

**Instructions.** Solve the following three exercises.

## 1 Response of the motion-energy model to moving gratings

Compute and plot the responses  $R(t)$  of the following two complex cell models to a 1-dimensional sinusoidal grating drifting in their receptive field. The response of complex cell 1 is obtained by squaring the response  $g_e(x, t)$  and adding the squared response of the corresponding odd filter  $g_o(x, t)$  (see exercises 1 and 2 of the previous assignment). The response of complex cell 2 is obtained in the same way, but using  $g_e^-(x, t)$  and the corresponding odd filter  $g_o^-(x, t)$ . Use the same grating (right or left motion) and simulation parameters as in exercise 2 of the previous assignment. Compare the results with those of exercise 2 in the previous assignment and explain the differences (see exercises 1 and 2 of the previous assignment for hints).

## 2 Determination of LGN neuron receptive field by reverse-correlation

**a.** Plot the temporal transfer function of an LGN X-cell with  $\nu_c = 5.5$  Hz.

**Hints.** Use the eq. 15.14 given in the "Firing rate codes and early vision" chapter. Normalize the peak value to 1. Use a step of 1 msec and plot up to 350 msec.

**b.** Plot the gain of this transfer function in the frequency domain. Use both linear and semilogarithmic axes.

**Hints.** Use eq. 15.15. Normalize the peak value to 1. Use a step of 0.1 Hz and plot up to 50 Hz.

**c.** Generate a spike train simulating the temporal response of an LGN neuron to a "white noise" stimulus (up to a cut-off frequency of 500 Hz) according to an inhomogenous Poisson process with a mean firing rate of 50 spk/sec.

**Hints.** The sampling interval in the time domain corresponding to 500 Hz cut-off frequency is  $\Delta t = 1$  msec. Use the function `normrnd(0,1,l_vect)` to generate a gaussian random vector. Generate 25 sec of data (i.e.,  $l_{vect} = 25000$ ). Now that you have your stimulus vector, filter it with the LGN transfer function of **a** (using `conv`). Rescale the result (i.e., multiply by a constant factor) so that it has a minimal value of -50 (in units of spk/sec) and then add 50 to obtain a time-varying firing rate vector with mean of 50 (spk/sec). Feed this signal through a inhomogeneous Poisson spike generator and integrate with a time step of 1 msec. You should obtain approximately 1250 spikes out (25 sec times 50 spikes/sec).

**d.** Compute an estimate of the LGN transfer function by reverse correlation with the stimulus. Compare with the transfer function of **a**. Can you explain why the estimate is so noisy?

**Hints.** Loop through the spikes generated in **c** and add the corresponding stimulus values up to 350 msec prior to a spike. Plot the corresponding transfer function (with a peak value normalized to 1) and the original LGN filter of **a** in the same figure.

**e.** Repeat **c** and **d** but use random noise of cut-off frequency of 25 Hz. Can you explain the difference with **d**?

**Hints.** Since 25 Hz cut-off frequency corresponds to a temporal sampling of 20 msec, generate a new random vector of length  $l_{vect}/20 = 25000/20$  elements. Call this random vector  $new_{stim}$ . Use `resample(new_stim, 20, 1)` to generate a sampling resolution of 1 msec. Read the MATLAB help for the `resample` function to understand what happens. Then proceed exactly as above.

### 3 ROC analysis for Poisson distributed spikes

Assume that a motion sensitive and direction-selective neuron responds to motion in its preferred direction with a discharge rate of 50 spk/sec and has a response (equal to the spontaneous discharge rate) of 30 spk/sec for motion in its antipreferred direction. Assume that spikes are distributed according to a Poisson distribution.

- a. What is the expected number of spikes in both cases if spikes are recorded over an interval of 200 msec?
- b. Compute and plot the probability distribution of spike numbers over an interval of 200 msec both in the case of spontaneous and evoked response (i.e., response to a moving stimulus in the preferred direction and antipreferred direction, respectively).

**Hints.** The Poisson spike number distribution is given in the "Quantal hypothesis and stochastic models of synaptic release" chapter. Take into account up to a maximum of 20 spikes in the interval.

- c. Compute the probability of false alarm and the probability of correct detection of the moving stimulus for each spike count (from 0 spikes to 20 spikes in the 200 msec interval). Plot the corresponding ROC curve.
- d. Compute and plot the error rate as a function of the probability of false alarm.