Essential Mathematics in Neuroscience

Problem Sheet 2: Plotting, Sketching and Trigonometry

You have one week to solve the following exercises. The solved problem sheets are due 24/Oct/09 at the beginning of the lecture. Whenever you use computer plots, please also hand in your clearly commented source code.

General remarks for all exercise sheets

- All solutions have to be handed in at the beginning of the lecture and have to be handwritten. Source code can be printed, of course.
- You may work in groups to discuss your solutions but everyone has to hand in his/her own solution and has to be able to reproduce it at the black board.

1. **Horizontal grating (matlab):** Write the matlab code to produce the horizontal grating of frequency $\omega = 2$ and vary the contrast (scaling factor and maximal contrast are given as an input).

2. **Plotting lines:** We suppose that the current $I$ flowing through a single open channel can be related to the membrane potential $V$ by the equation $I(V) = g \cdot (V - E)$, where $E$ is the reversal potential, and $g$ the conductance\(^1\) of the channel. Suppose we are given the data $I(-40mV) = 7pA$ and $I(-120mV) = -9pA$.

   (a) Plot the line passing through the points $(-40, 7)$ and $(-120, -9)$, and write down its equation.

   (b) Calculate the conductance $g$ and the reversal potential $E$.

   (c) (*) In the same coordinate system, plot the function $I(V) = \frac{g(V-E)}{(1+(0.02(V-E))^4)^{1/4}}$.

   You will see that it is very close to the $g(V - E)$ for voltages close to $E$, but saturates for very large voltages.

3. **Drawing functions (by hand):** There are many situations where a scientist needs to draw a function on a black board. Therefore it is important that you get a feel for the most important functions and that you can draw them intuitively.

   (a) The Gaussian (or also called normal) probability density function is one of the most important functions, and has several applications in neuroscience. It is used for example in the mathematical description of receptive fields or for density estimation. For the 1D case it is defined as

   $$ \mathcal{N}(x|\mu, \sigma) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2\sigma^2}(x-\mu)^2} $$

\(^1\)Remember: resistance $R = \frac{V}{I}$, SI unit $\Omega$ (Ohm); conductance $G = \frac{1}{R}$, SI unit $S$ (Siemens)
Figure 1: Gaussian distribution with $\mu = 0.0$ and $\sigma = 1.0$.

where $\sigma$ is called standard deviation and $\mu$ is called mean. Draw the function for the following parameters in one coordinate system and describe how the parameters alter the function with respect to the standard Gaussian shown in Figure 1.

i. $\mu = 2$, $\sigma = 1.0$
ii. $\mu = 0$, $\sigma = 4.0$
iii. $\mu = 0$, $\sigma = 0.5$

(b) Another very important set of functions is sine and cosine. In neuroscience, they are used in, e.g., signal processing, cell response curves, and as stimuli. Draw the following functions in one coordinate system and describe your findings. How are the functions related?

i. $\sin(x)$
ii. $\cos(x)$
iii. $\sin(x + \pi/2)$
iv. $\cos(x - \pi/2)$

Feedback

Please fill out the feedback part and hand it in with your solutions. This will help us to adjust the contents of one lecture and further problem sheets.

Time it took me to complete the problem sheet: _____ min

The last lecture was _____ too slow / too fast

The tasks were _____ easy / too difficult

Further feedback: