Pattern Recognition Assignment -2

by Siddhant Verma - 2K18/EC/167

Question 1

This repository contains the dataset

In [122]:
```
cd ./datasets/
```

```
[Errno 2] No such file or directory: './datasets/'
/mnt/c/Users/siddh/ML_lab/PR-assignment-2/datasets
```

In [123]:
```
ls
```

```
 Index*          bezdekIris.data*   iris.names*     sat.trn*
'Index (1)'*     iris.data*        'sat (1).doc'*   sat.tst*
```

In [124]:
```
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import seaborn as sns

from sklearn.manifold import TSNE
from sklearn.neighbors import KNeighborsClassifier
from sklearn import metrics
from sklearn.model_selection import train_test_split
```

1) Loading the dataset and converting it into numpy arrays

In [125]:
```
train = np.genfromtxt('./sat.trn')
train.shape
```

Out[125]: `(4435, 37)`

In [126]:
```
test = np.genfromtxt('./sat.tst')
test.shape
```

Out[126]: `(2000, 37)`

In [127]:
```
x_train = train[:,:36]
y_train = train[:,36]

xtest = test[:,:36]
ytest = test[:,36]
```

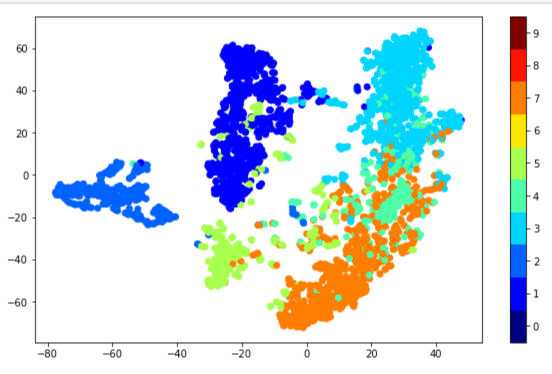
Splitting training data into training and validation 70:30

In [128]:
```
xtrain, xval, ytrain, yval = train_test_split(x_train, y_train, test_size=0.3, random_state=42)
```

In [129]:
```
tsne = TSNE(n_components=2, random_state=0)
tsnematrix = tsne.fit_transform(xtrain)
```

TSNE Visualisation of training set

In [130]:
```
plt.figure(figsize=(10, 6))
plt.scatter(tsnematrix[:,0], tsnematrix[:,1], c=ytrain, cmap=plt.cm.get_cmap("jet", 10))
plt.colorbar(ticks=range(10))
plt.clim(-0.5, 9.5)
plt.show()
```



2) KNN from scratch

Calculate distance to all neighbours

Using Euclidean distance.

Definiton

$$d(p,q) = d(q,p) = \sqrt{(q_1-p_1)^2 + (q_2-p_2)^2 + \cdots + (q_D-p_D)^2} = \sum_{d=1}^{D}(p_d-q_d)^2$$

Example

$p = (4,6)$
$q = (1,2)$
$d(p,q) = \sqrt{(1-4)^2 + (2-6)^2} = \sqrt{9+16} = \sqrt{25} = 5$

The formula used below in the knn_distances function has only been expanded to suit the mulitple dimensions of the matrices so it works well with 2-D matrices.

I have only expanded the $(a-b)^2$ as $a^2 + b^2 - 2.a.b$

Here in the code: @ is the matrix multiplication operator and .T is used to return the trasnpose of the matrix.

In [131]:
```
def knn_distances(xTrain,xTest,k):
    #the following formula calculates the Euclidean distances btw training and test samples.

    distances = -2 * xTrain@xTest.T + np.sum(xTest**2,axis=1) + np.sum(xTrain**2,axis=1)[:, np.newaxis]

    #because of float precision, some small numbers can become negatives. Need to be replace with 0

    distances[distances < 0] = 0
    distances = distances**.5

    # find the snearest neighbours thus sort them and take initial values
    indices = np.argsort(distances, 0) #get indices of sorted items
    distances = np.sort(distances,0) #distances sorted

    #returning the top-k closest distances.
    return indices[0:k,:], distances[0:k,:]


def knn_predictions(xTrain,yTrain,xTest,k=3):
    indices, distances = knn_distances(xTrain,xTest,k)
    yTrain = yTrain.flatten() #flattening into a single dimensional array
    rows, columns = indices.shape
    predictions = list()     #blank list

    for j in range(columns):
        temp = list()
        for i in range(rows):
            cell = indices[i][j]
            temp.append(yTrain[cell])    #appending to a list which stores the labels of all the nearest neighbours
        predictions.append(max(temp,key=temp.count)) #prediction = class which is present in highest number
    predictions=np.array(predictions)
    return predictions

def knn_accuracy(yTest,predictions):
    x=yTest.flatten()==predictions.flatten()
    grade=np.mean(x)
    return np.round(grade*100,2)
```

Valiadtion Predictions with k = 3 to check if working

In [132]:
```
predictions = knn_predictions(xtrain, ytrain, xval,3) #taking sample value of k = 3
print('Size of Predictions Array:\n', predictions.shape)
```

```
Size of Predictions Array:
 (1331,)
```

Validation Accuracy

In [133]:
```
print('Validation Accuracy:',knn_accuracy(predictions,yval),'%')
```

```
Validation Accuracy: 90.23 %
```

Testing Accuracy on k = 3

In [134]:
```
predictions = knn_predictions(xtrain, ytrain, xtest,3) #taking sample value of k = 3

print('Testing Accuracy:',knn_accuracy(predictions,ytest),'%')
```

```
Testing Accuracy: 89.9 %
```

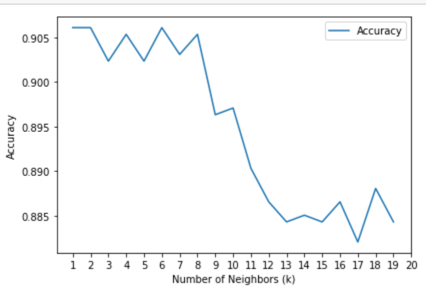
Grid Search on validation set

In [135]:
```
from sklearn.metrics import accuracy_score
from sklearn import metrics
import matplotlib.pyplot as plt
```

In [136]:
```
Ks = 20
mean_acc = np.zeros((Ks-1))
std_acc = np.zeros((Ks-1))
#ConfustionMx = [];
for n in range(1,Ks):

    yhat = knn_predictions(xtrain,ytrain,xval,n)
    mean_acc[n-1] = metrics.accuracy_score(yval, yhat)
    std_acc[n-1] = np.std(yhat==yval)/np.sqrt(yhat.shape[0])
```

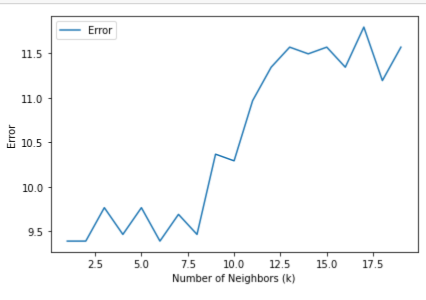
Accuracy on validation set for k = 1-20

In [137]:
```
xint = range(1,Ks+1)

plt.plot(range(1,Ks),mean_acc)
plt.legend(['Accuracy'])
plt.ylabel('Accuracy')
plt.xlabel('Number of Neighbors (k)')
plt.xticks(xint)
plt.tight_layout()
plt.show()
```



Error vs Number of neighbours graph on validation set

In [138]:
```
plt.plot(range(1,Ks),100*(1-mean_acc))
#plt.fill_between(range(1,Ks),mean_acc - 1 * std_acc,mean_acc + 1 * std_acc, alpha=0.05)
plt.legend(['Error'])
plt.ylabel('Error')
plt.xlabel('Number of Neighbors (k)')
plt.tight_layout()
plt.show()
```



Optimal value of k and accuracy for validation

In [139]:
```
print( "The best validation accuracy was:", np.round(mean_acc.max()*100,2), "% with k=", mean_acc.argmax()+1)
```

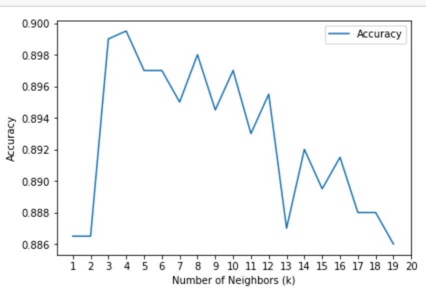
```
The best validation accuracy was: 90.61 % with k= 1
```

Grid search on Testing Set

In [140]:
```
Ks = 20
mean_acc = np.zeros((Ks-1))
std_acc = np.zeros((Ks-1))
#ConfustionMx = [];
for n in range(1,Ks):

    yhat = knn_predictions(xtrain,ytrain,xtest,n)
    mean_acc[n-1] = metrics.accuracy_score(ytest, yhat)
    std_acc[n-1] = np.std(yhat==ytest)/np.sqrt(yhat.shape[0])
```

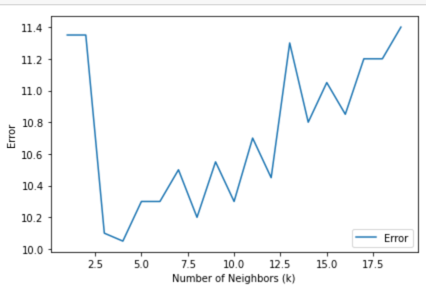
Accuracy on Testing set for k = 1-20

In [141]:
```
xint = range(1,Ks+1)

plt.plot(range(1,Ks),mean_acc)
plt.legend(['Accuracy'])
plt.ylabel('Accuracy')
plt.xlabel('Number of Neighbors (k)')
plt.xticks(xint)
plt.tight_layout()
plt.show()
```



Error vs Number of neighbours graph on validation set

In [142]:
```
plt.plot(range(1,Ks),100*(1-mean_acc))
plt.legend(['Error'])
plt.ylabel('Error')
plt.xlabel('Number of Neighbors (k)')
plt.tight_layout()
plt.show()
```



Optimal value of k and accuracy for testing

In [143]:
```
print( "The best testing accuracy was:", np.round(mean_acc.max()*100,2), "% with k=", mean_acc.argmax()+1)
```

```
The best testing accuracy was: 89.95 % with k= 4
```

using sklearn knn

Validation

In [144]:
```
krange = range(1,15)

scores = {}
scorelist = []

for k in krange:
    knn = KNeighborsClassifier(n_neighbors= k)
    knn.fit(xtrain, ytrain)

    ypred = knn.predict(xval)
    scores[k] = metrics.accuracy_score(yval, ypred)
    scorelist.append(metrics.accuracy_score(yval, ypred))
```

In [145]:
```
plt.plot(krange, scorelist)
```

Out[145]: `[<matplotlib.lines.Line2D at 0x7fca8c6fcfd0>]`

In [146]:
```
scorelist = np.array(scorelist)
print( "The best validation accuracy was:", np.round(scorelist.max()*100,2), "% with k=", scorelist.argmax()+1)
```

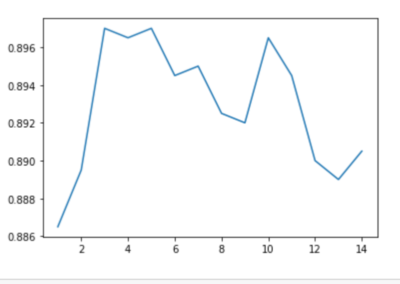
```
The best validation accuracy was: 90.61 % with k= 1
```

testing

In [147]:
```
krange = range(1,15)

scores = {}
scorelist = []

for k in krange:
    knn = KNeighborsClassifier(n_neighbors= k)
    knn.fit(xtrain, ytrain)

    ypred = knn.predict(xtest)
    scores[k] = metrics.accuracy_score(ytest, ypred)
    scorelist.append(metrics.accuracy_score(ytest, ypred))
```

In [148]:
```
plt.plot(krange, scorelist)
```

Out[148]: `[<matplotlib.lines.Line2D at 0x7fca722f0190>]`



In [149]:
```
scorelist = np.array(scorelist)
print( "The best testing accuracy was:", np.round(scorelist.max()*100,2), "% with k=", scorelist.argmax()+1)
```

```
The best testing accuracy was: 89.7 % with k= 3
```