k-NN on Amazon Fine Food Review

August 9, 2018

1 Objective :

Find the best the model with hghest accuracy for k-NN.

1.1 Workflow:

1. Sort data based on time.
2. Convert reviews of "Amazon Fine Food Review" dataset into vectors using :-
   - Bag of words.
   - TF-IDF
   - Average Word2vec
   - TF-IDF Word2ves
3. Split data into train and test.
4. Find best hyperparameter by k-fold cross validation.
5. Apply k-NN model on the train data.
6. Find accuracy of the model.
7. Print confusion matrix and plot error plots for every model.

```
In [1]: %matplotlib inline

        import sqlite3
        import pandas as pd
        import numpy as np
        import nltk
        import matplotlib.pyplot as plt
        import seaborn as sns
        from sklearn.feature_extraction.text import TfidfTransformer
        from sklearn.feature_extraction.text import TfidfVectorizer
        import re, gensim
        import string
        from nltk.corpus import stopwords
        from nltk.stem.wordnet import WordNetLemmatizer
        from sklearn.feature_extraction.text import CountVectorizer
        from sklearn.manifold import TSNE
        from sklearn.preprocessing import StandardScaler
        from sklearn.decomposition import TruncatedSVD
```

```
from sklearn.cross_validation import train_test_split
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score
from sklearn.cross_validation import cross_val_score
from collections import Counter
from sklearn.metrics import accuracy_score
from sklearn import cross_validation
from sklearn.metrics import confusion_matrix
```

```
/home/dev/anaconda3/lib/python3.6/site-packages/sklearn/cross_validation.py:41: DeprecationWar
  "This module will be removed in 0.20.", DeprecationWarning)
```

1.2 Importing data

In [2]:
```
"""
Reading data from .sqlite file,
choosing only positive and negative reviews not neutral reviews.
"""
# using the SQLite Table to read data.
con = sqlite3.connect('database.sqlite')

#filtering only positive and negative reviews i.e.
# not taking into consideration those reviews with Score=3
filtered_data = pd.read_sql_query("SELECT * FROM Reviews WHERE Score != 3", con)

# Give reviews with Score>3 a positive rating, and reviews with a score<3 a negative r
def partition(x):
    if x < 3:
        return 'negative'
    return 'positive'

#changing reviews with score less than 3 to be positive and vice-versa
actualScore = filtered_data['Score']
positiveNegative = actualScore.map(partition)
filtered_data['Score'] = positiveNegative
```

1.3 Cleansing data

In [3]:
```
"""
Below code snippet removes duplicate data from dataset that are repeatedly mentioned.
"""
#Sorting data according to ProductId in ascending order
sorted_data=filtered_data.sort_values('ProductId', axis=0, ascending=True,\
                                      inplace=False, kind='quicksort',\
                                      na_position='last')
#Deduplication of entries
final=sorted_data.drop_duplicates(subset={"UserId","ProfileName","Time","Text"},\
```

```
                                        keep='first', inplace=False)
final=final[final.HelpfulnessNumerator<=final.HelpfulnessDenominator]
final.shape
```

Out[3]: (364171, 10)

In [4]:
```
"""
Sorting data on the basis of TIME
"""
final = final[:30000]
final = final.sort_values(by=['Time'], axis=0)
final.shape
```

Out[4]: (30000, 10)

1.4 Text preprocessing

In [5]:
```
"""
This code snippet does text preprocessing
"""
def cleanhtml(sentence): #function to clean the word of any html-tags
    cleanr = re.compile('<.*?>')
    cleantext = re.sub(cleanr, ' ', sentence)
    return cleantext
def cleanpunc(sentence): #function to clean the word of any punctuation or special cha
    cleaned = re.sub(r'[?|!|\'|"|#]',r'',sentence)
    cleaned = re.sub(r'[.|,|)|(|\|/]',r' ',cleaned)
    return  cleaned
stop = set(stopwords.words('english')) #set of stopwords
sno = nltk.stem.SnowballStemmer('english') #initialising the snowball stemmer
final_text = []
for index in range(len(final['Text'])):
    filtered_sentence=[]
    sent=cleanhtml(final['Text'].iloc[index]) # remove HTMl tags
    for w in sent.split():
        for cleaned_words in cleanpunc(w).split():# clean punctuation marks from words
            if((cleaned_words.isalpha()) & (len(cleaned_words)>2)):# verifying word mu
                cleaned_words = cleaned_words.lower()
                if(cleaned_words not in stop):# blocks stopwords
                    s=(sno.stem(cleaned_words))# stemming in process
                    filtered_sentence.append(s)
                else:
                    continue
            else:
                continue
    str1 = " ".join(filtered_sentence) #final cleaned string of words
    final_text.append(str1)
```

In [6]:
```
amazon_data_text = pd.Series(final_text)
amazon_data_label = pd.Series(final['Score'])
```

```
print(amazon_data_text.shape)
print(amazon_data_label.shape)
```

```
(30000,)
(30000,)
```

```
In [7]: """
        Spliting sample data into train_data and test_data (75:25)
        """
        x_train, x_test, y_train, y_test = cross_validation.train_test_split(\
                                                                              amazon_data_text,\
                                                                              amazon_data_label
                                                                              test_size = 0.25,\
                                                                              random_state=0)
```

```
In [8]: print(y_test.value_counts())
```

```
positive    6355
negative    1145
Name: Score, dtype: int64
```

1.4.1 Bag of words.

```
In [9]: """
        This code snippet converts train data from text to vectors by BOW.
        """
        count_vect = CountVectorizer(analyzer='word') #in scikit-learn
        bow_text_train_vector = count_vect.fit_transform(x_train)
        bow_text_train_vector = bow_text_train_vector
        bow_text_train_vector.shape
```

```
Out[9]: (22500, 20439)
```

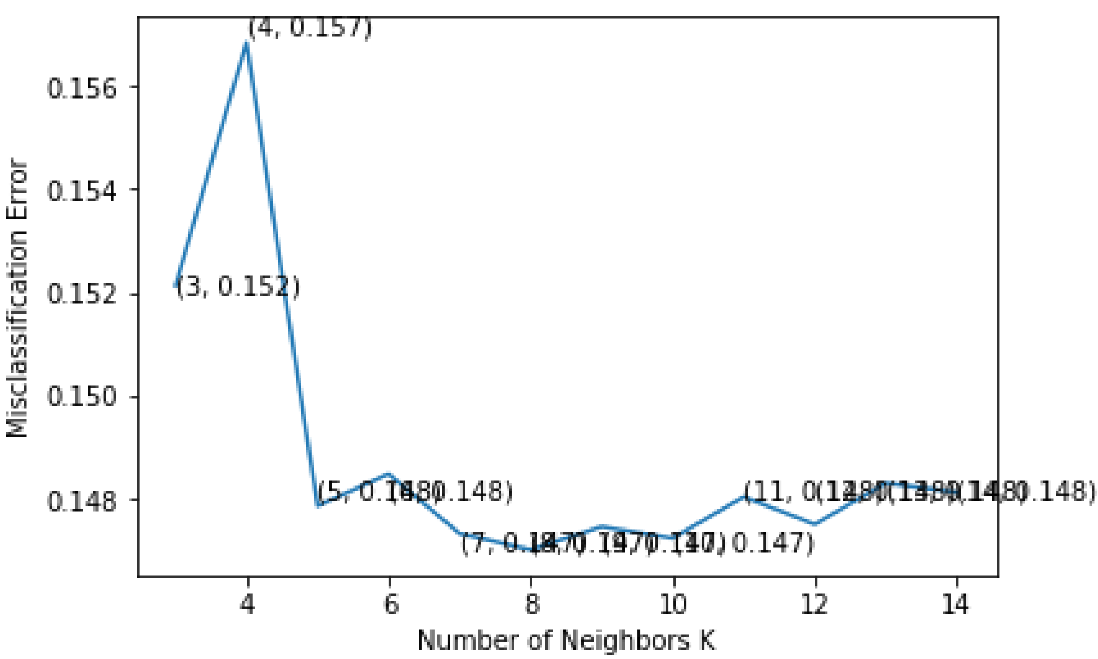
```
In [10]: """
         This code snippet converts test data from text to vectors by BOW.
         """
         bow_text_test_vector = count_vect.transform(x_test)
         bow_text_test_vector = bow_text_test_vector
         print(bow_text_test_vector.shape)
```

```
(7500, 20439)
```

```
In [11]: # empty list that will hold cv scores
         cv_scores = []
         k_values = list(range(3,15))
         # perform 10-fold cross validation
```

```
for k in k_values:
    knn = KNeighborsClassifier(n_neighbors=k)
    scores = cross_val_score(knn, bow_text_train_vector, y_train, cv=10, scoring='accu
    cv_scores.append(scores.mean())
# changing to misclassification error
MSE = [1 - x for x in cv_scores]

# determining best k
bow_optimal_k = k_values[MSE.index(min(MSE))]
print('\nThe optimal number of neighbors is %d.' % bow_optimal_k)

# plot misclassification error vs k
plt.plot(k_values, MSE)

for xy in zip(k_values, np.round(MSE,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')

plt.xlabel('Number of Neighbors K')
plt.ylabel('Misclassification Error')
plt.show()

print("the misclassification error for each k value is : ", np.round(MSE,3))
```

```
The optimal number of neighbors is 8.
```

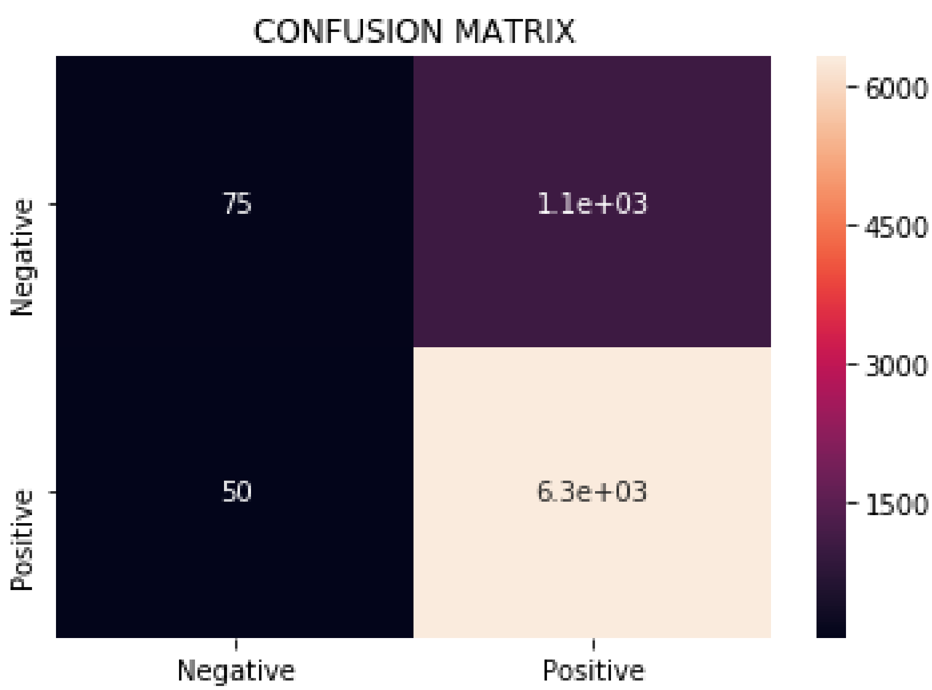


```
the misclassification error for each k value is :  [0.152 0.157 0.148 0.148 0.147 0.147 0.147 0
```

```
In [12]: """
         This code snippet apply k-NN(brute force)
         """
         # Instantiate learning model
         knn_brute = KNeighborsClassifier(n_neighbors= bow_optimal_k, algorithm = 'brute')
         # fitting the model
         knn_brute.fit(bow_text_train_vector, y_train)
         # response prediction
         pred = knn_brute.predict(bow_text_test_vector)
         # evaluate accuracy
         acc = accuracy_score(y_test, pred)*100
         print('\nThe accuracy of the knn classifier for k = %d is %f%%' % (bow_optimal_k, acc)
         conf_matrix = confusion_matrix(y_test, pred)
         confusion_matrix_df = pd.DataFrame(conf_matrix, ["Negative", "Positive"],\
                                            ["Negative", "Positive"],\
                                            dtype=int)
         sns.heatmap(confusion_matrix_df, annot=True)
         plt.title("CONFUSION MATRIX")
```

```
The accuracy of the knn classifier for k = 8 is 85.066667%
```

```
Out[12]: Text(0.5,1,'CONFUSION MATRIX')
```

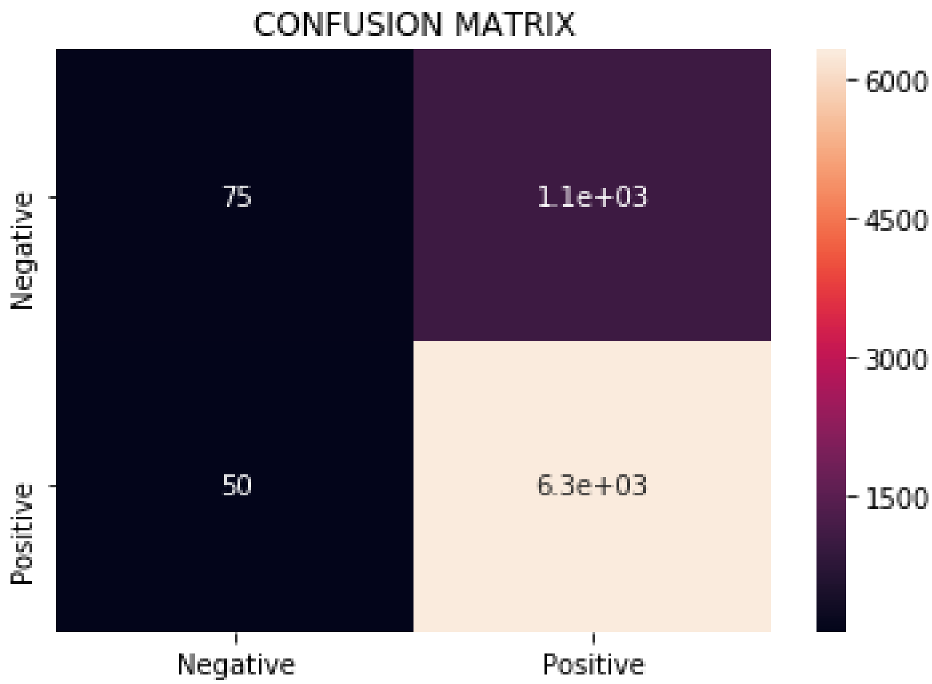


In [13]:
```
"""
This code snippet apply k-NN(kd tree)
"""
# Instantiate learning model
knn_brute = KNeighborsClassifier(n_neighbors= bow_optimal_k, algorithm = 'kd_tree')
# fitting the model
knn_brute.fit(bow_text_train_vector, y_train)
# response prediction
pred = knn_brute.predict(bow_text_test_vector)
# evaluate accuracy
acc = accuracy_score(y_test, pred)*100
print('\nThe accuracy of the knn classifier for k = %d is %f%%' % (bow_optimal_k, acc
conf_matrix = confusion_matrix(y_test, pred)
confusion_matrix_df = pd.DataFrame(conf_matrix, ["Negative", "Positive"],\
                                   ["Negative", "Positive"],\
                                   dtype=int)
sns.heatmap(confusion_matrix_df, annot=True)
plt.title("CONFUSION MATRIX")
```

```
/home/dev/anaconda3/lib/python3.6/site-packages/sklearn/neighbors/base.py:212: UserWarning: ca
  warnings.warn("cannot use tree with sparse input: "
```

```
The accuracy of the knn classifier for k = 8 is 85.066667%
```

Out[13]:
```
Text(0.5,1,'CONFUSION MATRIX')
```



Observation :

- Here we have applied Bag of words to convert text to vector.
- We got best hyperparameter for the k-NN model is 8.
- By applying above hyperparameter in k-NN we got accuracy of 85.066667%.

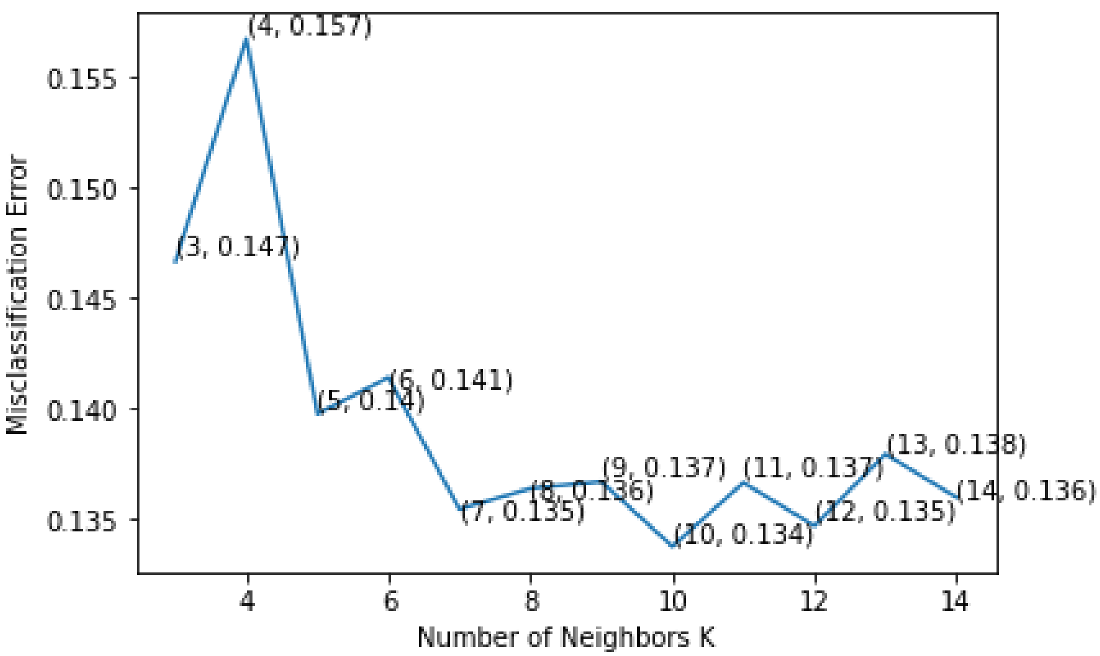
1.4.2 TF IDF.

```
In [14]: """
         This code snippet converts train data from text to vectors by TF_IDF.
         """
         tf_idf_vect = TfidfVectorizer(ngram_range=(1,2))
         final_tf_idf_train = tf_idf_vect.fit_transform(x_train)
         final_tf_idf_train.shape

Out[14]: (22500, 453052)
```

```
In [15]: """
         This code snippet converts test data from text to vectors by TF_IDF.
         """
         final_tf_idf_test = tf_idf_vect.transform(x_test)
         final_tf_idf_test.shape

Out[15]: (7500, 453052)
```

In [16]:
```
# empty list that will hold cv scores
cv_scores = []
k_values = list(range(3,15))
# perform 10-fold cross validation
for k in k_values:
    knn = KNeighborsClassifier(n_neighbors=k)
    scores = cross_val_score(knn, final_tf_idf_train, y_train, cv=10, scoring='accura
    cv_scores.append(scores.mean())
# changing to misclassification error
MSE = [1 - x for x in cv_scores]

# determining best k
tf_idf_optimal_k = k_values[MSE.index(min(MSE))]
print('\nThe optimal number of neighbors is %d.' % tf_idf_optimal_k)

# plot misclassification error vs k
plt.plot(k_values, MSE)

for xy in zip(k_values, np.round(MSE,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')

plt.xlabel('Number of Neighbors K')
plt.ylabel('Misclassification Error')
plt.show()
print("the misclassification error for each k value is : ", np.round(MSE,3))
```

```
The optimal number of neighbors is 10.
```

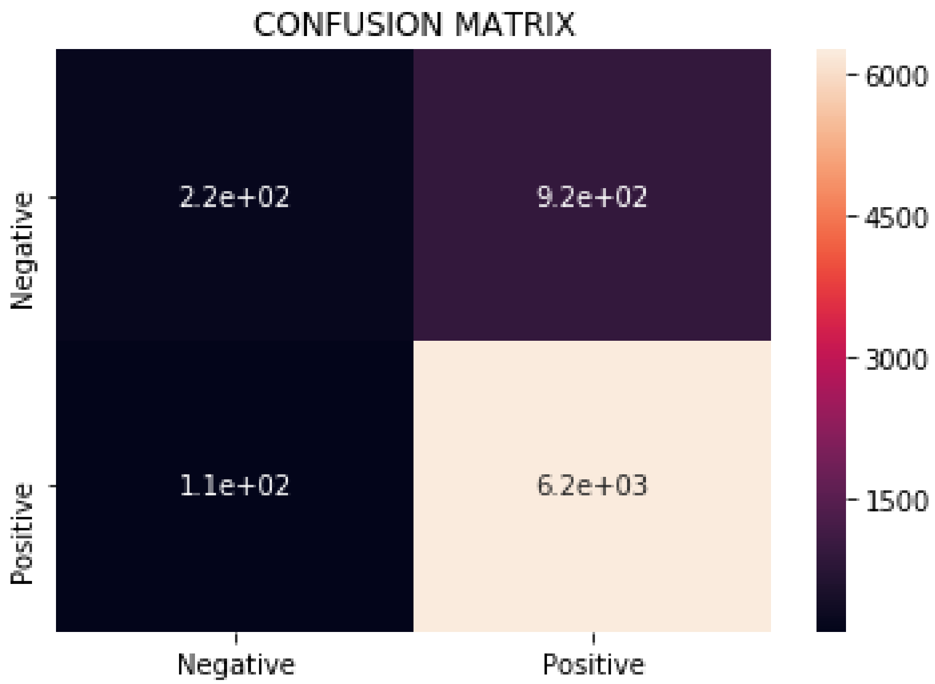


```
the misclassification error for each k value is :  [0.147 0.157 0.14  0.141 0.135 0.136 0.137 0
```

```
In [17]: """
         This code snippet apply k-NN(brute force)
         """
         # Instantiate learning model
         knn_brute = KNeighborsClassifier(n_neighbors= tf_idf_optimal_k, algorithm = 'brute')
         # fitting the model
         knn_brute.fit(final_tf_idf_train, y_train)
         # response prediction
         pred = knn_brute.predict(final_tf_idf_test)
         # evaluate accuracy
         acc = accuracy_score(y_test, pred)*100
         print('\nThe accuracy of the knn classifier for k = %d is %f%%' % (tf_idf_optimal_k, a
         conf_matrix = confusion_matrix(y_test, pred)
         confusion_matrix_df = pd.DataFrame(conf_matrix,\
                                            ["Negative", "Positive"],\
                                            ["Negative", "Positive"],\
                                            dtype=int)
         sns.heatmap(confusion_matrix_df, annot=True)
         plt.title("CONFUSION MATRIX")
```

```
The accuracy of the knn classifier for k = 10 is 86.240000%
```

```
Out[17]: Text(0.5,1,'CONFUSION MATRIX')
```

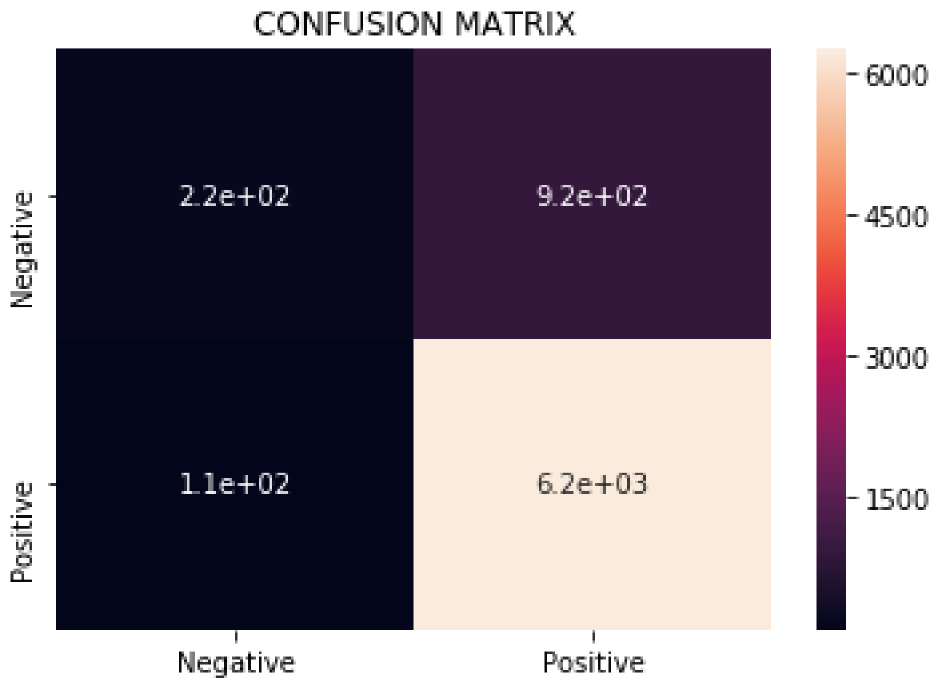



```
In [18]: """
         This code snippet apply k-NN(kd tree)
         """
         # Instantiate learning model
         kd_tree = KNeighborsClassifier(n_neighbors= tf_idf_optimal_k, algorithm = 'kd_tree')
         # fitting the model
         kd_tree.fit(final_tf_idf_train, y_train)
         # response prediction
         pred = kd_tree.predict(final_tf_idf_test)
         # evaluate accuracy
         acc = accuracy_score(y_test, pred)*100
         print('\nThe accuracy of the knn classifier for k = %d is %f%%' % (tf_idf_optimal_k, a
         conf_matrix = confusion_matrix(y_test, pred)
         confusion_matrix_df = pd.DataFrame(conf_matrix,\
                                            ["Negative", "Positive"],\
                                            ["Negative", "Positive"],\
                                            dtype=int)
         sns.heatmap(confusion_matrix_df, annot=True)
         plt.title("CONFUSION MATRIX")
```

```
/home/dev/anaconda3/lib/python3.6/site-packages/sklearn/neighbors/base.py:212: UserWarning: can
  warnings.warn("cannot use tree with sparse input: "
```

```
The accuracy of the knn classifier for k = 10 is 86.240000%
```

```
Out[18]: Text(0.5,1,'CONFUSION MATRIX')
```



Observation:

- Here we have applied TF IDF to convert text to vector.
- We got best hyperparameter for the k-NN model is 8.
- By applying above hyperparameter in k-NN we got accuracy of 86.240000%.

1.5 3) Word2Vec

```
In [19]: """
         Creating own vocabulary of words from reviews.
         """
         i=0
         list_of_train_sent=[]
         for sent in x_train:
             filtered_sentence=[]
             sent=cleanhtml(sent)
             for w in sent.split():
                 for cleaned_words in cleanpunc(w).split():
                     if(cleaned_words.isalpha()):
                         filtered_sentence.append(cleaned_words.lower())
```

```
                else:
                    continue
        list_of_train_sent.append(filtered_sentence)
    w2v_train_model=gensim.models.Word2Vec(list_of_train_sent,min_count=5,size=50, workers
    i=0
    list_of_test_sent=[]
    for sent in x_test:
        filtered_sentence=[]
        sent=cleanhtml(sent)
        for w in sent.split():
            for cleaned_words in cleanpunc(w).split():
                if(cleaned_words.isalpha()):
                    filtered_sentence.append(cleaned_words.lower())
                else:
                    continue
        list_of_test_sent.append(filtered_sentence)
    w2v_test_model=gensim.models.Word2Vec(list_of_test_sent,min_count=5,size=50, workers=
```

1.5.1 a) Average Word2Vec

In [20]:
```python
"""
This code snippet converts train data from text to vectors by Average Word2Vec
"""
# compute average word2vec for each review.
tain_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sent in list_of_train_sent: # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        try:
            vec = w2v_train_model.wv[word]
            sent_vec += vec
            cnt_words += 1
        except:
            pass
    if cnt_words == 0:
        cnt_words = 1
    sent_vec /= cnt_words
    tain_vectors.append(sent_vec)
train_avg_w2v = np.asmatrix(tain_vectors)
train_avg_w2v.shape
```

Out[20]: (22500, 50)

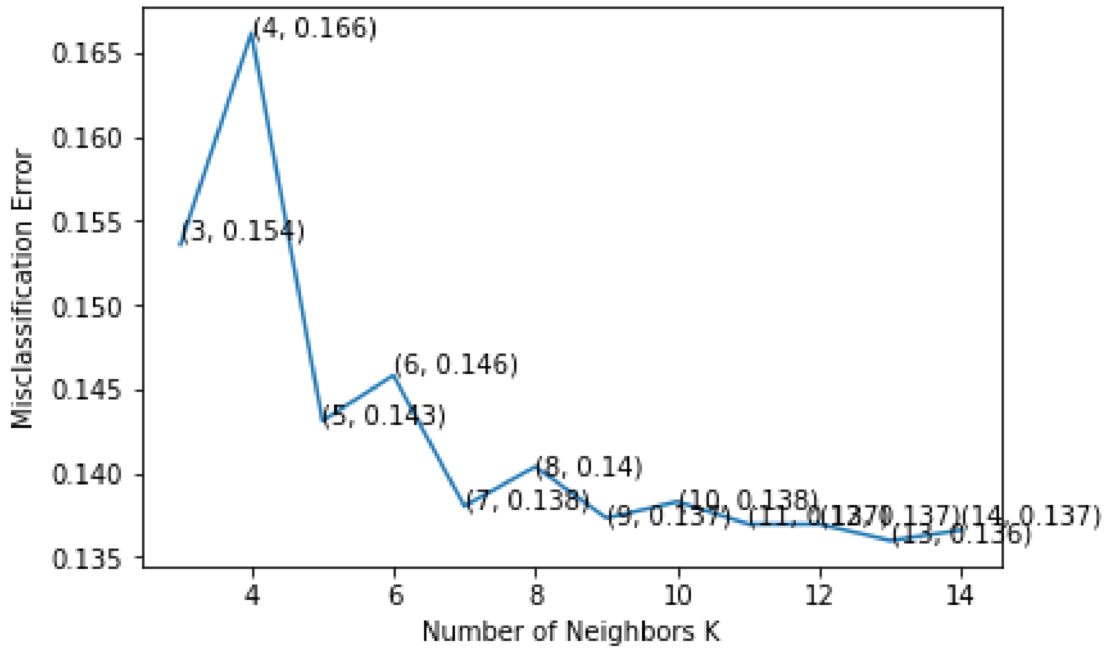
In [21]:
```python
"""
This code snippet converts test data from text to vectors by Average Word2Vec
"""
# compute average word2vec for each review.
```

```
test_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sent in list_of_test_sent: # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        try:
            vec = w2v_test_model.wv[word]
            sent_vec += vec
            cnt_words += 1
        except:
            pass
    if cnt_words == 0:
        cnt_words = 1
    sent_vec /= cnt_words
    test_vectors.append(sent_vec)
test_avg_w2v = np.asmatrix(test_vectors)
test_avg_w2v.shape
```

Out[21]: (7500, 50)

In [22]:
```
# empty list that will hold cv scores
cv_scores = []
k_values = list(range(3,15))
# perform 10-fold cross validation
for k in k_values:
    knn = KNeighborsClassifier(n_neighbors=k)
    scores = cross_val_score(knn, train_avg_w2v, y_train, cv= 10, scoring='accuracy')
    cv_scores.append(scores.mean())
# changing to misclassification error
MSE = [1 - x for x in cv_scores]

# determining best k
optimal_k = k_values[MSE.index(min(MSE))]
print('\nThe optimal number of neighbors is %d.' % optimal_k)

# plot misclassification error vs k
plt.plot(k_values, MSE)

for xy in zip(k_values, np.round(MSE,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')

plt.xlabel('Number of Neighbors K')
plt.ylabel('Misclassification Error')
plt.show()
print("the misclassification error for each k value is : ", np.round(MSE,3))
```

```
The optimal number of neighbors is 13.
```

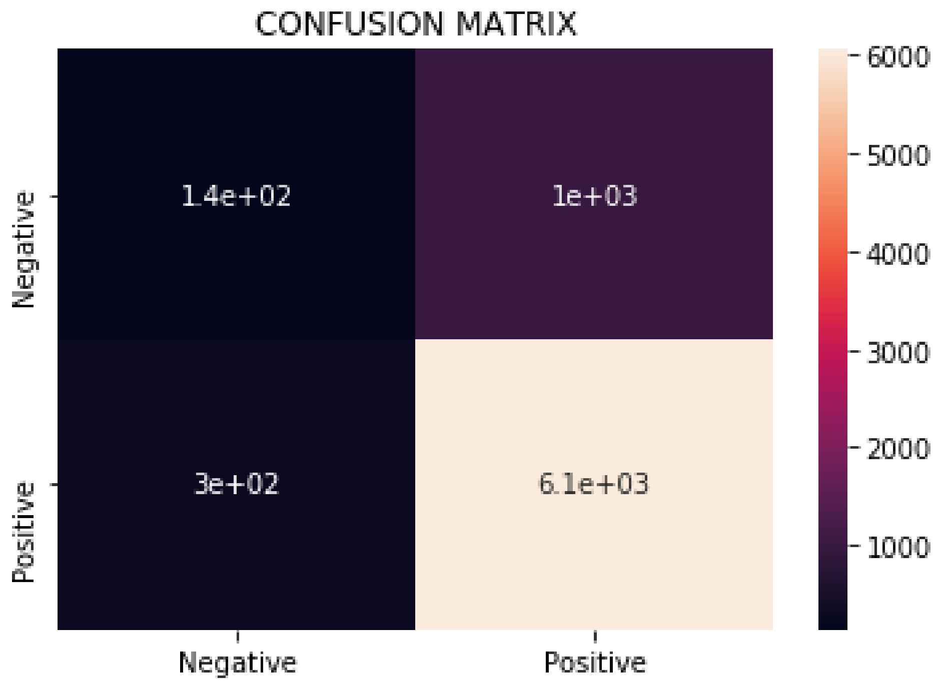



```
the misclassification error for each k value is :  [0.154 0.166 0.143 0.146 0.138 0.14  0.137 (
```

```
In [23]: """
         This code snippet apply k-NN(brute force)
         """
         # Instantiate learning model
         knn_brute = KNeighborsClassifier(n_neighbors= optimal_k, algorithm = 'brute')
         # fitting the model
         knn_brute.fit(train_avg_w2v, y_train)
         # response prediction
         pred = knn_brute.predict(test_avg_w2v)
         # evaluate accuracy
         acc = accuracy_score(y_test, pred)*100
         print('\nThe accuracy of the knn classifier for k = %d is %f%%' % (optimal_k, acc))
         conf_matrix = confusion_matrix(y_test, pred)
         confusion_matrix_df = pd.DataFrame(conf_matrix,\
                                            ["Negative", "Positive"],\
                                            ["Negative", "Positive"],\
                                            dtype=int)
         sns.heatmap(confusion_matrix_df, annot=True)
         plt.title("CONFUSION MATRIX")
```

```
The accuracy of the knn classifier for k = 13 is 82.626667%
```

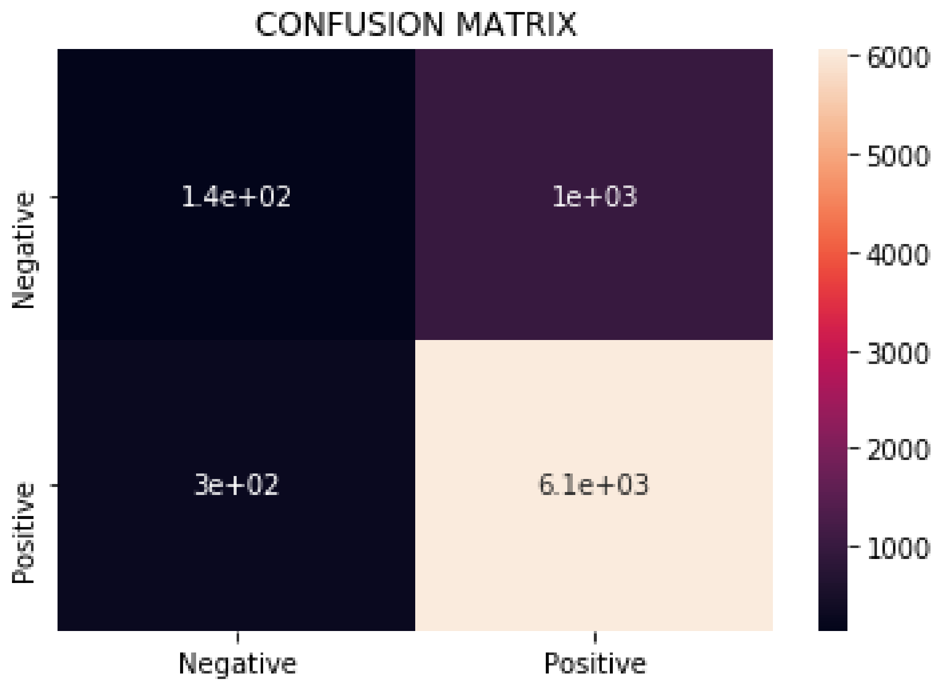
Out[23]: Text(0.5,1,'CONFUSION MATRIX')



In [24]:
```
"""
This code snippet apply k-NN(kd tree)
"""
# Instantiate learning model
kd_tree = KNeighborsClassifier(n_neighbors= optimal_k, algorithm = 'kd_tree')
# fitting the model
kd_tree.fit(train_avg_w2v, y_train)
# response prediction
pred = kd_tree.predict(test_avg_w2v)
# evaluate accuracy
acc = accuracy_score(y_test, pred)*100
print('\nThe accuracy of the knn classifier for k = %d is %f%%' % (optimal_k, acc))
conf_matrix = confusion_matrix(y_test, pred)
confusion_matrix_df = pd.DataFrame(conf_matrix,\
                                   ["Negative", "Positive"],\
                                   ["Negative", "Positive"],\
                                   dtype=int)
sns.heatmap(confusion_matrix_df, annot=True)
plt.title("CONFUSION MATRIX")
```

```
The accuracy of the knn classifier for k = 13 is 82.626667%
```

Out[24]: Text(0.5,1,'CONFUSION MATRIX')



Observation:

- Here we have applied average word2vec to convert text to vector.
- We got best hyperparameter for the k-NN model is 13.
- By applying above hyperparameter in k-NN we got accuracy of 82.6266667%.

1.5.2 b) TF IDF Word2Vec

In [25]:
```
"""
This code snippet converts train data from text to vectors by TF-IDF weighted Word2Ve
"""
tf_idf_vect = TfidfVectorizer(ngram_range=(1,2), analyzer = 'word')
final_tf_idf = tf_idf_vect.fit_transform(x_train)
tfidf_feat = tf_idf_vect.get_feature_names() # tfidf words/col-names
# final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf
tfidf_train_vectors = []; # the tfidf-w2v for each sentence/review is stored in this
row=0;
for sent in list_of_train_sent: # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length
    weight_sum =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        try:
            vec = w2v_train_model.wv[word]
```

```
                # obtain the tf_idfidf of a word in a sentence/review
                tf_idf = final_tf_idf[row, tfidf_feat.index(word)]
                sent_vec += (vec * tf_idf)
                weight_sum += tf_idf
            except:
                pass
        if weight_sum == 0:
            weight_sum = 1
        sent_vec /= weight_sum
        tfidf_train_vectors.append(sent_vec)
        row += 1
    train_tf_idf_w2v = np.asmatrix(tfidf_train_vectors)
    train_tf_idf_w2v.shape
```

Out[25]: (22500, 50)

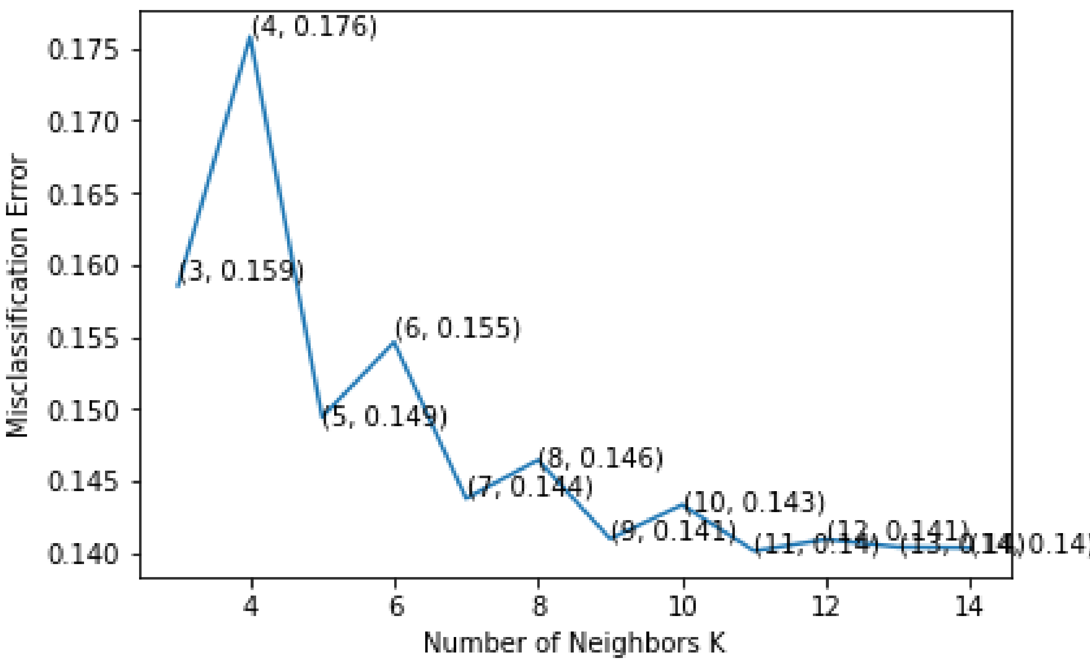
In [26]:
```
"""
This code snippet converts test data from text to vectors by TF-IDF weighted Word2Vec
"""
final_tf_idf = tf_idf_vect.transform(x_test)
tfidf_feat = tf_idf_vect.get_feature_names() # tfidf words/col-names
# final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf
tfidf_test_vectors = []; # the tfidf-w2v for each sentence/review is stored in this l
row=0;
for sent in list_of_test_sent: # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length
    weight_sum =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        try:
            vec = w2v_test_model.wv[word]
            # obtain the tf_idfidf of a word in a sentence/review
            tf_idf = final_tf_idf[row, tfidf_feat.index(word)]
            sent_vec += (vec * tf_idf)
            weight_sum += tf_idf
        except:
            pass
    if weight_sum == 0:
        weight_sum = 1
    sent_vec /= weight_sum
    tfidf_test_vectors.append(sent_vec)
    row += 1
test_tf_idf_w2v = np.asmatrix(tfidf_test_vectors)
test_tf_idf_w2v.shape
```

Out[26]: (7500, 50)

In [27]:
```
# empty list that will hold cv scores
cv_scores = []
k_values = list(range(3,15))
```

```python
# perform 10-fold cross validation
for k in k_values:
    knn = KNeighborsClassifier(n_neighbors=k)
    scores = cross_val_score(knn, train_tf_idf_w2v, y_train, cv= 10, scoring='accuracy
    cv_scores.append(scores.mean())
# changing to misclassification error
MSE = [1 - x for x in cv_scores]

# determining best k
optimal_k = k_values[MSE.index(min(MSE))]
print('\nThe optimal number of neighbors is %d.' % optimal_k)

# plot misclassification error vs k
plt.plot(k_values, MSE)

for xy in zip(k_values, np.round(MSE,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')

plt.xlabel('Number of Neighbors K')
plt.ylabel('Misclassification Error')
plt.show()
print("the misclassification error for each k value is : ", np.round(MSE,3))
```

```
The optimal number of neighbors is 11.
```

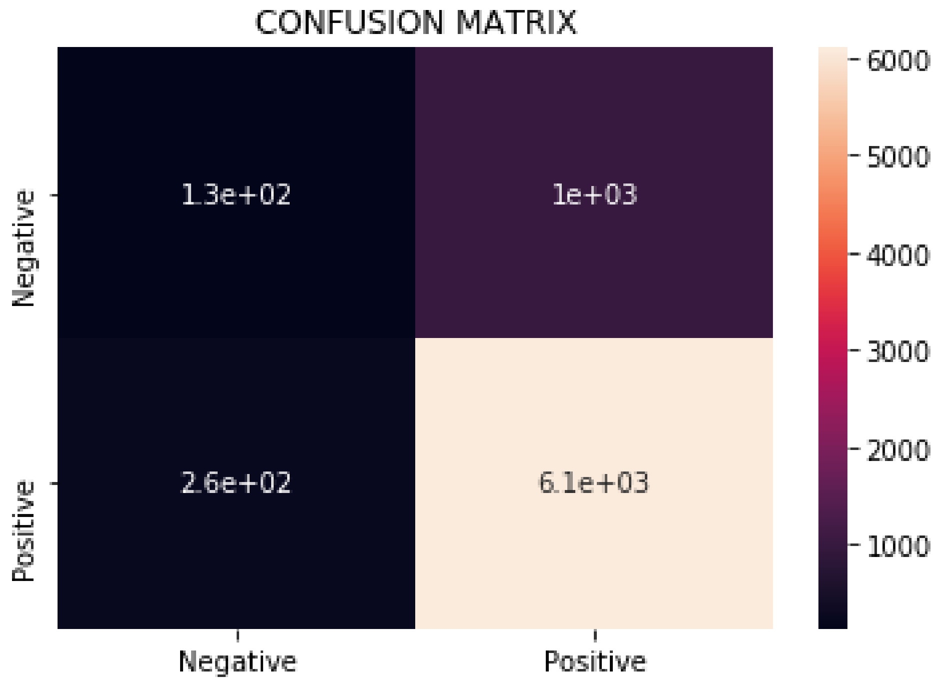


```
the misclassification error for each k value is :  [0.159 0.176 0.149 0.155 0.144 0.146 0.141 (
```

```
In [28]: """
         This code snippet apply k-NN(brute force)
         """
         # Instantiate learning model
         knn_brute = KNeighborsClassifier(n_neighbors= optimal_k, algorithm = 'brute')
         # fitting the model
         knn_brute.fit(train_tf_idf_w2v, y_train)
         # response prediction
         pred = knn_brute.predict(test_tf_idf_w2v)
         # evaluate accuracy
         acc = accuracy_score(y_test, pred)*100
         print('\nThe accuracy of the knn classifier for k = %d is %f%%' % (optimal_k, acc))
         conf_matrix = confusion_matrix(y_test, pred)
         confusion_matrix_df = pd.DataFrame(conf_matrix,\
                                            ["Negative", "Positive"],\
                                            ["Negative", "Positive"],\
                                            dtype=int)
         sns.heatmap(confusion_matrix_df, annot=True)
         plt.title("CONFUSION MATRIX")
```

```
The accuracy of the knn classifier for k = 11 is 83.080000%
```

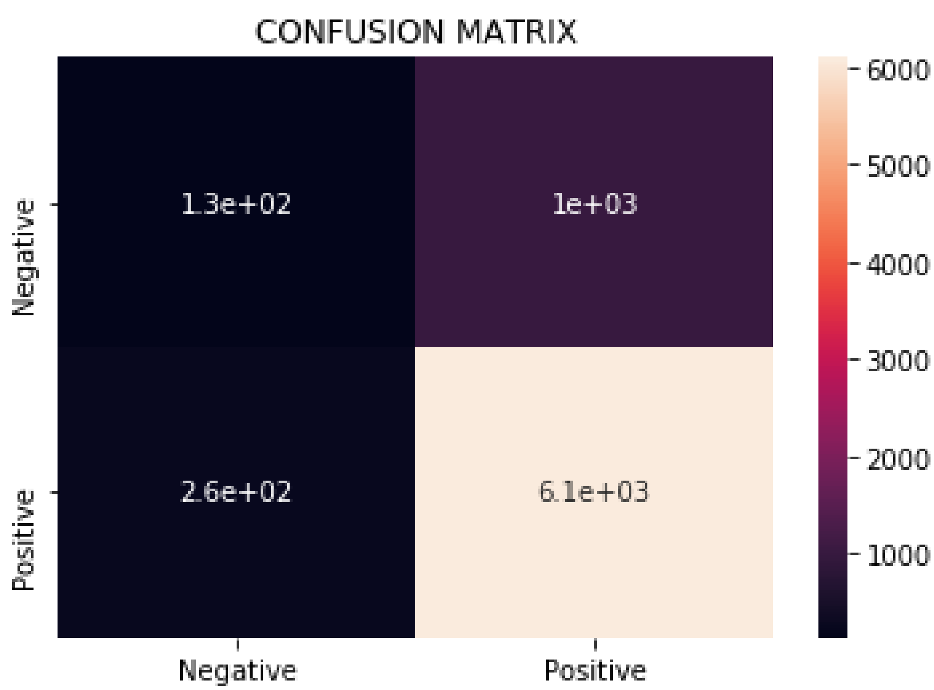
```
Out[28]: Text(0.5,1,'CONFUSION MATRIX')
```



In [29]:
```
"""
This code snippet apply k-NN(kd tree)
"""
# Instantiate learning model
kd_tree = KNeighborsClassifier(n_neighbors= optimal_k, algorithm = 'kd_tree')
# fitting the model
kd_tree.fit(train_tf_idf_w2v, y_train)
# response prediction
pred = kd_tree.predict(test_tf_idf_w2v)
# evaluate accuracy
acc = accuracy_score(y_test, pred)*100
print('\nThe accuracy of the knn classifier for k = %d is %f%%' % (optimal_k, acc))
conf_matrix = confusion_matrix(y_test, pred)
confusion_matrix_df = pd.DataFrame(conf_matrix,\
                                   ["Negative", "Positive"],\
                                   ["Negative", "Positive"],\
                                   dtype=int)
sns.heatmap(confusion_matrix_df, annot=True)
plt.title("CONFUSION MATRIX")
```

```
The accuracy of the knn classifier for k = 11 is 83.080000%
```

Out[29]: Text(0.5,1,'CONFUSION MATRIX')



Observation:

- Here we have applied TF IDF word2vec to convert text to vector.
- We got best hyperparameter for the k-NN model is 11.
- By applying above hyperparameter in k-NN we got accuracy of 83.080000%.

1.6 Conclusion :

1. From the above analysis with 30000 sample of data I got that TF IDF is the best with accuracy 86.240000% .
2. I think with large sample of data, algorithms would have perform better because from large data large vocabulary will be build.

1.6.1 Model-----Best_Hyperparameter------Accuracy

BOW----------------------------------8---------------------85.066667%
TF IDF-------------------------------10--------------------86.240000%
Avg word2vec--------------------13--------------------82.626667%
TF IDF word2vec----------------11--------------------83.080000%