DSP Week3 Homework

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Abstract

In this article I write three summary about videos we watched in class, the first is about our nature, it shows how beautiful our nature is at first and then it told us what our nature will be if we do nothing about the melting of glaciers. The second is about how wireless earbuds works, this video mainly introduce audio codecs to us, and tell us the process of ADC and DAC. For the last one, it is about the benefit that exercise can bring to our brain by enhancing our hippocampus and prefrontal cortex. In the first video, I find that the leg of the four-legged creatures in nature is usually composed of three part, then I associate it with our robot dog and I think if we apply this structure of legs to our robot dog, it will be more flexible. What's more, I also do a campus survey to find the most or least happy time in a day or in a week, 173 students answered this survey, most student think evening is the most happy time in a day, morning is the least time in a day, and most students think weekend is the most happy time in a week and at the beginning of a week is the least happy day among a week. Through this survey I find that our students is very busy nowadays, and also our life rhythm is not regular. In the last part of this article, I proved the properties of Fourier transform from its definition.

1 Talks about Videos

1.1 Summary of These Videos

1.1.1 One Planet

This video we saw this week, is mainly about some of the natural wonders that still exist and what we need to protect. It shows us the biological activity of different zones at first. Millions of seabirds from South America Peru coast go out for fishing in the morning; flamingos breed in salt pond, in Africa; dolphins in the ocean prey on mackerels; gnus from Africa grasslands suffer attack from hunting dogs while migrating to water migration; male birds dance rehearsal to attract females in jungle; in the northern forest when reindeer migrating to the south in search of food and habitat on the way encounter wolves prey on the scene. Then camera turns to the glaciers which can reflect light shot from the sun to keep our planet not too hot are melting more fast in north pole and the Greenland. This phenomenon leads to raising sea levels, changing salinity and disrupting ocean currents. Without the Humboldt Current, the coast of Peru would fall silent and the seabird spectacle would be no more. Crucial connections are disrupted with it, and spectacle in other places we saw in the first part of this video will be effected too. And what we do in next 20 years is significant for our planet.

1.1.2 How Wireless Headphones work?

In this video, it introduce that wireless headphone involves nine technology: Speaker, Audio Codecs, Bluetooth, SoC, PCB, Accelerometers, Li-lon Battery, MEMS microphone and Noise Cancellation. This video is mainly focused on Audio Codecs. At first, it opened a AirPods2 and told us the different components and where they're located inside AirPods. Next it shows how wireless earbuds works with bluetooth. Then video shows us how analog sound signal can be represented by digital information and how these digital information transform to analog sound signal we can hear. At last, they talked about audio file formats.

1.1.3 The Benefit to Our Brain by Exercise

This video is a TED speech lead by an expert of neuroscience, talking about the powerful effects of physical activity through her personal experiment and research. According to she, exercise can bring us immediate, long-lasting and protective benefits for our brain which can last for the rest of our life. She said exercise is the most transformative thing we can do for our brain today for the following three reasons: (1)it has immediate effects on our brain. (2)it improve attention function dependent on our prefrontal cortex. (3)we can get immediate mood effects and last for a long time. What is most important is that exercise can protect our brain from disease like dementia or Alzheimer. These is all because exercise can strength our hippocampus and prefrontal cortex.

1.2 Further Thoughts After Watching

1.2.1 About One Planet

At the beginning of video, we saw our earth from the space view, it is so small. As the Carl Edward Sagan said *"We successfully take this picture (from out space), and if you look closely, you'll see a not surprisingly small dot. And look at that dot of light. It's right here. It's our home. It's everything to us. Everyone you love, everyone you know, everyone you've ever heard of, everyone you've ever existed, has spent their whole lives on it."* [1] But it is in this small planet people who seek fame are intoxicated with officialdom, people who seek profit are intoxicated with the market. We don't care our earth any more. The earth is not only belong to us, but also belong to people of the past and the future. We should think about it for future people, because they are our children, grandchild, grandgrandchild$\cdots$ The spectacle we can see in the video, we hope our children can see too. So we need to do some thing to help our earth. It doesn't have to be something big, just like turning off the lights at home every day when you're not using them, or riding your bike more and driving less to work$\cdots$ It seems so small, but when almost every people on earth can do it, then it can make sense.

The interesting thing is that I find the legs of a flamingo are bent forward as the Figure 1 shows, don't like our human bent afterward.

Good observation.

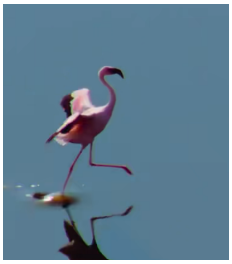
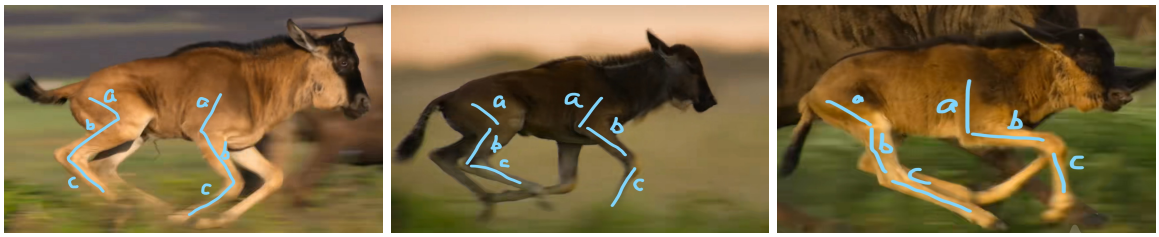
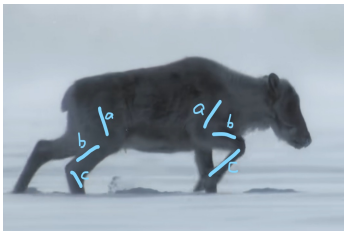


Figure 1: Leg of flamingo

After noticing this, I paid attention to the legs of other animals while watching the video and noticed that their front legs were bent backwards while their back legs were bent forward. What's more I find that the leg of gnu, hunting dog, reindeer and wolf are all composed of three part, as the Figure 2 shows.



(a) legs of gnu



(b) legs of reindeer

(c) legs of hunting dog

(d) legs of hunting dog

Figure 2: Leg of animals(*plus: all these picture are cut from video*)

Then I associate it with robot dog in our life, their legs are composed two part and its front leg bet forward, as the Figure 3 shows. We know it is difficult for us to keep our robot dog balance some time even in flat ground. So based on it, I think we can use the structure of the legs of real animals, so that our robot dogs may be more flexible and easy to keep balance. As the Figure 4 shows, if our robot dog x position and y height is sure(length of leg is fixed since produced), and then only one confirmed posture that legs can be(like triangle), while if we use three part for each leg, also x position and y height is sure, we may have infinite posture that legs can be. I think different posture it stand, may lead to different force distribution which may influence the balance of robot dog. As for bend direction, I think the real life has evolved over thousands of years, so there's reasons for that maybe we don't find now.

Figure 3: Leg of robot dog

1.2.2 About How Wireless Earbuds Work

After watch this video, I knew how wireless earbuds works. And why we use wireless earbuds more and more is that the cable to the earphone is too easy to tangle. Since we can use air to convert information like sound signal, why can't we use air to convert electronic energy. I once read a article about scientist Tesla, it is said that he successfully achieved in wireless energy convert, but his data were completely rejected by the mainstream scientific community of the time, and wireless power transmission was never developed. Its principle is the "schumann resonance" principle, the theory is that on earth there is a global "magnetic resonance" phenomenon, it is formed between the surface of the earth and the ionosphere, lightning can inspire

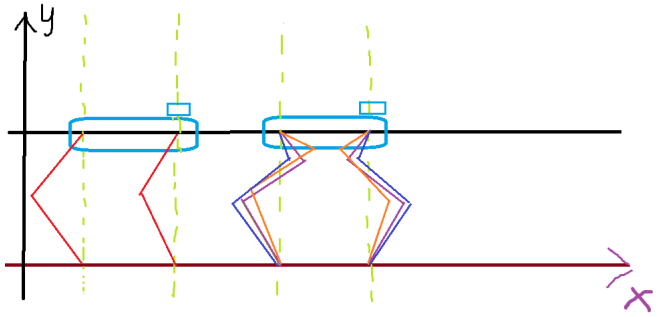


Figure 4: Compare two construction of robot legs

such global magnetic resonance, if the earth itself as a conductor, the electricity to the ionosphere, the use of magnetic resonance can make ac spreads in the atmosphere. As long as the earth is equipped with special antennas, it can receive electricity from the air! Maybe in the future we can pick this technology up, and achieve it to make our life more convenient.

1.2.3 About Exercise

Good honesty.

To be honest, I don't have too much thoughts about this video, I totally agree with her, because I usually get up early and exercise. It makes me feel good for the whole day. And I will keep this habit until I am too old to run. The Figure 5 is sport data of mine last month.

Good.

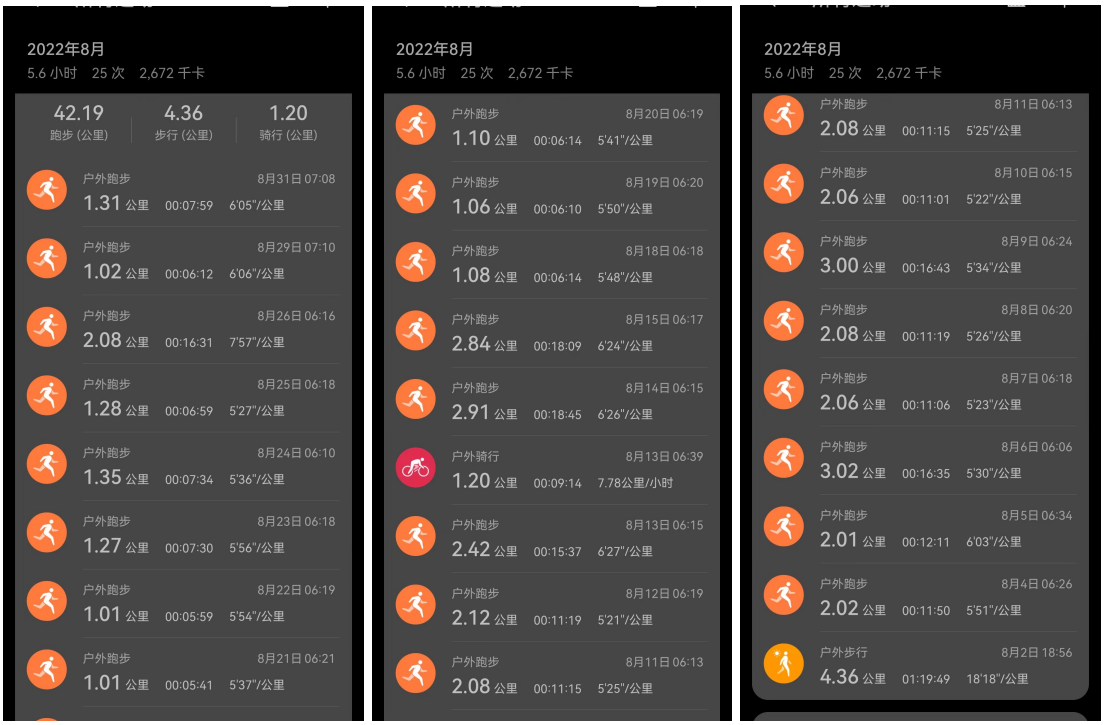


Figure 5: My sport data last month

jogging?

2 A Campus Survey

2.1 Introduction of the Survey

I used online questionnaire to do this survey, I send my questionnaire to student groups that cover almost all colleges in our school, and got 173 samples. My questionnaire is composed of four question, the first is "what is the most happy time in a day", the second question is "what is the least happy time in a day". For these two questions you can choose from 0:00-1:00 to 23:00-0:00. The third question is "what is the most happy day in a week", the last is "what is the least happy day in a week", for the last two question you can choose from Monday to Sunday, as the Figure 6 shows.

Why?

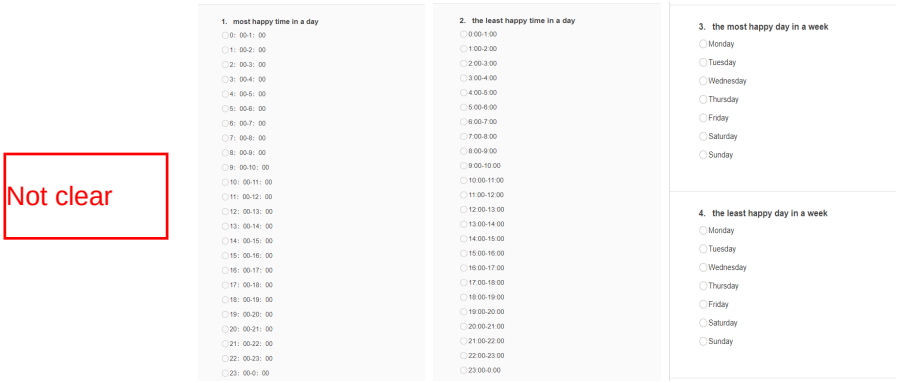


Figure 6: Questions in questionnaire

2.2 Result of the Survey

In this survey, I got 173 piece of effective answers as Figure 7 shows, and result of each question shows as the Figure 8.

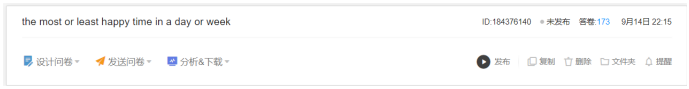
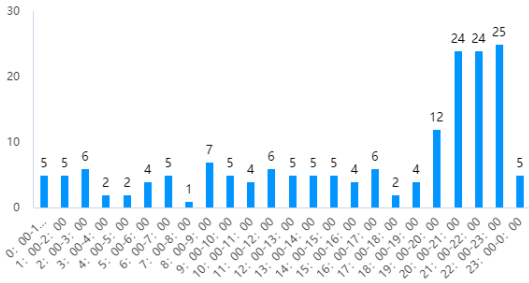
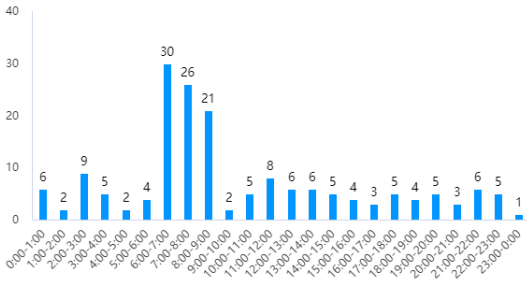


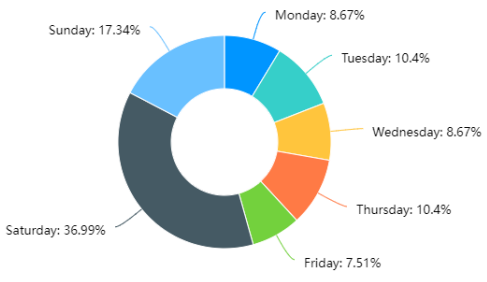
Figure 7: Number of answer



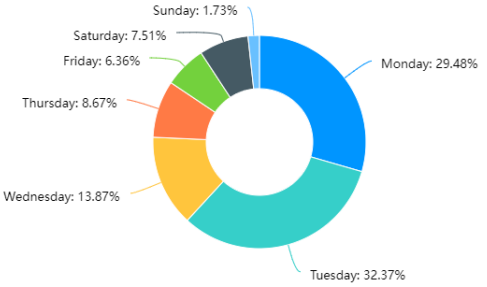
(a) Number of people at different time for ques1



(b) Number of people at different time for ques2



(c) the percentage of people per day for ques3



(d) the percentage of people per day for ques4

Figure 8: Result statistics

2.3 What can School Do to Help Our Campus Life more Suitable?

From result of the survey, we can find that most students think 20:00-23:00 is the most happy time in a day and 6:00 9:00 is the least happy time in a day. Also most students think weekend is the most happy day in a week and at the beginning of the week is the least happy day in a week.

This phenomenon is mainly because in the evening student almost have finished the all classes in a day, so that in the evening they have time to do what they want, they are free, and in the morning students need to get up early to eat breakfast and have the first class in the day, many people get out of bed angry so they think is the least happy time in a day. As for the

most and least happy day in a week it is so easy to understand that on weekends they can do what they want and don't need to follow the schedule as usually, but at the beginning of a week, they don't get used to the schedule after weekends.

I think our school can let students study by themselves, different student has different habits and study ability. Maybe some students like to get up early and go to bed early, maybe some students are night-bird, they like to study in the evening and it is also difficult for them to get up early. Also for a knowledge point, some students are smart, they don't need too much time time to absorb it, but some students may needs much time to absorb it. When this two type students sit in class, it is a waste of time for smart students when teacher talks slow and it is may difficult for the later one when teacher talks fast.

So our school can let teachers transcribe all class online or share us all datum relevant to this course in advance, and student don't need go to class on schedule, also there is no workday and weekend, student study at time when they want, for smart students, they can speed their study process, and for normal students they can repeat the knowledge they confused with. But to ensure all the students can grasp the knowledge school should test at a uncertain period. Those who failed needs to go to classroom and follow the schedule. Good suggestion

2.4 Questions behind the Survey

From statistics I infer that there are problems behind the phenomenon as follow: Good

(1) **Nowadays, college students have too much classes, and they have less time to do things they like**. Most student thinks that evening is the most happy time, if they are not busy in daytime, in daytime expect what they can do in evening they can also do what they can't do in evening, so I think students have too much classes.

(2) **The daily timetable of students are irregular**, many students think morning is the least happy time in a day, but if we have rest enough why morning will be the least happy time. Some students can't control their desire and stay up late to play computer games and need to get up early at nextday to have class. Also most students indulge themselves on weekends and have trouble to get used to the workday schedule at the beginning of the week. So I think it is because they don't have a organized life rhythm.

2.5 A Way that Computer can Analyze this Survey Automatically

Our computer can not analyze the survey without any data offered to it, so we need give it something in advance. The first thing we need to do is to do a new survey again, which is composed of five questions: the first four are same as we do, the last is problems that influence students' mood. Then we use these survey data to make a training data-set, and the four time segment participants chosen play a role as the influencing factors of classification, let the answer of fifth question as the result of classification, then we send this training data to our computer, and using decision-making tree algorithm to generate a decision tree. Then we back to our first survey composed of four question, we let our computer find the most answers and then it will get four time segments, next let it search that decision tree based on these four time segments and finally it can get the result as we got or maybe even better than results we got.

Also, I have s stupid and simple way to let our computer do it, but it may less accurate than machine-learn way. Namely we divide a day into four part: morning, afternoon, evening and night, and a week to three part: beginning(Monday & Tuesday), middle part(Wednesday to Friday) and weekend, then we have two questions about day time and two questions about week time, so totally are $4 \times 4 \times 3 \times 3 = 144$ kind results. We use 8 bits to encoding each combination(two bits for each time part), then we can list all results by deducing the corresponding results ourselves. Then we store these analyze-results in our computer. When our computer receive the data of survey, it get the most answer of each question,and find which time segment it belongs to. Then computer encoding it based on the time segments it got, finally it use the code to find the analyze-results in its storage.

3 Prove the Properties of Fourier Transform

3.1 Linearity

Suppose that $z(t) = ax(t) + by(t)$, so

$$\tilde{z}(f) = \int_{-\infty}^{\infty} [ax(t) + by(t)]e^{-j2\pi ft}dt = a\int_{-\infty}^{\infty} x(t)e^{-j2\pi ft}dt + b\int_{-\infty}^{\infty} y(t)e^{-j2\pi ft}dt = a\tilde{x}(f) + b\tilde{y}(f) \tag{1}$$

So $ax(t) + by(t) \leftrightarrow a\tilde{x}(f) + b\tilde{y}(f)$.

3.2 Scaling

First, we let $y(t) = x(st)$,

$$\tilde{y}(f) = \int_{-\infty}^{\infty} y(t)e^{-j2\pi ft}dt = \int_{-\infty}^{\infty} x(st)e^{-j2\pi ft}dt \tag{2}$$

We let st = m, so t = $\frac{m}{s}$, dt = $\frac{dm}{s}$.

When $s > 0$, $t \to \infty$, $m \to \infty$, $t \to -\infty$, $m \to -\infty$, so

$$\tilde{y}(f) = \frac{1}{s}\int_{-\infty}^{\infty} x(m)e^{-j2\pi f\frac{m}{s}}dm = \frac{1}{s}\tilde{x}(\frac{f}{s}) \tag{3}$$

When $s < 0$, $t \to \infty$, $m \to -\infty$, $t \to -\infty$, $m \to \infty$, so

$$\tilde{y}(f) = \frac{1}{s}\int_{\infty}^{-\infty} x(m)e^{-j2\pi f\frac{m}{s}}dm = -\frac{1}{s}\int_{-\infty}^{\infty} x(m)e^{-j2\pi f\frac{m}{s}}dm = \frac{1}{|s|}\tilde{x}(\frac{f}{s}) \tag{4}$$

When $s = 0$, it is meaningless, so $x(st) \leftrightarrow \frac{1}{|s|}\tilde{x}(\frac{f}{s})$

3.3 Conjugate

We let $y(t) = x^*(t)$, so

$$\begin{aligned}\tilde{y}(f) &= \int_{-\infty}^{\infty} y(t)e^{-j2\pi ft}dt = \int_{-\infty}^{\infty} x^*(t)e^{-j2\pi ft}dt \\ &= \int_{-\infty}^{\infty} (x(t)e^{j2\pi ft})^* dt \\ &= \big[\int_{-\infty}^{\infty} x(t)e^{-j2\pi(-f)t}dt\big]^* \\ &= \tilde{x}^*(-f)\end{aligned} \tag{5}$$

So $x^*(t) \leftrightarrow \tilde{x}^*(-f)$.

3.4 Duality

We know that

$$\begin{aligned}\because x(t) &= \int_{-\infty}^{\infty} \tilde{x}(f)e^{j2\pi ft}df \\ \therefore x(-t) &= \int_{-\infty}^{\infty} \tilde{x}(f)e^{-j2\pi ft}df\end{aligned} \tag{6}$$

Then we let $t \to f$ and $f \to t$, so

$$x(-f) = \int_{-\infty}^{\infty} \tilde{x}(t)e^{-j2\pi ft}dt \tag{7}$$

So, from forward Fourier transform, we can know that $\tilde{x}(t) \leftrightarrow x(-f)$

3.5 Time shift

We let $m = t - t_0$, so $t = m + t_0, dt = dm$, when $t \to \infty, m \to \infty; t \to -\infty, m \to -\infty$, so

$$\int_{-\infty}^{\infty} x(t-t_0)e^{-j2\pi ft}dt = \int_{-\infty}^{\infty} x(m)e^{-j2\pi f(m+t_0)}dm = e^{-j2\pi ft_0}\int_{-\infty}^{\infty} x(m)e^{-j2\pi fm}dm = \tilde{x}(f)e^{-j2\pi ft_0} \tag{8}$$

So $x(t - t_0) \leftrightarrow \tilde{x}(f)e^{-j2\pi ft_0}$

3.6 Frequency shift

First we let $y(t) = e^{j2\pi f_0 t}x(t)$, so

$$\tilde{y}(f) = \int_{-\infty}^{\infty} y(t)e^{-j2\pi ft}dt = \int_{-\infty}^{\infty} x(t)e^{-j2\pi(f-f_0)t}dt \tag{9}$$

Because:

$$\begin{aligned}\tilde{x}(f) &= \int_{-\infty}^{\infty} x(t)e^{-j2\pi ft}dt \\ \tilde{x}(f-f_0) &= \int_{-\infty}^{\infty} x(t)e^{-j2\pi(f-f_0)t}dt\end{aligned} \tag{10}$$

Therefore:

$$\tilde{y}(f) = \tilde{x}(f - f_0) \tag{11}$$

So $e^{j2\pi f_0 t}x(t) \leftrightarrow \tilde{x}(f - f_0)$

3.7 Differentiation

From definition:

$$x(t) = \int_{-\infty}^{\infty} \tilde{x}(f) e^{j2\pi ft} df \tag{12}$$

We take the derivative of t for both sides, then:

$$x^{'}(t) = \int_{-\infty}^{\infty} j2\pi f \tilde{x}(f) e^{j2\pi ft} df \tag{13}$$

Therefore according to definition $x^{'}(t) \leftrightarrow j2\pi f\tilde{x}(f)$

3.8 Convolution

First we let $z(t) = \int x(\tau)y(t-\tau)d\tau$, then

$$\begin{aligned} \tilde{z}(f) &= \int_{-\infty}^{\infty} y(t) e^{-j2\pi ft} dt \\ &= \int_{-\infty}^{\infty} [\int x(\tau)y(t-\tau)d\tau] e^{-j2\pi ft} dt \\ &= \int_{-\infty}^{\infty} x(\tau)[\int y(t-\tau) e^{-j2\pi ft} dt] d\tau \end{aligned} \tag{14}$$

Let $m = t - \tau$, so $t = m + \tau, dt = dm$, then

$$\begin{aligned} \tilde{y}(f) &= \int_{-\infty}^{\infty} x(\tau)\big[\int y(m) e^{-j2\pi fm} dm\big] e^{-j2\pi f\tau} d\tau \\ &= \tilde{y}(f) \int_{-\infty}^{\infty} e^{-j2\pi f\tau} d\tau \\ &= \tilde{x}(f)\tilde{y}(f) \end{aligned} \tag{15}$$

So $\int x(\tau)y(t-\tau)d\tau \leftrightarrow \tilde{x}(f)\tilde{y}(f)$

4 Conclusions

Better be "Key conclusions/results"

(1) **Nowadays, college students have too much classes, and they have less time to do things they like.**

(2) **The daily timetable of students are irregular.**

References

[1] Carl and Sagan. 《暗淡蓝点: 探寻人类的太空家园》. 科学新闻, 05:12–12, 2017.