Studying a Single FitzHugh-Nagumo (FHN) Model Using "The Virtual Heart" Software

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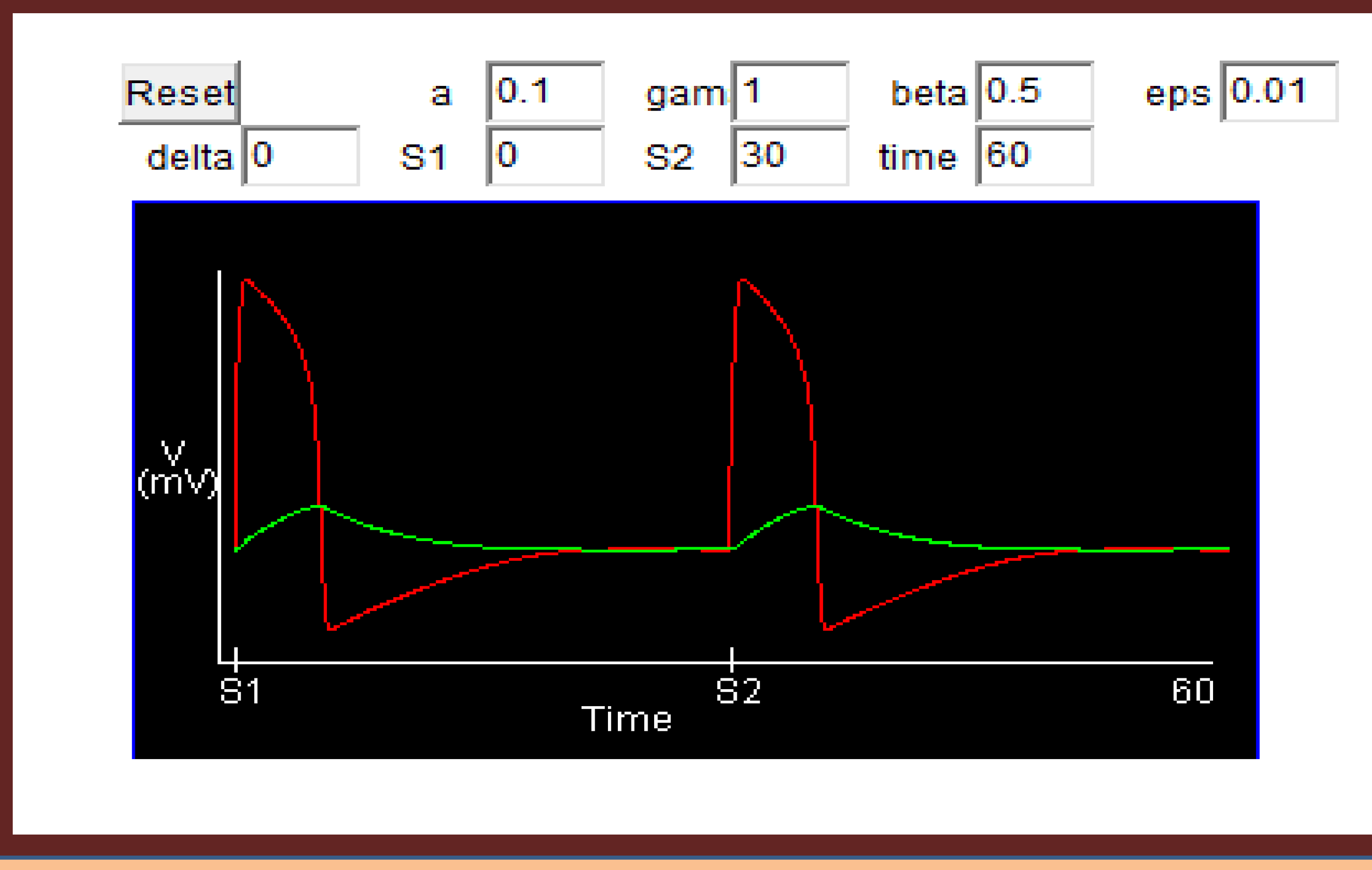
In this work, the FitzHugh-Nagumo model was investigated using the modeling, complex computational algorithms and interactive visualization of "The Virtual Heart" site (http://dev1.thevirtualheart.org/). This model allows observing an important phenomenon in the study of the heart dynamics - the phenomenon of cardiac tissue restitution.

We implement the model described by the following equations:

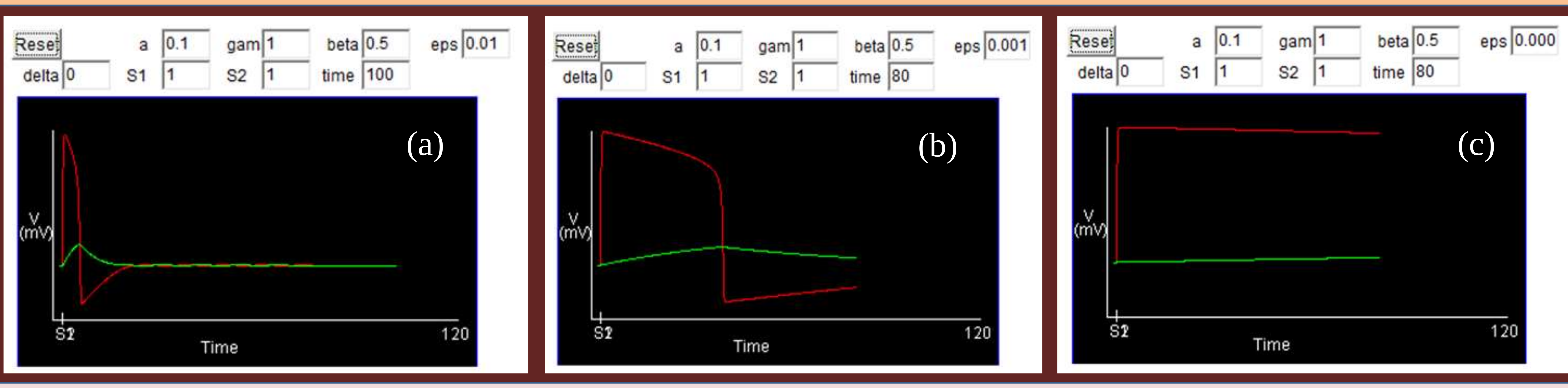
$$\frac{\partial V}{\partial t} = \frac{\partial^2 V}{\partial x^2} + (a - V)(V - 1)V - v \quad (1)$$

$$f(x_i) = \varepsilon(\beta V - \gamma v - \delta) \quad (2)$$

where V is the voltage (fast variable), v is the υ-shaped gate (slow variable), a is the excitation threshold, ε is the excitability, γ and δ are the parameters that change the state of rest and dynamics, t is the integration time.

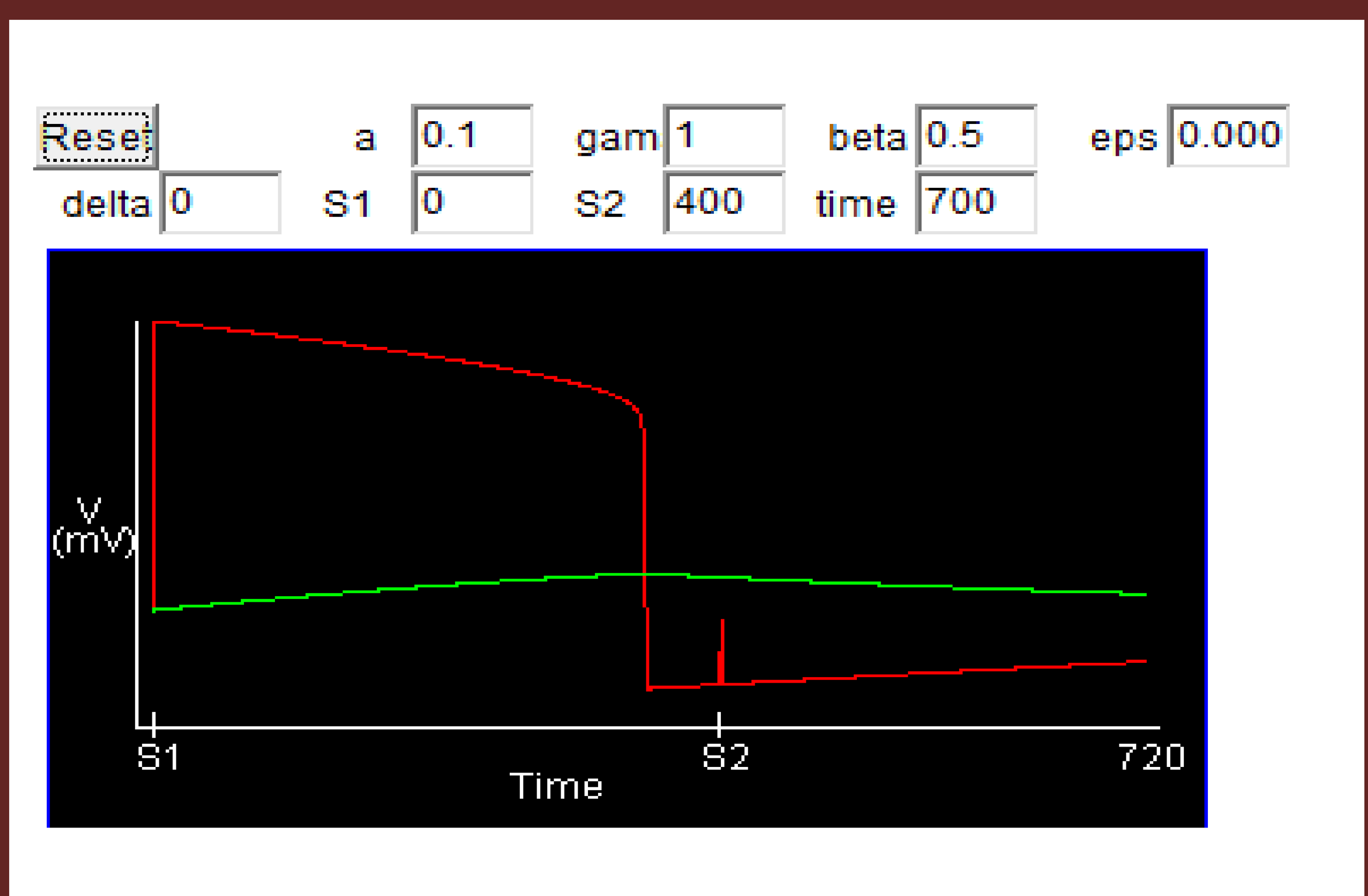


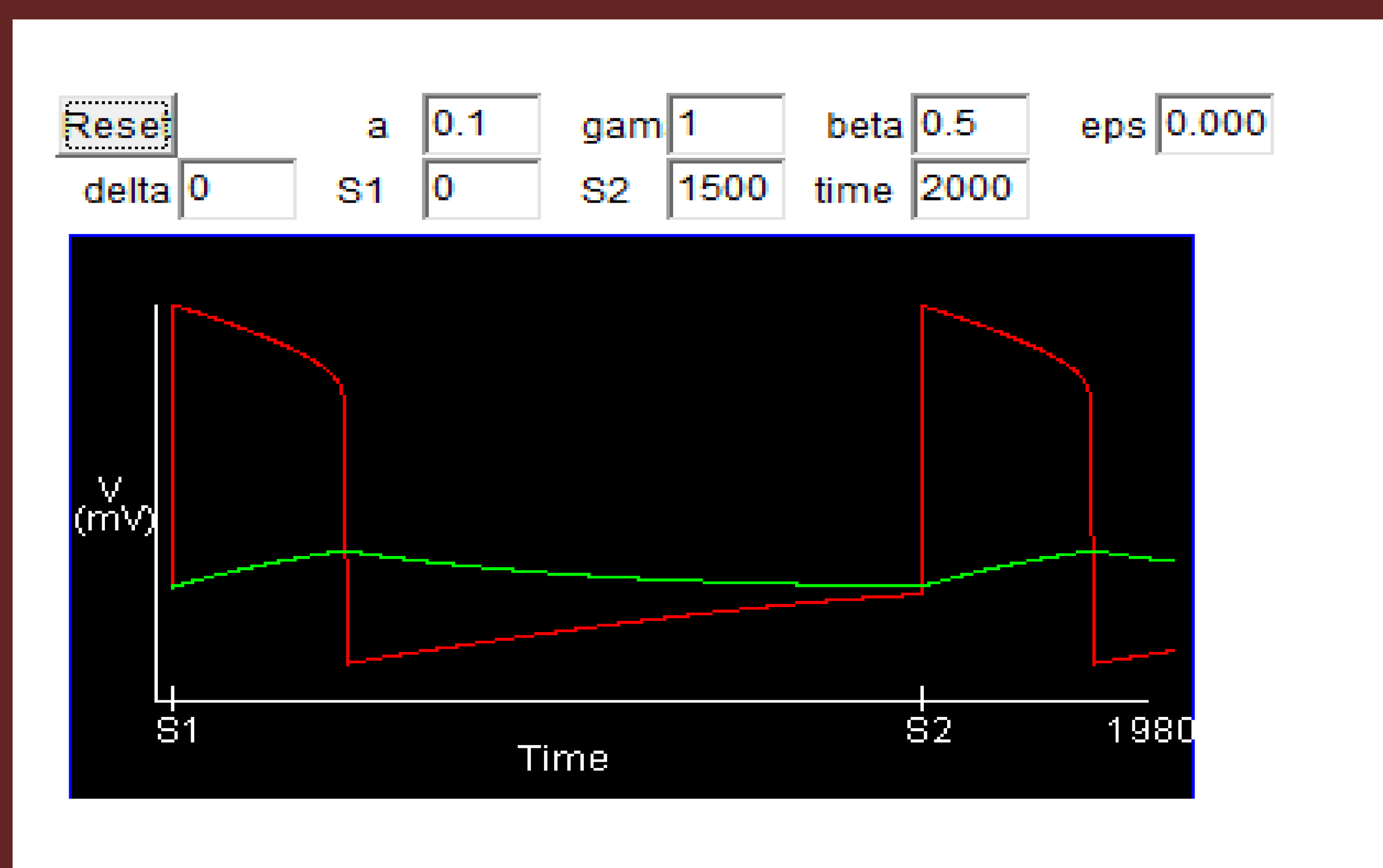
If an external influence is applied, setting S1 = 1, the system will exhibit the self-oscillatory behavior. The parameter ε is responsible for different dynamics of the time scale between V and v processes and in some cases is called the excitation slope. In the model, the smaller the value of ε, the faster the rate of growth of the action potential (AP) will be and the longer the plateau. Since the rate of rise is directly related to the excitability of the system, then in this model a decrease of ε increases the excitability and the duration of the potential.



Increase in the excitability and the duration of the action potential with a decrease in the values of ε: a) $\varepsilon = 0.01$; b) $\varepsilon = 0.001$; c) $\varepsilon = 0.0001$

When increasing the time up to 2000 and continuing to increase in S2, it can be seen that S2 must be at least 1500 in order for the system to restore its original properties and produce a second action potential until the second potential becomes the first.





The relationship between the duration of the action potential (APD) and the amount of time between the previous activation and the second stimulus (diastolic interval or DI) is known as restitution and is an important characteristic of cardiac tissue.