COMS30017 Computational Neuroscience

Week 3 Problem sheet

Video 1

- In your own words, what is a model?
- In computational neuroscience, what is the distinction between a biophysical model and a phenomenological model?
- Name two benefits and two disadvantages of abstract models compared to detail models.
- Name three types of single neuron model in common practice. What assumptions does each model carry?

Video 2

- Three key ion channel types in neurons are: sodium, potassium, and calcium. For each of these channel types, does the ion carry a positive or negative charge? And in each case, does the current flow inward to or outward from the cell?
- The dynamics of a simple two-state ion channel can be written as $\frac{ds}{dt} = (s_\infty - s)/\tau$. What does s_∞ and τ represent here?
- Name two functional ways point neuron models differ from dendritic neuron models.
- What is a dendritic spike? And in what functional ways is it different from an axonal/somatic action potential?

Video 3

- What physical component of the neuron does the capacitance term in the Hodgkin-Huxley model represent?
- Which of the following channel types is responsible for the upswing and downswing of the action potential in the HH model: potassium, calcium, sodium?
- What is the difference between the *m* and *h* gating variables in the HH sodium channel model?
- Sketch the shapes of the steady-state values of m, h, and n as a function of voltage on a piece of paper (without looking at the plots).
- Which of the three gating variables (m, h, and n) is the fastest?
- Name two ways in which the HH model is dissimilar to mammalian axons.

Video 4

- What is the difference between the Fano Factor and the Coefficient of variation (CV)?
- Fill in the blanks with “spike counts”, “inter-spike intervals”: the CV is usually applied to the ____ and the Fano Factor is usually applied to the ___.
- If someone gave you a plot of a peri-stimulus time histogram, what aspects about the neuron’s response would you be able to comment on, and what aspects would you have no information about?
- The equation for the spike-triggered average is: $S(\tau) = \frac{1}{N}\sum_{i=1}^{N} s(t_i - \tau)$. What does each term represent and why does it make sense to call this quantity a “spike-triggered average”?

Video 5

- Explain why neural decoding could be called “mind reading”.
- If someone told you that a signal had a $d' = 1$, what would that mean?
- For a signal detection task with baseline $\mathrm{P}(\mathrm{signal}) = \mathrm{P}(\mathrm{noise}) = 0.5$, derive the probability of a correct detection as a function of d'.
  [Derivation sketched here: http://www.scholarpedia.org/article/Signal-to-noise_ratio_in_neuroscience#Relationship_to_discriminability]
- Medical devices are one potential industrial application of neural decoding. Can you think of any more?