Artificial Neural Networks
Laboratory 9: **Self-Organizing Maps**

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1 Overview

This laboratory includes 3 tasks regarding self-organizing maps. Those tasks require the implementation of three Kohonen maps.

The learning algorithm

Algorithm 1 Training Kohonen Networks

Require: training data set $\mathbf{X}$, functions η (learning rate), ϕ (neighbourhood)
Ensure: weights $\mathbf{W}$

```
1: W ⟵ random(0, 1)
2: t ⟵ 1
3: repeat
4:    randomly choose x_i ∈ X
5:    w_z ⟵ argmin_{w∈W} Distance(w, x_i)
6:    for all w_j ∈ W do
7:       w_j ⟵ w_j + η(t)φ(w_z, t)(x_i − w_j)
8:    end for
9:    t ⟵ t + 1
10: until maximum number of iterations has been reached
```

Use a Gaussian function for the topological neighbourhood:

$$h_{j,i}(\mathbf{x}) = h_{j^*,i} = e^{-\frac{d_{j^*,i}^2}{2\sigma^2}}$$

Decrease the *width* of the neighbourhood with time:

$$\sigma(n) = \sigma_0 e^{-\frac{n}{\tau}}$$

Decrease the *learning rate* with time:

$$\eta(n) = \eta_0 e^{-\frac{n}{\tau_\eta}}$$

2 First task: Unidimensional lattice

In this first example you will have to generate a data set of bidimensional vectors. Build the data set by uniformly generating vectors from $(0, 1)\times(0, 1)$. Use that data set to train a self-organizing map composed of N neurons on a uni-dimensional lattice.

Plot the neurons with the connections between them as in this example from Haykin.

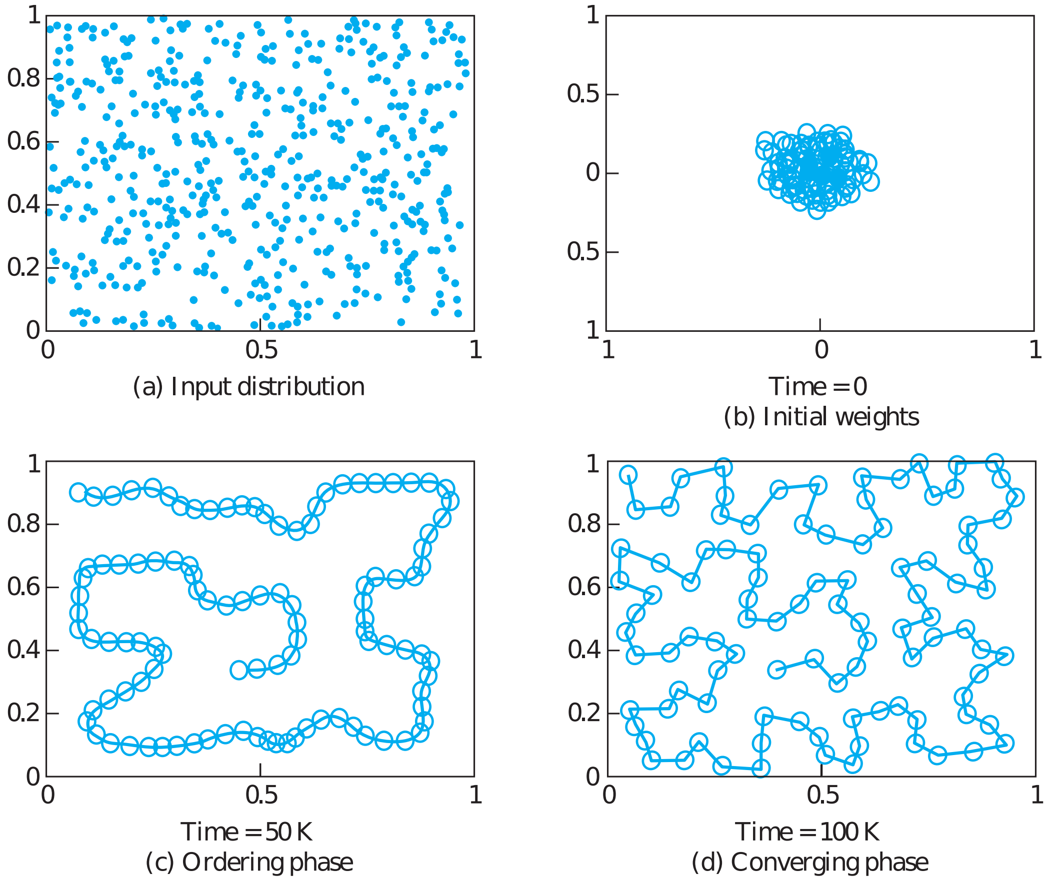

FIGURE 9.9 (a) Distribution of the two-dimensional input data. (b) Initial condition of the one-dimensional lattice. (c) Condition of the one-dimensional lattice at the end of the ordering phase. (d) Condition of the lattice at the end of the convergence phase. The times included under maps (b), (c), and (d) represent the numbers of iterations.

3 Second task: Bidimensional lattice

Repeat the experiment from the first task for a bidimensional lattice.

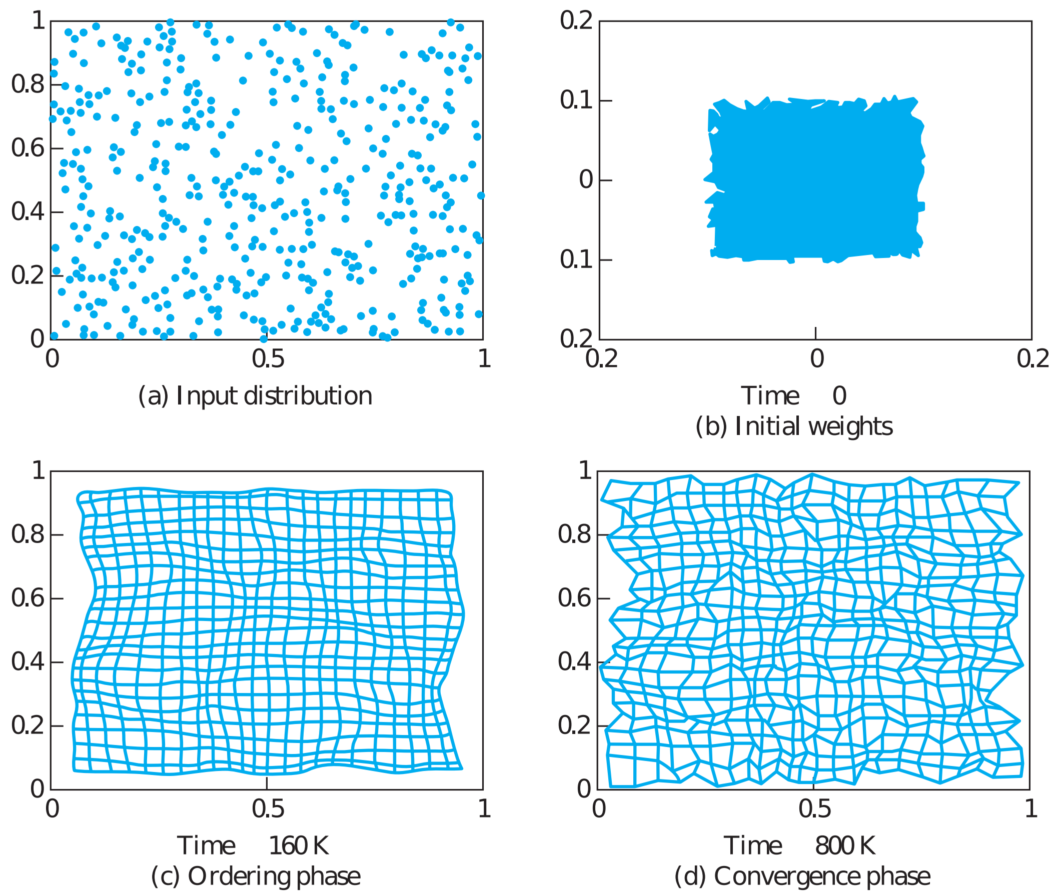

FIGURE 9.8 (a) Distribution of the input data. (b) Initial condition of the two-dimensional lattice. (c) Condition of the lattice at the end of the ordering phase. (d) Condition of the lattice at the end of the convergence phase. The times indicated under maps (b), (c), and (d) represent the numbers of iterations.

4 Third task: Image compression

Take an image and use a self-organizim map to segment it and eventually compress it to a lower dimensional color space.

Consider the input space to be the 3D RGB color space. Train a self-organizing map with $N \times N$ neurons to get a projection of the input space onto a set of $N \times N$ colors.

Transform the original image into a new one by replacing each pixel with the value of the closest neuron. The new image should have only $N \times N$

colors.

Figure 1: Original image: `1.jpg`

Figure 2: Image after segmentation `1.jpg`