DSP Homework 08

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10

October 24, 2022

Contents

1 About videos **1**
1.1 Summaries for videos . . . 1
1.1.1 About the Boston robots . . . 1
1.1.2 Exercise keeps our bone density . . . 2
1.2 Thoughts about videos . . . 2
1.2.1 About the Boston robots . . . 2
1.2.2 Exercise keeps our bone density . . . 2

2 A comprehensive comparison between the Shannon/Nyquist sampling method and the Wan sampling method **2**
2.1 Reconstruction effect comparison . . . 3
2.1.1 Reconstruction overall effect comparison . . . 3
2.1.2 Reconstruct a section of signal . . . 3
2.1.3 Reconstruct at derivative discontinuous points . . . 3
2.1.4 Reconstruction error . . . 3
2.1.5 A small summary about two reconstruction effect . . . 6
2.2 Other aspects compare . . . 6
2.3 A promoted test way . . . 6

3 Talks about USB hub **6**
3.1 How USB hub works . . . 6
3.2 A invention using USB hub working principle . . . 6
3.3 Evaluate on my invention . . . 7

A Code listings **7**

Abstract

In this article, I write two summaries about videos we watched in class, one is about Boston robots, and these robots can liberate the soldiers; the second video is about how exercise influence our bones, and after it, I write my further thoughts about these two video on chapter 1.2. Then I compare Nyquist sampling method with Wan sampling method mainly from the reconstruction effect. Last, I describe how a USB hub works and propose a invention based on its principle.(Plus:all the figure used in this article is draw by code, if there are exception, I will mark it in caption)

Good

1 About videos

1.1 Summaries for videos

1.1.1 About the Boston robots

At the beginning of the video, it shows us the evolution of robots in Boston Robots company, then it shows us robots can be applied in military, industry and transportation. Then it introduce us a robot named Atlas, which can trains itself to walk or do other things like human baby. The video shows what this robot can do, and why he can do it. Then the video shows us three types of military robots, different type has different application. At the end of the video, it state advantages and disadvantages of these military robot. The main advantages are that they can save human life and be controlled by human.

1.1.2 Exercise keeps our bone density

At the beginning of the video, the speaker says that the astronaut come back from out-space for their physicals. and we find that their bone density has decreased severely. And our bone is constantly changing and adopting to the stress placed upon it. Then the speaker introduce the structure of our bones. So in zero gravity space our bone density decrease. Then he says the importance of exercise from this. Exercise can increase our bone density, and also change its internal structure. Then he introduce compact bone tissue and spongy bone tissue, of which our bone is composed. And after it he says the sport that can both push and pull on the bones is helpful for increase bone density and he explained why it is helpful. Then he use the biceps curl as an example to explain how walk can produce pull force. Then he advise us get nuanced with different type of exercise choices based upon strength goals and other type of fitness goals and he advise us pick different type of exercise.

1.2 Thoughts about videos

1.2.1 About the Boston robots

In this video, what impress me most is that the robot can distinguish real people and model both of them wear the headgear, when real people cover his shoot goal, he stopped shooting. It is so advanced and convenient for some specific situation. But these advanced robots also has potential danger. Scientist Hawking once said that the future artificial intelligence may be the terminator of human beings! I think it is reasonable and possible, in the video, it shows that Atlas can train itself to do something like human baby, so if one day, with complexity of situation increase and we develop robot that are very and very advanced. These advanced robot may accelerate the rate of upgrade to redesign themselves, while human beings are limited by the long biological evolution. In such stark contrast, human beings simply cannot compete with artificial intelligence, and it is only a matter of time before they are surpassed. In the short term, it is obvious that robots bring us convenience, but in the long term, robots are a potential danger.

1.2.2 Exercise keeps our bone density

I have an intuitive understanding of what he said about exercise can increase bone density. Sometimes we walk together with our friends, and boys sometimes like to put their arms around their friends' shoulders. Most of my friends who play basketball usually, when they put their arm on my shoulder, I can feel their arms are heavy and hard, even though he is not fat, or even a little thin. And when some friends, who don't exercise usually, they put their arm on my shoulder, I can feel that it is so light and so soft, even some of them are fat. After watching this video, I have a deeper understanding of the importance of exercise, and it makes me more willing to keep exercising.

2 A comprehensive comparison between the Shannon/Nyquist sampling method and the Wan sampling method

Here we define a signal f(t) as the Equation 1 shows. And f(t) can be shown as the Figure 1. Then we use Nyquist sampling and Wan sampling to sample and reconstruct the signal, and compare the result mainly from the reconstruction effect. A good sampling method should has **less error, flexibility and all condition suitable**. And the blue line is the original signal, red line is reconstruction signal.

$$f(t) = \begin{cases} 1+t & -1 \le t < 0 \\ 1-t & 0 \le t < 1 \\ 0 & else \end{cases} \tag{1}$$

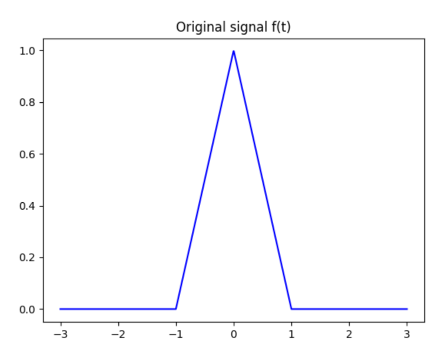


Figure 1: f(t)

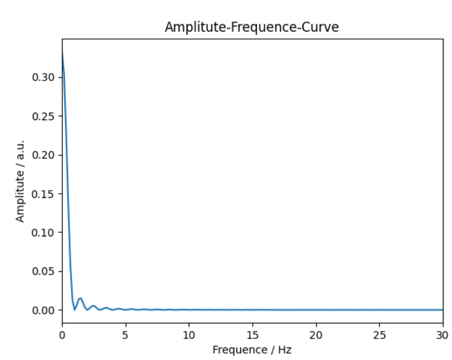
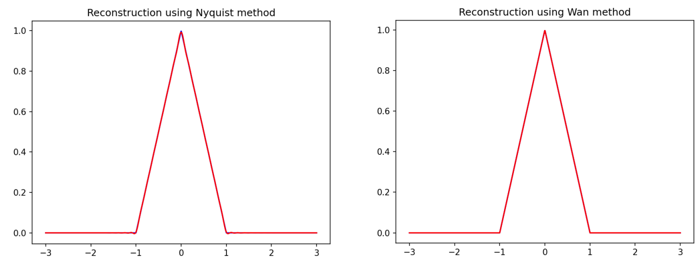


Figure 2: f(t) in frequency domain

2.1 Reconstruction effect comparison

2.1.1 Reconstruction overall effect comparison

If we using Nyquist sampling method we need know the bandwidth of f(t) before we sampling, so we make FFT for f(t), and get its frequency feature as the Figure 2 shows. So we let our cutoff frequency of LPF is $f_c = 7$, and our sampling period $T_s = 0.05$. Then we reconstruct the signal using Wan's sampling method and Nyquist sampling method. The reconstructed signal can be shown as the Figure 3.



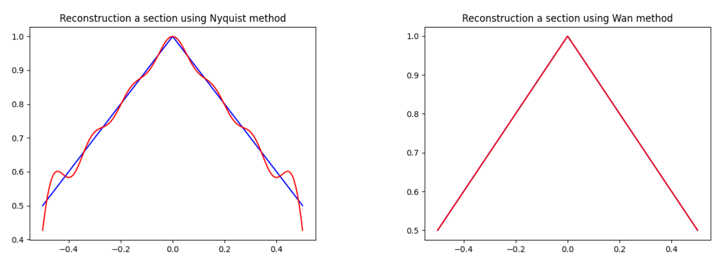
(a) Using Nyquist method (b) Using Wan's method

Figure 3: Reconstruction using two methods

From the figure, we can find that at $t = -1, 0, 1$, reconstruction using Nyquist method has a small fluctuation, and reconstruction using Wan's method looks well in general.

2.1.2 Reconstruct a section of signal

In real application we may only interesting in a section of the signal, so we reconstruct a section of the signal from $t \in [-0.5, 0.5)$, and compare them. And we only using the sampling points in this range. The result is shown by the Figure 4. From the reconstruction we can find that, if we only use sampling points in range we want, the Nyquist method has a severe distortion, while the Wan's method is very good.



(a) Using Nyquist method (b) Using Wan's method

Figure 4: Reconstruct a section of signal using two method

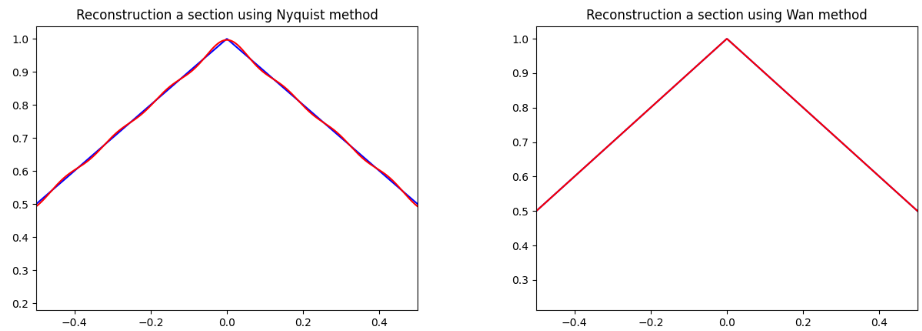
Then we using sampling points in range $t \in [-0.75, 0.75)$ and $t \in [-1, 1)$, and reconstruct them, the result can be show as the Figure 5. And we can find that the more sampling points we use, the better reconstruction effect is when using Nyquist method. We draw the reconstruction error to find some precise result, it can be show as the Figure 6. From the figure we can find that the more points in other range we use, the less error it has when using Nyquist method, but the number of other range points we use has no effect on the reconstruction error using Wan method. So Wan method has a better local adoptive.

2.1.3 Reconstruct at derivative discontinuous points

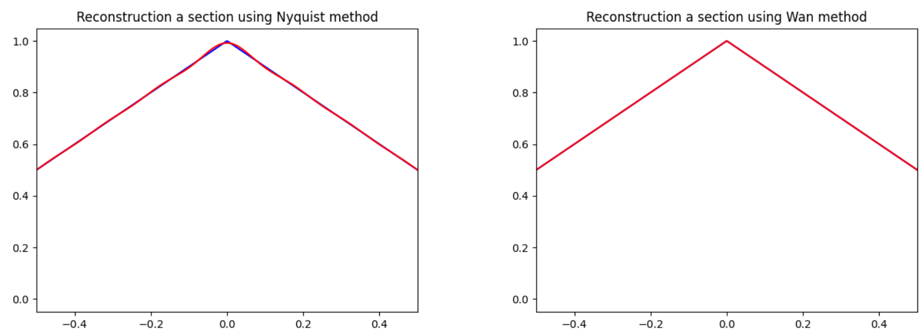
We magnify the Figure3 at derivative discontinuous points both in Wan method and Nyquist method, as the Figure7 shows. From the figure we can find that even at the derivative discontinuous points, Wan method has no fluctuation and Nyquist has a small fluctuation. So Wan method has no Gibbs phenomenon.

2.1.4 Reconstruction error

For overall reconstruction, we set the error is not larger than 0.0001 and 0.0002 for Wan method and set $T_s = 0.05, 0.005$ for Nyquist method. Then we compare the error of two method. The result can be shown as the Figure 8

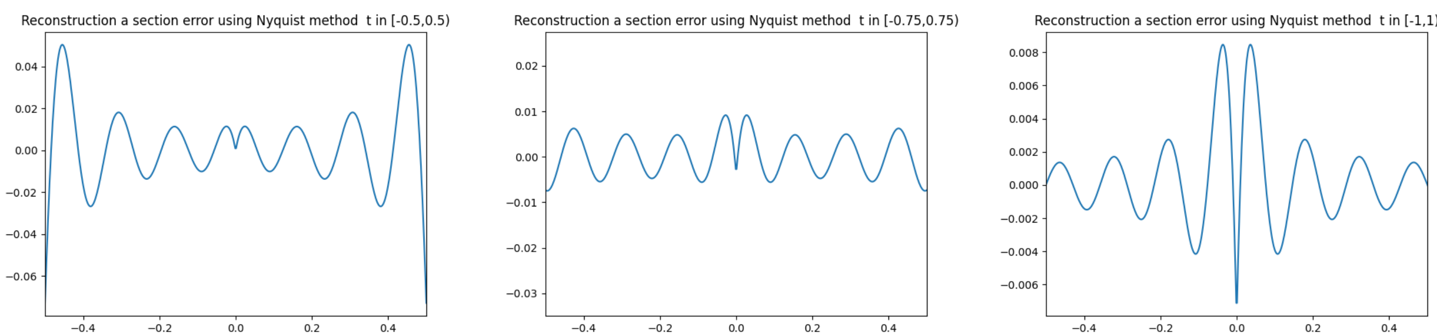


(a) Using points in $[-0.75, 0.75)$

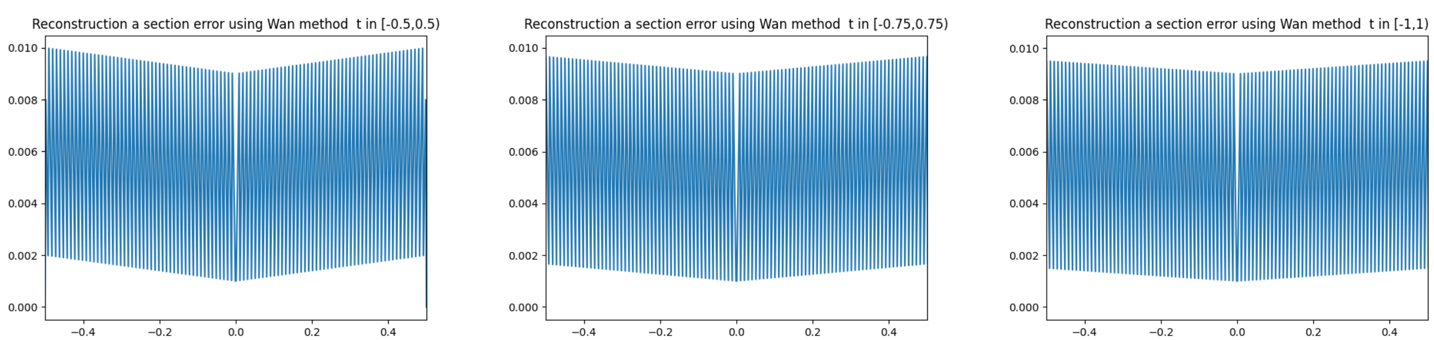


(b) Using points in $[-1, 1)$

Figure 5: Reconstruct a section of signal using two method

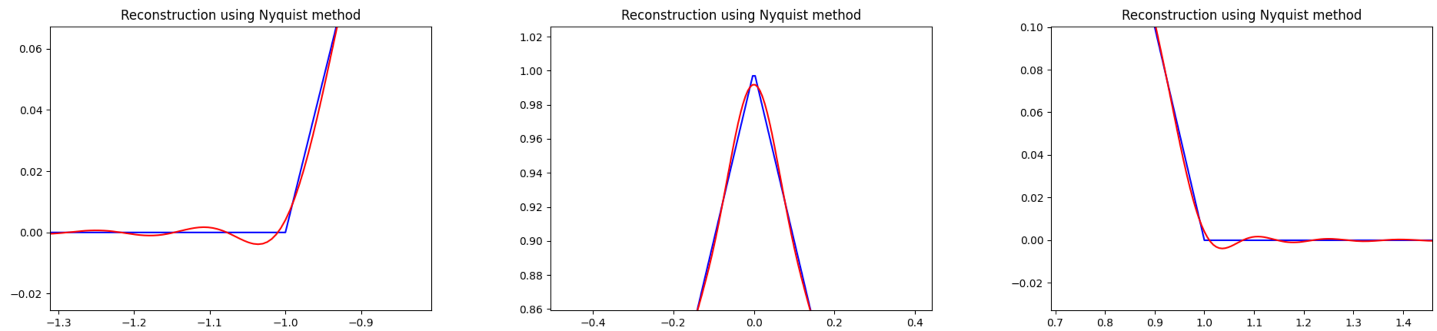


(a) Nyquist method

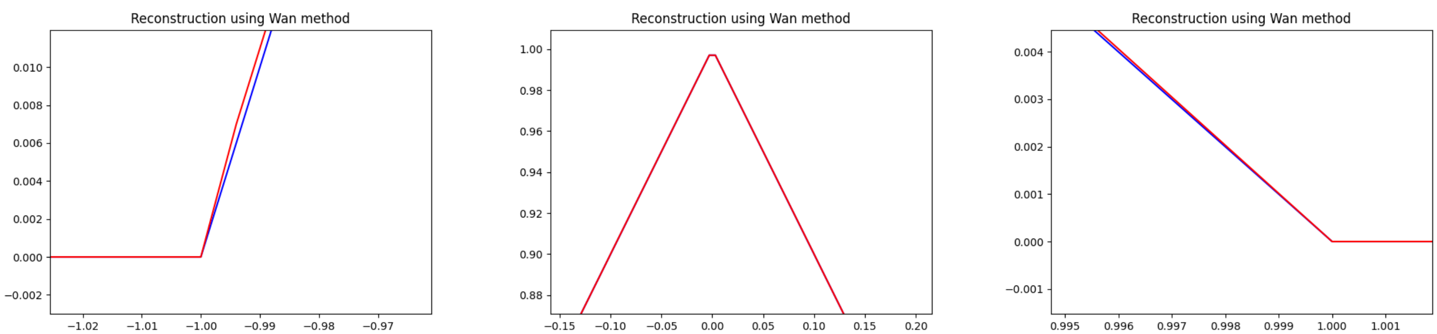


(b) Wan method

Figure 6: Reconstruct a section of signal using two method

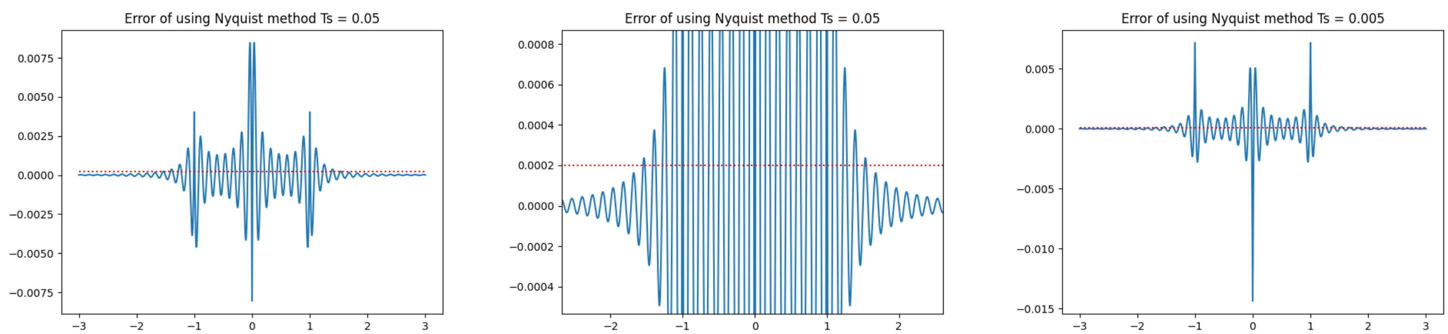


(a) Nyquist method

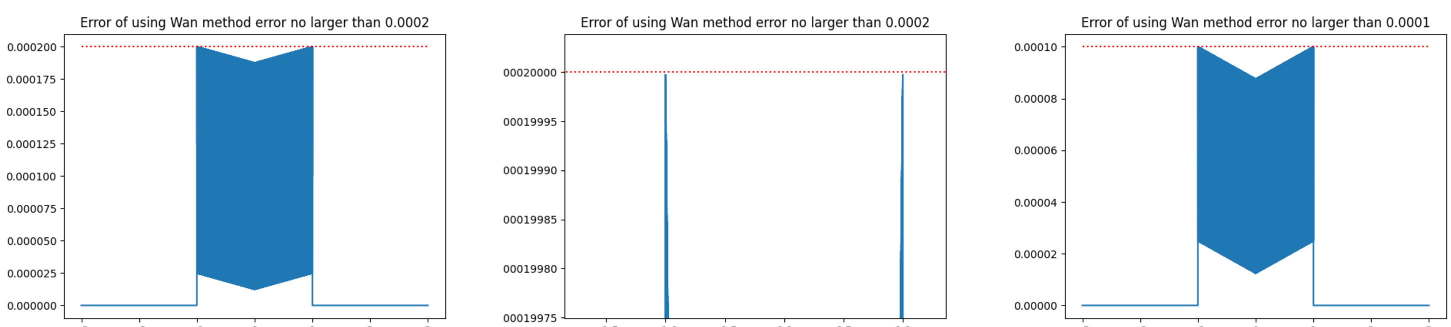


(b) Wan method

Figure 7: Reconstruct a section of signal using two method



(a) Nyquist method



(b) Wan method

Figure 8: Reconstruct error using two method

2.1.5 A small summary about two reconstruction effect

(1) For Wan method, each $\hat{x}(t)$ is reconstructed only from samples near t; but for Nyquist method, each $\hat{x}(t)$ has to do with all samples we get, the more samples we use, the less error it has. So the Wan method has a much better local adoptive.

(2) At derivative discontinuous points, Wan method has no fluctuation, while Nyquist method has a small fluctuation at these points. So for Wan method there is no Gibbs phenomenon(For discontinuous points is same we don't show it on the article consider the length of article).

(3) From the error of two method, we can find the point wise error of Wan method is limited in a value we set, but the error for Nyquist method is not controlled. And for the Wan method we can set the error value in advance, but for Nyquist method, we can't set the error value, and we can only decrease the error by increasing our sampling rate, but this way is not effective as we talked in error part.

2.2 Other aspects compare

For Wan method, $\hat{x}(t) = x(nT)$, where $t \in [n-1/2T, n+1/2T)$; for Nyquist method, $\hat{x}(t) = 2f_cT\sum_n x(nT)sinc[2\pi f_c(t-nT)]$. From the reconstruction formula we can see that, the implementation of Wan is easier, and Nyquist method is much more complex. Also when we using Nyquist method, we need to set a bandwidth for our signal, it is not easy to confirm a universal way to do this. But using Wan method, we don't need to consider this. Though when we using Wan method we need to know the derivation of the signal, but it is easy to achieve. Also when apply Wan method, we can set the reconstruction error in advance and the point wise error will within this value. Last, using Wan method, we can use a uneven sampling rate, which can reduce the storage.

2.3 A promoted test way

In the article we define original signal as the Equation 1 shows, it only has derivation discontinuous point at t = -1, 0, 1, we can define a signal has discontinuous point and derivation discontinuous point, like Equation 2 shows, it has a discontinuous point at t = 0.

$$f(t) = \begin{cases} 1+t & -1 \le t < 0 \\ 0.5(1-t) & 0 \le t < 1 \\ 0 & else \end{cases} \tag{2}$$

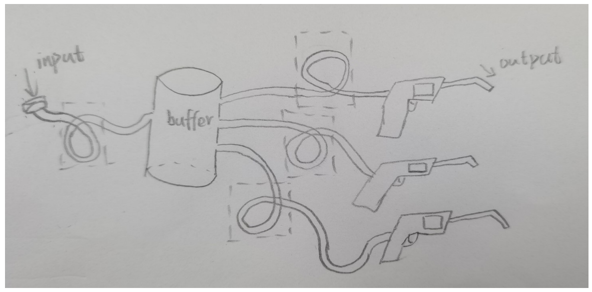
3 Talks about USB hub

3.1 How USB hub works

A USB hub provides an additional connection point to USB, it has several downstream port and only on upstream port, it is connected to host through the upstream port, and each downstream port allows connection to a hub or functional device, and each the two downstream ports can be individually enabled to connect high-speed, full-speed, or low-speed devices. A hub is mainly composed of three part: hub controller, hub repeater and transaction translator. The hub controller provides a mechanism for host-to-hub communication. Hub specific status and control commands allow the host to configure the hub and monitor and control each of its downstream ports [1]. A hub repeater plays a role in data transmission between high speed downstream device and upstream. A transaction translator plays a role in data transmission between low speed downstream device and upstream. All the device in USB bus are physically connected to host through a cascading star topology(like an inverted tree, hub is tree node). Each device has a sole advice and the host inquire the status of each device in topology in a polling mode, and so as to react each device. So if the number of devices are large, the reaction will be delay.

3.2 A invention using USB hub working principle

When we add oil in petrol station in a motorway service area, there is usually a few fuel filling column, but there is a huge place which can hold many cars in motorway service area. When we add oil, we need to line up after we have rest enough. But why can't we add oil when we rest? So I want to invent a new fuel truck nozzle, like Figure 9 shows. The input can both connect to fuel filling column or other gun's output. There is a small bump inside the output gun(electric powered), and the output of oil is controlled by the output end of the oil gun, we can put a QR code on it, and if a people wants add oil, he scan it, choose oil mass and pay it, then it works. The gun itself can measure how much oil has output already, and if it has reach the mass people want, then it stop. The place surrounded by dotted line represent it use a retractable pipeline(principle like the tapeline, we pull it, it can be pulled more length out). The buffer is like hub repeater and transaction translator in hub, plays a role in balancing rate difference between input and output.



Interesting.

Figure 9: A new fuel truck nozzle(draw by myself)

3.3 Evaluate on my invention

The biggest of this invention is safe problem, We can understand it from following two aspect. First, the gun it self use electronic to power bump in it, if some accidents comes, it may detonate the oil gun due to electronic power. Also when people add oil, they need to scan the QR code, we all know that in oil station, we need turn our phone off to avoid accidents, when they scan the QR code they need to use their phone, it is dangerous. Second, oil is in the pipeline and buffer all time, if some bad guys want to do some thing, it is so easy, and the result maybe very severe.

References

[1] 赵秋霞 and 马鸣锦. Usb 2.0 hub 事务转换器的工作机理. 计算机应用, 23:49–51, 2003.

[2] daikaimiao. http://t.csdn.cn/qkm2b/usb hub 简述.

Appendix A Code listings

```
from matplotlib import pyplot as plt
import numpy as np
from scipy.fft import fft
def func(t):
    if t < -1: return 0
    elif t < 0: return t + 1
    elif t < 1: return 1 - t
    else: return 0
def refuncW(t, T):
    n = int(t / T)
    return func(n * T)

t = np.linspace(-3,3,1000) #t = np.linspace(-3,3,80000) #need much time when draw error figure
t2 = np.linspace(-0.5,0.5,500) #or t2 = np.linspace(-0.75,0.75,750), t2 = np.linspace(-1,1,1000)
fv = np.array([func(x) for x in t])
fv2 = np.array([func(x) for x in t2])
T = 0.0001    #T = 0.01 or T = 0.0002
'''
the distance between two points must smaller than T other wise it will wrong,  when I draw the section
    reconstruction error figure, I set T = 0.01for qualitative analysis the how the number of sampling points we
    use influence the error, it has no effect.
'''
refvW = np.array([refuncW(x, T) for x in t])
refvW2 = np.array([refuncW(x, T) for x in t2])
def myfft(x,t):                # fourier transform to determine f_s
    fft_x = fft(x)                                        #  fft computer
    amp_x = abs(fft_x)/len(x)*2
    label_x = np.linspace(0,int(len(x)/2)-1,int(len(x)/2)) # generate frequency range
    amp = amp_x[0:int(len(x)/2)]                          # only compute first half
    # amp[0] = 0                                          # choose whether to remove the direct traffic signal
    fs =1/( t[2]-t[1])                                    # Calculate sampling frequency
    fre = label_x/len(x)*fs
    pha = np.unwrap(np.angle(fft_x))                      # The phase Angle was calculated and the 2pi jump was removed
    return amp,fre,pha
```

```
    amp,fre,pha = myfft(fv, t)

    plt.figure(1)
    plt.plot(fre,amp)
    plt.xlim(0, 30)
    plt.title('Amplitute-Frequence-Curve')
    plt.ylabel('Amplitute / a.u.')
    plt.xlabel('Frequence / Hz')

    refvN = np.zeros_like(t)
    refvN2 = np.zeros_like(t2)
    fc = 7 # from Fourier trans get
    Ts = 0.005 # from Fourier trans get or #Ts = 0.05 Ts must less than 0.05
    lineNumber = 6 / Ts
    lineNumber2 = 1 / Ts #[-0.5,0.5) #lineNumber2 = 1.5 / Ts #[-0.75,0.75) or lineNumber2 = 2 / Ts #[-1,1)

    def recon(t, fc, k, Ts):
        return np.sinc(2 * fc * (t - k * Ts))

    for k in np.arange(-lineNumber/2,lineNumber/2 + 1):
        refvN = func(k*Ts) * np.array([recon(x, fc, k, Ts) for x in t]) + refvN
    refvN =refvN * fc * Ts * 2 # reconstruct use Nyquist way
    for k in np.arange(-lineNumber2/2,lineNumber2/2 + 1):  #a range of signal
        refvN2 = func(k*Ts) * np.array([recon(x, fc, k, Ts) for x in t2]) + refvN2
    refvN2 =refvN2 * fc * Ts * 2 # reconstruct use Nyquist way
    errorW = refvW - fv
    errorN = refvN - fv

    plt.figure(2)
    plt.plot(t,fv,color = 'b')
    plt.title('Original signal f(t)')
    plt.figure(3)
    plt.plot(t,fv,'b',t,refvN,'r')
    plt.title('Reconstruction using Nyquist method')
    plt.figure(4)
    plt.plot(t,fv,'b',t,refvW,'r')
    plt.title('Reconstruction using Wan method')
    plt.figure(5)
    plt.plot(t,errorW)
    plt.plot((-3,3),(0.0001,0.0001),'r:')  # or plt.plot((-3,3),(0.0002,0.0002),'r:')
    plt.title('Error of using Wan method error no larger than 0.0001')  #0.0001 or 0.0002
    plt.figure(6)
    plt.plot(t,errorN)
    plt.plot((-3,3),(0.0001,0.0001),'r:') #or plt.plot((-3,3),(0.0002,0.0002),'r:')
    plt.title('Error of using Nyquist method Ts = 0.005') #0.005 or 0.05
    plt.figure(7)
    plt.plot(t2,fv2,'b',t2,refvN2,'r')
    plt.xlim(-0.5,0.5)
    plt.title('Reconstruction a section using Nyquist method')
    plt.figure(8)
    plt.plot(t2,fv2,'b',t2,refvW2,'r')
    plt.xlim(-0.5,0.5)
    plt.title('Reconstruction a section using Wan method')
    errorcN = refvN2 - fv2
    errorcW = refvW2 - fv2
    plt.figure(9)
    plt.plot(t2,errorcN)
    plt.xlim(-0.5,0.5)
    plt.title('Reconstruction a section error using Nyquist method t in [-0.5,0.5)')# or t in [-0.75,0.75),t in [-1,1)
    plt.figure(10)
    plt.plot(t2,errorcW)
    plt.xlim(-0.5,0.5)
    plt.title('Reconstruction a section error using Wan method t in [-0.5,0.5)') # or t in [-0.75,0.75), t in [-1,1)
    plt.show()
```