**Problem: A text file is attached that gives EEG data. The columns are different channels, and the rows are EEG output versus time. You will be doing these operations for all sixteen channels, which should be possible by operating directly on the matrix array. You can label the channels 1 through 16. Choose a 10 second segment of the data – the sampling rate was 500 samples per second. Do the following:**

**🡪Plot the raw data using Matlab or Excel. You may want to plot all sixteen channels together, or create some subplots for selected channels**

**🡪Plot the power spectrum using the fft in Matlab and then your choice of spectral estimation algorithms. Compare the result**

**🡪Use an FIR filter to plot obtain the waveforms for the delta, theta, alpha, and beta bands**

**🡪Plot the frequency spectrum for each band**

**🡪Assess the stationarity of the signal by plotting the spectrogram of a couple of channels of data**

Solution:

%part-1

clc

clear all

close all

load EEG1\_1c31;% loading data

Ts=2;% sampling period

Fs=500;%sampling frequency

[N,nu]=size(data);%obtain size of data

t=(1:N)\*Ts;%generates time vector

h=figure

plot(t,data,'r');% plot of 16 channels together

title('EEG DATA')

grid on

h1=figure

plot(t,data(:,1), 'b-')

figure(h1);hold on

plot(t,data(:,5), 'r-')

figure(h1);hold on

plot(t,data(:,10), 'm-')

figure(h1);hold on

plot(t,data(:,15), 'c-')

figure(h1);hold on

plot(t,data(:,16), 'k-')

legend('Channel 1', 'Channel 5', 'Channel 10', 'Channel 15','channel 16');

% part-2

y=fft(data);% fft of data

ps1=abs(y).^2;% power spectrum using fft

freq=(1:N)\*Fs/N;%frequency vector

h2=figure

plot(freq,20\*log(ps1),'b')

title('POWER SPECTRUM USING FFT METHOD')

[ps2,freq]=pwelch(data,chebwin(128,100),[],N,Fs**);% plotting half of the power spectrum with 50% overlap and chebwin window of length 128 ………even the textbook does the same**

h3=figure

plot(freq,10\*log10(ps2),'r')

title('POWER SPECTRUM USING PWELCH METHOD')

% part-5

%SPECTROGRAM of channel 1

[S1,F,T] = spectrogram(data(:,1),chebwin(128,100),0,Fs);

S1=abs(S1);

h5=figure;

mesh(T,F,S1);

xlabel('Time (sec)','FontSize',14);

ylabel('Frequency (Hz)','FontSize',14);

zlabel('S1','FontSize',14);

h6=figure;

contour(T,F,S1);

xlabel('Time (sec)');

ylabel('Frequency (Hz)');

title('channel 1');

% spectrogram of channel 10

[S10,F,T] = spectrogram(data(:,10),chebwin(128,100),0,Fs);

S10=abs(S10);

h7=figure;

mesh(T,F,S10);

xlabel('Time (sec)','FontSize',14);

ylabel('Frequency (Hz)','FontSize',14);

zlabel('S10','FontSize',14);

h8=figure;

contour(T,F,S10);

xlabel('Time (sec)');

ylabel('Frequency (Hz)');

title('channel 10');

% part -3

% NOTE: filters designed using FDA tool box

%DELTA

Fs = 500; % Sampling Frequency

Fpass = 0; % Passband Frequency

Fstop = 4; % Stopband Frequency

Dpass = 0.057501127785; % Passband Ripple

Dstop = 0.0001; % Stopband Attenuation

dens = 20; % Density Factor

% Calculate the order from the parameters using FIRPMORD.

[N, Fo, Ao, W] = firpmord([Fpass, Fstop]/(Fs/2), [1 0], [Dpass, Dstop]);

% Calculate the coefficients using the FIRPM function.

b1 = firpm(N, Fo, Ao, W, {dens});

Hd1 = dfilt.dffir(b1);

x1=filter(Hd1,data);

h4=figure

plot(t,x1,'r')

title('waveform for DELTA band')

%frequency spectrum of DELTA

L=10;

Fs=500;

NFFT = 2^nextpow2(L); % Next power of 2 from length of x1

Y1 = fft(x1,NFFT)/L;

f = Fs/2\*linspace(0,1,NFFT/2);

% Plot single-sided amplitude spectrum

h8=figure

plot(f,2\*abs(Y1(1:NFFT/2)))

title('Single-Sided Amplitude Spectrum of DELTA x1(t)')

xlabel('Frequency (Hz)')

ylabel('|Y1(f)|')

%THETA- BAND PASS FILTER (4-7)

Fs = 500; % Sampling Frequency

Fstop1 = 3.5; % First Stopband Frequency

Fpass1 = 4; % First Passband Frequency

Fpass2 = 7; % Second Passband Frequency

Fstop2 = 7.5; % Second Stopband Frequency

Dstop1 = 0.001; % First Stopband Attenuation

Dpass = 0.057501127785; % Passband Ripple

Dstop2 = 0.0001; % Second Stopband Attenuation

dens = 20; % Density Factor

% Calculate the order from the parameters using FIRPMORD.

[N, Fo, Ao, W] = firpmord([Fstop1 Fpass1 Fpass2 Fstop2]/(Fs/2), [0 1 ...

0], [Dstop1 Dpass Dstop2]);

% Calculate the coefficients using the FIRPM function.

b2 = firpm(N, Fo, Ao, W, {dens});

Hd2 = dfilt.dffir(b2);

x2=filter(Hd2,data);

h5=figure

plot(t,x2,'r')

title('waveform for THETA band')

%FREQUENCY SPECTRUM OF THETA

L=10;

Fs=500;

NFFT = 2^nextpow2(L); % Next power of 2 from length of x2

Y2 = fft(x2,NFFT)/L;

f = Fs/2\*linspace(0,1,NFFT/2);

% Plot single-sided amplitude spectrum THETA

h9=figure

plot(f,2\*abs(Y2(1:NFFT/2)))

title('Single-Sided Amplitude Spectrum of THETA x2(t)')

xlabel('Frequency (Hz)')

ylabel('|Y2(f)|')

%ALPHA BAND PASS FILTER (8-12)

Fs = 500; % Sampling Frequency

Fstop1 = 7.5; % First Stopband Frequency

Fpass1 = 8; % First Passband Frequency

Fpass2 = 12; % Second Passband Frequency

Fstop2 = 12.5; % Second Stopband Frequency

Dstop1 = 0.0001; % First Stopband Attenuation

Dpass = 0.057501127785; % Passband Ripple

Dstop2 = 0.0001; % Second Stopband Attenuation

dens = 20; % Density Factor

% Calculate the order from the parameters using FIRPMORD.

[N, Fo, Ao, W] = firpmord([Fstop1 Fpass1 Fpass2 Fstop2]/(Fs/2), [0 1 ...

0], [Dstop1 Dpass Dstop2]);

% Calculate the coefficients using the FIRPM function.

b3 = firpm(N, Fo, Ao, W, {dens});

Hd3 = dfilt.dffir(b3);

x3=filter(Hd3,data);

h6=figure

plot(t,x3,'r')

title('waveform for ALPHA band')

%FREQUENCY SPECTRUM OF ALPHA BAND

L=10;

Fs=500;

NFFT = 2^nextpow2(L); % Next power of 2 from length of x3

Y3 = fft(x3,NFFT)/L;

f = Fs/2\*linspace(0,1,NFFT/2);

% Plot single-sided amplitude spectrum ALPHA

h10=figure

plot(f,2\*abs(Y3(1:NFFT/2)))

title('Single-Sided Amplitude Spectrum of ALPHA x3(t)')

xlabel('Frequency (Hz)')

ylabel('|Y3(f)|')

%BETA BANDPASS FILTER (12-30)

Fs = 500; % Sampling Frequency

Fstop1 = 11.5; % First Stopband Frequency

Fpass1 = 12; % First Passband Frequency

Fpass2 = 30; % Second Passband Frequency

Fstop2 = 30.5; % Second Stopband Frequency

Dstop1 = 0.0001; % First Stopband Attenuation

Dpass = 0.057501127785; % Passband Ripple

Dstop2 = 0.0001; % Second Stopband Attenuation

dens = 20; % Density Factor

% Calculate the order from the parameters using FIRPMORD.

[N, Fo, Ao, W] = firpmord([Fstop1 Fpass1 Fpass2 Fstop2]/(Fs/2), [0 1 ...

0], [Dstop1 Dpass Dstop2]);

% Calculate the coefficients using the FIRPM function

b4 = firpm(N, Fo, Ao, W, {dens});

Hd4 = dfilt.dffir(b4);

x4=filter(Hd4,data);

h7=figure

plot(t,x4,'r')

title('waveform for BETA band')

%Frequency spectrum of BETA band

L=10;

Fs=500;

NFFT = 2^nextpow2(L); % Next power of 2 from length of x4

Y4 = fft(x4,NFFT)/L;

f = Fs/2\*linspace(0,1,NFFT/2);

% Plot single-sided amplitude spectrum BETA

h11=figure

plot(f,2\*abs(Y4(1:NFFT/2)))

title('Single-Sided Amplitude Spectrum of BETA x4(t)')

xlabel('Frequency (Hz)')

ylabel('|Y4(f)|')

**Figures:**

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**Spectrogram for channel( Mesh plot)**

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**Spectrogram for channel( Mesh plot)**

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**Note: I have not normalized.**

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