Nien-Du Yang et al., J Bioengineer & Biomedical Sci 2015, 5:3
http://dx.doi.org/10.4172/2155-9538.C1.005

OMICS International
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2nd Biomedical Engineering Conference and Expo

November 30-December 01, 2015 San Antonio, USA

An adaptive numerical algorithm with oversizing prevention for computation of cardiac action potential simulations

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In biological modeling, multi-dimensional cardiac action potential (AP) simulations require a considerably huge amount of computational time and memory. To address this issue, the development of a faster algorithm with better efficiency is needed.

Here we propose a new adaptive numerical algorithm that can reduce computational time as well as perform AP simulations with high accuracy and system stability. In our algorithm, proper time-steps are primarily arranged by solving a quadratic formula of the first derivative of the cardiac membrane potential. In addition, functions are included in our algorithm in order to improve numerical accuracy and system stability. A function is applied to prevent time-steps from oversizing and can consequently help to avoid the shape distortion of cardiac action potentials and increase computational stability during consecutive stimulus.

We conducted numerical experiments based on the LR (Luo-Rudy) phase 1 model and the LRd (Luo-Rudy dynamic) model of the cardiac ventricular action potential. The results showed that the generated cardiac action potentials using the proposed algorithm have a smaller error at peak values (Vmax), and can speed up the computation. Compare to the conventional hybrid method (Rush-Larson method with various time steps), the proposed algorithm is more accurate and can significantly reduce the computational time.

Biography

Nien-Du Yang is a second-year M.S student of Institute of Medical Science and Technology at National Sun Yat-sen University in Taiwan. He received his B.S degree in Electrical Engineering at National Sun Yat-sen University in 2013. His research focuses on the construction of endothelial-cell simulation model, and is currently in collaboration with a research group in the Center for Lipid Biosciences (CLB) at Kaohsiung Medical University Hospital.

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