PROGRAM 13

AIM: Write a program in Python to implement Back-Propagation Neural Network.

CODE:

```
import math
import random
import string
class NN:
def __init__(self, NI, NH, NO):
    # number of nodes in layers
    self.ni = NI + 1 # +1 for bias
self.nh = NH
    self.no = NO
    self.ai, self.ah, self.ao = [],[], []
    self.ai = [1.0]*self.ni
self.ah = [1.0]*self.nh
    self.ao = [1.0]*self.no
self.wi = makeMatrix (self.ni, self.nh)
self.wo = makeMatrix (self.nh, self.no)
    # initialize node weights to random vals
randomizeMatrix ( self.wi, -0.2, 0.2 )
randomizeMatrix ( self.wo, -2.0, 2.0 )
    self.ci = makeMatrix (self.ni, self.nh)
    self.co = makeMatrix (self.nh, self.no)

defrunNN (self, inputs):
iflen(inputs) != self.ni-1:
print('incorrect number of inputs')
for i in range(self.ni-1):
      self.ai[i] = inputs[i]
for j in range(self.nh):
            sum = 0.0
for i in range(self.ni):
            sum +=( self.ai[i] * self.wi[i][j] )
            self.ah[j] = sigmoid (sum)
for k in range(self.no):
            sum = 0.0
for j in range(self.nh):
            sum +=( self.ah[j] * self.wo[j][k] )
            self.ao[k] = sigmoid (sum)
return self.ao
defbackPropagate (self, targets, N, M):
output_deltas = [0.0] * self.no
for k in range(self.no):
            error = targets[k] - self.ao[k]
            output_deltas[k] =  error * dsigmoid(self.ao[k])
for j in range(self.nh):
for k in range(self.no):
            change = output_deltas[k] * self.ah[j]
            self.wo[j][k] += N*change + M*self.co[j][k]
            self.co[j][k] = change
            hidden_deltas = [0.0] * self.nh
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for j in range(self.nh):
        error = 0.0
for k in range(self.no):
        error += output_deltas[k] * self.wo[j][k]
        hidden_deltas[j] = error * dsigmoid(self.ah[j])
for i in range (self.ni):
        for j in range (self.nh):
                change= hidden_deltas[j] * self.ai[i]
                self.wi[i][j] += N*change + M*self.ci[i][j]
        self.ci[i][j] = change
error = 0.0
for k in range(len(targets)):
error = 0.5 * (targets[k]-self.ao[k])**2
return error
def weights(self):
print('Input weights:')
for i in range(self.ni):
print (self.wi[i])
print()
print('Output weights:')
for j in range(self.nh):
print (self.wo[j])
print ('')
def test(self, patterns):
for p in patterns:
inputs = p[0]
print('Inputs:', p[0], '-->', self.runNN(inputs), '\tTarget', p[1])
def train (self, patterns, max_iterations = 1000, N=0.5, M=0.1):
for i in range(max_iterations):
for p in patterns:
inputs = p[0]
targets = p[1]
self.runNN(inputs)
error = self.backPropagate(targets, N, M)
if i % 50 == 0:
print('Combined error', error)
self.test(patterns)
def sigmoid (x):
returnmath.tanh(x)
defdsigmoid (y):
return 1 - y**2
defmakeMatrix ( I, J, fill=0.0):
  m = []
for i in range(I):
m.append([fill]*J)
return m
defrandomizeMatrix ( matrix, a, b):
for i in range ( len (matrix) ):
for j in range ( len (matrix[0]) ):
matrix[i][j] = random.uniform(a,b)
def main ():
pat = [
    [[0,0], [1]],
    [[0,1], [1]],
    [[1,0], [1]],
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      [[1,1], [0]]
   ]
myNN = NN ( 2, 2, 1)
myNN.train(pat)
if __name__ == "__main__":
main()
```
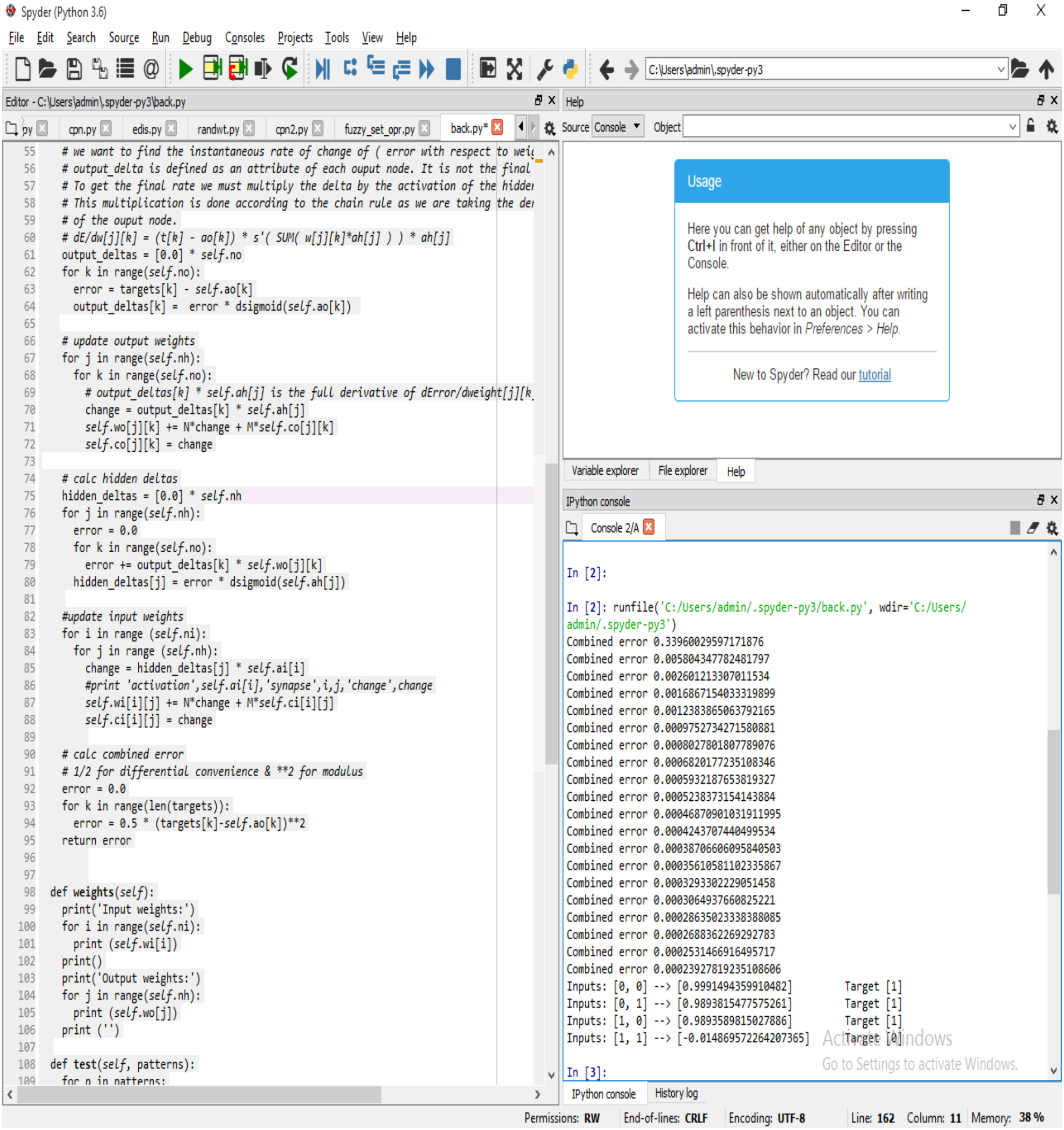

OUTPUT:



```
    # we want to find the instantaneous rate of change of ( error with respect to wei
    # output_delta is defined as an attribute of each ouput node. It is not the final
    # To get the final rate we must multiply the delta by the activation of the hidde
    # This multiplication is done according to the chain rule as we are taking the de
    # of the ouput node.
    # dE/dw[j][k] = (t[k] - ao[k]) * s'( SUM( w[j][k]*ah[j] ) ) * ah[j]
    output_deltas = [0.0] * self.no
    for k in range(self.no):
      error = targets[k] - self.ao[k]
      output_deltas[k] =  error * dsigmoid(self.ao[k])

    # update output weights
    for j in range(self.nh):
      for k in range(self.no):
        # output_deltas[k] * self.ah[j] is the full derivative of dError/dweight[j][k
        change = output_deltas[k] * self.ah[j]
        self.wo[j][k] += N*change + M*self.co[j][k]
        self.co[j][k] = change

    # calc hidden deltas
    hidden_deltas = [0.0] * self.nh
    for j in range(self.nh):
      error = 0.0
      for k in range(self.no):
        error += output_deltas[k] * self.wo[j][k]
      hidden_deltas[j] = error * dsigmoid(self.ah[j])

    #update input weights
    for i in range (self.ni):
      for j in range (self.nh):
        change = hidden_deltas[j] * self.ai[i]
        #print 'activation',self.ai[i],'synapse',i,j,'change',change
        self.wi[i][j] += N*change + M*self.ci[i][j]
        self.ci[i][j] = change

    # calc combined error
    # 1/2 for differential convenience & **2 for modulus
    error = 0.0
    for k in range(len(targets)):
      error = 0.5 * (targets[k]-self.ao[k])**2
    return error


  def weights(self):
    print('Input weights:')
    for i in range(self.ni):
      print (self.wi[i])
    print()
    print('Output weights:')
    for j in range(self.nh):
      print (self.wo[j])
    print ('')

  def test(self, patterns):
    for p in patterns:
```

Usage

Here you can get help of any object by pressing **Ctrl+I** in front of it, either on the Editor or the Console.

Help can also be shown automatically after writing a left parenthesis next to an object. You can activate this behavior in *Preferences > Help*.

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```
In [2]:

In [2]: runfile('C:/Users/admin/.spyder-py3/back.py', wdir='C:/Users/
admin/.spyder-py3')
Combined error 0.33960029597171876
Combined error 0.005804347782481797
Combined error 0.002601213307011534
Combined error 0.0016867154033319899
Combined error 0.0012383865063792165
Combined error 0.0009752734271580881
Combined error 0.0008027801807789076
Combined error 0.0006820177235108346
Combined error 0.0005932187653819327
Combined error 0.0005238373154143884
Combined error 0.00046870901031911995
Combined error 0.0004243707440499534
Combined error 0.00038706606095840503
Combined error 0.00035610581102335867
Combined error 0.0003293302229051458
Combined error 0.0003064937660825221
Combined error 0.00028635023338388085
Combined error 0.0002688362269292783
Combined error 0.0002531466916495717
Combined error 0.00023927819235108606
Inputs: [0, 0] --> [0.9991494359910482]       Target [1]
Inputs: [0, 1] --> [0.9893815477575261]       Target [1]
Inputs: [1, 0] --> [0.9893589815027886]       Target [1]
Inputs: [1, 1] --> [-0.014869572264207365]    Target [0]

In [3]:
```