

# ECE/CS 559 Neural Networks, Fall 2018 - Homework #6

Due: 11/06/2016, the end of class.

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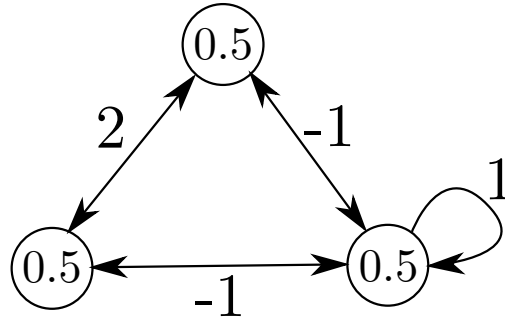
All the notes in the beginning of Homework #1 apply. As usual, please include the computer codes in your report.

1. **(0pts)** Let  $\phi(x) = 1$  if  $x \geq 0$ , and  $\phi(x) = -1$  if  $x < 0$ . Consider some  $\mathbf{x}_1, \dots, \mathbf{x}_n \in \{-1, +1\}^m$ . In associative memory, we have designed the synaptic weight matrix as  $\mathbf{W} = \sum_{i=1}^n \mathbf{x}_i \mathbf{x}_i^T$ . Suppose that there exists  $\mathbf{z} \in \mathbb{R}^m$  that satisfies the following properties:

- $\mathbf{z} = \phi(\mathbf{W}\mathbf{z})$ .
- For any  $i \in \{1, \dots, n\}$ , we have  $\mathbf{z} \neq \mathbf{x}_i$  and  $\mathbf{z} \neq -\mathbf{x}_i$ .

In class, we have called  $\mathbf{z}$  a spurious memory pattern. We never gave an example of  $\mathbf{x}_1, \dots, \mathbf{x}_n$  that results in the existence of a spurious pattern. Find such an example and show your work. You may use computer search.

2. **(100pts)** Consider the Hopfield network below. The activation function is, as usual,  $\phi(x) = 1$  if  $x \geq 0$ , and  $\phi(x) = -1$  if  $x < 0$ .



Draw the state transition diagrams (with energy levels) for both synchronous and asynchronous update rules. Indicate the urstate(s) and the steady state(s) of the network.