DSP Homework 06

Very good improvement.

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Abstract

This week, we watch two videos, The first video is about bluetooth's principles. This video is very vivid, which uses visual animation to show invisible things like electromagnetic wave. And I search some data about why the microwave can influence the signal transmission between the phone and earbuds online to understand this video further more. The second video tells that how to learn anything fast. It reminds me of memory palace and I have an example about this. Then I mainly use matlab to sample the square wave and compare the Fourier series and the Nyquist sampling method.

1 The videos we watched

1.1 Problem description

Write a summary of this week's video(s) and your further thoughts on the content.

1.2 Bluetooth's principles

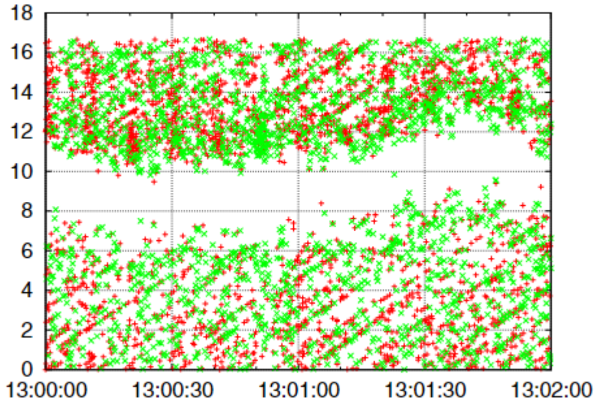
The first video is about bluetooth's principles. This video is very vivid, which uses visual animation to show invisible things like electromagnetic wave.

It mainly talks about the channel of bluetooth. The channel's bandwidth range is 2.4G to 2.4835G hertz which can be broken up into 79 different sections. When many signals is transfering in a room, they may use a same section. To make sure the blueteeth device can recieve the message from the special phone, the signal must be handled. The signal consists of three parts. The first part is access code that synchronize the phone and earbuds. It is similar to the address words on the letter. The next part is header which provides details of the information. The next part is the actual information, the contents of the message. And the signal's frequency hopping can avoid crowded and disturbed channels, at the same time, the frequency hopping is random so that it can prevents anyone form eavesdropping on the information. All this, without precise and complicated circuit, it is impossible to achieve.

My further thought: Why the microwave can influence the signal transmission between the phone and earbuds. Although the microwave's bandwidth is 2.45G hertz, the phone can avoid disturbed channels by frenquence hopping so that they can work like the phone usually treats other disturbed channels.

Good try

So I searched some information. Compared to other disturb signals, the microwave's strength is larger, which influence the phone and earbuds directly rather than influence the signal of message. And its bandwidth is wider, occupies most of the 79 channels, it leads to the data package is difficuit to transfer fast as the phone requires, then the transmisson will error and even earbuds disconnect with the phone.



The figure show that in some special channels, the microwave's influence to the signal of message.

1.3 How to learn anything fast

This video tells that how to learn anything fast. The host shows his excellent memory skills, and tells us what is important for learning is output, we need use twice strive on output than input. And when we learn something, we must focus on what we do, input all attention on it because it depends how much can we use to output, including reflect, implement and share.

My further thought: The host has a good memory, he says that he uses a method called visualization and association to remember 30 numbers. It reminds me of the memory palace, which is very famous.

People can remember pictures more easily than other things. Memory palace is according to this ,which is a very good method to remember some irregular things. First of all, we need a very familiar situation to us, our home, a road that we pass every day and so on. Then we need train ourselves to use these situations to remember some easy things to make the details is more and more clear for us. The specific methods is that we use the situation's objects to reflect the things we need remember so that we can use regular things which we can easy to remember to represent the irregular things. That's a good method!

I find a good example about memory palace. The Scripture of Ethics which is written by laozi, a great thinker of China, is very obscure to us, so if we want to remember the grand book when we can't understand it clealy, we can use this method.

The example:

we need to remember these sentences:

1.天下皆知美之为美

2.斯恶已。

3.皆知善之为善，

4.斯不善已。

5. 有无相生。

Then we use the familiar situation and details in it. First, becuaese these sentence maybe difficuit to understand, we need find to some easy things to substitute them, like play on words or funny pictures. As the first sentence, we can image the queen in the book 'Snow White' who is greedy for beauty is asking the mirror "who is the most beautiful people in the world" under the sky. The other sentences are like this, and then we need put these easy things regularly in this situation. If we use a room as our palace, we can put the first sencentence near the door and then gradually go inside to load other sentences.

2 Two sampling methods

Title can be more carefully written. Be both

2.1 Problem description

Use the Fourier series to develop a sampling method and compare it with the Shannon/Nyquist sampling method through examples.

2.2 Use the Fourier series to sample

Any periodic function can be represented by the infinite order of sine function and cosine function. Sine function and cosine function can be transformed in exponential form.

For x(t), we use the Fourier series to sample: $x(t) = \sum_{-\infty}^{\infty} C_n.e^{j2\pi nft/T_s}$

And $C_n = \frac{1}{T_s}\int_{-T_s/2}^{T_s/2} x(t)e^{-j2\pi nft/T_s}dt$,this is the samples.

For reconstruction:

$$\begin{aligned} &\int_{-T_s/2}^{T_s/2} |x(t)|^2 dt \\ &= \int_{-T_s/2}^{T_s/2} (\sum_{-\infty}^{\infty} C_n.e^{j2\pi nft/T_s})(\sum_{-\infty}^{\infty} C_m^*.e^{-j2\pi nft/T_s})dt \\ &= \sum_{-\infty}^{\infty} C_n \sum_{-\infty}^{\infty} C_m^* \int_{-T_s/2}^{T_s/2} .e^{j2\pi(n-m)ft/T_s} \\ &= T_s \sum_{-\infty}^{\infty} C_n \sum_{-\infty}^{\infty} C_m^* \delta(n-m) = T_s \sum_{-\infty}^{\infty} |C_n|^2 \end{aligned} \tag{1}$$

For phycical signals when $n->\infty, |C_n|^2->0$

so, we can get: $x(t) = \sum_{-N}^{N} C_n.e^{j2\pi nft/T_s}$

N must big enough, The bigger the N, the more accurate the function.

2.3 The Nyquist sampling method

Sampling:

$x_s(t) = x(t)S_T(t) = \frac{1}{T_s}\sum_{-\infty}^{\infty} x(nTs)\delta(t - nTs)$

Recontruction:

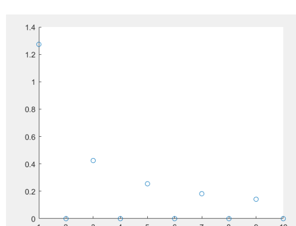
$x(t) = x_s(t) * h(t) = 2f_cTs\sum_{-\infty}^{\infty} x(nTs)sinc(2f_c(t - nTs))$

2.4 Compare two sampling methods

I choose a easy signal to compare them : square wave and its period Ts is 1s , frenquence fs is 1Hz.

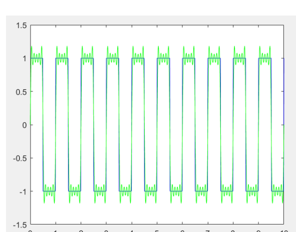
The Fourier series will become Sine series: $C_n = \frac{1}{n\pi(2 - 2cos(n\pi))}$

We can get samples (a part of all) :



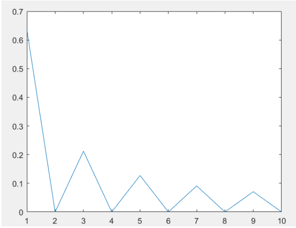
And the reconstruction with the origin function's comparison:

When N=10:



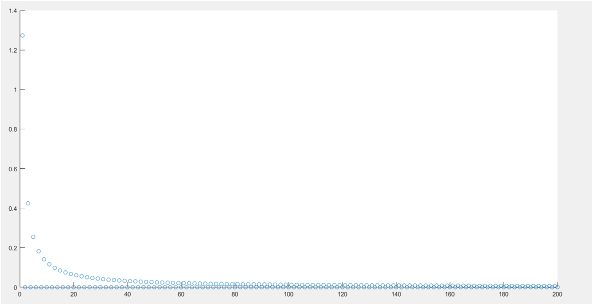
(Blue is origin function, green is reconstruction)

It is not completely accurate, because when N=10 , its spectrum is:



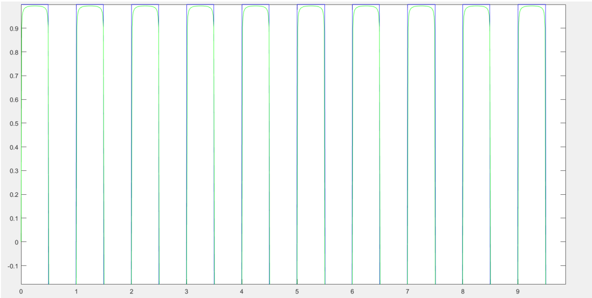
$$\int_{-T_s/2}^{T_s/2} |x(t)|^2 dt \quad \text{is not} \quad -> 0$$

N=10 is not enough big , When N = 100:



We can see: $$\int_{-T_s/2}^{T_s/2} |x(t)|^2 dt -> 0$$

So its rescontrution is more accurate(only the top have some error):



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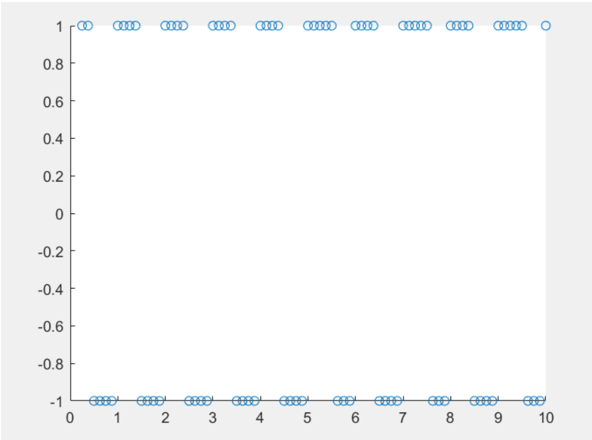
Nyquist sampling:

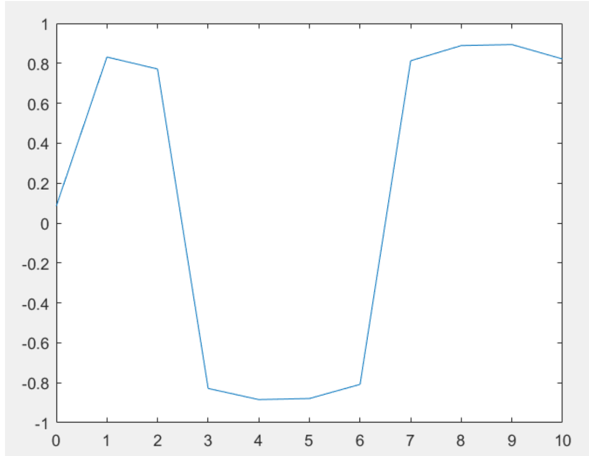
because its fm = 1hz, so the I use 8hz as the sampling period.

sampling:

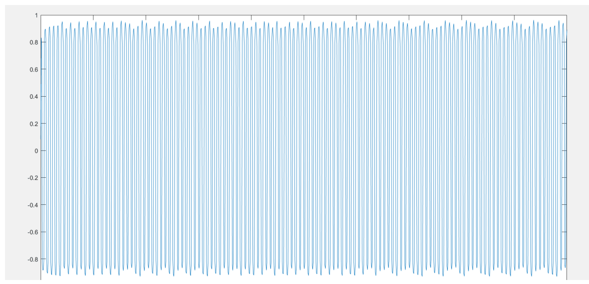


The rescontruction:

N=10:



N=1000:



I think its rescontruction is not good as we except, maybe the function or parameters I use have some problem. Although I changed many parameters which is like to online codes, they don't work, the result is not good.

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Conclusions: I think the Fourier series is more efficient to sample, because its calculation is easier and rescontruction is better than Nyquist sampling. But, the Nyquist sampling is more intuitive.

Reasonable conclusion. But one example usually is not enough

References

[1] web:*https://dl.acm.org/doi/epdf/10.1145/1282380.1282384*

Appendix A Code listings

matlab code :

code1,Fourier series:

```
x1 = input('please input')
x = 0 : 0.01 : x1;
y1 = square(2*pi*x,50);
%an = 0;
%bn = 1/pi/n*(2 - 2*cos(n*pi))
y = [];
for n = 1:x1
y = [y,1/pi/n*(2 - 2*cos(n*pi))];
fprintf('%6.2f',y);
end
figure(1);
n1 = [1:x1];
scatter(n1,y);
y2 = 0;
for n = 1:x1
y2 = y2 + 1/pi/n*(2 - 2*cos(n*pi))*sin(n*2*pi*x);
end
figure(2)
plot (x,y1,'b',x,y2,'g');
z = 1 : 1 : x1;
```

```
y3 = 1/2/pi./z.*(2 - 2*cos(z*pi));
figure(3)
plot(z,y3);
```

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code2,Nyquist sampling:

```
x1 = input('please input')
x = 0 : 0.01 : x1;
y1 = square(2*pi*x,50);
y = [];
for n = 0.25:0.125:x1;
y = [y,square(2*pi*n,50)]; fprintf('
end
n1 = [0.25:0.125:x1];
figure(1);
scatter(n1,y);
y2 = 0;
z = 0 : 1: x1;
for n = 1:(x1 - 0.25)/0.125 ;
y2 = y2 + y(n)*2*0.125*sinc(2*(z-n1(n))*pi)/pi;
end
figure(2);
plot(z,y2);
```