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)
```

Output:

```
===== RESTART: E:/Soft-Computing Practicals/1a.py =====
Enter value of x:3
Enter value of weight w:5
Enter value of bias b:7
net= 22
output= 1
```

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

```
n = int(input("Enter number of elements : "))
print("Enter the inputs")
inputs = []
for i in range(0, n):
    ele = float(input())
    inputs.append(ele)
print(inputs)
print("Enter the weights")
weights = []
for i in range(0, n):
    ele = float(input())
    weights.append(ele)
print(weights)
print("The net input can be calculated as Yin = x1w1 + x2w2 + x3w3")
Yin = []
for i in range(0, n):
    Yin.append(inputs[i] * weights[i])
print(round(sum(Yin), 3))
```

Output:

```
================== RESTART: E:/Soft-Computing Practicals/1b.py ====
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 a: Implement AND/NOT function using McCulloch-Pits neuron (use binary data representation).

```
num_ip = int(input("Enter the number of inputs : "))
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)
Yin = []
for i in range(0, num_ip):
    Yin.append(m[i] - n[i])
print("After assuming one weight as excitatory and the other as inhibitory Yin
= ", Yin)
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:

```
================== RESTART: E:/Soft-Computing Practicals/2a.py ==================
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]
```

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

```
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 * w12 + 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)

    if np.array_equal(y, z):
        con = 0
    else:
        print("Net is not learning. Enter another set of weights and Threshold
value")
        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 = "))
        theta = int(input("Theta = "))

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

Output:

```
========== RESTART: E:/Soft-Computing Practicals/2b.py ==========
Enter weights
Weight w11 = 1
Weight w12 = -1
Weight w21 = -1
Weight w22 = 1
Weight v1 = 1
Weight v2 = 1
Enter Threshold Value
Theta = 1
z1 [ 0 -1  1  0]
z2 [ 0  1 -1  0]
yin [0. 1. 1. 0.]
Output of Net
y [0 1 1 0]
z [0 1 1 0]
McCulloch-Pitts Net for XOR function
Weights of Neuron Z1
1 -1
Weights of Neuron Z2
-1 1
Weights of Neuron Y
1 1
Threshold value
1
```

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

```
import numpy as np
x1 = np.array([1, 1, 1, -1, 1, -1, 1, 1, 1])
x2 = np.array([1, 1, 1, 1, -1, 1, 1, 1, 1])
b = 0
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 weights =", wtnew)
print("Bias value =", b)
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 weights =", wtnew)
print("Bias value =", b)
```

Output:

```
================== RESTART: E:/Soft-Computing Practicals/3a.py =====
First input with target = 1
New weights = [ 1  1  1 -1  1 -1  1  1  1]
Bias value = 1
Second input with target = -1
New weights = [ 0  0  0 -2  2 -2  0  0  0]
Bias value = 0
```

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

```
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
    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:

```
================== RESTART: E:/Soft-Computing Practicals/3b.py =================
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 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]
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:

```
================== RESTART: E:/Soft-Computing Practicals/4a.py =================
calculate net input to z1 layer
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= 0.04762762829658278
din2= 0.011906907074145694
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:

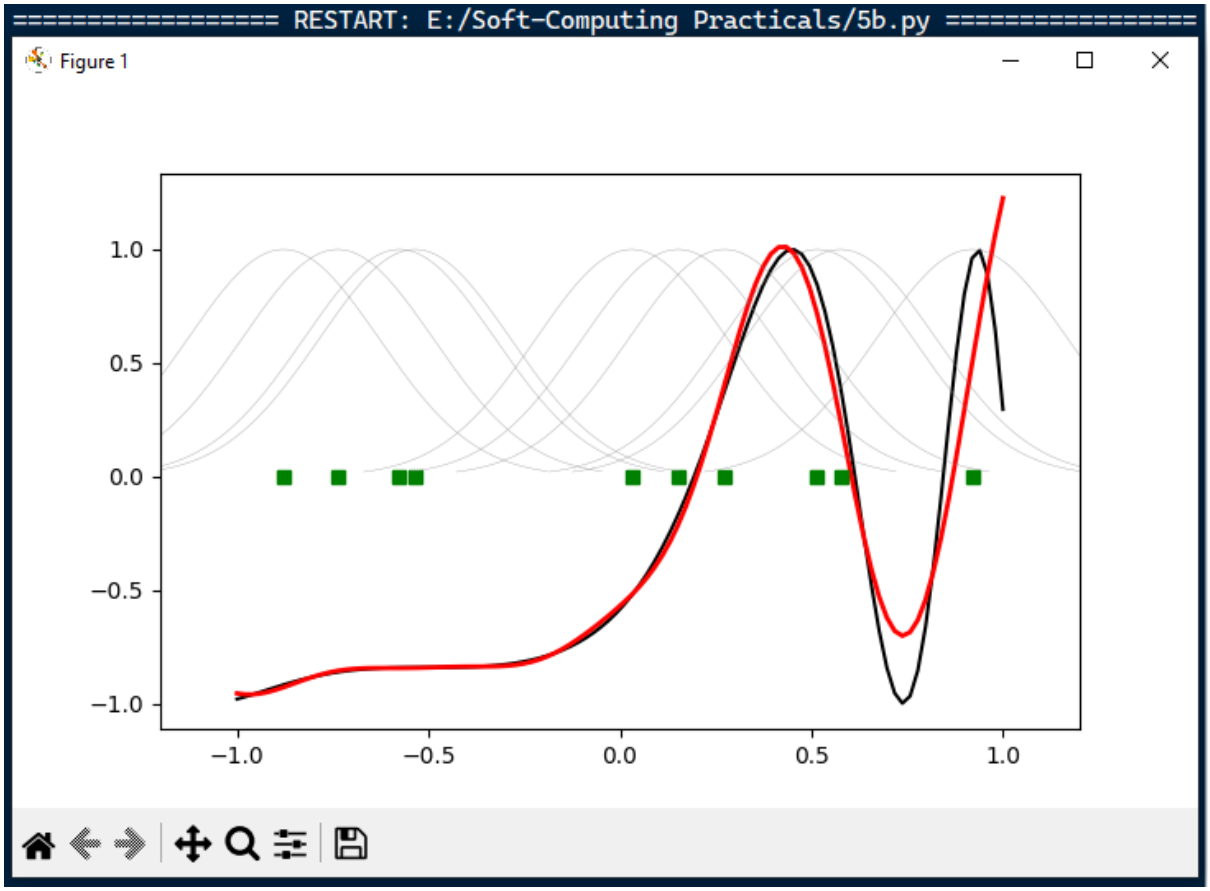
```
================== RESTART: E:/Soft-Computing Practicals/4b.py =================
Enter weight first network : 12
Enter base first network : 35
Enter weight second network : 23
Enter base second network : 45
Enter learning coefficient : 11
The updated weight of first n/w w11 =  12.0
The uploaded weight 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 b: Write a program for Radial Basis function

```
from scipy import *
from scipy.linalg import norm, pinv
from matplotlib import pyplot as plt
import numpy as np
class RBF:
    def __init__(self, indim, numCenters, outdim):
        self.indim = indim
        self.outdim = outdim
        self.numCenters = numCenters
        self.centers = [np.random.uniform(-1, 1, indim) for i in
range(numCenters)]
        self.beta = 8
        self.W = np.random.random((self.numCenters, self.outdim))
    def _basisfunc(self, c, d):
        assert len(d) == self.indim
        return np.exp(-self.beta * norm(c - d)**2)
    def _calcAct(self, X):
        G = np.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):
        rnd_idx = np.random.permutation(X.shape[0])[:self.numCenters]
        self.centers = [X[i, :] for i in rnd_idx]
        G = self._calcAct(X)
        self.W = np.dot(pinv(G), Y)
    def test(self, X):
        G = self._calcAct(X)
        Y = np.dot(G, self.W)
        return Y
if __name__ == '__main__':
    n = 100
    x = np.mgrid[-1:1:complex(0, n)].reshape(n, 1)
    y = np.sin(3 * (x + 0.5)**3 - 1)
    rbf = RBF(1, 10, 1)
    rbf.train(x, y)
    z = rbf.test(x)
    plt.figure(figsize=(12, 8))
    plt.plot(x, y, 'k-')
    plt.plot(x, z, 'r-', linewidth=2)
    plt.plot(rbf.centers, np.zeros(rbf.numCenters), 'gs')
    for c in rbf.centers:
        cx = np.arange(c - 0.7, c + 0.7, 0.01)
        cy = [rbf._basisfunc(np.array([cx_]), np.array([c])) for cx_ in cx]
        plt.plot(cx, cy, '-', color='gray', linewidth=0.2)
    plt.xlim(-1.2, 1.2)
```

```
    plt.show()
```

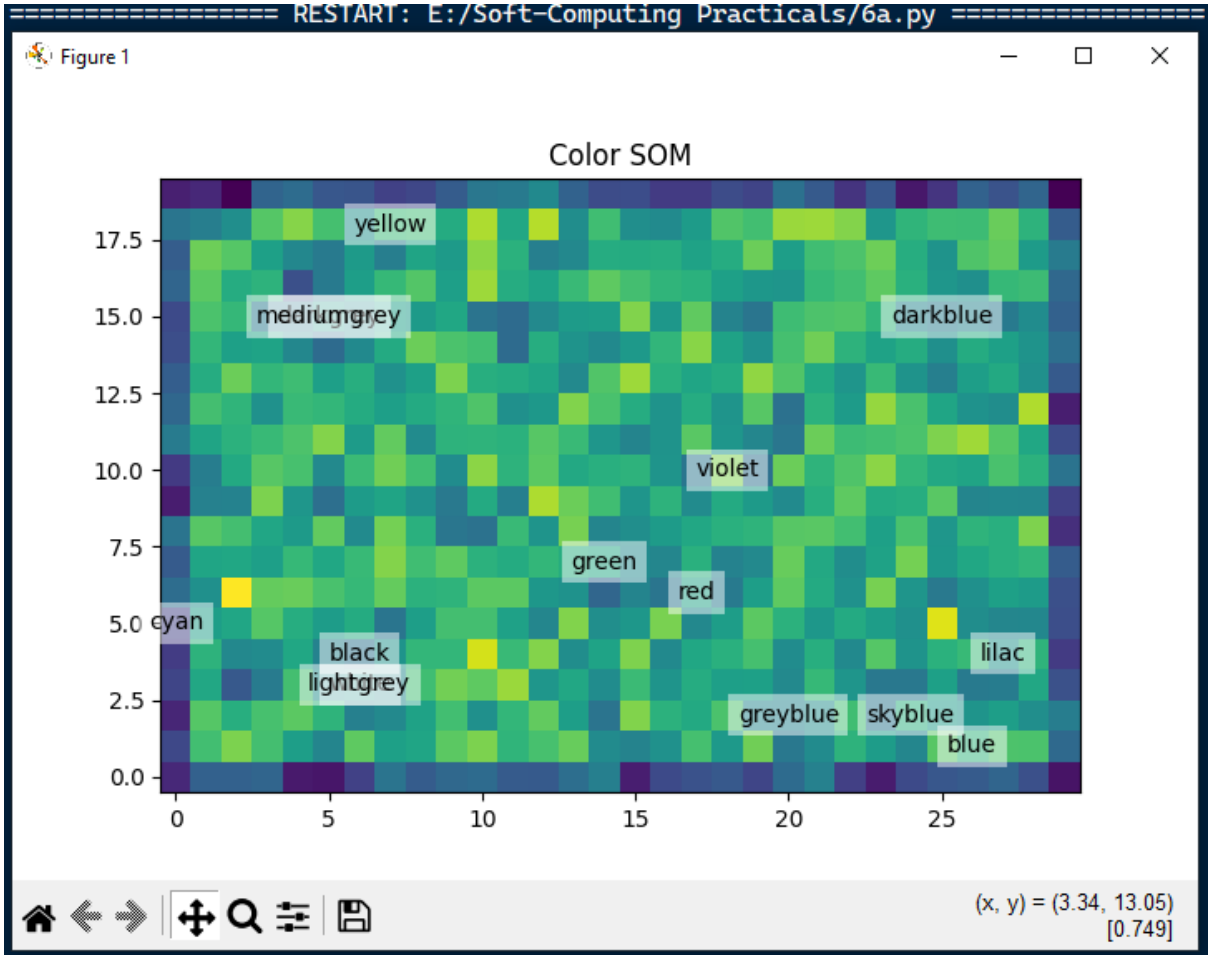
Output:



Practical 6 a: Self-Organizing Maps

```
import numpy as np
import matplotlib.pyplot as plt
from minisom import MiniSom
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.],
     [0.33, 0.33, 0.33],
     [0.5, 0.5, 0.5],
     [0.66, 0.66, 0.66]]
)
color_names = [
    'black', 'blue', 'darkblue', 'skyblue',
    'greyblue', 'lilac', 'green', 'red',
    'cyan', 'violet', 'yellow', 'white',
    'darkgrey', 'mediumgrey', 'lightgrey'
]
som = MiniSom(30, 20, 3, sigma=1.0, learning_rate=0.05)
som.train(colors, 400)
plt.imshow(som.distance_map().T, origin='lower')
plt.title('Color SOM')
for i, color in enumerate(colors):
    w = som.winner(color)
    plt.text(w[0], w[1], color_names[i], ha='center', va='center',
             bbox=dict(facecolor='white', alpha=0.5, lw=0))
plt.show()
```

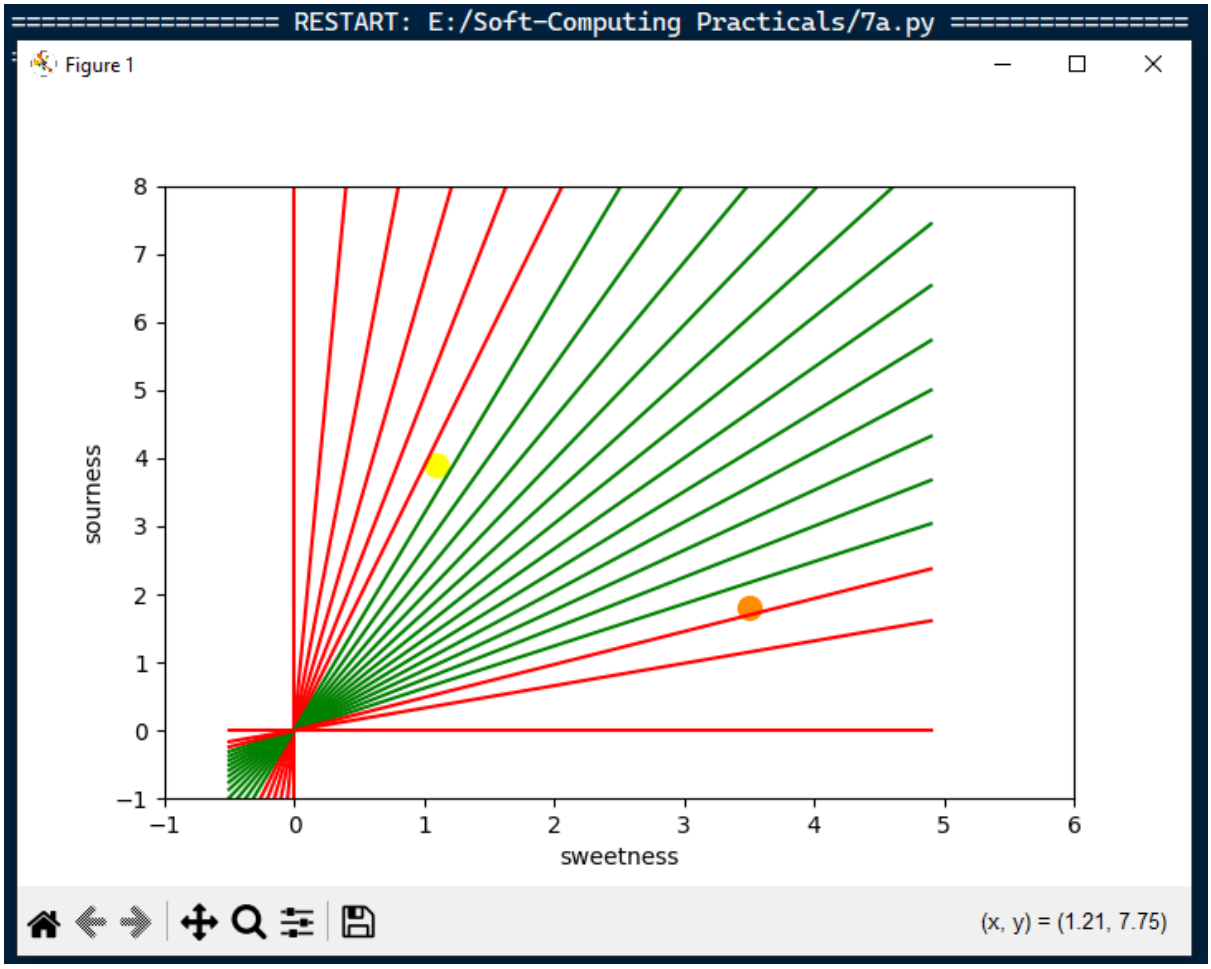
Output:


========== RESTART: E:/Soft-Computing Practicals/6a.py ==========
Figure 1
Color SOM
yellow
mediumgrey
darkblue
violet
green
red
cyan
black
lightgrey
lilac
greyblue
skyblue
blue
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
0
5
10
15
20
25
(x, y) = (3.34, 13.05)
[0.749]

Practical 7 a: Line Separation

```
import numpy as np
import matplotlib.pyplot as plt
def create_distance_function(a, b, c):
    def distance(x, y):
        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)
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, "o", color="yellow", 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)
    Y = slope * X
    results = [dist4line1(*point) for point in points]
    if results[0][1] != results[1][1]:
        ax.plot(X, Y, "g-")
    else:
        ax.plot(X, Y, "r-")
plt.show()
```

Output:


========== RESTART: E:/Soft-Computing Practicals/7a.py ==========
Figure 1
sourness
sweetness
(x, y) = (1.21, 7.75)

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

```
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

# First case: no overlapping elements
list1 = [1, 2, 3, 4, 5]
list2 = [6, 7, 8, 9]
if overlapping(list1, list2):
    print("overlapping")
else:
    print("not overlapping")

# Second case: overlapping elements
list1 = [1, 2, 3, 4, 5]
list2 = [4, 6, 7, 8, 9]
if overlapping(list1, list2):
    print("overlapping")
else:
    print("not overlapping")
```

Output:

```
================== RESTART: E:\Soft-Computing Practicals\8a.py ==================
not overlapping
overlapping
```

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

```
x = 5
if (type(x) is int):
    print("true")
else:
    print("false")

x = 5
if (type(x) is not int):
    print("true")
else:
    print("false")
```

Output:

```
================== RESTART: E:/Soft-Computing Practicals/8b.py =================
true
false
```

Practical 9 a: Find the ratios using fuzzy logic

```
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("FuzzyWuzzy Partial Ratio:", fuzz.partial_ratio(s1, s2))
print("FuzzyWuzzy Token Sort Ratio:", fuzz.token_sort_ratio(s1, s2))
print("FuzzyWuzzy Token Set Ratio:", fuzz.token_set_ratio(s1, s2))
print("FuzzyWuzzy W Ratio:", fuzz.WRatio(s1, s2), '\n\n')
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))
```

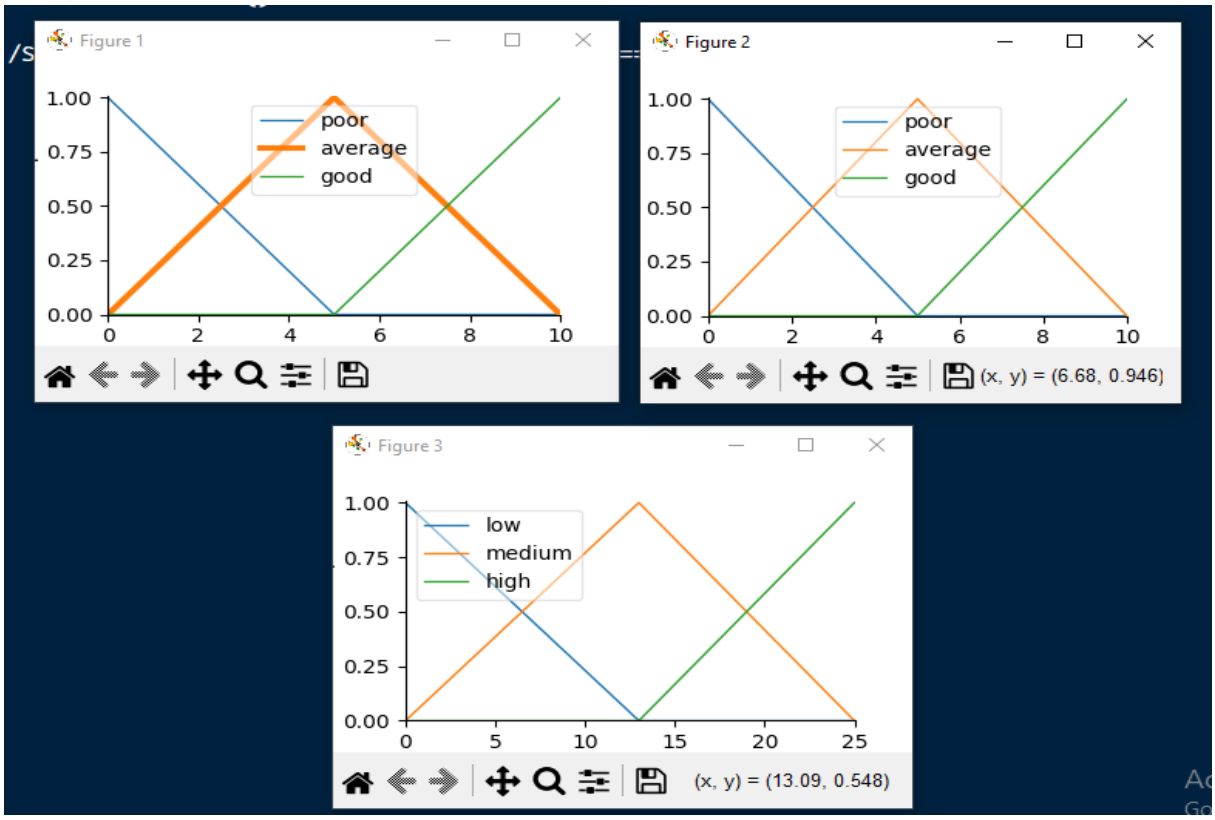
Output:

```
========== RESTART: E:/Soft-Computing Practicals/9a.py ==========
FuzzyWuzzy Ratio: 86
FuzzyWuzzy Partial Ratio: 86
FuzzyWuzzy Token Sort Ratio: 86
FuzzyWuzzy Token Set Ratio: 87
FuzzyWuzzy W Ratio: 86


List of ratios:
[('g. for fuzzys', 95), ('fuzzy for fuzzy', 94), ('fuzzy fuzzy', 86)]

Best among the above list: ('g. for fuzzys', 95)
```

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)
quality.automf(3)
service.automf(3)

# Custom membership functions for the 'tip' variable
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])

# Visualizing the membership functions for quality, service, and tip
quality['average'].view()
service.view()
tip.view()
```

Output:



Practical 10 a: Implementation of simple genetic algorithm

```
import random
POPULATION_SIZE = 100
GENES = '''abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ 1234567890, .-
;:_!"#%&/()=?@${[]}'''
TARGET = "I love GeeksforGeeks"
class Individual(object):
    def __init__(self, chromosome):
        self.chromosome = chromosome
        self.fitness = self.cal_fitness()
    @classmethod
    def mutated_genes(self):
        global GENES
        gene = random.choice(GENES)
        return gene
    @classmethod
    def create_gnome(self):
        global TARGET
        gnome_len = len(TARGET)
        return [self.mutated_genes() for _ in range(gnome_len)]
    def mate(self, par2):
        child_chromosome = []
        for gp1, gp2 in zip(self.chromosome, par2.chromosome):
            prob = random.random()
            if prob < 0.45:
                child_chromosome.append(gp1)
            elif prob < 0.90:
                child_chromosome.append(gp2)
            else:
                child_chromosome.append(self.mutated_genes())
        return Individual(child_chromosome)
    def cal_fitness(self):
        global TARGET
        fitness = 0
        for gs, gt in zip(self.chromosome, TARGET):
            if gs != gt:
                fitness += 1
        return fitness
def main():
    global POPULATION_SIZE
    generation = 1
    found = False
    population = []
    # Initializing population
    for _ in range(POPULATION_SIZE):
        gnome = Individual.create_gnome()
        population.append(Individual(gnome))
    while not found:
```

```
        population = sorted(population, key=lambda x: x.fitness)
        if population[0].fitness <= 0:
            found = True
            break
        new_generation = []
        s = int((10 * POPULATION_SIZE) / 100)
        new_generation.extend(population[:s])
        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 every 10 generations
        if generation % 10 == 0:
            print(f"Generation: {generation}\tString:
{''.join(population[0].chromosome)}\tFitness: {population[0].fitness}")
        generation += 1
    print(f"Generation: {generation}\tString:
{''.join(population[0].chromosome)}\tFitness: {population[0].fitness}")
if __name__ == '__main__':
    main()
```

Output:

```
================= RESTART: E:/Soft-Computing Practicals/10a.py =================
Generation: 10  String: . "Y!: Z0Oksf(:GeeWC    Fitness: 12
Generation: 20  String: I lIr[ _ekksforGeeWA    Fitness: 7
Generation: 30  String: I lIr[ _ekksforGeeWA    Fitness: 7
Generation: 40  String: I lIr[ _ekksforGeeWA    Fitness: 7
Generation: 50  String: I lIrr GeMksforGeefn    Fitness: 6
Generation: 60  String: I leva GeOksforGeeW$    Fitness: 5
Generation: 70  String: I lova GeeksforGeeWP    Fitness: 3
Generation: 80  String: I lova GeeksforGeeqs    Fitness: 2
Generation: 90  String: I love GeeksforGeeas    Fitness: 1
Generation: 92  String: I love GeeksforGeeks    Fitness: 0
```

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

```
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
```

```
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 = []
    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: