UNV Assignment 1

Deadline: Submit report by week 4.
Topics: Neural Coding; Linear Regression; Convolution

General guidelines for the assignment:

Assignment has to be submitted in the form of a report (referát) following the guidelines listed below:

- Format of the heading: Include a header having an assignment title, student's name who worked on it (like in case of a project, you should work in max. 4 student's group), study year, group etc…

- Format of the answers: First, the answer needs to be written in text format. Further, insert the MATLAB code/script relevant to the answer. Try to supplement your code with proper comments explaining it. Sometimes the questions are freely given in the assignment text. So read it carefully, and make sure you answer all the questions.

- Format of the figures: The figures should be self-explanatory. So, add a legend (Example: What each colored line represents?) and label the axes with proper units. Further, add a figure number, title and text description explaining the results shown in the figure. This could also include your evaluation/discussion whether the results in the figure are matching with your expected results.

- Format of the document: The report should ideally be in a PDF format (use PDFCreator for instance). Send the report via email to **kogneuro@gmail.com** (note that this email id is different from the one on which I read standard emails). The subject of the email should have the following structure: UNV Zx author_names. (x- assignment number).

Assignment description:

This assignment is based on the data described in the article by [R. Wessel, C. Koch, and F. Gabbiani, Coding of time-varying electric field amplitude modulations in a wave-type electric fish. *J Neurophysiol* 75:2280-93 (1996)] and on a Computational Neuroscience problem set by Sebastian Seung. Eigenmannia is a species of fish with a special organ that generates a weak oscillating electric field with a frequency of several hundred Hz. It also has an electro-sensory organ sensitive to such electrical field.

The aim of this assignment is to get you acquainted with the MATLAB and also an exploratory data analysis technique called linear regression. Each one of you will download the *fish.mat* matlab data file from http://ics.upjs.sk/~kopco/UPJSONLY/unv/z1/fish.mat This file contains data that you will analyze in the assignment. Note: The mathematical methods required for this assignment (regression) have been explained during the lab.

Instructions to load the data file:

1.) Launch MATLAB (on lab PC-s using command *matlab*)

2.) Load data using the command '***load***'

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>> load fish.mat
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Note: Remember to save/add the *fish.mat* file in the current workspace folder.

3.) Next step is to get familiar with the data set.

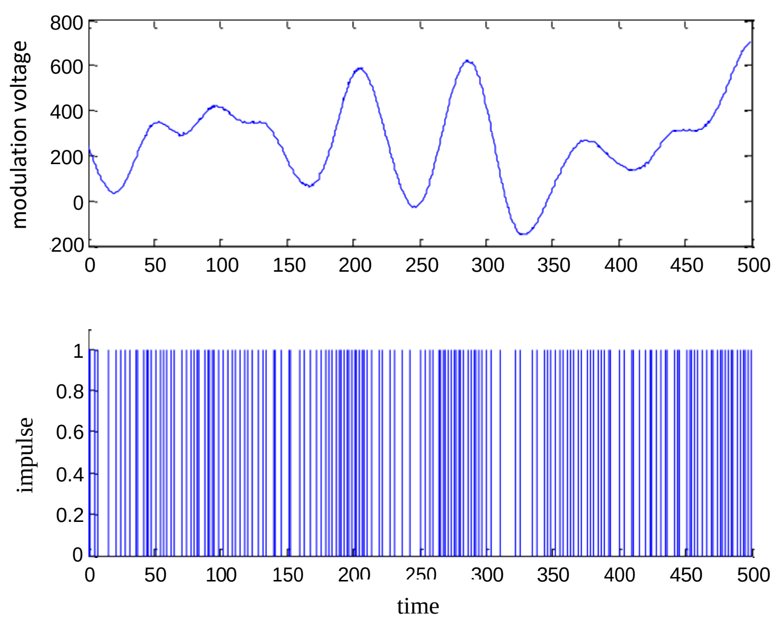
Command '***whos***' displays the list of variables in workspace:

- Variable ***time*** contains the sampling time during the experiment in milliseconds.
- Variable ***rho*** contains the binary vector corresponding to the neuron impulse in the electro-sensing organ.
- Variable ***stim*** contains the stimulus, i.e. the random depth of the amplitude modulation of the oscillating electric field to which the fish has been subjected.

1.) For each of the following questions, write the MATLAB commands (up to two) that you have used along with the answers. MATLAB commands should be very short, and you cannot use loops (ex: for, while).

a) How many impulses were recorded throughout the experiment?
b) How long (in seconds) was the experiment?
c) What is the average rate of impulses (in Hz) for the whole experiment?
d) How many impulses occurred during the first half of the experiment?
e) What is the average rate of impulses (in Hz) for the first half of the experiment?
f) What is the maximum stimulus value?
g) What is the time (in milliseconds) when 100^{th} impulse occurred?
h) What is the average value (arithmetic mean) of the sequence of impulses?
i) What is the variance of the sequence of impulses?
j) Calculate the mean value (arithmetic mean) of the sequence of impulses without using the built-in *mean* function.
k) What is sampling rate used in the experiment?

2.) Write a program that displays several hundred samples of the impulse and stimulus sequence as shown in the following figure (displays the first 500 milliseconds). You can select the beginning of the section you draw, and choose the size of the rendered section determined by the random number generator in MATLAB, but let it be a few hundred milliseconds:



Hint: Use the '*plot'* command for the first figure and '*line'* command or '*bar'* for the second. Using the '*subplot*' command, you can insert two figures in one figure window, and then describe the figure using the '*xlabel'* and '*ylabel'* commands. You are not supposed to use loops. Please include the code that was used to create the figures.

3.) Write a program that generates an estimate of the time dependence of probability of impulses using rectangular smoothing kernel. Use a kernel impulse convolution ('*conv'*) defined as *ones* (K, 1) / K where K is any odd number between 50 and 250 chosen by you. Why the K has to be odd? From the resulting vector, select the middle part (leaving the first and last (K-1) / 2 samples) to obtain a vector of the same length as *rho*. Name the new vector as *prob*. Multiply the vector *prob* with the correct constant to obtain an impulse frequency vector (in Hz or in pulses per second). Name the new vector as *rate* (Frequency). Create a variable called *rate2*, which will be a linearly scaled version of the *rate* vector (i.e., rate2 = k1 * rate + k2) where you determine the scaling (constants k1 and k2) so that the minimum and maximum rates2 is equal to the minimum and maximum of the stimulus. Include the code and the figure that shows *rates2* and *stimulus* as a function of time. Let the two plots overlap in one figure (Use: *hold* command).

4.) Approximate the probability of impulses as a function of stimulus. Using the *polyfit* function, find coefficients '*a'* and '*b'* such that a * stim + b optimally approximates the probability of impulses (*prob*). Include the program and the figure that shows the probability of impulses (*prob*) as a function of time and also a * stim + b as a function of time in the same figure. Approximation should be very good. Also create a figure that plots the *prob* as a function of the stimulus (without the data being linked by the line '-'. Use the plot (x, y, '.')) and a * stim + b as a function of stimulus. This figure should contain a line that approximates the data displayed by the points. Use the *corrcoef* command to calculate the correlation coefficient.

5.) Choose one of the following two tasks:

a. Find the coefficients '*a'* and '*b'* without the use of matlab functions *polyfit*, *var* and *cov*.
b. Perform steps described in question 4, but this time test the zero and second order polynomial models, and for all the three models calculate the mean quadratic error.

6.) What proportion of variance in the data is this model able to explain?

All the best!! Have fun ☺