

Supplementary Material

1 EQUATIONS OF THE INFERIOR-OLIVE MODEL

Below the equations of Inferior-Olive model as defined in De Gruijl et al. (2012) can be found. This model is used to benchmark *ExaFlexHH*.

$$\frac{dV_{dend}}{dt} = \frac{-I_{gap} + I_{app} - I_{sd} + I_{cah,d} + I_{kca,d} + I_{h,d} + I_{leak,d}}{C_{m,d}} \quad (S1)$$

where:

i = number current cell

j = number other cell

$$V_{i,j} = V_{dend,i} - V_{dend,j}$$

$$I_{gap_i} = \sum_{j=0}^{N-1} (w_{i,j} \cdot (0.8 \cdot e^{-0.01 \cdot V_{i,j}^2} + 0.2) \cdot V_{i,j})$$

I_{app} = input current, can vary per simulation step

$$I_{sd} = \frac{g_{int}}{1 - p_1} \cdot (V_{dend} - V_{soma})$$

$$I_{cah,d} = g_{cah,d} \cdot r_d^2 \cdot (V_{cah,d} - V_{dend})$$

$$I_{kca,d} = g_{kca,d} \cdot s_d \cdot (V_{kca,d} - V_{dend})$$

$$I_{h,d} = g_{h,d} \cdot q_d \cdot (V_{h,d} - V_{dend})$$

$$I_{leak,d} = g_{leak,d} \cdot (V_{leak,d} - V_{dend})$$

$$\frac{dr_d}{dt} = 0.2 \cdot \left(\frac{1.7}{1 + e^{-\frac{V_{dend} - 5}{13.9}}} \cdot (1 - r_d) - \frac{0.1 \cdot \frac{V_{dend} + 8.5}{-5}}{1 - e^{-\frac{V_{dend} + 8.5}{5}}} \cdot r_d \right) \quad (S2)$$

$$\frac{ds_d}{dt} = \min(0.00002 \cdot Ca2Plus_d, 0.01) \cdot (1 - s_d) - 0.015 \cdot s_d \quad (S3)$$

$$\frac{dq_d}{dt} = \frac{\frac{1}{\frac{V_{dend} + 80}{4}} - q_d}{\frac{1}{e^{-0.086 \cdot V_{dend} - 14.6}} + e^{0.070 \cdot V_{dend} - 1.87}} \quad (S4)$$

$$\frac{dCa2Plus_d}{dt} = -3 \cdot I_{cah,d} - 0.075 \cdot Ca2Plus_d \quad (S5)$$

$$\frac{dV_{soma}}{dt} = -\frac{I_{ds} - I_{as} + I_{cal,s} + I_{na,s} + I_{kdr,s} + I_{k,s} + I_{leak,s}}{C_{m,s}} \quad (S6)$$

where:

$$\begin{aligned} I_{ds} &= \frac{g_{int}}{p_1} \cdot (V_{soma} - V_{dend}) \\ I_{as} &= \frac{g_{int}}{1 - p_2} \cdot (V_{soma} - V_{axon}) \\ I_{cal,s} &= g_{cal,s} \cdot k_s^3 \cdot l_s \cdot (V_{cal,s} - V_{soma}) \\ m_s &= \frac{1}{1 + e^{-\frac{V_{soma} + 30}{5.5}}} \\ I_{na,s} &= g_{na,s} \cdot m_s^3 \cdot h_s \cdot (V_{na,s} - V_{soma}) \\ I_{kdr,s} &= g_{kdr,s} \cdot n_s^4 \cdot (V_{kdr,s} - V_{soma}) \\ I_{k,s} &= g_{k,s} \cdot x_s^4 \cdot (V_{k,s} - V_{soma}) \\ I_{leak,s} &= g_{leak,s} \cdot (V_{leak,s} - V_{soma}) \end{aligned}$$

$$\frac{dk_s}{dt} = \frac{1}{1 + e^{-\frac{(V_{soma} + 61)}{4.2}}} - k_s \quad (S7)$$

$$\frac{dl_s}{dt} = \frac{\frac{1}{1 + e^{-\frac{V_{soma} + 85.5}{-8.5}}} - l_s}{\frac{20 \cdot e^{\frac{30}{V_{soma} + 84}}}{1 + e^{-\frac{7.3}{7.3}}} + 35} \quad (S8)$$

$$\frac{dh_s}{dt} = \frac{\frac{1}{1 + e^{-\frac{V_{soma} + 70}{5.8}}} - h_s}{3 \cdot e^{-\frac{40}{-33}}} \quad (S9)$$

$$\frac{dn_s}{dt} = \frac{\frac{1}{1 + e^{-\frac{V_{soma} + 3}{10}}} - n_s}{5 + 47 \cdot e^{-\frac{(-50 - V_{soma})}{900}}} \quad (S10)$$

$$\frac{dx_s}{dt} = \frac{1.3 \cdot \frac{V_{soma} + 25}{10}}{1 - e^{-\frac{V_{soma} + 25}{10}}} \cdot (1 - x_s) - 1.69 \cdot e^{\frac{V_{soma} + 35}{-80}} \cdot x_s \quad (\text{S11})$$

$$\frac{dV_{axon}}{dt} = - \frac{I_{sa} + I_{na,a} + I_{k,a} + I_{leak,a}}{C_{m,a}} \quad (\text{S12})$$

where:

$$\begin{aligned} I_{sa} &= \frac{g_{int}}{p_2} \cdot (V_{axon} - V_{soma}) \\ m_a &= \frac{1}{1 + e^{-\frac{V_{axon} + 30}{5.5}}} \\ I_{na,a} &= g_{na,a} \cdot m_a^3 \cdot h_a \cdot (V_{na,a} - V_{axon}) \\ I_{k,a} &= g_{k,a} \cdot x_a^4 \cdot (V_{k,a} - V_{axon}) \\ I_{leak,a} &= g_{leak,a} \cdot (V_{leak,a} - V_{axon}) \\ \frac{dh_a}{dt} &= \frac{\frac{1}{1 + e^{-\frac{V_{axon} + 60}{-5.8}}} - h_a}{1.5 \cdot e^{\frac{V_{axon} + 40}{-33}}} \end{aligned} \quad (\text{S13})$$

$$\frac{dx_a}{dt} = \frac{1.3 \cdot \frac{V_{axon} + 25}{10}}{1 - e^{-\frac{V_{axon} + 25}{10}}} \cdot (1 - x_a) - 1.69 \cdot e^{\frac{V_{axon} + 35}{-80}} \cdot x_a \quad (\text{S14})$$

REFERENCES

De Gruijl, J. R., Bazzigaluppi, P., de Jeu, M. T. G., and De Zeeuw, C. I. (2012). Climbing fiber burst size and olivary sub-threshold oscillations in a network setting. *PLOS Computational Biology* 8, 1–10. doi:10.1371/journal.pcbi.1002814