

### Exercise 3 (due 3/7/07)

Simulate a line attractor network for a population of 64 neurons with bell-shape tuning curves:

$$f_i(s) = A \exp(K \cos(s - s_i)) + b \quad (1)$$

Use  $A=0.0131$ ,  $b=1$  and  $K=8$ . Make sure to express  $s$  in radians. Assume that the noise is independent across neurons and follows a Gaussian distribution with fixed variance ( $\sigma^2=25$ ). (you should be able to recycle your code from the previous homework)

Use the following mapping:

$$u_i(t + \Delta t) = \left(1 - \frac{\Delta t}{\tau}\right) u_i(t) + \frac{\Delta t}{\tau} \sum_{j=1}^{64} w_{ij} o_j(t)$$

$$o_i(t) = h(u_i(t))$$

$$h(x) = a \left( \ln(1 + \exp(b(x + c))) \right)^\beta$$

$$\frac{\Delta t}{\tau} = 0.3, \beta = 0.8, b = 10, c = 0.5, a = 6.34$$

- 1- Plot a representative tuning curve and the activation function  $h$ .
- 2- Compute and plot the weights to obtain a line attractor corresponding to hills with the appropriate profile (that is, the activities  $o_i$  should be close to  $f_i$ , as specified by equation 1). Use the equation:  $\tilde{W} = \left( \tilde{U} \tilde{O} / \left( \lambda + |\tilde{O}|^2 \right) \right)$ , where  $\tilde{W}$ ,  $\tilde{O}$  and  $\tilde{U}$  are Fourier transforms and  $\lambda=1734$ .
- 3- Start the network with a random pattern of activity and verify that it converges to a stable hill of activity (500-1000 iterations should suffice). Plot the activity over time for one trial.
- 4- Verify that the network is indeed stable for any (i.e. many) position of the hill.
- 5- Add a small amount of noise to the weights (+/-10% of their maximum value) and test whether the network is still stable everywhere. This can be tested by initializing the network with a smooth hill (from equation 1) and testing whether the hill drifts.

- 6- Generate 10000 hills of activity (using equation 1 above) corrupted by Poisson noise and use them as initial conditions for the line attractor network. Compute the peak position of the smooth hill of activity at the end of relaxation on each trial using a center of mass estimator. Compute the mean and variance of the peak position and compare to the Cramer-Rao bound (see previous homework). You should get a variance within 10% of the Cramer-Rao bound.