Exercise 2 for Computational Neuroscience

Prof. Dr. Florentin Wörgötter

Note: Most of the material in these exercises is covered in the lecture slides. Sometimes, however, textbook reading or internet search might be required, too.

These exercises are – of course – not mandatory but they should help you to understand the topic better and prepare for the exam.

Please see also PPTX file for Exercise 2

2) Calculating with Neurons

'Shunting inhibition is associated with a neuronal division operation.

A) Which channel is responsible for that normally? That is, which ion takes part?

B) How does shunting inhibition work? What's the ion flow, if shunting inhibition takes place? In what direction do the ions pass the membrane, if no additional channel is open (no other EPSP!)? Why is that so? Is there a net flow of ions?

C) What happens, if an EPSP occurs at the same time? How does the EPSP change, if shunting inhibition exists? Her we regard the case, that the EPSP is triggered by Na+ ions. In which direction do they flow, if the EPSP is triggered undisturbed? With simultaneous shunting inhibition one wonders: In which direction do the 'shunting-ions' flow (ion type=answer of part A)?

A):
B)
C)

Membrane Potential and Calculating with Neurons

Question A) We consider two similar synapses (the same transmitter, the same ion currents), which are located at the soma of the post-synaptic neuron (see Fig. 2 below). Both synapses receive independent, excitatory input from different neurons. The maximal amplitudes of the obtained EPSPs are A and B, if EPSPs occur alone. Our measurement point is exactly in the middle between the two synapses, and we measure that there „summation“ occurs. We obtain a total EPSP with the maximal amplitude C, where $C = \lambda A + \mu B$. The factors λ and μ are always at least a bit smaller than one. Which of the following reasons can account for the fact that λ and/or μ are ***significantly*** smaller than one (incomplete summation)?

a) Synapses have larger spatial distance between each other.
b) Input signals (action potentials) at A and B have large temporal difference between each other.
c) B fires before A which leads to LTD and as a consequence to a reduction of synaptic weight λ.
d) The reversal potential of ion currents triggered by inputs A and B is close to the resting potential.
e) The reversal potential of ion currents triggered by inputs A and B is far away from the resting potential.

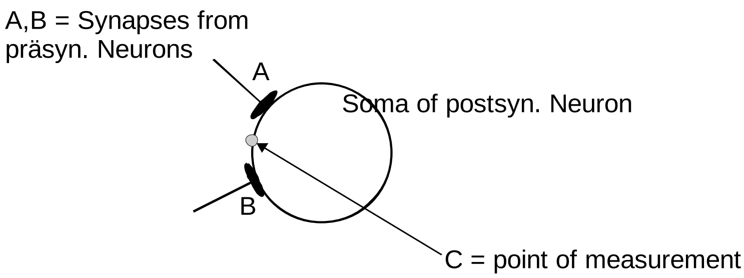

Fig.2) Summation at a neuron.

Question B) How does the integration at a neuron behave when the time constant is large?
Question C) What is a „coincidence detector neuron“?

Answers to the topic (2)

A) Indicate the right answer(s) from a-e:
B):
C)

Neurons as Filter

A)

i) Please describe (if necessary clearly draw) how the illusion of the Hermann Grid arises.

ii) Why does the illusion vanish at the fixation point, that is when fixating a crossing point?

B)

i) Draw a DoG (Difference of Gaussian) function.

ii) Which neurons do have receptive fields of the DoG-type?

iii) Why is a DoG function as a receptive field contrast-enhancing?

Answer to question A:

i)

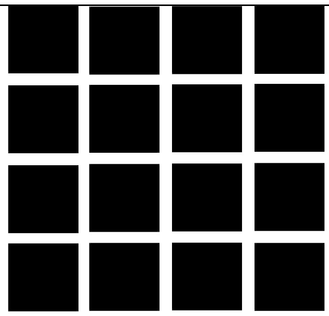

Fig. 3) Hermann Grid Illusion

ii)

Answer to question B:

i)

ii)

iii)

4) Correlations

Figure A shows two input neurons (triangles at the bottom, named “top“ and “bottom“) and eight target neurons (circles at the top). Figures B and C show two possible input spike-trains for neuron “top” and neuron “bottom”. This wiring has been demonstrated first for owls. The length of the axons (length of the lines in between the input neuron and the respective target neuron) corresponds to the time needed by a signal to propagate from the input neuron to the target neuron.

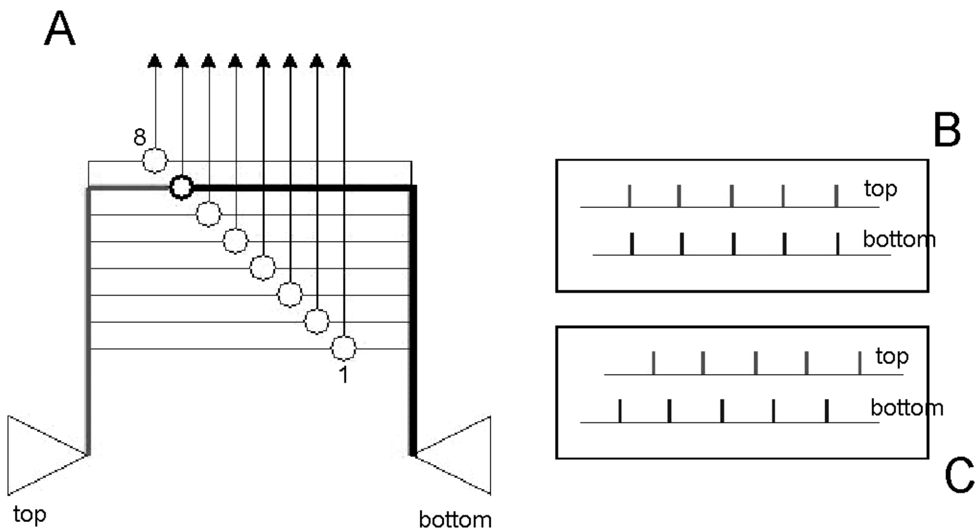

Fig. 8) A) Delay line circuit for sensory processing in the barn owl. B,C) possible input signals.

1) Which sensory system does this wiring diagram belong to?
2) Which physical stimulus property is calculated using this system?
3) Which input signals (B or C) would stimulate neuron 7 (bold lines) most effectively?
4) In turn, which of the neurons (1-8) does the other input signal stimulate most effectively (Note: Here, two neurons come into question)?