**SSY080 Matlab project**

You work in pairs and write a common report

The report should be written in English

Report is due on the 16th of October (Please indicate group ID)

Oral presentation is individual

You have learned in the course that systems can be used to model biological systems.

In this project, you will learn how to model an electromyographic (EMG) signal recorded with intramuscular electrodes (electrodes placed within a muscle).

A muscle is composed by several functional units called motor units. An EMG signal is the sum of the electric potential generated by motor units when they are activated. When a motor unit is activated it produces spikes known as action potentials.

Graphically, we can represent the EMG as the sum of trains of action potentials (Figure 1).

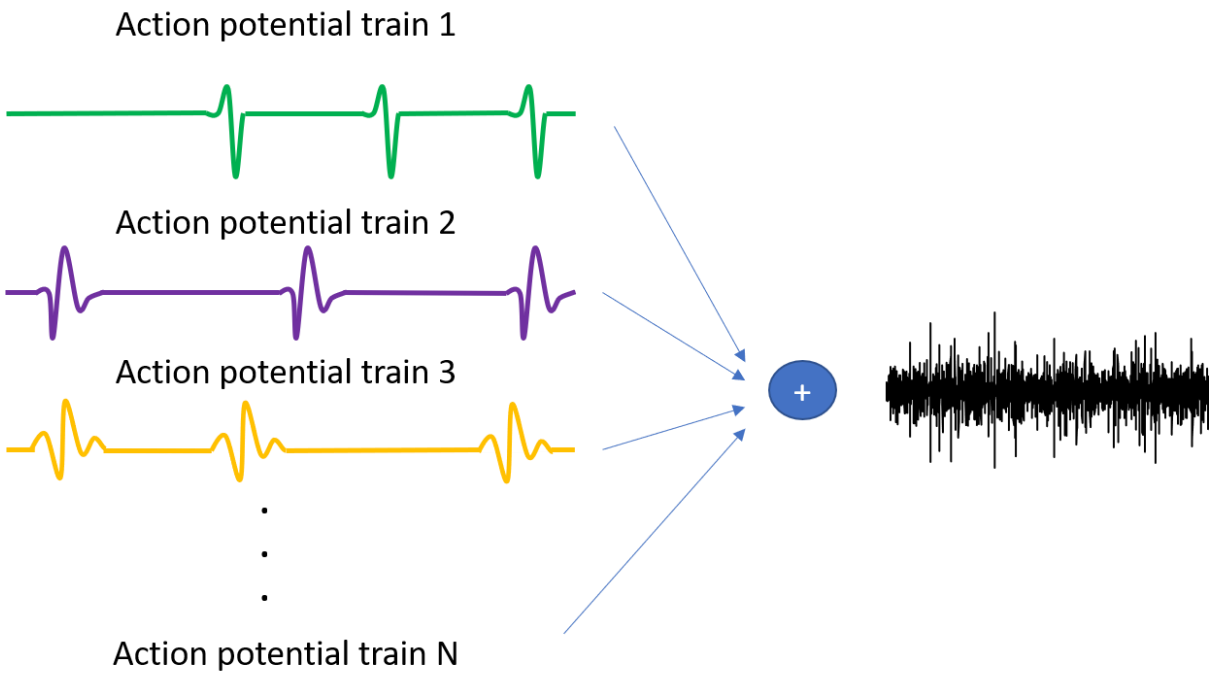


*Figure 1 Generation of the EMG signal.*

In Figure 1, we have considered 3 action potentials, represented in Figure 2.


*Figure 2 Action potentials.*

In each train of action potentials, the same action potential is repeated several times (only three times in Figure 1 for simplicity).

We can indicate with t11, t12, t13, … the time instants at which action potential 1 is discharged. The corresponding samples are s11, s12, s13, … This is represented in Figure 3.

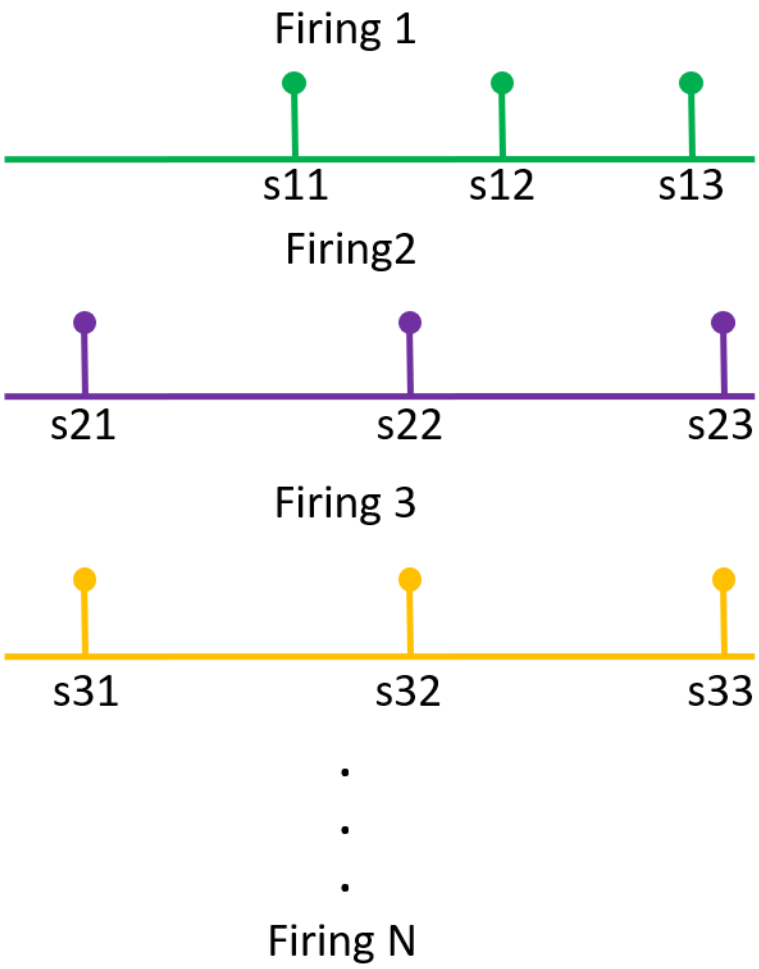


*Figure 3 Firings of the action potentials represented in Figure 2.*

*Assignment*

You are supposed to create an EMG signal composed by 8 action potential trains.

The signal duration should be 20 s, the sampling frequency 10,000 Hz.

We provide you two Matlab variables:

- action_potentials.mat
  It is a 8x100 matrix that contains the action potentials of 8 motor units.
  The number of rows (8) is the number of motor units.
  The number of columns (100) is the number of samples.
- firing_samples.mat
  It is composed by 8 cells, one for each motor unit. Each cell is a vector that contains the index of the samples at which the discharges of action potentials occur. Note that the number of discharges is different for the different units.

Question 1.

- Create the trains of action potentials corresponding to each unit (8 trains in total).
  Hint:
  First step, for each action potential train, you can create a binary vector with samples equal to 1 in correspondence of the firings and 0 otherwise (you are supposed to simulate 20 s of signal).
  Second step, you need to have a replica of the action potential in correspondence of each firing time. How can you obtain that?
- Comment on the procedure you have followed.
- Plot 1 of the 8 action potential trains as a function of time (therefore you should have 0-20 s in the time axis). In addition, plot the same action potential train in the time interval 10-10.5 s.
  Note: the unit for the time axis should be seconds; the unit for the amplitude of the action potentials is not provided and you should indicate A.U. (which stands for arbitrary unit).
- Sum the 8 action potential trains in order to obtain the EMG signal.
- Plot the EMG signal as function of time (in the time interval 10-10.5 s).

Question 2.

- Filter the 8 binary vectors with samples equal to 1 in correspondence of the firing times.
  You should use a filter with impulse response equal to a Hanning window of duration 1 s.
  The Matlab function for creating the Hanning window is “hann”.
- Plot the 8 filtered signals as a function of time (all in the same graph).
  Use the Matlab function “hold on”.
- Describe the filter characteristics (e.g. low-pass, high-pass)

You are supposed to provide

- A report that contains the replies to the above questions and comments on how you achieved the results. The report should not exceed 3 A4 pages.
- You should provide the Matlab code.

[ref] Templates were obtained from emglab.net