Project #4 - Integrals and Intervals

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2(a)

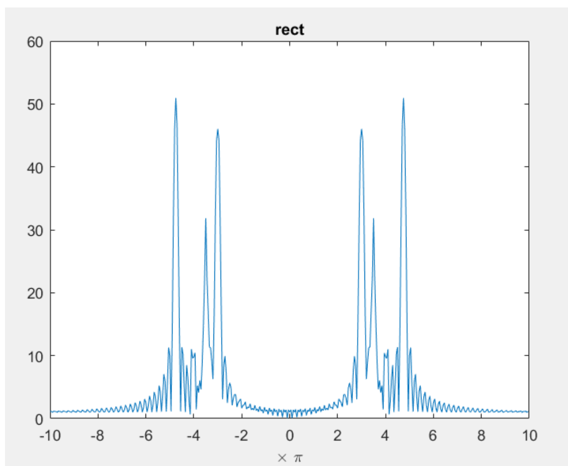

Figure 1: *DFT spectral estimation*

The spectral peaks at 3, 3.5 , 4.75 can be seen however we may not tell if at 4π, it is a peak or a sidelobe.

2(b)

*github link: https://github.com/IAMLYCHEE/EE483

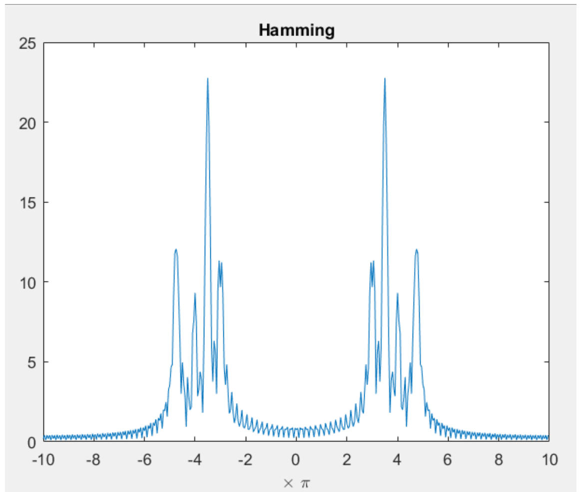

Figure 2: *Hamming*

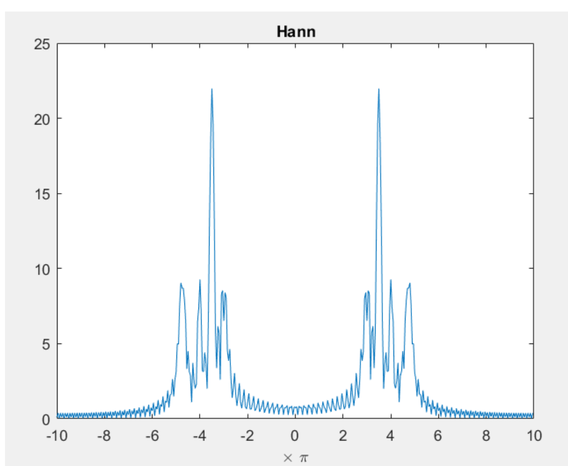

Figure 3: *Hann*

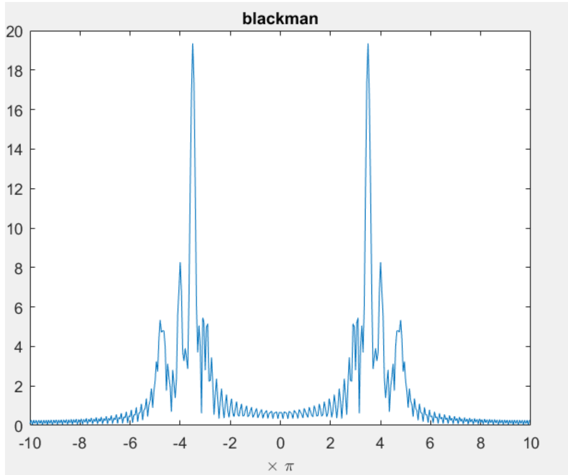

Figure 4: *Blackman*

Hamming window performs best to distinguish 4 peaks however, after appling these windows, the amplitude characteristic of the original signal may be eliminated.

2(c) 100 Hz results:(the x axis is scaled from frequency from -10π to 10π):

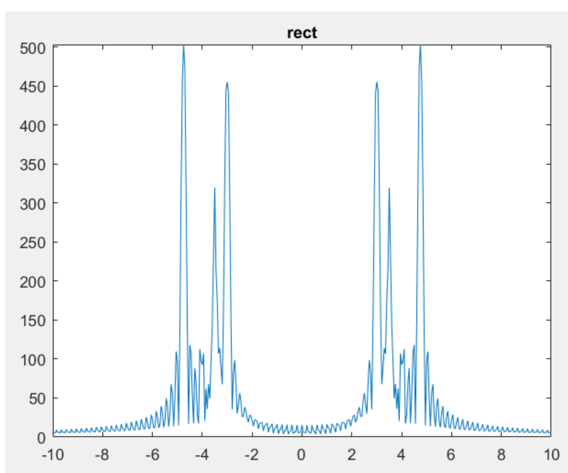

Figure 5

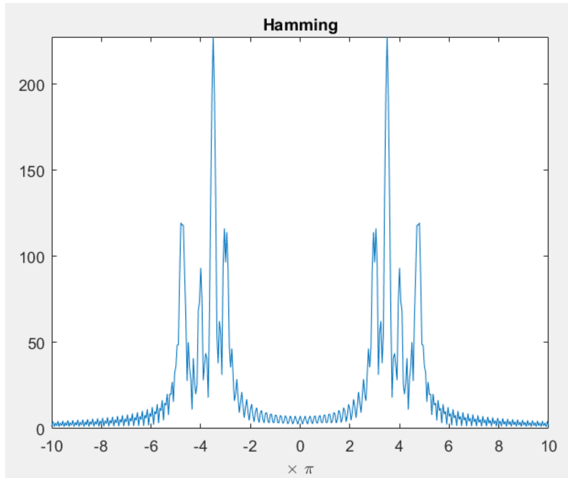

Figure 6: *Hamming*

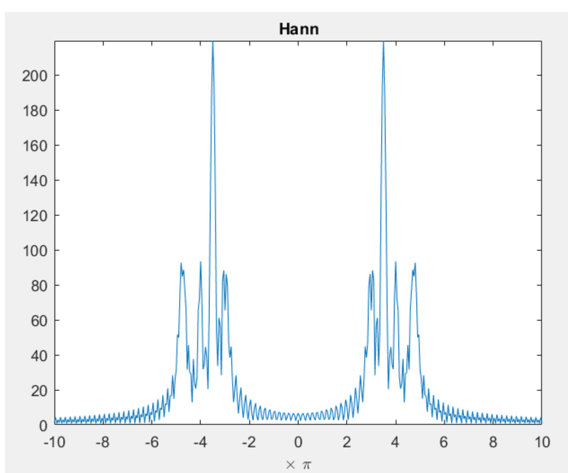

Figure 7: *Hann*

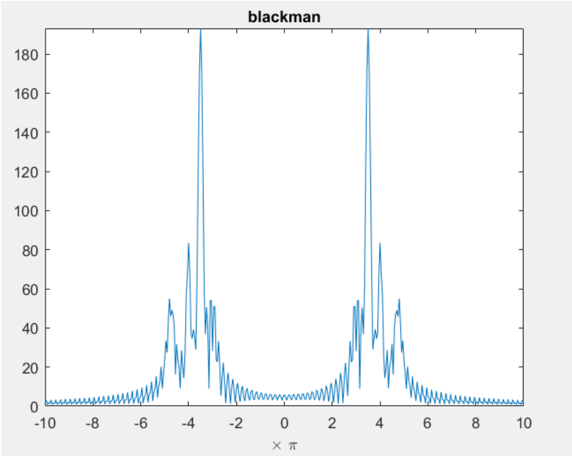

Figure 8: *Blackman*

If compared to the figures got with 10 Hz sampling, the 100 Hz sampling ones actually did not lead to improvements in the spectral estimation. Although it has effect on the amplitude bowever such effects also applied on sidelobe.

2(d)

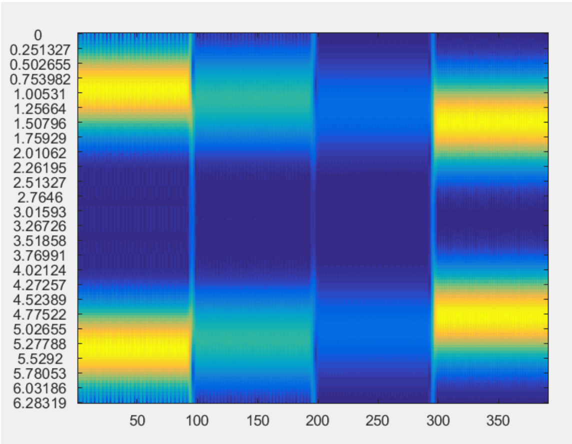

Figure 9: *STFT*

Yes, the images shows the feature of the giving signal,that its frequency is getting higher and in every 10 ten second the frequency remains the same.

appendix: code 2(a)(b)

```
clear
%a
```

```
fs = 100;
t = 0 : 1/fs : 40-1/fs;
N = length(t);
index = t * fs;
signal = cos(3 * pi * t) .* (t < 10) +...
    1/2 * sin(3.5 * pi * t) .* (t >= 10 & t < 20)+...
    1/6 * cos(4 * pi * t) .* (t >= 20 & t < 30) +...
    sin(4.75 * pi * t) .* (t >= 30 & t < 40);
X = fft(signal);
t = (index - N/2)/ N * fs * 2;
plot(t,abs(fftshift(X)))
xlabel('\times \pi')
axis([-10 10 0 max(abs(X))])
title('rect')
%b
%hamming
window = hamming(N);
x = signal .* window';
X = fft(x);
t = (index - N/2)/ N * fs * 2;
figure
plot(t,abs(fftshift(X)));
xlabel('\times \pi')
axis([-10 10 0 max(abs(X))])
title('Hamming')

%hann
window = hann(N);
x = signal .* window';
X = fft(x);
t = (index - N/2)/ N * fs * 2;
figure
plot(t,abs(fftshift(X)))
xlabel('\times \pi')
axis([-10 10 0 max(abs(X))])
title('Hann')

%blackman
window = blackman(N);
x = signal .* window';
X = fft(x);
t = (index - N/2)/ N * fs * 2;
figure
plot(t,abs(fftshift(X)))
xlabel('\times \pi')
axis([-10 10 0 max(abs(X))])
title('blackman')
```

2(c)

```
clear
%a
fs = 100;
t = 0 : 1/fs : 40-1/fs;
N = length(t);
index = t * fs;
signal = cos(3 * pi * t) .* (t < 10) +...
    1/2 * sin(3.5 * pi * t) .* (t >= 10 & t < 20)+...
    1/6 * cos(4 * pi * t) .* (t >= 20 & t < 30) +...
    sin(4.75 * pi * t) .* (t >= 30 & t < 40);
X = fft(signal);
t = (index - N/2)/ N * fs * 2;
plot(t,log(abs(fftshift(X))))
xlabel('\times \pi')
title('rect')
%b
%hamming
window = hamming(N);
x = signal .* window';
X = fft(x);
t = (index - N/2)/ N * fs * 2;
figure
plot(t,log(abs(fftshift(X))))
xlabel('\times \pi')
title('Hamming')

%hann
window = hann(N);
x = signal .* window';
X = fft(x);
t = (index - N/2)/ N * fs * 2;
figure
plot(t,log(abs(fftshift(X))))
xlabel('\times \pi')
title('Hann')

%blackman
window = blackman(N);
x = signal .* window';
X = fft(x);
t = (index - N/2)/ N * fs * 2;
figure
plot(t,log(abs(fftshift(X))))
xlabel('\times \pi')
title('blackman')
```

2(d)

```
clear
```

```
fs = 10;
t = 0 : 1/fs : 40-1/fs;
N = length(t);
index = t * fs;
signal = cos(3 * pi * t) .* (t < 10) +...
    1/2 * sin(3.5 * pi * t) .* (t >= 10 & t < 20)+...
    1/6 * cos(4 * pi * t) .* (t >= 20 & t < 30) +...
    sin(4.75 * pi * t) .* (t >= 30 & t < 40);
tWindow  = 1;
windowLength = fs * tWindow;
window = hamming(windowLength)';
yAmount = length(0:0.05:2*pi);
result = zeros(yAmount, N-windowLength + 1);
for m = 0 : N - windowLength
    k = 1;
    for omega = 0 : 0.05 : 2 * pi
        index = m + 1 : m + windowLength;
        result(k,m+1)=sum(signal(index) .* window .* exp(-1i*omega*index));
        k = k + 1; %put less frequency down the axis
    end
end
imagesc(abs(result));
ytickLabels = linspace(0,2*pi,length(1:5:size(result,1)));
set(gca, 'YTick',1:5:126 , 'YTickLabel', ytickLabels)
```