# MOTION & SLEEP - EXERCISE

You are about to discover one of the most exciting mysteries of human mankind: our dreams. But before that, let's try to solve a simpler problem.

We have let our devoted volunteer (also known as *the guinea pig*) sleep with his phone in one bed. Using an accelerometer, the phone was registering the acceleration values (static and dynamic) in 3 dimensions (x, y, z) along with the corresponding timestamp. In the same time, the volunteer was also plugged into another machine which was able to identify the sleep phase changes.

The results of this study are saved in two files:

- `phone.csv`: a comma-separated file with the lines formatted as:
  `[timestamp, x acceleration, y acceleration, z acceleration]`
- `sleep_phases.csv`: a comma-separated file with the lines formatted as:
  `[timestamp, sleep-phase number]`.

Your task is to display the relation between the motion of the phone (interpreted as the motion of our volunteer) and the change of the sleep phase. In other words, you will need to prepare the data (use appropriate date format, smooth the signal, if necessary, align the samples, etc.) and find the best way to display the relation between the accelerometer measurements and sleep phase changes. We will guide you through this process.

*You can use whichever programming/statistical tool you like, but we encourage you to become familiar with Matlab or Octave, as this will be useful when you start working with us.*

(1) Read the data into Matlab from the above mentioned files and display them as a series of 2D plots.
(2) Using the data from the file `phone.csv` compute the motion vector taking into account absolute values of the acceleration in all 3D axis. *Hint:* The accelerometer gives the values for a given time instant, while motion should rather refer to the changes of the signal in time.
(3) Align the signals according to the timestamps (assume the clocks in the phone and in the sleep analysis machine are synchronized).
(4) We are interested in the sleep phase *change* - therefore, generate the sleep phase changes vector where 1 corresponds to the sleep phase change and 0 corresponds to no change.
(5) Even when there is no important motion detected, the phone accelerometer registers certain measurement noise. Select the time interval where this noise can be observed (*i.e.* where no rapid movement can be observed) and compute the maximum value of this noise.
(6) Threshold the motion data with the value computed in the previous point. This way you will filter out the small variations of the signal and focus on the more important changes.
(7) Finally, to simplify the analysis of those two signals, assume that we are not interested in the magnitude of motion change, but only in the mere fact that it happened. To this end, create a vector of bins corresponding to the time intervals, where for each interval you count the number of changes exceeding the threshold computed in the previous point. The number of intervals should be around 150-200. Do the same for the sleep change signal. Plot both *binned* signals on one axis.

Voilà! You have just completed the first step towards discovering the mystery of human dream! The final plot should look more or less like that:

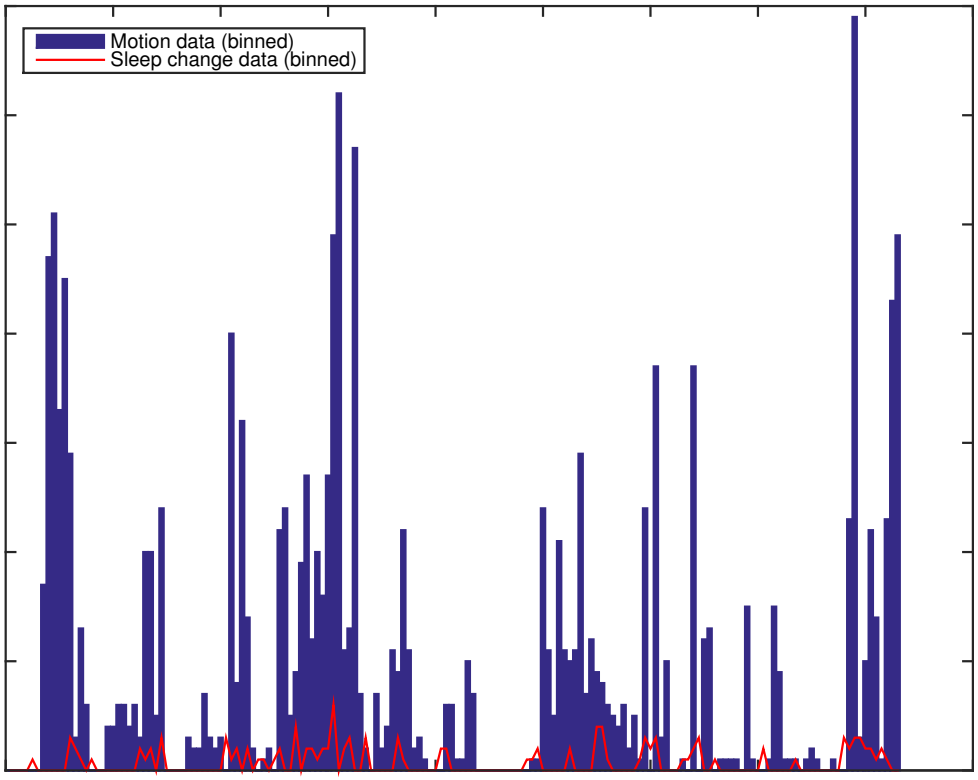


FIGURE 1. Relation between motion data and sleep change signal.

## BONUS POINTS

- Can you come up with other features derived from the accelerometer measurements that could be useful to identify the sleep changes based on the phone data?

- What other de-noising techniques would you use to smooth the resulting signals?