CN 530: Neural and Computational Models of Vision

Simulation Assignment 1

Note: No part of this assignment involves numerically solving the dynamics of any system of differential equations. Only equilibrium solutions, algebraicly computed, are required.

Item 1: Non-distance dependent shunting network

Part a) Consider the shunting network:

$$\frac{dx_i}{dt} = -Ax_i + (B - x_i)I_i - x_i \sum_{k \neq i} I_k$$

By choosing specific values for *A* and *B,* and using systematically increasing values for

$$L = \sum_{k \neq i} I_k$$

(e.g. 10, 100, 1000 ... or 500, 600, 700 ...), produce a plot of the shift property, *carefully labeling* quantities on axes and the background level associated with each curve. (Remember, shifts shrink for *linear L* increases.)

Part b) Produce a similar plot for the network:

$$\frac{dx_i}{dt} = -Ax_i + (B - x_i)I_i - (x_i + C) \sum_{k \neq i} I_k \quad .$$

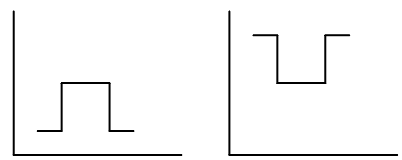
where *C* is a positive constant, and describe how the graph supports Grossberg's statement, “Thus the shift improves, rather than deteriorates, at the larger intensities *M* which might have been expected to cause saturation”. (Grossberg, 1983, p. 640, top of left column; also appears on page 30 of *The Adaptive Brain, II)*. You may have to rescale your original plot and/or change parameters to observe this effect by your “naked eye.” Getting the plot to look obvious to the naked eye is part of what you will be graded on! (The statement says that, with the addition of the hyperpolarizing term, *C,* the *S* curves are no longer parallel, but that they are more nearly parallel at larger intensities than at smaller ones.)

Item 2: Brightness contrast in simple network

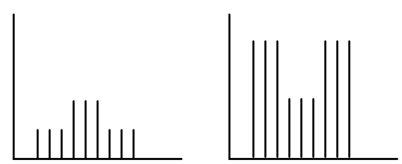
Take the equation given in problem (1a) and calculate the amount of increment (decrement) in the response of a network node whose "receptive field" is in the center region of a brightness contrast display, as the surround luminance is varied below (above) that of the center. Calculate equilibrium responses directly, using simple algebraic equations (as opposed to computing the temporal dynamics by integrating the differential equation numerically.) The situation you are to simulate is depicted in three ways below:

(a) pictorial

(b) plot of cross-section of
luminance



(c) discrete luminance inputs
where each pattern depicts
inputs to a nine-node network



Note that to do this problem, you are not required to use exactly nine nodes as shown in Figure 1c. The desired contrast effect can be shown for a variety of network configurations. When writing your report, be sure to specify precisely what you did, what happened, and why. Discuss your results in terms of the argument of Grossberg, S. (1982). Why do cells compete? UMAP Unit 484, **The UMAP Journal**, Vol III, No. 1. (Education Development Center, 0197-3622/82/010101.)

Item 3: Local vs. global normalization

Describe what happens when *both* of the patterns in Figure 1c are simultaneously presented "side by side" to the *same* network (say, having 18 nodes), and *why?* What do these results imply about the validity of the equation of Problem 1a for modeling the phenomenon of brightness contrast? In answering this last question, consider both the strengths *and* the weaknesses of using this equation to "model" brightness contrast.