UNIVERSITY OF MUMBAI
INSTITUTE OF DISTANCE AND OPEN LEARNING (IDOL)

PRACTICAL JOURNAL IN PAPER - IV

SOFT COMPUTING TECHNIQUES

SUBMITTED BY
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SEAT NO:508114

MASTERS OF SCIENCE IN INFORMATION TECHNOLOGY PART-1
SEMESTER-1

ACADEMIC YEAR
2022-2023

INSTITUTE OF DISTANCE AND OPEN LEARNING
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Certificate

This is to certify that

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M.sc (IT) Co-Ordinator, IDOL   External Examiner

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Practical 1

Practical 1 a: Design a simple linear neural network model.

x=float(input("Enter value of x:"))

w=float(input("Enter value of weight w:"))

b=float(input("Enter value of bias b:"))

net = int(w*x+b)

if(net<0):

 out=0

elif((net>=0)&(net<=1)):

 out =net

else:

 out=1

print("net=",net)

print("output=",out)

Practical 1 b: Calculate the output of neural net using both binary and bipolar

sigmoidal function

Figure 1 Neural net.
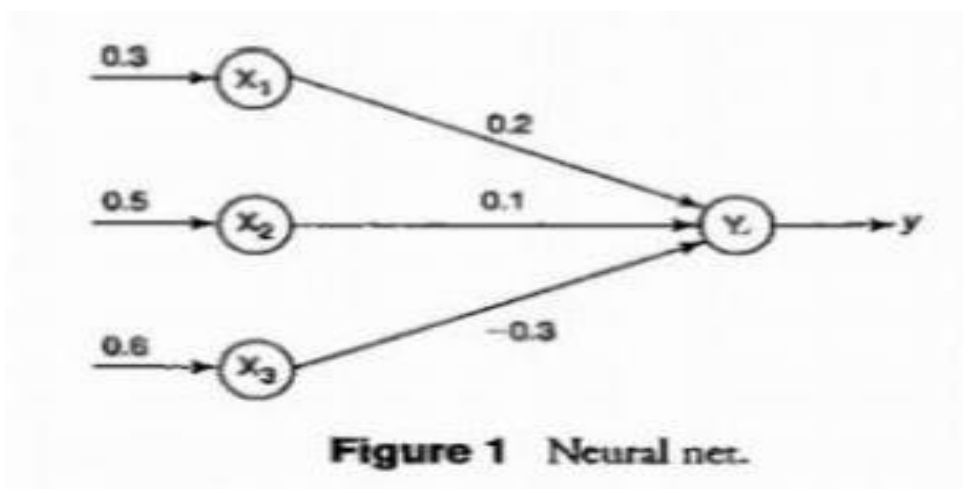
Code :

```python
# number of elements as input

n = int(input("Enter number of elements : "))

# In[2]:

print("Enter the inputs")

inputs = [] # creating an empty list for inputs

# iterating till the range

for i in range(0, n):

ele = float(input())

inputs.append(ele) # adding the element

print(inputs)

# In[3]:

print("Enter the weights")

# creating an empty list for weights

weights = []

# iterating till the range

for i in range(0, n):

ele = float(input())

weights.append(ele) # adding the element

print(weights)

# In[4]:

print("The net input can be calculated as Yin = x1w1 + x2w2 + x3w3")

# In[5]:

Yin = []

for i in range(0, n):

Yin.append(inputs[i]*weights[i])

print(round(sum(Yin),3))
```

Output :

```
Enter number of elements : 3
Enter the inputs
0.3
0.5
0.6
[0.3, 0.5, 0.6]
Enter the weights
0.2
0.1
-0.3
[0.2, 0.1, -0.3]
The net input can be calculated as   Yin = x1w1 + x2w2 + x3w3
-0.07
```

Practical 2

Practical 2 a: Implement AND/NOT function using McCulloch-Pits neuron (use binary data representation).

Code:

```
# enter the no of inputs
num_ip = int(input("Enter the number of inputs : "))
#Set the weights with value 1
w1 = 1
w2 = 1
print("For the ", num_ip , " inputs calculate the net input using yin = x1w1 + x2w2 ")
x1 = []
x2 = []
for j in range(0, num_ip):
 ele1 = int(input("x1 = "))
ele2 = int(input("x2 = "))
x1.append(ele1)
x2.append(ele2)
print("x1 = ",x1)
print("x2 = ",x2)
n = x1 * w1
m = x2 * w2
Yin = []
for i in range(0, num_ip):
Yin.append(n[i] + m[i])
print("Yin = ",Yin)
#Assume one weight as excitatory and the other as inhibitory, i.e.,
Yin = []
for i in range(0, num_ip):

Yin.append(n[i] - m[i])
print("After assuming one weight as excitatory and the other as inhibitory Yin = ",Yin)
#From the calculated net inputs, now it is possible to fire the neuron for input (1, 0)
#only by fixing a threshold of 1, i.e., θ ≥ 1 for Y unit.
#Thus, w1 = 1, w2 = -1; θ ≥ 1
Y=[]
for i in range(0, num_ip):
 if(Yin[i]>=1):
ele= 1
Y.append(ele)
if(Yin[i]<1):
ele= 0
Y.append(ele)
print("Y = ",Y)
```
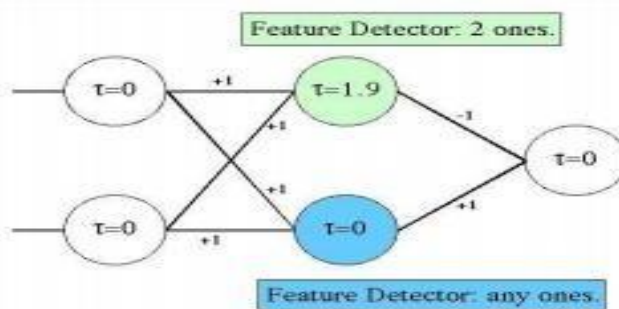
Output :

```
Enter the number of inputs : 4
For the  4  inputs calculate the net input using yin = x1w1 + x2w2

x1 = 0

x2 = 0

x1 = 0

x2 = 1

x1 = 1

x2 = 0

x1 = 1

x2 = 1
x1 =  [0, 0, 1, 1]
x2 =  [0, 1, 0, 1]
Yin =  [0, 1, 1, 2]
 After assuming one weight as excitatory and the other as inhibitory Yin =  [0, 1, -1, 0]
Y =  [0, 1, 0, 0]

In [14]:
```

Practical 2 b: Generate XOR function using McCulloch-Pitts neural net

The XOR (exclusive or) function is defined by the following truth table:

Input1	Input2	XOR Output
0	0	0
0	1	1
1	0	1
1	1	0

#Getting weights and threshold value

```python
import numpy as np
print('Enter weights')
w11=int(input('Weight w11='))
w12=int(input('weight w12='))


w21=int(input('Weight w21='))
w22=int(input('weight w22='))
v1=int(input('weight v1='))
v2=int(input('weight v2='))
print('Enter Threshold Value')
theta=int(input('theta='))
x1=np.array([0, 0, 1, 1])
x2=np.array([0, 1, 0, 1])
z=np.array([0, 1, 1, 0])
con=1
y1=np.zeros((4,))
y2=np.zeros((4,))
y=np.zeros((4,))
while con==1:
zin1=np.zeros((4,))
 zin2=np.zeros((4,))
 zin1=x1*w11+x2*w21
 zin2=x1*w21+x2*w22
 print("z1",zin1)
 print("z2",zin2)
 for i in range(0,4):
 if zin1[i]>=theta:
 y1[i]=1
 else:
 y1[i]=0
 if zin2[i]>=theta:
 y2[i]=1
 else:
 y2[i]=0
 yin=np.array([])
 yin=y1*v1+y2*v2
 for i in range(0,4):
 if yin[i]>=theta:
 y[i]=1
 else:
 y[i]=0
 print("yin",yin)
 print('Output of Net')
 y=y.astype(int)
 print("y",y)
 print("z",z)
```

```python
if np.array_equal(y,z):
con=0
else:
print("Net is not learning enter another set of weights and Threshold value")
w11=input("Weight w11=")
w12=input("weight w12=")

w21=input("Weight w21=")
w22=input("weight w22=")

v1=input("weight v1=")
v2=input("weight v2=")
theta=input("theta=")
print("McCulloch-Pitts Net for XOR function")
print("Weights of Neuron Z1")
print(w11)
print(w21)
print("weights of Neuron Z2")
print(w12)
print(w22)
print("weights of Neuron Y")
print(v1)
print(v2)
print("Threshold value")
print(theta)
```

Output :

Practical 3

Practical 3 a: Write a program to implement Hebb's rule

Using the Hebb rule, find the weights required to perform the following classifications of the given input patterns shown in Figure 16. The pattern is shown as 3×3 matrix form in the squares. The "+" symbols represent the value "1" and empty squares indicate "-1." Consider "I" belongs to the members of class (so has target value 1) and "O" does not belong to the members of class (so has target value -1).

'I'   'O'
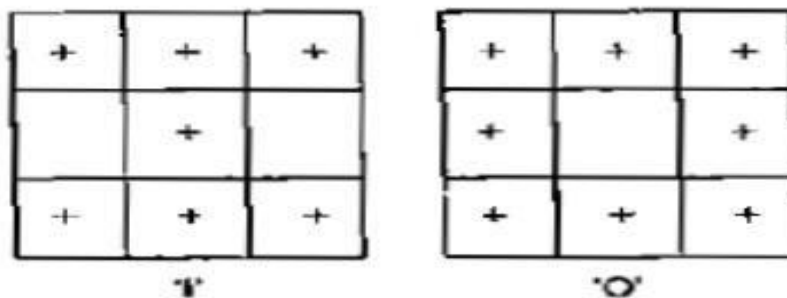
```
import numpy as np
#first pattern
x1=np.array([1,1,1,-1,1,-1,1,1,1])
#second pattern
x2=np.array([1,1,1,1,-1,1,1,1,1])
#initialize bais value
b=0
#define target
y=np.array([1,-1])
wtold=np.zeros((9,))
wtnew=np.zeros((9,))
wtnew=wtnew.astype(int)
wtold=wtold.astype(int)
bais=0
print("First input with target =1")
for i in range(0,9):
wtold[i]=wtold[i]+x1[i]*y[0]
wtnew=wtold
b=b+y[0]
print("new wt =", wtnew)
print("Bias value",b)
```

```python
print("Second input with target =-1")
for i in range(0,9):
wtnew[i]=wtold[i]+x2[i]*y[1]
b=b+y[1]
print("new wt =", wtnew)
print("Bias value",b)
```

Output :

```
First input with target =1
new wt = [ 1  1  1 -1  1 -1  1  1  1]
Bias value 1
Second input with target =-1
new wt = [ 0  0  0 -2  2 -2  0  0  0]
Bias value 0
```

Practical 3 b: Write a program to implement of delta rule

```python
#supervised learning
import numpy as np
import time
np.set_printoptions(precision=2)
x=np.zeros((3,))
weights=np.zeros((3,))
desired=np.zeros((3,))
actual=np.zeros((3,))
for i in range(0,3):
x[i]=float(input("Initial inputs:"))
for i in range(0,3):
 weights[i]=float(input("Initial weights:"))
for i in range(0,3):
desired[i]=float(input("Desired output:"))
a=float(input("Enter learning rate:"))
actual=x*weights
print("actual",actual)
print("desired",desired)
while True:
 if np.array_equal(desired,actual):
 break #no change
 else:
 for i in range(0,3):
 weights[i]=weights[i]+a*(desired[i]-actual[i])
 actual=x*weights
 print("weights",weights)
```

```
 print("actual",actual)
print("desired",desired)
print("*"*30)
print("Final output")
print("Corrected weights",weights)
print("actual",actual)
print("desired",desired)
```

Output :

```
Initial inputs:1
Initial inputs:1
Initial inputs:1
Initial weights:1
Initial weights:1
Initial weights:1
Desired output:2
Desired output:3
Desired output:4
Enter learning rate:1
actual [1. 1. 1.]
desired [2. 3. 4.]
weights [2. 3. 4.]
actual [2. 3. 4.]
desired [2. 3. 4.]
****************************
Final output
corrected weights [2. 3. 4.]
actual [2. 3. 4.]
desired [2. 3. 4.]
```

Practical 4

Practical 4 a: Write a program for Back Propagation Algorithm
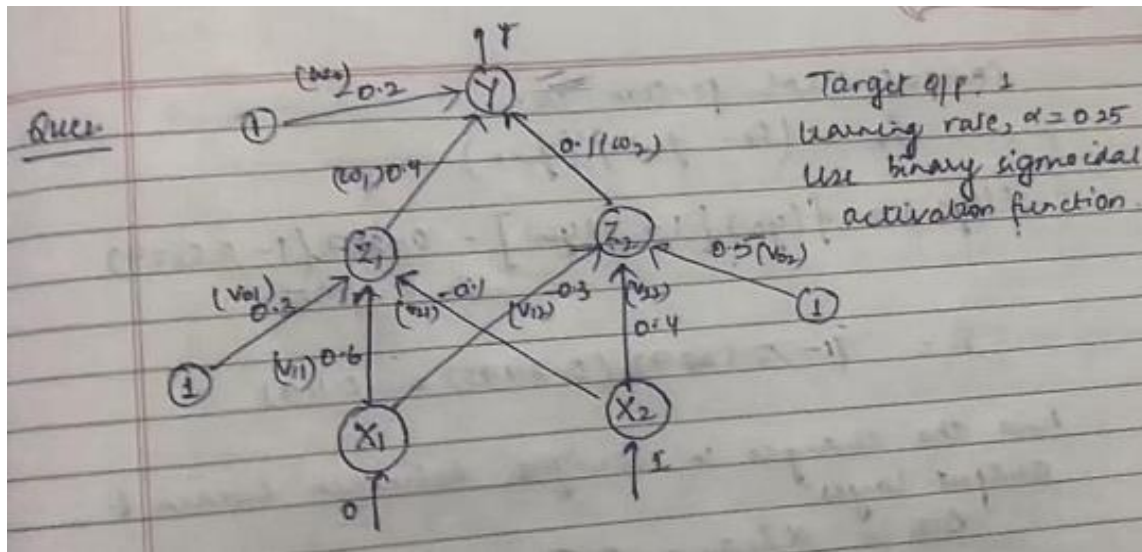

```
import numpy as np
import decimal
import math
np.set_printoptions(precision=2)
v1=np.array([0.6, 0.3])
v2=np.array([-0.1, 0.4])
w=np.array([-0.2,0.4,0.1])
b1=0.3
b2=0.5
x1=0
x2=1
alpha=0.25
print("calculate net input to z1 layer")
zin1=round(b1+ x1*v1[0]+x2*v2[0],4)
print("z1=",round(zin1,3))
print("calculate net input to z2 layer")
zin2=round(b2+ x1*v1[1]+x2*v2[1],4)
print("z2=",round(zin2,4))
print("Apply activation function to calculate output")
z1=1/(1+math.exp(-zin1))
z1=round(z1,4)
z2=1/(1+math.exp(-zin2))
z2=round(z2,4)
print("z1=",z1)
print("z2=",z2)
print("calculate net input to output layer")
yin=w[0]+z1*w[1]+z2*w[2]
```

```python
        print("yin=",yin)

        print("calculate net output")

        y=1/(1+math.exp(-yin))
        print("y=",y)
        fyin=y *(1- y)
        dk=(1-y)*fyin
        print("dk",dk)
        dw1= alpha * dk * z1
        dw2= alpha * dk * z2
        dw0= alpha * dk
        print("compute error portion in delta")
        din1=dk* w[1]
        din2=dk* w[2]
        print("din1=",din1)
        print("din2=",din2)
        print("error in delta")
        fzin1= z1 *(1-z1)
        print("fzin1",fzin1)
        d1=din1* fzin1
        fzin2= z2 *(1-z2)
        print("fzin2",fzin2)
        d2=din2* fzin2
        print("d1=",d1)
        print("d2=",d2)
        print("Changes in weights between input and hidden layer")
        dv11=alpha * d1 * x1
        print("dv11=",dv11)
        dv21=alpha * d1 * x2
        print("dv21=",dv21)
        dv01=alpha * d1
        print("dv01=",dv01)
        dv12=alpha * d2 * x1
        print("dv12=",dv12)
        dv22=alpha * d2 * x2
        print("dv22=",dv22)
        dv02=alpha * d2
        print("dv02=",dv02)
        print("Final weights of network")
        v1[0]=v1[0]+dv11
        v1[1]=v1[1]+dv12
        print("v=",v1)
        v2[0]=v2[0]+dv21
        v2[1]=v2[1]+dv22
        print("v2",v2)
```

```
w[1]=w[1]+dw1
w[2]=w[2]+dw2
b1=b1+dv01
b2=b2+dv02

w[0]=w[0]+dw0
print("w=",w)
print("bias b1=",b1, " b2=",b2)
```

Output :

```
z1= 0.2
calculate net input to z2 layer
z2= 0.9
Apply activation function to calculate output
z1= 0.5498
z2= 0.7109
calculate net input to output layer
yin= 0.09101
calculate net output
y= 0.5227368084248941
dk 0.11906907074145694
compute error portion in delta
din1= 0.047627628296585278
din2= 0.0119069070741455694
error in delta
fzin1 0.24751996
fzin2 0.20552119000000002
d1= 0.011788788650865037
d2= 0.0024471217110978417
Changes in weights between input and hidden layer
dv11= 0.0
dv21= 0.0029471971627162592
dv01= 0.0029471971627162592
dv12= 0.0
dv22= 0.0006117804277744604
dv02= 0.0006117804277744604
Final weights of network
v= [0.6 0.3]
v2 [-0.1  0.4]
w= [-0.17  0.42  0.12]
bias b1= 0.30294719716271623  b2= 0.5006117804277744
```

Practical 4 b: Write a Program For Error Back Propagation Algorithm (Ebpa) Learning

```
import math
a0=-1
t=-1
w10=float(input("Enter weight first network"))
b10=float(input("Enter base first network:"))
w20=float(input("Enter weight second network:"))
b20=float(input("Enter base second network:"))
c=float(input("Enter learning coefficient:"))
n1=float(w10*c+b10)
a1=math.tanh(n1)
n2=float(w20*a1+b20)
```

```
a2=math.tanh(float(n2))
e=t-a2
s2=-2*(1-a2*a2)*e
s1=(1-a1*a1)*w20*s2
w21=w20-(c*s2*a1)
w11=w10-(c*s1*a0)
b21=b20-(c*s2)

b11=b10-(c*s1)
print("The updated weight of first n/w w11=",w11)
print("The uploaded weight of second n/w w21= ",w21)

print("The updated base of first n/w b10=",b10)
print("The updated base of second n/w b20= ",b20)
```

Output :

```
Enter weight first network:12
Enter base first network:35
Enter weight second network:23
Enter base second network:45
Enter learning coefficient:11
The updated weight of first n/w w11= 12.0
The uploaded weight of second n/w w21=  23.0
The updated base of first n/w b10= 35.0
The updated base of second n/w b20=  45.0
```

Practical 5

Practical 5 a: Write a program for Hopfield Network.

```
#include "hop.h"
neuron::neuron(int *j)
{
inti;
for(i=0;i<4;i++)
{
weightv[i]= *(j+i);
}
}
int neuron::act(int m, int *x)
{
inti;
int a=0;
for(i=0;i<m;i++)
{
a += x[i]*weightv[i];
}
return a;
}
int network::threshld(int k)
{
if(k>=0)
return (1);
else
return (0);
}
network::network(int a[4],int b[4],int c[4],int d[4])
{
nrn[0] = neuron(a) ;
nrn[1] = neuron(b) ;
nrn[2] = neuron(c) ;
nrn[3] = neuron(d) ;
}
void network::activation(int *patrn)
{
inti,j;
for(i=0;i<4;i++)
{
for(j=0;j<4;j++)
{
cout<<"\n nrn["<<i<<"].weightv["<<j<<"] is "
```

```cpp
        <<nrn[i].weightv[j];

}
nrn[i].activation = nrn[i].act(4,patrn);

cout<<"\nactivation is "<<nrn[i].activation;
output[i]=threshld(nrn[i].activation);
cout<<"\noutput value is "<<output[i]<<"\n";
}
}
void main ()
{
int patrn1[]= {1,0,1,0},i;
int wt1[]= {0,-3,3,-3};
int wt2[]= {-3,0,-3,3};
int wt3[]= {3,-3,0,-3};
int wt4[]= {-3,3,-3,0};
cout<<"\nTHIS PROGRAM IS FOR A HOPFIELD NETWORK WITH A SINGLE LAYER
OF";
cout<<"\n4 FULLY INTERCONNECTED NEURONS. THE NETWORK SHOULD
RECALLTHE";
cout<<"\nPATTERNS 1010 AND 0101 CORRECTLY.\n";
//create the network by calling its constructor.
// the constructor calls neuron constructor as many times as thenumber of
// neurons in the network.
network h1(wt1,wt2,wt3,wt4);
//present a pattern to the network and get the activations of theneurons
h1.activation(patrn1);
//check if the pattern given is correctly recalled and give message
for(i=0;i<4;i++)
{
if (h1.output[i] == patrn1[i])
cout<<"\n pattern= "<<patrn1[i]<<
" output = "<<h1.output[i]<<" component matches";
else
cout<<"\n pattern= "<<patrn1[i]<<
" output = "<<h1.output[i]<<
" discrepancy occurred";
}
cout<<"\n\n";
int patrn2[]= {0,1,0,1};
h1.activation(patrn2);
for(i=0;i<4;i++)
{
if (h1.output[i] == patrn2[i])
cout<<"\n pattern= "<<patrn2[i]<<
```

```
" output = "<<h1.output[i]<<" component matches";
else
cout<<"\n pattern= "<<patrn2[i]<<
" output = "<<h1.output[i]<<
" discrepancy occurred";
}
}
```
======= End code of main program=============
//Hop.h

```cpp
//Single layer Hopfield Network with 4 neurons
#include <stdio.h>
#include <iostream.h>
#include <math.h>
class neuron
{
protected:
int activation;
friend class network;
public:
intweightv[4];
neuron() {};
neuron(int *j) ;
int act(int, int*);
};
class network
{
public:
neuron nrn[4];
int output[4];
intthreshld(int) ;
void activation(int j[4]);
network(int*,int*,int*,int*);
};
```

Practical 5 b: Write a program for Radial Basis function

```python
from scipy import *
from scipy.linalg import norm, pinv
from matplotlib import pyplot as plt
class RBF:
 def__init (self, indim, numCenters, outdim):
 self.indim =indim
 self.outdim =outdim
 self.numCenters =numCenters
 self.centers =[random.uniform(-1, 1, indim) for i in range(numCenters)]
```

```python
        self.beta =8
        self.W =random.random((self.numCenters, self.outdim))
    def _basisfunc(self, c, d):
        assert len(d) ==self.indim
        return exp(-self.beta *norm(c-d)**2)
    def _calcAct(self, X):

        # calculate activations of RBFs
        G =zeros((X.shape[0], self.numCenters), float)
        for ci, c in enumerate(self.centers):
        for xi, x in enumerate(X):
        G[xi,ci] =self._basisfunc(c, x)
        return G

    def train(self, X, Y):
        """ X: matrix of dimensions n x indim
        y: column vector of dimension n x 1 """
        # choose random center vectors from training set
        rnd_idx =random.permutation(X.shape[0])[:self.numCenters]
        self.centers =[X[i,:] for i in rnd_idx]
        print("center", self.centers)
        # calculate activations of RBFs
        G =self._calcAct(X)
        print (G)
        # calculate output weights (pseudoinverse)
        self.W =dot(pinv(G), Y)
    def test(self, X):
        """ X: matrix of dimensions n x indim """
        G =self._calcAct(X)
        Y =dot(G, self.W)
        return Y
if __name__ =='__main__':
    #        1D Example
    n =100
    x =mgrid[-1:1:complex(0,n)].reshape(n, 1)
    # set y and add random noise
    y =sin(3*(x+0.5)**3-1)
    # y += random.normal(0, 0.1, y.shape)
    # rbf regression
    rbf =RBF(1, 10, 1)
    rbf.train(x, y)
    z =rbf.test(x)
    # plot original data
    plt.figure(figsize=(12, 8))
    plt.plot(x, y, 'k-')
    # plot learned model
    plt.plot(x, z, 'r-', linewidth=2)
```
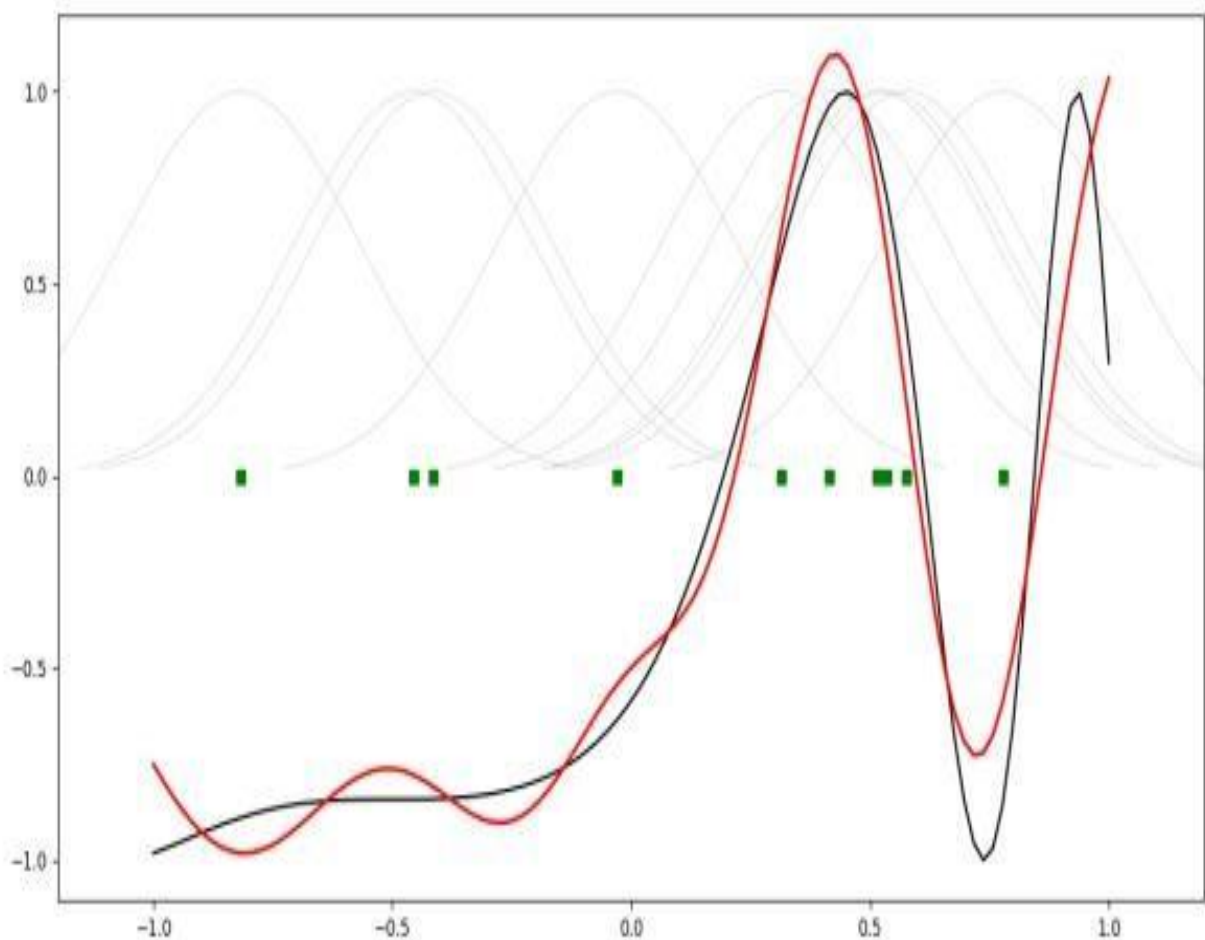
```
# plot rbfs
plt.plot(rbf.centers, zeros(rbf.numCenters), 'gs')
for c in rbf.centers:
# RF prediction lines
cx =arange(c-0.7, c+0.7, 0.01)
cy =[rbf._basisfunc(array([cx_]), array([c])) for cx_ in cx]
plt.plot(cx, cy, '-', color='gray', linewidth=0.2)
plt.xlim(-1.2, 1.2)

plt.show()
```

Output :

Practical 6

Practical 6 a: Self-Organizing Maps

The SOM algorithm is used to compress the information to produce a similarity graph while preserving the topologic relationship of the input data space. The basic SOM model construction algorithm can be interpreted as follows: 1) Create and initialize a matrix (weight vector) randomly to hold the neurons. If the matrix can be initialized with order and roughly compiles with the input density function, the map will converge quickly 2) Read the input data space. For each observation (instance), use the optimum fit approach, which is based on the Euclidean distance $c = \arg i \min \| x - mi \|$ to find the neuron which best matches this observation. Let x denote the training vector from the observation and mi denote a single neuron in the matrix. Update that neuron to resemble that observation using the following equation: $mi (t + 1) = mi (t) + h(t)[x(t) - mi (t)]$ (4) $mi(t)$: the weight vector before the neuron is updated. $(t + 1)$: the weight vector after the neuron is updated. (t): the training vector from the observation. $h(t)$: the neighborhood function (a smoothing kernel defined over the lattice points), defined though the following equation: $h(t) = \{ \; \alpha(t), \; i \in Nc \; \; 0, \; i \in Nc$ (5) : the neighborhood set, which decreases with time. (t): the learning-rate factor which can be linear, exponential or inversely proportional. It is a monotonically decreasing function of time (t)
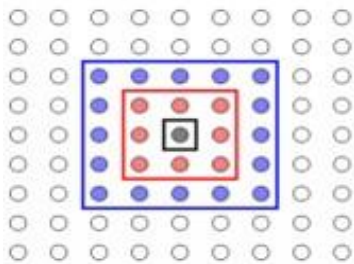
In general, SOMs might be useful for visualizing high-dimensional data in terms of its similarity structure. Especially large SOMs (i.e. with large number of Kohonen units) are known to perform mappings that preserve the topology of the original data, i.e. neighboring data points in input space will also be represented in adjacent locations on the SOM. The following code shows the 'classic' color mapping example, i.e. the SOM will map a number of colors into a rectangular area.

frommvpa2.suiteimport*

First, we define some colors as RGB values from the interval (0,1), i.e. with white being (1, 1, 1) and black being (0, 0, 0). Please note, that a substantial proportion of the defined colors represent variations of 'blue', which are supposed to be represented in more detail in the SOM.
colors=np.array(
 [[0.,0.,0.],
 [0.,0.,1.],

[0.,0.,0.5],
[0.125,0.529,1.0],
[0.33,0.4,0.67],
[0.6,0.5,1.0],
[0.,1.,0.],
[1.,0.,0.],

```
[0.,1.,1.],
[1.,0.,1.],
[1.,1.,0.],
[1.,1.,1.],
[.33,.33,.33],
[.5,.5,.5],
[.66,.66,.66]])
# store the names of the colors for visualization later on
color_names= \
['black','blue','darkblue','skyblue',
'greyblue','lilac','green','red',
'cyan','violet','yellow','white',
'darkgrey','mediumgrey','lightgrey']
```

Now we can instantiate the mapper. It will internally use a so-called Kohonen layer to map the data onto. We tell the mapper to use a rectangular layer with 20 x 30 units. This will be the output space of the mapper. Additionally, we tell it to train the network using 400 iterations and to use custom learning rate.

```
som=SimpleSOMMapper((20,30),400,learning_rate=0.05)
```

Finally, we train the mapper with the previously defined 'color' dataset.

```
som.train(colors)
```

Each unit in the Kohonen layer can be treated as a pointer into the high-dimensional input space, that can be queried to inspect which input subspaces the SOM maps onto certain sections of its 2D output space. The color-mapping generated by this example's SOM can be shown with a single matplotlib call:

```
pl.imshow(som.K,origin='lower')
```

And now, let's take a look onto which coordinates the initial training prototypes were mapped to. The get those coordinates we can simply feed the training data to the mapper and plot the output

```
mapped=som(colors)
pl.title('Color SOM')
# SOM's kshape is (rows x columns), while matplotlib wants (X x Y)
fori,minenumerate(mapped):
pl.text(m[1],m[0],color_names[i],ha='center',va='center',
bbox=dict(facecolor='white',alpha=0.5,lw=0))
```

Output :

Color SOM
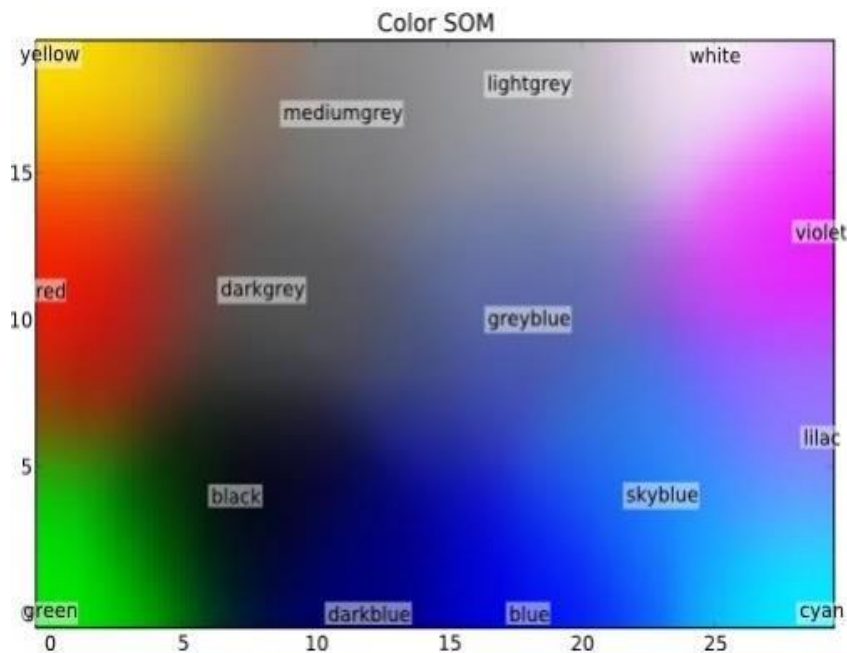
Practical 6 b: ADAPTIVE RESONANCE THEORY

```
from future import
division
importnumpyas np
fromneupy.utilsimportformat_data
fromneupy.core.propertiesimport (ProperFractionProperty,
IntProperty)
fromneupy.algorithms.baseimportBaseNetwork
__all_ = ('ART1',)
classART1(BaseNetwork):
"""

 Adaptive Resonance Theory (ART1) Network for binary
 data clustering.
 Notes
 - - - .
 - Weights are not random, so the result will be
 always reproduceble.
 Parameters
 - - - - - - -
 rho : float
 Control reset action in training process. Value must be
```

between ``0`` and ``1``, defaults to ``0.5``.
n_clusters : int
 Number of clusters, defaults to ``2``. Min value is also

``2``.
 {BaseNetwork.Parameters}
 Methods
 -----
 train(X)
 ART trains until all clusters are found.
 predict(X)
 Each prediction trains a new network. It's an alias to
 the ``train`` method.
 {BaseSkeleton.fit}
 Examples

>>>import numpy as np
>>>from neupy import algorithms
>>>
>>>data = np.array([
... [0, 1, 0],
... [1, 0, 0],
... [1, 1, 0],
...])
>>>>
>>>artnet = algorithms.ART1(
... step=2,
... rho=0.7,
... n_clusters=2,
... verbose=False
...)
>>>artnet.predict(data)
 array([0., 1., 1.])
 """
 rho =ProperFractionProperty(default=0.5)
n_clusters=IntProperty(default=2, minval=2)
deftrain(self, X):
 X =format_data(X)
ifX.ndim!=2:
raiseValueError("Input value must be 2 dimensional, got "
"{}".format(X.ndim))
nsamples, n_features=X.shape
n_clusters=self.n_clusters
step =self.step
 rho =self.rho

```python
ifnp.any((X !=0) & (X !=1)):
raiseValueError("ART1 Network works only with binary
matrices")
ifnothasattr(self, 'weight_21'):
self.weight_21 =np.ones((n_features, n_clusters))
ifnothasattr(self, 'weight_12'):

 scaler = step / (step +n_clusters-1)
self.weight_12 = scaler *self.weight_21.T

 weight_21 =self.weight_21
weight_12 =self.weight_12
ifn_features!= weight_21.shape[0]:
raiseValueError("Input data has invalid number of features. "
"Got {} instead of {}"
"".format(n_features, weight_21.shape[0]))
 classes =np.zeros(n_samples)
# Train network
fori, p inenumerate(X):
disabled_neurons= []
reseted_values= []
reset =True
while reset:
 output1 = p
 input2 = np.dot(weight_12, output1.T)
output2 =np.zeros(input2.size)
input2[disabled_neurons] =-np.inf
winner_index= input2.argmax()
output2[winner_index] =1
 expectation = np.dot(weight_21, output2)
 output1 =np.logical_and(p, expectation).astype(int)
reset_value= np.dot(output1.T, output1) / np.dot(p.T, p)
reset =reset_value< rho
if reset:
disabled_neurons.append(winner_index)
reseted_values.append((reset_value, winner_index))
iflen(disabled_neurons) >=n_clusters:
# Got this case only if we test all possible clusters
 reset =False
winner_index=None
ifnot reset:
ifwinner_indexisnotNone:
 weight_12[winner_index, :] = (step * output1) / (
 step + np.dot(output1.T, output1) -1
 )
 weight_21[:, winner_index] = output1
```

```python
        else:
            # Get result with the best `rho`
            winner_index = max(reseted_values)[1]
            classes[i] = winner_index
    return classes

    def predict(self, X):
        return self.train(X)
```

Practical 7

Practical 7 a: Line Separation

```python
import numpy as np
import matplotlib.pyplot as plt
def create_distance_function(a, b, c):
 """ 0 = ax + by + c """
 def distance(x, y):
 """ returns tuple (d, pos)
 d is the distance
 If pos == -1 point is below the line,
 0 on the line and +1 if above the line
 """
 nom = a * x + b * y + c
 if nom == 0:
 pos = 0
 elif (nom<0 and b<0) or (nom>0 and b>0):
 pos = -1
 else:
 pos = 1
 return (np.absolute(nom) / np.sqrt( a ** 2 + b ** 2), pos)
 return distance
points = [ (3.5, 1.8), (1.1, 3.9) ]
fig, ax = plt.subplots()
ax.set_xlabel("sweetness")
ax.set_ylabel("sourness")
ax.set_xlim([-1, 6])
ax.set_ylim([-1, 8])
X = np.arange(-0.5, 5, 0.1)
colors = ["r", ""] # for the samples
size = 10
for (index, (x, y)) in enumerate(points):
 if index== 0:
 ax.plot(x, y, "o", color="darkorange", markersize=size)
 else:
 ax.plot(x, y, "oy", markersize=size)
 step = 0.05
for x in np.arange(0, 1+step, step):
 slope = np.tan(np.arccos(x))
 dist4line1 = create_distance_function(slope, -1, 0)
 #print("x: ", x, "slope: ", slope)
 Y = slope * X
 results = []
```
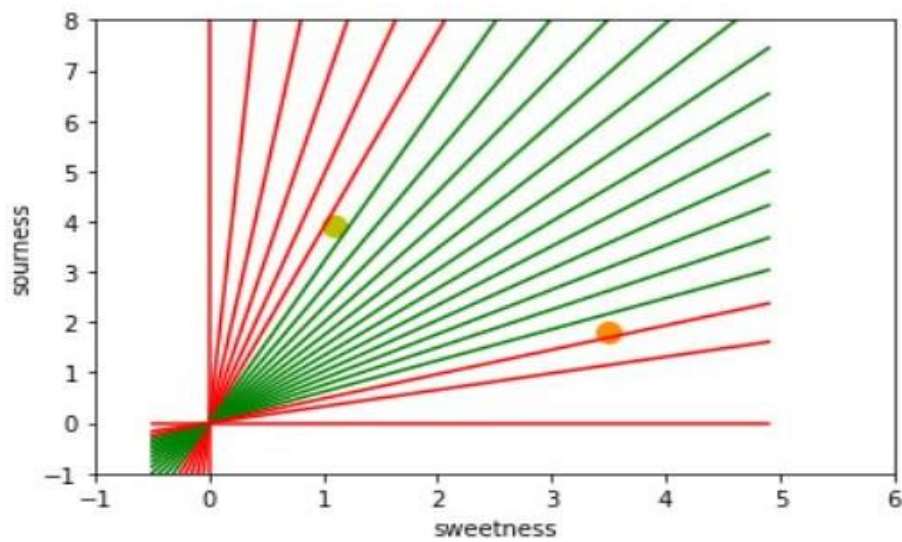
```
    for point in points:
    results.append(dist4line1(*point))
    #print(slope, results)
    if (results[0][1] != results[1][1]):

     ax.plot(X, Y, "g-")
    else:
     ax.plot(X, Y, "r-")
    plt.show()
```

Output :

Practical 8

Practical 8 a: Membership and Identity operators in, not in

```python
# Python program to illustrate
# Finding common member in list
# without using 'in' operator
# Define a function() that takes two lists
def overlapping(list1,list2):
c=0
d=0
for i in list1:
c+=1
for i in list2:
d+=1
for i in range(0,c):
for j in range(0,d):
if(list1[i]==list2[j]):
return 1
return 0
list1=[1,2,3,4,5]
list2=[6,7,8,9]
if(overlapping(list1,list2)):
print("overlapping")
else:
print("not overlapping")
# Python program to illustrate
# Finding common member in list
# without using 'in' operator
# Define a function() that takes two lists
def overlapping(list1,list2):
c=0
d=0
for i in list1:
c+=1
for i in list2:
d+=1
for i in range(0,c):
for j in range(0,d):
if(list1[i]==list2[j]):
return 1
return 0
list1=[1,2,3,4,5]
list2=[6,7,8,9]
if(overlapping(list1,list2)):
```

```
print("overlapping")

else:
print("not overlapping")
```

Output :

 Not overlapping

Practical 8 b: Membership and Identity Operators is, is not

```python
# Python program to illustrate the use
# of 'is' identity operator
x = 5
if (type(x) is int):
print ("true")
else:
print ("false")
# Python program to illustrate the
# use of 'is not' identity operator
x = 5.2
if (type(x) is not int):
print ("true")
else:
print ("false")
```
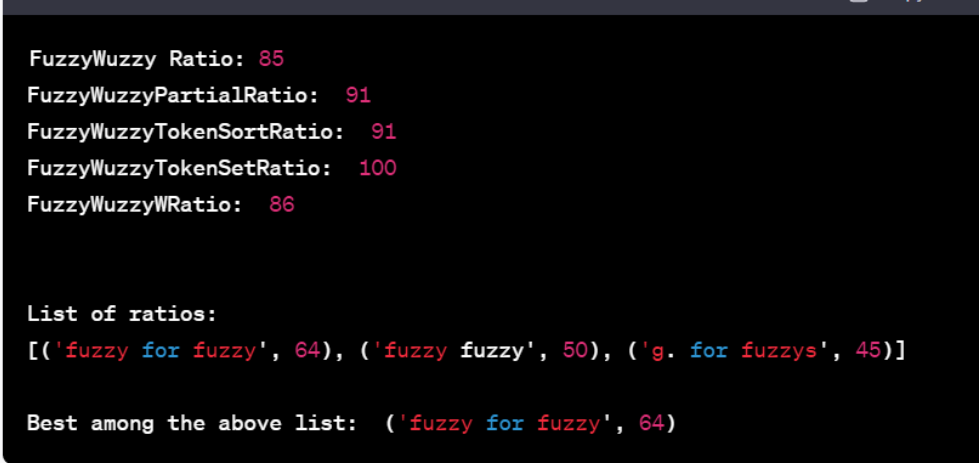
Output :

 True

Practical 9

Practical 9 a: Find the ratios using fuzzy logic

```
pip install fuzzywuzzy
pip install python-Levenshtein
# Python code showing all the ratios together,
# make sure you have installed fuzzywuzzy module
from fuzzywuzzy import fuzz
from fuzzywuzzy import process
s1 = "I love fuzzysforfuzzys"
s2 = "I am loving fuzzysforfuzzys"
print ("FuzzyWuzzy Ratio:", fuzz.ratio(s1, s2))
print ("FuzzyWuzzyPartialRatio: ", fuzz.partial_ratio(s1, s2))
print ("FuzzyWuzzyTokenSortRatio: ", fuzz.token_sort_ratio(s1, s2))
print ("FuzzyWuzzyTokenSetRatio: ", fuzz.token_set_ratio(s1, s2))
print ("FuzzyWuzzyWRatio: ", fuzz.WRatio(s1, s2),'\n\n')
# for process library,
query = 'fuzzys for fuzzys'
choices = ['fuzzy for fuzzy', 'fuzzy fuzzy', 'g. for fuzzys']
print ("List of ratios: ")
print (process.extract(query, choices), '\n')
print ("Best among the above list: ",process.extractOne(query, choices))
```

Output :

Practical 9 b: Solve Tipping Problem using fuzzy logic

```
import numpy as np
import skfuzzy as fuzz
from skfuzzy import control as ctrl
# New Antecedent/Consequent objects hold universe variables and membership
# functions
quality = ctrl.Antecedent(np.arange(0, 11, 1), 'quality')
```

```
service = ctrl.Antecedent(np.arange(0, 11, 1), 'service')
tip = ctrl.Consequent(np.arange(0, 26, 1), 'tip')
# Auto-membership function population is possible with .automf(3, 5, or 7)
quality.automf(3)
service.automf(3)
# Custom membership functions can be built interactively with a familiar,
# Pythonic API
tip['low'] = fuzz.trimf(tip.universe, [0, 0, 13])
tip['medium'] = fuzz.trimf(tip.universe, [0, 13, 25])
tip['high'] = fuzz.trimf(tip.universe, [13, 25, 25])
"""

To help understand what the membership looks like, use the ``view`` methods.
"""

# You can see how these look with .view()
quality['average'].view()
"""

.. image:: PLOT2RST.current_figure
"""
service.view()
"""
.. image:: PLOT2RST.current_figure
"""
tip.view()
"""
.. image:: PLOT2RST.current_figure
```

Output :


```scss
quality['average'].view()
```

This will generate a plot showing the triangular membership functions for the 'average' linguistic term. Similarly, you can view the membership functions for the 'service' input variable and the 'tip' output variable by adding the following lines of code:

```scss
service.view()
tip.view()
```

Note that to use the `.view()` function, you need to have the matplotlib library installed. If you don't have it installed, you can install it with the following command:

```
pip install matplotlib
```

Practical 10

Practical 10 a: Implementation of simple genetic algorithm

```
import random
# Number of individuals in each generation
POPULATION_SIZE =100
# Valid genes
GENES ='''abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOP
QRSTUVWXYZ 1234567890, .-;:_!"#%&/()=?@${[]}'''
# Target string to be generated
TARGET ="I love GeeksforGeeks"
class Individual(object):
 '''
 Class representing individual in population
 '''
 def __init_(self, chromosome):
 self.chromosome =chromosome
 self.fitness =self.cal_fitness()
 @classmethod
 def mutated_genes(self):
 '''
 create random genes for mutation
 '''
 global GENES
 gene =random.choice(GENES)
 return gene
 @classmethod
 def create_gnome(self):
 '''
 create chromosome or string of genes
 '''
 global TARGET
 gnome_len =len(TARGET)
 return[self.mutated_genes() for _ in range(gnome_len)]
 def mate(self, par2):
 '''
 Perform mating and produce new offspring
 '''
 # chromosome for offspring
 child_chromosome =[]
 for gp1, gp2 in zip(self.chromosome, par2.chromosome):
 # random probability
 prob =random.random()
 # if prob is less than 0.45, insert gene
```

```python
        # from parent 1
        if prob< 0.45:
        child_chromosome.append(gp1)
        # if prob is between 0.45 and 0.90, insert

        # gene from parent 2
        elif prob< 0.90:
        child_chromosome.append(gp2)
        # otherwise insert random gene(mutate),
        # for maintaining diversity
        else:
        child_chromosome.append(self.mutated_genes())
        # create new Individual(offspring) using
        # generated chromosome for offspring
        return Individual(child_chromosome)
    def cal_fitness(self):
        '''
        Calculate fittness score, it is the number of
        characters in string which differ from target
        string.
        '''
        global TARGET
        fitness =0
        for gs, gt in zip(self.chromosome, TARGET):
        if gs !=gt: fitness+=1
        return fitness
# Driver code
def main():
        global POPULATION_SIZE
        #current generation
        generation =1
        found =False
        population =[]
        # create initial population
        for _ in range(POPULATION_SIZE):
        gnome =Individual.create_gnome()
        population.append(Individual(gnome))
        while not found:
        # sort the population in increasing order of fitness score
        population =sorted(population, key =lambda x:x.fitness)
        # if the individual having lowest fitness score ie.
    # 0 then we know that we have reached to the target
        # and break the loop
        if population[0].fitness <=0:
        found =True
        break
```

```python
# Otherwise generate new offsprings for new generation
new_generation =[]
# Perform Elitism, that mean 10% of fittest population
# goes to the next generation
s =int((10*POPULATION_SIZE)/100)
new_generation.extend(population[:s])
# From 50% of fittest population, Individuals
# will mate to produce offspring
s =int((90*POPULATION_SIZE)/100)

for _ in range(s):
parent1 =random.choice(population[:50])
parent2 =random.choice(population[:50])
child =parent1.mate(parent2)
new_generation.append(child)
population =new_generation
print("Generation: {}\tString: {}\tFitness:
{}".format(generation,"".join(population[0].chromosome),population[0].fitness))
generation +=1
print("Generation: {}\tString: {}\tFitness: {}".format(generation,
"".join(population[0].chromosome),
population[0].fitness))
if__name__=='__main__':
main()
```

Output :

Generation: 1 String: tO{"-?=jH[k8=B4]Oe@} Fitness: 18
Generation: 2 String: tO{"-?=jH[k8=B4]Oe@} Fitness: 18
Generation: 3 String: .#lRWf9k_Ifslw #O$k_ Fitness: 17
Generation: 4 String: .-1Rq?9mHqk3Wo]3rek_ Fitness: 16
Generation: 5 String: .-1Rq?9mHqk3Wo]3rek_ Fitness: 16
Generation: 6 String: A#ldW) #lIkslwcVek) Fitness: 14
Generation: 7 String: A#ldW) #lIkslwcVek) Fitness: 14
Generation: 8 String: (, o x _x%Rs=, 6Peek3 Fitness: 13
Generation: 29 String: I lope Geeks#o, Geeks Fitness: 3
Generation: 30 String: I loMeGeeksfoBGeeks Fitness: 2
Generation: 31 String: I love Geeksfo0Geeks Fitness: 1
Generation: 32 String: I love Geeksfo0Geeks Fitness: 1
Generation: 33 String: I love Geeksfo0Geeks Fitness: 1
Generation: 34 String: I love GeeksforGeeks Fitness: 0

Practical 10 b: Create two classes: City and Fitness using Genetic algorithm

first create a City class that will allow us to create and handle our cities.
Create Population

```python
import numpy as np, random, operator, pandas as pd, matplotlib.pyplot as plt
from tkinter import Tk, Canvas, Frame, BOTH, Text
import math
class City:
 def __init__(self, x, y):

self.x = x
 self.y = y
 def distance(self, city):
 xDis = abs(self.x - city.x)
 yDis = abs(self.y - city.y)
 distance = np.sqrt((xDis ** 2) + (yDis ** 2))

 return distance
 def __repr__(self):
 return "(" + str(self.x) + "," + str(self.y) + ")"
class Fitness:
 def __init__(self, route):
 self.route = route
 self.distance = 0
 self.fitness= 0.0
 def routeDistance(self):
 if self.distance ==0:
 pathDistance = 0
 for i in range(0, len(self.route)):
 fromCity = self.route[i]
 toCity = None
 if i + 1 < len(self.route):
 toCity = self.route[i + 1]
 else:
 toCity = self.route[0]
 pathDistance += fromCity.distance(toCity)
 self.distance = pathDistance
 return self.distance
 def routeFitness(self):
 if self.fitness == 0:
 self.fitness = 1 / float(self.routeDistance())
 return self.fitness
def createRoute(cityList):
 route = random.sample(cityList, len(cityList))
 return route
```

```python
def initialPopulation(popSize, cityList):
    population = []
    for i in range(0, popSize):
        population.append(createRoute(cityList))
    return population
def rankRoutes(population):
    fitnessResults = {}
    for i in range(0,len(population)):
        fitnessResults[i] = Fitness(population[i]).routeFitness()
    return sorted(fitnessResults.items(), key = operator.itemgetter(1), reverse = True)
def selection(popRanked, eliteSize):
    selectionResults = []
    df = pd.DataFrame(np.array(popRanked), columns=["Index","Fitness"])

    df['cum_sum'] = df.Fitness.cumsum()
    df['cum_perc'] = 100*df.cum_sum/df.Fitness.sum()
    for i in range(0, eliteSize):
        selectionResults.append(popRanked[i][0])
    for i in range(0, len(popRanked) - eliteSize):
        pick = 100*random.random()
        for i in range(0, len(popRanked)):
            if pick <= df.iat[i,3]:

                selectionResults.append(popRanked[i][0])
                break
    return selectionResults
def matingPool(population, selectionResults):
    matingpool = []
    for i in range(0, len(selectionResults)):
        index = selectionResults[i]
        matingpool.append(population[index])
    return matingpool
def breed(parent1, parent2):
    child = []
    childP1 = []
    childP2 = []
    geneA = int(random.random() * len(parent1))
    geneB = int(random.random() * len(parent1))
    startGene = min(geneA, geneB)
    endGene = max(geneA, geneB)
    for i in range(startGene, endGene):
        childP1.append(parent1[i])
    childP2 = [item for item in parent2 if item not in childP1]
    child = childP1 + childP2
    return child
def breedPopulation(matingpool, eliteSize):
    children = []
```

```python
        length = len(matingpool) - eliteSize
    pool = random.sample(matingpool, len(matingpool))
   for i in range(0,eliteSize):
   children.append(matingpool[i])
    for i in range(0, length):
    child = breed(pool[i], pool[len(matingpool)-i-1])
    children.append(child)
    return children
def mutate(individual, mutationRate):
    for swapped in range(len(individual)):
    if(random.random() < mutationRate):
    swapWith = int(random.random() * len(individual))
    city1 = individual[swapped]
    city2 = individual[swapWith]
    individual[swapped] = city2

individual[swapWith] = city1
    return individual
def mutatePopulation(population, mutationRate):
    mutatedPop = []
    for ind in range(0, len(population)):
    mutatedInd = mutate(population[ind], mutationRate)
    mutatedPop.append(mutatedInd)
    return mutatedPop
def nextGeneration(currentGen, eliteSize, mutationRate):
    popRanked = rankRoutes(currentGen)
    selectionResults = selection(popRanked, eliteSize)

    matingpool = matingPool(currentGen, selectionResults)
    children = breedPopulation(matingpool, eliteSize)
    nextGeneration = mutatePopulation(children, mutationRate)
    return nextGeneration
def geneticAlgorithm(population, popSize, eliteSize, mutationRate, generations):
    pop = initialPopulation(popSize, population)
    print("Initial distance: " + str(1 / rankRoutes(pop)[0][1]))
    for i in range(0, generations):
    pop = nextGeneration(pop, eliteSize, mutationRate)
    print("Final distance: " + str(1 / rankRoutes(pop)[0][1]))
    bestRouteIndex = rankRoutes(pop)[0][0]
    bestRoute = pop[bestRouteIndex]
    return bestRoute
def geneticAlgorithmPlot(population, popSize, eliteSize, mutationRate, generations):
    pop = initialPopulation(popSize, population)
    progress = []
    progress.append(1 / rankRoutes(pop)[0][1])
    for i in range(0, generations):
```

```
    pop = nextGeneration(pop, eliteSize, mutationRate)
    progress.append(1 / rankRoutes(pop)[0][1])
    plt.plot(progress)
    plt.ylabel('Distance')
    plt.xlabel('Generation')
    plt.show()
def main():
cityList = []
 for i in range(0,25):
 cityList.append(City(x=int(random.random() * 200), y=int(random.random() * 200)))
geneticAlgorithmPlot(population=cityList, popSize=100, eliteSize=20,
mutationRate=0.01, generations=500)
if __name__ == '__main__':
 main()
```

Output :