Parameter update of Hindmarsh-Rose model

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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 fórmula 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:

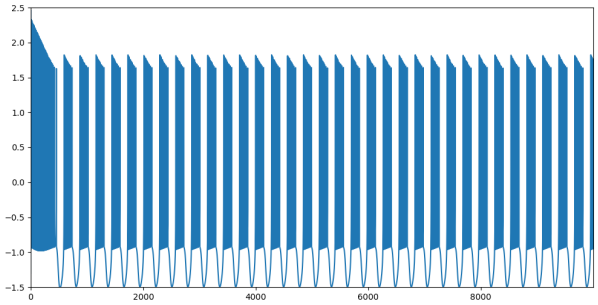
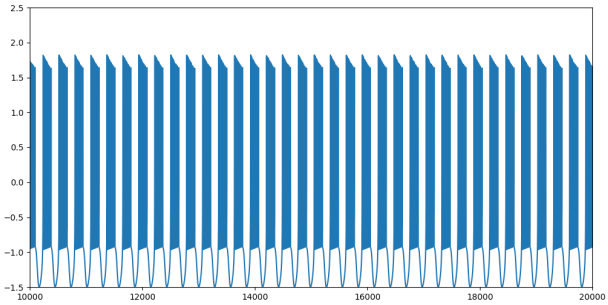
$$\frac{1}{\mu}\frac{dz(t)}{dt} = -vz(t) + S(x(t) + 1.6)$$

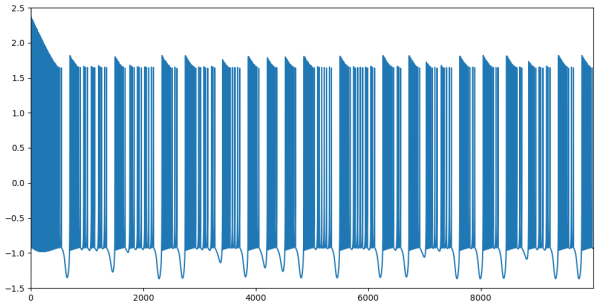
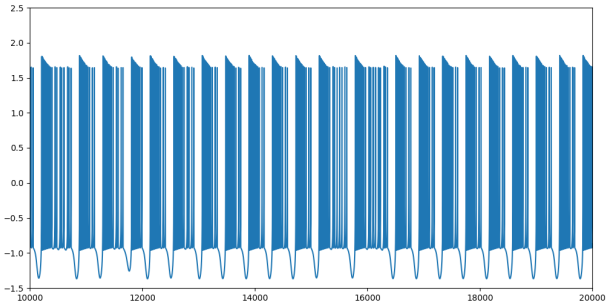
By the definition of derivative:

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

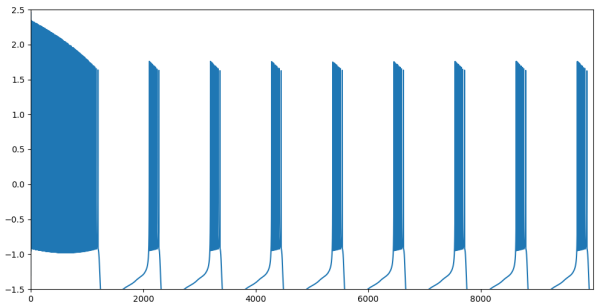
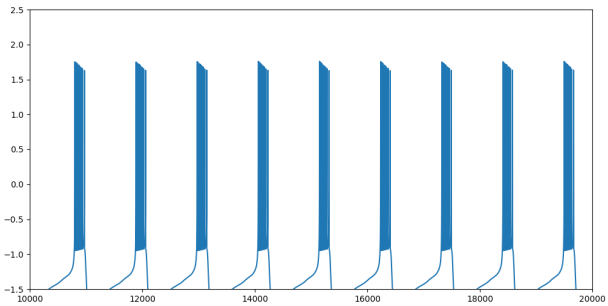
Old model vs new model

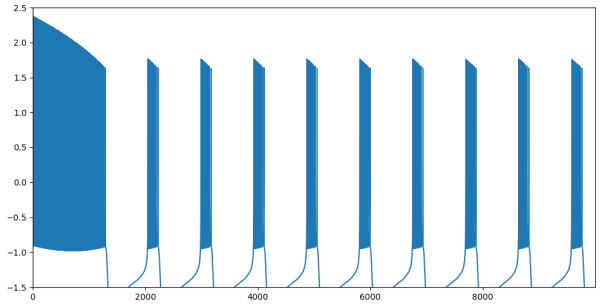
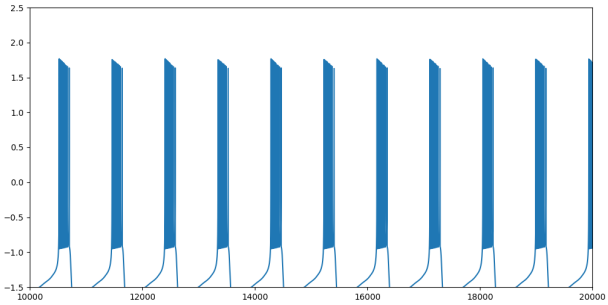
By assigning $v = 1$ and keeping $S = 4.0$ we have the same results as before:

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
	

New chaotic simulation	New chaotic simulation continue
	

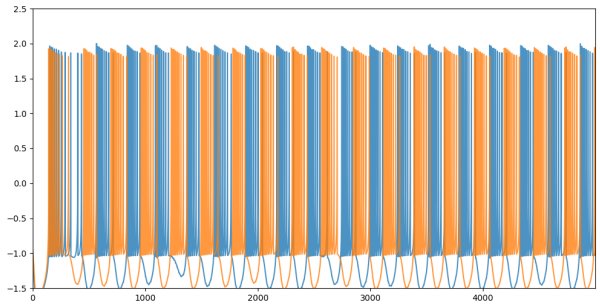
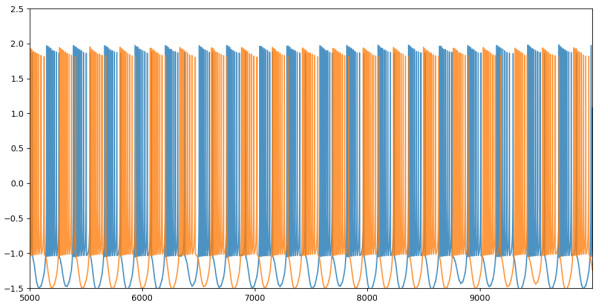
Old synapsis vs new synapsis

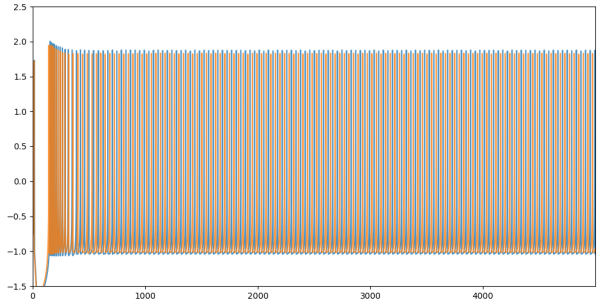
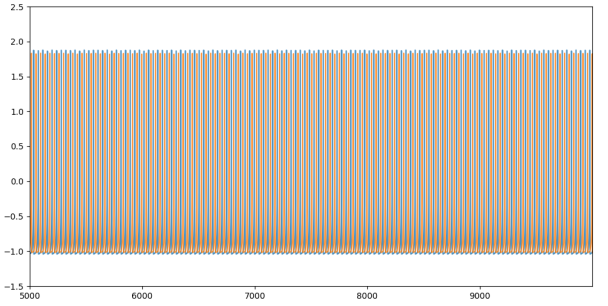
Here are the results of the synapsis between the old model and the new model.

Positive presynaptic current

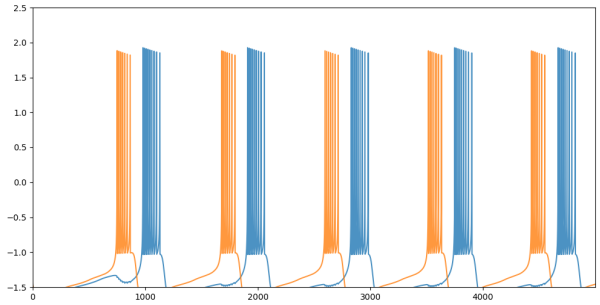
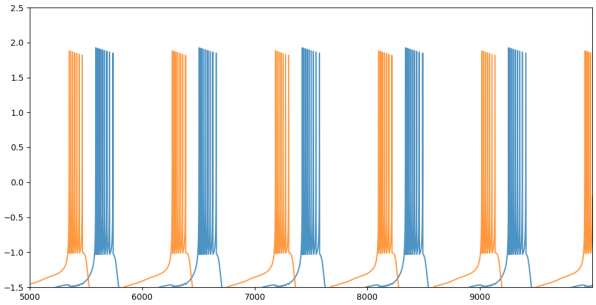
Here the synapis was calculated over x variable with positive presynaptic current:

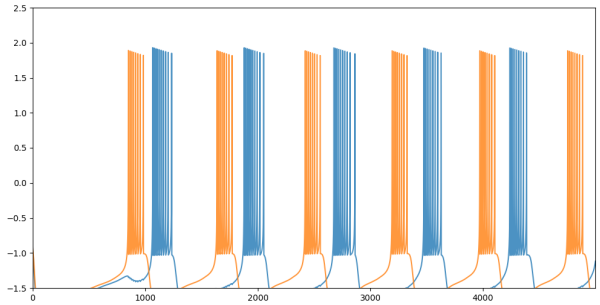
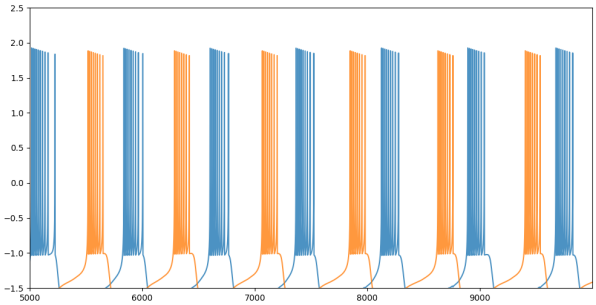
$$x(t+1) = x + \Delta t(y(t) + 3x^3(t) - x^2(t) - z(t) + e + I_{syn})$$

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:

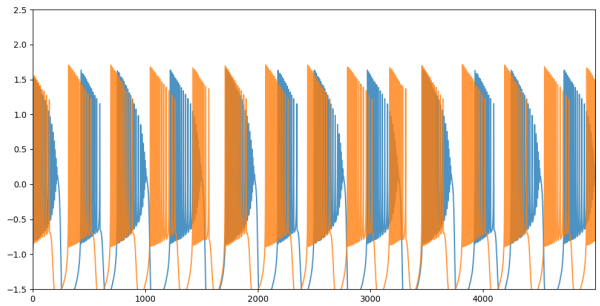
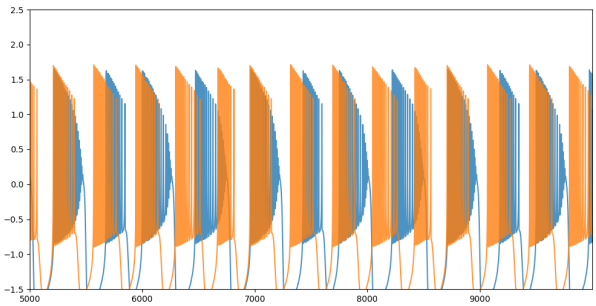
New regular synapsis simulation	New regular synapsis simulation continue
	

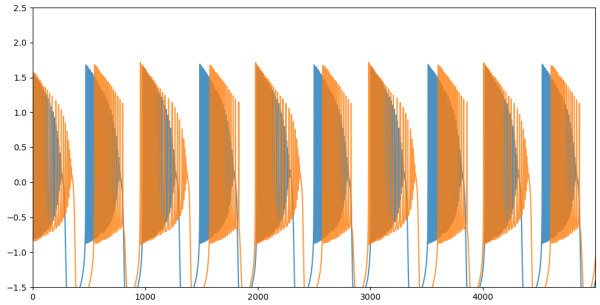
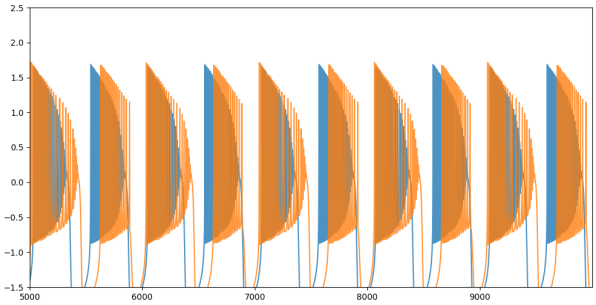
New chaotic synapsis simulation	New chaotic synapsis simulation continue
	

Negative presynaptic current

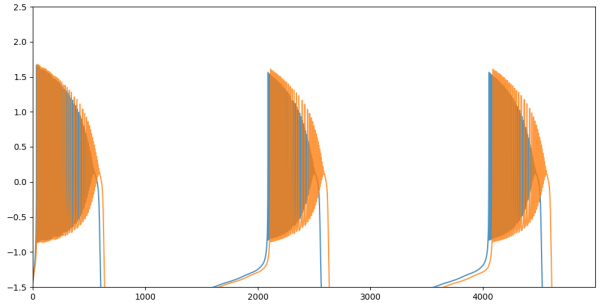
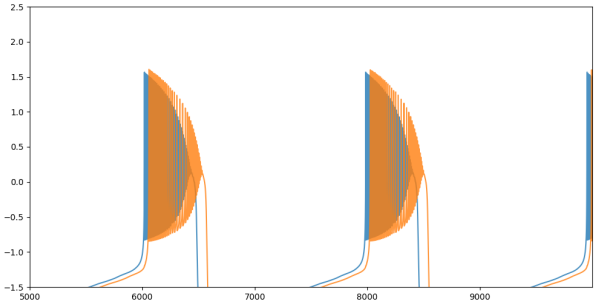
Here the synapis was calculated over x variable with negative presynaptic current:

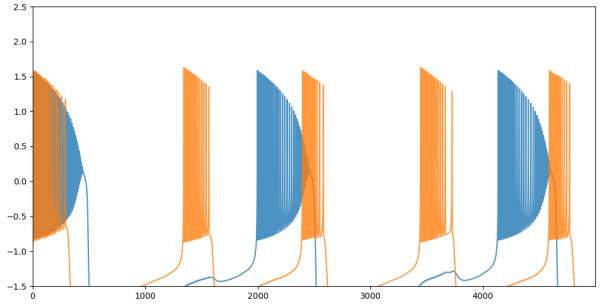
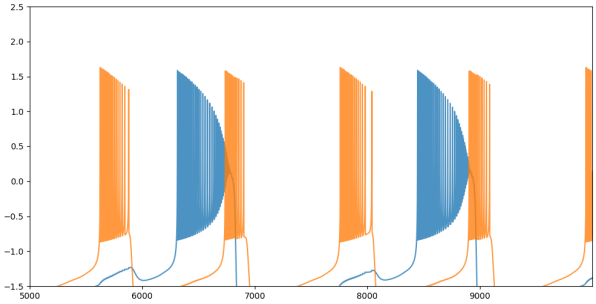
$$x(t+1) = x + \Delta t(y(t) + 3x^3(t) - x^2(t) - z(t) - e - I_{syn})$$

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
	

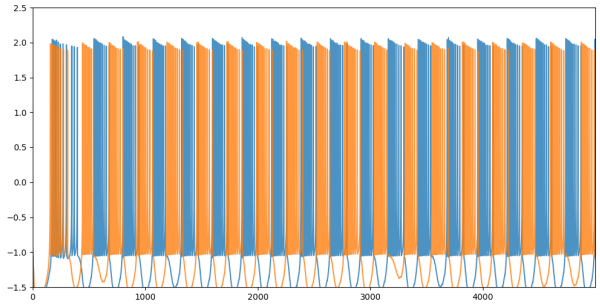
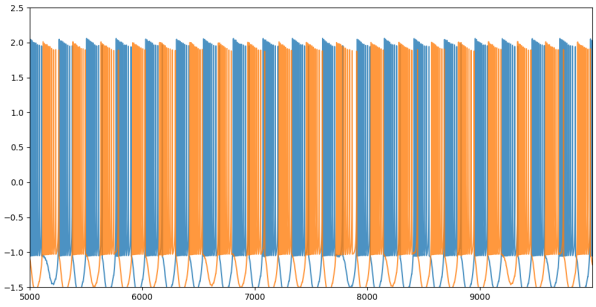
Positive presynaptic current in all variables

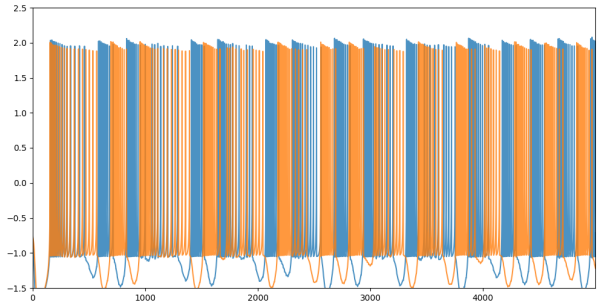
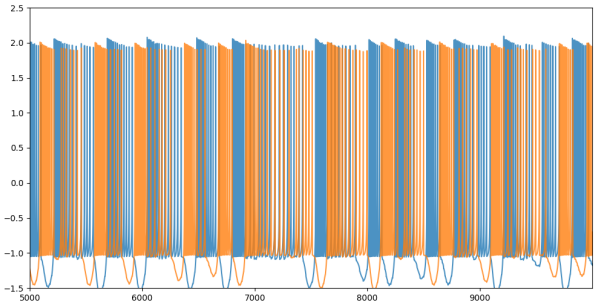
Here the synapis was calculated over x, y and z variables with positive presynaptic current:

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

$$y(t+1) = y(t) + \Delta t(1 - 5x^2 - y(t) + I_{syn})$$

$$z(t+1) = z + \Delta t\mu(-vz(t) + S(x + 1.6) + I_{syn})$$

Old regular synapsis simulation	Old regular synapsis simulation continue
	

Old chaotic synapsis simulation	Old chaotic synapsis simulation continue
	

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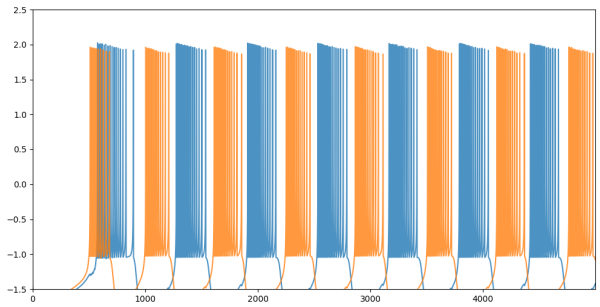
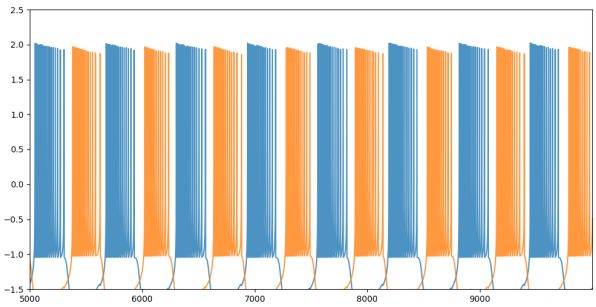
New regular synapsis simulation	New regular synapsis simulation continue
	

New chaotic synapsis simulation	New chaotic synapsis simulation continue