

PROGRAM 16

AIM: Write a program in Python to implement Hopfield neural network

CODE:

```
import numpy as np
x=np.array([[1,1,1,1,1],[1,-1,-1,1,-1],[-1,1,-1,-1,-1]])
x1=np.transpose(x)
t1=np.array([[1,1,1,-1,1]])
t2=np.array([[1,-1,-1,-1,-1]])
t3=np.array([[1,1,-1,-1,-1]])
w=np.zeros((5,5))
i=0
j=0
k=0
for i in range(len(x1)):
    for j in range(len(x[0])):
        for k in range(len(x)):
            w[i][j] += x1[i][k] * x[k][j]
print('Weight Matrix:\n')
for r in w:
    print(r)
print("\n\nWeight Matrix with no self connection:\n")
i=0
j=0
for i in range(int(5)):
    for j in range(int(5)):
        if(i==j):
            w[i][j]=0
for r in w:
    print(r)
E1=0
E2=0
E3=0
x11= x[0].reshape(5,1)
x12=x[1].reshape(5,1)
x13=x[2].reshape(5,1)
E1= -0.5 * np.matmul(x[0],np.matmul(w,x11))
print("\n\nEnergy Calculations for pattern [1,1,1,1,1]:',E1)

E2= -0.5 * np.matmul(x[1],np.matmul(w,x12))
print("\n\nEnergy Calculations for pattern [1,-1,-1,1,-1]:',E2)

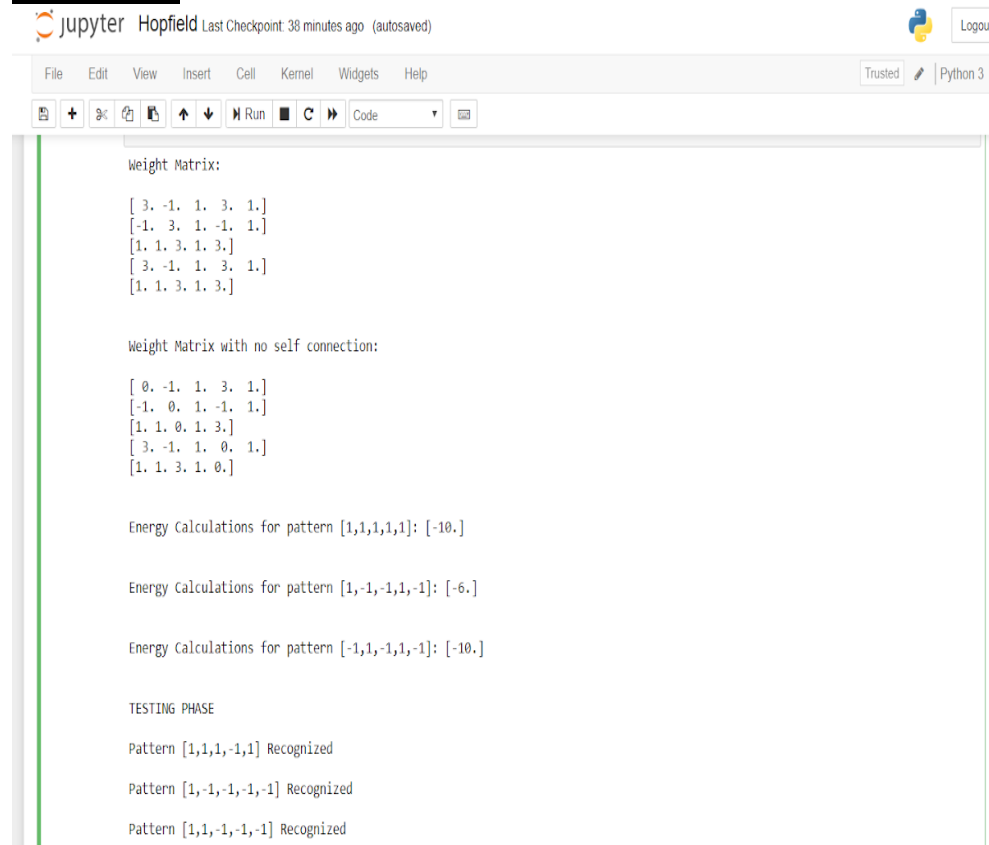
E3= -0.5 * np.matmul(x[2],np.matmul(w,x13))
print("\n\nEnergy Calculations for pattern [-1,1,-1,1,-1]:',E3)

print("\n\nTESTING PHASE')
w_dash=np.transpose(w)
Yin1=t1[0][3]+ np.matmul(x[0],w_dash[3])
if(Yin1>0):
    t1[0][3]=1
```

PROGRAM 16

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else:
    t1[0][3]=-1
    if((t1==x).any()):
        print("\nPattern [1,1,1,-1,1] Recognized ')
    else:
        print("\nPattern [1,1,1,-1,1] not Recognized ')
    Yin2=t2[0][3]+ np.matmul(x[1],w_dash[3])
    if(Yin2>0):
        t2[0][3]=1
    else:
        t2[0][3]=-1
    if((t2==x).any()):
        print("\nPattern [1,-1,-1,-1,-1] Recognized ')
    else:
        print("\nPattern [1,-1,-1,-1,-1] not Recognized ')
    Yin3=t3[0][0]+ np.matmul(x[2],w_dash[0])
    if(Yin3>0):
        t3[0][0]=1
    else:
        t3[0][0]=-1
    if((t3==x).any()):
        print("\nPattern [1,1,-1,-1,-1] Recognized ')
    else:
        print("\nPattern [1,1,-1,-1,-1] not Recognized ')
```

OUTPUT:



The screenshot shows a Jupyter Notebook interface with the following output:

```
Weight Matrix:
[ 3. -1.  1.  3.  1.]
[-1.  3.  1. -1.  1.]
[ 1.  1.  3.  1.  3.]
[ 3. -1.  1.  3.  1.]
[ 1.  1.  3.  1.  3.]

Weight Matrix with no self connection:
[ 0. -1.  1.  3.  1.]
[-1.  0.  1. -1.  1.]
[ 1.  1.  0.  1.  3.]
[ 3. -1.  1.  0.  1.]
[ 1.  1.  3.  1.  0.]

Energy Calculations for pattern [1,1,1,1,1]: [-10.]

Energy Calculations for pattern [1,-1,-1,1,-1]: [-6.]

Energy Calculations for pattern [-1,1,-1,1,-1]: [-10.]

TESTING PHASE

Pattern [1,1,1,-1,1] Recognized
Pattern [1,-1,-1,-1,-1] Recognized
Pattern [1,1,-1,-1,-1] Recognized
```