IO EGLIF Parameters Recheck

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June 2025

1 Physiological Electroresponsivness Features

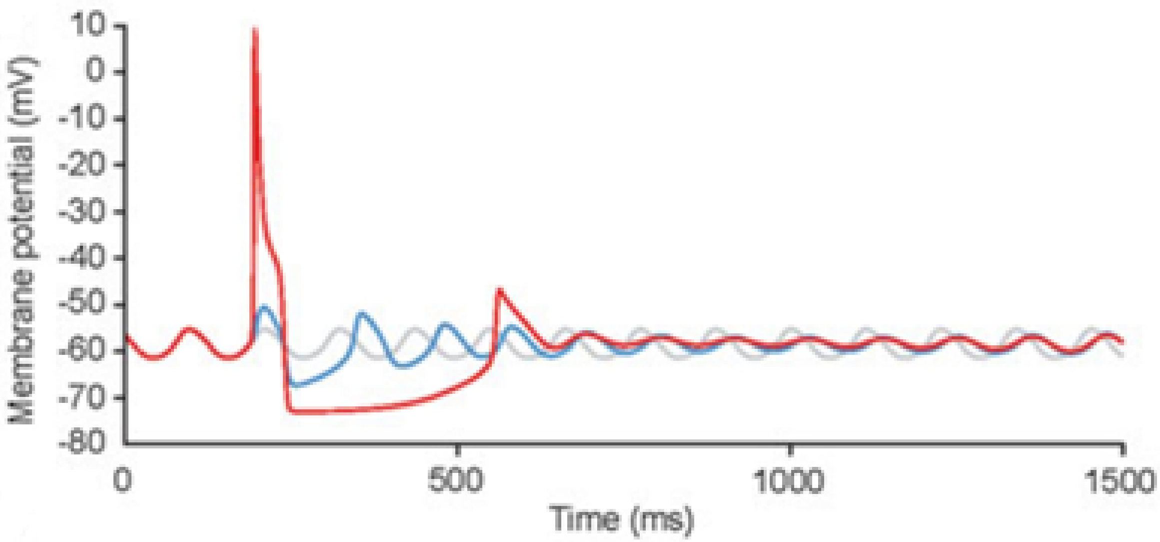


Figure 1: Spiking behavior of Inferior Olive neurons illustrating their intrinsic and network dynamics. Adapted from Loyola et al. (2022), From "Inferior Olive: All Ins and Outs" [1].

Physiological Features:

- **STO types**: LTO 1-3 Hz; Sinusoidal 3-10 Hz.
- **STO frequency**: 4.97 ± 1.85 Hz / range: 1.63 – 9.77 Hz.
- **STO amplitude**: 9.52 ± 5.4 mV / range: 1.13 – 21.14 mV
- **Spike**: fast sodium spike.
- **ADP**: broad after depolarization.
- **Spikelets**: one to seven spikelets at 130-450 Hz are superimposed on ADP.
- **AHP**: long lasting after hyperpolarization.
- **Spikes Rhythmicity**: for few hundred milliseconds (300 ms).
- **STO & Spike**: an action potential is generated on average every 10 STO cicles.

2 IO EGLIF Parameters

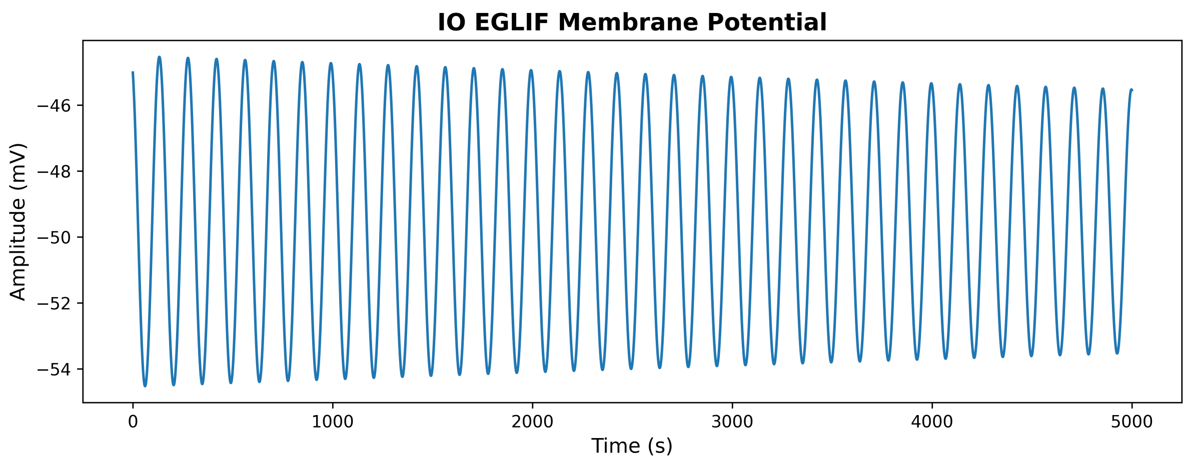
```
io:
  model: eglif_cond_alpha_multisyn
  constants:
    # Membrane Potential
    V_m: -45
    E_L: -45
    C_m: 189
    tau_m: 11
    I_e: -18.101
    k_adap: 1.928
    k_1: 0.191
    k_2: 0.091

    # V Threshold, Refractory Period and Escape rate
    V_th: -35
    t_ref: 1
    tau_V: 0.8
    lambda_0: 1.2

    # Reset on Spike
    V_reset: -45
    A1: 1810.923
    A2: 1358.197

    # Postsynaptic receptors
    tau_syn1: 1
    tau_syn2: 60
    E_rev1: 0
    E_rev2: -80
```

3 IO EGLIF STO



- Estimated STO frequency: 4.88 Hz
- Mean STO amplitude: 8.96 mV

The frequency and amplitude appear consistent with physiological values. However, the amplitude tends to decrease over time and no spikes are triggered in the absence of a stimulus. There is no variability in frequency or amplitude across neurons. Finally, STOs remain within the SSTO regime, while LTOs are not represented.

Idea: Would it be possible to introduce greater variability in amplitude so that in 1 out of 10 cycles, the membrane potential (V_m) reaches the threshold potential (V_th)?

4 DC Generator Background Noise

To analyze the spiking behavior under the influence of external input, a background noise generator was introduced. This generator was implemented as a `dc_generator` device with an amplitude of 20 and a synaptic weight of 1. Its activity was restricted to a brief 50 ms window, starting at 500 ms and stopping at 550 ms.

```
background_noise:
    device: dc_generator
    amplitude: 20
    weight: 1
    start: 500.0
    stop: 550.0
    delay: 0.1
```

4.1 IO EGLIF Rhythmic Firing

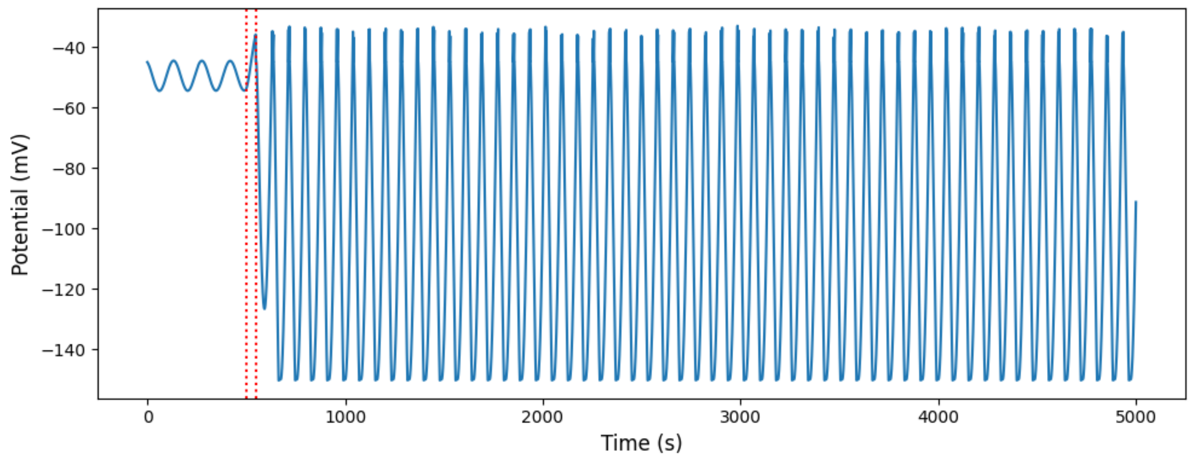


Figure 2: Complete time series of the DC generator output.

The resulting behavior deviated from expectations. Once a spike was triggered, rhythmic firing persisted throughout the entire simulation. While such rhythmic activity is physiologically plausible, it typically lasts for no more than **300 ms** under normal conditions.

4.2 IO EGLIF Spike

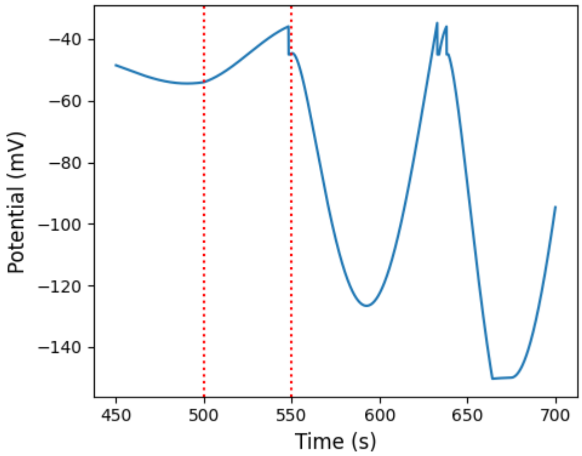


Figure 3: Zoomed-in segment of the DC generator output signal, showing detailed waveform behavior.

A DC input depolarizes the membrane potential to the threshold V_th, triggering a spike followed by an afterhyperpolarization (AHP). The AHP then induces a rebound depolarization, which leads to another spike accompanied by an afterdepolarization potential (ADP). A single spikelet is superimposed on the ADP, followed again by an AHP.

Issues:

- The afterhyperpolarization reaches approximately –150 mV, which is physiologically unrealistic.
- The afterhyperpolarization should last longer than 100 ms.
- Only a single spikelet is generated, whereas physiologically multiple spikelets are typically superimposed on the ADP.

Similar results can also be obtained using a Poisson generator device.

References

[1] S. Loyola, L. W. J. Bosman, J. R. De Gruijl, M. T. G. De Jeu, M. Negrello, T. M. Hoogland, and C. I. De Zeeuw, *From Inferior Olive: All Ins and Outs*, Handbook of the Cerebellum and Cerebellar Disorders. https://doi.org/10.1007/978-3-030-23810-0_43