Project 1: Spike latency coding

1) Implement the spike latency code described in Hopfield (1995). Note that Hopfield is vague about how exactly the input current is specified. To fill this gap, assume input current for neuron *j* is constant: $I_j(t) = I_j$. With a bit of algebra, you can solve for the constant input that yields a particular time advance τ_j : $I_j = I_0 + A[1 + \cos(2\,\pi f\ \tau_j)]$, where I_0, A, and f are the parameters of the subthreshold membrane potential oscillation, as described in the paper. Assume logarithmic coding of stimulus magnitude X with $\tau_j = \ln(X/\delta_j)$ for some neuron-specific scale factor δ_j (note that this is slightly different than what Hopfield wrote down, where δ is fixed and X is neuron-specific). Simulate this model with a population of neurons differing in the time advance to produce a latency code. Show how this latency code changes with stimulus magnitude (e.g., odor concentration).

2) Optimize a simple linear decoder to read out the stimulus magnitude from the latency code: $\hat{X} = \sum_j w_j \tau_j$, where the coefficients (w_j) are optimized by ordinary least squares based on training data with ground truth stimulus magnitudes. Show how the decoder behaves with different odor concentrations.

3) Discuss how this model relates to data from studies of mitral cells in the olfactory bulb (Schaefer & Margrie, 2007).

References:

Hopfield, J. J. (1995). Pattern recognition computation using action potential timing for stimulus representation. *Nature, 376*, 33-36.

Schaefer, A. T., & Margrie, T. W. (2007). Spatiotemporal representations in the olfactory system. *Trends in Neurosciences, 30*, 92-100.