

CSE 5526 - Autumn 2014

**Introduction to Neural Networks**

**Homework #4**

Due Tuesday, Nov. 25

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**Problem 1.** For a winner-take-all network with 5 neurons, the function of each neuron is defined as

$$y_i(t + 1) = \varphi \left( (S - 1)y_i(t) - \sum_{j \neq i} y_j(t) \right)$$

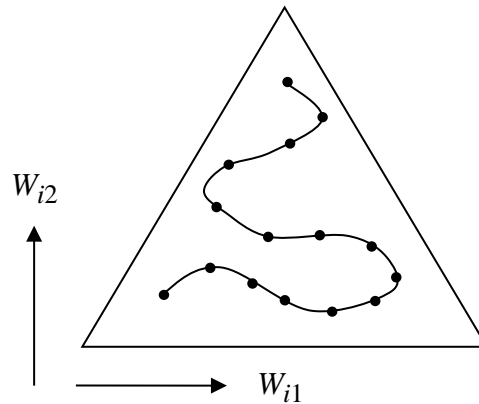
where  $S$  is the number of output neurons, and the activation function is defined as

$$\varphi(x) = \begin{cases} 0 & \text{if } x < 0 \\ x & \text{if } 0 \leq x \leq 1 \\ 1 & \text{if } x > 1 \end{cases}$$

The above network receives the input vector at time step 0,  $\mathbf{x}^T = (0.2, 0.2, 0.3, 0.4, 0.3)$ . Find the network output at time step 1 and 2.

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**Problem 2.** The following figure shows the final weight vectors of a self-organizing map that has been trained on two-dimensional input vectors which were drawn from a uniform distribution over the triangular area. Lines between units (represented by dots) connect topological neighbors. Draw the diagram of the network that has undergone such self-organization. Specify the elements of the network and their connections (no detailed values are needed).



**Problem 3.** Consider a Hopfield network made up of five neurons, which is required to store the following three fundamental memories:

$$\xi_1 = [+1, +1, +1, +1, +1]^T$$

$$\xi_2 = [+1, -1, -1, +1, -1]^T$$

$$\xi_3 = [-1, +1, -1, +1, +1]^T$$

- Evaluate the 5-by-5 synaptic-weight matrix of the network.
- Use asynchronous updating to demonstrate that all three fundamental memories,  $\xi_1, \xi_2, \xi_3$  satisfy the alignment condition
- Investigate the retrieval performance of the network when it is presented with a noisy version of  $\xi_1$  in which the second element is reversed in polarity
- Write down the energy function in terms of  $x_i$ s.