Lecture: Dynamical systems in neuroscience

Serhiy Yanchuk
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www.tu-berlin.de?neuro18

In this lecture, most prominent models will be introduced, which are used for the mathematical modeling of neurons. Firstly, we introduce elementary notions of neuroscience such as action potentials, postsynaptic potentials, firing thresholds, refractoriness, and adaptation. Then simple models such as integrate-and-fire model are introduced. Along with the classical Hodgkin-Huxley, there will be also some more recent models presented, which illustrate basic working principles of a neuron.

I assume that the students possess basic knowledge in nonlinear dynamics (as e.g. Nonlinear Dynamics I course given at TU Berlin). In addition, further necessary mathematical methods will be explained that can arise in mathematical neuroscience.

This lecture is focused on low-dimensional deterministic systems (ordinary differential equations) of a neuron and neural networks.

Time and Place

Lecture by Serhiy Yanchuk	MA650; Di: 10:00 - 12:00
Excercises by Rico Berner and Florian Stelzer:	MA650; Di: 12:00 - 14:00

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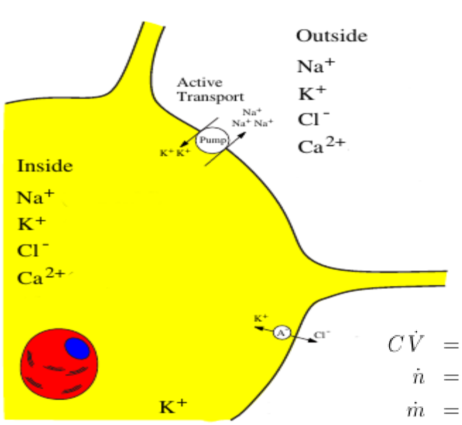
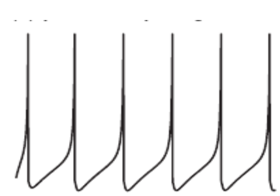
Literature

– W. Gerstner, W. M. Kistler, R. Naud and L. Paninski "Neuronal Dynamics From single neurons to networks and models of cognition", 2014
– E. Izhikevich "Dynamical systems in neuroscience: The geometry of excitability and bursting", The MIT Press, 2005
– Ph. Eckhoff und Ph. Holmes "A short course in mathematical neuroscience", Program in Applied and Computational Mathematics, Princeton University, 2015.





$$
\begin{aligned}
C\dot{V} &= I - \overbrace{\bar{g}_{\mathrm{K}} n^4 (V - E_{\mathrm{K}})}^{I_{\mathrm{K}}} - \overbrace{\bar{g}_{\mathrm{Na}} m^3 h (V - E_{\mathrm{Na}})}^{I_{\mathrm{Na}}} - \overbrace{g_{\mathrm{L}} (V - E_{\mathrm{L}})}^{I_{\mathrm{L}}} \\
\dot{n} &= \alpha_n(V)(1-n) - \beta_n(V) n \\
\dot{m} &= \alpha_m(V)(1-m) - \beta_m(V) m \\
\dot{h} &= \alpha_h(V)(1-h) - \beta_h(V) h \,,
\end{aligned}
$$