Homework 1: Report

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Problem 1:

Problem Statement: The membrane potentials of a neuron was plotted against 1000 mili-seconds. The spiking models were based on Izhikevich's 2003 paper, specifically the Regular Spiking model. The neuron was modeled with a range of input dc-current amplitude, and graphs include I=1 (Fig 1a), I=10 (Fig 1b), I=20 (Fig 1c), I=30 (Fig 1d), I =40 (Fig 1e), and the mean firing rate per ms within the last 800ms of each simulation (Fig 1f).

Results:

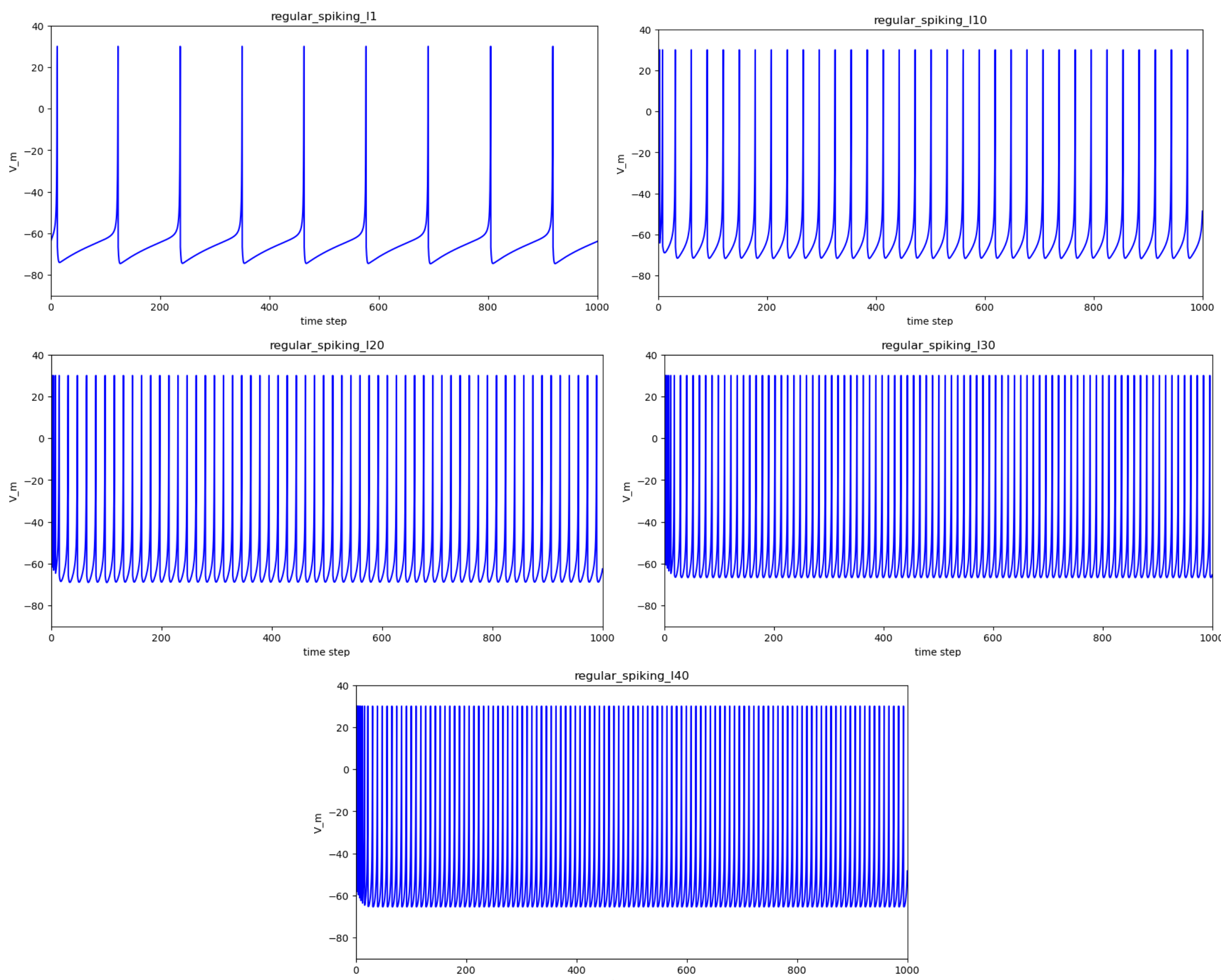

Figure 1: *Plot of membrane potential (mV) as a function of time (ms) with varying input current amplitude.* ***Fig 1.a*** *(top right): I = 1;* ***Fig 1.b*** *(top left): I = 10;* ***Fig 1.c*** *(middle right): I = 20;* ***Fig 1.d*** *(middle left): I = 30;* ***Fig 1.e*** *(bottom): I = 40.*

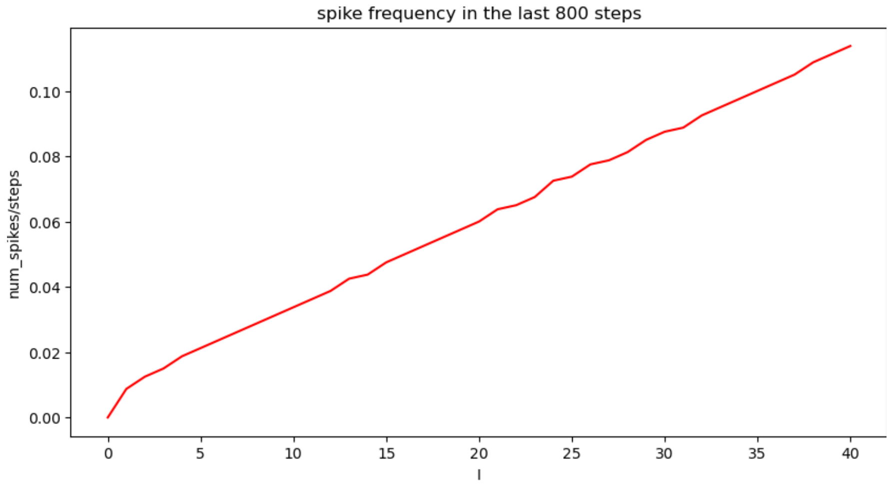

Figure 1f*: Plot of mean firing rate as a function of input I. The firing rate is calculated by averaging over the last 800 time steps of a 1,000 time step simulation.*

Discussion: We see that the more the input current amplitude increases the firings of neurons become more frequent. So the frequency of spikes correlates positively to the current amplitude entering the neuron. The neuron firing more will further excite or inhibit the neurons connected to its axon terminal, down the line. This will push the membrane potential of postsynaptic neurons over the threshold faster, causing them to fire too.

Problem 2:

Problem Statement: The same set up of graphs were plotted with the Fast Spiking neuron model. Plots include I=1 (Fig 2a), I=10 (Fig 2b), I=20 (Fig 2c), I=30 (Fig 2d), I =40 (Fig 2e), and the mean firing rate (Fig 2f).

Results:

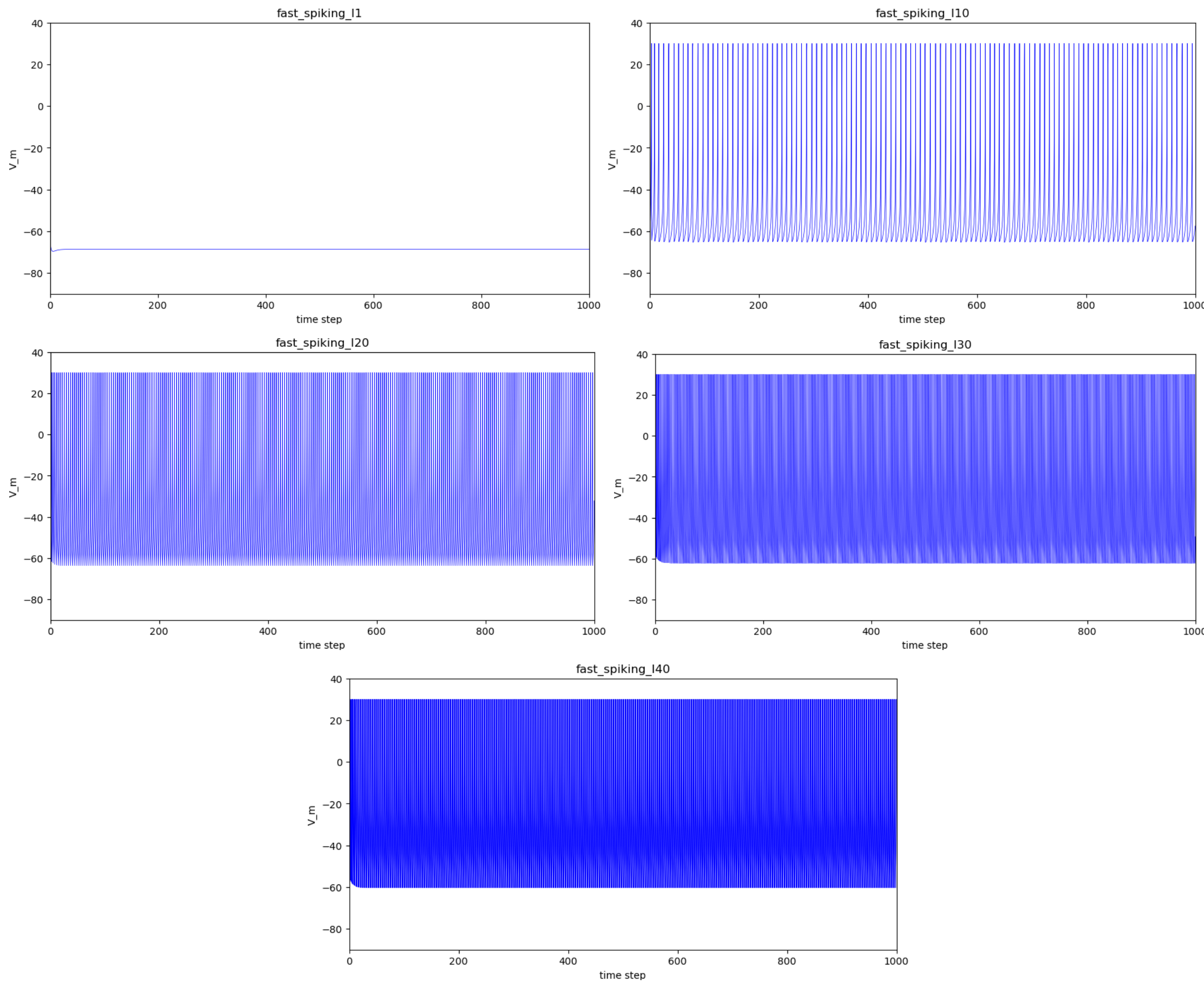

Figure 2: *Plot of membrane potential (mV) as a function of time (ms) with varying input current amplitude.* ***Fig 2.a*** *(top right): I = 1;* ***Fig 2.b*** *(top left): I = 10;* ***Fig 2.c*** *(middle right): I = 20;* ***Fig 2.d*** *(middle left): I = 30;* ***Fig 2.e*** *(bottom): I = 40.*

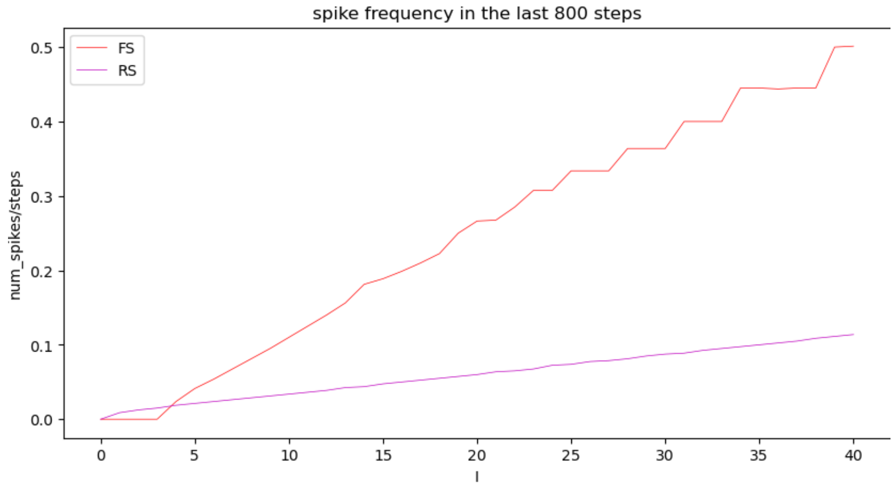

Figure 2f: *Plot of mean firing rate as a function of input I. The firing rate is calculated by averaging over the last 800 time steps of a 1,000 time step simulation.*

Discussion: We can see for the Fast Spiking model, R also correlates positively and even more with I than that for the Regular Spiking model. This makes sense, we did configure the neuron to have fast recovery, so it can fire more as the input current increases. We do see that for Fast Spiking as I increase, it may not always increase firing rate, given the horizontal segment of the line plot, but it does not seem to have plateaued yet.

Problem 3:

Problem Statement: 2 Chattering neurons were modeled, one excites the other, and the other inhibits the former one. Spiking models were modeled for both neurons against 1000ms, with 5 values to weights: W = 0 (Fig 3a), W=10 (Fig 3b), W=20 (Fig 3c), W=30 (Fig 3d), W=40 (Fig 3e).

Results:

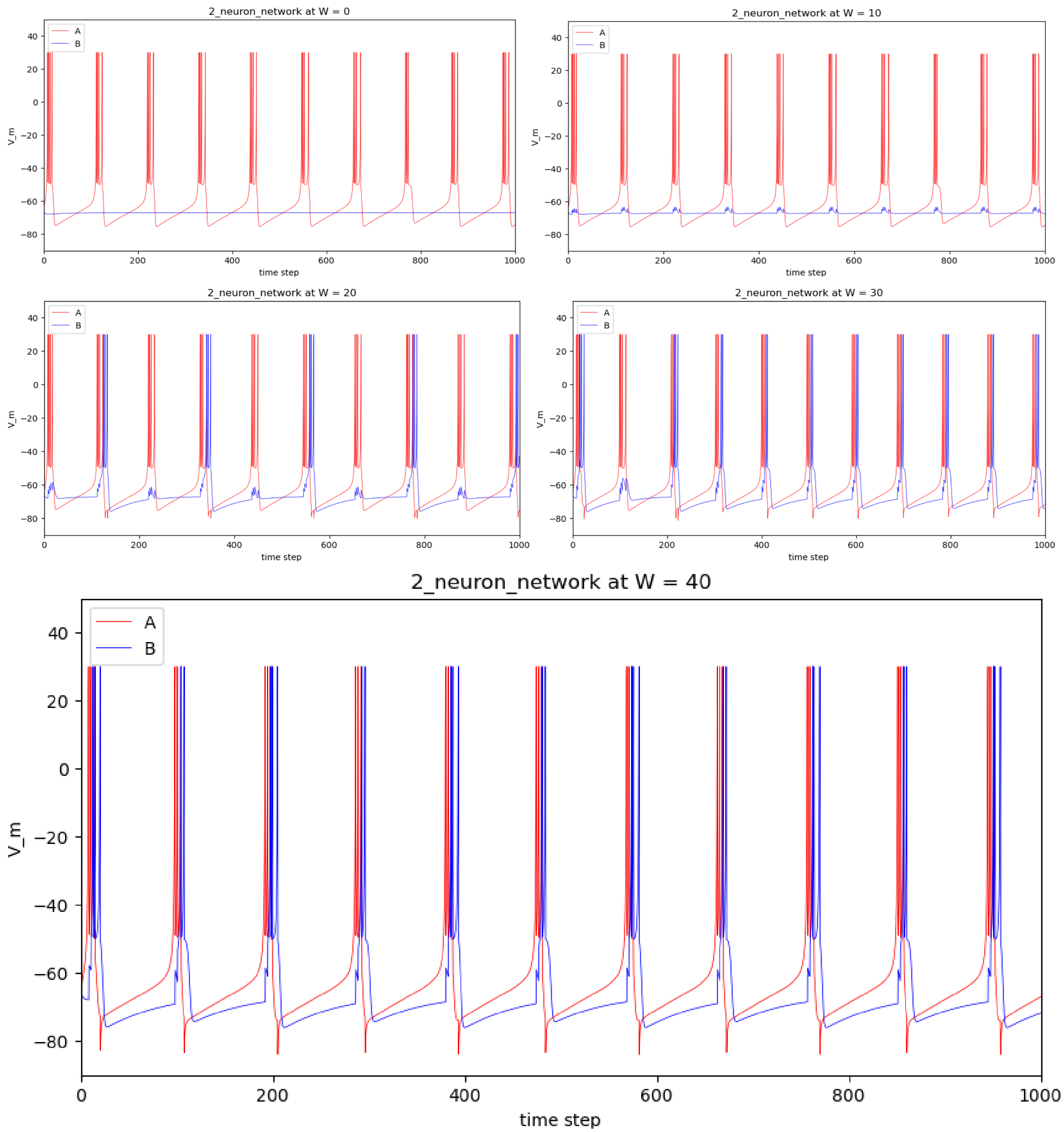

Figure 3: *Plot of membrane potential (mV) of 2 neurons as a function of time (ms) with varying weight values.* ***Fig 3.a*** *(top right): W = 0;* ***Fig 3.b*** *(top left): W = 10;* ***Fig 3.c*** *(middle right): W = 20;* ***Fig 3.d*** *(middle left): W = 30;* ***Fig 3.e*** *(bottom): W = 40.*

Discussion: For W = 0, neuron A fires the pattern as expected of the Chattering model, while neuron B does not fire at all. And as W increases, A retains the same patterns, as B's membrane potential increases in value and firings become more frequent, eventually to have the same spike frequency as A. Though B inhibits A, A fires with consistency across all weight values, while the more A excites B, B fires more frequently and eventually matches A.