Biological Electrochemical Activation for InFoMM C++ training

The FitzHugh-Nagumo model

$$\frac{dv}{dt} = v - v^3/3 - w + I,$$

$$\frac{dw}{dt} = 0.08(v + 0.7 - 0.8w),$$

is a two-dimensional simplification of the Hodgkin-Huxley model of spike generation in squid giant axons. As such, it is a mathematical model that approximates the electrical characteristics of excitable cells such as neurons and cardiac myocyte. The variable v models the membrane potential, while wacts as a recovery variable. The constant I is the activation current, and controls the behaviour of the model.

- 1. integrate the given FitzHugh-Nagumo equations in either (a) CVODE or (b) Boost.Numeric.Odeint. To start with, use initial values v = -1, w = -1, I = 1 and integrate over $0 \le t \le 200$ to see the periodic spiking behaviour of the membrane potential v.
- 2. Output t, v(t), and w(t) to a CSV file, using one column for each variable
- 3. Plot variables versus time using a method of your choice:
 - (a) Gnuplot (sudo apt-get install gnuplot to install with Ubuntu)
 - (b) Python Matplotlib (hint: use the numpy function loadtxt to read in the CSV file)
 - (c) Matlab
 - (d) Excel?
- 4. Plot the phase portrait along with the nullclines $\frac{dv}{dt} = 0$ and $\frac{dw}{dt} = 0$ 5. Vary the activation current I between 0 and 2 and see the change in behaviour of the model. Observe the 3 modes of activation with increasing I:
 - (a) resting (low constant v),
 - (b) spiking and
 - (c) blocked (high constant v)