World Academy of Science, Engineering and Technology
International Journal of Chemical and Molecular Engineering
Vol:12, No:07, 2018

Comparison of Spiking Neuron Models in Terms of Biological Neuron Behaviours

Authors : Fikret Yalcinkaya, Hamza Unsal

Abstract : To understand how neurons work, it is required to combine experimental studies on neural science with numerical simulations of neuron models in a computer environment. In this regard, the simplicity and applicability of spiking neuron modeling functions have been of great interest in computational neuron science and numerical neuroscience in recent years. Spiking neuron models can be classified by exhibiting various neuronal behaviors, such as spiking and bursting. These classifications are important for researchers working on theoretical neuroscience. In this paper, three different spiking neuron models; Izhikevich, Adaptive Exponential Integrate Fire (AEIF) and Hindmarsh Rose (HR), which are based on first order differential equations, are discussed and compared. First, the physical meanings, derivatives, and differential equations of each model are provided and simulated in the Matlab environment. Then, by selecting appropriate parameters, the models were visually examined in the Matlab environment and it was aimed to demonstrate which model can simulate well-known biological neuron behaviours such as Tonic Spiking, Tonic Bursting, Mixed Mode Firing, Spike Frequency Adaptation, Resonator and Integrator. As a result, the Izhikevich model has been shown to perform Regular Spiking, Continuous Explosion, Intrinsically Bursting, Thalmo Cortical, Low-Threshold Spiking and Resonator. The Adaptive Exponential Integrate Fire model has been able to produce firing patterns such as Regular Ignition, Adaptive Ignition, Initially Explosive Ignition, Regular Explosive Ignition, Delayed Ignition, Delayed Regular Explosive Ignition, Temporary Ignition and Irregular Ignition. The Hindmarsh Rose model showed three different dynamic neuron behaviours; Spike, Burst and Chaotic. From these results, the Izhikevich cell model may be preferred due to its ability to reflect the true behavior of the nerve cell, the ability to produce different types of spikes, and the suitability for use in larger scale brain models. The most important reason for choosing the Adaptive Exponential Integrate Fire model is that it can create rich ignition patterns with fewer parameters. The chaotic behaviours of the Hindmarsh Rose neuron model, like some chaotic systems, is thought to be used in many scientific and engineering applications such as physics, secure communication and signal processing.

Keywords : Izhikevich, adaptive exponential integrate fire, Hindmarsh Rose, biological neuron behaviours, spiking neuron models
Conference Title : ICCBE 2018 : International Conference on Chemical and Biomedical Engineering
Conference Location : Stockholm, Sweden
Conference Dates : July 12-13, 2018