

I-NEURODEI©: A VIRTUAL LABORATORY APPLICATION FOR TEACHING NEUROPHYSIOLOGY

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Abstract

Today's young people – “digital natives” are growing up in an immersive computing environment, from laptops and tablets to smartphones. New technologies, internet and broadband connectivity are reshaping the very way that universities teach and students learn. This software has great possibilities for academic institutions: distance education, sophisticated learning-management systems and the opportunity to collaborate with research partners from around the world. A single neuron virtual simulator implemented in IOS for iPad for teaching purposes is presented in this work that allows, on the one hand, the reproduction of membrane potential changes, and on the other, the interaction and manipulation of different elements (soma, stimulus generator and charts).

Keywords: Neuron virtual simulator; Neurophysiology; E-Learning; iPad application.

Objectives

i-NeuroDEI© was originally conceived as a distributed computing system on a PC called NeuroDEI© for the quantification and modeling of circuits between "neuron" elements with different levels of complexity. The basic functions of the PC simulator version were translated to the iOS operating system optimized for iPad. Besides, a survey was given to university students to evaluate the application's performance and its usability as well as the user experience.

About the App

i-NeuroDEI© was implemented in the iOS7.02 and consists of one screen with four different working areas as depicted in Figure 1. Touch screen gestures enable users to interact with or tap on the app, turning previous NeuroDEI© software into a more realistic simulation instrument

App Features:

The simulator presented in this paper contains the Hodgkin-Huxley model or “conductance-based model” allowing modifications of the following parameters: i) intra and extra cellular

concentration values ii) frequency and amplitude of stimulus signal (generator button).

The application interface is composed of two differentiated working areas: A) Experiment configuration B) Graphic instruments

A) The experiment configuration area has 7 buttons:

- Neuron: contains the Hodgkin-Huxley model.
- Connection: links Neuron and Generator button.
- Generator: by double tapping on this button the user can choose between the sawtooth, square or pulse waveform.
- Pause: allows stopping the simulation without losing the data already obtained.
- Clear: aimed to clean the working area.
- Help: offers a tutorial to guide the students.
- Copyright: shows the acknowledgment of those who contributed in this work.

B) Graphic instruments:

Once the simulation starts running, the computed values are displayed in three plots:

Left plot: simulates the membrane potential and stimulus signal showing the progress of the simulation in real time.

Right plots: simulate the temporal dynamics of sodium (top) and potassium (bottom) channel conductance.

The following data output can be recorded: 1. Resting membrane potential; 2. Latency period; 3. Potential threshold; 4. Action potential profile: amplitude, frequency, duration, maximum depolarization value and hyperpolarization potential; 5. Na⁺ and K⁺ extra and intracellular concentration; 6. Stimulus: Nature and Intensity; 7. Refractory period; 8. Na⁺ and K⁺ conductance through their specific ion channels.

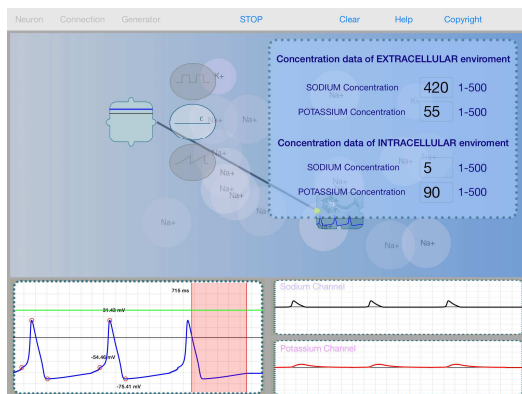


Figure 1. i-NeuroDEI© interface.

Results

The main challenge of this work was to develop custom libraries able to perform mathematical operations without sacrificing simulation time execution and chart refreshing on the application. Algorithms were optimized using the Euler iterative method. This method is a first-order numerical procedure for solving ordinary differential equations (ODEs) with a given initial value.

The original model has been extended to incorporate space and time summation phenomena simulation. Thus, the electrical behavior of the cell membrane can be observed when this is simultaneously stimulated with different signals.

i-NeuroDEI© successfully runs on iOS 6.1.3, 6.1.4 and 7.0.2. User application feedback for this beta version was obtained from surveys given to 20 medical and pharmaceutical students of La Laguna University. Users rated the app 3.85 out of 5, 70% confirmed their intention of exploring the simulator in more detail, 90% agreed that this kind of app will be useful in other aspects of their university education. Reviews of the application will be available once the app has been launched.

Conclusion

In summary, the i-NeuroDEI© app is a low cost resource that enhances the learning of neurophysiological concepts. The app also stimulates the university students to experiment on their own. Future works will be focused on enabling sharing and cooperation between users by means of allowing neuronal interactions on the app simulator as well as connections between different devices.

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