BSP 2021-2022/1 - Assignment 01

Total of 10 marks

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Marks attained for this part of the homework will count towards your final grade

To attain (full) marks for a question, any answer that includes images or a piece of knowledge, which should be referenced/cited, needs to highlight the source (book, article or web address). You are encouraged to help each other, but identical solutions will not be graded.

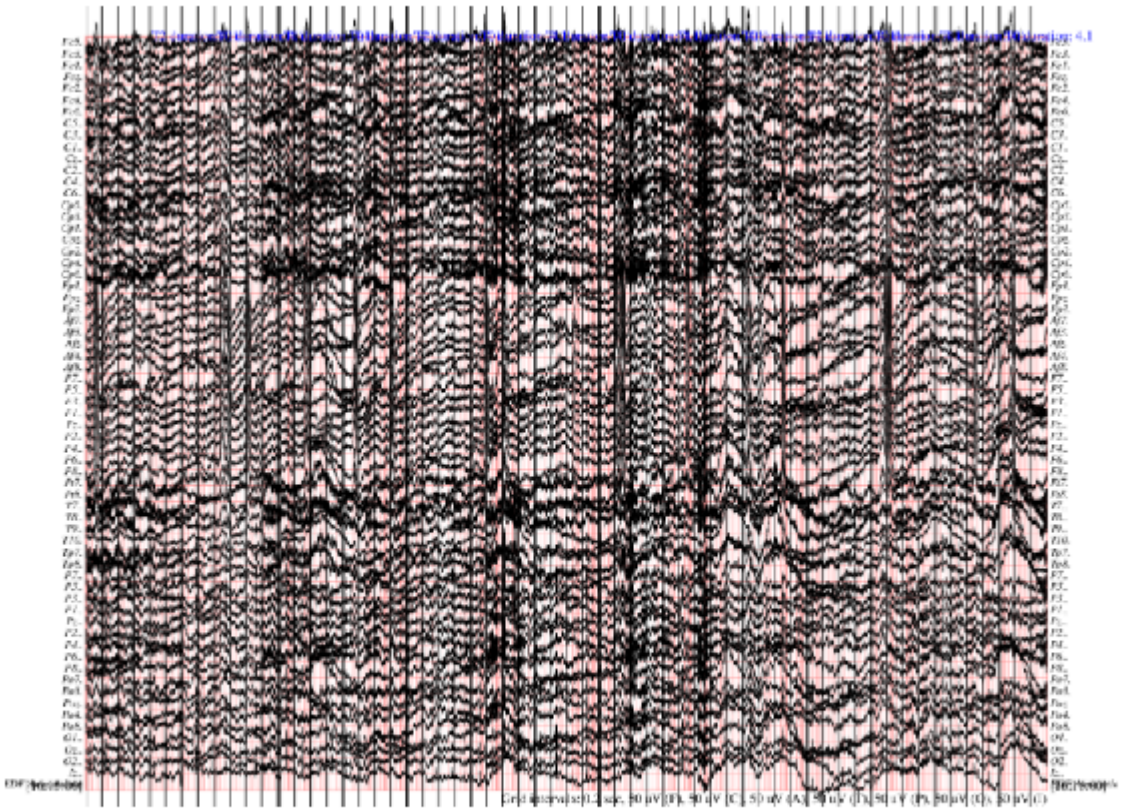
Physionet

Go to the website https://physionet.org. This is a database of various biomedical signals. The ATM is the service which allows you to download these signals: https://archive.physionet.org/cgi-bin/atm/ATM. Here you can read a manual about how to use this service. You can always return here with the '*help'* item of the toolbox.

- Find a *1-minute-long EEG signal* in the database, and plot it with the available toolbox item '*Plot waveform'*. Save a screenshot of the plot into your main working directory (./myplot.png) and load it into this file using the code below. Change the title accordingly.

(1 mark)

```
figure(1)
im = imread('myplot.PNG');
imshow(im)
title("EEG Motor Movement/Imagery Dataset (eegmmidb)")
subtitle("S020/S020R13") % subtitle function will work only from Matlab 2020b on
```



- Explain where and how this data was recorded, who the subjects were, and what was the purpose of the recording. (Look for the description of the database.)

The experiments were performed by the developers of the BCI200 instrumentation system. The main goal of the development is to provide communication and control capabilities to people with severe motor disabilities. 109 volunteers joined the experient which resulted in a huge dataset, containing over 1500 recordings.

The subjects had to perform motor and imagery tasks, like opening and closing left, right or both fists, then do the same task again, but this time with their imagination only. These consecutive tasks were repeated 3 times. [1] [2]

(1 mark)

Loading and Plotting

- Export your signal as a *.mat file (Toolbox – ‘Export signals as .mat’). Use the *.mat and *.info files for plotting the signal in Matlab. Use the code below for the plotting - replace question marks (?) in the code with the necessary data. You should obtain a similar plot, as before.

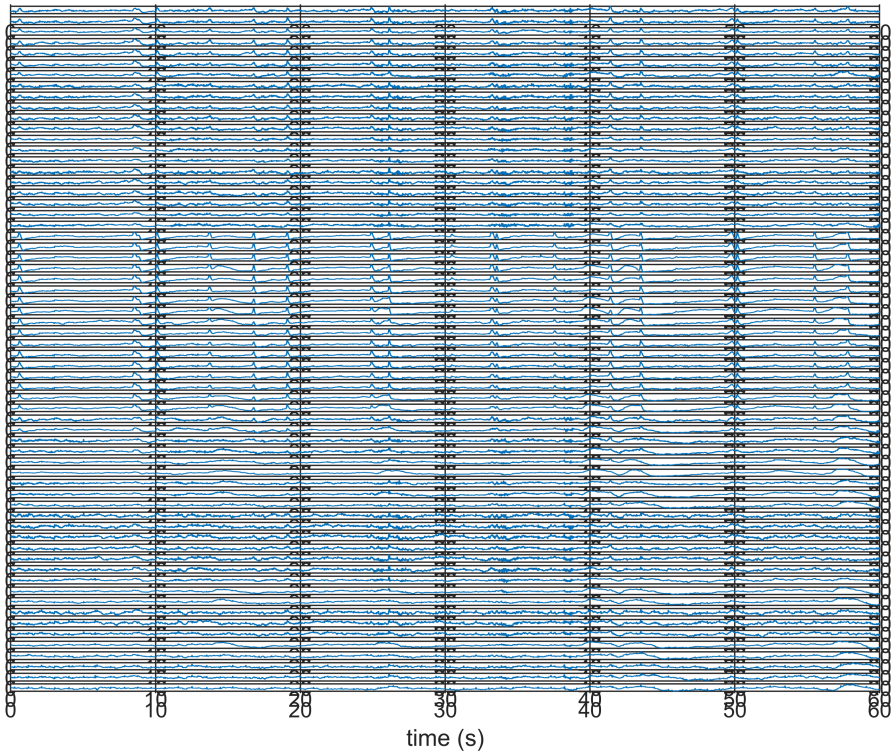
1. Create a time axis using the number of samples/sampling frequency /length of recording.

2. Correct the signals for base (a DC shift, has to be subtracted) and gain (amplification, divide by it), as noted in the *.info file
3. Use the plot() function for plotting your signal onto the previously designed time array. They have to be the same length!
4. If you have multiple datalines (rows), plot them using the subplot() function
5. Always label your axis with the appropriate units! (xlabel(), ylabel(), see the *.info file)

(3 marks)

```
signal = load("S020R13_edfm.mat");
signal = signal.val;
% number of samples
N = size(signal,2);
% number of channels
Ch = size(signal,1)-1; % I do not use the last row, because it contains only the annotation
% sampling  - read from the .info file
fs = 160;
% base(s) and gain(s) - copy-paste data from .info file, for all channels if
% necessary
base = zeros(64,1);
gain = ones(64,1);
% unit(s) - copy-paste data from .info file, for all channels if necessary
units = {'uV', 'uV', 'uV', 'uV', 'uV', 'uV', 'uV', 'uV'
         'uV', 'uV', 'uV', 'uV', 'uV', 'uV', 'uV', 'uV'
         'uV', 'uV', 'uV', 'uV', 'uV', 'uV', 'uV', 'uV'
         'uV', 'uV', 'uV', 'uV', 'uV', 'uV', 'uV', 'uV'
         'uV', 'uV', 'uV', 'uV', 'uV', 'uV', 'uV', 'uV'
         'uV', 'uV', 'uV', 'uV', 'uV', 'uV', 'uV', 'uV'
         'uV', 'uV', 'uV', 'uV', 'uV', 'uV', 'uV', 'uV'
         'uV', 'uV', 'uV', 'uV', 'uV', 'uV', 'uV', 'uV'};
% channel names - copy-paste data from .info file, for all channels if
% necessary
channel_names = {'Fc5.', 'Fc3.', 'Fc1.', 'Fcz.', 'Fc2.', 'Fc4.', 'Fc6.', 'C5..'
                 'C3..', 'C1..', 'Cz..', 'C2..', 'C4..', 'C6..', 'Cp5.', 'Cp3.'
                 'Cp1.', 'Cpz.', 'Cp2.', 'Cp4', 'Cp6.', 'Fp1.', 'Fpz.', 'Fp2.'
                 'Af7.', 'Af3.', 'Afz.', 'Af4.', 'Af8.', 'F7..', 'F5..', 'F3..'
                 'F1..', 'Fz..', 'F2..', 'F4..', 'F6..', 'F8..', 'Ft7.', 'Ft8.'
                 'T7..', 'T8..', 'T9..', 'T10.', 'Tp7.', 'Tp8.', 'P7..', 'P5..'
                 'P3..', 'P1..', 'Pz..', 'P2..', 'P4..', 'P6..', 'P8..', 'Po7.'
                 'Po3.', 'Poz.', 'Po4.', 'Po8.', 'O1..', 'Oz..', 'O2..', 'Iz..'};

% create the appropriate time array, starting from 0s
time = linspace(0, (N-1)/fs , N);

figure(2)
for I = 1: Ch

    subplot(Ch,1,I)
    % plotting the upcoming channel data
    plot(time,signal(I,:))
    %title(channel_names(I)) % My figure is a bit dense, so I hid the subplot titles.
    ylabel(units(I))
```

```
end
% title and axes

xlabel('time (s)')
```



Spectrum

During the semester we will learn a lot about the spectrum of signals. In a nutshell we can say: this representation of a signal indicates, what oscillations build it up. For example, an ECG signal will have a strong component around the frequency of the heartbeat, but from a raw signal the breathing rate or the powerline frequency can also be read.

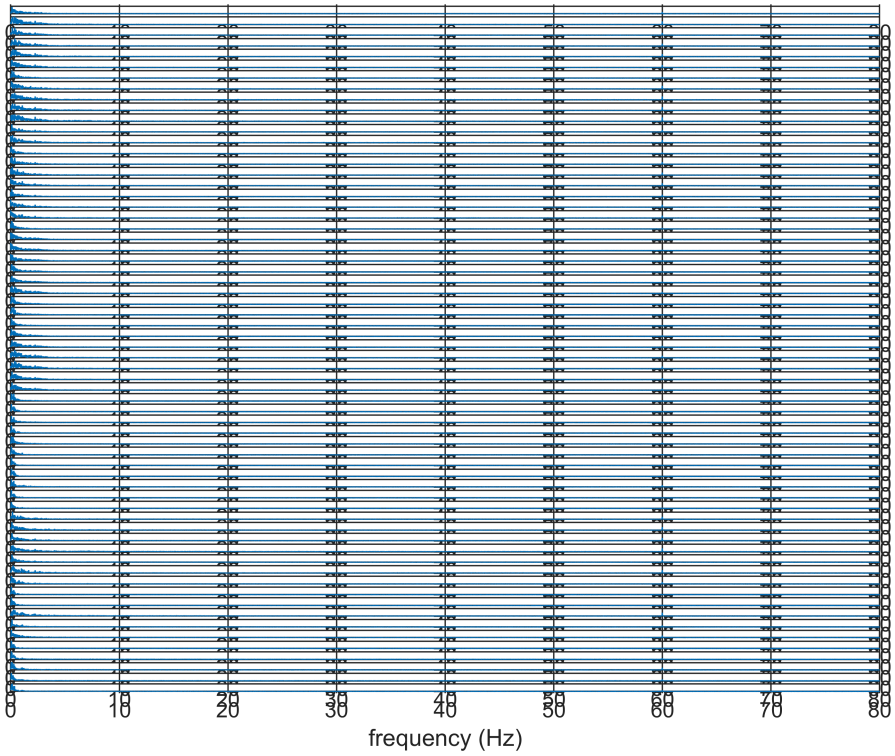
It is useful if you learn how to prepare these plots now, even though we will learn its theory only later.

- Plot the one-sided frequency plot of your data line(s). You can see some examples in the documentation of fft(). Follow these and the code below to create your own plot.

(3 marks)

```
% create the frequency array you will plot onto. It should start at 0 Hz
% and end at half of the sampling frequency.
frequency = fs*(0:(N/2))/N;
```

```
    % initialize the spectrum variable
    spectra = [];

    figure(3)
    title('Spectrum of the channels');
    for I = 1: Ch
        % create the spectrum of your signal channel, and append it to the
        % previous spectra
        spectrum = fft(signal(I,:));
        spectra = [spectrum; spectrum];

        P2 = abs(spectrum/N);
        P1 = P2(1:N/2+1);
        P1(2:end-1) = 2*P1(2:end-1);

        subplot(Ch,1,I)
        % plotting the upcoming channel data. Be aware: you should have the
        % same number of samples in the frequency and spectrum arrays.
        plot(frequency,P1)
    end

        xlabel('frequency (Hz)');
        ylabel('amplitude');
```

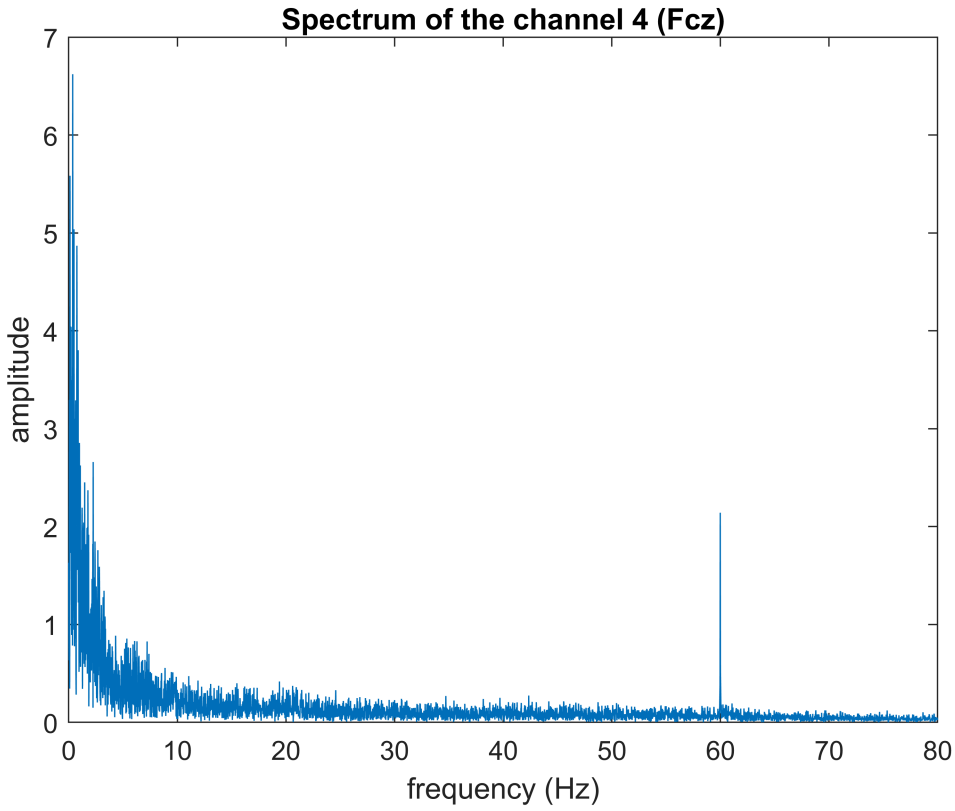



```
% [3]
% Title: Fast Fourier transform - MATLAB fft- MathWorks United Kingdom
% Author: Uk.mathworks.com
% Date: 2021
```

```
% Availability: <https://uk.mathworks.com/help/matlab/ref/fft.html?s_tid=doc_ta>
```

My figure is quite dense, because of the 64 channels, so I plotted the spectrum for one single channel.

```
spectrum = fft(signal(4,:));
P2 = abs(spectrum/N);
P1 = P2(1:N/2+1);
P1(2:end-1) = 2*P1(2:end-1);

figure(4)
plot(frequency, P1)
title('Spectrum of the channel 4 (Fcz)');
xlabel('frequency (Hz)');
ylabel('amplitude');
```



If we look at the diagram, we can see, that there is a high peak at 60 Hz, which is in the Gamma wave frequency band.

Apps

- Find a smartphone/online application capable of measuring/analysing some biomedical signal. Explain its operation –what does it measure, how does it work, does it need additional hardware, is it online/offline, etc. If possible, try it on yourself and include here a screenshot.

Link to the app: Cardiio: Heart Rate Monitor

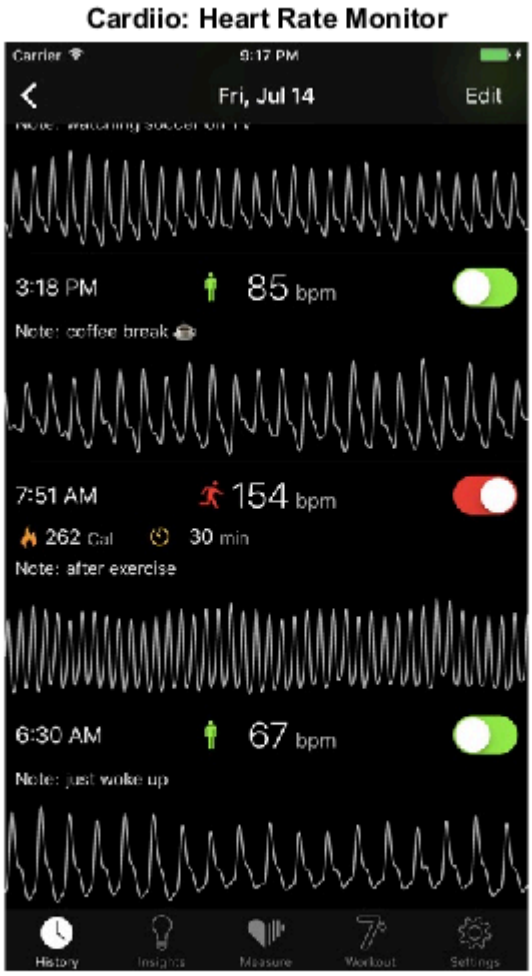
Measured signal: heart rate

Operation: It uses imaging photoplethysmography (PPG), so it recognizes the tiny changes in reflected light from face/fingers, which is then detected by the smartphone's or iPad's built-in camera. It measures the variations of light absorbtion caused by arterial blood-volume pulsations by examining the arterial oxygen saturation. [4] [5]

(2 marks)

I was not able to download this app, because my phone's storage is quite full, but I downloaded a screenshots from the app's web page instead.

```
figure(5)
im = imread('screenshot.jpg');
imshow(im)
title("Cardiio: Heart Rate Monitor")
```



Do not forget to generate a pdf report from this file (Save/ Export to PDF). You should upload both the pdf and mlx files to moodle.

References:

[1] Archive.physionet.org. 2021. *EEG Motor Movement/Imagery Dataset*. [online] Available at: <https://archive.physionet.org/physiobank/database/eegmmidb/>

[2] Schalk G, McFarland DJ, Hinterberger T, Birbaumer N, Wolpaw JR. BCI2000: a general-purpose brain-computer interface (BCI) system. IEEE Trans Biomed Eng. 2004 Jun;51(6):1034-43. doi: 10.1109/TBME.2004.827072. PMID: 15188875.

[3] Uk.mathworks.com. 2021. *Fast Fourier transform - MATLAB fft- MathWorks United Kingdom*. [online] Available at: <https://uk.mathworks.com/help/matlab/ref/fft.html?s_tid=doc_ta>

[4] App Store. 2021. *Cardiio: Heart Rate Monitor*. [online] Available at: <https://apps.apple.com/us/app/cardiio-heart-rate-monitor/id542891434>

[5] BJSM blog - social media's leading SEM voice. 2021. *A review of Cardiio: an app to accurately measure heart rate at rest and after exercise using imaging photoplethysmography - BJSM blog - social media's leading SEM voice*. [online] Available at: <https://blogs.bmj.com/bjsm/2017/02/17/review-cardiio-app-accurately-measure-heart-rate-rest-exercise-using-imaging-photoplethysmography/>