Tik-61.261 Principles of Neural Computing

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Exercise 2

1. The error-correction learning rule may be implemented by using inhibition to subtract the desired response (target value) from the output, and then applying the anti-Hebbian rule. Discuss this interpretation of error-correction learning.

2. Figure **??** shows a two-dimensional set of data points. Part of the data points belongs to class C_1 and the other part belongs to class C_2. Construct the decision boundary produced by the nearest neighbor rule applied to this data sample.

3. A generalized form of Hebb's rule is described by the relation

$$\Delta w_{kj}(n) = \alpha F(y_k(n))G(x_j(n)) - \beta w_{kj}(n)F(y_k(n))$$

   where $x_j(n)$ and $y_k(n)$ are the presynaptic and postsynaptic signals, respectively; $F(\cdot)$ and $G(\cdot)$ are functions of their respective arguments; and $\Delta w_{kj}(n)$ is the change produced in the synaptic weight w_{kj} at time n in response to the signals $x_j(n)$ and $y_j(n)$. Find the balance point and the maximum depression that are defined by this rule.

4. An input signal of unit amplitude is applied repeatedly to a synaptic connection whose initial value is also unity. Calculate the variation in the synaptic weight with time using the following rules:

   (a) The simple form of Hebb's rule described by

$$\Delta w_{kj}(n) = \eta y_k(n)x_j(n)$$

   assuming the learning rate $\eta = 0.1$.

   (b) The covariance rule described by

$$\Delta w_{kj} = \eta(x_j - \overline{x})(y_k - \overline{y})$$

   assuming that the time-averaged values of the presynaptic signal and postsynaptic signal are $\overline{x} = 0$ and $\overline{y} = 1.0$, respectively.

5. Formulate the expression for the output y_j of neuron j in the network of Figure **??**. You may use the following notations:

$$\begin{aligned}
x_i &= i\text{th input signal} \\
w_{ji} &= \text{synaptic weight from input } i \text{ to neuron } j \\
c_{kj} &= \text{weight of lateral connection from neuron } k \text{ to neuron } j \\
v_j &= \text{induced local field of neuron } j \\
y_j &= \varphi(v_j)
\end{aligned}$$

   What is the condition that would have to be satisfied for neuron j to be the winning neuron?

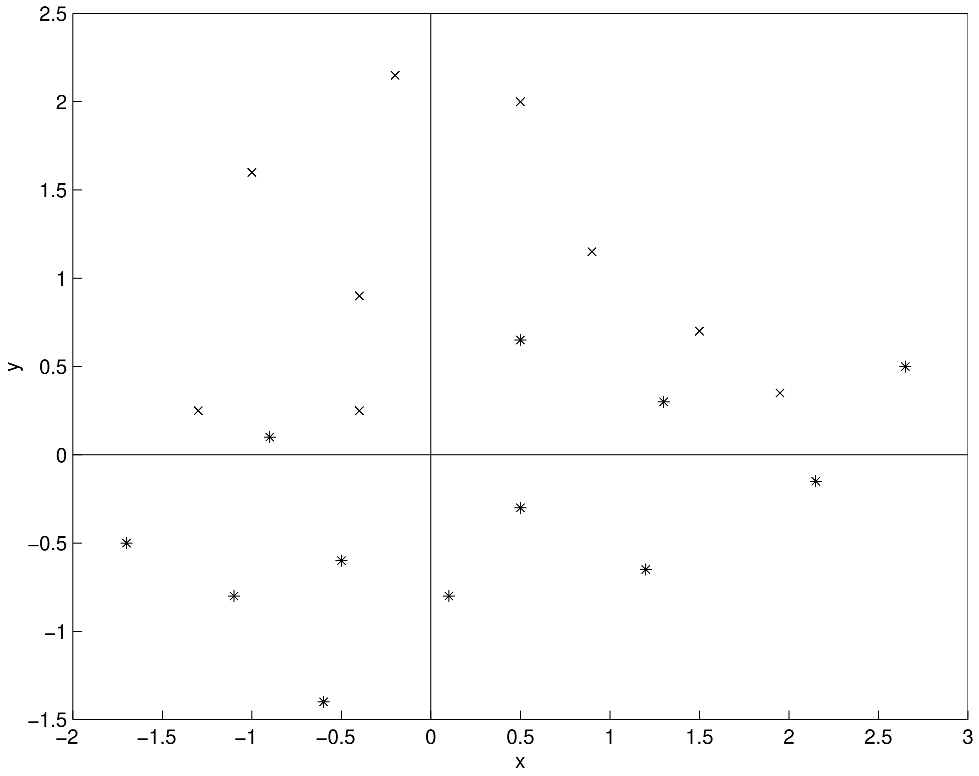

Figure 1: Data point belonging to class C_1 and C_2 are plotted with 'x' and '*', respectively.

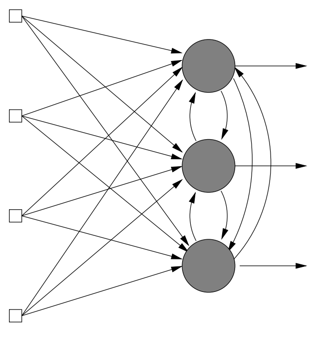

Figure 2: Simple competitive learning network with feedforward connections from the source nodes to the neurons, and lateral connections among the neurons.