VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
on

MACHINE LEARNING
(20CS6PCMAL)

Submitted by

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in partial fulfillment for the award of the degree of
BACHELOR OF ENGINEERING
in
COMPUTER SCIENCE AND ENGINEERING

B.M.S. COLLEGE OF ENGINEERING
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CERTIFICATE

This is to certify that the Lab work entitled **"MACHINE LEARNING"** carried out by **VEDHAVATHI N L (1BM20CS417)** who is bonafide student of **B. M. S. College of Engineering.** It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visveswaraya Technological University, Belgaum during the year 2022. The Lab report has been approved as it satisfies the academic requirements in respect of a **Machine Learning - (20CS6PCMAL)** work prescribed for the said degree.

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Program 1

Implement and demonstrate the FIND-S algorithm for finding the most specific hypothesis based on a given set of training data samples.

CODE

```
import csv
def updatehypothesis(x,h):

if h == []:

        for i in range(0,len(x)):

            h.append("$")


        print("Initial State : ", h)

        return x


    for i in range(0,len(x)):

        if x[i].upper() != h[i].upper() :

            h[i] = "?"

    print("Most Specific Hypothesis : ", h)

    return h

 if__name__== "_main_":

    data = []

    h = []

    with open('findsdataset.csv','r') as file :

        reader = csv.reader(file)

        print("Data Set : ")


        for row in reader:

            data.append(row)
```

```
        print(row)

if data:
    for x in data:
        if x[-1].upper() == "YES":
            x.pop()
            h = updatehypothesis(x,h)

print("Maximally Specific Hypothesis : " , h)
```

OUTPUT

1	sky	airtemp	humidity	wind	water	forecast	enjoysport
2	sunny	warm	normal	strong	warm	same	yes
3	sunny	warm	high	strong	warm	same	yes
4	rainy	cold	high	strong	warm	change	no
5	sunny	warm	high	strong	cool	change	yes

```
Data Set :
['sunny', 'warm', 'normal', 'strong', 'warm', 'same', 'yes']
['sunny', 'warm', 'high', 'strong', 'warm', 'same', 'yes']
['rainy', 'cold', 'high', 'strong', 'warm', 'change', 'no']
['sunny', 'warm', 'high', 'strong', 'cool', 'change', 'yes']
Initial State :  ['$', '$', '$', '$', '$', '$']
Most Specific Hypothesis :  ['sunny', 'warm', '?', 'strong', 'warm', 'same']
Most Specific Hypothesis :  ['sunny', 'warm', '?', 'strong', '?', '?']
Maximally Specific Hypothesis :  ['sunny', 'warm', '?', 'strong', '?', '?']
```

Program 2

For a given set of training data examples stored in a .CSV file, implement and demonstrate the Candidate-Elimination algorithm to output a description of the set of all hypotheses consistent with the training examples.

Code

```
import csv
a=[]
with open('../input/lab1find-s/Lab1 - Sheet1.csv','r') as csvfile:
    for row in csv.reader(csvfile):
        a.append(row)
    print(a)
    print("")

num_attributes = len(a[0])-1
s=['0']*num_attributes

g=[["?" for i in range(len(s))] for i in range(len(s))]
for i in range(0,len(a)):
    if a[i][num_attributes]=='yes':
        for j in range(0,num_attributes):
            if s[j]=='0' or s[j]==a[i][j]:
                s[j]=a[i][j]
            else:
                s[j]='?'
    else:
        for j in range(0,num_attributes):
            if(s[j] == a[i][j] or s[j] =='?'):
                g[j][j]='?'
                continue
```

```
            else:
                g[j][j] = s[j]
    for j in range(0,num_attributes):
        if s[j]!=g[j][j] or s[j]=='?':
            g[j][j]='?'

indices = [i for i, val in enumerate(g) if val == ['?', '?', '?', '?', '?', '?']]
for i in indices:
    g.remove(['?', '?', '?', '?', '?', '?'])
print("Specific hypothesis:",s)
print("General hypothesis:",g)
```

OUTPUT

1	sky	airtemp	humidity	wind	water	forecast	enjoysport
2	sunny	warm	normal	strong	warm	same	yes
3	sunny	warm	high	strong	warm	same	yes
4	rainy	cold	high	strong	warm	change	no
5	sunny	warm	high	strong	cool	change	yes

```
[['sky', 'airtemp', 'humidity', 'wind', 'water', 'forcast', 'enjoysport'], ['sunny', 'warm', 'normal', 'strong', 'warm', 'same',
'yes'], ['sunny', 'warm', 'high', 'strong', 'warm', 'same', 'yes'], ['rainy', 'cold', 'high', 'strong', 'warm', 'change', 'no'],
['sunny', 'warm', 'high', 'strong', 'cool', 'change', 'yes']]
Specific hypothesis: ['sunny', 'warm', '?', 'strong', '?', '?']
General hypothesis: [['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?']]
```

Program 3

Write a program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample

CODE

```
import math
import csv
def load_csv(filename):
    lines=csv.reader(open(filename,"r"));
    dataset = list(lines)
    headers = dataset.pop(0)
    return dataset,headers
class Node:
    def__init_(self,attribute):
        self.attribute=attribute
        self.children=[]
        self.answer=""
def subtables(data,col,delete):
    dic={}
    coldata=[row[col] for row in data]
    attr=list(set(coldata))

    counts=[0]*len(attr)
    r=len(data)
    c=len(data[0])
    for x in range(len(attr)):
        for y in range(r):
            if data[y][col]==attr[x]:
                counts[x]+=1
```

```
    for x in range(len(attr)):
        dic[attr[x]]=[[0 for i in range(c)] for j in range(counts[x])]
        pos=0
        for y in range(r):
            if data[y][col]==attr[x]:
                if delete:
                    del data[y][col]
                dic[attr[x]][pos]=data[y]
                pos+=1
    return attr,dic

def entropy(S):
    attr=list(set(S))
    if len(attr)==1:
        return 0

    counts=[0,0]
    for i in range(2):
        counts[i]=sum([1 for x in S if attr[i]==x])/(len(S)*1.0)

    sums=0
    for cnt in counts:
        sums+=-1*cnt*math.log(cnt,2)
    return sums

def compute_gain(data,col):
    attr,dic = subtables(data,col,delete=False)
```

```
    total_size=len(data)
    entropies=[0]*len(attr)
    ratio=[0]*len(attr)

    total_entropy=entropy([row[-1] for row in data])
    for x in range(len(attr)):
        ratio[x]=len(dic[attr[x]])/(total_size*1.0)
        entropies[x]=entropy([row[-1] for row in dic[attr[x]]])
        total_entropy-=ratio[x]*entropies[x]
    return total_entropy

def build_tree(data,features):
    lastcol=[row[-1] for row in data]
    if(len(set(lastcol)))==1:
        node=Node("")
        node.answer=lastcol[0]
        return node

    n=len(data[0])-1
    gains=[0]*n
    for col in range(n):
        gains[col]=compute_gain(data,col)
    split=gains.index(max(gains))
    node=Node(features[split])
    fea = features[:split]+features[split+1:]


    attr,dic=subtables(data,split,delete=True)
```

```
    for x in range(len(attr)):
        child=build_tree(dic[attr[x]],fea)
        node.children.append((attr[x],child))
    return node

def print_tree(node,level):
    if node.answer!="":
        print(" "*level,node.answer)
        return

    print(" "*level,node.attribute)
     for value,n in node.children:
       print("  "*(level+1),value)
        print_tree(n,level+2)


def classify(node,x_test,features):
    if node.answer!="":
        print(node.answer)
        return
    pos=features.index(node.attribute)
    for value, n in node.children:
        if x_test[pos]==value:
            classify(n,x_test,features)


dataset,features=load_csv("../input/playtennis/ID3.csv")
```

```
node1=build_tree(dataset,features)

print("The decision tree for the dataset using ID3 algorithm is")
print_tree(node1,0)

# testdata,features=load_csv("../input/playtennis/ID3.csv")
# print(features,"\n\n",testdata)

# for xtest in testdata:
#     print("The test instance:",xtest)
#     print("The label for test instance:",end="  ")
#     classify(node1,xtest,features)
```

OUTPUT

Outlook	Temperature	Humidity	Wind	Answer
sunny	hot	high	weak	no
sunny	hot	high	strong	no
overcast	hot	high	weak	yes
rain	mild	high	weak	yes
rain	cool	normal	weak	yes
rain	cool	normal	strong	no
overcast	cool	normal	strong	yes
sunny	mild	high	weak	no
sunny	cool	normal	weak	yes
rain	mild	normal	weak	yes
sunny	mild	normal	strong	yes
overcast	mild	high	strong	yes
overcast	hot	normal	weak	yes
rain	mild	high	strong	no

```
Your Notebook is now running in the cloud.
Enter some code at the bottom of this console and press [Enter].
The decision tree for the dataset using ID3 algorithm is
 Outlook
   sunny
     Humidity
       normal
         yes
       high
         no
   overcast
     yes
   rain
     Wind
       strong
         no
       weak
         yes
```

Program 4

Write a program to implement the naïve Bayesian classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets

CODE

```
import pandas as pd

data = pd.read_csv('../input/playtennisnb/PlayTennis.csv')
data.head()

y = list(data['PlayTennis'].values)
X = data.iloc[:,1:].values

print(f'Target Values: {y}')
print(f'Features: \n{X}')

y_train = y[:8]
y_val = y[8:]

X_train = X[:8]
X_val = X[8:]

print(f"Number of instances in training set: {len(X_train)}")
print(f"Number of instances in testing set: {len(X_val)}")

class NaiveBayesClassifier:
    def___init_(self, X, y):

        self.X, self.y = X, y
```

```
self.N = len(self.X)

        self.dim = len(self.X[0])

        self.attrs = [[] for _ in range(self.dim)]

        self.output_dom = {}

        self.data = []

        for i in range(len(self.X)):
            for j in range(self.dim):
                if not self.X[i][j] in self.attrs[j]:
                    self.attrs[j].append(self.X[i][j])

            if not self.y[i] in self.output_dom.keys():
                self.output_dom[self.y[i]] = 1

            else:
                self.output_dom[self.y[i]] += 1

            self.data.append([self.X[i], self.y[i]])
    def classify(self, entry):

        solve = None
        max_arg = -1
```

```
        for y in self.output_dom.keys():

            prob = self.output_dom[y]/self.N

            for i in range(self.dim):
                cases = [x for x in self.data if x[0][i] == entry[i] and x[1] == y]
                n = len(cases)
                prob *= n/self.N

            if prob > max_arg:
                max_arg = prob
                solve = y

        return solve

nbc = NaiveBayesClassifier(X_train, y_train)

total_cases = len(y_val)

good = 0
bad = 0
predictions = []

for i in range(total_cases):
    predict = nbc.classify(X_val[i])
    predictions.append(predict)

    if y_val[i] == predict:
```

```
        good += 1
    else:
        bad += 1

print('Predicted values:', predictions)
print('Actual values:', y_val)
print()
print('Total number of testing instances in the dataset:', total_cases)
print('Number of correct predictions:', good)
print('Number of wrong predictions:', bad)
print()
print('Accuracy of Bayes Classifier:', good/total_cases)
```

Outlook	Temperature	Humidity	Wind	Answer
sunny	hot	high	weak	no
sunny	hot	high	strong	no
overcast	hot	high	weak	yes
rain	mild	high	weak	yes
rain	cool	normal	weak	yes
rain	cool	normal	strong	no
overcast	cool	normal	strong	yes
sunny	mild	high	weak	no
sunny	cool	normal	weak	yes
rain	mild	normal	weak	yes
sunny	mild	normal	strong	yes
overcast	mild	high	strong	yes
overcast	hot	normal	weak	yes
rain	mild	high	strong	no

OUTPUT

```
Your Notebook is now running in the cloud.
Enter some code at the bottom of this console and press [Enter].
  PlayTennis   Outlook Temperature Humidity    Wind
0         No     Sunny         Hot     High    Weak
1         No     Sunny         Hot     High  Strong
2        Yes  Overcast         Hot     High    Weak
3        Yes      Rain        Mild     High    Weak
4        Yes      Rain        Cool   Normal    Weak
Target Values: ['No', 'No', 'Yes', 'Yes', 'Yes', 'No', 'Yes', 'No', 'Yes', 'Yes', 'Yes', 'Yes', 'Yes', 'No']
Features:
[['Sunny' 'Hot' 'High' 'Weak']
 ['Sunny' 'Hot' 'High' 'Strong']
 ['Overcast' 'Hot' 'High' 'Weak']
 ['Rain' 'Mild' 'High' 'Weak']
 ['Rain' 'Cool' 'Normal' 'Weak']
 ['Rain' 'Cool' 'Normal' 'Strong']
 ['Overcast' 'Cool' 'Normal' 'Strong']
 ['Sunny' 'Mild' 'High' 'Weak']
 ['Sunny' 'Cool' 'Normal' 'Weak']
 ['Rain' 'Mild' 'Normal' 'Weak']
 ['Sunny' 'Mild' 'Normal' 'Strong']
 ['Overcast' 'Mild' 'High' 'Strong']
 ['Overcast' 'Hot' 'Normal' 'Weak']
 ['Rain' 'Mild' 'High' 'Strong']]
Number of instances in training set: 8
Number of instances in testing set: 6
Predicted values: ['No', 'Yes', 'No', 'Yes', 'Yes', 'No']
Actual values: ['Yes', 'Yes', 'Yes', 'Yes', 'Yes', 'No']

Total number of testing instances in the dataset: 6
Number of correct predictions: 4
Number of wrong predictions: 2

Accuracy of Bayes Classifier: 0.6666666666666666
```

Program 5

Write a program to construct a Bayesian network considering training data. Use this model to make predictions.

CODE

```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd

dataset = pd.read_csv('../input/salarydata/salaryData.csv')
X = dataset.iloc[:, :-1].values
y = dataset.iloc[:, 1].values


from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=1/3, random_state=0)


# Fitting Simple Linear Regression to the Training set
from sklearn.linear_model import LinearRegression
regressor = LinearRegression()
regressor.fit(X_train, y_train)


# Predicting the Test set results
y_pred = regressor.predict(X_test)


# Visualizing the Training set results
viz_train = plt
viz_train.scatter(X_train, y_train, color='green')
viz_train.plot(X_train, regressor.predict(X_train), color='black')
viz_train.title('Salary VS Experience (Training set)')
viz_train.xlabel('Year of Experience')
viz_train.ylabel('Salary')
viz_train.show()
```

```
# Visualizing the Test set results
viz_test = plt
viz_test.scatter(X_test, y_test, color='green')
viz_test.plot(X_train, regressor.predict(X_train), color='black')
viz_test.title('Salary VS Experience (Test set)')
viz_test.xlabel('Year of Experience')
viz_test.ylabel('Salary')
viz_test.show()
```

YearsExperience	Salary
1.1	39343
1.3	46205
1.5	37731
2.0	43525
2.2	39891
2.9	56642
3.0	60150
3.2	54445
3.2	64445
3.7	57189
3.9	63218
4.0	55794
4.0	56957
4.1	57081
4.5	61111
4.9	67938
5.1	66029
5.3	83088
5.9	81363
6.0	93940


Salary VS Experience (Training set)
Salary
Year of Experience

OUTPUT


Salary VS Experience (Test set)
Salary
Year of Experience

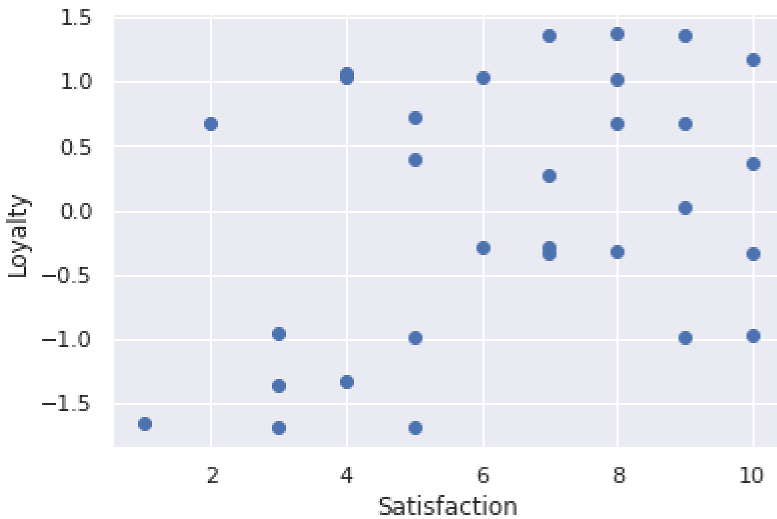
Program 6

Apply k-Means algorithm to cluster a set of data stored in a .CSV file.

CODE

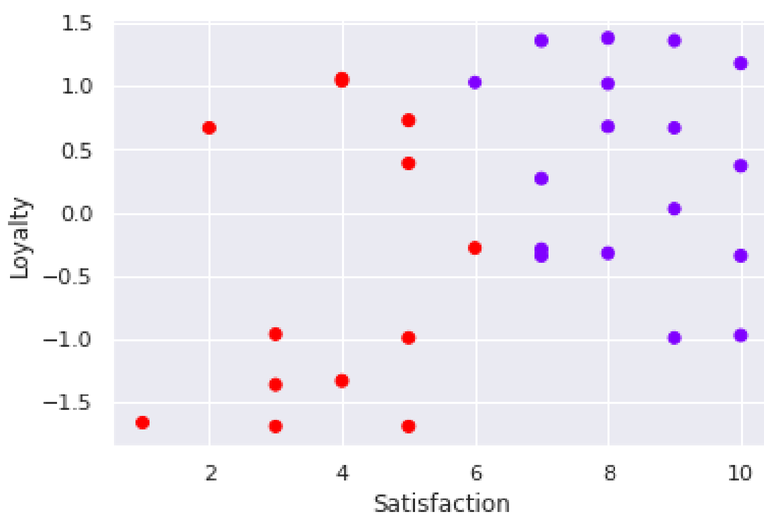
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import  seaborn as sns
sns.set()
from sklearn.cluster import KMeans

data = pd.read_csv("../input/K-Means/Dataset.csv")
data

plt.scatter(data['Satisfaction'],data['Loyalty'])
plt.xlabel('Satisfaction')
plt.ylabel('Loyalty')
plt.show()

x=data.copy()
kmean=KMeans(2)
kmean.fit(x)

clusters=x.copy()
clusters['cluster_pred']=kmean.fit_predict(x)

plt.scatter(clusters['Satisfaction'],clusters['Loyalty'],c=clusters['cluster_pred'],cmap='rainbow')
plt.xlabel('Satisfaction')
plt.ylabel('Loyalty')
plt.ylabel('Loyalty')
plt.show()
```

Satisfaction	Loyalty
4	-1.33
6	-0.28
5	-0.99
7	-0.29
4	1.06
1	-1.66
10	-0.97
8	-0.32
8	1.02
8	0.68
10	-0.34
5	0.39
5	-1.69
2	0.67
7	0.27



1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
Loyalty
2
4
6
8
10
Satisfaction

OUTPUT



1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
Loyalty
2
4
6
8
10
Satisfaction

Program 7

Apply EM algorithm to cluster a set of data stored in a .CSV file. Compare the results of k-Means algorithm and EM algorithm.

CODE

```
import matplotlib.pyplot as plt
from sklearn import datasets
from sklearn.cluster import KMeans
import sklearn.metrics as sm
import pandas as pd
import numpy as np

iris = datasets.load_iris()

X = pd.DataFrame(iris.data)
X.columns = ['Sepal_Length','Sepal_Width','Petal_Length','Petal_Width']

y = pd.DataFrame(iris.target)
y.columns = ['Targets']

model = KMeans(n_clusters=3)
model.fit(X)


plt.figure(figsize=(14,7))

colormap = np.array(['red', 'lime', 'black'])

# Plot the Original Classifications
plt.subplot(1, 2, 1)
plt.scatter(X.Petal_Length, X.Petal_Width, c=colormap[y.Targets], s=40)
plt.title('Real Classification')
plt.xlabel('Petal Length')
plt.ylabel('Petal Width')

# Plot the Models Classifications
plt.subplot(1, 2, 2)
plt.scatter(X.Petal_Length, X.Petal_Width, c=colormap[model.labels_], s=40)
plt.title('K Mean Classification')
plt.xlabel('Petal Length')
plt.ylabel('Petal Width')

print('The accuracy score of K-Mean: ',sm.accuracy_score(y, model.labels_))
print('The Confusion matrixof K-Mean:\n',sm.confusion_matrix(y, model.labels_))

from sklearn import preprocessing
scaler = preprocessing.StandardScaler()
scaler.fit(X)
xsa = scaler.transform(X)
xs = pd.DataFrame(xsa, columns = X.columns)
```

```
from sklearn.mixture import GaussianMixture
gmm = GaussianMixture(n_components=3)
gmm.fit(xs)

y_gmm = gmm.predict(xs)

plt.subplot(2, 2, 3)
plt.scatter(X.Petal_Length, X.Petal_Width, c=colormap[y_gmm], s=40)
plt.title('GMM Classification')
plt.xlabel('Petal Length')
plt.ylabel('Petal Width')

print('The accuracy score of EM: ',sm.accuracy_score(y, y_gmm))
print('The Confusion matrix of EM:\n',sm.confusion_matrix(y, y_gmm))
```

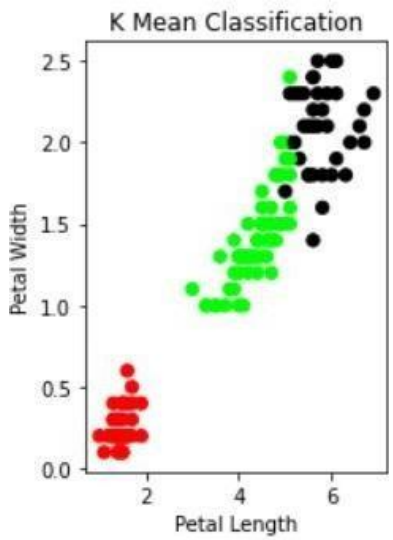
OUTPUT

```
<Figure size 1008x504 with 0 Axes>
Text(0, 0.5, 'Petal Width')
```

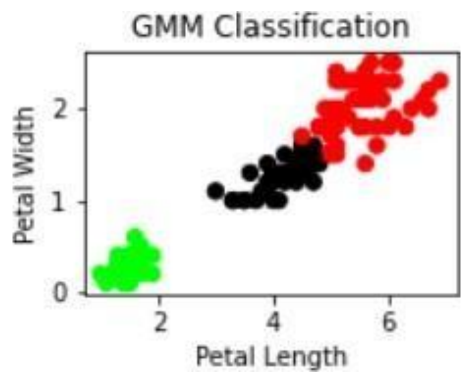
```
Text(0, 0.5, 'Petal Width')
```

```
The accuracy score of K-Mean:  0.8933333333333333
The Confusion matrixof K-Mean:
 [[50  0  0]
 [ 0 48  2]
 [ 0 14 36]]
Text(0, 0.5, 'Petal Width')
```

```
The accuracy score of EM:  0.0
The Confusion matrix of EM:
 [[ 0 50  0]
 [ 5  0 45]
 [50  0  0]]
```



K Mean Classification
2.5
2.0
1.5
1.0
0.5
0.0
Petal Width
2
4
6
Petal Length



GMM Classification
2
1
0
Petal Width
2
4
6
Petal Length

Program 8

Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions.

CODE

```
from sklearn.model_selection import train_test_split
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import classification_report, confusion_matrix
from sklearn import datasets

iris = datasets.load_iris()
X = iris.data
Y = iris.target

print('sepal-length','sepal-width','petal-length','petal-width')
print(X)
print('target')
print(Y)

x_train, x_test, y_train, y_test = train_test_split(X,Y,test_size=0.3)

classier = KNeighborsClassifier(n_neighbors=5)
classier.fit(x_train, y_train)

y_pred=classier.predict(x_test)

print('Confusion Matrix')
print(confusion_matrix(y_test,y_pred))


print('Accuracy')
print(classification_report(y_test,y_pred))
```

OUTPUT

```
target
[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2
 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
 2 2]
Confusion Matrix
[[19  0  0]
 [ 0 16  1]
 [ 0  0  9]]
Accuracy
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        19
           1       1.00      0.94      0.97        17
           2       0.90      1.00      0.95         9

    accuracy                           0.98        45
   macro avg       0.97      0.98      0.97        45
weighted avg       0.98      0.98      0.98        45
```

Program 9

Implement the Linear Regression algorithm in order to fit data points. Select appropriate data set for your experiment and draw graphs.

CODE

```
import numpy as np
import pandas as pd
import csv
import pgmpy
from pgmpy.estimators import MaximumLikelihoodEstimator
from pgmpy.models import BayesianNetwork
from pgmpy.inference import VariableElimination

#read Cleveland Heart Disease data
heartDisease = pd.read_csv('../input/heartdisease/heartDiseaseDataset.csv')
heartDisease = heartDisease.replace('?',np.nan)

#display the data
print('Sample instances from the dataset are given below')
print(heartDisease.head())

#display the Attributes names and datatypes
print('\n Attributes and datatypes')
print(heartDisease.dtypes)

#Create Model-Bayesian Network
model =
BayesianNetwork([('age','heartDisease'),('sex','heartDisease'),('exang','heartDisease'),('cp','heartDisease'),('
restecg','heartDisease'),('heartDisease','chol')])

#Learning CPDs using Maximum Likelihood Estimators
print('\n Learning CPD using Maximum likelihood estimators')
model.fit(heartDisease,estimator=MaximumLikelihoodEstimator)

#Inferencing with Bayesian Network
print('\n Inferencing with Bayesian Network:')
heartDiseasetest_infer = VariableElimination(model)

#computing the Probability of heartDisease given restecg
print('\n 1.Probability of heartDisease given evidence= restecg :1')
q1=heartDiseasetest_infer.query(variables=['heartDisease'],evidence={'restecg':1})
print(q1)

#computing the Probability of heartDisease given cp
print('\n 2.Probability of heartDisease given evidence= cp:2 ')
q2=heartDiseasetest_infer.query(variables=['heartDisease'],evidence={'cp':2})
print(q2)
```

OUTPUT

age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	heartDisease
63	1	1	145	233	1	2	150	0	2.3	3	0	6	0
67	1	4	160	286	0	2	108	1	1.5	2	3	3	2
67	1	4	120	229	0	2	129	1	2.6	2	2	7	1
37	1	3	130	250	0	0	187	0	3.5	3	0	3	0
41	0	2	130	204	0	2	172	0	1.4	1	0	3	0
56	1	2	120	236	0	0	178	0	0.8	1	0	3	0
62	0	4	140	268	0	2	160	0	3.6	3	2	3	3
57	0	4	120	354	0	0	163	1	0.6	1	0	3	0
63	1	4	130	254	0	2	147	0	1.4	2	1	7	2
53	1	4	140	203	1	2	155	1	3.1	3	0	7	1
57	1	4	140	192	0	0	148	0	0.4	2	0	6	0
56	0	2	140	294	0	2	153	0	1.3	2	0	3	0
56	1	3	130	256	1	2	142	1	0.6	2	1	6	2
44	1	2	120	263	0	0	173	0	0	1	0	7	0
52	1	3	172	199	1	0	162	0	0.5	1	0	7	0
57	1	3	150	168	0	0	174	0	1.6	1	0	3	0
48	1	2	110	229	0	0	168	0	1	3	0	7	1
54	1	4	140	239	0	0	160	0	1.2	1	0	3	0
48	0	3	130	275	0	0	139	0	0.2	1	0	3	0
49	1	2	130	266	0	0	171	0	0.6	1	0	3	0
64	1	1	110	211	0	2	144	1	1.8	2	0	3	0
58	0	1	150	283	1	2	162	0	1	1	0	3	0

```
Sample instances from the dataset are given below
   age  sex  cp  trestbps  chol  fbs  restecg  thalach  exang  oldpeak  slope  \
0   63    1   1       145   233    1        2      150      0      2.3      3
1   67    1   4       160   286    0        2      108      1      1.5      2
2   67    1   4       120   229    0        2      129      1      2.6      2
3   37    1   3       130   250    0        0      187      0      3.5      3
4   41    0   2       130   204    0        2      172      0      1.4      1

   ca  thal  heartDisease
0   0     6             0
1   3     3             2
2   2     7             1
3   0     3             0
4   0     3             0

 Attributes and datatypes
age               int64
sex               int64
cp                int64
trestbps          int64
chol              int64
fbs               int64
restecg           int64
thalach           int64
exang             int64
oldpeak         float64
slope             int64
ca                int64
thal              int64
heartDisease      int64
dtype: object
```

```
Learning CPD using Maximum likelihood estimators

Inferencing with Bayesian Network:

1.Probability of heartDisease given evidence= restecg :1
```

Finding Elimination Order: : 100% 4/4 [00:00<00:00, 81.79it/s]

Eliminating: exang: 100% 4/4 [00:00<00:00, 64.63it/s]

```
+-----------------+---------------------+
| heartDisease    |   phi(heartDisease) |
+=================+=====================+
| heartDisease(0) |              0.1972 |
+-----------------+---------------------+
| heartDisease(1) |              0.1970 |
+-----------------+---------------------+
| heartDisease(2) |              0.1976 |
+-----------------+---------------------+
| heartDisease(3) |              0.1976 |
+-----------------+---------------------+
| heartDisease(4) |              0.2106 |
+-----------------+---------------------+
```

```
2.Probability of heartDisease given evidence= cp:2
```

Finding Elimination Order: : 100% 4/4 [00:00<00:00, 69.85it/s]

Eliminating: exang: 100% 4/4 [00:00<00:00, 89.18it/s]

```
+-----------------+---------------------+
| heartDisease    |   phi(heartDisease) |
+=================+=====================+
| heartDisease(0) |              0.3138 |
+-----------------+---------------------+
| heartDisease(1) |              0.2150 |
+-----------------+---------------------+
| heartDisease(2) |              0.1552 |
+-----------------+---------------------+
| heartDisease(3) |              0.1633 |
+-----------------+---------------------+
| heartDisease(4) |              0.1527 |
+-----------------+---------------------+
```

Program 10

Implement the non-parametric Locally Weighted Regression algorithm in order to fit data points. Select appropriate data set for your experiment and draw graphs.

CODE

```
from numpy import *
from os import listdir
import matplotlib
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np1
import numpy.linalg as np
from scipy.stats.stats import pearsonr
def kernel(point,xmat, k):
    m,n = np1.shape(xmat)
    weights = np1.mat(np1.eye((m)))
    for j in range(m):
        diff = point - X[j]
        weights[j,j] = np1.exp(diff*diff.T/(-2.0*k**2))
    return weights


def localWeight(point,xmat,ymat,k):
    wei = kernel(point,xmat,k)
    W = (X.T*(wei*X)).I*(X.T*(wei*ymat.T))
    return W

def localWeightRegression(xmat,ymat,k):
    m,n = np1.shape(xmat)
    ypred = np1.zeros(m)
    for i in range(m):
        ypred[i] = xmat[i]*localWeight(xmat[i],xmat,ymat,k)
    return ypred

#load data points
data = pd.read_csv('../input/tipsdata/tips.csv')
bill = np1.array(data.total_bill)
tip = np1.array(data.tip)

#preparing and add 1 in bill
mbill = np1.mat(bill)
mtip = np1.mat(tip)
# mat is used to convert to n dimesiona to 2 dimensional array form
m= np1.shape(mbill)[1] # print(m) 244 data is stored in m
one = np1.mat(np1.ones(m))
X= np1.hstack((one.T,mbill.T)) # create a stack of bill from ONE
```

```
print(X)
```

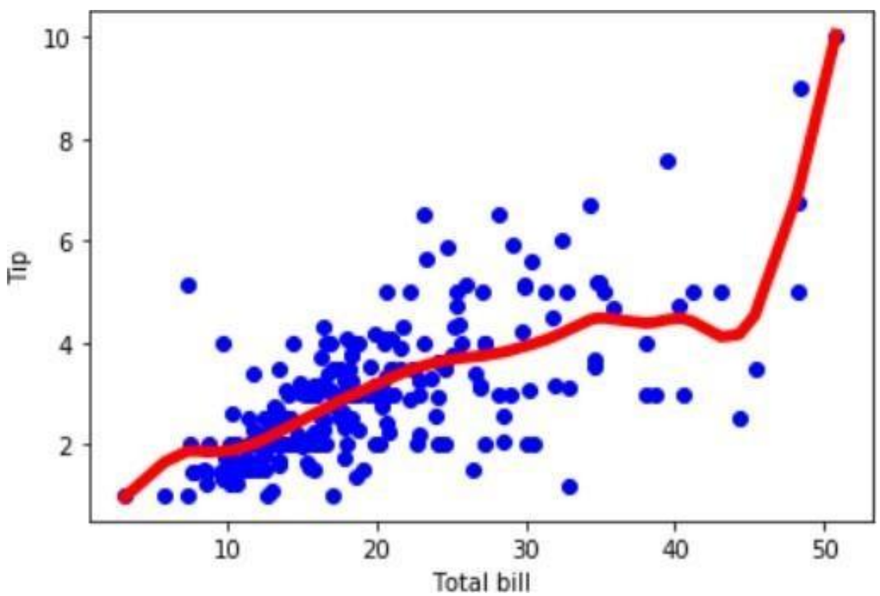
```
#set k here
ypred = localWeightRegression(X,mtip,2)
SortIndex = X[:,1].argsort(0)

xsort = X[SortIndex][:,0]
fig = plt.figure()
ax = fig.add_subplot(1,1,1)
ax.scatter(bill,tip, color='blue')
ax.plot(xsort[:,1],ypred[SortIndex], color = 'red', linewidth=5)
plt.xlabel('Total bill')
plt.ylabel('Tip')
plt.show();


import numpy as np
from bokeh.plotting import figure, show, output_notebook
from bokeh.layouts import gridplot
from bokeh.io import push_notebook


def local_regression(x0, X, Y, tau):
    # add bias term
    x0 = np.r_[1, x0]
    # Add one to avoid the loss in information
    X = np.c_[np.ones(len(X)), X]
    # fit model: normal equations with kernel
    xw = X.T * radial_kernel(x0, X, tau) # XTranspose * W
    beta = np.linalg.pinv(xw @ X) @ xw @ Y #@ Matrix Multiplication or Dot Product
    return x0 @ beta # @ Matrix Multiplication or Dot Product for prediction

def radial_kernel(x0, X, tau):
    return np.exp(np.sum((X - x0) ** 2, axis=1) / (-2 * tau * tau))
# Weight or Radial Kernal Bias Function

n = 1000
# generate dataset
X = np.linspace(-3, 3, num=n)
print("The Data Set ( 10 Samples) X :\n",X[1:10])
Y = np.log(np.abs(X ** 2 - 1) + .5)
print("The Fitting Curve Data Set (10 Samples) Y:\n",Y[1:10])
# jitter X
X += np.random.normal(scale=.1, size=n)
print("Normalised (10 Samples) X :\n",X[1:10])
```

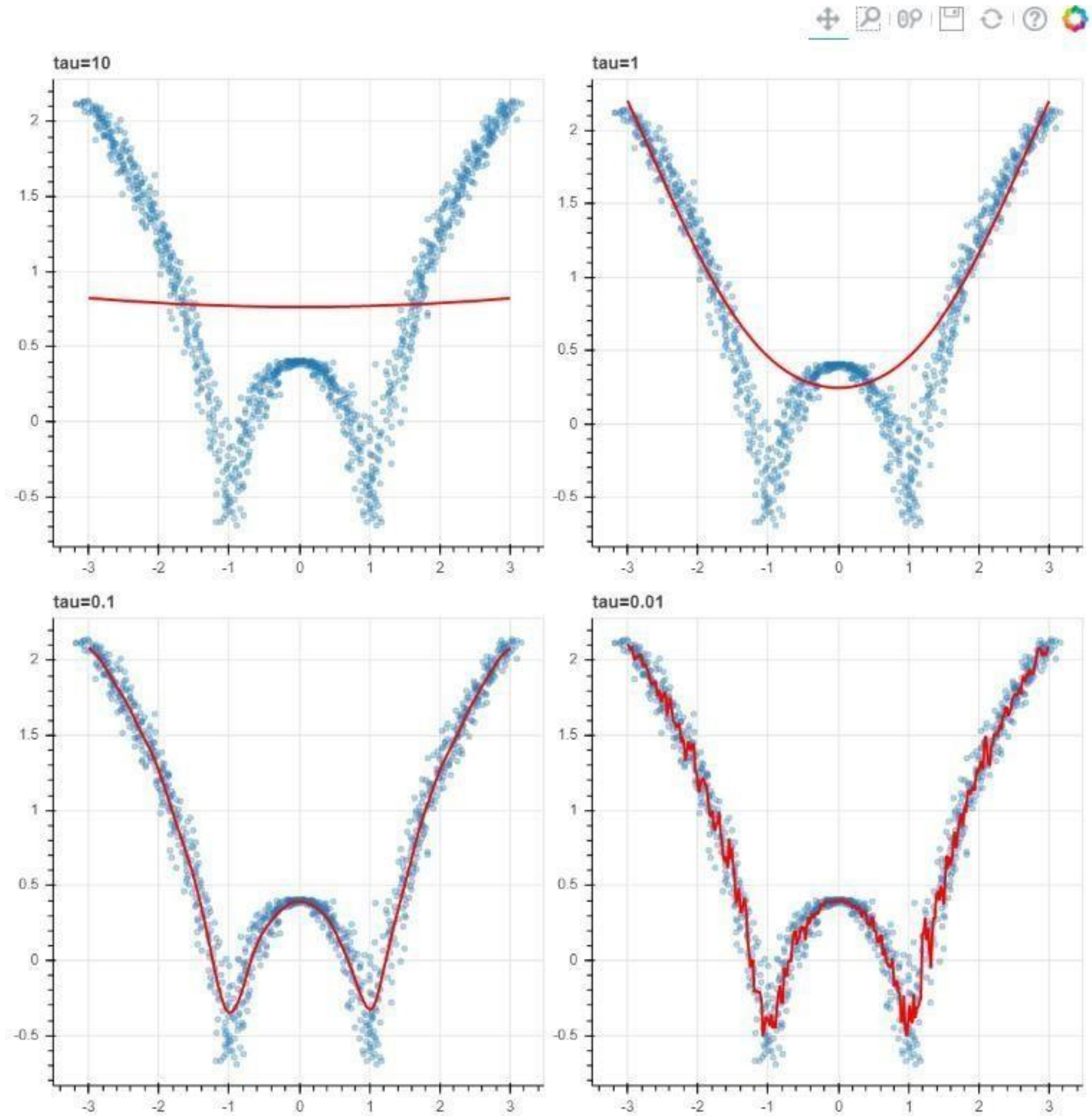
```
domain = np.linspace(-3, 3, num=300)
print(" Xo Domain Space(10 Samples) :\n",domain[1:10])

def plot_lwr(tau):
    # prediction through regression
    prediction = [local_regression(x0, X, Y, tau) for x0 in domain]
    plot = figure(plot_width=400, plot_height=400)
    plot.title.text='tau=%g' % tau
    plot.scatter(X, Y, alpha=.3)
    plot.line(domain, prediction, line_width=2, color='red')
    return plot

show(gridplot([[plot_lwr(10.), plot_lwr(1.)],
[plot_lwr(0.1), plot_lwr(0.01)]]))

from numpy import *
from os import listdir
import matplotlib
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np1
import numpy.linalg as np
from scipy.stats.stats import pearsonr

def kernel(point,xmat, k):
    m,n = np1.shape(xmat)
    weights = np1.mat(np1.eye((m)))
    for j in range(m):
        diff = point - X[j]
        weights[j,j] = np1.exp(diff*diff.T/(-2.0*k**2))
    return weights

def localWeight(point,xmat,ymat,k):
    wei = kernel(point,xmat,k)
    W = (X.T*(wei*X)).I*(X.T*(wei*ymat.T))
    return W

def localWeightRegression(xmat,ymat,k):
    m,n = np1.shape(xmat)
    ypred = np1.zeros(m)
    for i in range(m):
        ypred[i] = xmat[i]*localWeight(xmat[i],xmat,ymat,k)
```

```
    return ypred

# load data points
data = pd.read_csv('../input/tipsdata/tips.csv')
bill = np1.array(data.total_bill)
tip = np1.array(data.tip)

#preparing and add 1 in bill
mbill = np1.mat(bill)
mtip = np1.mat(tip) # mat is used to convert to n dimesiona to 2 dimensional array form
m= np1.shape(mbill)[1]
# print(m) 244 data is stored in m
one = np1.mat(np1.ones(m))
X= np1.hstack((one.T,mbill.T)) # create a stack of bill from ONE
#print(X)
#set k here
ypred = localWeightRegression(X,mtip,0.3)
SortIndex = X[:,1].argsort(0)
xsort = X[SortIndex][:,0]

fig = plt.figure()
ax = fig.add_subplot(1,1,1)
ax.scatter(bill,tip, color='green')
ax.plot(xsort[:,1],ypred[SortIndex], color = 'red', linewidth=5)
plt.xlabel('Total bill')
plt.ylabel('Tip')
plt.show();
```

OUTPUT

total_bill	tip	sex	smoker	day	time	size
16.99	1.01	Female	No	Sun	Dinner	2
10.34	1.66	Male	No	Sun	Dinner	3
21.01	3.5	Male	No	Sun	Dinner	3
23.68	3.31	Male	No	Sun	Dinner	2
24.59	3.61	Female	No	Sun	Dinner	4
25.29	4.71	Male	No	Sun	Dinner	4
8.77	2.0	Male	No	Sun	Dinner	2
26.88	3.12	Male	No	Sun	Dinner	4
15.04	1.96	Male	No	Sun	Dinner	2
14.78	3.23	Male	No	Sun	Dinner	2
10.27	1.71	Male	No	Sun	Dinner	2
35.26	5.0	Female	No	Sun	Dinner	4
15.42	1.57	Male	No	Sun	Dinner	2
18.43	3.0	Male	No	Sun	Dinner	4
14.83	3.02	Female	No	Sun	Dinner	2
21.58	3.92	Male	No	Sun	Dinner	2
10.33	1.67	Female	No	Sun	Dinner	3
16.29	3.71	Male	No	Sun	Dinner	3
16.97	3.5	Female	No	Sun	Dinner	3
20.65	3.35	Male	No	Sat	Dinner	3
17.92	4.08	Male	No	Sat	Dinner	2




tau=10
tau=1
tau=0.1
tau=0.01
-3 -2 -1 0 1 2 3
-0.5 0 0.5 1 1.5 2