VISVESVARAYA TECHNOLOGICAL UNIVERSITY

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LAB REPORT on

Machine Learning

Submitted by

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in partial fulfilment for the award of the degree of

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Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "Machine Learning" carried out by **Aruna Ravi K R (1BM19CS225),** 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 Visvesvaraya 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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Index Sheet

Sl. No.	Experiment Title
1	Find-S
2	Candidate Elimination
3	Decision Tree
4	Naïve Bayes
5	Linear Regression
6	Bayesian network
7	k-Means algorithm
8	EM algorithm
9	k-Nearest Neighbour algorithm
10	Non-Parametric Locally Weighted Regression algorithm

Course Outcome

CO1	Ability to apply the different learning algorithms.
CO2	Ability to analyse the learning techniques for given dataset
CO3	Ability to design a model using machine learning to solve a problem.
CO4	Ability to conduct practical experiments to solve problems using appropriate machine learning Techniques.

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

a) Using CSV as input:

```
import csv

def updateHypothesis(x,h):
    if h==[]:
        return x

    for i in range(0,len(h)):
        if x[i].upper()!=h[i].upper():
            h[i] = '?'

    return h

if __name__ == "__main__":
    data = []
    h = []

    # reading csv file
    with open('Desktop/FindS.csv', 'r') as file:
        reader = csv.reader(file)
        print("Data: ")
        for row in reader:
            data.append(row)
            print(row)
    if data:
        for x in data:
            if x[-1].upper()=="YES":
                x.pop() # removing last field
                h = updateHypothesis(x,h)
    print("\nHypothesis: ",h)
```

Output:

```
Data:
['Time', 'Weather', 'Temperature', 'Company', 'Humidity', 'Wind', 'Goes']
['Morning', 'Sunny', 'Warm', 'Yes', 'Mild', 'Strong', 'Yes']
['Evening', 'Rainy', 'Cold', 'No', 'Mild', 'Normal', 'No']
['Morning', 'Sunny', 'Moderate', 'Yes', 'Normal', 'Normal', 'Yes']
['Evening', 'Sunny', 'Cold', 'Yes', 'High', 'Strong', 'Yes']

Hypothesis:  ['?', 'Sunny', '?', 'Yes', '?', '?']
```

B) Using user Input:

```
import numpy as np
import pandas as pd

n=int(input("Enter the number of attributes "))
l=int(input("Enter the number of rows "))

print("Enter the ",n,"ättributes")
attributes=[]
for i in range(1,n+1):
  print("Enter the name of ",i," attribute ")
  name=input()

for i in range(1,l+1):
  print("Ënter the values of ",i," row")
  print("Enter the values of attributes")
  res=[]
  for j in range(1,l+1):
    res.append(input())
  attributes.append(res)

print("Enter the target values")
target=[]
for i in range(1,l+1):
  print("Enter the value of ",i," target")
  x=input()
  target.append(x)

def findS(c,t):
    for i, val in enumerate(t):
        if val == "Yes":
            specific_hypothesis = c[i].copy()
            break

    for i, val in enumerate(c):
        if t[i] == "Yes":
            for x in range(len(specific_hypothesis)):
                if val[x] != specific_hypothesis[x]:
                    specific_hypothesis[x] = '?'
                else:
                    pass

    return specific_hypothesis

print("\n The final hypothesis is:",findS(attributes,target))
```

Output:

```
Enter the  3 ättributes
Enter the name of  1  attribute

Enter the name of  2  attribute

Enter the name of  3  attribute

Ënter the values of  1  row
Enter the values of attributes

Ënter the values of  2  row
Enter the values of attributes

Ënter the values of  3  row
Enter the values of attributes

Enter the target values
Enter the value of  1  target

Enter the value of  2  target

Enter the value of  3  target

 The final hypothesis is: ['?', 'Rainy', 'Cold']
```

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

```
import numpy as np
import pandas as pd

#to read the data in the csv file
data = pd.DataFrame(data=pd.read_csv('/content/drive/MyDrive/enjoysport.csv'))
print(data,"\n")

#making an array of all the attributes
concepts = np.array(data.iloc[:,0:-1])
print("The attributes are: ",concepts)

#segregating the target that has positive and negative examples
target = np.array(data.iloc[:,-1])
print("\n The target is: ",target)

#training function to implement candidate_elimination algorithm
def learn(concepts, target):
 specific_h = concepts[0].copy()
 print("\n Initialization of specific_h and general_h")
 print(specific_h)
 general_h = [["?" for i in range(len(specific_h))] for i in
range(len(specific_h))]
 print(general_h)
 for i, h in enumerate(concepts):
     if target[i] == "yes":
         for x in range(len(specific_h)):
             if h[x]!= specific_h[x]:
                 specific_h[x] ='?'
                 general_h[x][x] ='?'
            #  print(specific_h)
     if target[i] == "no":
         for x in range(len(specific_h)):
             if h[x]!= specific_h[x]:
                 general_h[x][x] = specific_h[x]
             else:
                 general_h[x][x] = '?'
     print("\n Steps of Candidate Elimination Algorithm",i+1)
     print(specific_h)
     print(general_h)
 indices = [i for i, val in enumerate(general_h) if val ==
['?', '?', '?', '?', '?', '?']]
 for i in indices:
     general_h.remove(['?', '?', '?', '?', '?', '?'])
 return specific_h, general_h
s_final, g_final = learn(concepts, target)

#obtaining the final hypothesis
print("\nFinal Specific_h:", s_final, sep="\n")
```

print("\nFinal General_h:", g_final, sep="\n")

Output:

```
     sky  temp humidity    wind water forcast enjoysport
0  sunny  warm   normal  strong  warm    same        yes
1  sunny  warm     high  strong  warm    same        yes
2  rainy  cold     high  strong  warm  change         no
3  sunny  warm     high  strong  cool  change        yes

The attributes are:  [['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
 ['sunny' 'warm' 'high' 'strong' 'warm' 'same']
 ['rainy' 'cold' 'high' 'strong' 'warm' 'change']
 ['sunny' 'warm' 'high' 'strong' 'cool' 'change']]

 The target is:  ['yes' 'yes' 'no' 'yes']

 Initialization of specific_h and general_h
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?
'?', '?'], ['?', '?', '?', '?', '?', '?']]

 Steps of Candidate Elimination Algorithm 1
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?
'?', '?'], ['?', '?', '?', '?', '?', '?']]

 Steps of Candidate Elimination Algorithm 2
['sunny' 'warm' '?' 'strong' 'warm' 'same']
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?
'?', '?'], ['?', '?', '?', '?', '?', '?']]

 Steps of Candidate Elimination Algorithm 3
['sunny' 'warm' '?' 'strong' 'warm' 'same']
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?',
'?', '?', '?'], ['?', '?', '?', '?', '?', 'same']]

 Steps of Candidate Elimination Algorithm 4
['sunny' 'warm' '?' 'strong' '?' '?']
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?',
'?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

Final Specific_h:
['sunny' 'warm' '?' 'strong' '?' '?']

Final General_h:
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?']]
```

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.

a)ID3 :

```
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)

'''Main program'''
dataset,features=load_csv("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("id3.csv")

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

Output:

```
The decision tree for the dataset using ID3 algorithm is
 Outlook
   rain
     Wind
       strong
         no
       weak
         yes
   overcast
     yes
   sunny
     Humidity
       normal
         yes
       high
         no
The test instance: ['sunny', 'hot', 'high', 'weak', 'no']
The label for test instance:   no
The test instance: ['sunny', 'hot', 'high', 'strong', 'no']
The label for test instance:   no
The test instance: ['overcast', 'hot', 'high', 'weak', 'yes']
The label for test instance:   yes
The test instance: ['rain', 'mild', 'high', 'weak', 'yes']
The label for test instance:   yes
The test instance: ['rain', 'cool', 'normal', 'weak', 'yes']
The label for test instance:   yes
The test instance: ['rain', 'cool', 'normal', 'strong', 'no']
The label for test instance:   no
The test instance: ['overcast', 'cool', 'normal', 'strong', 'yes']
The label for test instance:   yes
The test instance: ['sunny', 'mild', 'high', 'weak', 'no']
The label for test instance:   no
The test instance: ['sunny', 'cool', 'normal', 'weak', 'yes']
The label for test instance:   yes
The test instance: ['rain', 'mild', 'normal', 'weak', 'yes']
The label for test instance:   yes
The test instance: ['sunny', 'mild', 'normal', 'strong', 'yes']
The label for test instance:   yes
The test instance: ['overcast', 'mild', 'high', 'strong', 'yes']
The label for test instance:   yes
The test instance: ['overcast', 'hot', 'normal', 'weak', 'yes']
The label for test instance:   yes
The test instance: ['rain', 'mild', 'high', 'strong', 'no']
The label for test instance:   no
```

b) Using SKlearn:

import pandas **as** pd

import numpy **as** np

from sklearn.datasets **import** load_iris

data **=** load_iris()

In [2]:

df **=** pd**.**DataFrame(data**.**data, columns **=** data**.**feature_names)

In [3]:

df**.**head()

df['Species'] **=** data**.**target

#replace this with the actual names

target **=** np**.**unique(data**.**target)

target_names **=** np**.**unique(data**.**target_names)

targets **=** dict(zip(target, target_names))

df['Species'] **=** df['Species']**.**replace(targets)

In [5]:

x **=** df**.**drop(columns**=**"Species")

y **=** df["Species"]

In [6]:

feature_names **=** x**.**columns
labels **=** y**.**unique()

In [7]:

from sklearn.model_selection **import** train_test_split

X_train, test_x, y_train, test_lab **=** train_test_split(x,y,test_size **=** 0.4,random_state **=** 42)

In [8]:

from sklearn.tree **import** DecisionTreeClassifier
clf **=** DecisionTreeClassifier(max_depth **=**4, random_state **=** 42)

In [9]:

clf**.**fit(X_train, y_train)

test_pred **=** clf**.**predict(test_x)

In [11]:

from sklearn **import** metrics

import seaborn **as** sns

import matplotlib.pyplot **as** plt

confusion_matrix = metrics.confusion_matrix(test_lab,test_pred)

In [12]:

confusion_matrix

matrix_df = pd.DataFrame(confusion_matrix)
ax = plt.axes()
sns.set(font_scale=1.3)
plt.figure(figsize=(10,7))
sns.heatmap(matrix_df, annot=**True**, fmt="g", ax=ax, cmap="magma")
ax.set_title('Confusion Matrix - Decision Tree')
ax.set_xlabel("Predicted label", fontsize =15)
ax.set_xticklabels(['']+labels)
ax.set_ylabel("True Label", fontsize=15)
ax.set_yticklabels(list(labels), rotation = 0)
plt.show()

clf.score(test_x,test_lab)

from sklearn **import** tree
fig = plt.figure(figsize=(25,20))
_ = tree.plot_tree(clf,
                   feature_names=data.feature_names,
                   class_names=data.target_names,
                   filled=**True**)

Output:

Out[3]:

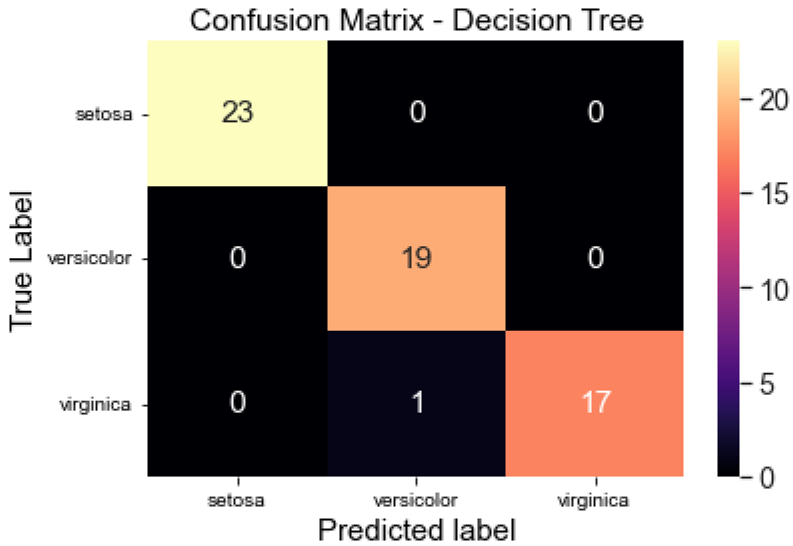
	sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)
0	5.1	3.5	1.4	0.2
1	4.9	3.0	1.4	0.2
2	4.7	3.2	1.3	0.2
3	4.6	3.1	1.5	0.2
4	5.0	3.6	1.4	0.2

Out[9]:

```
DecisionTreeClassifier(max_depth=4, random_state=42)
```

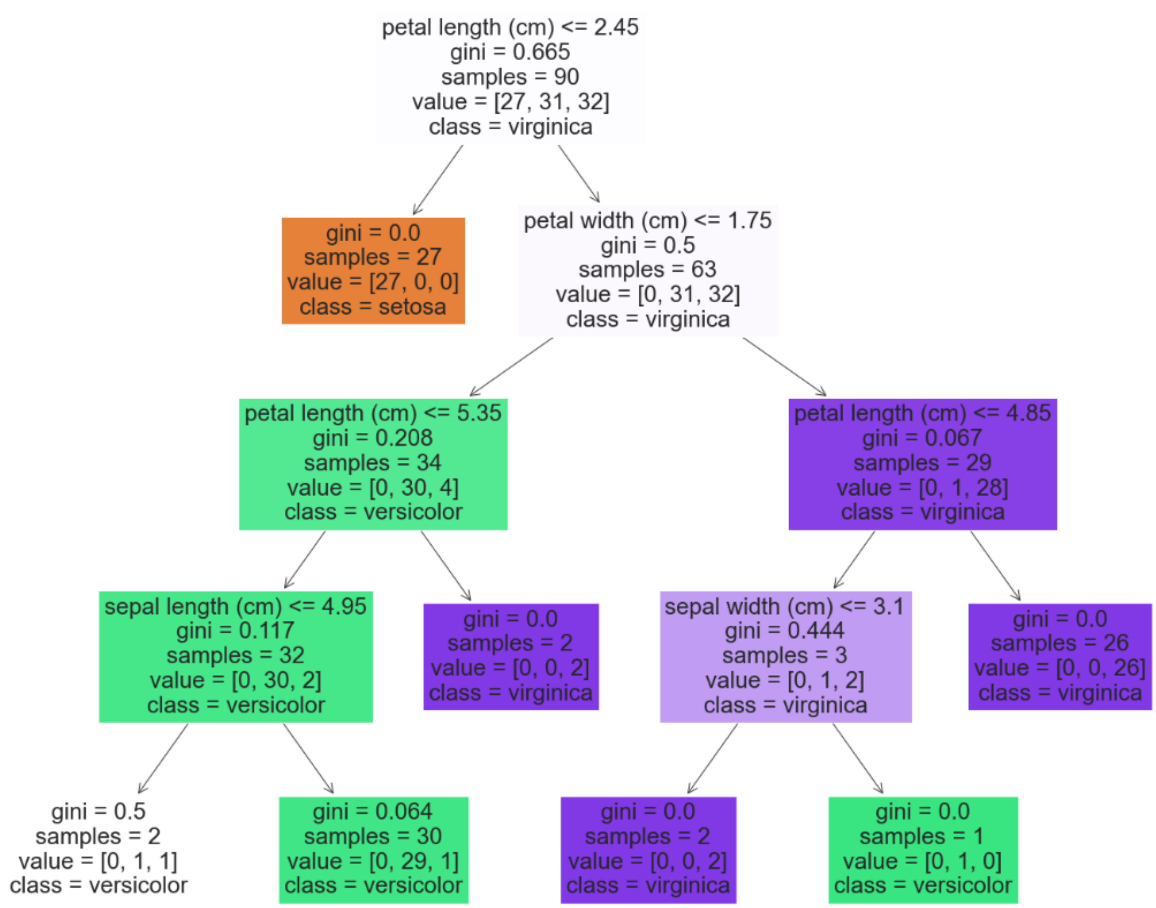
Out[12]:

```
array([[23,  0,  0],
       [ 0, 19,  0],
       [ 0,  1, 17]], dtype=int64)
```



In [14]:
```
clf.score(test_x,test_lab)
```

Out[14]:
```
0.9833333333333333
```



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

a) Without using SKlearn:

```
import numpy as np
import pandas as pd
data = pd.read_csv('/content/dataset.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
```

```python
        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)
```

Output:

Out[2]:

	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
```

b)Using SKlearn:

```python
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
from sklearn.model_selection import train_test_split
from sklearn.naive_bayes import GaussianNB
from sklearn import metrics

df = pd.read_csv("/content/pima_indian.csv")
feature_col_names = ['num_preg', 'glucose_conc', 'diastolic_bp', 'thickness', 'insulin', 'bmi', 'diab_pred', 'age']
predicted_class_names = ['diabetes']
X = df[feature_col_names].values
y = df[predicted_class_names].values
print(df.head)
xtrain,xtest,ytrain,ytest=train_test_split(X,y,test_size=0.33)
print ('\nThe total number of Training Data:',ytrain.shape)
print ('The total number of Test Data:',ytest.shape)
clf = GaussianNB().fit(xtrain,ytrain.ravel())
predicted = clf.predict(xtest)
predictTestData= clf.predict([[6,148,72,35,0,33.6,0.627,50]])
print('\nConfusion matrix')
print(metrics.confusion_matrix(ytest,predicted))
print('\nAccuracy of the classifier:',metrics.accuracy_score(ytest,predicted))
print('The value of Precision:', metrics.precision_score(ytest,predicted))
print('The value of Recall:', metrics.recall_score(ytest,predicted))
print("Predicted Value for individual Test Data:", predictTestData)
```

Output:

```
<bound method NDFrame.head of      num_preg  glucose_conc  diastolic_bp  ...  diab_pred  age  diabetes
0           6           148            72  ...      0.627   50         1
1           1            85            66  ...      0.351   31         0
2           8           183            64  ...      0.672   32         1
3           1            89            66  ...      0.167   21         0
4           0           137            40  ...      2.288   33         1
..        ...           ...           ...  ...        ...  ...       ...
763        10           101            76  ...      0.171   63         0
764         2           122            70  ...      0.340   27         0
765         5           121            72  ...      0.245   30         0
766         1           126            60  ...      0.349   47         1
767         1            93            70  ...      0.315   23         0

[768 rows x 9 columns]>

The total number of Training Data: (514, 1)
The total number of Test Data: (254, 1)

Confusion matrix
[[156  16]
 [ 35  47]]

Accuracy of the classifier: 0.7992125984251969
The value of Precision: 0.746031746031746
The value of Recall: 0.573170731707317
Predicted Value for individual Test Data: [1]
```

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

a)Using SKlearn:

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

# Importing the dataset
dataset = pd.read_csv('salary_data.csv')
X = dataset.iloc[:, :-1].values #get a copy of dataset exclude last column
y = dataset.iloc[:, 1].values #get array of dataset in column 1st:
# Splitting the dataset into the Training set and Test set
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)
# Visualizing the Training set results
viz_train = plt
viz_train.scatter(X_train, y_train, color='red')
viz_train.plot(X_train, regressor.predict(X_train), color='blue')
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='red')
viz_test.plot(X_train, regressor.predict(X_train), color='blue')
viz_test.title('Salary VS Experience (Test set)')
viz_test.xlabel('Year of Experience')
viz_test.ylabel('Salary')
viz_test.show()
# Predicting the Test set results
y_pred = regressor.predict(X_test)
print(y_pred)
```

Output:

```
Out[4]: LinearRegression(copy_X=True, fit_intercept=True, n_jobs=None, normalize=False)
```

```
In [8]: # Predicting the Test set results
        y_pred = regressor.predict(X_test)
        print(y_pred)

[ 40835.10590871 123079.39940819  65134.55626083  63265.36777221
 115602.64545369 108125.8914992  116537.23969801  64199.96201652
  76349.68719258 100649.1375447 ]
```

b) Without using SKlearn:

```
import pandas as pd
import numpy as np

class LR():
    def __init__(self):
        self.w = []
    def fit(self, X, y):
        self.w = np.linalg.solve(X.T@X, X.T@y)
    def predict(self, X):
        return X@self.w
    def score(self, X, y):
        SS_reg = np.sum((X@self.w - y)**2)
        SS_tot = np.sum((y - np.mean(y))**2)
        return (1 - (SS_reg/SS_tot))


from sklearn.model_selection import train_test_split
from sklearn.datasets import fetch_california_housing

fetch_california_housing

data, labels = fetch_california_housing(return_X_y = True)

data.shape, labels.shape

one = np.ones(data.shape[0])
data = np.column_stack((one, data))

X_train,X_test, y_train, y_test = train_test_split(data, labels, train_size = 0.75, random_state = 42)

lro = LR()
lro.fit(X_train, y_train)

lro.w

lro.predict(X_test)

lro.score(X_test, y_test)
```

Output:

```
data.shape, labels.shape
```

```
((20640, 9), (20640,))
```

```
lro.w
```

```
array([-3.70278276e+01,  4.47600069e-01,  9.56752596e-03, -1.24755956e-01,
        7.94471254e-01, -1.43902596e-06, -3.44307993e-03, -4.18555257e-01,
       -4.33405135e-01])
```

```
lro.predict(X_test)
```

```
array([0.72412832, 1.76677807, 2.71151581, ..., 1.72382152, 2.34689276,
       3.52917352])
```

```
lro.score(X_test, y_test)
```

```
0.5910509795491321
```

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

a) Using built-in:

```
!pip install pgmpy
import numpy as np
import pandas as pd
import csv
from pgmpy.estimators import MaximumLikelihoodEstimator
from pgmpy.models import BayesianModel
from pgmpy.inference import VariableElimination
heartDisease = pd.read_csv('heart_disease.csv')
heartDisease = heartDisease.replace('?',np.nan)

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

print('\n Attributes and datatypes')
print(heartDisease.dtypes)
model=
BayesianModel([('age','Heartdisease'),('sex','Heartdisease'),('exang','Heartdisease'),('cp','Heartdisease'),('He
artdisease','restecg'),('Heartdisease','chol')])
print('\nLearning CPD using Maximum likelihood estimators')
model.fit(heartDisease,estimator=MaximumLikelihoodEstimator)
print('\n Inferencing with Bayesian Network:')
HeartDiseasetest_infer = VariableElimination(model)

print('\n 1. Probability of HeartDisease given evidence= restecg')
q1=HeartDiseasetest_infer.query(variables=['Heartdisease'],evidence={'restecg':1})
print(q1)

print('\n 2. Probability of HeartDisease given evidence= cp ')
q2=HeartDiseasetest_infer.query(variables=['Heartdisease'],evidence={'cp':2})
print(q2)
```

Output:

```
Inferencing with Bayesian Network:

1. Probability of HeartDisease given evidence= restecg
```

Finding Elimination Order: : 100% 4/4 [00:00<00:00, 100.26it/s]

Eliminating: exang: 100% 4/4 [00:00<00:00, 190.96it/s]

```
+----------------+---------------------+
| Heartdisease   |   phi(Heartdisease) |
+================+=====================+
| Heartdisease(0) |             0.1012 |
+----------------+---------------------+
| Heartdisease(1) |             0.0000 |
+----------------+---------------------+
| Heartdisease(2) |             0.2392 |
+----------------+---------------------+
| Heartdisease(3) |             0.2015 |
+----------------+---------------------+
| Heartdisease(4) |             0.4581 |
+----------------+---------------------+
```

```
2. Probability of HeartDisease given evidence= cp
```

Finding Elimination Order: : 100% 3/3 [00:00<00:00, 60.16it/s]

Eliminating: exang: 100% 3/3 [00:00<00:00, 91.15it/s]

```
+----------------+---------------------+
| Heartdisease   |   phi(Heartdisease) |
+================+=====================+
| Heartdisease(0) |             0.3610 |
+----------------+---------------------+
| Heartdisease(1) |             0.2159 |
+----------------+---------------------+
| Heartdisease(2) |             0.1373 |
+----------------+---------------------+
| Heartdisease(3) |             0.1537 |
+----------------+---------------------+
| Heartdisease(4) |             0.1321 |
+----------------+---------------------+
```

b) Without using built-in:

```
import bayespy as bp
import numpy as np
import csv
from colorama import init
from colorama import Fore, Back, Style
init()
```

```
# Define Parameter Enum values
# Age
ageEnum = {'SuperSeniorCitizen': 0, 'SeniorCitizen': 1,
        'MiddleAged': 2, 'Youth': 3, 'Teen': 4}
# Gender
genderEnum = {'Male': 0, 'Female': 1}
# FamilyHistory
familyHistoryEnum = {'Yes': 0, 'No': 1}
# Diet(Calorie Intake)
dietEnum = {'High': 0, 'Medium': 1, 'Low': 2}
# LifeStyle
lifeStyleEnum = {'Athlete': 0, 'Active': 1, 'Moderate': 2, 'Sedetary': 3}
# Cholesterol
cholesterolEnum = {'High': 0, 'BorderLine': 1, 'Normal': 2}
# HeartDisease
heartDiseaseEnum = {'Yes': 0, 'No': 1}
import pandas as pd
data = pd.read_csv("heart_disease_data.csv")
data =np.array(data, dtype='int8')
N = len(data)
# Input data column assignment
p_age = bp.nodes.Dirichlet(1.0*np.ones(5))
age = bp.nodes.Categorical(p_age, plates=(N,))
age.observe(data[:, 0])

p_gender = bp.nodes.Dirichlet(1.0*np.ones(2))
gender = bp.nodes.Categorical(p_gender, plates=(N,))
gender.observe(data[:, 1])

p_familyhistory = bp.nodes.Dirichlet(1.0*np.ones(2))
familyhistory = bp.nodes.Categorical(p_familyhistory, plates=(N,))
familyhistory.observe(data[:, 2])

p_diet = bp.nodes.Dirichlet(1.0*np.ones(3))
diet = bp.nodes.Categorical(p_diet, plates=(N,))
diet.observe(data[:, 3])
```

```
p_lifestyle = bp.nodes.Dirichlet(1.0*np.ones(4))
lifestyle = bp.nodes.Categorical(p_lifestyle, plates=(N,))
lifestyle.observe(data[:, 4])

p_cholesterol = bp.nodes.Dirichlet(1.0*np.ones(3))
cholesterol = bp.nodes.Categorical(p_cholesterol, plates=(N,))
cholesterol.observe(data[:, 5])
p_heartdisease = bp.nodes.Dirichlet(np.ones(2), plates=(5, 2, 2, 3, 4, 3))
heartdisease = bp.nodes.MultiMixture(
    [age, gender, familyhistory, diet, lifestyle, cholesterol], bp.nodes.Categorical, p_heartdisease)
heartdisease.observe(data[:, 6])
p_heartdisease.update()
m = 0
while m == 0:
    print("\n")
    res = bp.nodes.MultiMixture([int(input('Enter Age: ' + str(ageEnum))), int(input('Enter Gender: ' +
str(genderEnum))), int(input('Enter FamilyHistory: ' + str(familyHistoryEnum))), int(input('Enter dietEnum: ' +
str(
        dietEnum))), int(input('Enter LifeStyle: ' + str(lifeStyleEnum))), int(input('Enter Cholesterol: ' +
str(cholesterolEnum)))], bp.nodes.Categorical, p_heartdisease).get_moments()[0][heartDiseaseEnum['Yes']]
    print("Probability(HeartDisease) = " + str(res))

# print(Style.RESET_ALL)
    m = int(input("Enter for Continue:0, Exit :1 "))
```

Output:

```
Enter Age: {'SuperSeniorCitizen': 0, 'SeniorCitizen': 1, 'MiddleAged': 2, 'Youth': 3, 'Teen': 4}0
Enter Gender: {'Male': 0, 'Female': 1}0
Enter FamilyHistory: {'Yes': 0, 'No': 1}0
Enter dietEnum: {'High': 0, 'Medium': 1, 'Low': 2}0
Enter LifeStyle: {'Athlete': 0, 'Active': 1, 'Moderate': 2, 'Sedetary': 3}2
Enter Cholesterol: {'High': 0, 'BorderLine': 1, 'Normal': 2}1
Probability(HeartDisease) = 0.5
Enter for Continue:0, Exit :1 0
```

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

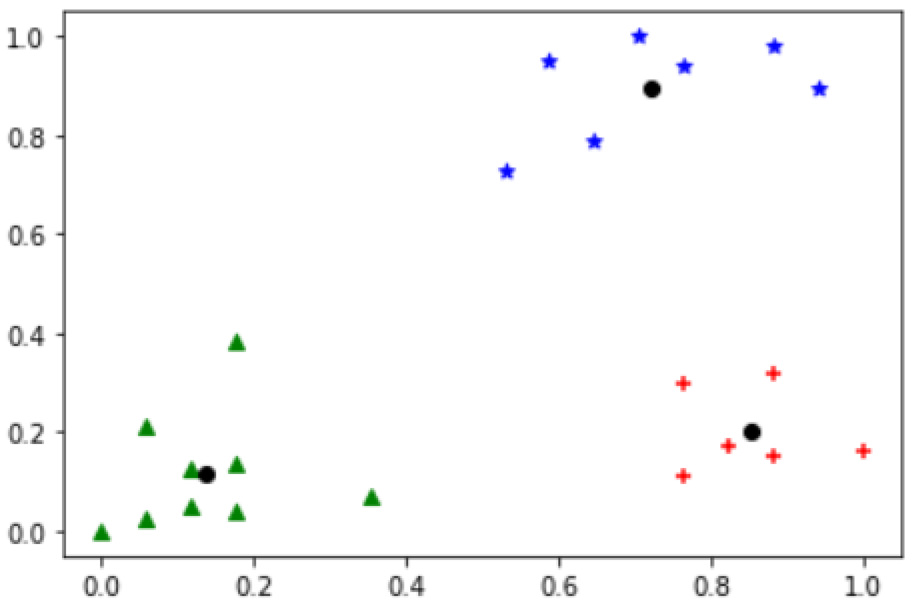
a) Using built-in:

```
import pandas as pd
from sklearn.cluster import KMeans
from sklearn.preprocessing import MinMaxScaler
from matplotlib import pyplot as plt
%matplotlib inline
df = pd.read_csv('income.csv')
df.head(10)
scaler = MinMaxScaler()
scaler.fit(df[['Age']])
df[['Age']] = scaler.transform(df[['Age']])

scaler.fit(df[['Income($)']])
df[['Income($)']] = scaler.transform(df[['Income($)']])
df.head(10)
plt.scatter(df['Age'], df['Income($)'])

k_range = range(1, 11)
sse = []
for k in k_range:
    kmc = KMeans(n_clusters=k)
    kmc.fit(df[['Age', 'Income($)']])
    sse.append(kmc.inertia_)
plt.xlabel = 'Number of Clusters'
plt.ylabel = 'Sum of Squared Errors'
plt.plot(k_range, sse)

km = KMeans(n_clusters=3)
km
df0 = df[df.cluster == 0]
df0
df1 = df[df.cluster == 1]
df1
df2 = df[df.cluster == 2]
df2
```

```
p1 = plt.scatter(df0['Age'], df0['Income($)'], marker='+', color='red')
p2 = plt.scatter(df1['Age'], df1['Income($)'], marker='*', color='blue')
p3 = plt.scatter(df2['Age'], df2['Income($)'], marker='^', color='green')
c = plt.scatter(km.cluster_centers_[:,0], km.cluster_centers_[:,1], color='black')
plt.xlabel('Age')
plt.ylabel('Income($)')
plt.legend((p1, p2, p3, c),
        ('Cluster 1', 'Cluster 2', 'Cluster 3', 'Centroid'))
```

Output:

```
KMeans(n_clusters=3)
```



b) Without using built-in:

```
import math;
import sys;
import pandas as pd
import numpy as np
from random import choice
from matplotlib import pyplot
from random import shuffle, uniform;
def ReadData(fileName):
   f = open(fileName,'r')
   lines = f.read().splitlines()
   f.close()
```

```
    items = []
    for i in range(1,len(lines)):
        line = lines[i].split(',')
        itemFeatures = []
        for j in range(len(line)-1):
            v = float(line[j])
            itemFeatures.append(v)
        items.append(itemFeatures)
    shuffle(items)
    return items
def FindColMinMax(items):
    n = len(items[0])
    minima = [float('inf') for i in range(n)]
    maxima = [float('-inf') -1 for i in range(n)]
    for item in items:
        for f in range(len(item)):
            if(item[f] < minima[f]):
                minima[f] = item[f]
            if(item[f] > maxima[f]):
                maxima[f] = item[f]
    return minima,maxima

def EuclideanDistance(x,y):
    S = 0
    for i in range(len(x)):
        S += math.pow(x[i]-y[i],2)
    return math.sqrt(S)
def InitializeMeans(items,k,cMin,cMax):
    f = len(items[0])
    means = [[0 for i in range(f)] for j in range(k)]
    for mean in means:
        for i in range(len(mean)):
            mean[i] = uniform(cMin[i]+1,cMax[i]-1)

    return means

def UpdateMean(n,mean,item):
```

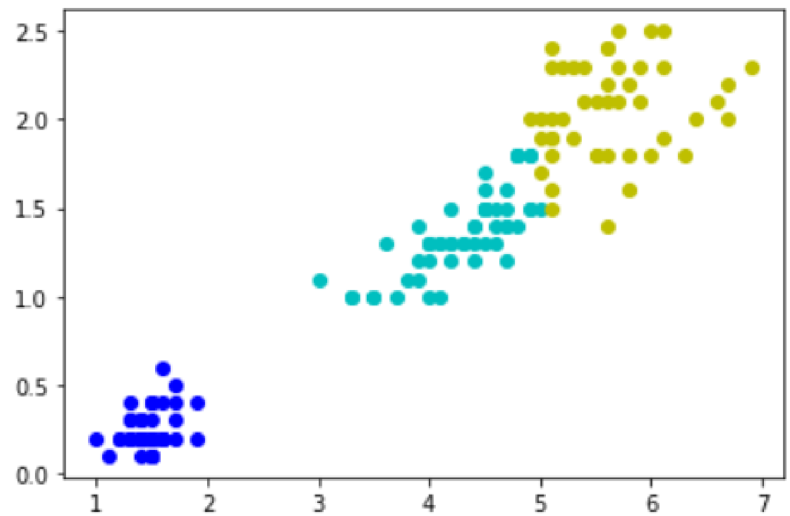
```
    for i in range(len(mean)):
        m = mean[i]
        m = (m*(n-1)+item[i])/float(n)
        mean[i] = round(m,3)
    return mean
def FindClusters(means,items):
    clusters = [[] for i in range(len(means))]
    for item in items:
        index = Classify(means,item)
        clusters[index].append(item)
    return clusters

def Classify(means,item):
        minimum = float('inf');
    index = -1
    for i in range(len(means)):
        dis = EuclideanDistance(item,means[i])
        if(dis < minimum):
            minimum = dis
            index = i
        return index
def CalculateMeans(k,items,maxIterations=100000):
    cMin, cMax = FindColMinMax(items)
    means = InitializeMeans(items,k,cMin,cMax)
    clusterSizes = [0 for i in range(len(means))]
    belongsTo = [0 for i in range(len(items))]
    for e in range(maxIterations):
        noChange = True;
        for i in range(len(items)):
            item = items[i];
            index = Classify(means,item)
            clusterSizes[index] += 1
            cSize = clusterSizes[index]
            means[index] = UpdateMean(cSize,means[index],item)
            if(index != belongsTo[i]):
                noChange = False
            belongsTo[i] = index
```

```
        if (noChange):
            break
    return means

def CutToTwoFeatures(items,indexA,indexB):
    n = len(items)
    X = []
    for i in range(n):
        item = items[i]
        newItem = [item[indexA],item[indexB]]
        X.append(newItem)
    return X

def PlotClusters(clusters):
    n = len(clusters)
    X = [[] for i in range(n)]
    for i in range(n):
        cluster = clusters[i]
        for item in cluster:
            X[i].append(item)
    colors = ['r','b','g','c','m','y']
    for x in X:
        c = choice(colors)
        colors.remove(c)
        Xa = []
        Xb = []
        for item in x:
            Xa.append(item[0])
            Xb.append(item[1])
        pyplot.plot(Xa,Xb,'o',color=c)
    pyplot.show()


def main():
    items = ReadData('data.txt')
    k = 3
    items = CutToTwoFeatures(items,2,3)
    print(items)
```

```
    means = CalculateMeans(k,items)
    print("\nMeans = ", means)
    clusters = FindClusters(means,items)
    PlotClusters(clusters)
    newItem = [1.5,0.2]
    print(Classify(means,newItem))

if __name__ == "__main__":
    main()
```

Output:

```
Means =  [[4.308, 1.372], [5.639, 2.059], [1.465, 0.255]]
```




```
2
```

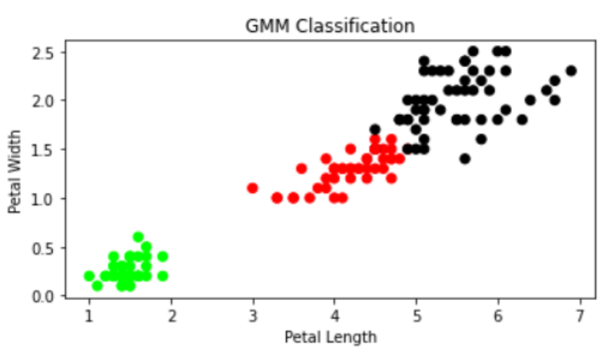
8) Apply EM algorithm to cluster a set of data stored in a .CSV file. Compare the results of k-Means algorithm and EM algorithm.

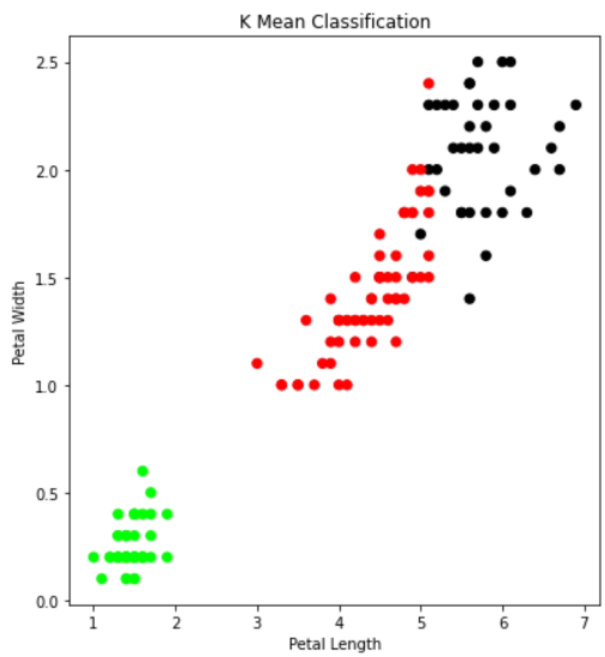
```
import matplotlib.pyplot as plt
from sklearn import datasets
from sklearn.cluster import KMeans
import sklearn.metrics as sm
import pandas as pd
import numpy as np
iris = datasets.load_iris()
X = pd.DataFrame(iris.data)
X.columns = ['Sepal_Length','Sepal_Width','Petal_Length','Petal_Width']
y = pd.DataFrame(iris.target)
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: ',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)
```

```
#xs.sample(5)

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

y_gmm = gmm.predict(xs)
#y_cluster_gmm
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: ',sm.confusion_matrix(y, y_gmm))
```

Output:

```
The accuracy score of K-Mean:  0.24
The Confusion matrixof K-Mean:  [[ 0 50  0]
 [48  0  2]
 [14  0 36]]
The accuracy score of EM:  0.3333333333333333
The Confusion matrix of EM:  [[ 0 50  0]
 [45  0  5]
 [ 0  0 50]]
```





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

```
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('class: 0-Iris-Setosa, 1- Iris-Versicolour, 2- Iris-Virginica')
print(y)
x_train, x_test, y_train, y_test = train_test_split(x,y,test_size=0.3)
#To Training the model and Nearest nighbors K=5
classifier = KNeighborsClassifier(n_neighbors=5)
classifier.fit(x_train, y_train)
#To make predictions on our test data
y_pred=classifier.predict(x_test)
print('Confusion Matrix')
print(confusion_matrix(y_test,y_pred))
print('Accuracy Metrics')
print(classification_report(y_test,y_pred))
```

Output:

```
 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
[[14  0  0]
 [ 0 14  0]
 [ 0  2 15]]
Accuracy Metrics
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        14
           1       0.88      1.00      0.93        14
           2       1.00      0.88      0.94        17

    accuracy                           0.96        45
   macro avg       0.96      0.96      0.96        45
weighted avg       0.96      0.96      0.96        45
```

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.

a) Using built-in:

```
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


 # predict value
 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)]]))
```

Output:

```
 The Data Set ( 10 Samples) X :
  [-2.99399399 -2.98798799 -2.98198198 -2.97597598 -2.96996997 -2.96396396
  -2.95795796 -2.95195195 -2.94594595]
 The Fitting Curve Data Set (10 Samples) Y :
  [2.13582188 2.13156806 2.12730467 2.12303166 2.11874898 2.11445659
  2.11015444 2.10584249 2.10152068]
 Normalised (10 Samples) X :
  [-3.08663662 -2.79327673 -3.13292877 -3.03726639 -3.0967025  -2.9652877
  -3.00708877 -2.94234969 -2.79405157]
  Xo Domain Space(10 Samples) :
  [-2.97993311 -2.95986622 -2.93979933 -2.91973244 -2.89966555 -2.87959866
  -2.85953177 -2.83946488 -2.81939799]
```

b) Without using built-in:

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

def kernel(point, xmat, k):
    m,n = np.shape(xmat)
    weights = np.mat(np.eye((m)))
    for j in range(m):
        diff = point - X[j]
        weights[j,j] = np.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 = np.shape(xmat)
    ypred = np.zeros(m)
    for i in range(m):
        ypred[i] = xmat[i]*localWeight(xmat[i],xmat,ymat,k)
    return ypred
data = pd.read_csv('10-dataset.csv')
bill = np.array(data.total_bill)
tip = np.array(data.tip)

#preparing and add 1 in bill
mbill = np.mat(bill)
mtip = np.mat(tip)
m= np.shape(mbill)[1]
one = np.mat(np.ones(m))
X = np.hstack((one.T,mbill.T))
ypred = localWeightRegression(X,mtip,0.5)
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: