ReScience

[Re] A neural model of the saccade generator in the reticular formation

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Reviewers
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Received Month, Day, 2017
Accepted Month, Day, 2017
Published Month, Day, 2017

Competing Interests:
The authors have declared that no competing interests exist.

A reference implementation of

→ *A neural model of the saccade generator in the reticular formation*, G. Gancarz, S. Grossberg, Neural Networks, 1159-1174, 1998

Introduction

We provide an implementation of the saccade generator (SG); a rate neuron model of the neural circuitry in the reticular formation proposed by Gancarz & Grossberg [2]. The same group has recently sucessfully embedded the SG into a larger model of the eye movement network [4] showcasing its compatible nature. This compatibility of the SG model might prove useful in the future for studying the interplay of neural (sub)systems of visuo-motor integration. It is thus of interest to implement the model in publicly available, widely used, and actively developed neural simulation frameworks such as NEST [3]. We show that the model translates well to the NEST framework as our implementation faithfully reproduces most simulation results reported in the original publication. Our code uses the Python interface [1] for legibility with both model and analysis scripts being implemented using Python 2.7.12.

Methods

We largely follow the descriptions of the model provided in the original publication with a number well-motivated exceptions. First, in the original description, neuron activations are bounded from below at zero resulting in their rectification at every step in the numerical integration. Since this effectively alters neuron dynamics from their original description, we refrained from this practice. Instead, input received by each neuron from other neurons was passed through a rectified linear gain function before summation. This assured that neuron dynamics accorded with their description. Second, the gain function

$$g(x) = \frac{x^4}{0.1^4 + x^4}$$

{#eq:1} (equation A11) in the original publication was replaced by

$$g(x) = \frac{1}{e^{-40(x-0.1)}}$$

{#eq:2} to prevent positive responses to negative net input but otherwise preserve the shape of the curve for x > 0. Third, according to equation A12 in the original publication horizontal eye position θ is given by $\theta = 260(\mathrm{TN_r} - 0.5)$. However, activation of tonic neurons (TNs) is 0 rather than 0.5 when the eye is at the center of its range and a factor of 260 produces saccades of excessively high amplitudes. We found a factor of 150 to reproduce original simulations better. Finally, the original implementation uses the fourth order Runge–Kutta method for numerical integration. Instead, we used the Exponential Euler method which is standardly implemented in NEST for the numerical integration of rate neurons [5].

In addition to these changes, the original model description has two features which cannot be straightforwardly translated to NEST. First, whether a nonlinear gain function is applied to a neuron's input can depend on the origin of said input. This is notably the case for excitatory burst neurons (EBNs) and omnipause neurons (OPNs). Since NEST only applies a single gain function per neuron to each of its input, we opted for using a linear gain function for EBNs and OPNs and to pass those inputs requiring an additional nonlinear gain function through an auxiliary unit instantaneously applying the desired nonlinearity. Second, constant input to a neuron was provided by an appropriately weighted bias node.

Results

In the remainder we present the results of our simulations for all nine experiments reported in the original publication. While our results generally accord very well with those of Gancarz & Grossberg [2], some simulations required slightly divergent parameter values to reproduce original results.

1) Saccadic staircase simulation

The first simulation reported by Gancarz & Grossberg [2] showcases the evolution of activity for each neuron type in the horizontal SG to a constant input (I = 1) applied to the left long-lead burst neuron (LLBN) for 265 ms.

Cell activity profiles in the reticular formation

blubber

Visually guided saccades

Bli Bla Blub

Oblique staircase simulation

Bli Bla Blub

Tuning curve of excitatory burst neuron (EBN)

Bli Bla Blub

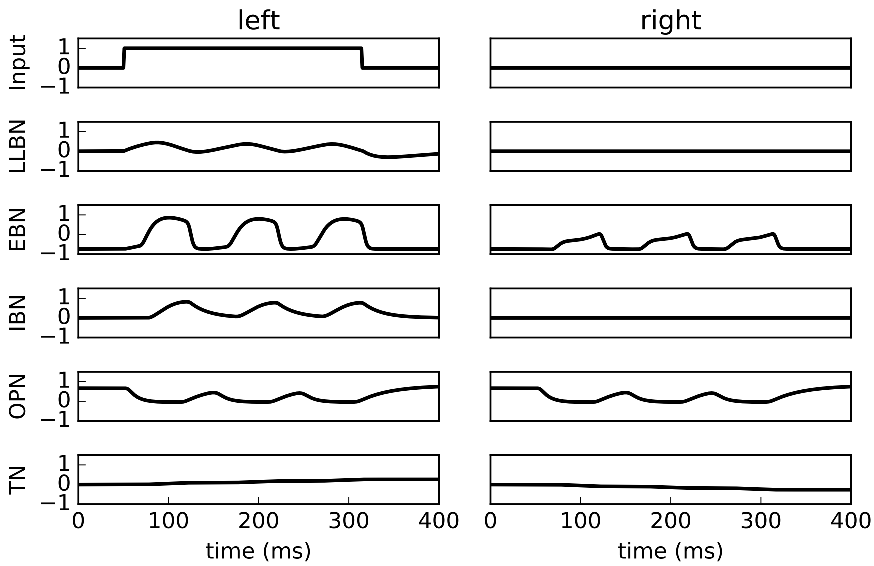

Figure 1: Figure caption for part (A) and part (B) . Description of stuff happening in the original implementation of Gancarz & Grossberg [2].

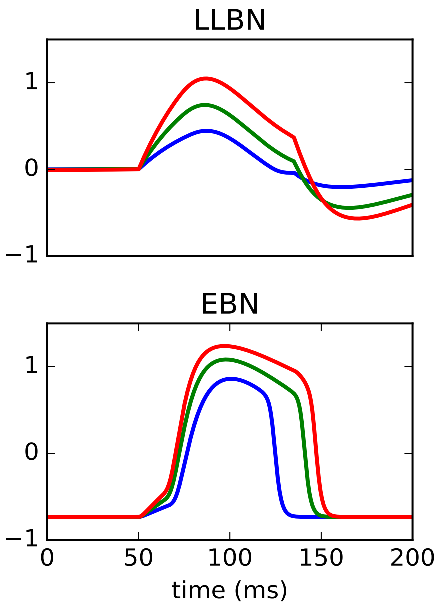

Figure 2: Figure caption for part (A) and part (B) . Description of stuff happening in the original implementation of Gancarz & Grossberg [2].

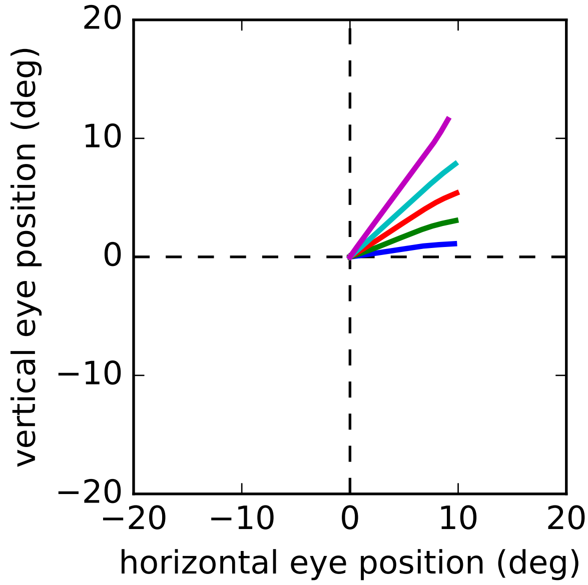

Figure 3: Figure caption for part (A) and part (B) . Description of stuff happening in the original implementation of Gancarz & Grossberg [2].

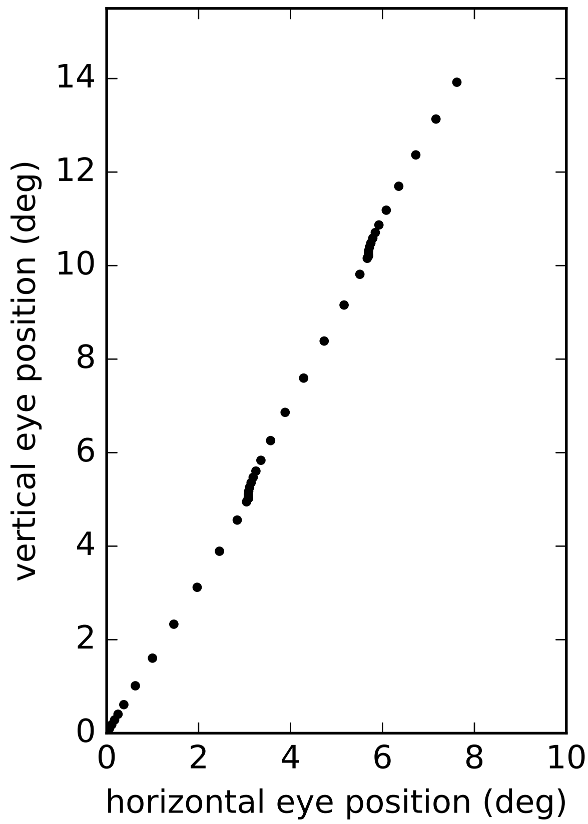

Figure 4: Figure caption for part (A) and part (B) . Description of stuff happening in the original implementation of Gancarz & Grossberg [2].

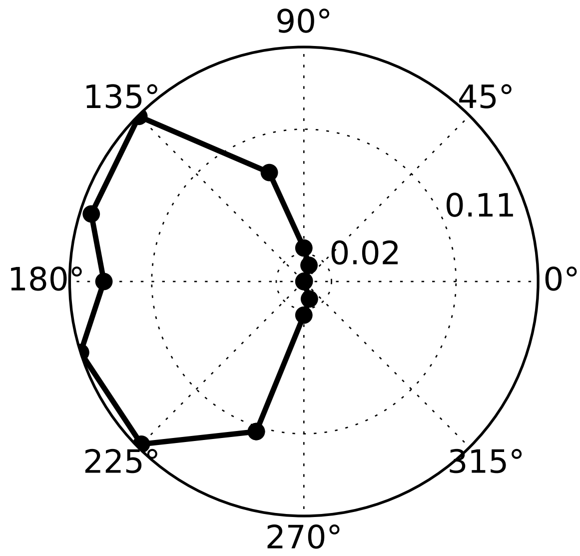

Figure 5: Figure caption for part (A) and part (B) . Description of stuff happening in the original implementation of Gancarz & Grossberg [2].

Effects of frequency of external stimulation

Bli Bla Blub

Trading saccade velocity and duration

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Smooth staircase simulation

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Interrupted saccade simulation

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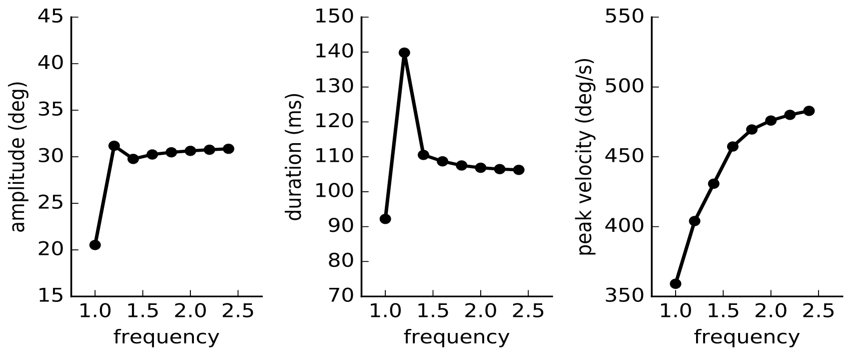

Figure 6: Figure caption for part (A) and part (B) . Description of stuff happening in the original implementation of Gancarz & Grossberg [2].

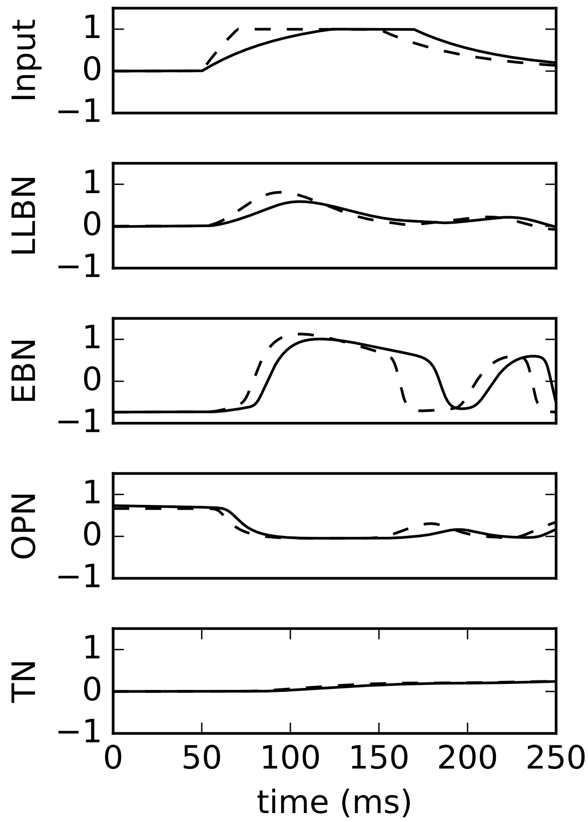

Figure 7: Figure caption for part (A) and part (B) . Description of stuff happening in the original implementation of Gancarz & Grossberg [2].

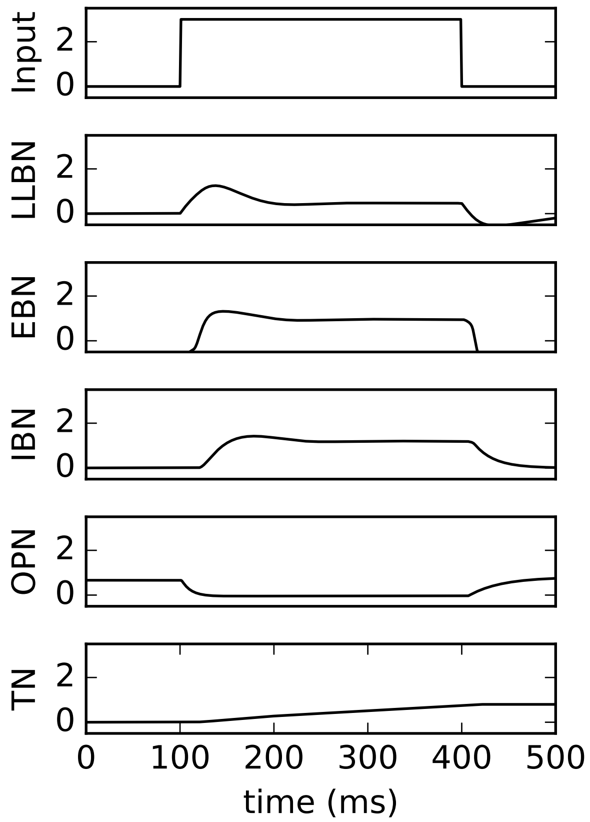

Figure 8: Figure caption for part (A) and part (B) . Description of stuff happening in the original implementation of Gancarz & Grossberg [2].

Figure 9: Figure caption for part (A) and part (B) . Description of stuff happening in the original implementation of Gancarz & Grossberg [2].

Figure 10: Figure caption

Conclusion

Conclusion, at the very minimum, should indicate very clearly if you were able to replicate original results. If it was not possible but you found the reason why (error in the original results), you should exlain it.

Table 1: Table caption {#tbl:table}

Heading 1			Heading 2		
cell1 row1	cell2 row 1	cell3 row 1	cell4 row 1	cell5 row 1	cell6 row 1
cell1 row2	cell2 row 2	cell3 row 2	cell4 row 2	cell5 row 2	cell6 row 2
cell1 row3	cell2 row 3	cell3 row 3	cell4 row 3	cell5 row 3	cell6 row 3

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$$A = \sqrt{\frac{B}{C}}$$

{#eq:1}

Acknowledgments

All network simulations carried out with NEST (http://www.nest-simulator.org).

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