

[실습예제 18-2][도전!]

```
20 phi = lambda u: 1/(1+np.exp(-u))
21 dphi = lambda u: np.exp(-u)/(1+np.exp(-u))**2
22
23 np.random.seed(1)
24 L, M = 11, 4
25 bW, W = np.random.rand(L,1), np.random.rand(L,2)
26 bV, V = np.random.rand(M,1), np.random.rand(M,L)
27
28 MaxIter = 10000
29 alpha = 1.0
30 ns = MaxIter/10
31
32 print('n={:5d}'.format(0))
33 for n in range(MaxIter):
34     gradbW, gradW = np.zeros((L,1)), np.zeros((L,2))
35     gradbV, gradV = np.zeros((M,1)), np.zeros((M,L))
36     for i in range(N):
37         ti = t[:,i:i+1]
38         xi = x[:,i:i+1]
39         uh = bW + W@xi
40         zi = phi(uh)
41         ui = bV + V@zi
42
43         dEdu = dphi(ui)*(phi(ui)-ti)
44         gradbV += 1/N*dEdu
45         gradV += 1/N*dEdu@zi.T
46
47         dEduh = dphi(uh)*(V.T@dEdu)
48         gradbW += 1/N*dEduh
49         gradW += 1/N*dEduh@xi.T
50
51     bW, W = bW-alpha*gradbW, W-alpha*gradW
52     bV, V = bV-alpha*gradbV, V-alpha*gradV
53
54     Eval = 0.0
55     for i in range(N):
56         ti = t[:,i:i+1]
57         xi = x[:,i:i+1]
58         uh = bW + W@xi
59         zi = phi(uh)
60         ui = bV + V@zi
61
62         Eval += 0.5/N*np.sum((phi(ui)-ti)**2)
63
64     if (n+1)%ns == 0:
65         print('n={:5d}, Eval={:.4f}'.format(n+1,Eval))
```

```
n=      0
n= 1000, Eval=0.2326
n= 2000, Eval=0.1958
n= 3000, Eval=0.1473
```

```

n= 4000, Eval=0.0958
n= 5000, Eval=0.0660
n= 6000, Eval=0.0498
n= 7000, Eval=0.0391
n= 8000, Eval=0.0318
n= 9000, Eval=0.0268
n=10000, Eval=0.0229

66 x1 = np.linspace(-1, 1)
67 x2 = np.linspace(-1, 1)
68 xx1, xx2 = np.meshgrid(x1, x2)
69
70 uuh = [0 for k in range(L)]
71 for k in range(L):
72     uuh[k] = bW[k,0] + W[k,0]*xx1 + W[k,1]*xx2
73
74 yy = [0 for j in range(M)]
75 for j in range(M):
76     uu = bV[j,0]
77     for k in range(L):
78         uu += V[j,k]*phi(uuh[k])
79     yy[j] = phi(uu)
80
81 fig = plt.figure()
82 ax = plt.axes()
83 ax.scatter(x[0,:], x[1,:], c=t[1,:]+2*t[2,:]+3*t[3:], cmap='rainbow')
84 for j in range(M):
85     ax.contour(xx1, xx2, yy[j], [0.5])
86 ax.set_aspect('equal')
87 plt.show()

```

