**Chapter 1 – Neural Encoding I: Firing Rates and Spike Statistics**

In this chapter, we learned about the semi-randomness of neural activity, and how neuroscientists find meaning within this order by looking at averages and describing distributions rather than looking at individual trials.

**Delta function ∂(t – t0):** Used to represent the occurrence of a spike at time t0. = 0 at all times besides t0, and = 1/delta t at time t0, so as delta t becomes infinitesimal, its height goes to infinity, but the AREA UNDERNEATH ONE SPIKE IS ALWAYS ONE.

* Thus the integral of this over a time interval [a,b] gives the number of spikes that occurred in that interval

**Trial averaged firing rate:** Calculates the estimated firing rate at each time point in interval

* (sum of number of spikes at t0 across all trials) / (number of trials \* delta t)
  + delta t is the size of the time bins

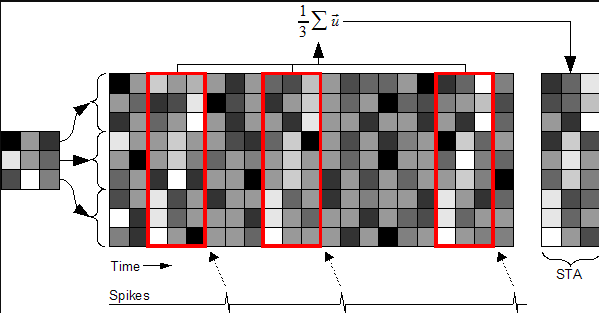
**Linear Filter:** Transforms data in a linear way.

**Kernel:** Used here to describe some sort of weighting function

**Tuning Curve:** Plots firing rate/response to stimuli vs stimuli values. Gives a good view of the range of stimuli values that the cell responds to, and which stimuli elicit the most powerful response.



**Spike Triggered Average (STA)**: Sometimes it’s hard to characterize what the stimulus actually was, as many of them are not single events but rely on a chain of conditions before a spike is triggered. In this case, we can look at windows of time immediately preceding the spikes, and average these together to find an averaged “spike triggering stimulus”. Conditions that are more important to the triggering of the spike will be more prevalent preceding the spike, and those that are unimportant will be averaged out across these many samples.



**Homogeneous Poisson Process (constant over time?)**: Statistical distribution used to simulate the randomness of neural activity. Varies about the mean with variance proportional to the mean (i.e. a higher mean firing rate will create a distribution with more variance).

* **Fano Factor:** variance/mean firing rate
  + =1 for Poisson; we ~1 in neuronal activity, but sometimes slightly higher
* **Inhomogeneous (**changes over time?)

**Independent Spike Code**: generation of each spike is independent of other spikes; information carried in the instanaeous firing rate r(t).

* Evidence suggests this is the most influential, but not necessarily sole, factor

**Correlation Spike Code:** generation of each spike is dependent on generation of other spikes in spike train; information is encoded not only in the firing rate, but also in the spacing of spikes

**Chapter 2 -- Neural Encoding II: Reverse Correlation and Visual Receptive Fields**

In this Chapter, we look at how we can estimate the firing rate of an arbitrary stimulus using reverse correlation to provide linear approximations, and techniques to provide nonlinear approximations as well. These topics are explored within the context of visual receptive fields.

**Reverse Correlation:** the “look back” approach; look at stimulus values preceding the spike several hundred ms, as it is likely the cumulative effect of all this activity that triggers a spike rather than a single instantaneous stimulus value.

* Creates a weighting function D(t) that gives different time points preceding a spike more value than others.
  + Can also have a spatial component D(t,x,y) where different spots in 2D/3D space have different preferences (e.g. ON/OFF ganglion)
* D(t) = average firing rate \* STA/ variance

**Most Effective Stimulus**:

* Stimulus energy held fixed?

What is so bad at about a linear approximation?

* It is not bounded; neuron can never saturate with activity
* It can become negative; a negative firing rate does not exist
* Neuronal activity is a nonlinear process

**Plot L(t) vs r(t) and find the function that sufficiently relates the two! This will be our nonlinear adjustment…**

**Maximum Likelihood Decoding (decision making)**

For every decision, simply choose the option that has the highest likelihood of occurring probalistically…

Error = P(ERROR | stim1)\*p(stim1) + P(ERROR | stim2)\*p(stim2)

**Introduction to Early Visual Systems**

* Rod/cone light receptors hyperpolarized 🡪 Bipolar cells (swaps hyper to depolarization) 🡪 retinal ganglion cells activated 🡪 Connect to form optic nerve
  + There exists both ON (activate in light) and OFF ganglion cells
* **NO FEEDBACK between eyes and LGN**
* Complex and Simple cells
  + **Simple cells**: sum linearly across spatial receptive fields; stimulus depends on location AND orientation
  + **Complex cells**: sums nonlinearly; stimulus only dependent on orientation

**The Retinotopic Map**

* Neighboring points in a visual image evoke activity in neighboring regions of visual cortex
  + Retinotopic map: map of transformation of coordinates of visual world to corresponding locations on brain/cortical surface
  + Objects located at a fixed distance from one eye lie on a sphere…
    - “north pole” lies at fixation point; where the center of retina is focused
    - sort of like polar coordinates…
      * e = distance from focal point radially (i.e. r)
      * A = angle above horizontal (i.e. theta)

**Visual Stimuli**

* Represented by a luminance (light intensity) at each point in space
  + Adapts to overall luminance level though, so we have to subtract out background luminance
    - Dividing this by the background luminance provides a dimensionless measure of **contrast**
* Parametrize the stimulus by describing its…
  + Orientation (angle below vertical)
  + Its angular frequency (how fast the stimulus oscillates)
  + Its contrast amplitude
  + K = spatial frequency?; related to contrast amplitude proportionally
* **The Nyquist Frequency**
  + Highest resolution of visual stimulus is at the fovea (focal point?) where cone photoreceptors are packed in a dense array…
  + The Nyquist Frequency describes the resolution of an array of tightly packed photoreceptors of size delta x; (maximum resolution?)
    - Aliasing = sampled points of spatial freqs K < Knyq and 2Knyq – K can be confused with each other because they match at periodic intervals, but THEY ARE NOT THE SAME GRAPHS.

**Reverse Correlation Methods: Simple Cells**

* Separability: If the kernel D(t), the weighting factor determined from reverse correlation (i.e. how much each part of a stimulus affects the firing rate), can be written as a product of two terms D(x,y,t) = Dspatial(x,y)Dtemporal(t).
  + Obviously, the weighting factor depends on both position and time. Think of the spatial component as representing different aspects of the stimulus.
  + D(x,y,t) can ONLY change by an overall multiplicative factor?
* Spatial Receptive Fields
  + Dspatial has both ON sections and OFF sections. If Dspatial(x,y) is negative (OFF SECTION), luminance values below background will INCREASE the firing rate. If Dspatial(x,y) is positive (ON SECTION), luminance values above background will INCREASE firing rate.
    - \THUS, neurons most reactive to light-dark edges that lie along this boundary between ON and OFF regions…