Research Interns: Assignment III

Active neuronal properties

1. Insert Hodgkin Huxley channels into a single compartmental neuronal model. Plot the f–I ("firing frequency" *vs*. "amplitude of current injected") curve for the neuron by varying the current amplitudes (**Hint**: Use the APCount point process to get the firing frequency automatically). With this as the base, do the following independently:

   (i) Vary the densities of the sodium and potassium channels (gnabar and gkbar);
   (ii) Vary R_m and C_m;
   (iii) Vary the reversal potentials for Na and K;
   (iv) Vary the diameters of the compartments;
   (v) Vary the temperature at which the simulations run.

   In each of the five cases, plot the f–I curves and the action potential waveform shape. Compare the f-I curve and the action potential shape across different parametric differences, and comment on each of the outcomes with respect to what you would expect from theory.

2. What are the effects of increasing/decreasing dt, the integration time constant, on a typical HH simulation, above. Provide waveforms for each case of dt, commenting on the importance of choosing the right dt. How does it compare with a similar exercise you did with passive models in the previous assignment?

3. *Active vs. passive backpropagation:* Connect a long dendrite to a somatic compartment (choose appropriate dimensions!). Insert Hodgkin Huxley channels only to the soma. Insert passive elements and compartmentalize the dendrite on the basis of computing the space constant at 100 Hz. Do the following, and comment on the outcomes by relating each of them to theory:

   (i) Initiate a single action potential at the soma by injecting a large current for a short duration (find out what duration works for your choice of morphological parameters, and conductance densities above — the goal is to get a single action potential!). Plot two graphs from these simulation outcomes for distances spanning the entire dendrite: (a) latency to reach action potential peak *vs.* distance from soma; (b) amplitude of action potential *vs.* distance from the soma (**Hint**: Use the minmax.mod file to automate this — that will give you both max amplitude as well as the time point at which that value is reached!).
   (ii) Vary R_a for both the compartments and repeat (i).
   (iii) Vary R_m and C_m for both the compartments and repeat (i).
   (iv) Insert Hodgkin Huxley channels into the dendrites and repeat (i)–(iii). Comment on propagation delay attenuation with such active backpropagation, and compare with the respective passive cases, linking them to theory.