Homework 1

STUDENT: ALON TZROYA

ID: 209010651

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GITHUB LINK: https://github.com/Alontz04/NeurophotonicsHW1.git

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To run the file you need to extract the file change matlab directory to the same directory and to run the file “hw1_209010651” in your own folder. ***Make sure you matlab is 2023b at least.

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1. Calculating difference over time

In the homework assignment I was asked to compute the difference between HbR and HbO over time. To do so I coded the function CalcNIRS and in it this segment of code is computing the difference over time for each time index and wavelength of measurement for each of the channels.

```
for channelIndex = 1:channelLength % The wavelength in hand
    for timeIndex = 1:length(t)
        result = (1 ./ pathlength) .* (inv([HbOMu_Use HbRMu_Use]) * squeeze(OD(timeIndex, channelIndex, :)));
        dHbO(timeIndex, channelIndex) = result(1);
        dHbR(timeIndex, channelIndex) = result(2);
    end
end
```

Figure 1. Calculation code segment

This calculation is based on the lecture notes as:

NIRS – Near Infrared Spectroscopy

$$\begin{bmatrix} \Delta[HbO] \\ \Delta[HbR] \\ \Delta[oxCCO] \end{bmatrix} = \frac{1}{pathlength} \begin{bmatrix} \varepsilon_{HbO}(\lambda_1) & \varepsilon_{HbR}(\lambda_1) & \varepsilon_{oxCCO}(\lambda_1) \\ \varepsilon_{HbO}(\lambda_2) & \varepsilon_{HbR}(\lambda_2) & \varepsilon_{oxCCO}(\lambda_2) \\ \vdots & \vdots & \vdots \\ \varepsilon_{HbO}(\lambda_n) & \varepsilon_{HbR}(\lambda_n) & \varepsilon_{oxCCO}(\lambda_n) \end{bmatrix}^{-1} \times \begin{bmatrix} \Delta A(\lambda_1) \\ \Delta A(\lambda_2) \\ \vdots \\ \Delta A(\lambda_n) \end{bmatrix}$$

pathlength = SDS $\cdot$ $DPF(\lambda)$

HW:
Given $A(\lambda, t)$ for two λ , SDS and $DPF(\lambda)$
Calculate and Plot $\Delta[HbO](t)$ and $\Delta[HbR](t)$

SDS – Source Detector Separation
DPF - Differential Pathlength Factor

Figure 2. Lecture notes for calculations

In our code the data is saved in a struct:

```
dHbR.([dataFile(fileIndex)]) = dHbRData;
dHbO.([string(dataFile(fileIndex))]) = dHbOData;
```

I did it because the arrays where in different size, so it was convenient to save them this way in the same variable.

2. Plotting difference over time

Afterwards we were asked to plot the first two channel. Here are both of them for the first file:

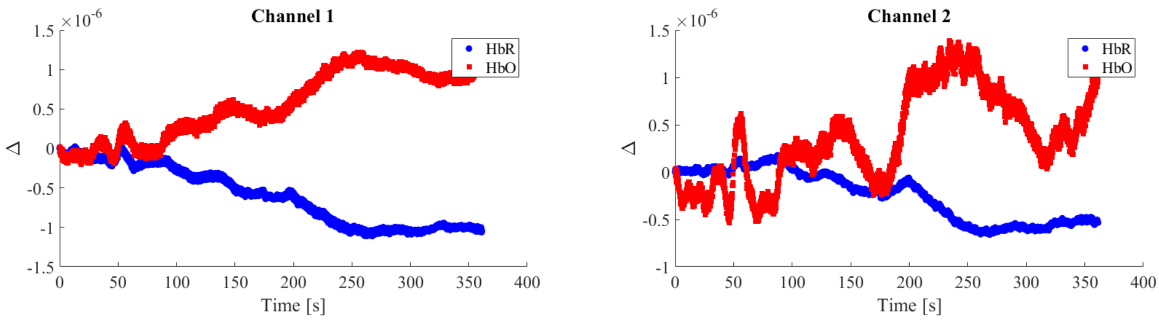

Figure 3. Difference of HbR and HbO over time for the first file

Here are the results for the second file (measurement):

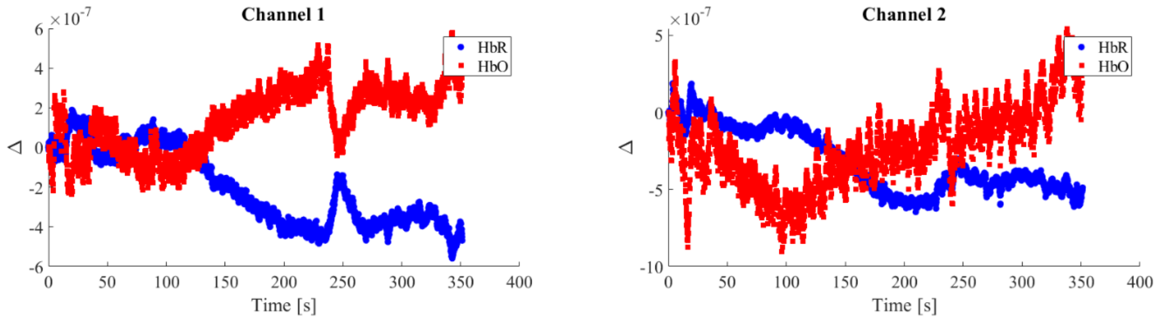

Figure 4. Difference of HbR and HbO over time for the second file

3. Fourier transform

In this part we were asked to plot the Fourier transorm of the first channel from the first file. Noise was defined as the average of the signal in fourier domain in frequencies above 2.5Hz and the signal was defined according to the pulse frequncy. The pulse frequcny is the hear beat frequancy which is around 1 Hz. So we scan the fourier transform between 1 to 2.5 for the peak and we calculate the noise according to the noise frequncy 2.5 hz up to the maxium frequancy before the fourier tranform shows the other half (image) so we average from 2.5 to 4 hz approximatly. Here is the segement of code that compute the SNR:

```
% Calculate SNR
noiseThresholdFreq = 2.5; % Define noise level
noise = mean(fftChannel1(f > noiseThresholdFreq & f < Fs/2)); % Find the noise in the signal

[~, pulseScanIndexStart] = min(abs(f - 1)); % Scan from 1 Hz
[~, pulseScanIndexEnd] = min(abs(f - noiseThresholdFreq)); % Scan up to 2.5 Hz = noise
scanPulse = fftChannel1(pulseScanIndexStart:pulseScanIndexEnd);
[signalStrength, PulseFrequency] = max(scanPulse); % Adjust the threshold as needed

SNR = signalStrength / noise; % Signal-to-Noise Ratio
disp(['SNR: ', num2str(SNR)]);
```

Figure 5. Computation of the SNR in code

With this we have plotted the following graph where we omitted the DC component at f=0Hz.

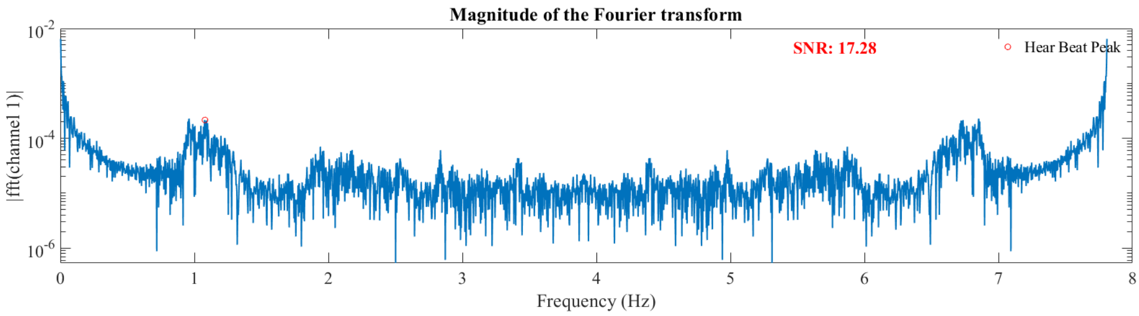

Figure 6. The Magnitude of the Fourier transform for the first channel from the first file (measurement)

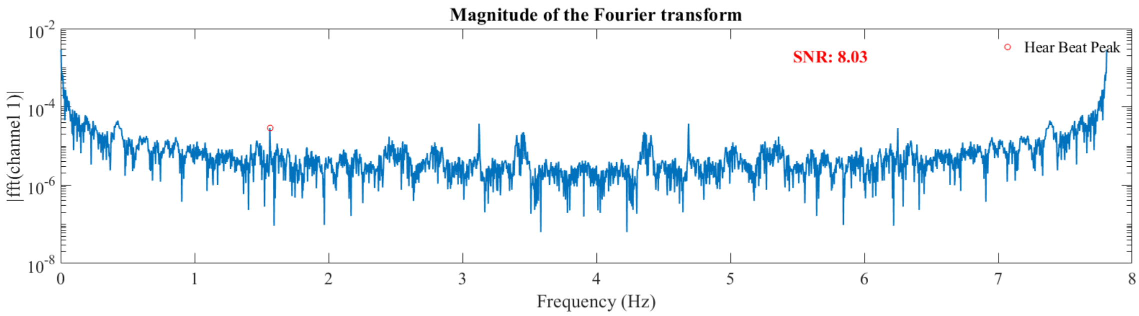

Figure 7. The results from the second file including the Fourier transform and SNR

I have later added the std and plotted both wavelengths as seen in the following figures. This revealed that in the second file there is a diversion of the heartbeat pulse compared to the first file. This makes sense as we saw the result of HbR and HbO that seemed much nosier then the first file.

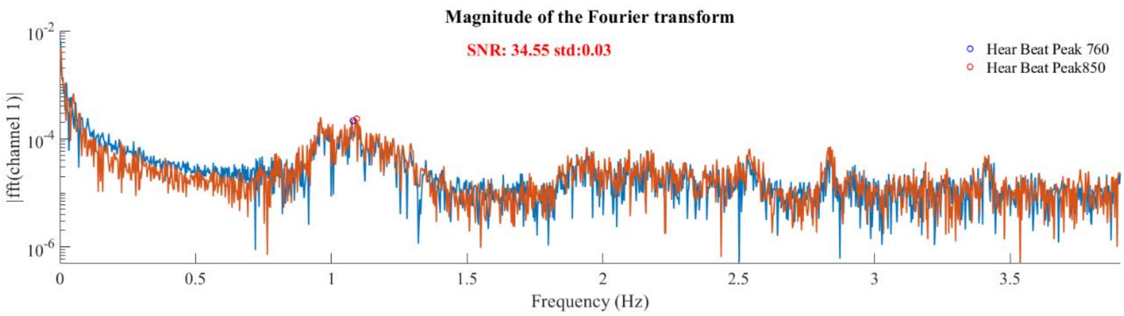

Figure 8. Fourier transform for the first channel of the first file, blue line is for 760nm while the red is for 850nm.

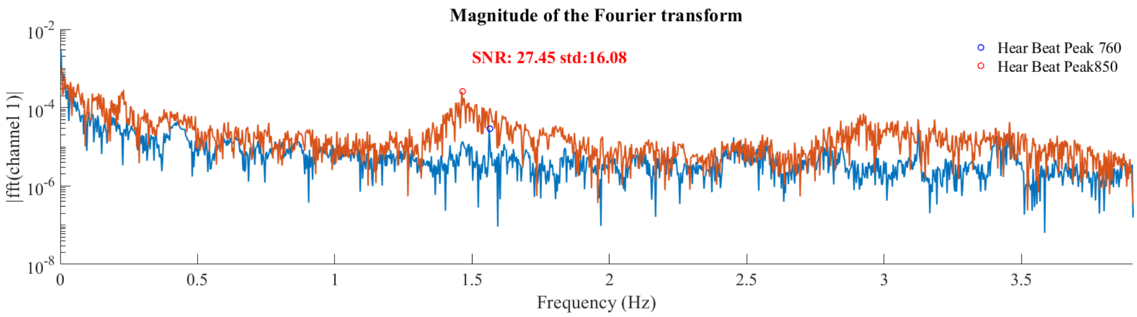

Figure 9. Fourier transform for the first channel of the second file, blue line is for 760nm while the red is for 850nm.

4. Final Output

This is the final product of the code where this is for the first file:

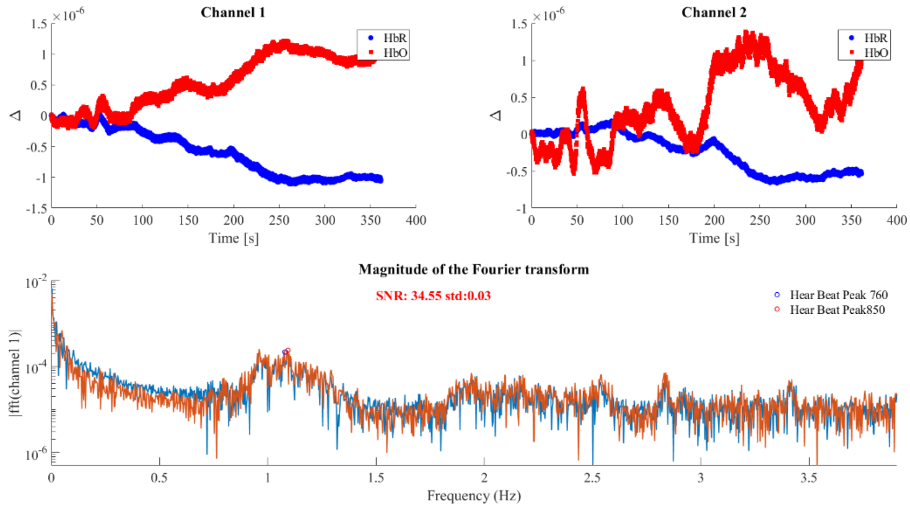

Figure 10. Final product of the first file from the function

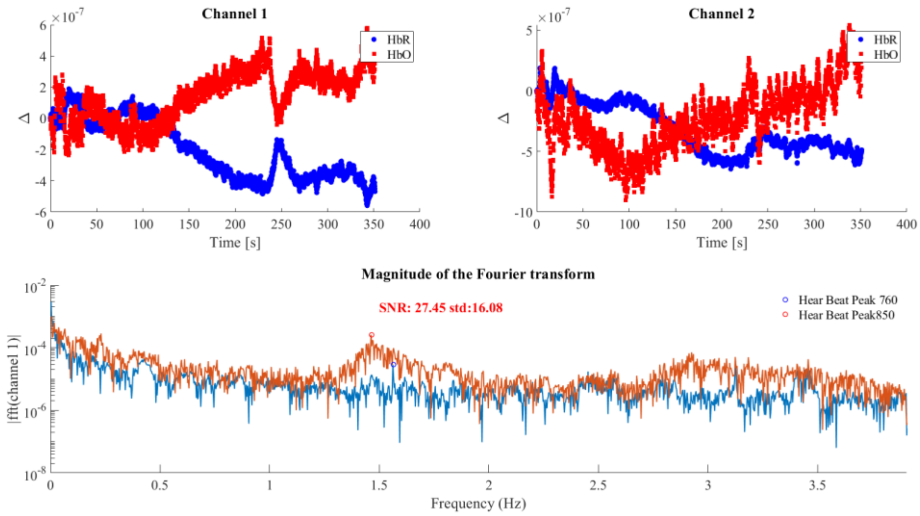

Figure 11. Final product of the second file from the function

In this part I test the code to see it can work with plotting 1:20 channels. Yet the Fourier transform remains only for the first channel.

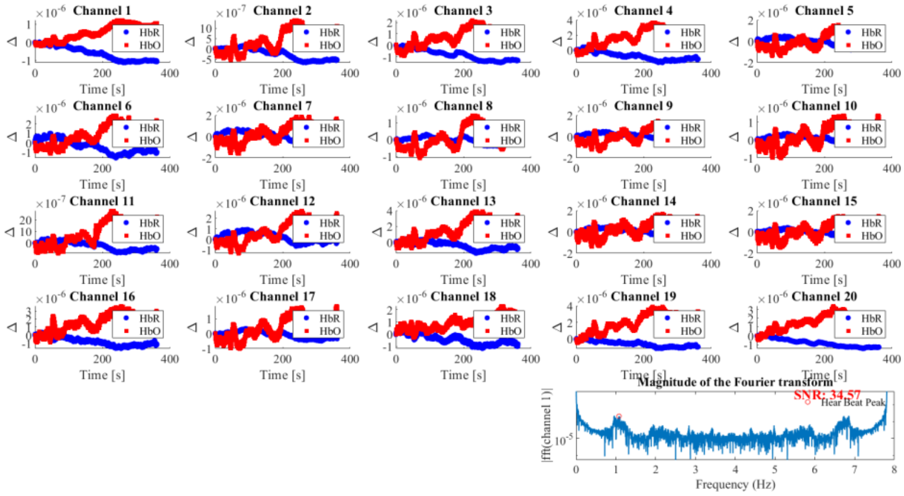

Figure 12. Results for 20 channels plot for the first file