

[실습예제 17-2][도전!]

```
13 phi = lambda u: 1/(1+np.exp(-u))
14 dphi = lambda u: np.exp(-u)/(1+np.exp(-u))**2
15
16 np.random.seed(1)
17 L = 5
18 W, V = np.random.rand(L+1,3), np.random.rand(4,L+1)
19
20 MaxIter = 10000
21 alpha = 1.0
22 ns = MaxIter/10
23 print('n={:5d}'.format(0))
24 for n in range(MaxIter):
25     gradW, gradV = np.zeros((L+1,3)), np.zeros((4,L+1))
26     for i in range(N):
27         ti = t[1:,i:i+1]
28         tx = x[:,i:i+1]
29         uh = W[1:,:]@tx
30
31         tz = np.ones((L+1,1))
32         tz[1:,:] = phi(uh)
33         ui = V[1:,:]@tz
34
35         dEdu = (phi(ui)-ti)*dphi(ui)
36         gradV[1:,:] += 1/N*dEdu@tz.T
37         dEduh = dphi(uh)*(V[1:,1:].T@dEdu)
38         gradW[1:,:] += 1/N*dEduh@tx.T
39
40     W, V = W-alpha*gradW, V-alpha*gradV
41
42     Eval = 0.0
43     for i in range(N):
44         ti = t[1:,i:i+1]
45         tx = x[:,i:i+1]
46         uh = W[1:,:]@tx
47
48         tz = np.ones((L+1,1))
49         tz[1:,:] = phi(uh)
50         ui = V[1:,:]@tz
51
52         Eval += 0.5/N*np.sum((phi(ui)-ti)**2)
53
54     if (n+1)%ns == 0:
55         print('n={:5d}, Eval={:.4f}'.format(n+1,Eval))
```

```
n=      0
n= 1000, Eval=0.1026
n= 2000, Eval=0.0098
n= 3000, Eval=0.0042
n= 4000, Eval=0.0026
n= 5000, Eval=0.0019
n= 6000, Eval=0.0014
```

```
n= 7000, Eval=0.0012
n= 8000, Eval=0.0010
n= 9000, Eval=0.0009
n=10000, Eval=0.0007
```

```
56 x1 = np.linspace(-1.5, 1.5)
57 x2 = np.linspace(-1.5, 1.5)
58 xx1, xx2 = np.meshgrid(x1, x2)
59
60 uuh = [0 for k in range(L+1)]
61 for k in range(1,L+1):
62     uuh[k] = W[k,0] + W[k,1]*xx1 + W[k,2]*xx2
63
64 yy = [0 for j in range(4)]
65 for j in range(1,4):
66     uu = V[j,0]
67     for k in range(1,L+1):
68         uu += V[j,k]*phi(uuh[k])
69     yy[j] = phi(uu)
70
71 fig = plt.figure()
72 ax = plt.axes()
73 ax.set_aspect('equal')
74 ax.scatter(x[1,:], x[2,:], c=t[2,:]+2*t[3,:], cmap='brg')
75 for j in range(1,4):
76     ax.contour(xx1, xx2, yy[j], [0.5])
77 plt.show()
```

