

```
#plt.plot([0, 1], [0, 1], linestyle='--')
plt.xlabel("K value")
plt.ylabel('AUC value')
plt.title('auc of Training and cross validation data points')
plt.legend()
```

Out[16]: <matplotlib.legend.Legend at 0x7f01e8090fd0>



In [17]:
```
knn = KNeighborsClassifier(n_neighbors=11, algorithm='brute', weights=
'uniform', n_jobs=-1)
knn.fit(xtr, dtrain['numeric_score'])

#performance metrics for cv data:
y_pred_test = knn.predict_proba(xtest)
y_pred = knn.predict(xtest)
fpr_test, tpr_test, thresholds_test= roc_curve(ytest, y_pred_test[:,1])
auc_test = auc(fpr_test, tpr_test)
print(np.round(auc_test,2))

y_pred_tr = knn.predict_proba(xtr)
fpr_tr, tpr_tr, thresholds_tr = roc_curve(dtrain['numeric_score'], y_pr
ed_tr[:,1])
```

0.58

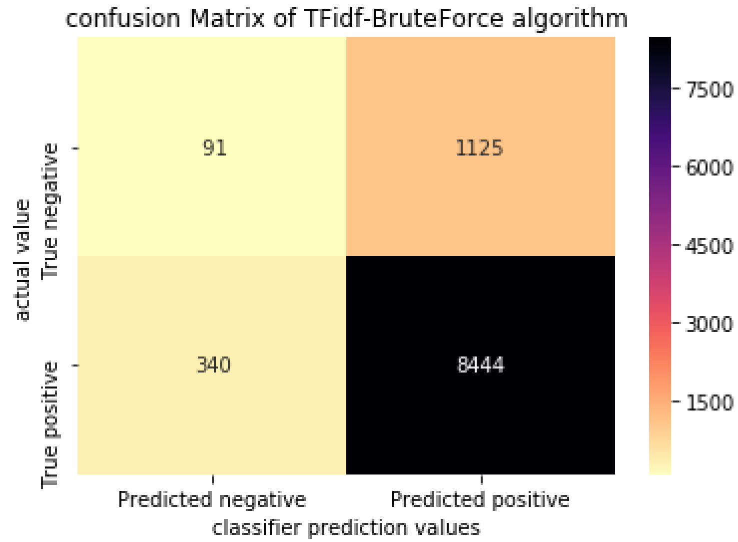
In [18]:
```
plt.plot(fpr_test, tpr_test, color='m', marker='o',label='ROC -testdat
a')
plt.plot([0, 1], [0, 1], linestyle='--')
plt.plot(fpr_tr, tpr_tr, linestyle='-', color='g', marker='o', label='R
OC - training data')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC of Test vs Training Data')
plt.legend()
```

Out[18]: <matplotlib.legend.Legend at 0x7f01eec19a58>

In [19]:
```
%time
#creating confusion matrix:

cf = confusion_matrix(ytest, y_pred)
labels = ['True negative', 'True positive']

df_cf = pd.DataFrame(cf, index=labels, columns=['Predicted negative',
'Predicted positive'])
```

```
sns.heatmap(df_cf, annot=True,fmt='3d', cmap='magma_r')

plt.title("confusion Matrix of TFidf-BruteForce algorithm")
plt.xlabel("classifier prediction values")
plt.ylabel("actual value")
plt.show()
```

```
CPU times: user 0 ns, sys: 0 ns, total: 0 ns
Wall time: 7.63 µs
```



TFidfKD tree - optimal k = 47 , AUC = 0.58

5. Avg-W2V-BruteForce implementation

In [9]:
```
#sampling precossed 'text' column for w2v:
d = df.head(50000)
x = d['Text']
y = d['numeric_score'].apply(lambda x: 0 if int(x) < 3 else 1)

#train-test split and balancing the dataset:
```

```
#train test split:
xt, xtest, yt, ytest = train_test_split(x, y, test_size=0.2, shuffle=Fa
lse)
xtr, xcv, ytr, ycv = train_test_split(xt, yt, test_size=0.2, shuffle=Fa
lse)
```

Balancing train data

In [10]:
```
#balancing the training dataset:
dtrain = pd.concat([xtr, ytr], axis=1)
print(dtrain.head(2))
d0 = dtrain[dtrain['numeric_score'] == 0.0]
d1 = dtrain[dtrain['numeric_score'] == 1.0]

d1_count, d0_count = ytr.value_counts()
print(d1_count)
print(d0_count)

#oversampling of minority class:
d0_over = d0.sample(d1_count, replace=True)
print(len(d0_over))

#concatenation:
dtrain = pd.concat([d1, d0_over], axis=0)
print(len(dtrain))
```

```
                                                     Text  numeric_scor
e
117924  this witty little book makes my son laugh at l...
1
117901  i can remember seeing the show when it aired o...
1
28510
3490
28510
57020
```

creating train, cv and test list of words

In [11]:
```
%%time

#training list of words:
train_list = []
for sentence in dtrain['Text']:
    tmp_list = []
    for word in sentence.split():
        tmp_list.append(word)
    train_list.append(tmp_list)

#cv list of words
cv_list = []
for sentence in xcv:
    tmp_list = []
    for word in sentence.split():
        tmp_list.append(word)
    cv_list.append(tmp_list)

#test list of words:
test_list = []
for sentence in xtest:
    tmp_list = []
    for word in sentence.split():
        tmp_list.append(word)
    test_list.append(tmp_list)
```

```
CPU times: user 1.37 s, sys: 784 ms, total: 2.16 s
Wall time: 2.16 s
```

instantiating word2vec object for Training data

In [12]:
```
%%time

#importing w2v library
from gensim.models import Word2Vec
```

```
#instantiating training,cv, test word to vector object:
trainw2v = Word2Vec(train_list, size=1000, workers=8)
cvw2v = Word2Vec(cv_list, size=1000, workers=8)
testw2v = Word2Vec(test_list, size=1000, workers=8)

#training word2vec List:
train_vocab = list(trainw2v.wv.vocab.keys())

#cv word2vec List:
cv_vocab = list(cvw2v.wv.vocab.keys())

#test word2vec List:
test_vocab = list(testw2v.wv.vocab.keys())
```

```
CPU times: user 3min 20s, sys: 956 ms, total: 3min 21s
Wall time: 29.6 s
```

Avg-W2V representation of train,CV and test data

In [13]:

```
%%time

#avg-w2v for training data***************************:
train_vector = []
for sentence in train_list:
    vector = np.zeros(1000)
    for word in sentence:
        cnt = 0
        if word in train_vocab:
            vector = vector + trainw2v.wv[word]
            cnt = cnt + 1
    if cnt != 0:
        vector = vector / cnt
    train_vector.append(vector)

train_vector = np.array(train_vector)
print(train_vector.shape)
```

```
#avg-w2v for cv data***********************************;
cv_vector = []
for sentence in cv_list:
    vector = np.zeros(1000)
    for word in sentence:
        cnt = 0
        if word in cv_vocab:
            vector = vector + cvw2v.wv[word]
            cnt = cnt + 1
    if cnt != 0:
        vector = vector / cnt
    cv_vector.append(vector)

cv_vector = np.array(cv_vector)
print(cv_vector.shape)



#avg-w2v for test data*********************************;
test_vector = []
for sentence in test_list:
    vector = np.zeros(1000)
    for word in sentence:
        cnt = 0
        if word in test_vocab:
            vector = vector + testw2v.wv[word]
            cnt = cnt + 1
    if cnt != 0:
        vector = vector / cnt
    test_vector.append(vector)

test_vector = np.array(test_vector)
print(test_vector.shape)
```

```
(57020, 1000)
(8000, 1000)
(10000, 1000)
CPU times: user 25min 15s, sys: 3.56 s, total: 25min 19s
Wall time: 25min 15s
```

standardizing data

In [14]:
```
#standardizing the data:
sc = StandardScaler(with_mean=False)
xtr = sc.fit_transform(train_vector)
xcv = sc.transform(cv_vector)
xtest = sc.transform(test_vector)
print(xtr.shape)
print(xcv.shape)
print(xtest.shape)
```

```
(57020, 1000)
(8000, 1000)
(10000, 1000)
```

KNN-BruteForce-Avg-W2V implementation

In [17]:
```
psutil.virtual_memory()
```

Out[17]:
```
svmem(total=25285955584, available=21630160896, percent=14.5, used=3301
593088, free=20907450368, active=3202215936, inactive=944029696, buffer
s=42205184, cached=1034706944, shared=19697664, slab=59912192)
```

In [17]:
```
%%time

auc_cv_dict = {}
auc_tr_dict = {}


for i in range(3, 50, 4):
    knn = KNeighborsClassifier(n_neighbors=i, algorithm='brute', weight
s='uniform')
    knn.fit(xtr, dtrain['numeric_score'])

    #performance metrics for cv data:
    y_pred_cv = knn.predict_proba(xcv)
```

```
    fpr_cv, tpr_cv, thresholds_cv = roc_curve(ycv, y_pred_cv[:,1])
    auc_cv_dict[i] = auc(fpr_cv, tpr_cv)


    #performance metrics for training data:
    y_pred_tr = knn.predict_proba(xtr)
    fpr_tr, tpr_tr, thresholds_tr = roc_curve(dtrain['numeric_score'],
y_pred_tr[:,1])
    auc_tr_dict[i] = auc(fpr_tr, tpr_tr)
```

```
CPU times: user 1h 42min 19s, sys: 11min 44s, total: 1h 54min 4s
Wall time: 23min 20s
```

Optimal k

In [18]:

```
#sorting dictionary wrt higest AuC Score of both training and cv data:
cv_tup = sorted(auc_cv_dict.items(), key= lambda x: x[1],reverse=True)
tr_tup = sorted(auc_tr_dict.items(), key= lambda x: x[1],reverse=True)
print(cv_tup)
print()
print('optimal k and auc value on cv data is:\n {}'.format(cv_tup[0]))
```

```
[(47, 0.5907651924655328), (43, 0.586925073335929), (23, 0.576936329494
5998), (39, 0.576748418926174), (19, 0.5759431209104817), (11, 0.574433
9858087105), (31, 0.5734264587625986), (27, 0.573264644745871), (35, 0.
5723076942026087), (15, 0.5699346015795572), (7, 0.5697014261957956),
(3, 0.5251706244897123)]

optimal k and auc value on cv data is:
 (47, 0.5907651924655328)
```

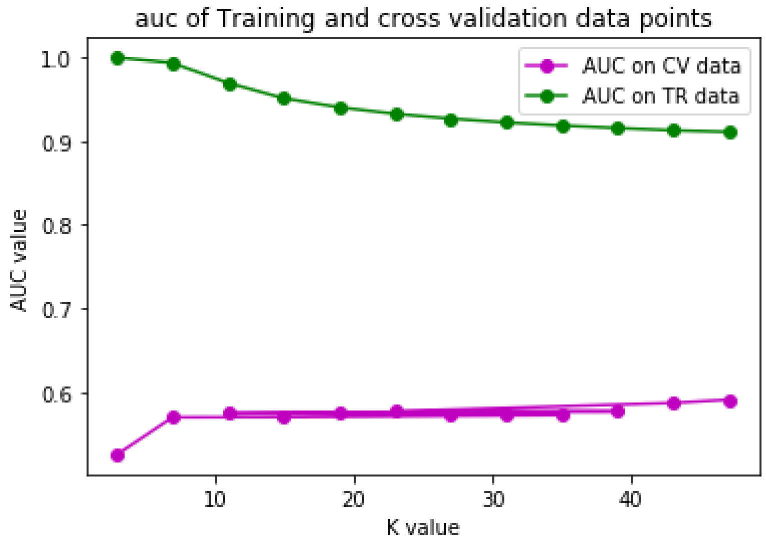
AUC for training vs cv datapoints

In [19]:

```
plt.plot([x[0] for x in cv_tup], [x[1] for x in cv_tup], linestyle='-',
 color='m', marker='o',label='AUC on CV data')
plt.plot([x[0] for x in tr_tup], [x[1] for x in tr_tup], linestyle='-',
 color='g', marker='o', label='AUC on TR data')
#plt.plot([0, 1], [0, 1], linestyle='--')
```

```
plt.xlabel("K value")
plt.ylabel('AUC value')
plt.title('auc of Training and cross validation data points')
plt.legend()
```

Out[19]: <matplotlib.legend.Legend at 0x7f7138de9940>



KNN-BruteForce classifier on optimal k

In [20]:
```
knn = KNeighborsClassifier(n_neighbors=11, algorithm='brute', weights=
'uniform', n_jobs=-1)
knn.fit(xtr, dtrain['numeric_score'])

#performance metrics for cv data:
y_pred_test = knn.predict_proba(xtest)
y_pred = knn.predict(xtest)
fpr_test, tpr_test, thresholds_test= roc_curve(ytest, y_pred_test[:,1])
auc_test = auc(fpr_test, tpr_test)
print(np.round(auc_test,2))

y_pred_tr = knn.predict_proba(xtr)
```

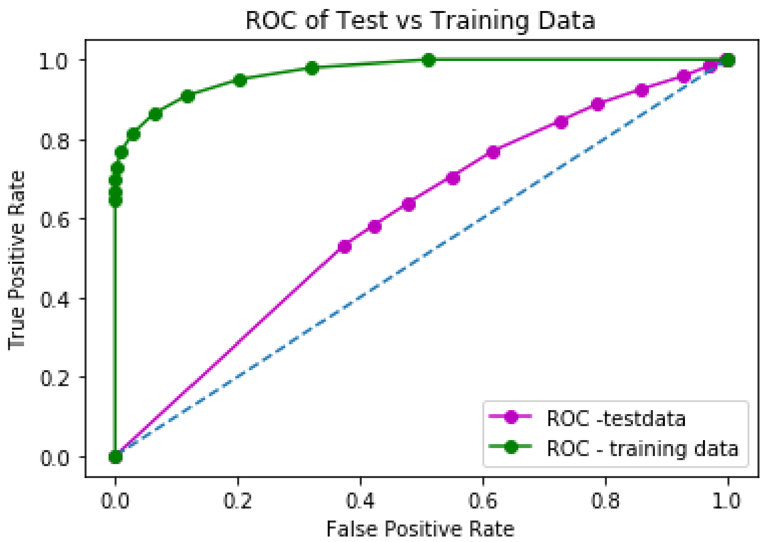
```
fpr_tr, tpr_tr, thresholds_tr = roc_curve(dtrain['numeric_score'], y_pr
ed_tr[:,1])
```

0.6

ROC curve of training vs test datapoints

In [21]:
```
plt.plot(fpr_test, tpr_test, color='m', marker='o',label='ROC -testdat
a')
plt.plot([0, 1], [0, 1], linestyle='--')
plt.plot(fpr_tr, tpr_tr, linestyle='-', color='g', marker='o', label='R
OC - training data')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC of Test vs Training Data')
plt.legend()
```

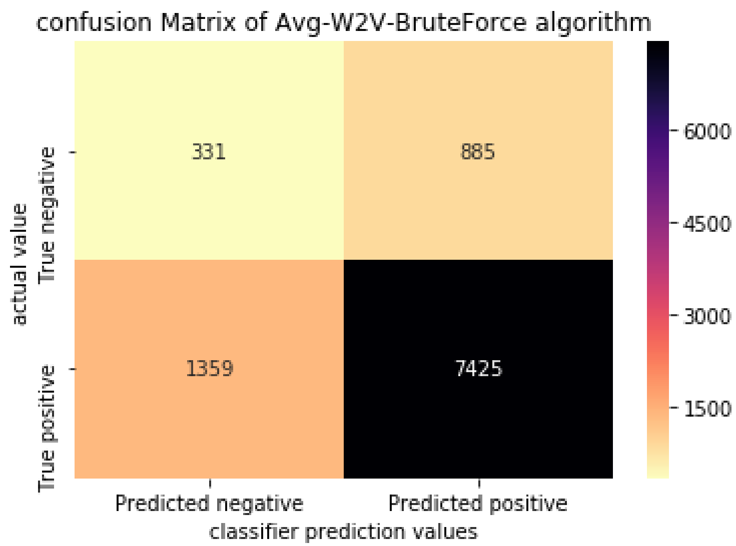
Out[21]: <matplotlib.legend.Legend at 0x7f7138cc6128>



Plotting confusion matrix

In [22]:
```
%time
#creating confusion matrix:

cf = confusion_matrix(ytest, y_pred)
labels = ['True negative', 'True positive']

df_cf = pd.DataFrame(cf, index=labels, columns=['Predicted negative',
'Predicted positive'])
sns.heatmap(df_cf, annot=True,fmt='3d', cmap='magma_r')

plt.title("confusion Matrix of Avg-W2V-BruteForce algorithm")
plt.xlabel("classifier prediction values")
plt.ylabel("actual value")
plt.show()
```

```
CPU times: user 0 ns, sys: 0 ns, total: 0 ns
Wall time: 6.68 µs
```



AvgW2V-BruteForce - optimal k = 47 , AUC = 0.60

6. AvgWV- Kdtree implementation

In [14]:
```
psutil.virtual_memory()
```

Out[14]:
```
svmem(total=25285955584, available=21927403520, percent=13.3, used=3012
493312, free=21198508032, active=3601829888, inactive=260513792, buffer
s=45678592, cached=1029275648, shared=11325440, slab=61198336)
```

In [15]:
```
%%time

#avg-w2v for training data***************************:
train_vector = []
for sentence in train_list:
    vector = np.zeros(1000)
    for word in sentence:
        cnt = 0
        if word in train_vocab:
            vector = vector + trainw2v.wv[word]
            cnt = cnt + 1
    if cnt != 0:
        vector = vector / cnt
    train_vector.append(vector)

train_vector = np.array(train_vector)
print(train_vector.shape)


#avg-w2v for cv data***********************************:
cv_vector = []
for sentence in cv_list:
    vector = np.zeros(1000)
    for word in sentence:
        cnt = 0
        if word in cv_vocab:
            vector = vector + cvw2v.wv[word]
            cnt = cnt + 1
    if cnt != 0:
        vector = vector / cnt
```

```
    cv_vector.append(vector)

cv_vector = np.array(cv_vector)
print(cv_vector.shape)




#avg-w2v for test data**********************************:
test_vector = []
for sentence in test_list:
    vector = np.zeros(1000)
    for word in sentence:
        cnt = 0
        if word in test_vocab:
            vector = vector + testw2v.wv[word]
            cnt = cnt + 1
    if cnt != 0:
        vector = vector / cnt
    test_vector.append(vector)

test_vector = np.array(test_vector)
print(test_vector.shape)
```

```
(57020, 1000)
(8000, 1000)
(10000, 1000)
CPU times: user 26min 33s, sys: 3.94 s, total: 26min 37s
Wall time: 26min 32s
```

In [16]:

```
#standardizing the data:
sc = StandardScaler(with_mean=False)
xtr = sc.fit_transform(train_vector)
xcv = sc.transform(cv_vector)
xtest = sc.transform(test_vector)
print(xtr.shape)
print(xcv.shape)
print(xtest.shape)
```

```
(57020, 1000)
(8000, 1000)
(10000, 1000)
```

In [17]:

```
%%time

auc_cv_dict = {}
auc_tr_dict = {}


for i in range(3, 50, 4):
    knn = KNeighborsClassifier(n_neighbors=i, algorithm='kd_tree', weig
hts='uniform', n_jobs=4)
    knn.fit(xtr, dtrain['numeric_score'])

    #performance metrics for cv data:
    y_pred_cv = knn.predict_proba(xcv)
    fpr_cv, tpr_cv, thresholds_cv = roc_curve(ycv, y_pred_cv[:,1])
    auc_cv_dict[i] = auc(fpr_cv, tpr_cv)


    #performance metrics for training data:
    y_pred_tr = knn.predict_proba(xtr)
    fpr_tr, tpr_tr, thresholds_tr = roc_curve(dtrain['numeric_score'],
y_pred_tr[:,1])
    auc_tr_dict[i] = auc(fpr_tr, tpr_tr)
```

```
CPU times: user 1d 2h 58min 50s, sys: 4.98 s, total: 1d 2h 58min 55s
Wall time: 7h 42min 9s
```

optimal K

In [18]:

```
#sorting dictionary wrt higest AuC Score of both training and cv data:
cv_tup = sorted(auc_cv_dict.items(), key= lambda x: x[1],reverse=True)
tr_tup = sorted(auc_tr_dict.items(), key= lambda x: x[1],reverse=True)
print(cv_tup)
print()
print('optimal k and auc value on cv data is:\n {}'.format(cv_tup[0]))
```

```
[(47, 0.5319765127955474), (43, 0.5290349926275317), (39, 0.52654558174
60241), (35, 0.5251305173999337), (31, 0.5176950016712571), (27, 0.5072
208157797458), (7, 0.504448191878476), (3, 0.5032813911879258), (23, 0.
5032499059677349), (19, 0.5015346158056421), (11, 0.5002669700333066),
(15, 0.4999117797986824)]

optimal k and auc value on cv data is:
 (47, 0.5319765127955474)
```

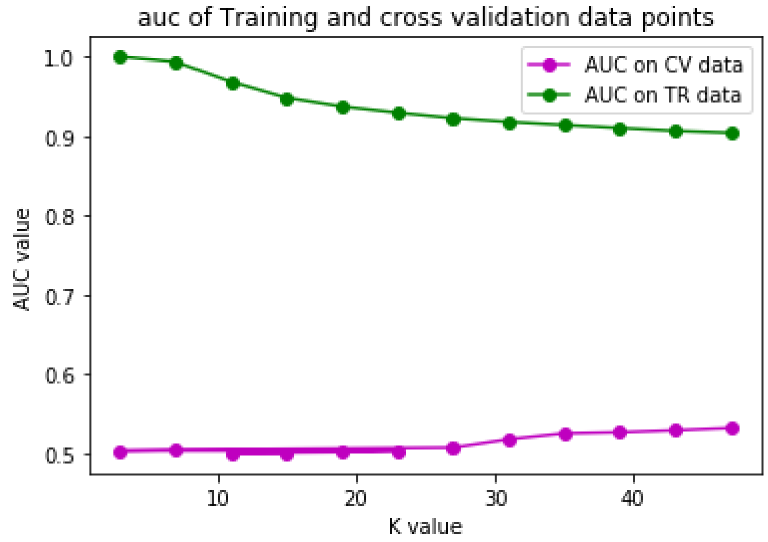
AUC of train vs CV datapoints

In [19]:

```
plt.plot([x[0] for x in cv_tup], [x[1] for x in cv_tup], linestyle='-',
 color='m', marker='o',label='AUC on CV data')
plt.plot([x[0] for x in tr_tup], [x[1] for x in tr_tup], linestyle='-',
 color='g', marker='o', label='AUC on TR data')
#plt.plot([0, 1], [0, 1], linestyle='--')
plt.xlabel("K value")
plt.ylabel('AUC value')
plt.title('auc of Training and cross validation data points')
plt.legend()
```

Out[19]:

```
<matplotlib.legend.Legend at 0x7f7171410438>
```



KD-Tree implementation on optimal K

In [ ]:
```
knn = KNeighborsClassifier(n_neighbors=11, algorithm='kd_tree', weights
='uniform')
knn.fit(xtr, dtrain['numeric_score'])

#performance metrics for cv data:
y_pred_test = knn.predict_proba(xtest)
y_pred = knn.predict(xtest)
fpr_test, tpr_test, thresholds_test= roc_curve(ytest, y_pred_test[:,1])
auc_test = auc(fpr_test, tpr_test)
print(np.round(auc_test,2))

y_pred_tr = knn.predict_proba(xtr)
fpr_tr, tpr_tr, thresholds_tr = roc_curve(dtrain['numeric_score'], y_pr
ed_tr[:,1])
```

```
0.62
```

ROC of train vs CV datapoints

In [ ]:
```
plt.plot(fpr_test, tpr_test, color='m', marker='o',label='ROC -testdat
a')
plt.plot([0, 1], [0, 1], linestyle='--')
plt.plot(fpr_tr, tpr_tr, linestyle='-', color='g', marker='o', label='R
OC - training data')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC of Test vs Training Data')
plt.legend()
```

Plotting confusion matrix

In [ ]:
```
%time
#creating confusion matrix:

cf = confusion_matrix(ytest, y_pred)
labels = ['True negative', 'True positive']

df_cf = pd.DataFrame(cf, index=labels, columns=['Predicted negative',
'Predicted positive'])
sns.heatmap(df_cf, annot=True,fmt='3d', cmap='magma_r')

plt.title("confusion Matrix of Avg-W2V-BruteForce algorithm")
plt.xlabel("classifier prediction values")
plt.ylabel("actual value")
plt.show()
```

TF-idf-weighted-w2v-BruteForce

In [63]:
```
#sampling precossed 'text' column for w2v:
d = df.head(10000)
x = d['Text']
y = d['numeric_score'].apply(lambda x: 0 if int(x) < 3 else 1)

#train-test split and balancing the dataset:
```

```
#train test split:
xt, xtest, yt, ytest = train_test_split(x, y, test_size=0.2, shuffle=Fa
lse)
xtr, xcv, ytr, ycv = train_test_split(xt, yt, test_size=0.2, shuffle=Fa
lse)
```

balancing the dataset

In [64]:
```
#balancing the training dataset:
dtrain = pd.concat([xtr, ytr], axis=1)
print(dtrain.head(2))
d0 = dtrain[dtrain['numeric_score'] == 0.0]
d1 = dtrain[dtrain['numeric_score'] == 1.0]

d1_count, d0_count = ytr.value_counts()
print(d1_count)
print(d0_count)

#oversampling of minority class:
d0_over = d0.sample(d1_count, replace=True)
print(len(d0_over))

#concatenation:
dtrain = pd.concat([d1, d0_over], axis=0)
print(len(dtrain))
```

```
                                                     Text  numeric_scor
e
117924  this witty little book makes my son laugh at l...
1
117901  i can remember seeing the show when it aired o...
1
5651
749
5651
11302
```

Creating list of list of training, test, cv data

In [65]:
```
%%time

#training list of words:
train_list = []
for sentence in dtrain['Text']:
    tmp_list = []
    for word in sentence.split():
        tmp_list.append(word)
    train_list.append(tmp_list)

#cv list of words
cv_list = []
for sentence in xcv:
    tmp_list = []
    for word in sentence.split():
        tmp_list.append(word)
    cv_list.append(tmp_list)

#test list of words:
test_list = []
for sentence in xtest:
    tmp_list = []
    for word in sentence.split():
        tmp_list.append(word)
    test_list.append(tmp_list)
```

```
CPU times: user 436 ms, sys: 28 ms, total: 464 ms
Wall time: 465 ms
```

instantiating w2v for training test, cv data

In [66]:
```
%%time

#importing w2v library
from gensim.models import Word2Vec
```

```
#instantiating training,cv, test word to vector object:
trainw2v = Word2Vec(train_list, size=1000, workers=8)
cvw2v = Word2Vec(cv_list, size=1000, workers=8)
testw2v = Word2Vec(test_list, size=1000, workers=8)

#training word2vec List:
train_vocab = list(trainw2v.wv.vocab.keys())

#cv word2vec List:
cv_vocab = list(cvw2v.wv.vocab.keys())

#test word2vec List:
test_vocab = list(testw2v.wv.vocab.keys())
```

```
CPU times: user 39.9 s, sys: 292 ms, total: 40.2 s
Wall time: 6.64 s
```

for future

In [67]:

```
xtr = dtrain['Text']
xc = xcv
x_test = xtest
ytr = dtrain['numeric_score']
yc = ycv
y_test = ytest
```

tf-idf of train data and creation of dictionary of training data

In [68]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
model = TfidfVectorizer()
tf_idf_matrix = model.fit_transform(dtrain['Text'])
xcv = model.transform(xcv)
xtest = model.transform(xtest)

# we are converting a dictionary with word as a key, and the idf as a v
alue
dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))
```

tfidf-w2v for training data

In [69]:
```
import tqdm
```

TFIDF-W2V for training data

In [70]:
```
tfidf_feat = model.get_feature_names() # tfidf words/col-names
# final_tf_idf is the sparse matrix with row= sentence, col=word and ce
ll_val = tfidf

tfidf_train_vectors = []; # the tfidf-w2v for each sentence/review is s
tored in this list
row=0;
for sent in train_list: # for each review/sentence
    sent_vec = np.zeros(1000) # as word vectors are of zero length
    weight_sum =0; # num of words with a valid vector in the sentence/r
eview
    for word in sent: # for each word in a review/sentence
        if word in train_vocab and word in tfidf_feat:
            vec = trainw2v.wv[word]
            tf_idf = dictionary[word]*(sent.count(word)/len(sent))
            sent_vec += (vec * tf_idf)
            weight_sum += tf_idf
    if weight_sum != 0:
        sent_vec /= weight_sum
    tfidf_train_vectors.append(sent_vec)
    row += 1
```

TFIDF-W2V for CV data

In [71]:
```
%%time

tfidf_feat = model.get_feature_names() # tfidf words/col-names
# final_tf_idf is the sparse matrix with row= sentence, col=word and ce
ll_val = tfidf
```

```
tfidf_cv_vectors = []; # the tfidf-w2v for each sentence/review is stor
ed in this list
row=0;
for sent in cv_list: # for each review/sentence
    sent_vec = np.zeros(1000) # as word vectors are of zero length
    weight_sum =0; # num of words with a valid vector in the sentence/r
eview
    for word in sent: # for each word in a review/sentence
        if word in cv_vocab and word in tfidf_feat:
            vec = cvw2v.wv[word]
            tf_idf = dictionary[word]*(sent.count(word)/len(sent))
            sent_vec += (vec * tf_idf)
            weight_sum += tf_idf
    if weight_sum != 0:
        sent_vec /= weight_sum
    tfidf_cv_vectors.append(sent_vec)
    row += 1
```

```
CPU times: user 43.9 s, sys: 72 ms, total: 44 s
Wall time: 43.9 s
```

TFIDF-W2V for test data

In [72]:

```
%%time

tfidf_feat = model.get_feature_names() # tfidf words/col-names
# final_tf_idf is the sparse matrix with row= sentence, col=word and ce
ll_val = tfidf

tfidf_test_vectors = []; # the tfidf-w2v for each sentence/review is st
ored in this list
row=0;
for sent in test_list: # for each review/sentence
    sent_vec = np.zeros(1000) # as word vectors are of zero length
    weight_sum =0; # num of words with a valid vector in the sentence/r
eview
    for word in sent: # for each word in a review/sentence
        if word in test_vocab and word in tfidf_feat:
```

```
            vec = testw2v.wv[word]
            tf_idf = dictionary[word]*(sent.count(word)/len(sent))
            sent_vec += (vec * tf_idf)
            weight_sum += tf_idf
    if weight_sum != 0:
        sent_vec /= weight_sum
    tfidf_test_vectors.append(sent_vec)
    row += 1
```

```
CPU times: user 1min 2s, sys: 112 ms, total: 1min 2s
Wall time: 1min 2s
```

conversion of list into array

In [73]:
```
xtr = np.array(tfidf_train_vectors)
xcv = np.array(tfidf_cv_vectors)
xtest = np.array(tfidf_test_vectors)
```

standardizing data

In [74]:
```
#standardizing the data:
sc = StandardScaler(with_mean=False)
xtr = sc.fit_transform(xtr)
xcv = sc.transform(xcv)
xtest = sc.transform(xtest)
print(xtr.shape)
print(xcv.shape)
print(xtest.shape)
```

```
(11302, 1000)
(1600, 1000)
(2000, 1000)
```

BruteForce KNN on tfidf-w2v

In [75]:
```
%%time
```

```
auc_cv_dict = {}
auc_tr_dict = {}


for i in range(3, 50, 4):
    knn = KNeighborsClassifier(n_neighbors=i, algorithm='brute', weight
s='uniform', n_jobs=-1)
    knn.fit(xtr, dtrain['numeric_score'])
    #performance metrics for cv data:
    y_pred_cv = knn.predict_proba(xcv)
    fpr_cv, tpr_cv, thresholds_cv = roc_curve(ycv, y_pred_cv[:,1])
    auc_cv_dict[i] = auc(fpr_cv, tpr_cv)

    #performance metrics for training data:
    y_pred_tr = knn.predict_proba(xtr)
    fpr_tr, tpr_tr, thresholds_tr = roc_curve(dtrain['numeric_score'],
y_pred_tr[:,1])
    auc_tr_dict[i] = auc(fpr_tr, tpr_tr)
```

```
CPU times: user 29.7 s, sys: 46.4 s, total: 1min 16s
Wall time: 1min 58s
```

optimal K

In [76]:

```
#sorting dictionary wrt higest AuC Score of both training and cv data:
cv_tup = sorted(auc_cv_dict.items(), key= lambda x: x[1],reverse=True)
tr_tup = sorted(auc_tr_dict.items(), key= lambda x: x[1],reverse=True)
print(cv_tup)
print('*' * 70)
print(tr_tup)
```

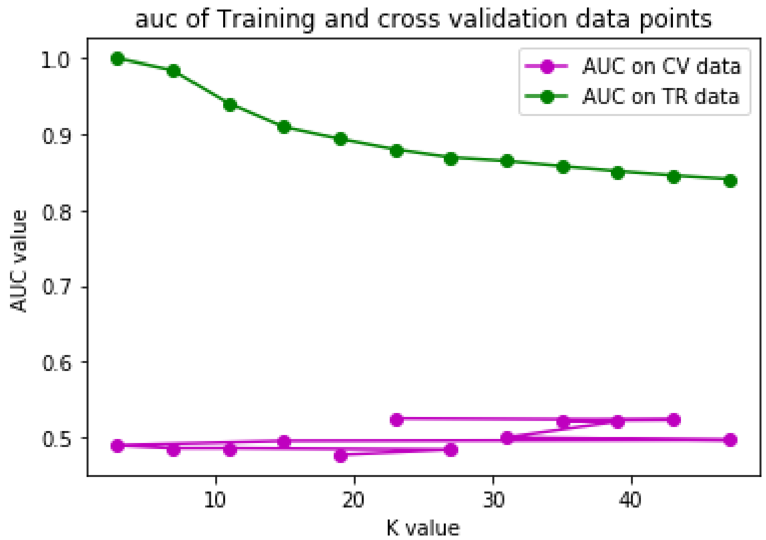
```
[(23, 0.525170196332022), (43, 0.5233986276517397), (35, 0.521909971080
0955), (39, 0.5211083867722871), (31, 0.5), (47, 0.49659382802536334),
(15, 0.49547565159598356), (3, 0.4896849347056816), (7, 0.4858858292468
251), (11, 0.485852149233892), (27, 0.4840042391909612), (19, 0.4769561
3515115587)]
**********************************************************************
[(3, 0.9998257332410884), (7, 0.9841385151739375), (11, 0.9408878229058
```

```
92), (15, 0.9094238891261333), (19, 0.8936542662115293), (23, 0.8797253
574668421), (27, 0.8691822811822496), (31, 0.8643623726470895), (35, 0.
8575178069156252), (39, 0.8508994904803221), (43, 0.8452976831664981),
(47, 0.8404385685249307)]
```

AUC of train vs cv data

In [77]:
```
plt.plot([x[0] for x in cv_tup], [x[1] for x in cv_tup], linestyle='-',
 color='m', marker='o',label='AUC on CV data')
plt.plot([x[0] for x in tr_tup], [x[1] for x in tr_tup], linestyle='-',
 color='g', marker='o', label='AUC on TR data')
#plt.plot([0, 1], [0, 1], linestyle='--')
plt.xlabel("K value")
plt.ylabel('AUC value')
plt.title('auc of Training and cross validation data points')
plt.legend()
```

Out[77]: <matplotlib.legend.Legend at 0x7f74f347bf98>



KNN brute force on optimal K

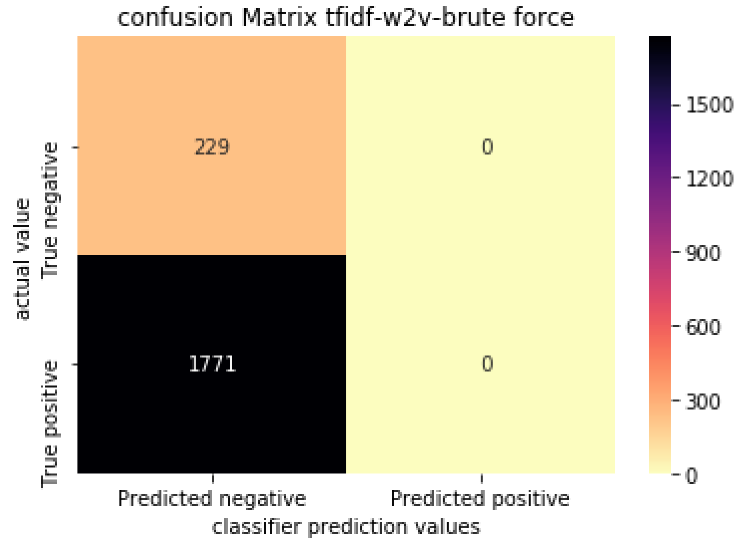
In [78]:
```
knn = KNeighborsClassifier(n_neighbors=11, algorithm='brute', weights=
'uniform', n_jobs=12)
knn.fit(xtr, dtrain['numeric_score'])
#performance metrics for cv data:
y_pred_test = knn.predict_proba(xtest)
y_pred = knn.predict(xtest)
fpr_test, tpr_test, thresholds_test= roc_curve(ytest, y_pred_test[:,1])
auc_test = auc(fpr_test, tpr_test)
print(auc_test)

y_pred_tr = knn.predict_proba(xtr)
fpr_tr, tpr_tr, thresholds_tr = roc_curve(dtrain['numeric_score'], y_pr
ed_tr[:,1])
```

```
0.48215795975431447
```

confusion matrix

In [79]:
```
%time
#creating confusion matrix:

cf = confusion_matrix(ytest, y_pred)
labels = ['True negative', 'True positive']

df_cf = pd.DataFrame(cf, index=labels, columns=['Predicted negative',
'Predicted positive'])
sns.heatmap(df_cf, annot=True,fmt='3d', cmap='magma_r')

plt.title("confusion Matrix tfidf-w2v-brute force")
plt.xlabel("classifier prediction values")
plt.ylabel("actual value")
plt.show()
```

```
CPU times: user 0 ns, sys: 0 ns, total: 0 ns
Wall time: 6.68 µs
```



ROC curve

In [80]:
```
plt.plot(fpr_test, tpr_test, color='m', marker='o',label='ROC -testdata')
plt.plot([0, 1], [0, 1], linestyle='--')
plt.plot(fpr_tr, tpr_tr, linestyle='-', color='g', marker='o', label='ROC - training data')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC of Test vs Training Data')
plt.legend()
```

Out[80]: <matplotlib.legend.Legend at 0x7f74f7130ef0>

TFIDF-W2V Bruteforce: optimal k =15, AUC=0.54

KDtree implementation

In [81]:

```
%%time
auc_cv_dict = {}
auc_tr_dict = {}


for i in range(3, 50, 4):
    knn = KNeighborsClassifier(n_neighbors=i, algorithm='kd_tree', weig
hts='uniform', n_jobs=-1)
    knn.fit(xtr, dtrain['numeric_score'])
    #performance metrics for cv data:
    y_pred_cv = knn.predict_proba(xcv)
    fpr_cv, tpr_cv, thresholds_cv = roc_curve(ycv, y_pred_cv[:,1])
    auc_cv_dict[i] = auc(fpr_cv, tpr_cv)

    #performance metrics for training data:
```

```
    y_pred_tr = knn.predict_proba(xtr)
    fpr_tr, tpr_tr, thresholds_tr = roc_curve(dtrain['numeric_score'],
y_pred_tr[:,1])
    auc_tr_dict[i] = auc(fpr_tr, tpr_tr)
```

```
CPU times: user 1h 19min 30s, sys: 212 ms, total: 1h 19min 30s
Wall time: 7min 25s
```

optimal K

In [82]:

```
#sorting dictionary wrt higest AuC Score of both training and cv data:
cv_tup = sorted(auc_cv_dict.items(), key= lambda x: x[1],reverse=True)
tr_tup = sorted(auc_tr_dict.items(), key= lambda x: x[1],reverse=True)
print(cv_tup)
print('*' * 70)
print(tr_tup)
```

```
[(23, 0.525170196332022), (43, 0.5233986276517397), (35, 0.521909971080
0955), (39, 0.5211083867722871), (31, 0.5), (47, 0.49659382802536334),
(15, 0.49547565159598356), (3, 0.4896849347056816), (7, 0.4858858292468
251), (11, 0.485852149233892), (27, 0.4840042391909612), (19, 0.4769561
3515115587)]
**********************************************************************
[(3, 0.9998257332410884), (7, 0.9841385151739375), (11, 0.9408878229058
92), (15, 0.9094238891261333), (19, 0.8936542662115293), (23, 0.8797253
574668421), (27, 0.8691822811822496), (31, 0.8643623726470895), (35, 0.
8575178069156252), (39, 0.8508994904803221), (43, 0.8452976831664981),
(47, 0.8404385685249307)]
```

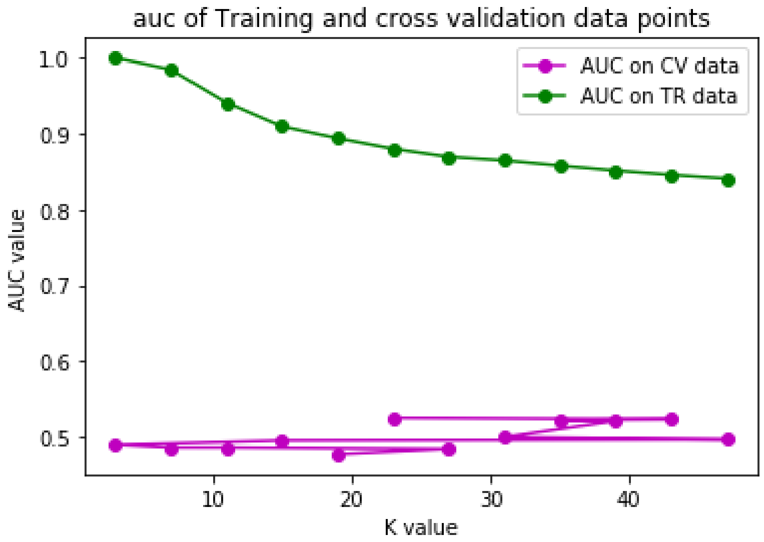
AUC on train vs cv data

In [83]:

```
plt.plot([x[0] for x in cv_tup], [x[1] for x in cv_tup], linestyle='-',
 color='m', marker='o',label='AUC on CV data')
plt.plot([x[0] for x in tr_tup], [x[1] for x in tr_tup], linestyle='-',
 color='g', marker='o', label='AUC on TR data')
#plt.plot([0, 1], [0, 1], linestyle='--')
plt.xlabel("K value")
```

```
plt.ylabel('AUC value')
plt.title('auc of Training and cross validation data points')
plt.legend()
```

Out[83]: <matplotlib.legend.Legend at 0x7f74f34be7f0>



KD tree algo on optimal K

In [84]:

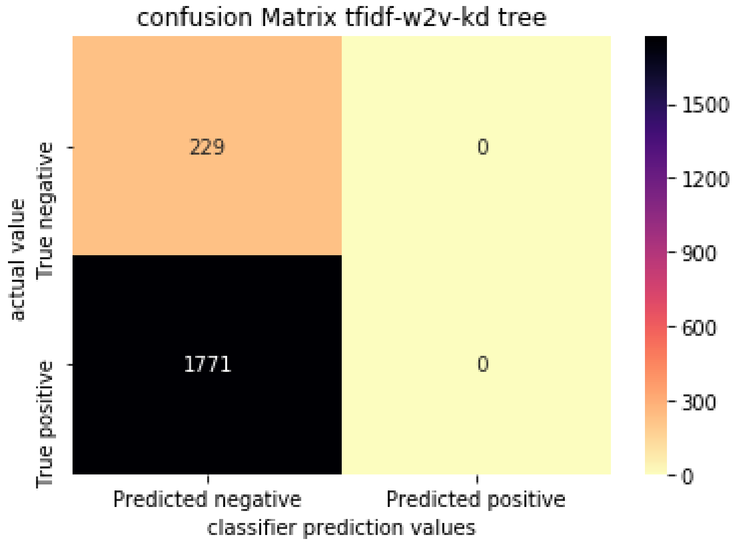
```
knn = KNeighborsClassifier(n_neighbors=15, algorithm='kd_tree', weights
='uniform', n_jobs=12)
knn.fit(xtr, dtrain['numeric_score'])
#performance metrics for cv data:
y_pred_test = knn.predict_proba(xtest)
y_pred = knn.predict(xtest)
fpr_test, tpr_test, thresholds_test= roc_curve(ytest, y_pred_test[:,1])
auc_test = auc(fpr_test, tpr_test)
print(auc_test)

y_pred_tr = knn.predict_proba(xtr)
fpr_tr, tpr_tr, thresholds_tr = roc_curve(dtrain['numeric_score'], y_pr
ed_tr[:,1])
```

0.47885757682605984

confusion matrix

In [85]:
```
%time
#creating confusion matrix:

cf = confusion_matrix(ytest, y_pred)
labels = ['True negative', 'True positive']

df_cf = pd.DataFrame(cf, index=labels, columns=['Predicted negative',
'Predicted positive'])
sns.heatmap(df_cf, annot=True,fmt='3d', cmap='magma_r')

plt.title("confusion Matrix tfidf-w2v-kd tree")
plt.xlabel("classifier prediction values")
plt.ylabel("actual value")
plt.show()
```

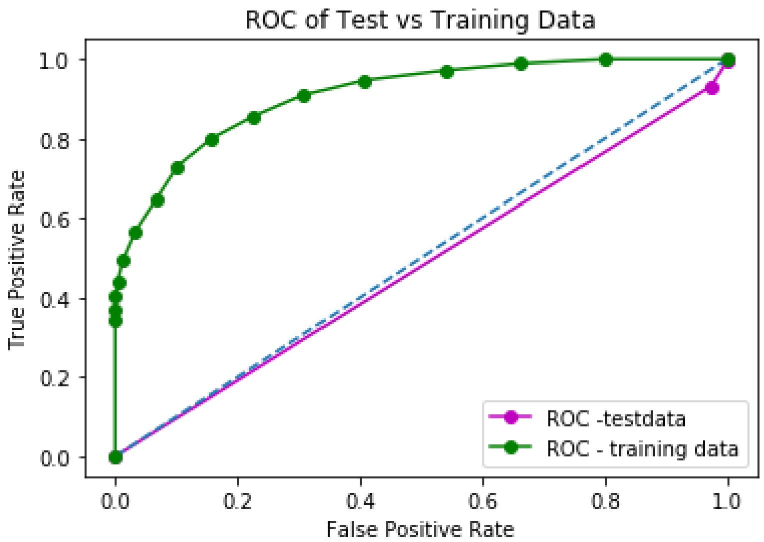
```
CPU times: user 0 ns, sys: 0 ns, total: 0 ns
Wall time: 6.2 µs
```



ROC curve

In [86]:
```
plt.plot(fpr_test, tpr_test, color='m', marker='o',label='ROC -testdat
a')
plt.plot([0, 1], [0, 1], linestyle='--')
plt.plot(fpr_tr, tpr_tr, linestyle='-', color='g', marker='o', label='R
OC - training data')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC of Test vs Training Data')
plt.legend()
```

Out[86]: <matplotlib.legend.Legend at 0x7f74f11c7f60>



tfidf-w2v kdtree - optimal k =15, AUC = 0.51

consolidating performance of all four vectorizers and diplaying

In [5]:
```
perf_dict = dict(algorithm = ['Brute-Bow', 'Brute-Tfidf', 'Brute-W2V',
```

```
'Brute-Tfidf-W2V',
                            'KD-Bow', 'KD-Tfidf', 'KD-W2V', 'KD-Tfidf-
W2V'],
                Koptimal = [47, 11,47, 15, 39, 47, 47, 15 ],
                AUC = [0.71, 0.67, 0.60, 0.54, 0.70, 0.58, 0.62, 0.51])

perf_df = pd.DataFrame(perf_dict)
perf_df
```

Out[5]:

	AUC	Koptimal	algorithm
0	0.71	47	Brute-Bow
1	0.67	11	Brute-Tfidf
2	0.60	47	Brute-W2V
3	0.54	15	Brute-Tfidf-W2V
4	0.70	39	KD-Bow
5	0.58	47	KD-Tfidf
6	0.62	47	KD-W2V
7	0.51	15	KD-Tfidf-W2V

SUMMARY :

- taken 50K datapoints for each vectorizers and observed:
- out of eight vectorizerizers, we could see best AUC was observed in case of BOW-brute force implementation observed.
- least AUC was observed in case of tfidf-w2v-KNN implementation for both of its version(brute and KDtree).
- least time taken to train the model and finding optimal k was bow-bruteForce-KNN ~ 43min 14s.
- Maximum time taken to train the model and finding optimal k was w2v-KDtree-KNN ~ 7h 42min 9s.

```
In [ ]:
```