

[실습예제 23-2][도전!]

```
7 N, M = len(labels), len(np.unique(labels))
8 t = np.eye(M)[labels,:]
9
10 for i in range(M):
11     xmin, xmax = np.min(x[:,i]), np.max(x[:,i])
12     x[:,i] = -1 + 2*(x[:,i]-xmin)/(xmax-xmin)
13
14 phi = lambda u: 1/(1+np.exp(-u))
15 dphi = lambda u: np.exp(-u)/(1+np.exp(-u))**2
16
17 soft = lambda u: np.exp(u)/np.sum(np.exp(u))
18 dsoft = lambda u: np.diag(soft(u)[0])-soft(u).T@soft(u)
19
20 np.random.seed(1)
21 D, L = 4, 7
22 b1, W1 = np.random.rand(1,L), np.random.rand(D,L)
23 b2, W2 = np.random.rand(1,M), np.random.rand(L,M)
24
25 MaxIter = 1000
26 alpha = 1.0
27 ns = MaxIter/10
28
29 print('n={:5d}'.format(0))
30 for n in range(MaxIter):
31     gradb1, gradW1 = np.zeros((1,L)), np.zeros((D,L))
32     gradb2, gradW2 = np.zeros((1,M)), np.zeros((L,M))
33     for i in range(N):
34         ti = t[i:i+1,:]
35         xi = x[i:i+1,:]
36         uh = b1 + xi@W1
37         zi = phi(uh)
38         ui = b2 + zi@W2
39
40         dEdu = (soft(ui)-ti)@dsoft(ui)
41         gradb2 += 1/N*dEdu
42         gradW2 += 1/N*zi.T@dEdu
43
44         dEduh = (dEdu@W2.T)*dphi(uh)
45         gradb1 += 1/N*dEduh
46         gradW1 += 1/N*xi.T@dEduh
47
48     b1, W1 = b1-alpha*gradb1, W1-alpha*gradW1
49     b2, W2 = b2-alpha*gradb2, W2-alpha*gradW2
50
51     Eval = 0.0
52     count = 0
53     for i in range(N):
54         ti = t[i:i+1,:]
55         xi = x[i:i+1,:]
56         uh = b1 + xi@W1
57         zi = phi(uh)
```

```
58     ui = b2 + zi@W2
59     yi = soft(ui)
60
61     Eval += 0.5/N*np.sum((yi-ti)**2)
62     count += np.argmax(yi)==np.argmax(ti)
63
64     acc = count/N*100
65
66     if (n+1)%ns == 0:
67         print('n={:5d}, Eval={:.4f}, Acc={:5.1f}'.format(n+1,Eval,acc))
```

```
n=      0
n= 100, Eval=0.1304, Acc= 88.0
n= 200, Eval=0.0843, Acc= 92.7
n= 300, Eval=0.0620, Acc= 95.3
n= 400, Eval=0.0461, Acc= 96.7
n= 500, Eval=0.0354, Acc= 97.3
n= 600, Eval=0.0289, Acc= 97.3
n= 700, Eval=0.0250, Acc= 98.0
n= 800, Eval=0.0225, Acc= 98.0
n= 900, Eval=0.0208, Acc= 98.7
n= 1000, Eval=0.0195, Acc= 98.7
```
