CN 530 Neural and Computational Models of Vision

Simulation Assignment 3

The theme of this assignment is *boundary-gated diffusion.* The problem statement is *deliberately* "open-ended," (not to say vague), as befits an exploration of a currently debated topic in the field, about which no consensus among experts exists.

Note carefully: The simulations asked for are all "1-D," so computational load should not be excessive. You are actively encouraged to consult the course TF concerning the relative merits of simulation speed vs. ease of development for such options as (1) your own C code vs. (2) MatLab. You can use the same software you used for Assignment 2 to generate FCS inputs and (with minor modification) BCS inputs, so implementation of the diffusion equations represents the major novelty. The requirements of your simulations are:

Item 1: Replication of simple filling-in simulation.

Replicate two of the simplest G & T 1988 simulations, specifically those whose results are plotted in Figures 14a and 14b. By "replicate" is meant "solve for equilibrium" the pertinent equations. *I will leave it up to you* whether to employ exactly the published parameters, simulation resolution, and so forth, or whether to use other parameters and resolutions that give qualitatively similar results. **Note 1:** You should solve all stages other than the diffusion stage at equilibrium; that is, do *not* numerically integrate those equations. **Note 2:** If you have access to software for solving the diffusion stage at equilibrium -- effectively requiring the inversion of a large, banded matrix to solve simultaneous algebraic equations -- you may use it. **Note 3:** If you choose to numerically integrate the diffusion equations, *consult the teaching fellow before proceeding, and see Note 5 in this paragraph*. If the time you have devoted to this step of Item 1 exceeds four hours, consult the teaching fellow. You are also welcome to approach the teaching fellow, in any case, *before* this "milestone" is achieved! Note 3 is included as a disclaimer against allegations of "injury" on the part of anyone experiencing difficulties. **Note 4:** You *do not have to* numerically integrate the diffusion equation, as reasonable results can be obtained in the present case by a relaxation approach: In the first iteration, solve for the "equilibrium" of each node based on the inputs -- from Levels 2, 5, and 6 -- to that node. After all nodes have been solved for, repeat the procedure with "new" input values for Level 6 nodes, based on the results of the first step, etc. In other words, solve Eq. 25 from Grossberg and Todorović (1988) repeatedly for each S_{ij}, using the S_{pq} values from the previous time step for each iteration. This calculation should be carried out until the maximum change across all S_{ij}, nodes falls below some criterion in a given iteration. **Note 5: If you have a particular interest in performing a numerical solution of ordinary differential equations, either because you want the practice or because you want to observe the temporal dynamics of the boundary-gated diffusion process – that is, to see what the state of the system looks like at times before equilibrium – then contact me before proceeding. Experience with solutions of "stiff" systems of equations is a plus for this option.** We can negotiate some substitutions in the assignment statement, whereby you skip some of the parts in this assignment statement, in favor of a greater exploration of the system's temporal aspects. **Note 6:** Some of you may see narrow peaks in your simulation output, sticking up from each side of a "plateau," in the form of a "Batman" profile; others of you may not. It is not the case that either of these outcomes is correct and the other incorrect. Do try, however, to understand what aspects of parameter choices or simulation technique may be responsible for what you observe.

Item 2: Brightness ramps

Try to demonstrate *some* combination of inputs and parameters that yields a "noticeable" brightness gradient at equilibrium in the shape of a *ramp*, i.e. a sloping line. If the sloping line also curves a bit, that's okay. That is, the resulting plot is *not* composed entirely of horizontal plateaus and sharp steps between plateaus, but contains some smooth drop from a high to a low level over space. **Note:** The combination of inputs and parameters required to do this with the G & T, 1988 formulation *may* seem "implausible" in order to achieve this end in a way that is visible to the naked eye in your plots. If you find that you cannot accomplish this in a reasonable time (i.e. two hours of trying, assuming that you *did* get part 1 to work), then simply "write up" an explanation of *why* this task is tricky with the G & T, 1988 system.

Item 3: Retinex

Implement a "1-D" achromatic version of the Retinex algorithm and run it on the same inputs that you used for Item 1 of this assignment. Discuss the similarities or differences in the results achieved by the Retinex algorithm as compared with the G & T model. Note that whether the two approaches give similar outputs for the COCE illusion or not depends on exactly how you choose the inputs and the parameters of the models, so it is up to you to describe clearly what your plots show and why!