**1. Exercise Sheet – Brain-Inspired Computing (WS 15/16)**

Due date 19.10.16.

Name(s): Group: Points: ___/___/___/___

## 1.1 The Power of the Brain (20 Points)

Estimate the average energy consumption in the human brain using the approximate numbers given in the course

a) per action potential and

b) per synaptic event.

For simulating 1 s in a network consisting of $1.23 \cdot 10^9$ neurons, each with an average firing rate of 1 Hz and an average number of $6 \cdot 10^3$ presynaptic partners, the K supercomputer needs 40 minutes (`http://www.riken.jp/en/pr/press/2013/20130802_1/`). During this time, it consumes 12.6 MW of power.

c) Calculate the energy consumption per spike and per synaptic event of this simulation.

Scale up the simulation in c) to the size of the human brain. Assuming one could simply stack K computers to be able to perform this simulation,

d) how much power would they require?

Compare your result to the output of a typical nuclear power plant in Japan (at the moment, only one such power plant is operational there). Assuming that the energy/flop is constant and that you could magically speed up the K computer to real-time,

e) how many reactors would you then need?

## 1.2 Stimulus Currents (30 Points)

Use the simplified equivalent circuit from the course to calculate the effect of various stimulus-current on the membrane potential of a cell. Sketch the results.

a) A Dirac delta function: $I(t) = I_0 \cdot \frac{c_m}{g_l} \delta(t - t_0)$.

b) A step current: $I(t) = I_0 \cdot \Theta(t - t_0)$, where $\Theta$ represents the Heaviside step function.

c) An exponential current: $I(t) = I_0 \cdot \Theta(t - t_0) \cdot \frac{c_m}{\tau_s g_l} \cdot \exp(-\frac{t-t_0}{\tau_s})$. We will see later that this is a good approximation of the synaptic input current following a spike.

d) Re-evaluate the result from c) in the limit of very short synaptic time constants ($\tau_s \rightarrow 0$). Compare with your result from a).

## 1.3 FACETS Live! (50 Points)

Play around with the FACETS Live! system (see moodle for instructions). Run the two-neuron demo. Plot the output firing rate of the first neuron as a function of its input current and the firing rate of the second neuron as a function of its input firing rate.