Supplement B

This supplement explains the mathematical models that were used to translate the waveforms generated at the electrode to the resulting electric potential at the nodes of Ranvier of the simulated axon-models.

Monopolar set-up

The first electrode implementation is a monopolar configuration, one that has been used by most previous research. Suppl. B Fig. 1 displays the model and the different geometrical variables that are involved. With this model, the extracellular voltages for all the internodal segments (V_e in the MRG Model) can be calculated from the stimulation current. Assuming the electrode is modelled as a single point source placed in an infinite homogeneous isotropic medium, and the return electrode is placed at infinity, the electric potential at any (inter)nodal segment is given by:

$$V_{e,n}(t) = \rho_e \left[\frac{I_{\text{block}}(t)}{4\pi r} \right] \quad \text{(Eq. B.1)}$$

where $I_{block}(t)$ is the KHFAC current delivered to the block electrode, ρ_e is the extracellular resistivity, and r is the distance between the electrode and the internodal segment. When the axon is modelled to be on the y-axis, such that $x = 0$ and $z = 0$ for all axon segments, r can be rewritten to:

$$\sqrt{(y_n - y_e)^2 + x_e^2 + z_e^2} \quad \text{(Eq. B.2)}$$

with y_n being the location of the axon (inter)nodal segment on the y-axis, and y_e, x_e and z_e being respectively the y-, x- and z-position of the electrode. This can be plugged back into Equation B.1:

$$V_{e,s}(t) = \rho_e \left[\frac{I_{\text{block}}(t)}{4\pi \sqrt{(y_n - y_e)^2 + x_e^2 + z_e^2}} \right] \quad \text{(Eq. B.3)}$$

The value of extracellular resistivity ρ_e is taken from the MRG model to be 500 Ωcm.

Bipolar set-up

The second electrode implementation that will be researched is a bipolar configuration, which models the influence of both the KHFAC electrode and the return electrode. Supp. B Fig. 2 displays the model and the different geometrical variables that are involved.

Assuming again that the electrodes are placed in an infinite homogeneous isotropic medium, and modelling the bipolar electrode-array as a dipole, the voltage at any (inter)nodal segment is given by the sum of the electric potential resulting from the active electrode and from the return electrode. These potentials are given by Equation B.1.

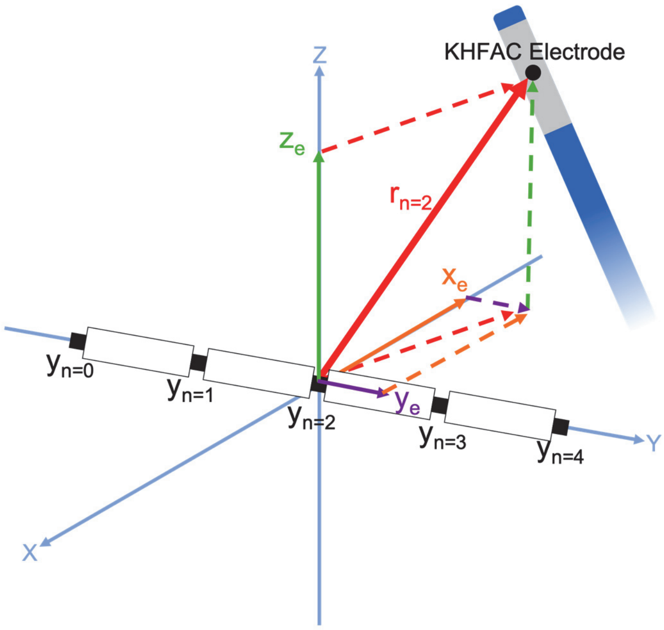
However, for the return electrode, the current flows in opposite direction compared to the active electrode; this results in the following equation:

$$V_{e,n}(t) = \rho_e \left[\frac{I_{\text{block}}(t)}{4\pi r_+} + \frac{-I_{\text{block}}(t)}{4\pi r_-} \right] \quad \text{(Eq. B.4)}$$

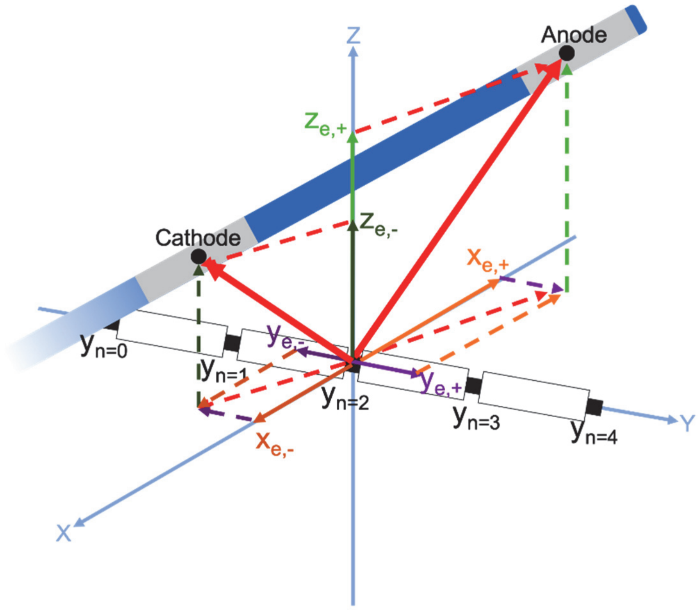
With r_+ being the distance to the anode and r_- being the distance to the cathode. Implementing the x-, y- and z-location for both poles, as was done in Equation B.2, yields the following result:

$$V_{e,n}(t) = \frac{\rho_e I_{\text{block}}(t)}{4\pi} \left[\frac{1}{\sqrt{(y_n - y_{e,+})^2 + x_{e,+}^2 + z_{e,+}^2}} - \frac{1}{\sqrt{(y_n - y_{e,-})^2 + x_{e,-}^2 + z_{e,-}^2}} \right] \quad \text{(Eq. B.5)}$$

The value of extracellular resistivity ρ_e is again 500 Ωcm, the same as in the monopolar set-up.



Suppl. B Fig. 1. The simulation set-up for a monopolar electrode configuration. The axon is situated on the y-axis. Variables z_e, x_e and y_e represent the coordinates of the monopolar electrode, and y_n represents the location of a node of Ranvier. The distance vector between a node and the electrode signal source is given by r_n.



Suppl. B Fig. 2. The simulation set-up for a bipolar electrode configuration. The axon is situated on the y-axis. Variables $z_{e,+}$, $x_{e,+}$ and $y_{e,+}$ represent the coordinates of the anode of the bipolar electrode; $z_{e,-}$, $x_{e,-}$ and $y_{e,-}$ represent the coordinates of the cathode of the bipolar electrode; y_n represents the location of a node of Ranvier.