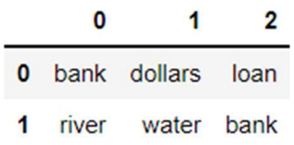
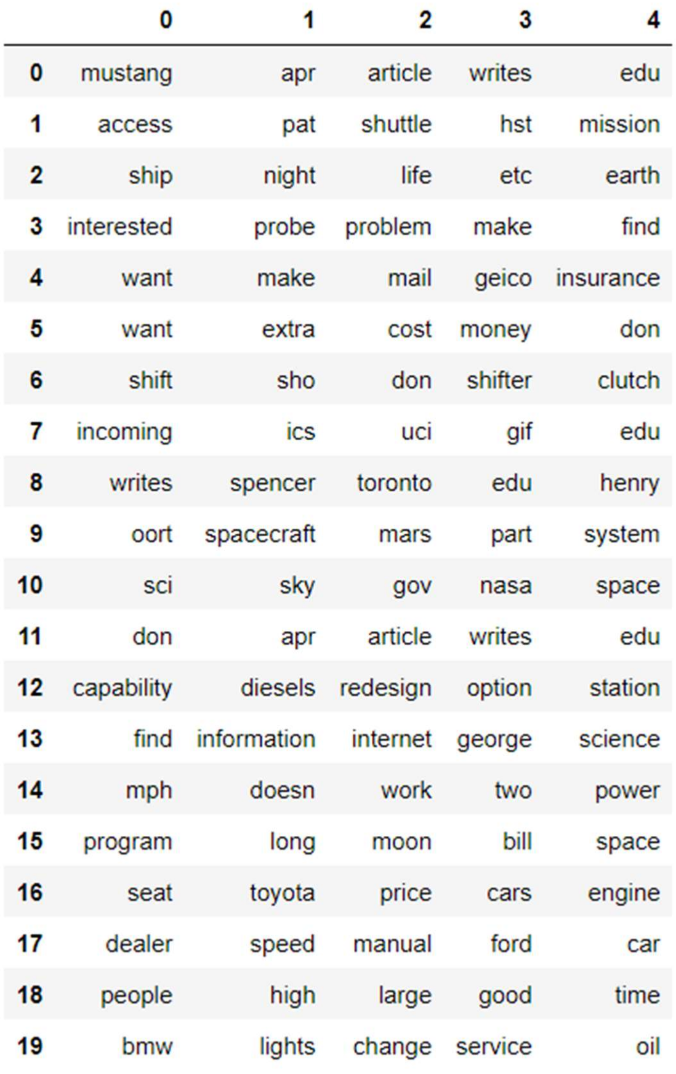
PROGRAMMING PROJECT 4

TASK1:



	0	1	2
0	bank	dollars	loan
1	river	water	bank

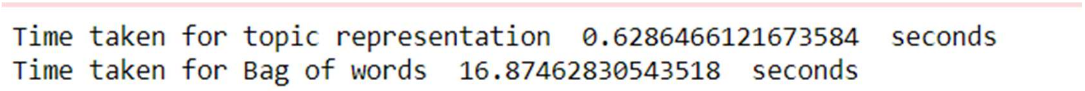
The answer for the artificial data set, it contains top 3 values because while concluding for the smaller data set we noticed only three significant values for each topic



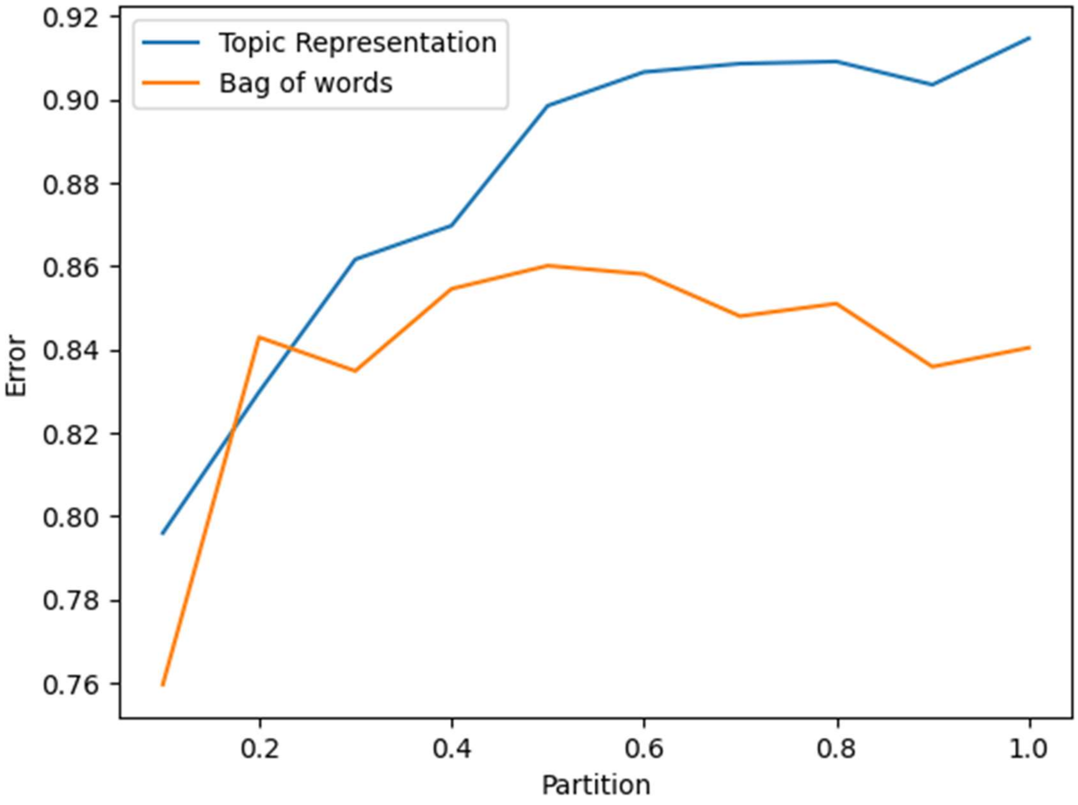
	0	1	2	3	4
0	mustang	apr	article	writes	edu
1	access	pat	shuttle	hst	mission
2	ship	night	life	etc	earth
3	interested	probe	problem	make	find
4	want	make	mail	geico	insurance
5	want	extra	cost	money	don
6	shift	sho	don	shifter	clutch
7	incoming	ics	uci	gif	edu
8	writes	spencer	toronto	edu	henry
9	oort	spacecraft	mars	part	system
10	sci	sky	gov	nasa	space
11	don	apr	article	writes	edu
12	capability	diesels	redesign	option	station
13	find	information	internet	george	science
14	mph	doesn	work	two	power
15	program	long	moon	bill	space
16	seat	toyota	price	cars	engine
17	dealer	speed	manual	ford	car
18	people	high	large	good	time
19	bmw	lights	change	service	oil

These are top 5 values for each topic for the newsletter data set. Few of the topics above make sense, like bmw lights change service oil, can be considered a part of 1 topic, but few topics have words that don't have any relationship.

Task2:



```
Time taken for topic representation  0.6286466121673584  seconds
Time taken for Bag of words  16.87462830543518  seconds
```



From the graphs topic representation graph has more error rate and bag of words has a lesser error rate.

The assignment is written in ipynb format and can be run using the jupyter notebook

The data files are attached to the directory, in case of data not loading please check the path

There are no specific instructions to run the file

In [1]:

```
import random
import numpy as np
from IPython.display import clear_output
import csv
import pandas as pd
import time
import matplotlib.pyplot as plt
```

Task 1

In [2]:

```
def read_all_documents(path, D):
    corpus = []
    for f in range(1,D+1):
        file_path = f'{path}/{f}'
        with open(file_path,'r') as file:
            corpus.append(file.read().split())
    return corpus
```

In [3]:

```
def LDA(corpus,K):
    N_iters=500
    N_words=0
    a=5/K
    b=0.01
    for i in corpus:
        N_words=N_words+len(i)
    vocab=[]
    for i in corpus:
        for j in i:
            if j not in vocab:
                vocab.append(j)
    pi_n=random.sample(range(0,N_words),N_words)
    w_n=[]
    for i in corpus:
        for j in i:
            w_n.append(vocab.index(j))
    d_n=[]
    for i in range(len(corpus)):
        for j in range(len(corpus[i])):
            d_n.append(i)
    z_n=[]
    for i in range(N_words):
        z_n.append(random.randint(0,K-1))
    w_n=np.array(w_n)
    z_n=np.array(z_n)
    d_n=np.array(d_n)
    c_d = np.zeros((D, K))
    c_t = np.zeros((K, len(vocab)))
    P=np.zeros(K)
    for i in range(c_d.shape[0]):
        for j in range(c_d.shape[1]):
            c_d[i,j] = np.sum(z_n[np.where(d_n==i)[0]]==j)

    for i in range(c_t.shape[0]):
        for j in range(c_t.shape[1]):
            c_t[i,j] = np.sum(w_n[np.where(z_n==i)[0]]==j)

    for i in range(N_iters):
        for n in range(N_words):
            word=w_n[pi_n[n]]
            topic=z_n[pi_n[n]]
            doc=d_n[pi_n[n]]
            c_d[doc][topic]=c_d[doc][topic]-1
            c_t[topic][word]=c_t[topic][word]-1
            for k in range(K):
                P[k]=((c_t[k,word] + b)/(len(vocab)*b + np.sum(c_t[k,:])))*((c_d[doc,k] + a)/(K*a + np.sum(c_d[doc,:])))
            pnorm = sum(P)
            pnorm = pnorm if pnorm>0 else 1
            P = [pp/pnorm for pp in P]
            topic=np.random.choice(np.arange(K),p=P)
            z_n[pi_n[n]]=topic
            c_d[doc][topic]=c_d[doc][topic]+1
            c_t[topic][word]=c_t[topic][word]+1
    return(z_n,c_d,c_t,vocab)
```

In [4]:

```
path = 'pp4data/artificial'
D = 10
corpus = read_all_documents(path, D)
K=2
ans=(LDA(corpus,K))
```

In [5]:

```
path = 'pp4data/20newsgroups/'
D = 200
corpus = read_all_documents(path, D)
K=20
newans=(LDA(corpus,K))
```

In [6]:

```
data=[]
for j in range(2):
    newarr=sorted(range(len(ans[2][j])), key=lambda i: ans[2][j][i])[-3:]
    temp=[]
    for i in newarr:
        temp.append(ans[3][i])
    data.append(temp)
```

In [7]:

```
f = open('csv_file', 'w')
writer = csv.writer(f)
writer.writerows(data)
f.close()

df=pd.read_csv("csv_file",header=None)
df
```

Out[7]:

	0	1	2
0	bank	dollars	loan
1	river	water	bank

In [8]:

```
data=[]
for j in range(20):
    newarr=sorted(range(len(newans[2][j])), key=lambda i: newans[2][j][i])[-5:]
    temp=[]
    for i in newarr:
        temp.append(newans[3][i])
    data.append(temp)
```

In [9]:

```
f = open('topicwords', 'w')
writer = csv.writer(f)
writer.writerows(data)
f.close()

df=pd.read_csv("topicwords",header=None)
df
```

Out[9]:

	0	1	2	3	4
0	mustang	apr	article	writes	edu
1	access	pat	shuttle	hst	mission
2	ship	night	life	etc	earth
3	interested	probe	problem	make	find
4	want	make	mail	geico	insurance
5	want	extra	cost	money	don
6	shift	sho	don	shifter	clutch
7	incoming	ics	uci	gif	edu
8	writes	spencer	toronto	edu	henry
9	oort	spacecraft	mars	part	system
10	sci	sky	gov	nasa	space
11	don	apr	article	writes	edu
12	capability	diesels	redesign	option	station
13	find	information	internet	george	science
14	mph	doesn	work	two	power
15	program	long	moon	bill	space
16	seat	toyota	price	cars	engine
17	dealer	speed	manual	ford	car
18	people	high	large	good	time
19	bmw	lights	change	service	oil

In [20]:

```
P1=[]
for i in range(10):
    temp=[]
    for k in range(2):
        temp.append((ans[1][i,k] + 5/2)/(5 + np.sum(ans[1][i,:])))
    P1.append(temp)
P1=np.array(P1)
P1
```

Out[20]:

```
array([[0.91346154, 0.08653846],
       [0.20175439, 0.79824561],
       [0.75641026, 0.24358974],
       [0.16666667, 0.83333333],
       [0.78205128, 0.21794872],
       [0.13068182, 0.86931818],
       [0.71978022, 0.28021978],
       [0.20967742, 0.79032258],
       [0.6875    , 0.3125    ],
       [0.15853659, 0.84146341]])
```

In [21]:

```
P2=[]
for i in range(200):
    temp=[]
    for k in range(20):
        temp.append((newans[1][i,k] + 5/20)/(5 + np.sum(newans[1][i,:])))
    P2.append(temp)
P2=np.array(P2)
P2
```

Out[21]:

```
array([[0.10416667, 0.02083333, 0.02083333, ..., 0.02083333, 0.02083333,
        0.10416667],
       [0.05681818, 0.01136364, 0.03863636, ..., 0.05681818, 0.05681818,
        0.58409091],
       [0.14130435, 0.01086957, 0.01086957, ..., 0.01086957, 0.05434783,
        0.01086957],
       ...,
       [0.01666667, 0.01666667, 0.28333333, ..., 0.01666667, 0.08333333,
        0.01666667],
       [0.00438596, 0.60087719, 0.00438596, ..., 0.00438596, 0.00438596,
        0.00438596],
       [0.1712963 , 0.00462963, 0.02314815, ..., 0.00462963, 0.06018519,
        0.02314815]])
```

Task 2

In [36]:

```
def bagOfWords(corpus):
    word=[]
    for i in corpus:
        for j in i:
            word.append(j)
    count=0
    d={}
    for i in word:
        if i not in d:
            d[i] = count
            count=count+1
    doc = []
    for i,j in enumerate(corpus):
        doc.extend([i for k in range(len(j))])
    doc = np.array(doc)
    w = []
    for i in word:
        w.append(d[i])
    w = np.array(w)
    doc_words = np.zeros((200,len(d)))
    for i in range(doc_words.shape[0]):
        for j in range(doc_words.shape[1]):
            doc_words[i,j] = np.sum(w[np.where(doc==i)[0]]==j)
    return doc_words
words=bagOfWords(corpus)
```

In [37]:

```
partition = [0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1]
labels = pd.read_csv(r'pp4data/20newsgroups/index.csv', header=None)
y=labels[1].to_numpy().flatten()
```

In [38]:

```
def discriminative(X,Y):
    N = X.shape[0]
    N_test = int(N/3)
    N_train = N-N_test
    index=[]
    for j in range(N):
        index.append(j)
    discriminative_result = {}
    logisticR_X = np.c_[np.ones(N),X]
    for times in range(1, 31):
        test_index = random.sample(index, N_test)
        train_index = [x for x in index if x not in test_index]
        xtrain = logisticR_X[train_index,:]
        ytrain = Y[train_index]
        xtest = logisticR_X[test_index,:]
        ytest = Y[test_index]
        for pv in partition:
            pv_N = int(pv*N_train)
            p_x = xtrain[:pv_N,]
            p_y = ytrain[:pv_N]
            W_old = np.zeros(p_x.shape[1])
            W_new = np.matrix(np.zeros(p_x.shape[1]))
            d = X.shape[1]
            for iteration in range(100):
                if not(np.linalg.norm(W_new-W_old)**2)/(np.linalg.norm(W_old)**2>0.001):
                      break
                a = np.dot(p_x, W_old)
                y = 1/(1 + np.exp(-a))
                R = np.diag(y*(1-y))
                W_new = W_old - np.dot(np.linalg.inv(0.01*np.identity(d+1) + np.dot(np.dot(p_x.T,R),p_x)),np.dot(p_x.T, (y-p_
                W_old=W_new
            a = np.dot(p_x, W_new)
            y = 1/(1 + np.exp(-a))
            total = np.zeros((d+1,d+1))
            for i in range(y.size):
                total+= (y[i]*(1-y[i]))*np.dot(p_x[i,:], p_x[i,:])
            SN = 0.01*np.identity(d+1) + total
            prob = np.zeros(xtest.shape[0])
            for i in range(prob.size):
                phi = xtest[i,:]
                mu = np.dot(W_new.T, phi)
                sigma_square = np.dot(np.dot(phi.T, SN), phi)
                k = 1/np.sqrt(1 + (np.pi*sigma_square/8))

                prob[i] = 1/(1 + np.exp(-(k*mu)))

            pred_labels = np.where(prob>=0.5,1,0)
            misclassified_instances = np.sum(np.logical_xor(ytest, pred_labels))
            test_error_rate = misclassified_instances/ytest.size


            discriminative_result[(str(times),str(pv))] = test_error_rate

    return(discriminative_result)
def error(generative):
    g_avg = {}


    for p in partition:
            x = np.array([generative[(str(t),str(p))] for t in range(1,31)])
            g_avg[(str(p), "Discriminative")] = (np.mean(x), np.std(x))
    return g_avg
```

In [39]:

```
start1 = time.time()
prediction1 = discriminative(P2,y)
end1 = time.time()
diff1 = end1-start1
print("Time taken for topic representation ",diff1," seconds")

start2 = time.time()
prediction2 = discriminative(words,y)
end2 = time.time()
diff2 = end2-start2
print("Time taken for Bag of words ",diff2," seconds")
```

```
C:\Users\Aaryan Agarwal\AppData\Local\Temp\ipykernel_23112\2718418435.py:25: RuntimeWarning: invalid value encountered in tr
ue_divide
  if not(np.linalg.norm(W_new-W_old)**2)/(np.linalg.norm(W_old)**2>0.001):

Time taken for topic representation  0.6286466121673584  seconds
Time taken for Bag of words  16.87462830543518  seconds
```

In [40]:
```
result1=error(prediction1)
result2=error(prediction2)
```

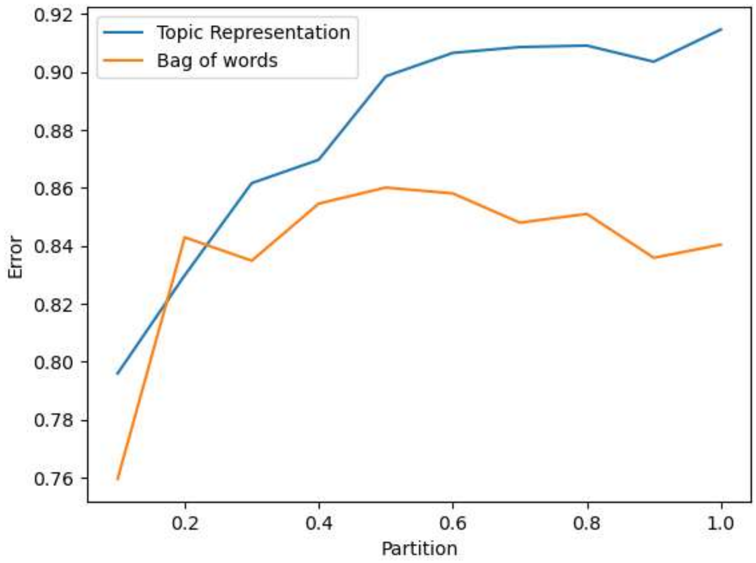
In [41]:
```
result1
```

Out[41]:
```
{('0.1', 'Discriminative'): (0.20404040404040408, 0.0684040523367152),
 ('0.2', 'Discriminative'): (0.17020202020202022, 0.05170543190616634),
 ('0.3', 'Discriminative'): (0.13838383838383836, 0.05445184635128709),
 ('0.4', 'Discriminative'): (0.13030303030303028, 0.040580423084041 75),
 ('0.5', 'Discriminative'): (0.1015151515151515, 0.0391503736894616),
 ('0.6', 'Discriminative'): (0.09343434343434341, 0.02981509523867766),
 ('0.7', 'Discriminative'): (0.09141414141414139, 0.03862563394949271),
 ('0.8', 'Discriminative'): (0.09090909090909088, 0.03477154440011819),
 ('0.9', 'Discriminative'): (0.09646464646464643, 0.035096467986043815),
 ('1', 'Discriminative'): (0.08535353535353533, 0.034877750849736454)}
```

In [42]:
```
result2
```

Out[42]:
```
{('0.1', 'Discriminative'): (0.2404040404040404, 0.0706059883527325),
 ('0.2', 'Discriminative'): (0.15707070707070706, 0.04924954623451553),
 ('0.3', 'Discriminative'): (0.16515151515151516, 0.045848461481965114),
 ('0.4', 'Discriminative'): (0.14545454545454545, 0.05415121274214227),
 ('0.5', 'Discriminative'): (0.1398989898989899, 0.044892711835682594),
 ('0.6', 'Discriminative'): (0.1419191919191919, 0.04587070991781632),
 ('0.7', 'Discriminative'): (0.15202020202020206, 0.04074665343743424),
 ('0.8', 'Discriminative'): (0.14898989898989898, 0.03412362814466438),
 ('0.9', 'Discriminative'): (0.16414141414141417, 0.034789878988473785),
 ('1', 'Discriminative'): (0.15959595959595962, 0.034712808641292094)}
```

In [49]:
```
plt.plot(partition,[1-result1[(str(p),'Discriminative')][0] for p in partition], label = 'Topic Representation')
plt.plot(partition, [1-result2[(str(p),'Discriminative')][0] for p in partition], label = 'Bag of words')
plt.xlabel('Partition')
plt.ylabel('Error')
plt.legend()
plt.show()
```



In [ ]: