Assignment 3
Theoretical Neuroscience

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Due 24 October, 2014

1. **Hebbian convergence**
   Consider a pure Hebbian learning rule driven by anticorrelations, with $\dot{\mathbf{v}} = \begin{pmatrix} 1 & -a \\ -a & 1 \end{pmatrix} \mathbf{v}$, where $a > 0$. If hard constraints are imposed such that $0 \leq v_1, v_2 \leq 1$ (by suppressing changes in just the variable(s) that would lead outside these bounds), derive the range(s) of initial values of $\mathbf{v}$ that will end up at $\mathbf{v} = (1, 1)$. What happens if you change the learning rate (i.e., the time-constant of the differential equation)?

2. **Oja's rule and Multiplicative normalization**
   Oja's rule performs dynamic normalization of the norm of the weights, so that $|\mathbf{w}(t)|^2 \to 1/\alpha$ as $t \to \infty$. Write down a multiplicative normalization term that makes $d|\mathbf{w}(t)|^2/dt = 0, \forall t$. Simulate the rule and compare it with the Oja rule - are the outcomes the same?

3. **Levels of understanding - a computational analysis**

   a) Read Marr's and Poggio's Levels of Understanding.

   b) Write a short (∼half page) computational analysis of a system of your choice, in the style of *Examples of computational theories (page 7-9)*.