

[실습예제 20-2][도전!]

```
20 phi = lambda u: 1/(1+np.exp(-u))
21 dphi = lambda u: np.exp(-u)/(1+np.exp(-u))**2
22
23 soft = lambda u: np.exp(u)/np.sum(np.exp(u))
24 dsoft = lambda u: np.diag((soft(u).T)[0])-soft(u)@soft(u).T
25
26 np.random.seed(1)
27 L, M = 11, 4
28 b1, W1 = np.random.rand(L,1), np.random.rand(L,2)
29 b2, W2 = np.random.rand(M,1), np.random.rand(M,L)
30
31 MaxIter = 10000
32 alpha = 1.0
33 ns = MaxIter/10
34
35 print('n={:5d}'.format(0))
36 for n in range(MaxIter):
37     gradb1, gradW1 = np.zeros((L,1)), np.zeros((L,2))
38     gradb2, gradW2 = np.zeros((M,1)), np.zeros((M,L))
39     for i in range(N):
40         ti = t[:,i:i+1]
41         xi = x[:,i:i+1]
42         uh = b1 + W1@xi
43         zi = phi(uh)
44         ui = b2 + W2@zi
45
46         dEdu = dsoft(ui)@(soft(ui)-ti)
47         gradb2 += 1/N*dEdu
48         gradW2 += 1/N*dEdu@zi.T
49
50         dEduh = dphi(uh)*(W2.T@dEdu)
51         gradb1 += 1/N*dEduh
52         gradW1 += 1/N*dEduh@xi.T
53
54     b1, W1 = b1-alpha*gradb1, W1-alpha*gradW1
55     b2, W2 = b2-alpha*gradb2, W2-alpha*gradW2
56
57     Eval = 0.0
58     for i in range(N):
59         ti = t[:,i:i+1]
60         xi = x[:,i:i+1]
61         uh = b1+W1@xi
62         zi = phi(uh)
63         ui = b2+W2@zi
64
65         Eval += 0.5/N*np.sum((soft(ui)-ti)**2)
66
67     if (n+1)%ns == 0:
68         print('n={:5d}, Eval={:.4f}'.format(n+1,Eval))
```

n= 0

```

n= 1000, Eval=0.2071
n= 2000, Eval=0.1446
n= 3000, Eval=0.0649
n= 4000, Eval=0.0331
n= 5000, Eval=0.0215
n= 6000, Eval=0.0155
n= 7000, Eval=0.0120
n= 8000, Eval=0.0097
n= 9000, Eval=0.0081
n=10000, Eval=0.0070

```

```

69 x1 = np.linspace(-1, 1)
70 x2 = np.linspace(-1, 1)
71 xx1, xx2 = np.meshgrid(x1, x2)
72
73 uuh = [0 for l in range(L)]
74 for l in range(L):
75     uuh[l] = b1[l,0] + W1[l,0]*xx1 + W1[l,1]*xx2
76
77 uu = [0 for k in range(M)]
78 for k in range(M):
79     uu[k] = b2[k,0]
80     for l in range(L):
81         uu[k] += W2[k,l]*phi(uuh[l])
82
83 sigma = 0
84 for k in range(M):
85     sigma += np.exp(uu[k])
86
87 yy = [0 for j in range(M)]
88 for j in range(M):
89     yy[j] = np.exp(uu[j])/sigma
90
91 fig = plt.figure()
92 ax = plt.axes()
93 gcmmap = plt.colormaps.get_cmap('rainbow')
94 ax.scatter(x[0,:], x[1,:], c=t[1,:]+2*t[2,:]+3*t[3,:], cmap=gcmmap)
95 for j in range(M):
96     ax.contour(xx1, xx2, yy[j], [0.5])
97     ax.contourf(xx1, xx2, yy[j], [0.5,1.0], colors=[gcmmap(j/(M-1))], alpha=0.3)
98 ax.set_aspect('equal')
99 plt.show()

```

