

**USN: 1BM21CS409**

Date: 1-04-2023

## Lab 1: Exploring Datasets

### IRIS DATASET:

- Features in the Iris dataset:
  1. sepal length in cm
  2. sepal width in cm
  3. petal length in cm
  4. petal width in cm
- Target classes to predict:
  1. Iris Setosa
  2. Iris Versicolour
  3. Iris Virginica

```
{'data': array([[5.1, 3.5, 1.4, 0.2],
 [4.9, 3. , 1.4, 0.2],
 [4.7, 3.2, 1.3, 0.2],
 [4.6, 3.1, 1.5, 0.2],
 [5. , 3.6, 1.4, 0.2],
 [5.4, 3.9, 1.7, 0.4],
 [4.6, 3.4, 1.4, 0.3],
 [5. , 3.4, 1.5, 0.2],
 [4.4, 2.9, 1.4, 0.2],
 [4.9, 3.1, 1.5, 0.1],
 [5.4, 3.7, 1.5, 0.2],
 [4.8, 3.4, 1.6, 0.2],
 [4.8, 3. , 1.4, 0.1],
 [4.3, 3. , 1.1, 0.1],
 [5.8, 4. , 1.2, 0.2],
 [5.7, 4.4, 1.5, 0.4],
 [5.4, 3.9, 1.3, 0.4],
 [5.1, 3.5, 1.4, 0.3],
 [5.7, 3.8, 1.7, 0.3],
```

[4.7, 3.2, 1.6, 0.2],  
[4.8, 3.1, 1.6, 0.2],  
[5.4, 3.4, 1.5, 0.4],  
[5.2, 4.1, 1.5, 0.1],  
[5.5, 4.2, 1.4, 0.2],  
[4.9, 3.1, 1.5, 0.2],  
[5. , 3.2, 1.2, 0.2],  
[5.5, 3.5, 1.3, 0.2],  
[4.9, 3.6, 1.4, 0.1],  
[4.4, 3. , 1.3, 0.2],  
[5.1, 3.4, 1.5, 0.2],  
[5. , 3.5, 1.3, 0.3],  
[4.5, 2.3, 1.3, 0.3],  
[4.4, 3.2, 1.3, 0.2],  
[5. , 3.5, 1.6, 0.6],  
[5.1, 3.8, 1.9, 0.4],  
[4.8, 3. , 1.4, 0.3],  
[5.1, 3.8, 1.6, 0.2],

```
In [17]: print(iris['target_names'])  
['setosa' 'versicolor' 'virginica']
```

```
In [20]: n_samples,n_features=iris.data.shape  
print("no.of samples:",n_samples)  
print("no.of features:",n_features)  
  
no.of samples: 150  
no.of features: 4
```

```
In [28]: iris.data[[12,26,89,114]]
```

```
Out[28]: array([[4.8, 3. , 1.4, 0.1],  
               [5. , 3.4, 1.6, 0.4],  
               [5.5, 2.5, 4. , 1.3],  
               [5.8, 2.8, 5.1, 2.4]])
```

```
In [29]: print(iris.data.shape)  
  
(150, 4)
```

```
In [31]: print(iris.target.shape)  
  
(150,)
```

```
In [32]: import numpy as np  
np.bincount(iris.target)
```

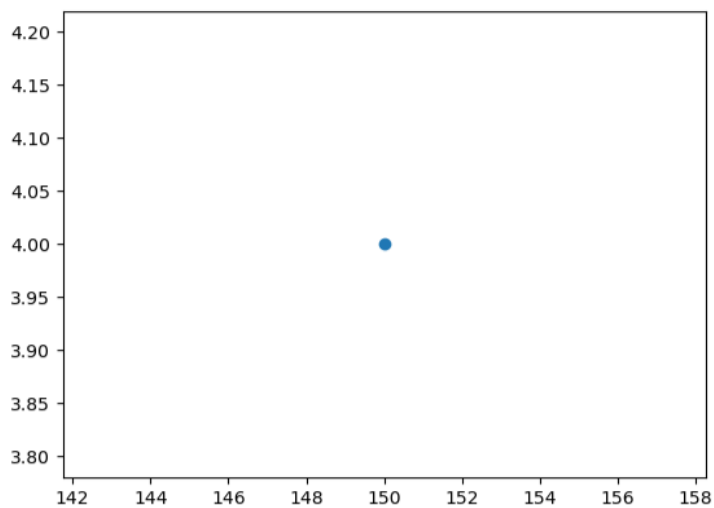
Scattered graph for samples vs features.

```
In [32]: import numpy as np  
np.bincount(iris.target)
```

```
Out[32]: array([50, 50, 50], dtype=int64)
```

```
In [42]: import matplotlib.pyplot as plt  
plt.scatter(n_samples,n_features)
```

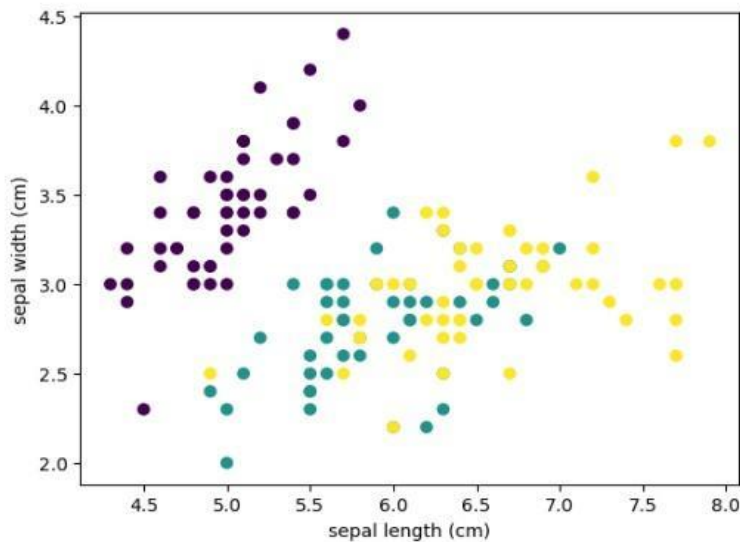
```
Out[42]: <matplotlib.collections.PathCollection at 0x1d1c8c45550>
```



Scattered graph: with first two features( sepal width vs sepal length)  
The three colors represents three different classes respectively.

In [47]:

```
features = iris.data.T
plt.scatter(features[0], features[1],
            c=iris.target)
plt.xlabel(iris.feature_names[0])
plt.ylabel(iris.feature_names[1]);
```



In [49]: iris.data[[1,2,3,4,5]]

```
Out[49]: array([[4.9, 3. , 1.4, 0.2],
               [4.7, 3.2, 1.3, 0.2],
               [4.6, 3.1, 1.5, 0.2],
               [5. , 3.6, 1.4, 0.2],
               [5.4, 3.9, 1.7, 0.4]])
```

## WINE DATASET:

In [51]: `from sklearn.datasets import load_wine`  
`wine=load_wine()`

In [52]: `print(wine)`

```
{'data': array([[1.423e+01, 1.710e+00, 2.430e+00, ..., 1.040e+00, 3.920e+00,
                1.065e+03],
               [1.320e+01, 1.780e+00, 2.140e+00, ..., 1.050e+00, 3.400e+00,
                1.050e+03],
               [1.316e+01, 2.360e+00, 2.670e+00, ..., 1.030e+00, 3.170e+00,
```

In [57]: `wine.data`

```
Out[57]: array([[1.423e+01, 1.710e+00, 2.430e+00, ..., 1.040e+00, 3.920e+00,
                1.065e+03],
               [1.320e+01, 1.780e+00, 2.140e+00, ..., 1.050e+00, 3.400e+00,
                1.050e+03],
               [1.316e+01, 2.360e+00, 2.670e+00, ..., 1.030e+00, 3.170e+00,
                1.185e+03],
               ...,
               [1.327e+01, 4.280e+00, 2.260e+00, ..., 5.900e-01, 1.560e+00,
                8.350e+02],
               [1.317e+01, 2.590e+00, 2.370e+00, ..., 6.000e-01, 1.620e+00,
                8.400e+02],
               [1.413e+01, 4.100e+00, 2.740e+00, ..., 6.100e-01, 1.600e+00,
                5.600e+02]])
```

In [58]: `wine.keys()`

```
Out[58]: dict_keys(['data', 'target', 'frame', 'target_names', 'DESCR', 'feature_names'])
```

In [60]: `print(wine['target_names'])`

```
['class_0' 'class_1' 'class_2']
```

```
In [9]: print(wine['feature_names'])
```

```
['alcohol', 'malic_acid', 'ash', 'alcalinity_of_ash', 'magnesium', 'total_phenols', 'flavanoids', 'nonflavanoid_phenols', 'proanthocyanins', 'color_intensity', 'hue', 'od280/od315_of_diluted_wines', 'proline']
```

```
In [11]: import numpy as np  
np.bincount(wine.target)
```

```
Out[11]: array([59, 71, 48], dtype=int64)
```

**Date:** 15/04/2023

**Lab 2:** FIND-S ALGORITHM FOR ENJOY SPORT:

**Program 2** – Implement and demonstrate the FIND-S algorithm for finding the most specific hypothesis based on a given set of training data samples. Read the training data from a .CSV file Data set:Enjoysport

a. Enjoysport

Example	Sky	AirTemp	Humidity	Wind	Water	Forecast	EnjoySport
1	Sunny	Warm	Normal	Strong	Warm	Same	Yes
2	Sunny	Warm	High	Strong	Warm	Same	Yes
3	Rainy	Cold	High	Strong	Warm	Change	No
4	Sunny	Warm	High	Strong	Cool	Change	Yes

**Algorithm:**

initialize h to the most specific hypothesis in H  $h = (\emptyset, \emptyset, \emptyset, \emptyset, \emptyset, \emptyset)$

1. First training example  $X_1 = \langle \text{Sunny, Warm, Normal, Strong Warm Same} \rangle$ . EnjoySport = +ve Observing. The first training example, it is clear that hypothesis h is too specific. None of the " $\emptyset$ " constraints in h are satisfied by this example, so each is replaced by the next more general constraint that fits the example  $h_1 = \langle \text{Sunny, Warm, Normal, Strong Warm, Same} \rangle$ .
2. Consider the second training example  $x_2 = \langle \text{Sunny, Warm, High, Strong, Warm, Same} \rangle$ . EnjoySport = +ve. The second training example forces the algorithm to further generalize h, this time substituting a "?" in place of any attribute value in h that is not satisfied by the new example. Now  $h_2 = \langle \text{Sunny, Warm, ?, Strong, Warm, Same} \rangle$
3. Consider the third training example  $x_3 = \langle \text{Rainy, Cold, High, Strong, Warm, Change} \rangle$ . EnjoySport = ve. The FIND-S algorithm simply ignores every negative example. So the hypothesis remain as before, so  $h_3 = \langle \text{Sunny, Warm, ?, Strong, Warm, Same} \rangle$
4. Consider the fourth training example  $x_4 = \langle \text{Sunny, Warm, High, Strong, Cool, Change, EnjoySport +ve} \rangle$ . The fourth example leads to a further generalization of h as  $h_4 = \langle \text{Sunny, Warm, ?, Strong, ?, ?} \rangle$
5. So the final hypothesis is  $\langle \text{Sunny, Warm, ?, Strong, ?, ?} \rangle$

5/4/23

## Lab Program 1

## Find S algorithm

Dataset : enjoysports.csv file

Sample	Sky	Air Temp	Humidity	Wind	Water	Forecast	enjoy sports?
1)	Sunny	Warm	normal	Strong	Warm	Same	Yes +
2)	Sunny	Warm	high	Strong	Warm	Same	Yes +
3)	Sunny	Cold	high	Strong	Warm	Same	No -
4)	Sunny	Warm	high	Strong	Warm	Same	Yes +

\* Find S algorithm: Is a basic-concept-learning algo in ML.

\* It finds what is most-specific hypothesis that fits all the "Positive" examples.

\* This algo starts with the most specific hypothesis and moves to the most general hypothesis.

{} → accepts any value General.

⌀ → accepts No value. Specific (value)

MGD → (???) accepts everything

MSD → (⌀ ⌀ ⌀ ⌀) accepts None

→ Null

initial hypo : {⌀, ⌀, ⌀, ⌀}

iteration 1  $h_1 = \langle \text{'Sunny', 'warm', 'normal', 'strong', 'warm', 'Same'} \rangle +ve$

iteration 2  $h_2 = \langle \text{'Sunny', 'warm', 'high', 'strong', 'warm', 'Same'} \rangle$

iteration 3  $h_3 = \langle \text{'Raining', 'cold', 'high', 'strong', 'warm', 'Change'} \rangle$

iteration 4  $h_4 = \langle \text{'Sunny', 'warm', 'high', 'strong', 'cool', 'Change'} \rangle$

(Not considered) i.e. ...

1) Initialize 'h' to the most specific hypo in H.

2) For each positive training instance 'x' each attribute constraint  $a_i$  in  $h$  if the constraint  $a_i$  is not satisfied by 'x' then do nothing.  
else replace  $a_i$  in  $h$  by the next more general constraint that is required by 'x' hypothesis  $h$ .

3) Output hypothesis  $h$ .

## Program

```
import csv
def updateHypothesis(h, x):
    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 = []
```

```
    with open("Desktop Finds.csv", "r") as file:
```

```
        reader = csv.reader(file)
```

```
        print("Data:")
```

```
        data.append(row)
```

```
        print(row)
```

```
    if data:
```

```
        for x in data:
```

```
            if x[-1].upper() == "Yes": x.pop()
```

```
            updateHypothesis(x, h)
```

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



CREATING CSV FILE:

enjoysport.csv ☆ 📁 ☁

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	A	B	C	D	E	F	G
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
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```
[ ] import numpy as np
import pandas as pd

from google.colab import drive
drive.mount("/content/drive")

Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).

[ ] path = "/content/enjoysport.csv.csv"

Double-click (or enter) to edit

[ ] data = pd.read_csv(path)

[ ] print(data, "\n")
```

```
[ ]
```

	Sky	AirTemp	Humidity	Wind	Water	Forecast	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

```
[ ] d = np.array(data)[:,-1]
print("\n The attributes are: ",d)

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']]

[ ] target = np.array(data)[:,-1]
print("\n The target is: ",target)

The target is: ['Yes' 'Yes' 'No' 'Yes']
```

```
[ ] 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(d,target))
```

The final hypothesis is: ['Sunny' 'Warm' '?' 'Strong' '?' '?']

## SECOND DATASET: FIND-S ALGORITHM

example	<i>citations</i>	<i>size</i>	<i>inLibrary</i>	<i>price</i>	<i>editions</i>	<i>buy</i>
1	some	small	no	affordable	many	no
2	many	big	no	expensive	one	yes
3	some	big	always	expensive	few	no
4	many	medium	no	expensive	many	yes
5	many	small	no	affordable	many	yes

## CREATING CSV FILE


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1	citation	size	inLibrary	price	editions	buy
2	some	small	no	affordable	many	no
3	many	big	no	expensive	one	yes
4	some	big	always	expensive	few	no
5	many	medium	no	expensive	many	yes
6	many	small	noo	affordable	many	yes
7						
8						



```
import numpy as np
import pandas as pd
```

```
[ ] from google.colab import drive
drive.mount("/content/drive")
```

Mounted at /content/drive

```
[ ] path = "/content/finde_1BM20CS066 - Sheet1.csv"
```

```
[ ] data = pd.read_csv(path)
```

```
[ ] print(data, "\n")
```

	citation	size	inLibrary	price	editions	buy
0	some	small	no	affordable	many	no
1	many	big	no	expensive	one	yes
2	some	big	always	expensive	few	no
3	many	medium	no	expensive	many	yes
4	many	small	noo	affordable	many	yes

```
[ ] d = np.array(data)[:,-1]
print("\n The attributes are: ",d)
```

The attributes are: [['some' 'small' 'no' 'affordable' 'many']  
['many' 'big' 'no' 'expensive' 'one']  
['some' 'big' 'always' 'expensive' 'few']  
['many' 'medium' 'no' 'expensive' 'many']  
['many' 'small' 'noo' 'affordable' 'many']]

```
target = np.array(data)[:,-1]
print("\n The target is: ",target)
```



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

+ Code

+ Text

```
[ ] def find_s(d,target):
    for i,val in enumerate(target):
        if val=='yes':
            hypothesis=d[i].copy()
            break

    for i,var in enumerate(d):
        if target[i]=="yes":
            for x in range(len(hypothesis)):
                if var[x]!=hypothesis[x]:
                    hypothesis[x]='?'
            else:
                pass

    return hypothesis

print("The Hypothesis is",find_s(d,target))
```

The Hypothesis is ['many' '?' '?' '?' '?']

**DATE:** 15/04/2023

**LAB 3:** CANDIDATE- ELIMINATION- ENJOY SPORT

**Program 3:**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.  
Data set:EnjoySport

Example	Sky	AirTemp	Humidity	Wind	Water	Forecast	EnjoySport
1	Sunny	Warm	Normal	Strong	Warm	Same	Yes
2	Sunny	Warm	High	Strong	Warm	Same	Yes
3	Rainy	Cold	High	Strong	Warm	Change	No
4	Sunny	Warm	High	Strong	Cool	Change	Yes

**ALGORITHM:**

Step1: Load Data set

Step2: Initialize General Hypothesis and Specific Hypothesis.

Step3: For each training example

Step4: If example is positive example

if attribute\_value == hypothesis\_value:

Do nothing

else:

replace attribute value with '?' (Basically generalizing it)

Step5: If example is Negative example

Make generalize hypothesis more specific.

12/4/23

## Lab Program 2

### Candidate Elimination Algorithm

Example	Sky	Air temp	Humidity	Wind	Water
1	Sunny	warm	Normal	Strong	warm
2	Sunny	warm	high	Strong	warm
3	Rainy	cold	high	Strong	warm
4	Sunny	warm	high	Strong	cool

Forecast	Enjoy sport	Target
Same	Yes +ve	variable.
Same	Yes +ve	
Change	No -ve	concept learning
Change	Yes +ve	

gives out binary results.

Considers both negative and Positive values.

To find consistent hypothesis for a given solution of training example

most General  $G_0 = \langle ?, ?, ?, ?, ? \rangle$

Most specific  $S_0 = \langle \emptyset, \emptyset, \emptyset, \emptyset, \emptyset \rangle$

Start from Generic Boundary,

first takes generic attribute values.

Whenever matches retain generic values if matches expected is +ve and outcome +ve.

$$G_1 = G_0$$

A null value in  $S_0$  is replaced by  $S_1$ .

$$S_0 = \langle \emptyset, \emptyset, \emptyset, \emptyset, \emptyset \rangle$$

No match  $\rightarrow$  negative classification

\* All question marks match with example, hence +ve classification. Target variable = +ve  $\Rightarrow$  GB

\* All null values doesn't match, hence -ve Classifier. But expected = +ve classifier, therefore it is inconsistent hypothesis. When inconsistency exist write next general hypothesis that is:

→ Replace Null values by 1<sup>st</sup> examples.

I)  $G_1 = \langle ?, ?, ?, ?, ? \rangle$   
 $S_1 = \langle \text{Sunny, warm, Normal, Strong, warm, same} \rangle$

II)  $G_1 = \langle ? ? ? ? ? \rangle$   
Consider prev generic hypothesis.

$G_2 = G_1$

if generic +ve → retain

if match retain

if Target value -ve → start from 1

if Target value +ve → start from 6

$S_2 = \langle \text{Sunny, warm, ?, Strong, warm, same} \rangle$

\* GB, all ? matches with  $S_1$ , hence +ve Classification and expd.

\* SB, when inconsistency make it General(?)

Target value

III)  $S_3 = \langle \text{Sunny, warm, ?, Strong, warm, same} \rangle$  -ve  
 $G_3 = \langle \text{Sunny, ?, ?, ?, 1, ?} \rangle$

\* Since all values are generic in Previous hypothesis, only possible when example is +ve. and if there exists inconsistency, then all hypothesis which are consistent with all the training examples seen now.



\* ? match with all the attribute but expected -ve.  
hence inconsistency.

\* All hypothesis which are consistent till now.

→ To do that, consider 1 ? at a time.

Program

```
import numpy as np
import pandas as pd
data = pd.DataFrame(data=pd.read_csv('enjoySport.csv'))
concepts = np.array(data.iloc[:, 0:-1])
print(concepts)
target = np.array(data.iloc[:, 0:-1])
print(target)
print('general - h')
print('specific - n')
```

$X_1 (+)$

$S_4 = \langle ? \text{ large, light, ? thick} \rangle$

$G_4 = \langle ? ? \text{ light, ? ? } \rangle, \langle ? ? ? ? \text{ thick} \rangle$

Dataset

Size	Trunk	Fuel economy	No. of Passengers	Type	Target value.
Small	Available	High	4	economy	Y
Big	Available	low	2	sports	N
Small	Available	high	4	economy	Y
Small	Not Available	low	2	sports	N

$G_0 = \langle ? , ? , ? , ? , ? \rangle$

$S_0 = \langle \emptyset, \emptyset, \emptyset, \emptyset, \emptyset \rangle$

$S_1 = \langle \text{small, available, high, 4, economy} \rangle$


$G_1 = \langle ? , ? , ? , ? , ? \rangle$

$S_2 = \langle \text{small, ? , high, 4, economy} \rangle$

$G_2 = \{ \langle \text{small, ? , ? , ? , ? } \rangle ; \langle ? , ? , \text{high, ? , ? } \rangle ; \langle ? , ? , ? , 4, ? \rangle ; \langle ? , ? , ? , ? , \text{economy} \rangle \}$

$S_3 = \langle \text{small}, ?, \text{high}, 4, \text{economy} \rangle$   
 $G_3 = \langle \text{small}, ?, ?, ?, ? \rangle; \langle ?, ?, \text{high}, ?, ? \rangle;$   
 $\langle ?, ?, ?, 4, ? \rangle; \langle ?, ?, ?, ? \text{economy} \rangle.$

$S_4 = \langle ?, ?, \text{high}, 4, \text{economy} \rangle$   
 $G_4 = \langle ?, ?, \text{high}, ?, ? \rangle; \langle ?, ?, ?, 4, ? \rangle;$   
 $\langle ?, ?, ?, ? \text{economy} \rangle.$



## CREATING CSV FILE:

enjoysport.csv ☆ 📄 ☁

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A1 fx Sky

	A	B	C	D	E	F	G
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
6							
7							



```
[ ] import numpy as np
import pandas as pd
```

```
[ ] from google.colab import drive
drive.mount('/content/drive')
```

```
[ ] data = pd.DataFrame(data=pd.read_csv('/content/enjoysport.csv.csv'))
```

```
[ ] print(data, "\n")
```

	Sky	AirTemp	Humidity	Wind	Water	Forecast	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

---

```
[ ] concepts = np.array(data.iloc[:,0:-1])
```

```
[ ] print(concepts)

[['Sunny' 'Warm' 'Normal' 'Strong' 'Warm' 'Same']
 ['Sunny' 'Warm' 'High' 'Strong' 'Warm' 'Same']
 ['Rainy' 'Cold' 'High' 'Strong' 'Warm' 'Change']
 ['Sunny' 'Warm' 'High' 'Strong' 'Cool' 'Change']]
```

```
[ ] target = np.array(data.iloc[:,-1])
print(target)

['Yes' 'Yes' 'No' 'Yes']
```

```
[ ] import csv
```

```

▶ with open("/content/enjoysport.csv.csv") as f:
    csv_file = csv.reader(f)
    data = list(csv_file)

    specific = data[1][:-1]
    general = [['?' for i in range(len(specific))] for j in range(len(specific))]

    for i in data:
        if i[-1] == "Yes":
            for j in range(len(specific)):
                if i[j] != specific[j]:
                    specific[j] = "?"
                    general[j][j] = "?"

            elif i[-1] == "No":
                for j in range(len(specific)):
                    if i[j] != specific[j]:
                        general[j][j] = specific[j]
                    else:
                        general[j][j] = "?"

        print("\nStep " + str(data.index(i)) + " of Candidate Elimination Algorithm")
        print(specific)
        print(general)

    gh = [] # gh = general Hypothesis
    for i in general:
        for j in i:
            if j != '?':
                gh.append(i)
                break
    print("\nFinal Specific hypothesis:\n", specific)
    print("\nFinal General hypothesis:\n", gh)

```

```

Step 0 of Candidate Elimination Algorithm
['Sunny', 'Warm', 'Normal', 'Strong', 'Warm', 'Same']
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

Step 1 of Candidate Elimination Algorithm
['Sunny', 'Warm', 'Normal', 'Strong', 'Warm', 'Same']
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

Step 2 of Candidate Elimination Algorithm
['Sunny', 'Warm', '?', 'Strong', 'Warm', 'Same']
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

Step 3 of Candidate Elimination Algorithm
['Sunny', 'Warm', '?', 'Strong', 'Warm', 'Same']
[['Sunny', '?', '?', '?', '?', '?'], ['?', 'Warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', 'Same']]

Step 4 of Candidate Elimination Algorithm
['Sunny', 'Warm', '?', 'Strong', '?', '?']
[['Sunny', '?', '?', '?', '?', '?'], ['?', 'Warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

Final Specific hypothesis:
['Sunny', 'Warm', '?', 'Strong', '?', '?']

Final General hypothesis:
[['Sunny', '?', '?', '?', '?', '?'], ['?', 'Warm', '?', '?', '?', '?']]

```

```

[ ] def learn(concepts, target):
    specific_h = concepts[0].copy()
    general_h = [['?' for i in range(len(specific_h))] for i in range(len(specific_h))]
    print("Step 0:")
    print("Specific Hypothesis: ", specific_h)
    print("General Hypothesis: ", general_h)
    print("-----")
    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] = '?'
        elif 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("Step", i+1, ":")
    print("Specific Hypothesis: ", specific_h)
    print("General Hypothesis: ", general_h)
    print("-----")
    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)
print("Final S:", s_final, sep="\n")
print("Final G:", g_final, sep="\n")

```

```

Step 0:
Specific Hypothesis: ['Sunny' 'Warm' 'Normal' 'Strong' 'Warm' 'Same']
General Hypothesis: [['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

Step 1:
Specific Hypothesis: ['Sunny' 'Warm' 'Normal' 'Strong' 'Warm' 'Same']
General Hypothesis: [['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

Step 2:
Specific Hypothesis: ['Sunny' 'Warm' '?' 'Strong' 'Warm' 'Same']
General Hypothesis: [['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

Step 3:
Specific Hypothesis: ['Sunny' 'Warm' '?' 'Strong' 'Warm' 'Same']
General Hypothesis: [['Sunny', '?', '?', '?', '?', '?'], ['?', 'Warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

Step 4:
Specific Hypothesis: ['Sunny' 'Warm' '?' 'Strong' '?' '?' ]
General Hypothesis: [['Sunny', '?', '?', '?', '?', '?'], ['?', 'Warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

Final 5:
['Sunny' 'Warm' '?' 'Strong' '?' '?' ]
Final 6:
[['Sunny', '?', '?', '?', '?', '?'], ['?', 'Warm', '?', '?', '?', '?']]

```

## SECOND DATASET:

example	citations	size	inLibrary	price	editions	buy
1	some	small	no	affordable	many	no
2	many	big	no	expensive	one	yes
3	some	big	always	expensive	few	no
4	many	medium	no	expensive	many	yes
5	many	small	no	affordable	many	yes

## CREATING CSV FILE:

finds\_1BM20CS066

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	A	B	C	D	E	F
1	citation	size	inLibrary	price	editions	buy
2	some	small	no	affordable	many	no
3	many	big	no	expensive	one	yes
4	some	big	always	expensive	few	no
5	many	medium	no	expensive	many	yes
6	many	small	noo	affordable	many	yes
7						
8						

```

from google.colab import drive
drive.mount('/content/drive')

Mounted at /content/drive

[ ] import numpy as np
import pandas as pd

[ ] data = pd.DataFrame(data=pd.read_csv('/content/finds_1BM20CS066 - Sheet1.csv'))
print(data,"\n")

  citation  size inlibrary  price editions  buy
0  some  small      no  affordable  many   no
1  many   big      no   expensive   one   yes
2  some   big  always  expensive   few   no
3  many  medium      no   expensive  many  yes
4  many   small     noo  affordable  many  yes

[ ] concepts = np.array(data.iloc[:,0:-1])
print("The attributes are: ",concepts)

The attributes are: [['some' 'small' 'no' 'affordable' 'many']
['many' 'big' 'no' 'expensive' 'one']
['some' 'big' 'always' 'expensive' 'few']
['many' 'medium' 'no' 'expensive' 'many']
['many' 'small' 'noo' 'affordable' 'many']]

[ ] target = np.array(data.iloc[:, -1])
print("\n The target is: ",target)

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

```

```
[ ] 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)
        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)
```

Initialization of specific\_h and general\_h

```
['some' 'small' 'no' 'affordable' 'many']
[['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?']]
['some' 'small' 'no' 'affordable' 'many']
```

Steps of Candidate Elimination Algorithm 1

```
['some' 'small' 'no' 'affordable' 'many']
[['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?']]
['?' 'small' 'no' 'affordable' 'many']
['?' '?' 'no' 'affordable' 'many']
['?' '?' 'no' 'affordable' 'many']
['?' '?' 'no' '?' 'many']
['?' '?' 'no' '?' '?']
['?' '?' 'no' '?' '?']
```

Steps of Candidate Elimination Algorithm 2

```
['?' '?' 'no' '?' '?']
[['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?']]
['?' '?' 'no' '?' '?']
```

Steps of Candidate Elimination Algorithm 3

```
['?' '?' 'no' '?' '?']
[['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?'], ['?', '?', 'no', '?', '?'], ['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?']]
['?' '?' 'no' '?' '?']
['?' '?' 'no' '?' '?']
['?' '?' 'no' '?' '?']
['?' '?' 'no' '?' '?']
['?' '?' 'no' '?' '?']
['?' '?' 'no' '?' '?']
```

Steps of Candidate Elimination Algorithm 4

```
['?' '?' 'no' '?' '?']
[['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?'], ['?', '?', 'no', '?', '?'], ['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?']]
['?' '?' 'no' '?' '?']
['?' '?' 'no' '?' '?']
['?' '?' 'no' '?' '?']
['?' '?' 'no' '?' '?']
['?' '?' 'no' '?' '?']
['?' '?' 'no' '?' '?']
```

Steps of Candidate Elimination Algorithm 5

```
['?' '?' 'no' '?' '?']
[['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?']]
```

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

Final Specific\_h:

```
['?' '?' '?' '?' '?']
```

Final General\_h:

```
[['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?']]
```

**Program 4:** 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.

Day	Outlook	Temperature	Humidity	Wind	PlayTennis
D1	Sunny	Hot	High	Weak	No
D2	Sunny	Hot	High	Strong	No
D3	Overcast	Hot	High	Weak	Yes
D4	Rain	Mild	High	Weak	Yes
D5	Rain	Cool	Normal	Weak	Yes
D6	Rain	Cool	Normal	Strong	No
D7	Overcast	Cool	Normal	Strong	Yes
D8	Sunny	Mild	High	Weak	No
D9	Sunny	Cool	Normal	Weak	Yes
D10	Rain	Mild	Normal	Weak	Yes
D11	Sunny	Mild	Normal	Strong	Yes
D12	Overcast	Mild	High	Strong	Yes
D13	Overcast	Hot	Normal	Weak	Yes
D14	Rain	Mild	High	Strong	No

ALGORITHM:

- Create a Root node for the tree
- If all Examples are positive, Return the single-node tree Root, with label = +
- If all Examples are negative, Return the single-node tree Root, with label = -
- If Attributes is empty, Return the single-node tree Root, with label = most common value of Target\_attribute in Examples
- Otherwise Begin
  - $A \leftarrow$  the attribute from Attributes that best\* classifies Examples
  - The decision attribute for Root  $\leftarrow A$
  - For each possible value,  $v_i$ , of A,
    - Add a new tree branch below Root, corresponding to the test  $A = v_i$
    - Let  $Examples_{v_i}$  be the subset of Examples that have value  $v_i$  for A
    - If  $Examples_{v_i}$  is empty
    - Then below this new branch add a leaf node with label = most common value of Target\_attribute in Examples
    - Else below this new branch add the subtree  $ID3(Examples_{v_i}, Target\_attribute, Attributes - \{A\})$
    - End
  - Return Root



19/4/23

# Decision Tree - Play Golf

1) Day	Outlook	Temp	Humidity	wind	Play
1	Sunny	Hot	high	weak	No
2	Sunny	Hot	high	Strong	No
3	Overcast	Hot	high	weak	Yes
4	Rain	Mild	high	weak	Yes
5	Rain	cool	Normal	Weak	Yes
6	Rain	cool	Normal	Strong	No
7	Overcast	cool	Normal	Strong	Yes
8	Sunny	Mild	high	weak	No
9	Sunny	cool	Normal	Weak	Yes
10	Rain	Mild	Normal	weak	Yes
11	Sunny	Mild	Normal	Strong	Yes
12	Overcast	Mild	high	Strong	Yes
13	Overcast	hot	Normal	Weak	Yes
14	Rain	Mild	High	Strong	No

$$= (-9/14 \log_2 9/14) + (-5/14 \log_2 5/14)$$

$$= 1.094$$

Information Gain:  $G(S, A, T)$

$$= E(S) - \sum_{v \in \text{Attr}(A)} \frac{|S_v|}{|S|} E(S_v)$$

$$\text{Entropy}(S) = -P_+ \log_2 P_+ - P_- \log_2 P_-$$



$$G(s, \text{temp}) = E(s) - \left[ \frac{4}{14} * E(\text{temp} = \text{hot}) \right] + \frac{6}{14} * E(\text{temp} = \text{mild}) + \frac{4}{14} * E(\text{temp} = \text{cool})$$

$$E(s) = \left[ \frac{4}{14} * \left( -\frac{2}{4} \log_2 \frac{2}{4} \right) + \left( -\frac{2}{4} \log_2 \frac{2}{4} \right) + \right.$$

$$\left. \left[ \frac{6}{14} * \left( -\frac{4}{6} \log_2 \frac{4}{6} \right) + \left( -\frac{2}{6} \log_2 \frac{2}{6} \right) + \right. \right.$$

$$\left. \left[ \frac{4}{14} * \left( -\frac{3}{4} \log_2 \frac{3}{4} \right) + \left( -\frac{1}{4} \log_2 \frac{1}{4} \right) \right] \right]$$

$$= 0.94 - 0.969$$

$$= \boxed{0.029}$$

$$\begin{aligned} G(s, \text{Humidity}) &= 0.151 \text{ Entropy}(s) \\ &= -(7/14) \text{entropy}(S_{\text{high}}) \\ &\quad - (7/14) \text{entropy}(S_{\text{normal}}) \\ &= 0.40 - (7/14) \cdot 0.985 - (7/14) \cdot 0.592 \\ &= \boxed{0.0489} \end{aligned}$$

Ans  
19/14/23

$$\begin{aligned} G(s, \text{Wind}) &= \text{Entropy}(s) \\ &\quad - (8/14) \text{entropy}(S_{\text{weak}}) \\ &\quad - (6/14) \text{entropy}(S_{\text{strong}}) \\ &= 0.940 - (8/14) \cdot 0.811 - (6/14) \cdot 1 \\ &= \boxed{0.48} \end{aligned}$$

## Algorithm

IDS (Example, Target-attribute, attribute)

- \* Create a root node for the tree.
- \* If all examples are +ve,  
return the single node tree  
Root with label = +ve.
- \* If all examples are -ve,  
return the single node tree  
Root with label = -ve.
- \* Otherwise Begin,
  - $A \leftarrow$  the attribute from attributes that best\* classifies examples.
  - The decision attribute for root  $\leftarrow A$
  - Add a new tree-branch below root, corresponding to the test  $A = V_i$
  - Let example  $V_i$  be the subset of example that have values  $V_i$  from  $A$ .
  - If example  $V_i$  that is empty.
    - \* Then a below this new branch at a leaf node with label  $S$ ' most common value of Target-attribute in example.

→ Else, below this new branch add the subtree  
 ID3 (examples  $V_i$ , target attribute, attribute - {A})

\* end

\* Return Root.

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1BM20CS066\_ID3 ☆ 📁 ☁

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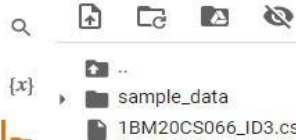
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	A	B	C	D	E
1	outlook	temperture	humidity	wind	play tennis
2	sunny	hot	high	weak	no
3	sunny	hot	high	strong	no
4	overcast	hot	high	weak	yes
5	rain	mild	high	weak	yes
6	rain	cool	normal	weak	yes
7	rain	cool	normal	strong	no
8	overcast	cool	normal	strong	yes
9	sunny	mild	high	weak	no
10	sunny	cool	normal	weak	yes
11	rain	mild	normal	weak	yes
12	sunny	mild	normal	strong	yes
13	overcast	mild	high	strong	yes
14	overcast	hot	normal	weak	yes
15	rain	mild	high	strong	no
16					



## Files



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Disk 84.31 GB available

+ Code + Text

```
✓ [53] import math
      import csv
```

```
✓ [55] def load_csv(filename):
      lines=csv.reader(open(filename,"r"))
      dataset = list(lines)
      headers = dataset.pop(0)
      return dataset,headers
```

```
✓ [56] class Node:
      def __init__(self,attribute):
          self.attribute=attribute
          self.children=[]
          self.answer=""
```

```
✓ [57] 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
```

```

✓ [58] 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

```

```

✓ [59] 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

```

```

✓ [60] 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

```

```

✓ [61] 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)

```



```
✓ [62] def classify(node,x_test,features):  
0s     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)
```

```
✓ [63]  
0s dataset,features=load_csv("1BM20CS066_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("1BM20CS066_ID3.csv")  
  
    for xtest in testdata:  
        print("The test instance:",xtest)  
        print("The label for test instance:")  
        classify(node1,xtest,features)
```

```
✓ 0s ▶ The decision tree for the dataset using ID3 algorithm is  
    outlook  
    rain  
    wind  
    weak  
    yes  
    strong  
    no  
    sunny  
    humidity  
    high  
    no  
    normal  
    yes  
    overcast  
    yes
```



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

## PROGRAM 5: Simple linear regression program

Dataset used:

	A	B
1	x	y
2	1	1
3	2	2
4	3	1.3
5	4	3.75
6	5	2.25
7		

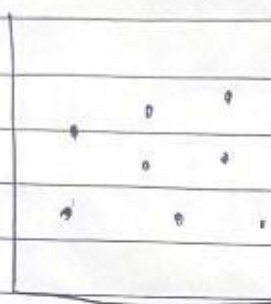
ALGORITHM:

- The main function to calculate values of coefficients
- Initialize the parameters.
- Predict the value of a dependent variable by giving an independent variable.
- Calculate the error in prediction for all data points.
- Calculate partial derivatives w.r.t  $a_0$  and  $a_1$ .
- Calculate the cost for each number and add them.
- Update the values of  $a_0$  and  $a_1$ .

## Linear Regression

$$b_0 = \frac{(\sum y)(\sum x^2) - (\sum x)(\sum xy)}{n(\sum x^2) - (\sum x)^2}$$

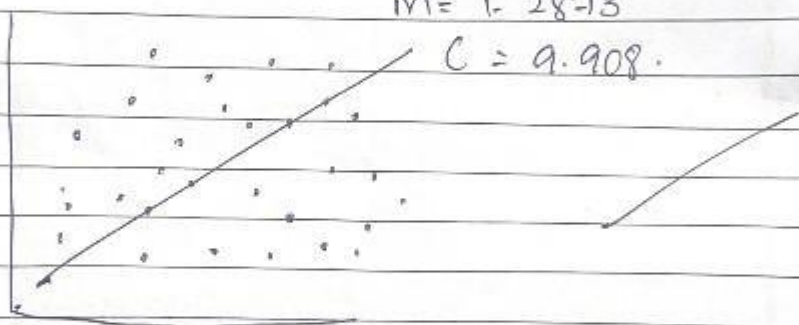
$$b_1 = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$$



$$Y = MX + C$$

$$M = 1.2873$$

$$C = 9.908$$



A straight-line equation involving slope ( $dy/dx$ ) and Y-intercept

$$Y = MX + C$$

$y$  = dependent value of  $x$ .

$$Y = b_1 x_i + b_0$$

$Y_i$  = Predicted  $Y$  Value for observation

$b_0$  = Estimate of Regression Intercept

$b_1$  = Estimate of regression slope

$X_i$  = Input.

```
[ ] import numpy as np
import matplotlib.pyplot as plt
```

```
[ ] def plot_regression_line(x, y, b):

    plt.scatter(x, y, color = "m",
                marker = "o", s = 30)

    y_pred = b[0] + b[1]*x

    plt.plot(x, y_pred, color = "g")

    plt.xlabel('x CO-EFF')
    plt.ylabel('y CO-EFF')

    plt.show()
```

```
[ ] def estimate_coef(x, y):

    n = np.size(x)

    m_x = np.mean(x)
    m_y = np.mean(y)

    SS_xy = np.sum(y*x) - n*m_y*m_x
    SS_xx = np.sum(x*x) - n*m_x*m_x

    b_1 = SS_xy / SS_xx
    b_0 = m_y - b_1*m_x

    return (b_0, b_1)
```

```
▶ def plot_regression_line(x, y, b):
    plt.scatter(x, y, color = "b",
                marker = "*", s = 30)

    y_pred = b[0] + b[1]*x

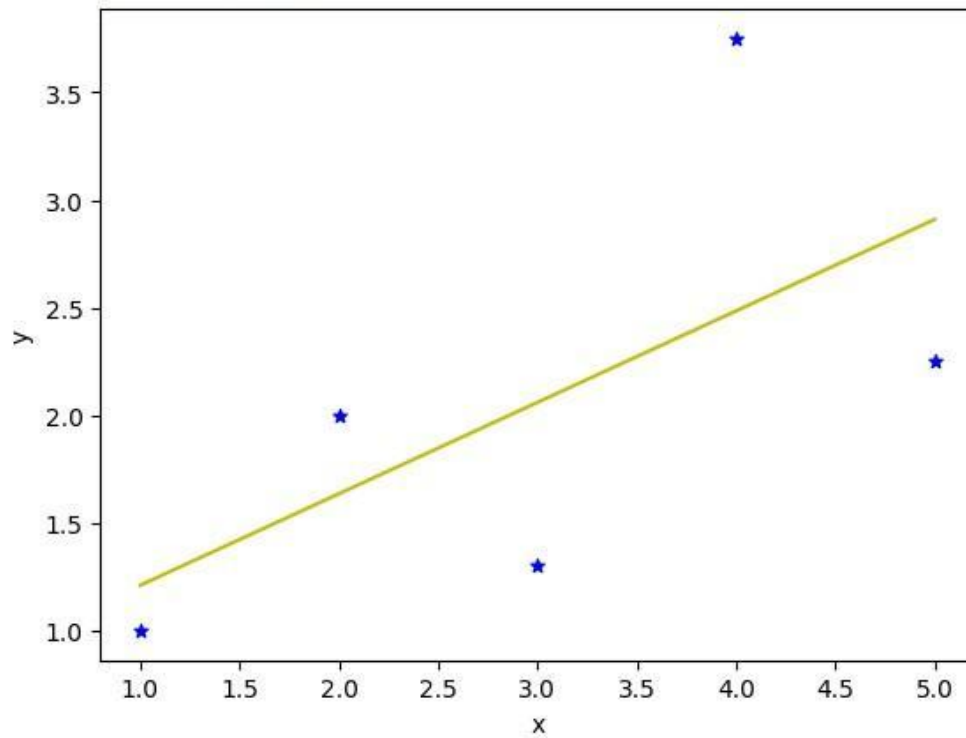
    plt.plot(x, y_pred, color = "y")

    plt.xlabel('x')
    plt.ylabel('y')

    plt.show()
```

```
def main():  
  
    x = np.array([1,2,3,4,5])  
    y = np.array([1,2,1.3,3.75,2.25])  
  
    b = estimate_coef(x, y)  
    print("Estimated coefficients:\nb_0 = {} \nb_1 = {}".format(b[0], b[1]))  
  
    plot_regression_line(x, y, b)  
  
if __name__ == "__main__":  
    main()
```

```
Estimated coefficients:  
b_0 = 0.7850000000000001  
b_1 = 0.42499999999999996
```



### Conclusion:

This model is not appropriate for this model. All the points of this dataset are away from the prediction line.

**Program 6:**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.

**Data set used:**

	A	B
1	outlook	play
2	rainy	Yes
3	sunny	Yes
4	overcast	Yes
5	overcast	Yes
6	sunny	No
7	rainy	Yes
8	sunny	Yes
9	overcast	Yes
10	rainy	No
11	sunny	No
12	sunny	Yes
13	rainy	No
14	overcast	Yes
15	overcast	Yes

**Algorithm:**

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

Formula for naive bayes classifier is as follows →

1. Convert the given dataset into frequency tables.
2. Generate Likelihood table by finding the probabilities of given features.
3. Now, use Bayes theorem to calculate the posterior probability.
4. Test accuracy of the result and visualizing the test set result.

The screenshot shows a Jupyter Notebook titled "1BM20CS066\_NBC.ipynb". The interface includes a menu bar (File, Edit, View, Insert, Runtime, Tools, Help) and a toolbar. The left sidebar shows a file explorer with a folder named "sample\_data" and a file named "1BM20CS066\_NBC.csv". The main area displays two code cells. The first cell, labeled [7], imports numpy as np, math, csv, and pdb. The second cell, labeled [9], defines a function read\_data(filename) that reads a CSV file and returns metadata and training data, and another function splitDataset(dataset, splitRatio) that splits the dataset into training and testing sets.

```
[7] import numpy as np
import math
import csv
import pdb

def read_data(filename):
    with open(filename, 'r') as csvfile:
        datareader = csv.reader(csvfile)
        metadata = next(datareader)
        traindata = []
        for row in datareader:
            traindata.append(row)
    return (metadata, traindata)

[9] def splitDataset(dataset, splitRatio):
    trainSize = int(len(dataset) * splitRatio)
    trainSet = []
    testset = list(dataset)
    i = 0
    while len(trainSet) < trainSize:
        trainSet.append(testset.pop(i))
    return [trainSet, testset]
```



```

0s def classify(data,test):

    total_size = data.shape[0]
    print("\n")
    print("training data size=",total_size)
    print("test data size=",test.shape[0])

    countYes = 0
    countNo = 0
    probYes = 0
    probNo = 0
    print("\n")
    print("target    count    probability")

    for x in range(data.shape[0]):
        if data[x,data.shape[1]-1] == 'Yes':
            countYes +=1
        if data[x,data.shape[1]-1] == 'No':
            countNo +=1

    probYes=countYes/total_size
    probNo= countNo / total_size

    print('Yes',"\\t",countYes,"\\t",probYes)
    print('No',"\\t",countNo,"\\t",probNo)

    prob0 =np.zeros((test.shape[1]-1))
    prob1 =np.zeros((test.shape[1]-1))
    accuracy=0
    print("\n")
    print("instance prediction  target")

    for t in range(test.shape[0]):
        for k in range (test.shape[1]-1):
            count1=count0=0
            for j in range (data.shape[0]):
                #how many times appeared with no
                if test[t,k] == data[j,k] and data[j,data.shape[1]-1]=='No':
                    count0+=1
                #how many times appeared with yes
                if test[t,k]==data[j,k] and data[j,data.shape[1]-1]=='Yes':
                    count1+=1

```

```

        prob0[k]=count0/countNo
        prob1[k]=count1/countYes

    probno=probNo
    probyes=probYes
    for i in range(test.shape[1]-1):
        probno=probno*prob0[i]
        probyes=probyes*prob1[i]
    if probno>probyes:
        predict='No'
    else:
        predict='Yes'

    print(t+1,"\\t",predict,"\\t    ",test[t,test.shape[1]-1])
    if predict == test[t,test.shape[1]-1]:
        accuracy+=1
    final_accuracy=(accuracy/test.shape[0])*100
    print("accuracy",final_accuracy,"%")
    return

```

```

metadata,traindata= read_data("/content/1BM20CS066_NBC.csv")
splitRatio=0.6
trainingset, testset=splitDataset(traindata, splitRatio)
training=np.array(trainingset)
print("\n The Training data set are:")
for x in trainingset:
    print(x)

testing=np.array(testset)
print("\n The Test data set are:")
for x in testing:
    print(x)
classify(training,testing)

```

### output:

The Training data set are:

```

['rainy', 'Yes']
['sunny', 'Yes']
['overcast', 'Yes']
['overcast', 'Yes']
['sunny', 'No']
['rainy', 'Yes']
['sunny', 'Yes']
['overcast', 'Yes']

```

The Test data set are:

```

['rainy' 'No']
['sunny' 'No']
['sunny' 'Yes']
['rainy' 'No']
['overcast' 'Yes']
['overcast' 'Yes']

```

training data size= 8

test data size= 6

target	count	probability
Yes	7	0.875
No	1	0.125

instance	prediction	target
1	Yes	No
2	Yes	No
3	Yes	Yes
4	Yes	No
5	Yes	Yes
6	Yes	Yes

accuracy 50.0 %

## Naive Bayes

### Training Dataset

Color	Type	Origin	Stolen
Red	Sports	domestic	Yes
Red	Sports	Domestic	No
Red	Sports	Domestic	Yes
Yellow	Sports	Domestic	No
Yellow	Sports	Imported	Yes
Yellow	SUV	Imported	No

Size = 6

### Test Data Set

Color	Type	Origin	Stolen
Yellow	SUV	imported	Yes
Yellow	SUV	Domestic	No
Red	SUV	Imported	No
Red	Sports	Imported	Yes

Size = 4

Target	Count	Probability
Yes	3	$\frac{1}{2}$
No	3	$\frac{1}{2}$

Instance	Prediction	Target
1	No	Yes
2	No	No
3	No	No
4	Yes	Yes

Accuracy : 75.0%

$$P(h|D) = \frac{P(D|h) \cdot P(h)}{P(D)}$$

$P(H|D)$  = Posterior Probability

$P(H)$  = Prior Probability

$P(D)$  = Probability over data set

$P(D|H)$  = Current Probability

~~O/p-  
17/5/23~~

## Program 7:K- means clustering

### Algorithm:

Initialize k means with random values

For a given number of iterations:

Iterate through items:

Find the mean closest to the item by calculating the euclidean distance of the item with each of the means

Assign item to mean

Update mean by shifting it to the average of the items in that cluster

### Dataset:

Kmeans_1BM20CS066.csv			
1 to 22 of 22 entries			
1	Name	Age	Income(\$)
2	Rob	27	70000
3	Michael	29	90000
4	Mohan	29	61000
5	Ismail	28	60000
6	Kory	42	150000
7	Gautam	39	155000
8	David	41	160000
9	Andrea	38	162000
10	Brad	36	156000
11	Angelina	35	130000
12	Donald	37	137000
13	Tom	26	45000
14	Arnold	27	48000
15	Jared	28	51000
16	Stark	29	49500
17	Ranbir	32	53000
18	Dipika	40	65000
19	Priyanka	41	63000
20	Nick	43	64000
21	Alia	39	80000
22	Sid	41	82000
21	Abdul	39	58000

Show 25 per page

## K-means Algorithm

- ① Select the number  $K$  to decide the number of clusters.
- ② Select random  $K$  points or centroids.
- ③ Assign each data point to their closest centroid which will form the predefined  $K$  cluster.
- ④ Calculate the Variance and new place centroid of each cluster.
- ⑤ Repeat the third steps, which means re-align each datapoint to new closest centroid.
- ⑥ If any re-assignment occurs, go to step 4 else FINISH

7/6/25  
⑦ Model is ready.

GMM - Gaussian Mixture model.



✓  
2s

```
[1] import pandas as pd
from sklearn.cluster import KMeans
from sklearn.preprocessing import MinMaxScaler
from matplotlib import pyplot as plt
%matplotlib inline
```

✓  
0s

```
df = pd.read_csv('/content/Kmeans_1BM20CS066.csv')
df.head(10)
```



	1	Name	Age	Income(\$)
0	2	Rob	27	70000
1	3	Michael	29	90000
2	4	Mohan	29	61000
3	5	Ismail	28	60000
4	6	Kory	42	150000
5	7	Gautam	39	155000
6	8	David	41	160000
7	9	Andrea	38	162000
8	10	Brad	36	156000
9	11	Angelina	35	130000



✓  
0s

```
[4] scaler = MinMaxScaler()
scaler.fit(df[['Age']])
df[['Age']] = scaler.transform(df[['Age']])

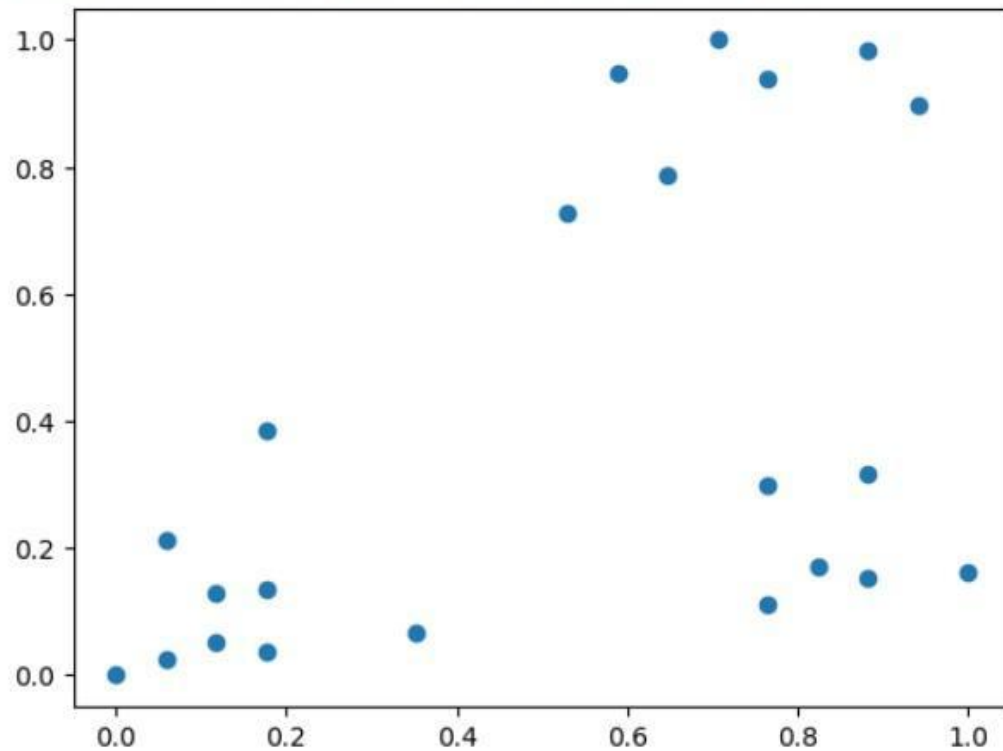
scaler.fit(df[['Income($)']])
df[['Income($)']] = scaler.transform(df[['Income($)']])
df.head(10)
```

	1	Name	Age	Income(\$)
0	2	Rob	0.058824	0.213675
1	3	Michael	0.176471	0.384615
2	4	Mohan	0.176471	0.136752
3	5	Ismail	0.117647	0.128205
4	6	Kory	0.941176	0.897436
5	7	Gautam	0.764706	0.940171
6	8	David	0.882353	0.982906
7	9	Andrea	0.705882	1.000000
8	10	Brad	0.588235	0.948718
9	11	Angelina	0.529412	0.726496



```
plt.scatter(df['Age'], df['Income($)'])
```

```
<matplotlib.collections.PathCollection at 0x7f43820d1a50>
```

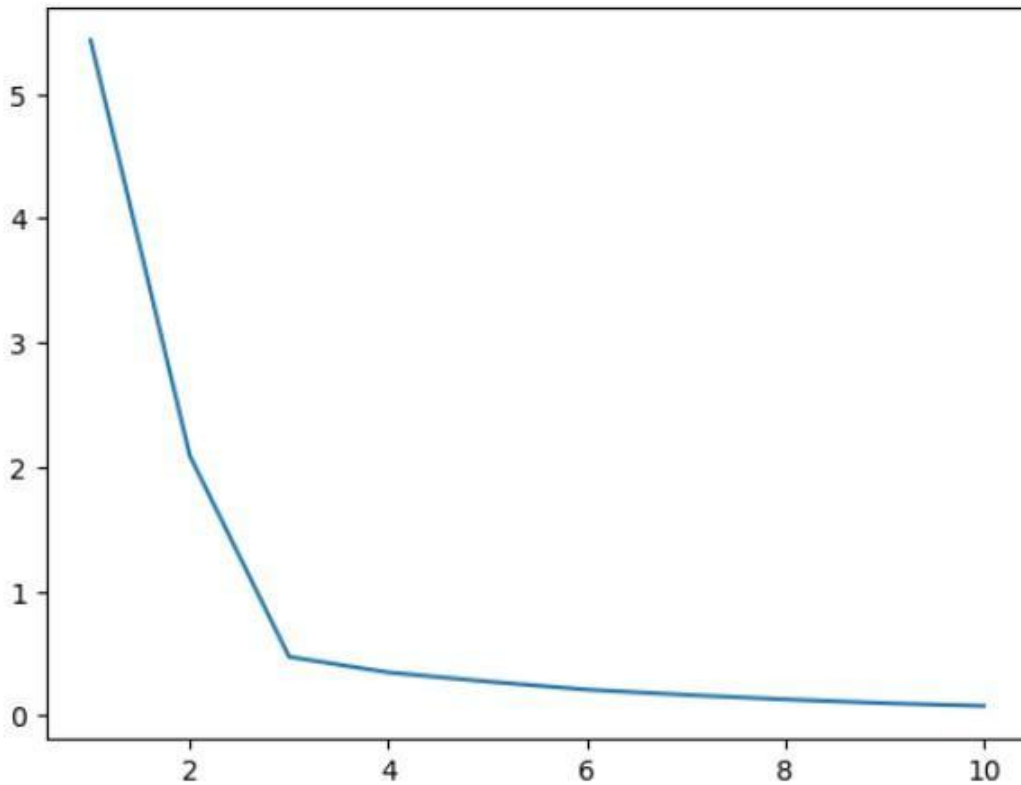


```
k_range = range(1, 11)
sse = []
for k in k_range:
    kmc = KMeans(n_clusters=k)
    kmc.fit(df[['Age', 'Income($)']])
    sse.append(kmc.inertia_)
sse
```

```
[5.434011511988178,
 2.091136388699078,
 0.4750783498553096,
 0.3491047094419566,
 0.2798062931046179,
 0.2203764169077067,
 0.1685851223602976,
 0.13265419827245162,
 0.1038375258660356,
 0.08510915216361345]
```

```
plt.xlabel = 'Number of Clusters'
plt.ylabel = 'Sum of Squared Errors'
plt.plot(k_range, sse)
```

[<matplotlib.lines.Line2D at 0x7f438004a6e0>]



```
[8] km = KMeans(n_clusters=3)
km
```

KMeans  
KMeans(n\_clusters=3)

```
y_predict = km.fit_predict(df[['Age', 'Income($)']])
y_predict
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of 'n_init' will change from 10 to 'auto' in 1.4. Set the value of warnings.warn(
array([1, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 2, 2, 2, 2, 2],
      dtype=int32)
```

```
[10] df['cluster'] = y_predict
df.head()
```

	1	Name	Age	Income(\$)	cluster
0	2	Rob	0.058824	0.213675	1
1	3	Michael	0.176471	0.384615	1
2	4	Mohan	0.176471	0.136752	1
3	5	Ismail	0.117647	0.128205	1
4	6	Kory	0.941176	0.897436	0

```
[11] df0 = df[df.cluster == 0]
df0
```

	1	Name	Age	Income(\$)	cluster
4	6	Kory	0.941176	0.897436	0
5	7	Gautam	0.764706	0.940171	0
6	8	David	0.882353	0.982906	0
7	9	Andrea	0.705882	1.000000	0
8	10	Brad	0.588235	0.948718	0
9	11	Angelina	0.529412	0.726496	0

```
✓ [12] df1 = df[df.cluster == 1]
0s df1
```

	1	Name	Age	Income(\$)	cluster
0	2	Rob	0.058824	0.213675	1
1	3	Michael	0.176471	0.384615	1
2	4	Mohan	0.176471	0.136752	1
3	5	Ismail	0.117647	0.128205	1
11	13	Tom	0.000000	0.000000	1
12	14	Arnold	0.058824	0.025641	1
13	15	Jared	0.117647	0.051282	1
14	16	Stark	0.176471	0.038462	1
15	17	Ranbir	0.352941	0.068376	1



```
✓ [13] df2 = df[df.cluster == 2]
0s df2
```

	1	Name	Age	Income(\$)	cluster
16	18	Dipika	0.823529	0.170940	2
17	19	Priyanka	0.882353	0.153846	2
18	20	Nick	1.000000	0.162393	2
19	21	Alia	0.764706	0.299145	2
20	22	Sid	0.882353	0.316239	2
21	21	Abdul	0.764706	0.111111	2

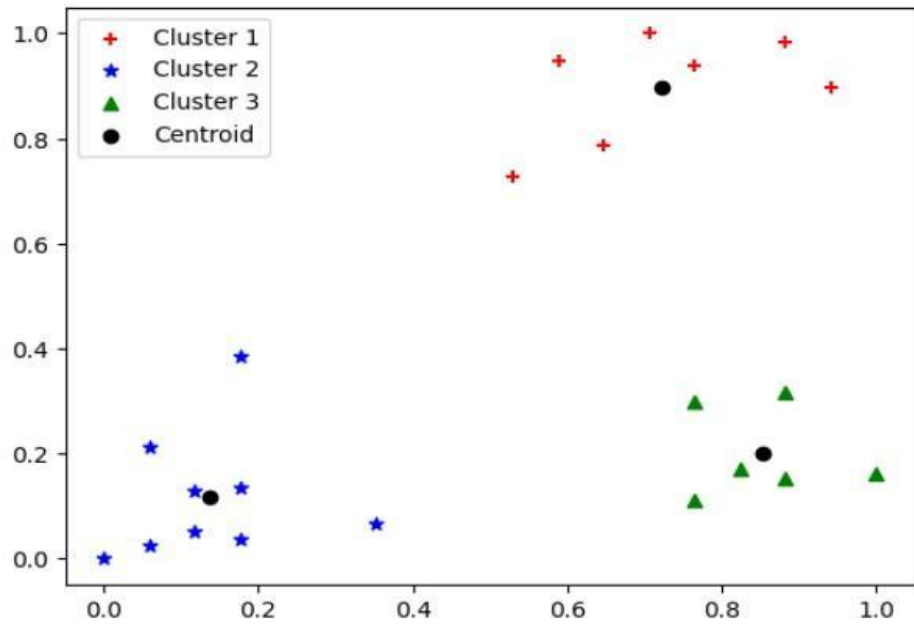


```
✓ [14] km.cluster_centers_
```

```
array([[0.72268908, 0.8974359 ],
       [0.1372549 , 0.11633428],
       [0.85294118, 0.2022792 ]])
```

```
[17] 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.legend((p1, p2, p3, c),
           ('Cluster 1', 'Cluster 2', 'Cluster 3', 'Centroid'))
```

<matplotlib.legend.Legend at 0x7f437d4c73a0>



## Program 8: KNN ALGORITHM

Dataset used: Iris dataset

Algorithm:

- Select the number K of the neighbor
- Calculate the Euclidean distance of K number of neighbors
- Take the K nearest neighbors as per the calculated Euclidean distance.
- Among these k neighbors, count the number of the data points in each category.
- Assign the new data points to that category for which the number of the neighbor is maximum.

✓  
0s



```
import numpy as np
import matplotlib.pyplot as plt
from sklearn import datasets
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler

def most_common(lst):
    return max(set(lst), key=lst.count)

def euclidean(point, data):
    # Euclidean distance between points a & data
    return np.sqrt(np.sum((point - data)**2, axis=1))

class KNeighborsClassifier:
    def __init__(self, k=5, dist_metric=euclidean):
        self.k = k
        self.dist_metric = dist_metric

    def fit(self, X_train, y_train):
        self.X_train = X_train
        self.y_train = y_train

    def predict(self, X_test):
        neighbors = []
        for x in X_test:
            distances = self.dist_metric(x, self.X_train)
            y_sorted = [y for _, y in sorted(zip(distances, self.y_train))]
            neighbors.append(y_sorted[:self.k])
        return list(map(most_common, neighbors))
```





```
def evaluate(self, X_test, y_test):
    y_pred = self.predict(X_test)
    accuracy = sum(y_pred == y_test) / len(y_test)
    return accuracy

iris = datasets.load_iris()
X = iris['data']
y = iris['target']

# Split data into train & test sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2)

# Preprocess data
ss = StandardScaler().fit(X_train)
X_train, X_test = ss.transform(X_train), ss.transform(X_test)

# Test knn model across varying ks
accuracies = []
ks = range(1, 30)
for k in ks:
    knn = KNeighborsClassifier(k=k)
    knn.fit(X_train, y_train)
    accuracy = knn.evaluate(X_test, y_test)
    accuracies.append(accuracy)

# Visualize accuracy vs. k
fig, ax = plt.subplots()
ax.plot(ks, accuracies)
ax.set(xlabel="k",
       ylabel="Accuracy",
       title="Performance of knn")
plt.show()
```

## K-nearest Neighbor Algorithm

- \* For each given training example  $(x, f(x))$ , add the example to the list training examples to the list training examples classification algorithm.
- \* Given a query instance  $x_q$  to be classified,  
Let  $x_1, \dots, x_k$  denote the  $k$  instances from training examples that are nearest to  $x_q$ .

\* Return

$$\hat{f}(x_q) \leftarrow \frac{\sum_{i=1}^k f(x_i)}{k}$$

~~Separate~~

Output.

sepal-length sepal-width petal-length petal-width

[5.1 3.5 1.4 0.2]

[4.9.3 1.4 0.2]

[4.7 3.2 1.8 0.2]

[4.6 3.1 1.5 0.2]

[5.0 3.6 1.4 0.2]

. . . .

. . . .

[6.2 3.4 5.4 2.3]

[5.9.3 5.1.1.8]

Class : 0 - Iris-setosa, 1 - Iris Versicolor, 2 - Iris-Virginica

[000 --- 0011 --- 11222 --- 22]

### Confusion Matrix

$\begin{bmatrix} 20 & 0 & 0 \end{bmatrix}$

$\begin{bmatrix} 0 & 10 & 0 \end{bmatrix}$

$\begin{bmatrix} 0 & 1 & 14 \end{bmatrix}$

### Accuracy Metrics

	Precision	Recall	f1-score	support
0	1.00	1.00	1.00	20
1	0.91	1.00	0.95	10
2	1.00	0.93	0.97	15

Avg/total      0.98      0.98      0.98      45

O/p/pen

7/6/23

**Program 9:** Apply EM algorithm to cluster a set of data stored in a .CSV file. Compare the results of k-Means algorithm and EM algorithm.

Algorithm for k means clustering:

- Initialize k means with random values
- For a given number of iterations:
- Iterate through items:
- Find the mean closest to the item by calculating the euclidean distance of the item with each of the means
- Assign item to mean
- Update mean by shifting it to the average of the items in that

clusters Algorithm for EM algorithm:

- The very first step is to initialize the parameter values. Further, the system is provided with incomplete observed data with the assumption that data is obtained from a specific model.
- This step is known as Expectation or E-Step, which is used to estimate or guess the values of the missing or incomplete data using the observed data. Further, E-step primarily updates the variables.
- This step is known as Maximization or M-step, where we use complete data obtained from the 2<sup>nd</sup> step to update the parameter values. Further, M-step primarily updates the hypothesis.
- The last step is to check if the values of latent variables are converging or

not. Dataset: Iris dataset

```
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 matrix of 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('EM Classification')
plt.xlabel('Petal Length')
plt.ylabel('Petal Width')

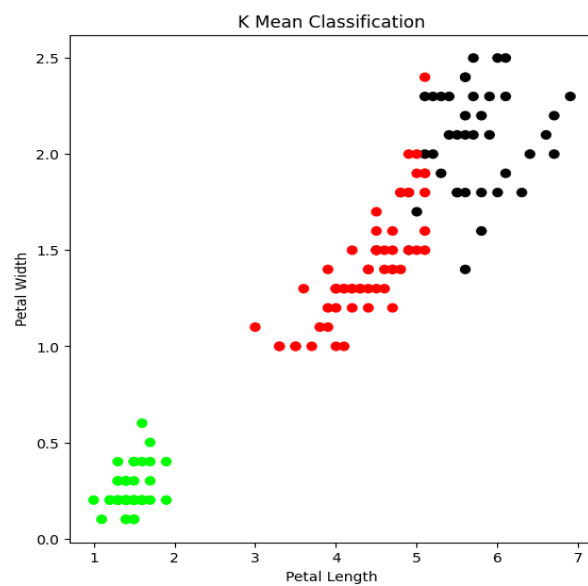
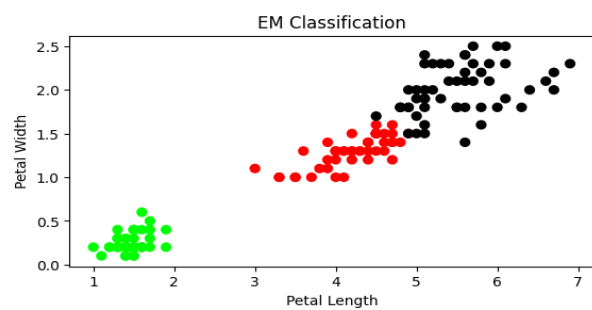
print('The accuracy score of EM: ', sm.accuracy_score(y, y_gmm))
print('The Confusion matrix of EM: ', sm.confusion_matrix(y, y_gmm))

```

```

The accuracy score of K-Mean: 0.24
The Confusion matrix of 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]]

```





## EM- Algorithm

- \* **Expectation step (E step):** It involves the estimation of all missing values in dataset so that after completing this step, there should not be any missing value.
  - \* **Maximize step (M-step):** This step involves the use of estimated data in E-step and updating the parameter.
  - \* Repeat E step and M step until the convergence of value occur.
- ① Initialize Parameter values. Further, the system is provided with incomplete observed data with assumption that data is obtained from specific model.
  - ② E-step, which is used to estimate or guess the value of the missing data using the observed data.
  - ③ Maximization step, where we use the complete data obtained from 2<sup>nd</sup> step to update parameter values.
- \* The last step is to check if value of variables are converging or not.
  - \* If yes, stop Process else repeat until convergence occurs.

Euclidean distance Formula:

$$\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

$x_1$  = x co-ordinate of point 1

$y_1$  = y co-ordinate of point 1

$x_2$  = x co-ordinate of pt 2

$y_2$  = y co-ordinate of pt 2

~~0/0~~  
~~ans~~

**Program 10:** Implement the non-parametric Locally Weighted Regression algorithm in order to fit data points. Select the appropriate data set for your experiment and draw graphs.

Algorithm:

1.  $F$  is approximated near  $X_q$  using a linear function:

$$\hat{f}(x) = w_0 + \sum_{u=1}^k w_u K_u(d(x_u, x))$$

2. Minimize the squared error:

$$E_3(x_q) \equiv \frac{1}{2} \sum_{x \in k \text{ nearest nbrs of } x_q} (f(x) - \hat{f}(x))^2 K(d(x_q, x))$$

$$\Delta w_j = \eta \sum_{x \in k \text{ nearest nbrs of } x_q} K(d(x_q, x)) (f(x) - \hat{f}(x)) a_j(x)$$

3. It is weighted because the contribution of each training example is weighted by its distance from the query point.

Dataset: tip.csv



```
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,yamat,k):
    wei = kernel(point,xmat,k)
    W = (X.T*(wei*X)).I*(X.T*(wei*yamat.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

```

```

[ ] def graphPlot(X,ypred):
    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();

```

```

data = pd.read_csv('/content/tips.csv')
bill = np.array(data.total_bill)
tip = np.array(data.tip)

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))

# increase k to get smooth curves
ypred = localWeightRegression(X,mtip,3)
graphPlot(X,ypred)

```

## Lab-7 Locally weighted Regression Algorithm

- 1) Read the given data sample to  $x$  and the curve (linear or non linear) to  $y$ .
- 2) Set the value of Smoothing Parameter of free Parameter say  $\tau$ .
- 3) Set the bias / Point of Interest set  $x_0$  which is subset of  $x$ .
- 4) Determine the weight matrix using:  
$$w(x, w_0) = e^{-\frac{(x - x_0)^2}{2\tau^2}}$$
- 5) Determine the value of model term parameter  $\beta$  using:

$$\hat{\beta}(x_0) = (X^T W X)^{-1} X^T W y$$

- 6) Prediction =  $x_0 * \beta$ ;

D/p Sum  
7/6/23

