-Artificial Neural Network-

Chapter 9 Self Organization Map(SOM)

朝陽科技大學

資訊管理系

李麗華 教授

Introduction

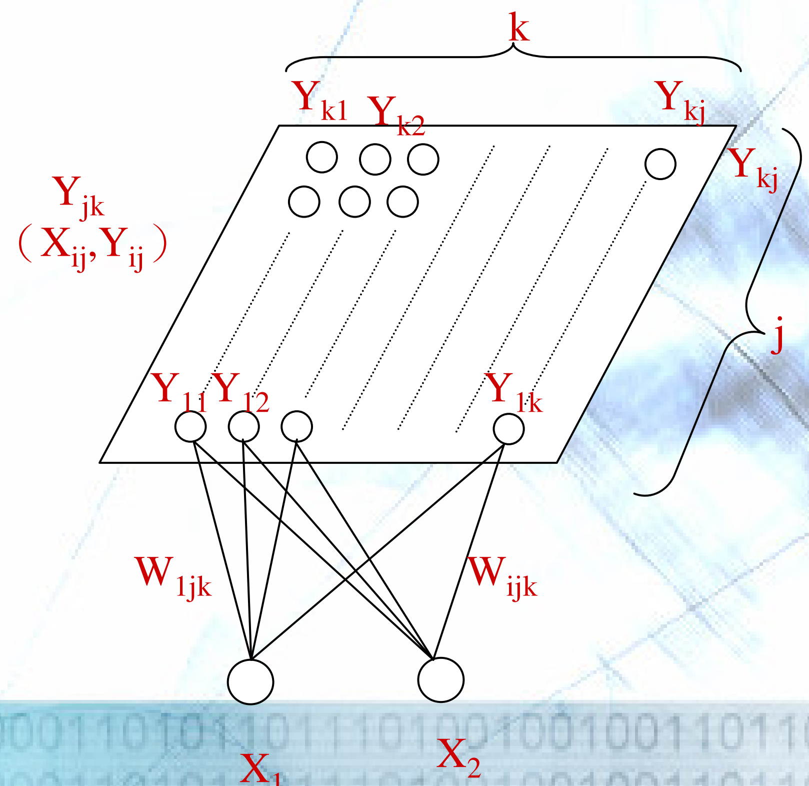
- It's proposed by Kohonen in 1980.
- SOM is an unsupervised two layered network that can organize a topological map from a random starting point.

  SOM is also called Kohnen's self organizating feature map.

  The resulting map shows the natural relationships among the patterns that are given to the network.
- The application is good for clustering analysis.

Network Structure

– One input layer
– One competitive layer which is usually a 2-Dim grid



Input layer：f(x)：x
Output layer：competitive layer with topological map relationship
Weights：randomly assigned

Concept of Neighborhood

①Center：the winning node C is the center.

②Distance：

$$r_j = \sqrt{(N_x - C_x)^2 + (N_y - C_y)^2}$$

N is the node is output N to C

r_j is the distance from N to C

③R Factor（鄰近係數）：

RF_j：f（r_j,R）=$e^{(-rj/R)}$

$e^{(-rj/R)} \longrightarrow$ 1 when r_j = ∮

$e^{(-rj/R)} \longrightarrow$ ∮ when r_j= ∞

$e^{(-rj/R)} \longrightarrow$ 0.368 when r_j = R

R：the radius of the neighborhood

r_j ：distance from N to C

The longer the distance, the smaller the neighborhood area.

④R Factor Adjustment：R_n=R-rate・R^{n-1} , R-rate<1.0

Learning

1. Setup network
2. Randomly assign weights to W
3. Set the coordinate value of the output layer N（x,y）
4. Input a training vector X
5. Compute the winning node
6. Update weight △W with R factor
7. $\eta^{n} = \eta\text{-rate} \cdot \eta^{n-1}$
   $R^{n} = R\text{-rate} \cdot \eta^{n-1}$
8. Repeat from 4 to 7 until converge

Reuse the network

1. Setup the network
2. Read the weight matrix
3. Set the coordriate value of the output layer N（x,y）
4. Read input vector
5. Compute the winning node
6. Output the clustering result Y.

Computation process

1. Setup network

$X_1 \sim X_n$ （Input Vector）

N_{jk} （Output）

2. Compute winning node

$$net_{jk} = \sqrt{\sum_i \left(X_i - W_{ijk}\right)^2}$$

$$net_{j^*k^*} = \min_{j \bullet k} \left[net_{jk} \right]$$

3. $$Y_{jh} = \begin{cases} 1 & \textbf{if } j=j^*\&k=k^* \\ \varphi & \textbf{others} \end{cases}$$

Computation process (cont.)

4. Update Weights

$\triangle W_{ijk} = \eta\ (X_i - W_{ijk})\ \cdot RF_{jk}$

When $RF_{JK} = e^{(-r_{jk}/R)}$

$r_{jk} = (N_{jk} - N_{j^*k^*})^2 = (j - j^*)^2 + (k - k^*)^2$

$W_{ijk} = \triangle W_{ijk} + W_{ijk}$

5. Repeat 1-4 for all input

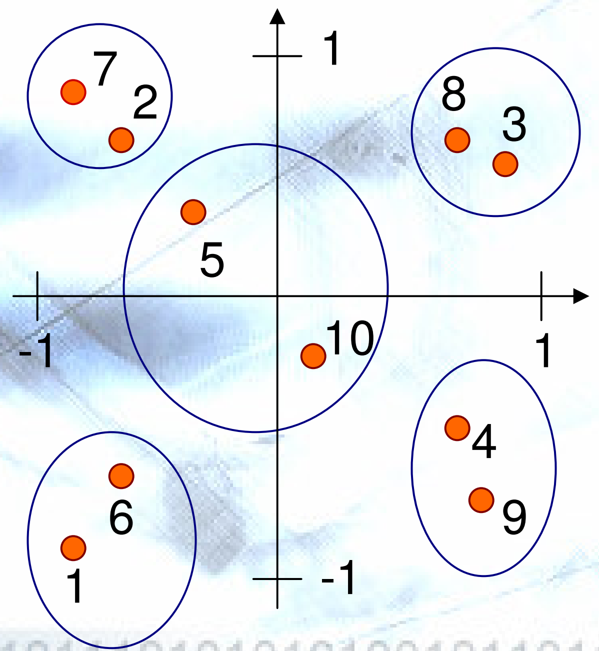
6. $\eta^n = \eta\text{-rate} \cdot \eta^{n-1}$ $R^n = R_{\text{-rate}} \cdot R^{n-1}$

7. Repeat until converge

Example

- Let there be one 2-Dim clustering problem.
- The vector space include 5 different clusters and each has 2 sample sets.

	X1	X2
1	-0.9	-0.8
2	-0.8	0.6
3	0.9	0.6
4	0.7	-0.4
5	-0.2	0.2
6	-0.7	-0.6
7	-0.9	0.8
8	0.7	0.6
9	0.8	-0.8
10	0.1	-0.2



Solution

①Setup an 2X9 network

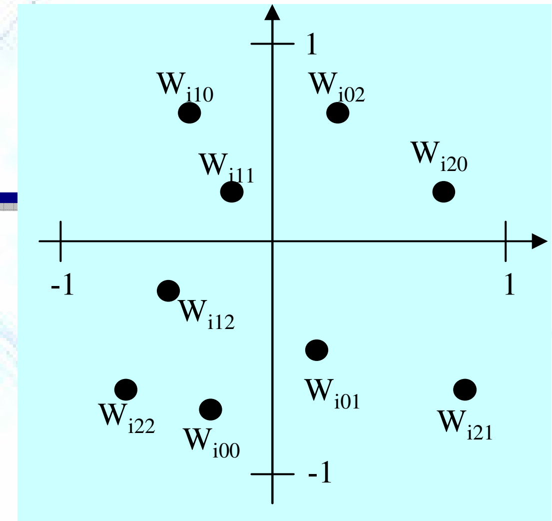
②Randomly assign weights

③Let R=2.0 η =1.0 $RF_{jk} = e^{\frac{-rj}{R}}$

④代入第一個pattern[-0.9, -0.8]

- $net_{00}=[(-0.9+0.2)^2+(-0.8+0.8)^2]=0.49$
- $net_{01}=[(-0.9-0.2)^2+(-0.8+0.4)^2]=1.37$
- $net_{02}=[(-0.9+0.3)^2+(-0.8-0.6)^2]=2.32$
- $net_{10}=[(-0.9+0.4)^2+(-0.8-0.6)^2]=1.71$
- $net_{11}=[(-0.9+0.3)^2+(-0.8-0.2)^2]=1.36$
- $net_{12}=[(-0.9+0.6)^2+(-0.8+0.2)^2]=0.45$
- $net_{20}=[(-0.9+0.7)^2+(-0.8-0.2)^2]=1.04$
- $net_{21}=[(-0.9-0.8)^2+(-0.8+0.6)^2]=2.93$
- $net_{22}=[(-0.9+0.8)^2+(-0.8+0.6)^2]=0.05$ 【MIN】

$\min_{j,k}[net_{jk}] \longrightarrow net_{22}$ **Winning Node**



	X1	X2
W_{i00}	-0.2	-0.8
W_{i01}	0.2	-0.4
W_{i02}	0.3	0.6
W_{i10}	-0.4	0.6
W_{i11}	-0.3	0.2
W_{i12}	-0.6	-0.2
W_{i20}	0.7	0.2
W_{i21}	0.8	-0.6
W_{i22}	-0.8	-0.6

Solution (cont.)

⑤Update weight

j*=2 k*=2

$$r_{00}=\sqrt{(0-2)^2+(0-2)^2}=2.282$$

$RF_{00}=0.243$

$$r_{01}=\sqrt{(0-2)^2+(1-2)^2}$$

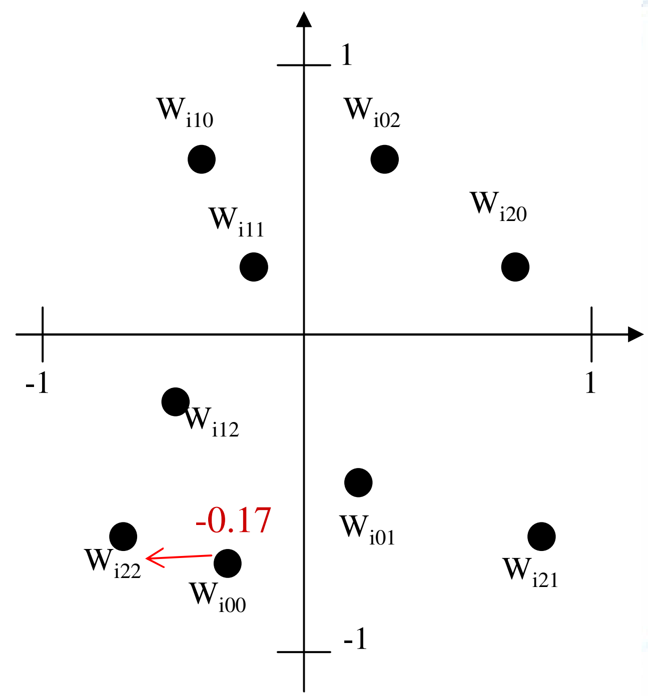
$RF_{01}=$

$$r_{02}=\sqrt{(0-2)^2+(2-2)^2}$$

⋮

$$r_{22}=\sqrt{(2-2)^2+(2-2)^2}=\phi$$

$RF_{22}=1$



$$\triangle W_{00}=\eta \cdot (X_1-W_{00}) \cdot RF_{00}$$

$$1.0\times(-0.9+0.2)\times(0.243)=-0.17$$