project2

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1 EE219 Project 2

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1.1 Required Packages:

nltk v3.2.5
numpy v1.14.0
scikit-learn v0.19.1
scipy 1.0.0
matplotlib v2.1.2

```
In [27]: import string
         from sklearn.feature_extraction.text import *
         from sklearn.base import BaseEstimator, TransformerMixin
         from sklearn.decomposition import NMF, TruncatedSVD, PCA
         import nltk

         from sklearn.metrics import *
         import matplotlib.pyplot as plt
         import numpy as np
         import itertools
         from sklearn.cluster import KMeans
         from sklearn.metrics.cluster import *

         from sklearn.preprocessing import Normalizer, FunctionTransformer, scale
         from sklearn.pipeline import make_pipeline

         '''
         try:
             nltk.download("stopwords")  # if the host does not have the package
         except (RuntimeError):
             pass
         '''
```

```
# globals
MIN_DF = 3


class SparseToDenseArray(BaseEstimator, TransformerMixin):
    def __init__(self):
        pass

    def transform(self, X, *_):
        if hasattr(X, 'toarray'):
            return X.toarray()
        return X

    def fit(self, *_):
        return self


tfidf_transformer = TfidfTransformer(smooth_idf=False)


def doTFIDF(data, mindf):
    vectorizer = CountVectorizer(min_df=mindf, stop_words=ENGLISH_STOP_WORDS)
    m = vectorizer.fit_transform(data)
    m_train_tfidf = tfidf_transformer.fit_transform(m)
    return m_train_tfidf


def cluster_kmean(data, n):
    km = KMeans(n_clusters=n, max_iter=100, n_init=10, verbose=False).fit(data)
    pred = km.predict(data)
    return pred


def report_stats(label, predict, classes, display=True, msg=None):
    n = len(classes)
    cmatrix = contingency_matrix(label, predict)
    if display:
        plt.imshow(cmatrix, interpolation='nearest', cmap=plt.cm.BuGn)
        plt.title("Contingency Table")
        tick_marks = np.arange(n)
        className = []
        for i in range(n):
            className.append(str(i))
        plt.xticks(tick_marks, className)
        plt.yticks(tick_marks, classes)
        fmt = 'd'
        thresh = cmatrix.max() / 2.
        for i, j in itertools.product(range(n), range(n)):
```

```
                plt.text(j, i, format(cmatrix[i, j], fmt),
                         horizontalalignment="center",
                         color="white" if cmatrix[i, j] > thresh else "black")
            plt.tight_layout()
            plt.ylabel('Ground Truth Label')
            plt.xlabel('Cluster Label')
            plt.show()

        homogeneity = homogeneity_score(label, predict)
        completeness = completeness_score(label, predict)
        v_measure = v_measure_score(label, predict)
        adjusted_Rand_Index = adjusted_rand_score(label, predict)
        adjusted_Mutual_Info_Score = adjusted_mutual_info_score(label, predict)

        if isinstance(msg, str):
            print(msg)
        print("Homogeneity: %0.3f" % homogeneity)
        print("Completeness: %0.3f" % completeness)
        print("V-measure: %0.3f" % v_measure)
        print("Adjusted Rand-Index: %.3f" % adjusted_Rand_Index)
        print("Adjusted Mutual Info Score: %0.3f" % adjusted_Mutual_Info_Score)

        return [cmatrix, [homogeneity, completeness, v_measure, adjusted_Rand_Index, adjus
```

This part is to load data and import the library that we need for this project.

```
In [15]: import numpy as np
         import logging
         import os
         import pickle
         from logging.config import fileConfig
         from sklearn.datasets import fetch_20newsgroups

         # create logger
         fileConfig('logging_config.ini')
         logger = logging.getLogger()
         logger.setLevel("WARNING")
         # logger.setLevel("INFO")

         categories = ['comp.graphics', 'comp.os.ms-windows.misc', 'comp.sys.ibm.pc.hardware',
                       'comp.sys.mac.hardware', 'rec.autos', 'rec.motorcycles', 'rec.sport.base

         cat_comp = categories[:4]    # Computer Technologies
         cat_rec = categories[4:]     # Recreational Activities
         CAT = ["Computer Technologies", "Recreational Activities"]

         logging.info("loading data")
         all_data = fetch_20newsgroups(subset='all', shuffle=True, random_state=42)
```

```
train_data = fetch_20newsgroups(subset='train', categories=categories, shuffle=True, r
test_data = fetch_20newsgroups(subset='test', categories=categories, shuffle=True, ra

# create labels
# 0 for computer technology, 1 for recreational activities
all_label = all_data.target
train_label = [(x//4) for x in train_data.target]
test_label = [(x//4) for x in test_data.target]

CAT_ALL = all_data.target_names

logging.info("loading finished")
```

a)

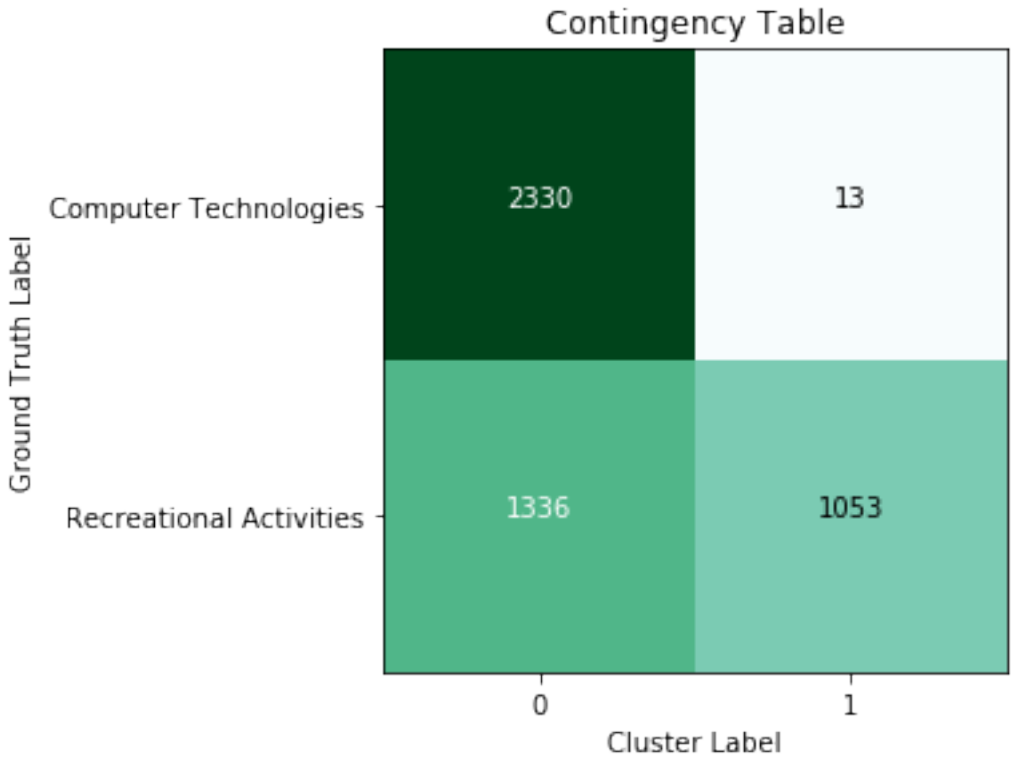
```
In [40]: from timeit import default_timer as timer

GET_DATA_FROM_FILES = True
DETAILS = False

logging.info("Problem 1")
start = timer()

X_train_tfidf = None
if GET_DATA_FROM_FILES and os.path.isfile("./train_tfidf.pkl"):
    logging.info("Loading tfidf vector.")
    X_train_tfidf = pickle.load(open("./train_tfidf.pkl", "rb"))
else:
    X_train_tfidf = doTFIDF(train_data.data, MIN_DF)
    pickle.dump(X_train_tfidf, open("./train_tfidf.pkl", "wb"))

print("With min_df = %d , (training documents, terms extracted): " % MIN_DF, X_train_t

duration = timer() - start
logging.debug("Computation Time in secs: %d" % duration)
logging.info("finished Problem 1")
```

```
With min_df = 3 , (training documents, terms extracted):  (4732, 20297)
```

b)

```
In [28]: logging.info("Problem 2")
start = timer()

km_pred = None
if GET_DATA_FROM_FILES and os.path.isfile("./kmean.pkl"):
    logging.info("Loading predicted kmean.")
```

```
        km_pred = pickle.load(open("./kmean.pkl", "rb"))
    else:
        km_pred = cluster_kmean(X_train_tfidf, 2)
        pickle.dump(km_pred, open("./kmean.pkl", "wb"))

    report_stats(train_label, km_pred, CAT)

    duration = timer() - start
    logging.debug("Computation Time in secs: %d" % duration)
    logging.info("finished Problem 2")
```

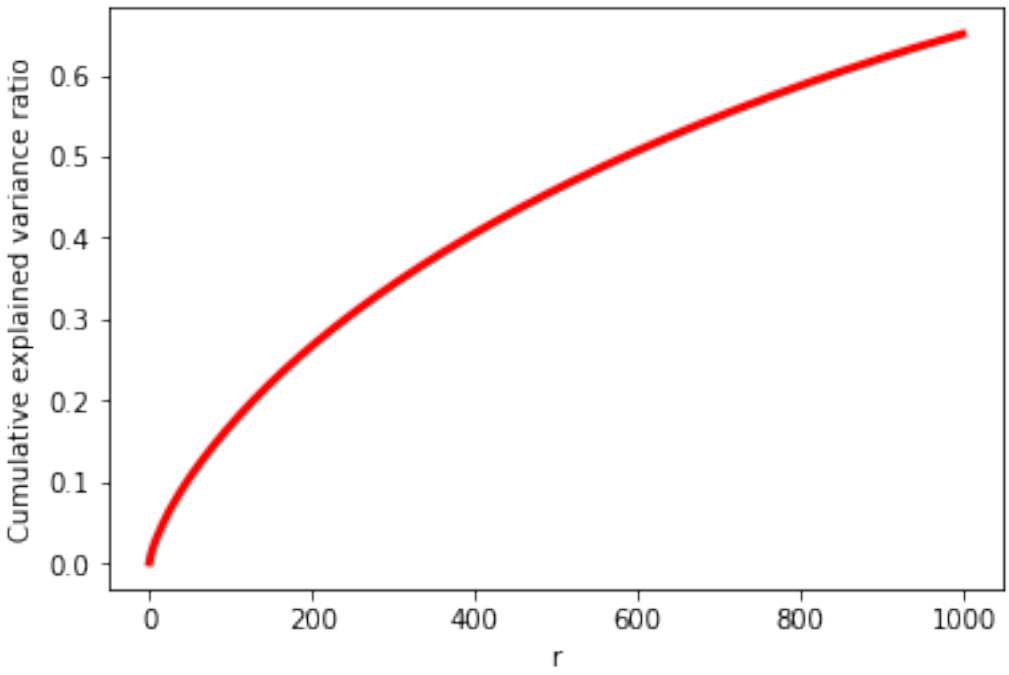



```
Homogeneity: 0.245
Completeness: 0.319
V-measure: 0.277
Adjusted Rand-Index: 0.185
Adjusted Mutual Info Score: 0.245
```

c) - 1

```
In [18]: logging.info("Problem 3")
         start = timer()
```

```
R_MAX = 1000
ratio = None
if GET_DATA_FROM_FILES and os.path.isfile("./ratio.pkl"):
    logging.info("Loading ratio.")
    ratio = pickle.load(open("./ratio.pkl", "rb"))
else:
    svd = TruncatedSVD(n_components=R_MAX, n_iter=7)
    svd.fit_transform(X_train_tfidf)
    ratio = svd.explained_variance_ratio_.cumsum()
    pickle.dump(ratio, open("./ratio.pkl", "wb"), True)

plt.plot(range(R_MAX), ratio, 'r', lw=3, label='Cumulative explained variance ratio')
plt.ylabel('Cumulative explained variance ratio')
plt.xlabel('r')
plt.show()
```



c) - 2

```
In [29]: r = [1, 2, 3, 5, 10, 20, 50, 100, 300]

         # LSI
         y_lsi = None
         cmatrix_lsi = None
         if GET_DATA_FROM_FILES and not DETAILS \
```

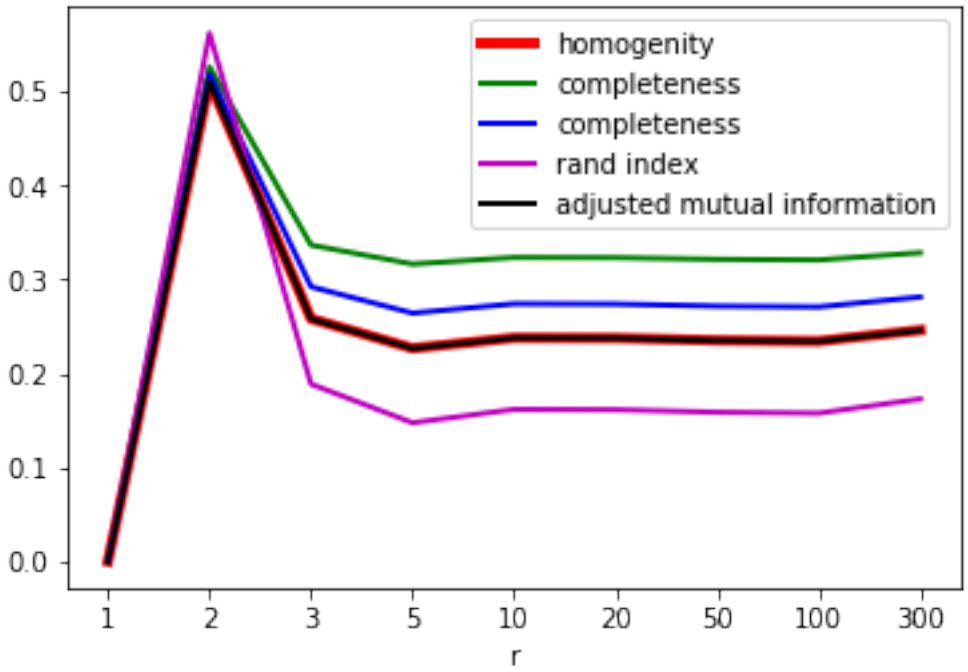
```
        and os.path.isfile("./y_lsi.pkl") \
        and os.path.isfile("./cmatrix_lsi.pkl"):
    logging.info("Loading y and cmatrix for LSI.")
    y_lsi = pickle.load(open("./y_lsi.pkl", "rb"))
    cmatrix_lsi = pickle.load(open("./cmatrix_lsi.pkl", "rb"))
else:
    y_lsi = []
    cmatrix_lsi = []
    for i in r:
        svd = TruncatedSVD(n_components=i, random_state=None)
        # normalizer = Normalizer(copy=False)
        # pipeline = make_pipeline(svd, normalizer)
        # X_train_lsi = pipeline.fit_transform(X_train_tfidf)
        X_train_lsi = svd.fit_transform(X_train_tfidf)
        kmean = cluster_kmean(X_train_lsi, 2)
        msg = 'With r = %d' % i + " Using LSI"
        result = report_stats(train_label, kmean, CAT, display=False, msg=msg)
        print("-  "*10)
        print("The contingency matrix is: ")
        cmatrix_lsi.append(result[0])
        print(result[0])
        y_lsi.append(result[1])
        print("-"*30)

    pickle.dump(y_lsi, open("./y_lsi.pkl", "wb"), True)
    pickle.dump(cmatrix_lsi, open("./cmatrix_lsi.pkl", "wb"), True)

y_transpose = np.array(y_lsi).T.tolist()

r_len = len(r)
l1, = plt.plot(range(r_len), y_transpose[0], 'r', lw=4, label='homogenity')
l2, = plt.plot(range(r_len), y_transpose[1], 'g', lw=2, label='completeness')
l3, = plt.plot(range(r_len), y_transpose[2], 'b', lw=2, label='completeness')
l4, = plt.plot(range(r_len), y_transpose[3], 'm', lw=2, label='rand index')
l5, = plt.plot(range(r_len), y_transpose[4], 'k', lw=2, label='adjusted mutual informa
tick_marks = np.arange(r_len)
labels = [str(a) for a in r]
plt.xticks(tick_marks, labels)
plt.legend(handles=[l1, l2, l3, l4, l5])
plt.xlabel('r')
plt.show()

best_r = [np.argmax(y_transpose[i]) for i in range(5)]
print("*"*60)
bi_lsi = np.bincount(best_r).argmax() # best_r_index
print("The best R value for TruncatedSVD is %d" % r[bi_lsi])
print("The contingency matrix is: ")
print(cmatrix_lsi[bi_lsi])
```

```
        print("Homogeneity: %0.3f" % y_transpose[0][bi_lsi])
        print("Completeness: %0.3f" % y_transpose[1][bi_lsi])
        print("V-measure: %0.3f" % y_transpose[2][bi_lsi])
        print("Adjusted Rand-Index: %.3f" % y_transpose[3][bi_lsi])
        print("Adjusted Mutual Info Score: %0.3f" % y_transpose[4][bi_lsi])
        print("*"*60)
```

```
With r = 1 Using LSI
Homogeneity: 0.000
Completeness: 0.000
V-measure: 0.000
Adjusted Rand-Index: -0.000
Adjusted Mutual Info Score: -0.000
-  -  -  -  -  -  -  -  -  -
The contingency matrix is:
[[1051 1292]
 [1046 1343]]
------------------------------
With r = 2 Using LSI
Homogeneity: 0.511
Completeness: 0.526
V-measure: 0.518
Adjusted Rand-Index: 0.562
Adjusted Mutual Info Score: 0.510
-  -  -  -  -  -  -  -  -  -
The contingency matrix is:
[[  45 2298]
 [1842  547]]
------------------------------
With r = 3 Using LSI
Homogeneity: 0.258
Completeness: 0.337
V-measure: 0.292
Adjusted Rand-Index: 0.189
Adjusted Mutual Info Score: 0.258
-  -  -  -  -  -  -  -  -  -
The contingency matrix is:
[[   4 2339]
 [1055 1334]]
------------------------------
With r = 5 Using LSI
Homogeneity: 0.227
Completeness: 0.316
V-measure: 0.264
Adjusted Rand-Index: 0.147
Adjusted Mutual Info Score: 0.227
-  -  -  -  -  -  -  -  -  -
The contingency matrix is:
```

```
[[   1 2342]
 [ 933 1456]]
------------------------------
With r = 10 Using LSI
Homogeneity: 0.238
Completeness: 0.323
V-measure: 0.274
Adjusted Rand-Index: 0.162
Adjusted Mutual Info Score: 0.238
-  -  -  -  -  -  -  -  -  -
The contingency matrix is:
[[   2 2341]
 [ 977 1412]]
------------------------------
With r = 20 Using LSI
Homogeneity: 0.238
Completeness: 0.323
V-measure: 0.274
Adjusted Rand-Index: 0.161
Adjusted Mutual Info Score: 0.237
-  -  -  -  -  -  -  -  -  -
The contingency matrix is:
[[2341    2]
 [1413  976]]
------------------------------
With r = 50 Using LSI
Homogeneity: 0.235
Completeness: 0.321
V-measure: 0.272
Adjusted Rand-Index: 0.159
Adjusted Mutual Info Score: 0.235
-  -  -  -  -  -  -  -  -  -
The contingency matrix is:
[[   2 2341]
 [ 968 1421]]
------------------------------
With r = 100 Using LSI
Homogeneity: 0.234
Completeness: 0.321
V-measure: 0.271
Adjusted Rand-Index: 0.158
Adjusted Mutual Info Score: 0.234
-  -  -  -  -  -  -  -  -  -
The contingency matrix is:
[[   2 2341]
 [ 965 1424]]
------------------------------
With r = 300 Using LSI
```

```
Homogeneity: 0.246
Completeness: 0.328
V-measure: 0.281
Adjusted Rand-Index: 0.173
Adjusted Mutual Info Score: 0.246
-  -  -  -  -  -  -  -  -  -
The contingency matrix is:
[[   3 2340]
 [1010 1379]]
------------------------------
```



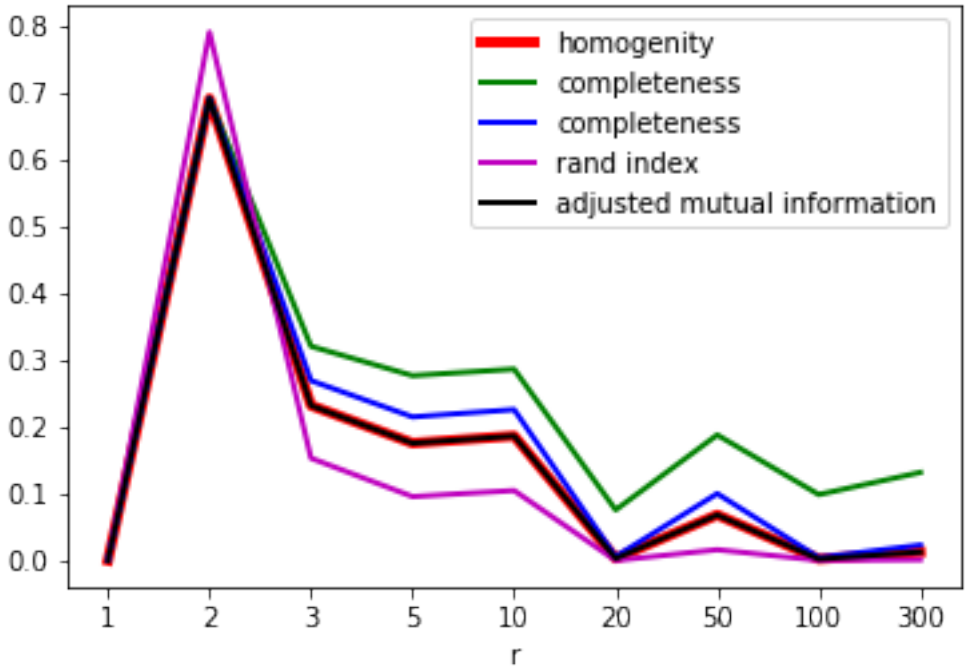

```
************************************************************
The best R value for TruncatedSVD is 2
The contingency matrix is:
[[  45 2298]
 [1842  547]]
Homogeneity: 0.511
Completeness: 0.526
V-measure: 0.518
Adjusted Rand-Index: 0.562
Adjusted Mutual Info Score: 0.510
************************************************************
```

Note: the result(best R value) is random and unrepeatable with different random_state! (Need luck to get to global minimum for each R.)

c) - 3

```
In [30]: # NMF
         # if GET_DATA_FROM_FILES and not DETAILS \
         if os.path.isfile("./y_nmf.pkl") \
                 and os.path.isfile("./cmatrix_nmf.pkl"):
             logging.info("Loading y and cmatrix for NMF.")
             y_nmf = pickle.load(open("./y_nmf.pkl", "rb"))
             cmatrix_nmf = pickle.load(open("./cmatrix_nmf.pkl", "rb"))
         else:
             y_nmf = []
             cmatrix_nmf = []
             for i in r:
                 nmf = NMF(n_components=i)
                 # normalizer = Normalizer(copy=False)
                 # pipeline = make_pipeline(svd, normalizer)
                 # X_train_lsi = pipeline.fit_transform(X_train_tfidf)
                 X_train_nmf = nmf.fit_transform(X_train_tfidf)
                 kmean = cluster_kmean(X_train_nmf, 2)
                 msg = 'With r = %d' % i + " Using NMF"
                 result = report_stats(train_label, kmean, CAT, display=False, msg=msg)
                 print("-  "*10)
                 print("The contingency matrix is: ")
                 cmatrix_nmf.append(result[0])
                 print(result[0])
                 y_nmf.append(result[1])
                 print("-"*30)
             pickle.dump(y_nmf, open("./y_nmf.pkl", "wb"), True)
             pickle.dump(cmatrix_nmf, open("./cmatrix_nmf.pkl", "wb"), True)

         y_transpose = np.array(y_nmf).T.tolist()

         r_len = len(r)
         l1, = plt.plot(range(r_len), y_transpose[0], 'r', lw=4, label='homogenity')
         l2, = plt.plot(range(r_len), y_transpose[1], 'g', lw=2, label='completeness')
         l3, = plt.plot(range(r_len), y_transpose[2], 'b', lw=2, label='completeness')
         l4, = plt.plot(range(r_len), y_transpose[3], 'm', lw=2, label='rand index')
         l5, = plt.plot(range(r_len), y_transpose[4], 'k', lw=2, label='adjusted mutual informa
         tick_marks = np.arange(r_len)
         labels = [str(a) for a in r]
         plt.xticks(tick_marks, labels)
         plt.legend(handles=[l1, l2, l3, l4, l5])
         plt.xlabel('r')
         plt.show()
```

```
best_r = [np.argmax(y_transpose[i]) for i in range(5)]
print("*"*60)
bi_nmf = np.bincount(best_r).argmax() # best_r_index
print("The best R value for NMF is %d" % r[bi_nmf])
print("The contingency matrix is: ")
print(cmatrix_nmf[bi_nmf])
print("Homogeneity: %0.3f" % y_transpose[0][bi_nmf])
print("Completeness: %0.3f" % y_transpose[1][bi_nmf])
print("V-measure: %0.3f" % y_transpose[2][bi_nmf])
print("Adjusted Rand-Index: %.3f" % y_transpose[3][bi_nmf])
print("Adjusted Mutual Info Score: %0.3f" % y_transpose[4][bi_nmf])
print("*"*60)

duration = timer() - start
logging.debug("Computation Time in secs: %d" % duration)
logging.info("finished Problem 3")
```



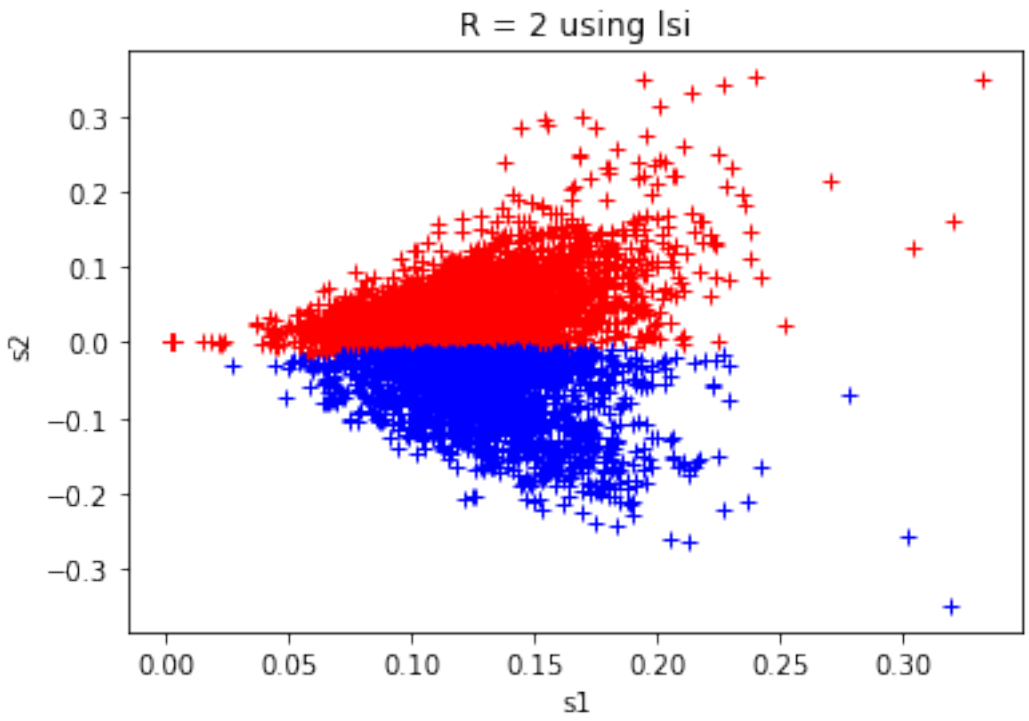

```
************************************************************
The best R value for NMF is 2
The contingency matrix is:
[[2224  119]
 [ 145 2244]]
Homogeneity: 0.690
Completeness: 0.690
V-measure: 0.690
```

```
Adjusted Rand-Index: 0.789
Adjusted Mutual Info Score: 0.690
**********************************************************
```

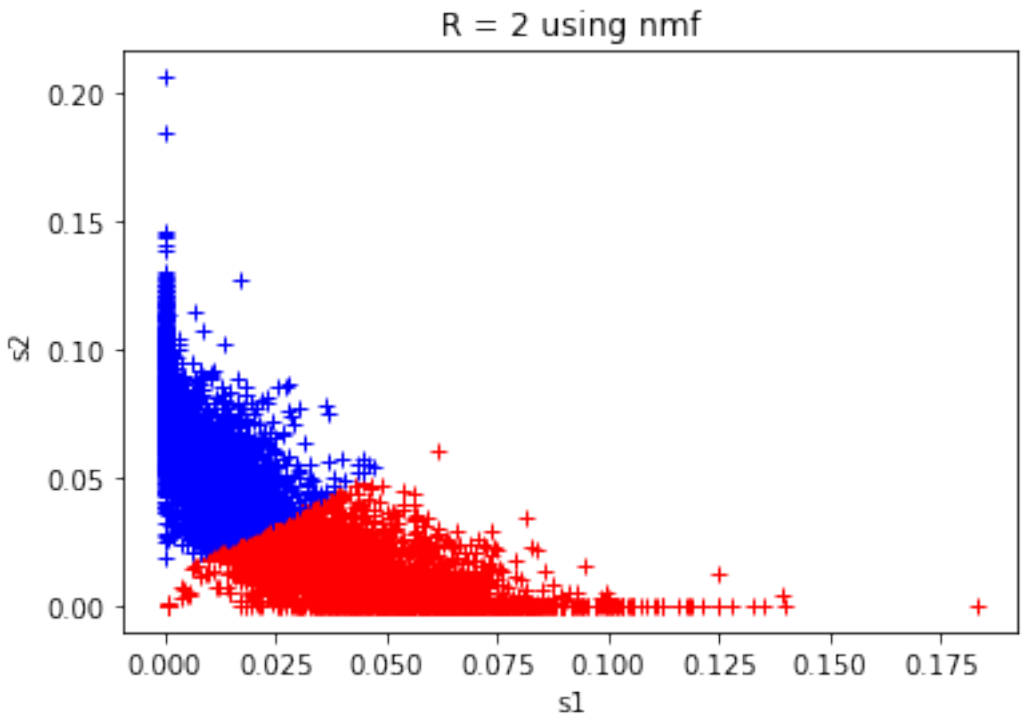
d)

```
In [31]: logging.info("Problem 4")
         start = timer()

         # plot best LSI and NMF result

         def plot_cluster_2D(r, reduct_method, norm=False, log_bf=False, log_af=False, report_s
             if r < 2:
                 logging.warning("Cannot plot. Dimension smaller than 2.")
                 return

             reduct = None
             if reduct_method is 'lsi':
                 if log_bf or log_af:
                     logging.warning("Cannot apply log to lsi.")
                     return
                 reduct = TruncatedSVD(n_components=r, random_state=None)
             elif reduct_method is 'nmf':
                 reduct = NMF(n_components=r)
             else:
                 logging.warning("Cannot plot. Unknown dimensionality reduction method.")
                 return

             X_train_svd = None
             if norm:
                 if log_bf:
                     log_trans_bf = FunctionTransformer(np.log1p)
                     pipeline = make_pipeline(reduct, log_trans_bf)
                     X_train_not_norm = pipeline.fit_transform(X_train_tfidf)
                 else:
                     X_train_not_norm = reduct.fit_transform(X_train_tfidf)

                 X_train_svd = scale(X_train_not_norm)
             else:
                 X_train_svd = reduct.fit_transform(X_train_tfidf)

             X_train_km = None
             if log_af:
                 log_trans_af = FunctionTransformer(np.log1p)
                 matrix_min = np.amin(X_train_svd)
                 X_train_km = np.nan_to_num(log_trans_af.fit_transform(X_train_svd-matrix_min))
             else:
```

```
            X_train_km = X_train_svd

        kmeans = cluster_kmean(X_train_km, 2)

        x1 = X_train_km[kmeans == 0][:, 0]
        y1 = X_train_km[kmeans == 0][:, 1]
        x2 = X_train_km[kmeans == 1][:, 0]
        y2 = X_train_km[kmeans == 1][:, 1]

        plt.plot(x1, y1, 'r+')
        plt.plot(x2, y2, 'b+')
        title = "R = %d using " % r + reduct_method \
                + (" and logarithmic transformation" if log_bf else '')\
                + (" and normalization" if norm else '') \
                + (" and logarithmic transformation" if log_af else '')
        plt.title(title)
        plt.xlabel('s1')
        plt.ylabel('s2')
        plt.show()

        if report_stat:
            result = report_stats(train_label, kmeans, CAT, display=False, msg=title)
            print("-  "*10)
            print("The contingency matrix is: ")
            print(result[0])


plot_cluster_2D(r[bi_lsi], reduct_method='lsi', report_stat=True)
plot_cluster_2D(r[bi_nmf], reduct_method='nmf', report_stat=True)
```

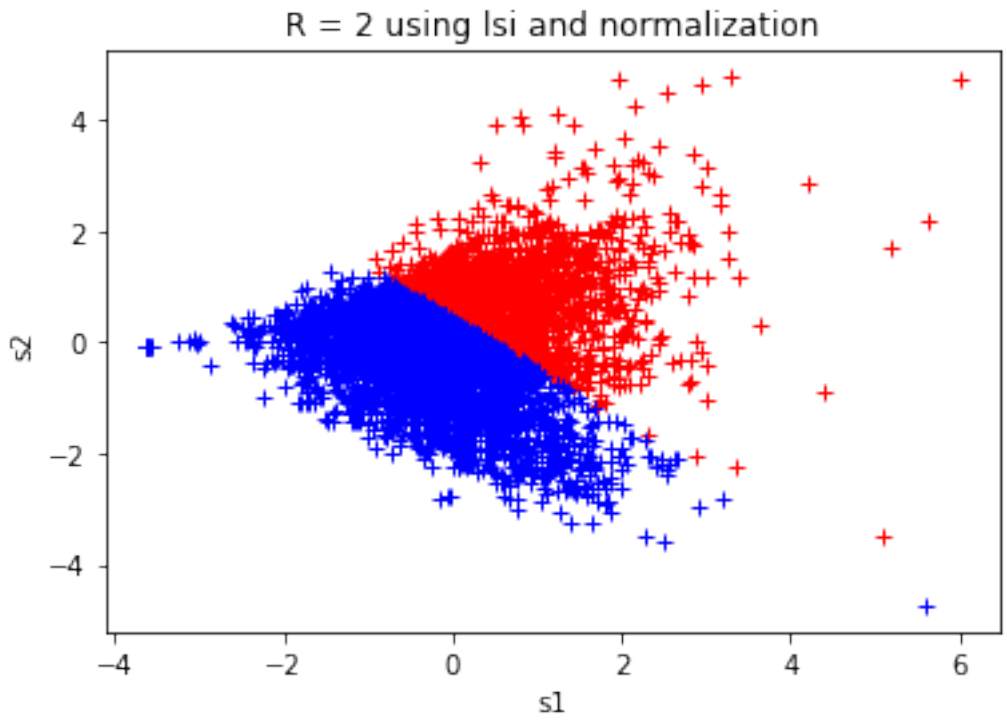



```
R = 2 using lsi
Homogeneity: 0.516
Completeness: 0.531
V-measure: 0.523
Adjusted Rand-Index: 0.572
Adjusted Mutual Info Score: 0.516
-  -  -  -  -  -  -  -  -  -
The contingency matrix is:
[[2294   49]
 [ 527 1862]]
```



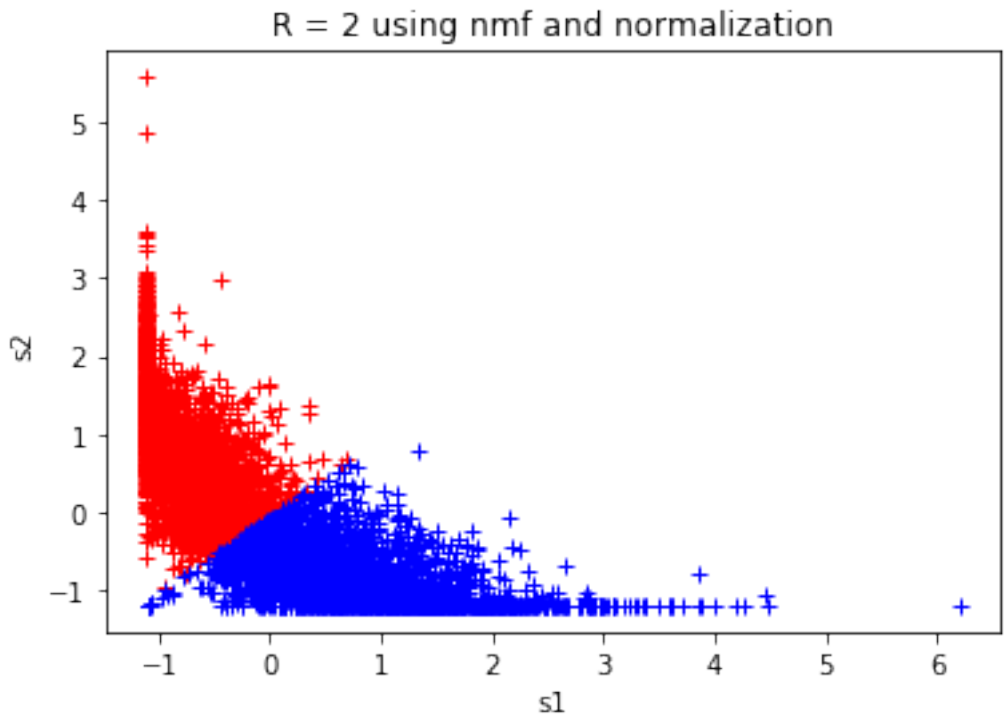

```
R = 2 using nmf
Homogeneity: 0.691
Completeness: 0.691
V-measure: 0.691
Adjusted Rand-Index: 0.790
Adjusted Mutual Info Score: 0.691
-  -  -  -  -  -  -  -  -  -
The contingency matrix is:
[[2224  119]
 [ 144 2245]]
```

```
In [32]: plot_cluster_2D(r[bi_lsi], reduct_method='lsi', norm=True, report_stat=True)
```



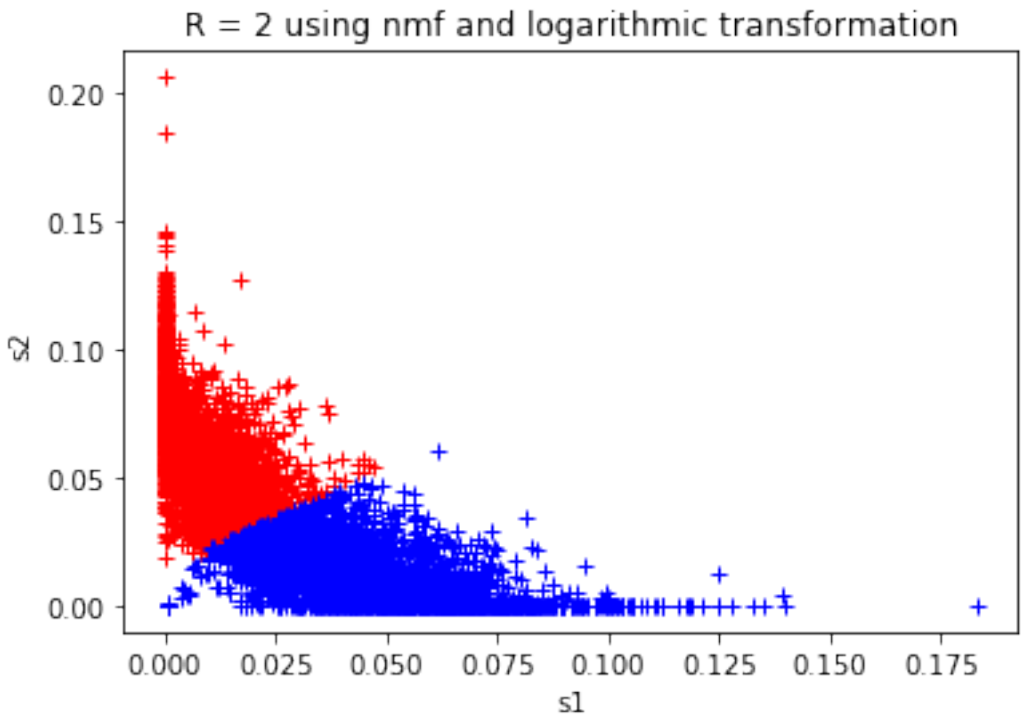

```
R = 2 using lsi and normalization
Homogeneity: 0.196
Completeness: 0.218
V-measure: 0.206
Adjusted Rand-Index: 0.220
Adjusted Mutual Info Score: 0.196
-  -  -  -  -  -  -  -  -  -
The contingency matrix is:
[[1293 1050]
 [ 205 2184]]
```

```
In [33]: plot_cluster_2D(r[bi_nmf], reduct_method='nmf', norm=True, report_stat=True)
```



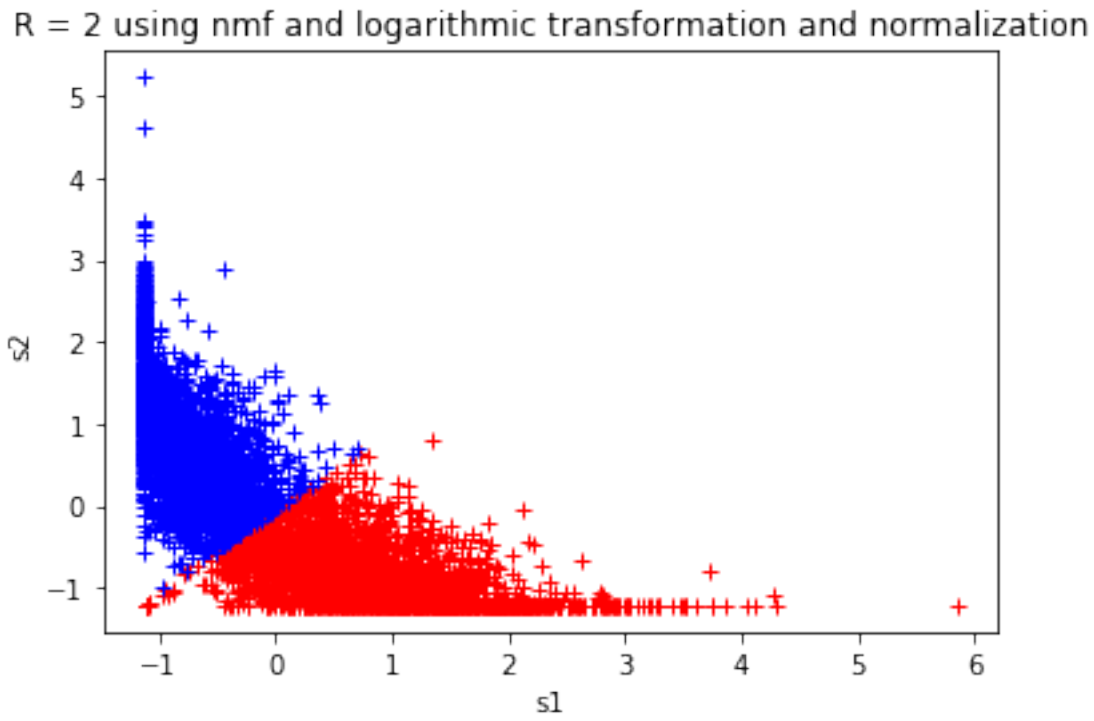

```
R = 2 using nmf and normalization
Homogeneity: 0.711
Completeness: 0.712
V-measure: 0.711
Adjusted Rand-Index: 0.807
Adjusted Mutual Info Score: 0.711
-  -  -  -  -  -  -  -  -  -
The contingency matrix is:
[[ 148 2195]
 [2296   93]]
```

```
In [34]: plot_cluster_2D(r[bi_nmf], reduct_method='nmf', log_bf=True, report_stat=True)
```

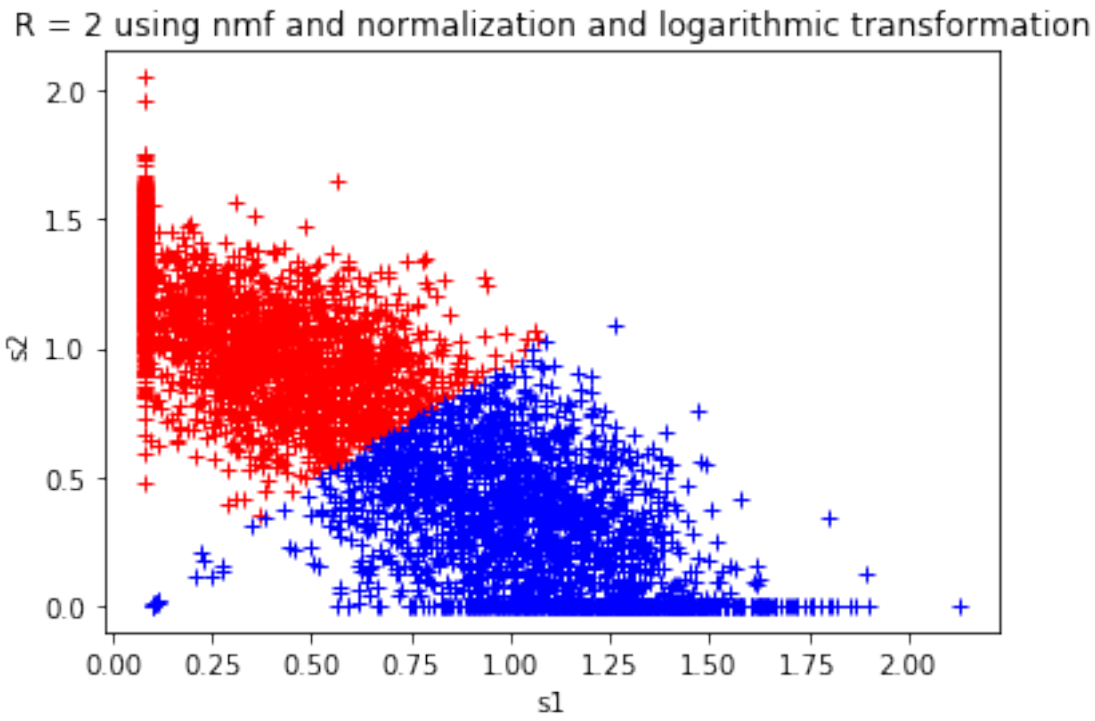



```
R = 2 using nmf and logarithmic transformation
Homogeneity: 0.691
Completeness: 0.691
V-measure: 0.691
Adjusted Rand-Index: 0.790
Adjusted Mutual Info Score: 0.691
-  -  -  -  -  -  -  -  -  -
The contingency matrix is:
[[ 119 2224]
 [2245  144]]
```

```
In [25]: plot_cluster_2D(r[bi_nmf], reduct_method='nmf', norm=True, log_bf=True, report_stat=T
         plot_cluster_2D(r[bi_nmf], reduct_method='nmf', norm=True, log_af=True, report_stat=T
```




```
R = 2 using nmf and logarithmic transformation and normalization
Homogeneity: 0.709
Completeness: 0.710
V-measure: 0.710
Adjusted Rand-Index: 0.805
Adjusted Mutual Info Score: 0.709
-  -  -  -  -  -  -  -  -  -
The contingency matrix is:
[[2193  150]
 [  93 2296]]
```

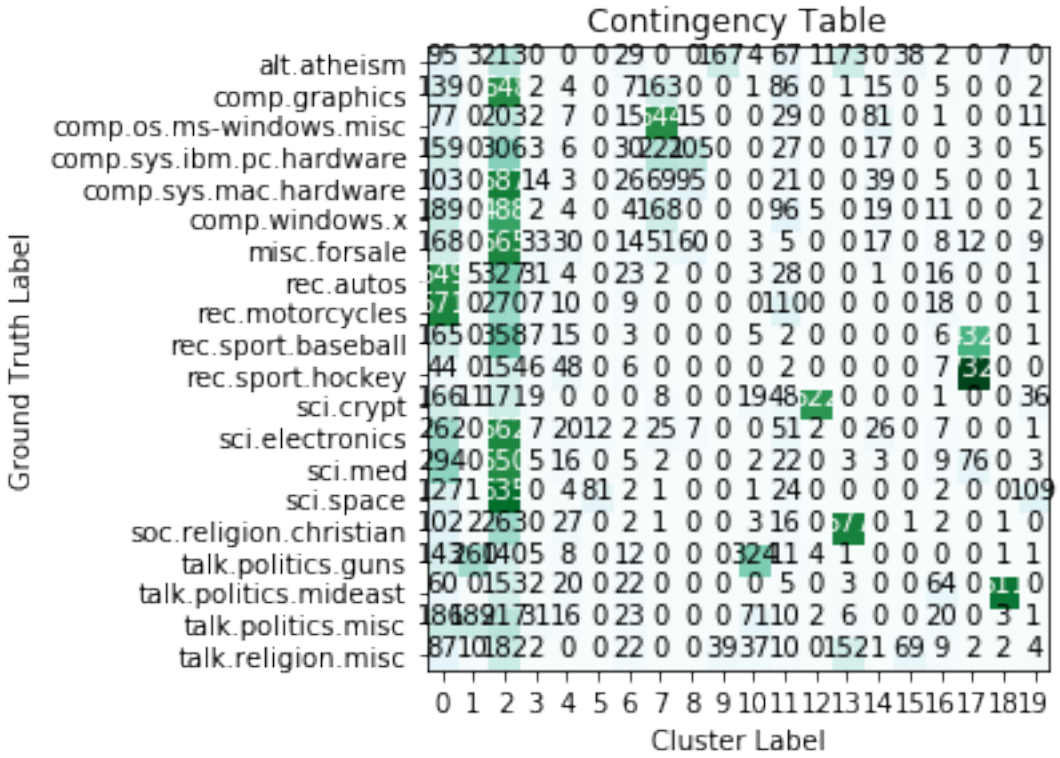



```
R = 2 using nmf and normalization and logarithmic transformation
Homogeneity: 0.708
Completeness: 0.708
V-measure: 0.708
Adjusted Rand-Index: 0.803
Adjusted Mutual Info Score: 0.708
-  -  -  -  -  -  -  -  -  -
The contingency matrix is:
[[ 158 2185]
 [2301   88]]
```

e)

```
In [35]: # Without preprocessing

         X_all_tfidf = None
         if GET_DATA_FROM_FILES and os.path.isfile("./all_tfidf.pkl"):
             logging.info("Loading tfidf vector.")
             X_all_tfidf = pickle.load(open("./all_tfidf.pkl", "rb"))
         else:
             X_all_tfidf = doTFIDF(all_data.data, MIN_DF)
             pickle.dump(X_train_tfidf, open("./all_tfidf.pkl", "wb"))
```

```
kmeans = cluster_kmean(X_all_tfidf, 20)
result = report_stats(all_label, kmeans, CAT_ALL, display=True, msg="Without dimensio
```

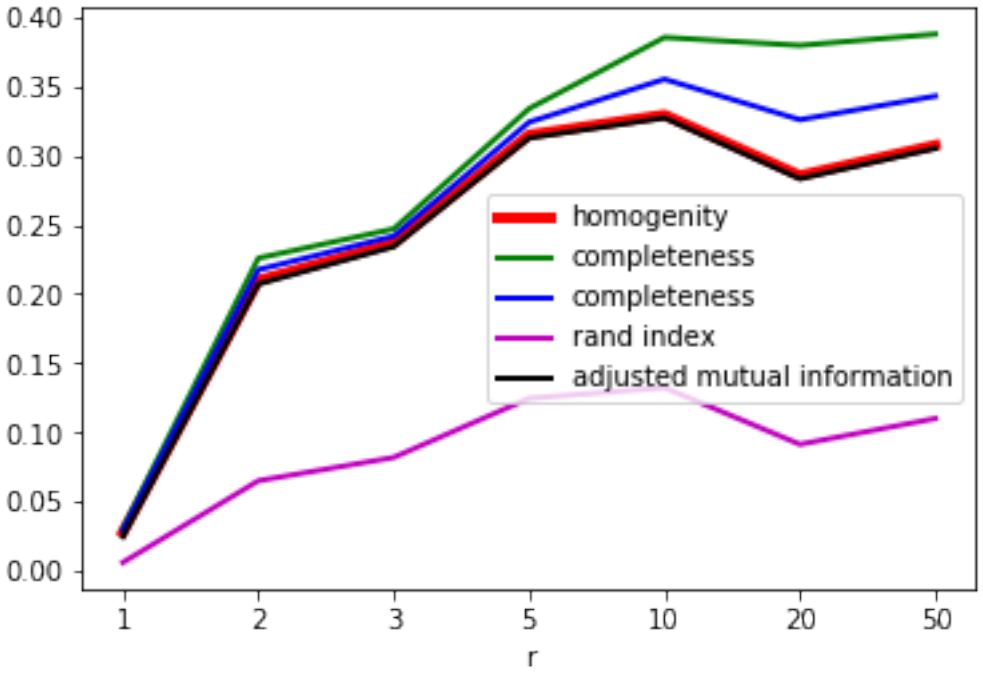



```
Without dimensionality reduction
Homogeneity: 0.281
Completeness: 0.382
V-measure: 0.324
Adjusted Rand-Index: 0.081
Adjusted Mutual Info Score: 0.279
```

```
In [38]: r2 = [1, 2, 3, 5, 10, 20, 50]

         # LSI
         y_lsi_all = None
         cmatrix_lsi_all = None
         if GET_DATA_FROM_FILES and not DETAILS \
                 and os.path.isfile("./y_lsi_all.pkl") \
                 and os.path.isfile("./cmatrix_lsi_all.pkl"):
             logging.info("Loading y_all and cmatrix_all for LSI.")
             y_lsi_all = pickle.load(open("./y_lsi_all.pkl", "rb"))
             cmatrix_lsi_all = pickle.load(open("./cmatrix_lsi_all.pkl", "rb"))
         else:
```

```
        y_lsi_all = []
        cmatrix_lsi_all = []
        for i in r2:
            svd = TruncatedSVD(n_components=i, random_state=None)
            X_all_lsi = svd.fit_transform(X_all_tfidf)
            kmean = cluster_kmean(X_all_lsi, 20)
            msg = 'With r = %d' % i + " Using LSI"
            result = report_stats(all_label, kmean, CAT_ALL, display=False, msg=msg)
#           print("-  "*10)
#           print("The contingency matrix is: ")
            cmatrix_lsi_all.append(result[0])
#           print(result[0])
            y_lsi_all.append(result[1])
            print("-"*30)

        pickle.dump(y_lsi_all, open("./y_lsi.pkl", "wb"), True)
        pickle.dump(cmatrix_lsi_all, open("./cmatrix_lsi.pkl", "wb"), True)

    y_transpose = np.array(y_lsi_all).T.tolist()

    r2_len = len(r2)
    l1, = plt.plot(range(r2_len), y_transpose[0], 'r', lw=4, label='homogenity')
    l2, = plt.plot(range(r2_len), y_transpose[1], 'g', lw=2, label='completeness')
    l3, = plt.plot(range(r2_len), y_transpose[2], 'b', lw=2, label='completeness')
    l4, = plt.plot(range(r2_len), y_transpose[3], 'm', lw=2, label='rand index')
    l5, = plt.plot(range(r2_len), y_transpose[4], 'k', lw=2, label='adjusted mutual infor
    tick_marks = np.arange(r2_len)
    labels = [str(a) for a in r2]
    plt.xticks(tick_marks, labels)
    plt.legend(handles=[l1, l2, l3, l4, l5])
    plt.xlabel('r')
    plt.show()

    best_r2 = [np.argmax(y_transpose[i]) for i in range(5)]
    print("*"*60)
    bi_lsi_all = np.bincount(best_r2).argmax() # best_r_index
    print("The best R value for TruncatedSVD is %d" % r[bi_lsi_all])
    # print("The contingency matrix is: ")
    # print(cmatrix_lsi_all[bi_lsi_all])
    print("Homogeneity: %0.3f" % y_transpose[0][bi_lsi_all])
    print("Completeness: %0.3f" % y_transpose[1][bi_lsi_all])
    print("V-measure: %0.3f" % y_transpose[2][bi_lsi_all])
    print("Adjusted Rand-Index: %.3f" % y_transpose[3][bi_lsi_all])
    print("Adjusted Mutual Info Score: %0.3f" % y_transpose[4][bi_lsi_all])
    print("*"*60)

With r = 1 Using LSI
Homogeneity: 0.028
```

```
Completeness: 0.031
V-measure: 0.029
Adjusted Rand-Index: 0.006
Adjusted Mutual Info Score: 0.025
------------------------------
With r = 2 Using LSI
Homogeneity: 0.210
Completeness: 0.226
V-measure: 0.217
Adjusted Rand-Index: 0.065
Adjusted Mutual Info Score: 0.207
------------------------------
With r = 3 Using LSI
Homogeneity: 0.237
Completeness: 0.247
V-measure: 0.242
Adjusted Rand-Index: 0.082
Adjusted Mutual Info Score: 0.234
------------------------------
With r = 5 Using LSI
Homogeneity: 0.315
Completeness: 0.334
V-measure: 0.324
Adjusted Rand-Index: 0.125
Adjusted Mutual Info Score: 0.313
------------------------------
With r = 10 Using LSI
Homogeneity: 0.329
Completeness: 0.385
V-measure: 0.355
Adjusted Rand-Index: 0.132
Adjusted Mutual Info Score: 0.327
------------------------------
With r = 20 Using LSI
Homogeneity: 0.285
Completeness: 0.379
V-measure: 0.326
Adjusted Rand-Index: 0.091
Adjusted Mutual Info Score: 0.283
------------------------------
With r = 50 Using LSI
Homogeneity: 0.307
Completeness: 0.388
V-measure: 0.343
Adjusted Rand-Index: 0.110
Adjusted Mutual Info Score: 0.305
------------------------------
```



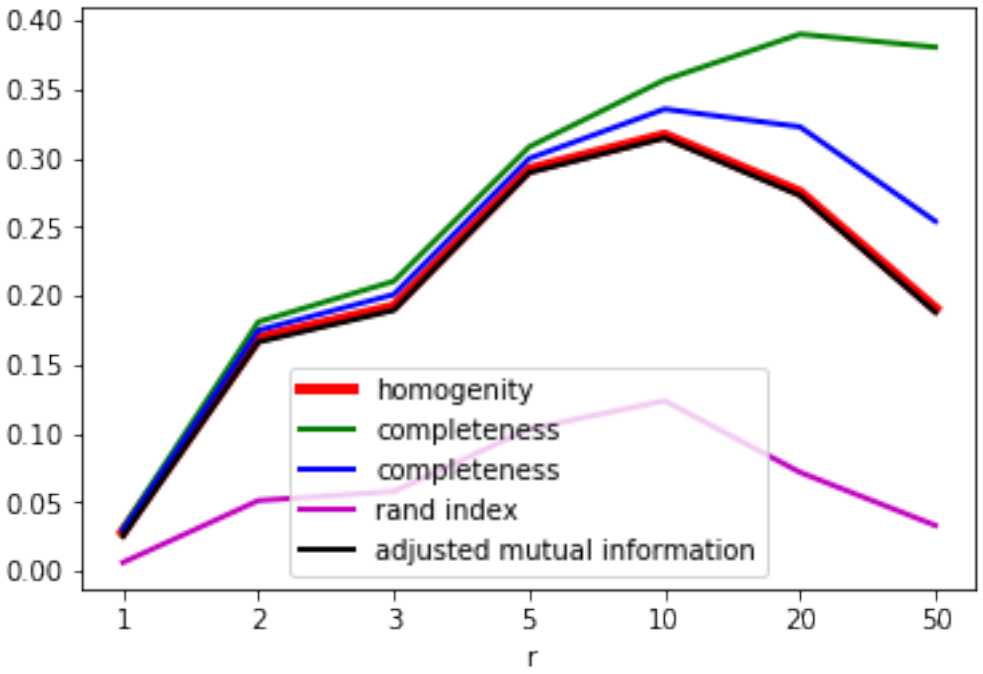

```
************************************************************
The best R value for TruncatedSVD is 10
Homogeneity: 0.329
Completeness: 0.385
V-measure: 0.355
Adjusted Rand-Index: 0.132
Adjusted Mutual Info Score: 0.327
************************************************************
```

```
In [39]: # NMF
         y_nmf_all = None
         cmatrix_nmf_all = None
         if GET_DATA_FROM_FILES and not DETAILS \
                 and os.path.isfile("./y_nmf_all.pkl") \
                 and os.path.isfile("./cmatrix_nmf_all.pkl"):
             logging.info("Loading y_all and cmatrix_all for NMF.")
             y_nmf_all = pickle.load(open("./y_nmf_all.pkl", "rb"))
             cmatrix_nmf_all = pickle.load(open("./cmatrix_nmf_all.pkl", "rb"))
         else:
             y_nmf_all = []
             cmatrix_nmf_all = []
             for i in r2:
                 svd = NMF(n_components=i)
                 X_all_nmf = svd.fit_transform(X_all_tfidf)
```

```
            kmean = cluster_kmean(X_all_nmf, 20)
            msg = 'With r = %d' % i + " Using NMF"
            result = report_stats(all_label, kmean, CAT_ALL, display=False, msg=msg)
#           print("-  "*10)
#           print("The contingency matrix is: ")
            cmatrix_nmf_all.append(result[0])
#           print(result[0])
            y_nmf_all.append(result[1])
            print("-"*30)

        pickle.dump(y_nmf_all, open("./y_nmf_all.pkl", "wb"), True)
        pickle.dump(cmatrix_nmf_all, open("./cmatrix_nmf_all.pkl", "wb"), True)

    y_transpose = np.array(y_nmf_all).T.tolist()

    r2_len = len(r2)
    l1, = plt.plot(range(r2_len), y_transpose[0], 'r', lw=4, label='homogenity')
    l2, = plt.plot(range(r2_len), y_transpose[1], 'g', lw=2, label='completeness')
    l3, = plt.plot(range(r2_len), y_transpose[2], 'b', lw=2, label='completeness')
    l4, = plt.plot(range(r2_len), y_transpose[3], 'm', lw=2, label='rand index')
    l5, = plt.plot(range(r2_len), y_transpose[4], 'k', lw=2, label='adjusted mutual infor
    tick_marks = np.arange(r2_len)
    labels = [str(a) for a in r2]
    plt.xticks(tick_marks, labels)
    plt.legend(handles=[l1, l2, l3, l4, l5])
    plt.xlabel('r')
    plt.show()

    best_r2 = [np.argmax(y_transpose[i]) for i in range(5)]
    print("*"*60)
    bi_nmf_all = np.bincount(best_r2).argmax() # best_r_index
    print("The best R value for NMF is %d" % r[bi_nmf_all])
    # print("The contingency matrix is: ")
    # print(cmatrix_nmf_all[bi_nmf_all])
    print("Homogeneity: %0.3f" % y_transpose[0][bi_nmf_all])
    print("Completeness: %0.3f" % y_transpose[1][bi_nmf_all])
    print("V-measure: %0.3f" % y_transpose[2][bi_nmf_all])
    print("Adjusted Rand-Index: %.3f" % y_transpose[3][bi_nmf_all])
    print("Adjusted Mutual Info Score: %0.3f" % y_transpose[4][bi_nmf_all])
    print("*"*60)
```

```
With r = 1 Using NMF
Homogeneity: 0.028
Completeness: 0.031
V-measure: 0.030
Adjusted Rand-Index: 0.006
Adjusted Mutual Info Score: 0.025
------------------------------
```

```
With r = 2 Using NMF
Homogeneity: 0.169
Completeness: 0.181
V-measure: 0.175
Adjusted Rand-Index: 0.051
Adjusted Mutual Info Score: 0.166
------------------------------
With r = 3 Using NMF
Homogeneity: 0.192
Completeness: 0.210
V-measure: 0.201
Adjusted Rand-Index: 0.058
Adjusted Mutual Info Score: 0.189
------------------------------
With r = 5 Using NMF
Homogeneity: 0.292
Completeness: 0.308
V-measure: 0.300
Adjusted Rand-Index: 0.103
Adjusted Mutual Info Score: 0.289
------------------------------
With r = 10 Using NMF
Homogeneity: 0.317
Completeness: 0.357
V-measure: 0.336
Adjusted Rand-Index: 0.124
Adjusted Mutual Info Score: 0.315
------------------------------
With r = 20 Using NMF
Homogeneity: 0.275
Completeness: 0.390
V-measure: 0.323
Adjusted Rand-Index: 0.072
Adjusted Mutual Info Score: 0.273
------------------------------
With r = 50 Using NMF
Homogeneity: 0.191
Completeness: 0.381
V-measure: 0.254
Adjusted Rand-Index: 0.033
Adjusted Mutual Info Score: 0.188
------------------------------
```




```
************************************************************
The best R value for NMF is 10
Homogeneity: 0.317
Completeness: 0.357
V-measure: 0.336
Adjusted Rand-Index: 0.124
Adjusted Mutual Info Score: 0.315
************************************************************
```

```
In [45]: def try_other_transform(r, reduct_method, norm=False, log_bf=False, log_af=False, rep
             if r < 2:
                 logging.warning("Cannot plot. Dimension smaller than 2.")
                 return

             reduct = None
             if reduct_method is 'lsi':
                 if log_bf or log_af:
                     logging.warning("Cannot apply log to lsi.")
                     return
                 reduct = TruncatedSVD(n_components=r, random_state=None)
             elif reduct_method is 'nmf':
                 reduct = NMF(n_components=r)
             else:
                 logging.warning("Cannot plot. Unknown dimensionality reduction method.")
```

```
            return

        X_all_svd = None
        if norm:
            if log_bf:
                log_trans_bf = FunctionTransformer(np.log1p)
                pipeline = make_pipeline(reduct, log_trans_bf)
                X_all_not_norm = pipeline.fit_transform(X_all_tfidf)
            else:
                X_all_not_norm = reduct.fit_transform(X_all_tfidf)

            X_all_svd = scale(X_all_not_norm)
        else:
            X_all_svd = reduct.fit_transform(X_all_tfidf)

        X_all_km = None
        if log_af:
            log_trans_af = FunctionTransformer(np.log1p)
            matrix_min = np.amin(X_all_svd)
            X_all_km = np.nan_to_num(log_trans_af.fit_transform(X_all_svd - matrix_min))
        else:
            X_all_km = X_all_svd

        kmeans = cluster_kmean(X_all_km, 20)
        title = "R = %d using " % r + reduct_method \
            + (" and logarithmic transformation" if log_bf else '')\
            + (" and normalization" if norm else '') \
            + (" and logarithmic transformation" if log_af else '')

        if report_stat:
            result = report_stats(all_label, kmeans, CAT_ALL, display=False, msg=title)
            print('-'*60)
#           print("-  "*10)
#           print("The contingency matrix is: ")
#           print(result[0])
```

In [47]:
```
try_other_transform(r2[bi_lsi_all], reduct_method='lsi', report_stat=True)
try_other_transform(r2[bi_nmf_all], reduct_method='nmf', report_stat=True)
try_other_transform(r2[bi_lsi_all], reduct_method='lsi', norm=True, report_stat=True)
try_other_transform(r2[bi_nmf_all], reduct_method='nmf', norm=True, report_stat=True)
try_other_transform(r2[bi_nmf_all], reduct_method='nmf', log_bf=True, report_stat=True
try_other_transform(r2[bi_nmf_all], reduct_method='nmf', norm=True, log_bf=True, repo
try_other_transform(r2[bi_nmf_all], reduct_method='nmf', norm=True, log_af=True, repo
```

```
R = 10 using lsi
Homogeneity: 0.333
```

```
Completeness: 0.375
V-measure: 0.353
Adjusted Rand-Index: 0.133
Adjusted Mutual Info Score: 0.331
------------------------------------------------------------
R = 10 using nmf
Homogeneity: 0.316
Completeness: 0.356
V-measure: 0.335
Adjusted Rand-Index: 0.123
Adjusted Mutual Info Score: 0.314
------------------------------------------------------------
R = 10 using lsi and normalization
Homogeneity: 0.311
Completeness: 0.350
V-measure: 0.329
Adjusted Rand-Index: 0.127
Adjusted Mutual Info Score: 0.309
------------------------------------------------------------
R = 10 using nmf and normalization
Homogeneity: 0.301
Completeness: 0.337
V-measure: 0.318
Adjusted Rand-Index: 0.118
Adjusted Mutual Info Score: 0.299
------------------------------------------------------------
R = 10 using nmf and logarithmic transformation
Homogeneity: 0.315
Completeness: 0.355
V-measure: 0.334
Adjusted Rand-Index: 0.123
Adjusted Mutual Info Score: 0.313
------------------------------------------------------------
R = 10 using nmf and logarithmic transformation and normalization
Homogeneity: 0.313
Completeness: 0.353
V-measure: 0.332
Adjusted Rand-Index: 0.119
Adjusted Mutual Info Score: 0.311
------------------------------------------------------------
R = 10 using nmf and normalization and logarithmic transformation
Homogeneity: 0.338
Completeness: 0.349
V-measure: 0.343
Adjusted Rand-Index: 0.158
Adjusted Mutual Info Score: 0.336
------------------------------------------------------------
```