Simulating Spiking Neurons Using a Simple Mathematical Model

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Abstract

Evolving studies related to external electrical stimulation of the spinal cord has shown to enable voluntary motor function in paralyzed patients with spinal cord injury[1]. However, a complete understanding of this phenomena is not yet understood and thus optimal stimulus parameters are learned through exhaustive trial and error during clinical testing. The purpose of this study is to use finite element analysis techniques in an attempt to provide insight between the electrical stimulation waveforms and parameters and the resulting neurological responses. The COMSOL Multiphysics® software was used to determine the electric field distribution generated by two electrodes placed on the epidural layer of the spinal cord. The electric field results were then used as an input to the mathematically based Izhikevich neural model[2] to simulate the resulting transient action potentials generated in the axons.

Reference

[1] S. Harkema et al., "Effect of epidural stimulation of the lumbosacral spinal cord on voluntary movement, standing, and assisted stepping after motor complete paraplegia: a case study", Lancet, 377, 1938-47(2011)

[2] E. M. Izhikevich, “Simple model of spiking neurons,” IEEE Trans. Neural Networks, 14, 1569–1572(2003)

Figures used in the abstract

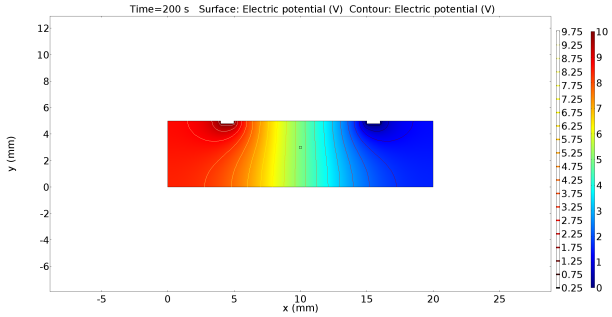

Figure 1: Electrical potential of two electrodes placed on a 20 mm model of spinal cord

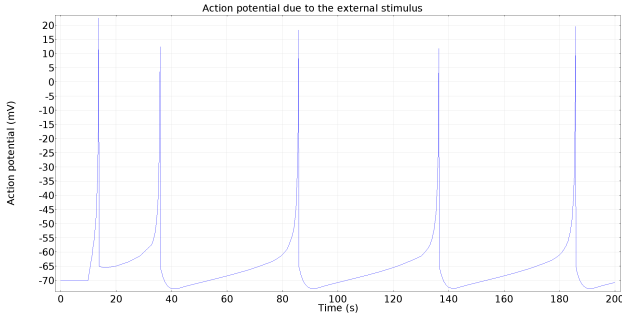

Figure 2: Tonic spiking response using Izhikevich neural model