Neuroprothetik Exercise 6
Electric Stimulation

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SS 2018

1 Calculate the Potential Field

The potential at a distance r from a current point-source can be calculated by:

$$\Phi = \frac{\rho}{4\pi} \cdot \frac{I}{r}$$

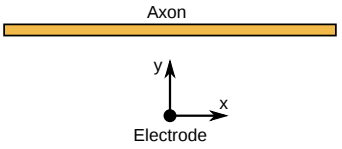
1.1 Potential Field

Using the following parameters, plot the potential field for a $50\,\mu m$ by $50\,\mu m$ slice in a distance of $10\,\mu m$ from the point source.

Paramters	
$\rho_{medium} = 300\,\Omega\text{cm}$	$I = 1\,\text{mA}$

1.2 Activation Function

Calculate and plot a) the external potential, b) the electric field and c) the activation function along a $50\,\mu m$ peace of axon positioned $10\,\mu m$ from a current point source. Plot the three graphs for a electrode current of 1 mA and for -1 mA



2 Create a Neuron Model

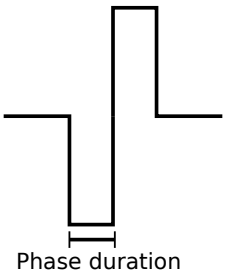
Enhance the model from the last exercise to consider the influence of an external potential. Change the parameters given in the table below.

Parameters		
$\rho_{axon} = 0.01\,\mathrm{k\Omega cm}$	$r_{axon} = 1.5 \cdot 10^{-4}\,\mathrm{cm}$	$l_{comp} = 0.5 \cdot 10^{-4}\,\mathrm{cm}$

2.1 Stimulate the Axon

Create the following stimulation sequences and run a simultain with your axon positioned as in section 1.2. Run the simulation for about 30 ms and position your puls at t=5 ms

1. Stimulation by a mono-phasic current pulse, phase duration = 1 ms, current = -0.25 mA
2. Stimulation by a mono-phasic current pulse, phase duration = 1 ms, current = -1 mA
3. Stimulation by a bi-phasic current pulse (negative phase first), phase duration = 1 ms, amplitude = 0.5 mA
4. Stimulation by a bi-phasic current pulse (negative phase first), phase duration = 1 ms, amplitude = 2 mA
5. Stimulation by a mono-phasic current pulse, phase duration = 1 ms, current = 0.25 mA
6. Stimulation by a mono-phasic current pulse, phase duration = 1 ms, current = 5 mA



Plot the results and give a short interpretation.

3 Solution

Here you can see how the resulting plots should look like. This is just to give you an idea if your results are valid.

3.1 Potential Field

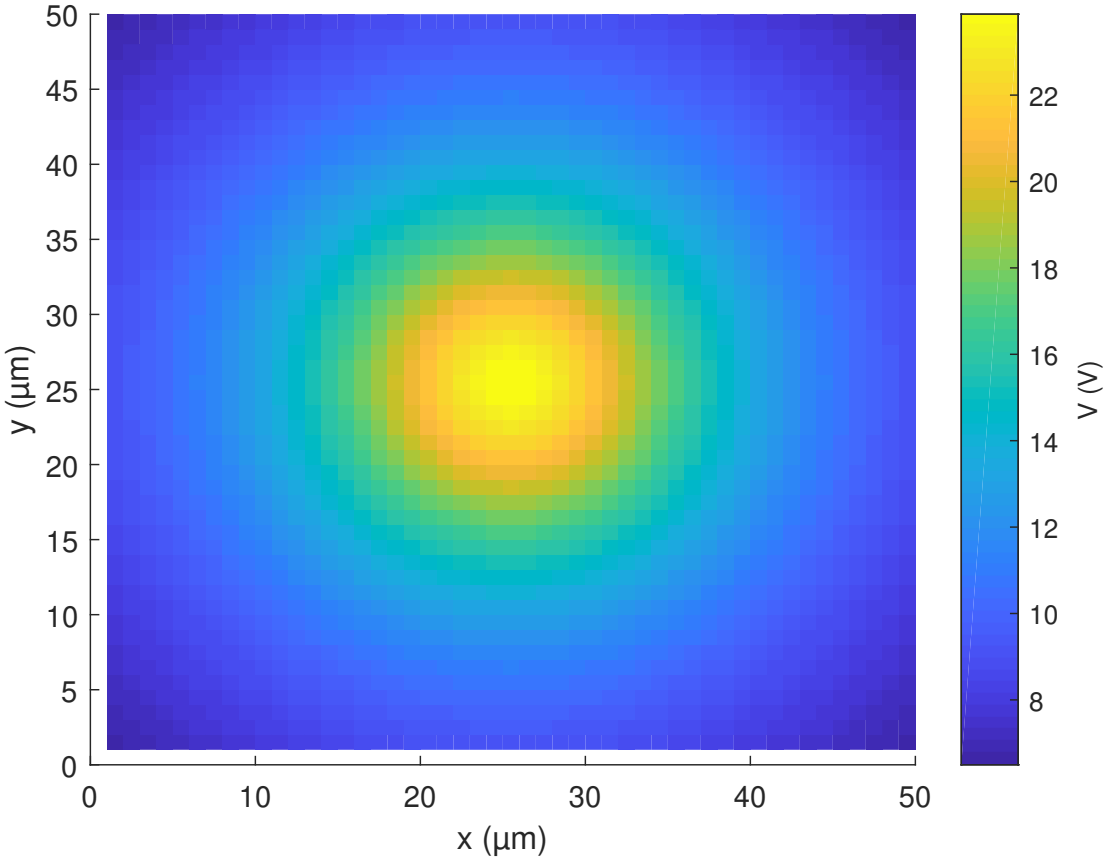


Abbildung 1: Potential field for $I = 1\,\mathrm{mA}$

3.2 Activation Function

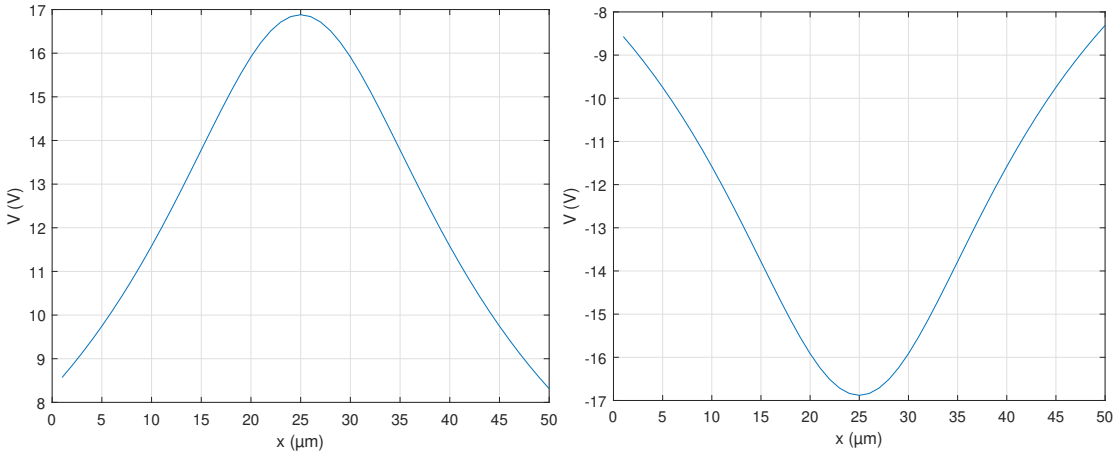


Abbildung 2: External potential in $d = 10\,\mu\text{m}$ for $i = 1\,\text{mA}$ (left) and $i = -1\,\text{mA}$ (right)

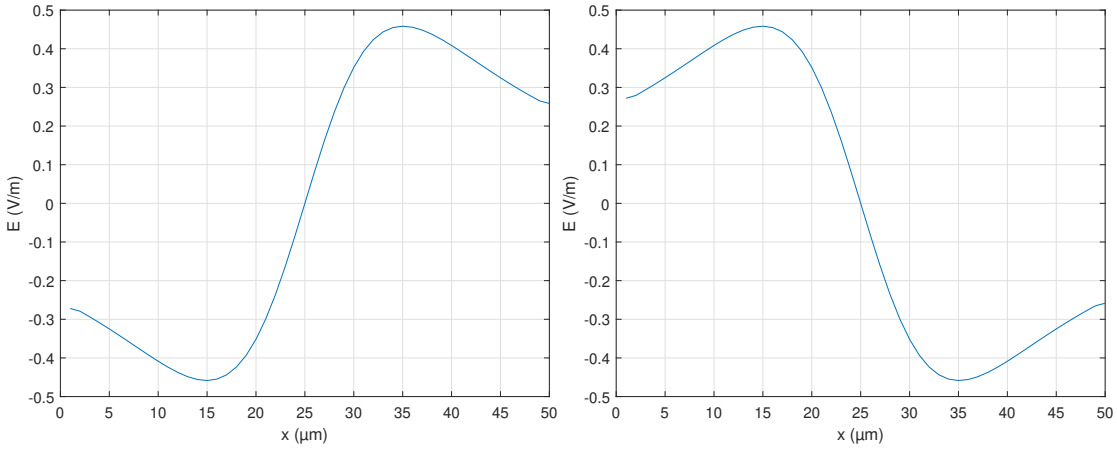


Abbildung 3: Electric field in $d = 10\,\mu\text{m}$ for $i = 1\,\text{mA}$ (left) and $i = -1\,\text{mA}$ (right)

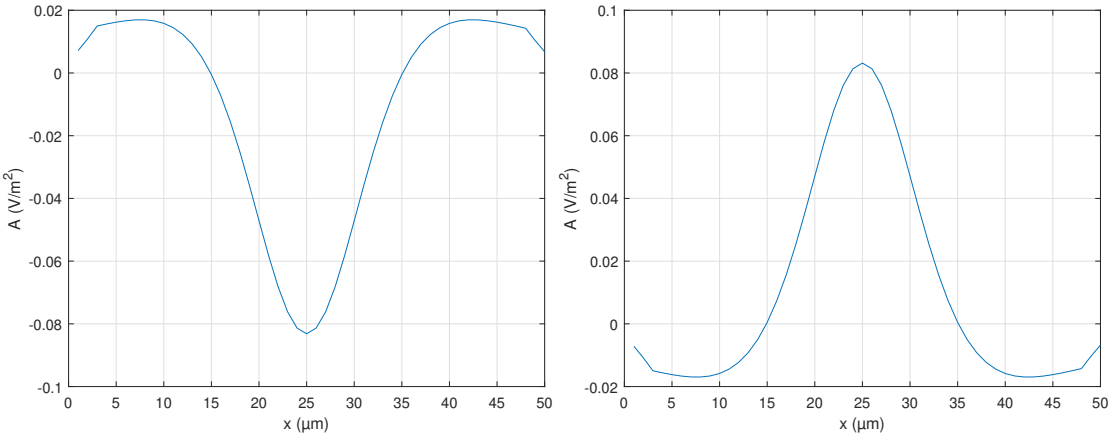


Abbildung 4: Activation function in $d = 10\,\mu\text{m}$ for $i = 1\,\text{mA}$ (left) and $i = -1\,\text{mA}$ (right)

3.3 Create a Neuron Model

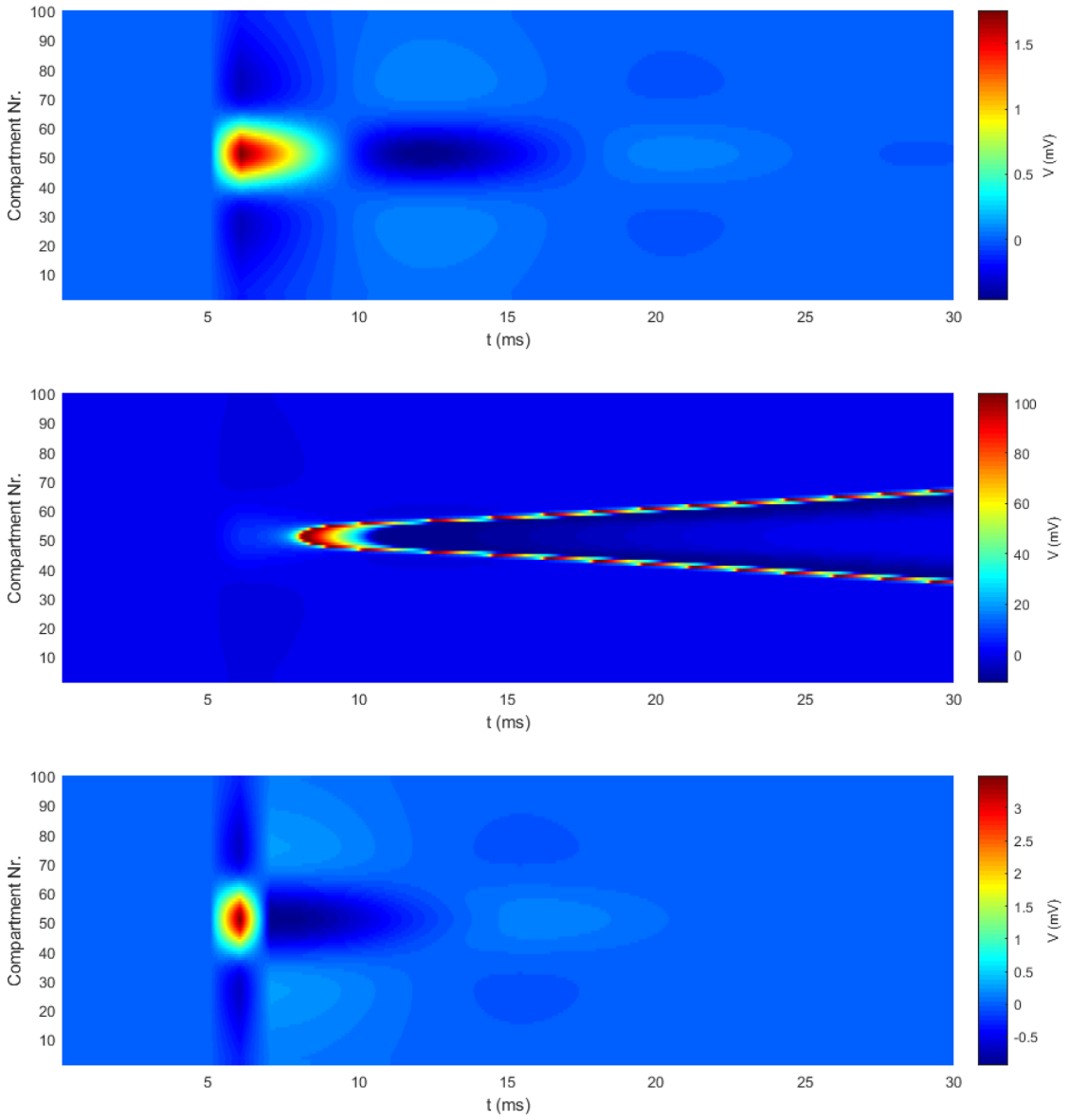


Abbildung 5: Propagation of the action potential when stimulated at $t = 5\,\mathrm{ms}$ with a phase duration of 1 ms. Additionally parameter: Top: mono-phasic pulse with $-0.25\,\mathrm{mA}$. Middle: mono-phasic pulse with $-1\,\mathrm{mA}$. Bottom: bi-phasic pulse with $0.5\,\mathrm{mA}$

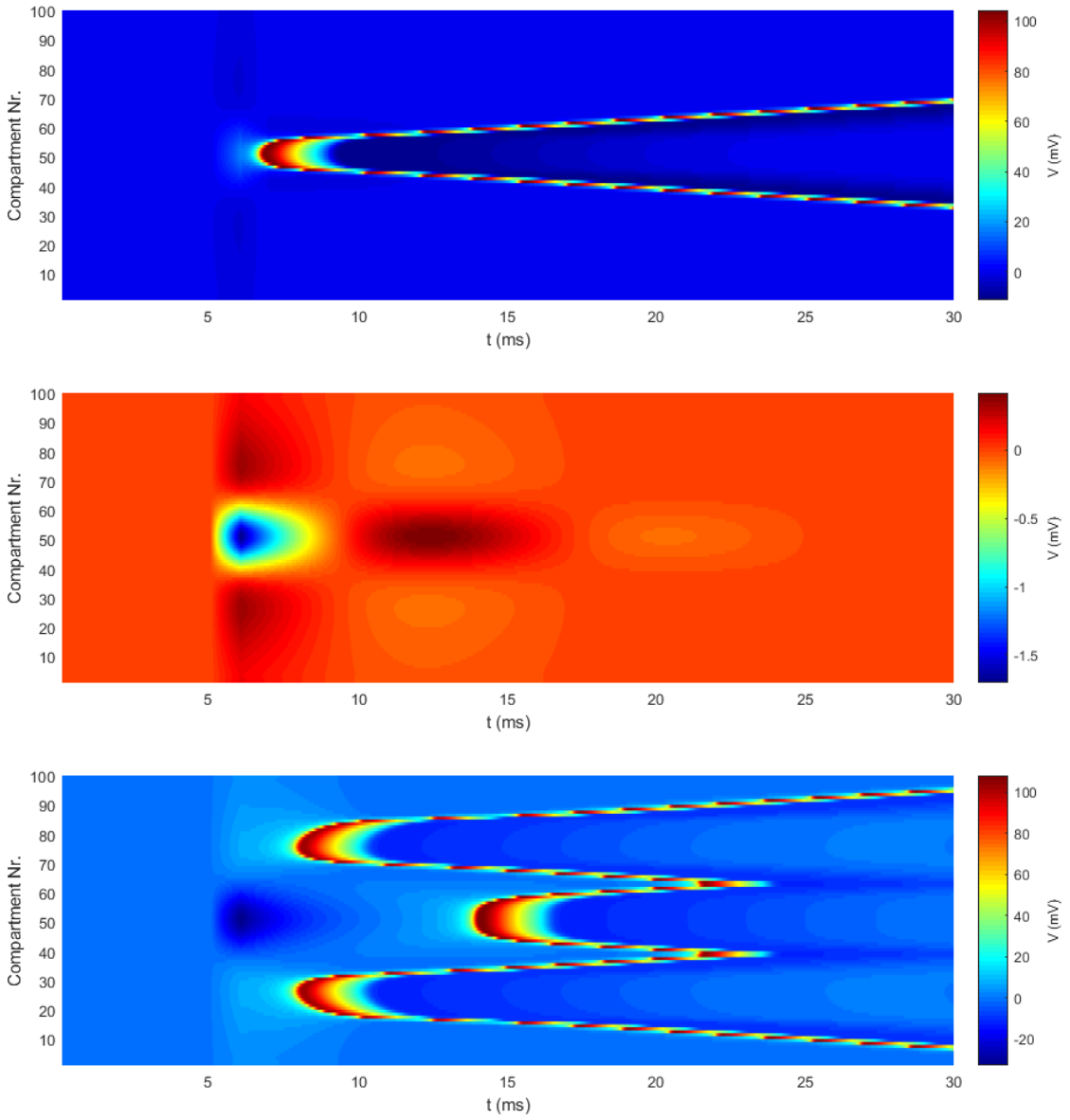


Abbildung 6: Propagation of the action potential when stimulated at $t = 5\,\text{ms}$ with a phase duration of 1 ms. Additionally parameter: Top: bi-phasic pulse with 2 mA. Middle: mono-phasic pulse with 0.25 mA. Bottom: mono-phasic pulse with 5 mA