Computational Neuroscience: Assignment 4

The goal of this exercise is to combine the population code from A3, add an integration-to-bound decision stage, and compute reaction time distributions and psychometric curves. Model the decision-making stage by a hypothetical decision neuron accumulating the spikes received from the sensory neurons

$$d = \sum_{t=1}^{T} \mathbf{w}^\top \mathbf{r}(t) = \sum_{t=1}^{T} \sum_{i=1}^{N} w_i r_i(t).$$

Use weights $\mathbf{w}$ proportional to $\mathbf{f}(\phi_1) - \mathbf{f}(\phi_2)$ where ϕ_1 and ϕ_2 represent the two stimuli to be discriminated. When the decision variable d reaches a bound B, or when the 1 second-long stimulus is over, the corresponding decision is made. The time, when $|d|$ reaches B is the reaction time T. If $|d|$ never reaches B, then $T = 1$. (Suggestion: Use 10ms time bins.)

a) Assume a homogenous population code with uncorrelated Poisson-like response variability as in A3a. Plot the read-out weights $\mathbf{w}$ for a *vertical vs horizontal* (coarse) orientation discrimination task.

b) Plot d as a function of time for 10 example runs of the experiment. Assume $c = 0$ and $B = \infty$.

c) Slowly increase contrast c and plot 10 runs of d as a function of time for a value of c^* for which in *about* two thirds of all trials $d(T = 1) > 0$. (I.e. percent correct is about 2/3.)

d) Plot the psychometric function (percent correct as a function of contrast c) for 20 contrast values between 0 and $3c^*$. Simulate 1000 trials at each contrast level. Plot 1σ error bars (including 67% of the data). (Matlab command: errorbar. Also $\sigma = \sqrt{p(1-p)/n}$ for a Bernoulli distribution where p is percent correct and n is the number of trials.)

e) Find a value for the bound B for which about three quarter of the trials are decided at $T < 1$ at c^*. Plot the corresponding reaction time distribution.

f) Separate the trials into correct trials and incorrect trials, and plot a histogram over reaction times for each group (correct and incorrect).

g) Plot the psychometric function for this finite value of B and compare to the function in (d).

h) Plot the *median* reaction time as a function of contrast c for the same range of contrasts as in (d), separate for correct and incorrect trials.

Remember: Briefly summarize/interpret each plot.