

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

n= 0

n= 1000, Eval=0.2351

```

n= 2000, Eval=0.0770
n= 3000, Eval=0.0422
n= 4000, Eval=0.0289
n= 5000, Eval=0.0218
n= 6000, Eval=0.0176
n= 7000, Eval=0.0147
n= 8000, Eval=0.0126
n= 9000, Eval=0.0109
n=10000, Eval=0.0097

```

```

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

```

