THE STOCHASTIC, MARKOVIAN, HODGKIN-HUXLEY TYPE OF MATHEMATICAL MODEL OF THE NEURON

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Abstract: The aim of this paper is to show how the Hodgkin-Huxley model of the neuron's membrane potential can be extended to a stochastic one. This extension can be done either by adding fluctuations to the equations of the model or by using Markov kinetic schemes' formalism. We are presenting a new extension of the model. This modification simplifies computational complexity of the neuron model especially when considering a hardware implementation. The hardware implementation of the extended model as a system on a chip using a field-programmable gate array (FPGA) is demonstrated in this paper. The results confirm the reliability of the extended model presented here.

Key words: *Hodgkin-Huxley model, stochastic differential equations, Markov kinetics, kinetic formalism, field-programmable gate array (FPGA)*

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1. Introduction

A developed by nature in the evolution process biological neuron provides better results than the classic artificial neuron in information processing tasks. Current research shows that classification tasks could be resolved with the use of only one living neural cell [3]. This is a significant advantage over the artificial neural networks. More accurate neuron models could result in a higher level of artificial intelligence (AI) in developed devices.

The main problem in using biological neuron models is their computational complexity requiring long simulation time and the necessity of using powerful, and expensive computing machines. In this work we present an efficient model of a neural cell optimized for hardware implementation. Our model is unique because it reduces computational complexity while maintaining full mathematical projection of the modeled processes.

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