Parameter update of Hindmarsh-Rose model

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Index

- Introduction
- Parameters
- Contrast
 - Old model vs new model
 - Old synapsis vs new synapsis
 - * Positive presynaptic current
 - * Negative presynaptic current
 - * Positive presynaptic current in all variables

Introduction

In this document the differences between the Hindmarsh-Rose model and the same model but with the addition of the parameter v (and the consecuent modification of S)

Parameters

The parameters choosed are based on the file "HRmod.pdf" inside the directory **resources**/, being v = 0.1, e = 3.281, $\mu = 0.0021$ and S = 1.0.

The values for the sinápsis $S_{fast} = 0.44$, $V_{fast} = -1.66$, $E_{syn} = -1.92$ are obtained from **Table 2** and $gfast_1 = 0.241$ and $gfast_2 = 0.186$ from **Table 3** of the file "pract3-15.pdf" in the same directory previously mentioned.

Contrast

Multiple executions have been realized for comparing the implementation of the synapsis and the new parameter, modifying the value of the variable z. The new formula for this variable is the result of the following equation:

$$z(t) + \Delta t \mu (-vz(t) + S(x(t) + 1.6))$$

Which is the resoult of resolving this equation:

$$\frac{1}{\mu} \frac{dz(t)}{dt} = -vz(t) + S(x(t) + 1.6)$$

By the definition of derivative:

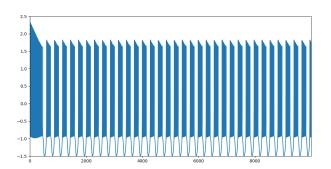
$$\frac{df(t)}{dt} \approx \frac{f(t + \Delta t) - f(t)}{\Delta t}$$

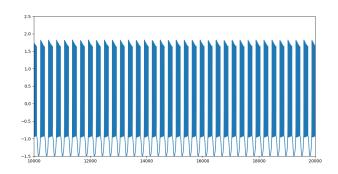
Old model vs new model

By assigning v = 1 and keeping S = 4.0 we have the same results as before:

Old regular simulation

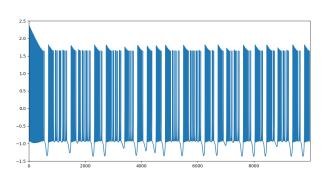
Old regular simulation continue

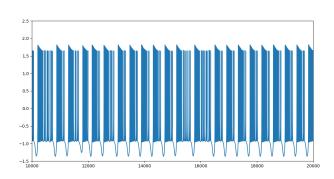




Old chaotic simulation

Old chaotic simulation continue

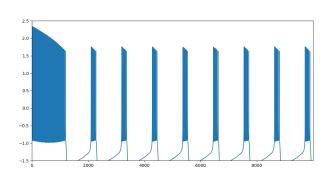


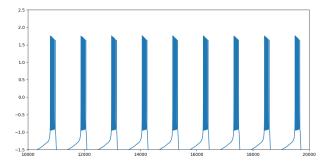


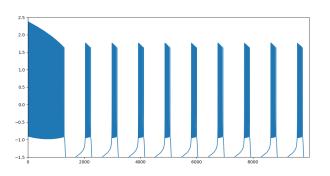
By changing $v = 1 \Rightarrow v = 0.1$ and $S = 4.0 \Rightarrow S = 1.0$ we have:

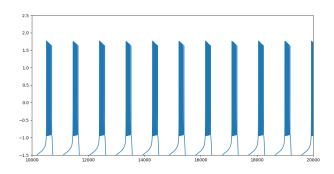
New regular simulation

New regular simulation continue









Old synapsis vs new synapsis

Here are the results of the synapsis between the old model and the new model.

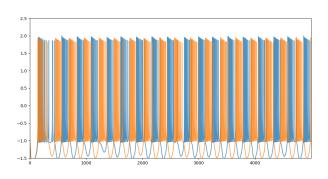
Positive presynaptic current

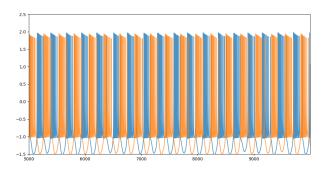
Here the synapis was calculated over x variable with positive presynaptic current:

$$x(t+1) = x + \Delta t(y(t) + 3x^{3}(t) - x^{2}(t) - z(t) + e + I_{syn})$$

Old regular synapsis simulation

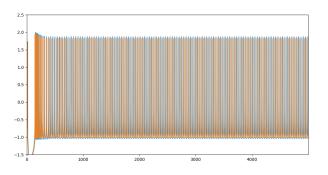
Old regular synapsis simulation continue

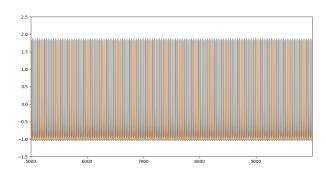




Old chaotic synapsis simulation

Old chaotic synapsis simulation continue

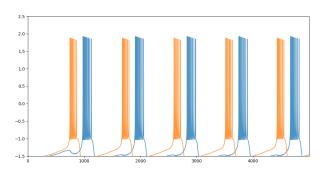


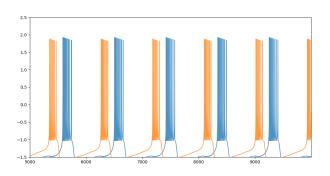


By changing $v=1 \Rightarrow v=0.1$ and $S=4.0 \Rightarrow S=1.0$ we have:

New regular synapsis simulation

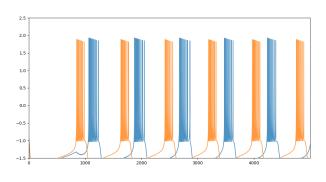
New regular synapsis simulation continue

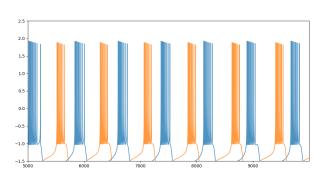




New chaotic synapsis simulation

New chaotic synapsis simulation continue





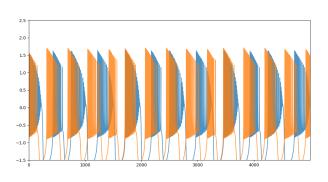
Negative presynaptic current

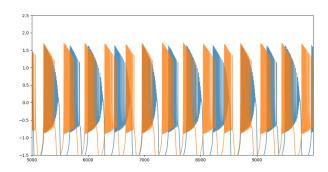
Here the synapis was calculated over x variable with negative presynaptic current:

$$x(t+1) = x + \Delta t(y(t) + 3x^{3}(t) - x^{2}(t) - z(t) + e - I_{syn})$$

Old regular synapsis simulation

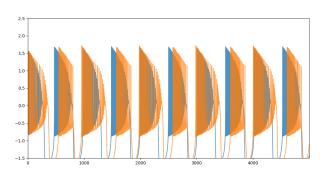
Old regular synapsis simulation continue

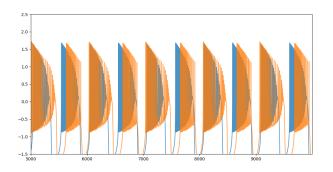




Old chaotic synapsis simulation

Old chaotic synapsis simulation continue

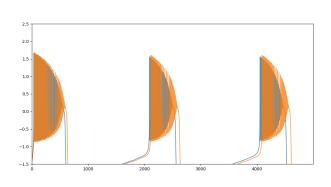


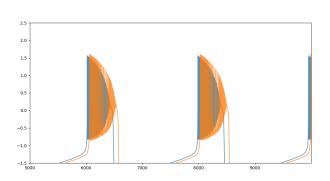


By changing $v=1 \Rightarrow v=0.1$ and $S=4.0 \Rightarrow S=1.0$ we have:

New regular synapsis simulation

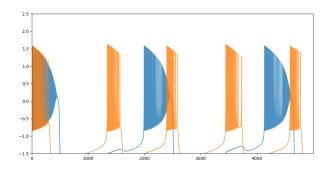
New regular synapsis simulation continue

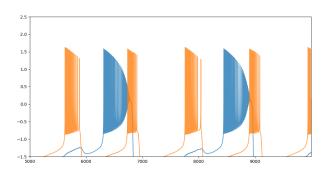




New chaotic synapsis simulation

New chaotic synapsis simulation continue





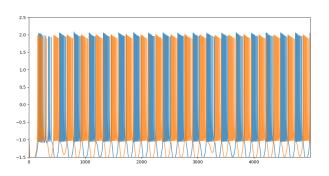
Positive presynaptic current in all variables

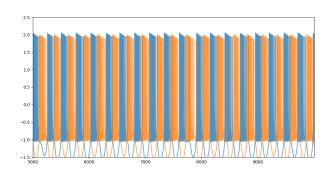
Here the synapis was calculated over x, y and z variables with positive presynaptic current:

$$x(t+1) = x(t) + \Delta t(y(t) + 3x^{3}(t) - x^{2}(t) - z(t) + e + I_{syn})$$
$$y(t+1) = y(t) + \Delta t(1 - 5x^{2} - y(t) + I_{syn})$$
$$z(t+1) = z + \Delta t \mu(-vz(t) + S(x+1.6) + I_{syn})$$

Old regular synapsis simulation

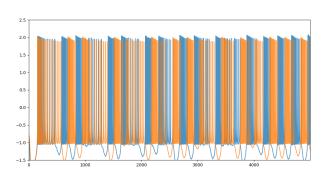
Old regular synapsis simulation continue

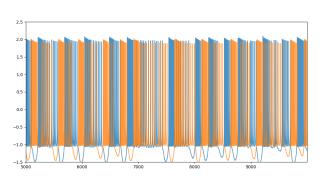




Old chaotic synapsis simulation

Old chaotic synapsis simulation continue





By changing $v = 1 \Rightarrow v = 0.1$ and $S = 4.0 \Rightarrow S = 1.0$ we have:

New regular synapsis simulation

New regular synapsis simulation continue

