NTU GICE Newsletter
Graduate Institute of Communication Engineering, National Taiwan University

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In this issue

Technology Developed in GICE

User Listening Behavior Analysis via Representation Learning

Cooperation between the Multimedia Processing and Communications (MPAC) Lab and KKBOX Inc.

from Communication and Signal Processing Group

I. INTRODUCTION

An efficient approach to understanding user listening behaviors is necessary for the development of a music recommendation system. One critical issue of listening behavior analysis is how to identify and represent the music preferences of users. As the music preference of a user is dynamic and varies with the listening context, such as time, location, user's mood, etc., we focus on the analysis of dynamic listening behavior in this work.

Many approaches represent songs and user preferences by one single scheme based on latent representation [1, 2]. The unified representation, which is a multi-dimensional vector, is learned from a listening record or a rating record. Each dimension of the vector represents a latent feature of songs and user preferences. Therefore, each song or user is an object represented by a vector in a latent space, making the evaluation of similarity between songs or the matching between songs and users a simple matter of distance measure between vectors.

The music preference of a user may change with the listening session [3]. A listening session here refers to a sequence of songs (and the associated time code) which a user continuously listened to. To account for the dynamic nature of music preference, we incorporate the notion of session into the learning stage of a latent representation. In our approach, each session of the listening record of a user is also represented as an object in the latent space. The contextual information, such as the time of day and the device used for music listening, associated with each session enables the analysis of user preference at a fine level.

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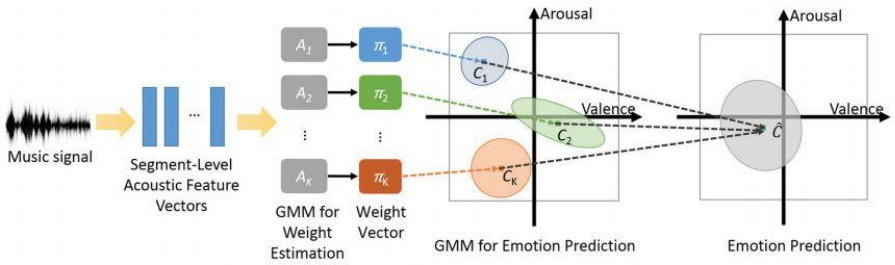
GICE Honors

The research results of Professor Homer H. Chen's team published on the front cover of IEEE/ACM Transaction on Audio, Speech, and Language Processing in 2017 July / August.



The AEG model for emotion prediction. First, the acoustic posterior weights are estimated from the music signal using the acoustic GMM. Then, the weighted combination of the predictions obtained from the bivariate Gaussian distribution component MER models yields the emotion prediction. For more, see "Component Tying for Mixture Model Adaptation in Personalization of Music Emotion Recognition" by Y-A. Chen, *et al.*, p. 1409.

Y.-A. Chen, J.-C. Wang, Y.-H. Yang, and H. H. Chen

Message from the Director

Tzong-Lin Wu

Professor & GICE Director

This issue we invite Prof. Homer H. Chen and Prof. Ruey-beei Wu to share their resent research.
In addition to some exiting on-going research from GICE, we are glory to share with readers some great news. The research results of Professor Homer H. Chen's team were chosen and published on the front cover of IEEE/ACM Transaction on Audio, Speech, and Language Processing in 2017 July / August.
Congratulations!

Besides, we are happy to see Mathis Zamboni who was awarded master degree from NTUGICE and INPT-ENSEEIHT following the reciprocal agreement of Double Degree Program.

Please enjoy the latest issue!

Technology *(Continued from page 1)*

II. LATENT REPRESENTATION LEARNING

In our approach, a network that describes the relationship between users, sessions, and songs stored in a listening record is first constructed, and then a network embedding method is applied to learn the latent representation from the network.

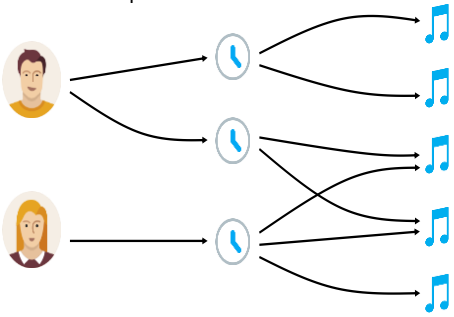


Fig. 1. A user-session-song network.

The basic idea to construct a network that describes the relationship between users and songs is to consider each user or song as an object in the network and connect each user with the songs the user listened to [2]. We further incorporate listening sessions into the network construction and consider each user, session, or song as an object in the network. As shown in Fig. 1, a user is connected with all sessions of the user, and a session is connected with all songs appearing in the session. This makes the network capture the dynamic music preferences of users. A network embedding method aims at learning the latent representation of objects in a network. Such representation captures the relationship between the objects in the network. Objects having a similar neighborhood in the network are represented by similar vectors. We apply the DeepWalk algorithm [4] to learn a two-dimensional latent representation for visual analysis.

III. Experiment

Dataset: We used a listening record of one hundred thousand users from a leading online music service provider [5]. The listening record contains every listening event of these users from January 1, 2015 to June 30, 2015. All users are anonymized to maintain privacy. A session, which indicates the listening experience of a user, is defined as a sequence of events of the user with the following constraints: The gap between any two neighboring events in a session is shorter than 10 minutes, and the listening device stays the same in a session.

Visualization and analysis: The user listening behavior is analyzed through the distribution of sessions and songs associated with a user in latent space. A session is close to the songs that appear in the session, and sessions form a cluster if they contain similar songs. Fig. 2 shows the analyses for nine example users. In each plot, the sessions and songs associated with a user are plotted.

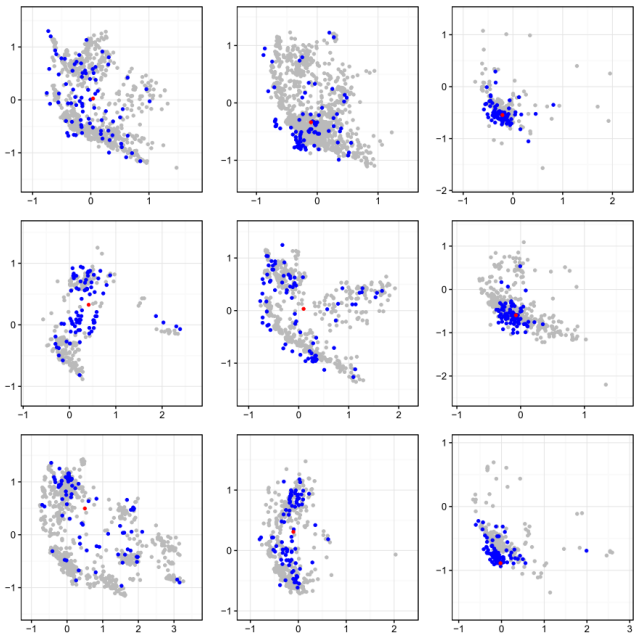


Fig. 2. Listening behavior analysis for nine example users. The sessions and songs associated with a user are plotted in each plot, where a red point represents a user, a blue point represents a session, and a gray point represents a song.

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Technology *(Continued from page 2)*

One important discovery is that users can be divided into two types, one with a single preference and the other with dynamic preference. For some users, the sessions are mostly located in one small area in the latent space. This means that the users listens to the same songs most of the time and hence belong to the first type. For other users, the sessions have a wide distribution and form several clusters. This indicates that the users belong to the second type.

In order to analyze the dynamic preference of an individual, we distinguish sessions by the context information (the device used for listening and the time of day). In Fig. 3, we color each session according to the device used for listening, and we can clearly see that the sessions form clusters according to the listening device. This indicates there is relevance between the music preference and the listening device. In Fig. 4, we color each session according to the time of day, and each plot shows a user whose music preference is related to the time for music listening. However, this kind of listening behavior is not easy to be observed on users. Probably it is because the relationship between time and music preference is too complex to be explained.

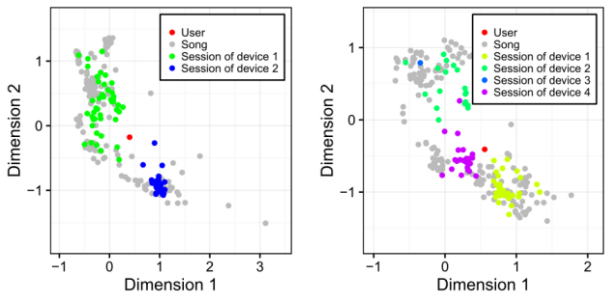

Fig. 3. The sessions are distinguished by the device used for music listening. Each plot illustrates a user whose music preference is related to the listening device.

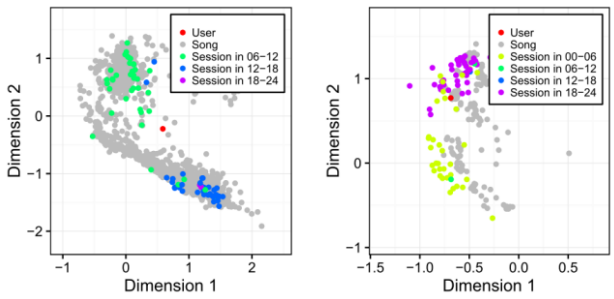

Fig. 4. Each plot shows a user whose music preference is related to the time for music listening. The sessions tend to form clusters according to the time (hour of day).

IV. CONCLUSION

We have described an approach to understanding user listening behaviors. The proposed approach generates the latent representation of users, sessions, and songs from a listening record. Such representation makes the relationship between these objects easy to analyze. We have performed a visual analysis of user behavior and preference in a two-dimensional latent space and shown that the information obtained from the two-dimensional analysis is useful for personalized music recommendation. The contextual information associated with each session enables both user preference analysis and music recommendation at a fine level.

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Technology

Fan-Out Wafer-Level Packaging for Three-Dimensional Memory Integration

from Electromagnetics Group

I. Introduction

The data rate and circuit density of electronic devices continuously grows since the mobile applications become pervasive and diversified. From the JEDEC's roadmap [1], LPDDR4 technology is one of the popular development trends of mobile DRAM, with the bandwidth reaching dozens Gbps. In order to make mobile devices slim and small, wafer-level packaging (WLP) is the best compromised solution in the balance among product appearance, performance, and price. Originally developed a decade ago and focused on the components level due to low loss in the molding compound fan-out region [2], WLP has been recently applied in mobile application processors (AP) [3].

II. Design of SIignal and Power Integrity

A three-dimensional integrated LPDDR4 packaging using WLP-based technology is shown in Fig. 1. DRAM dies are vertically stacked on a substrate above the WLP. A systematic and thorough model is constructed and performed for the combined analysis of power and signal integrity in the WLP from the periphery of package to the face-downward AP.

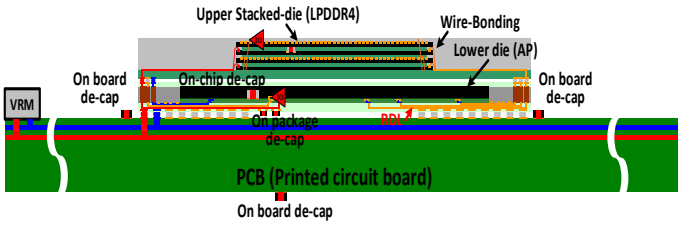


Fig. 1 3-D integration using WLP in LPDDR4 application.

It is found that the re-distribution layer (RDL) is the most crucial part of the whole interconnects. In order to simplify the signal integrity analysis, the equivalent model for a signal line is shown in Fig. 2. Here, R_S and C_L stand for the source resistance and load capacitance, respectively, which are determined by the LPDDR4 circuit. Other parameters are the total R_{WLP}, L_{WLP}, C_{WLP}. of WLP while G_{WLP} is negligible. The equivalent model in Fig. 2 is a 2nd order series RLC circuit satisfying

$$\frac{d^2}{dt^2}V_C(t)+\frac{R_O}{L_O}\frac{d}{dt}V_C(t)+\frac{1}{L_OC_O}V_C(t)=\frac{1}{L_OC_O}V_S(t) \qquad (1)$$

where the normalized resistance (also called damping factor) is identified as

$$\zeta=\frac{\alpha}{\omega_O}=\frac{R_O}{2}\sqrt{\frac{C_O}{L_O}}=\frac{R_S+R_{WLP}}{2}\sqrt{\frac{C_{WLP}+C_L}{L_{WLP}}} \qquad (2)$$

It should lie in 0.8 to 0.9 for satisfactory signal integrity.

Basically, the 1st layer RDL is for signal routing and the 2nd layer RDL is for power distribution network. For the power integrity, Fig. 3 shows the two different types of the layout pattern design of RDL. The pattern in Fig. 3(a) is the one-layer RDL design, which has the worst power integrity, and the pattern in Fig. 3(b) is the proposed two-layer RDL design with 1:1 ratio of P/G traces.

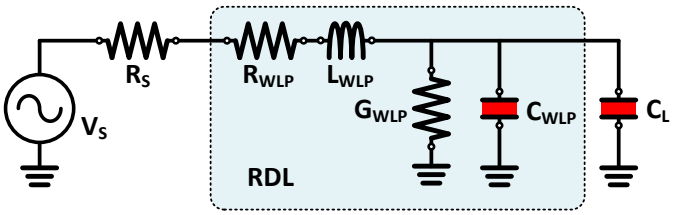
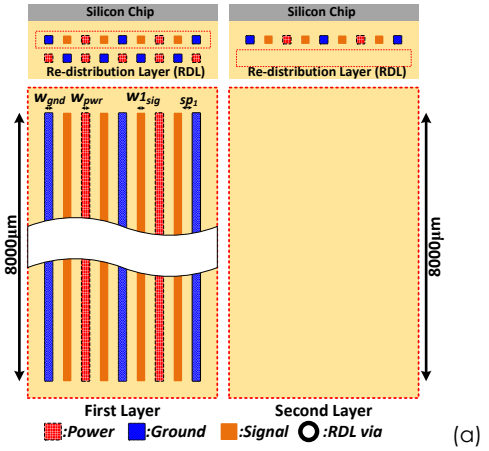
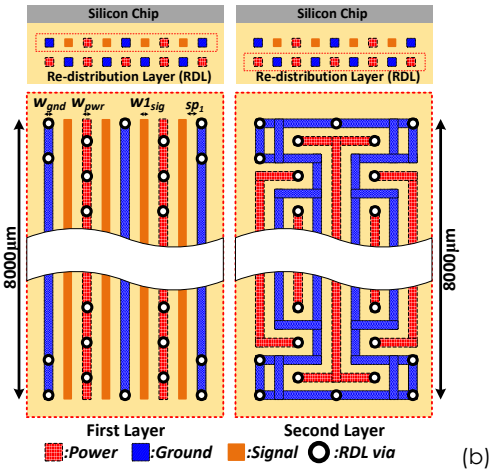


Fig. 2 Simplified model of single line for WLP structure.



(a)



(b)

Fig. 3 Two types of layout pattern design.

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III. Simulation and Eye-Diagram

The eye diagrams of the layout patterns in Figs. 3(a) and (b) are shown in Figs. 4(a) and (b). The pattern in Fig. 3(a) violates the LPDDR4 mask, and it indicates that just one layer of RDL is not enough for LPDDR4 4266 application. The pattern in Fig. 3(b) has the best PI performance, where the power inductance is reduced from 2.01nH to 0.42nH due to the layout design.

If the process scaling shrinks from 5 μm to 2 μm by keeping the same separation between 1st layer and 2nd layer RDL, the signal resistance R_{WLP} increases severely from 5.8Ω to 36.2Ω and the eye closes. By properly changing the signal trace width, spacing, and separation, the normalized resistance can be optimized from 1.29 to 0.88. The optimized eye diagram for two-layer RDL structure of SI/PI design is shown in Fig. 5 using 2 μm WLP process.

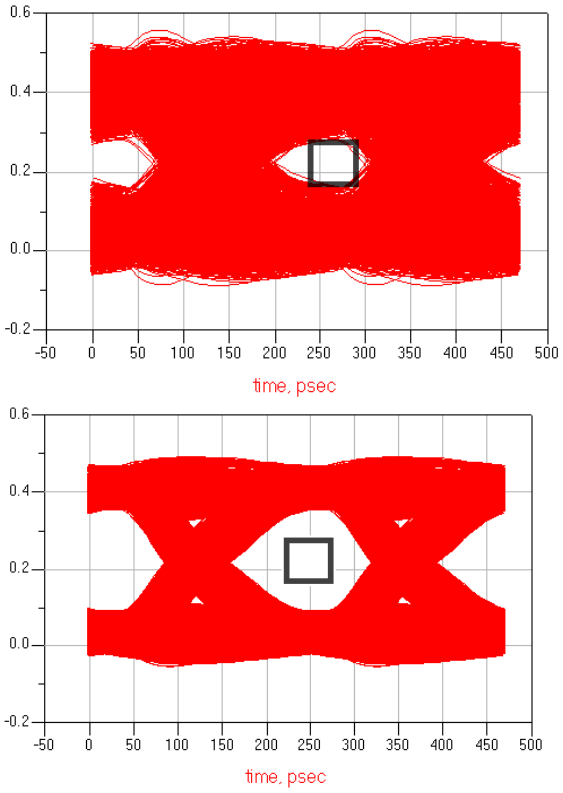

Fig. 4 Eye diagram comparisons for two layout patterns.

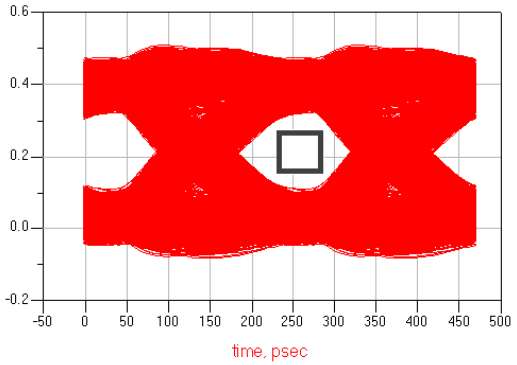

Fig. 5 Eye diagram for the optimized normalized resistance design.

IV. Conclusion

Signal and power integrity design becomes the challenging issue in three-dimensional integration WLP. The optimal P/G meshed layout design can increase eye height 141% and eye width 55%, as compared with one-layer RDL in LPDDR4 applications for 5 μm WLP process. By properly designing the normalized resistance, LPDDR4 can well work at 4266Mbps using WLP.

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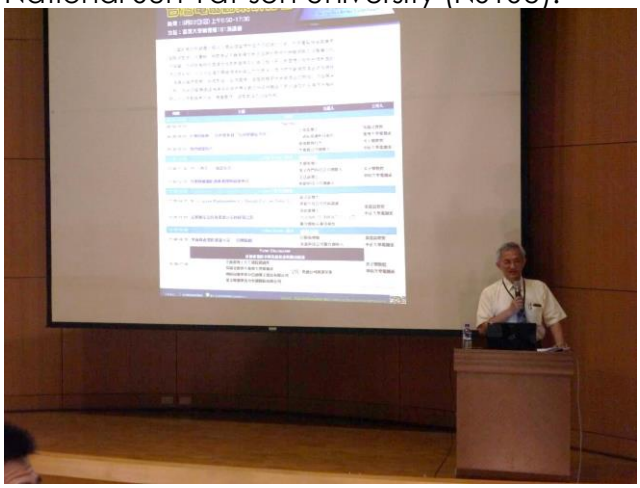
Activities

- The 2017 1st Seminar of TEMIAC - "Taiwan Electromagnetic Entrepreneurship"

The 2017 1st Seminar of Taiwan Electromagnetic Industry-Academia Consortium (TEMIAC) titled "Taiwan Electromagnetic Entrepreneurship" was held at the auditorium hall 101 of the Barry Lam Building at National Taiwan University (NTU) in Taipei, Taiwan, on Thursday, June 22nd, 2017. The seminar was organized by TEMIAC, High - Speed RF and mmWave Technology Center. The co-organizers are the Department of Electrical Engineering of NTU, the Graduate Institute of Communication Engineering of NTU, the Communication Research Center of NTU, the Information and Communications Research Laboratories of Industrial Technology Research Institute (ITRI), the Smart Network System Institute of Institute for Information Industry (III), and the Telecommunication Research and Development Center of National Sun Yat-sen University (NSYSU).



The seminar was composed of seven distinguished sessions and an inspiring panel discussion. Each topic of the seven sessions is as follows: The Startup of Taiwan, My Entrepreneurship Era, RF Pioneering, Innovation Application of IoT and Business Model, Microwave Radiometer for Breast Cancer Detection, the RD Road from the Laboratory to the Business and the Sparkle between the Academic and the Industry – Innovative Technology Transfer. The participants were the professionals from the industrial sectors, governmental organizations, and academic institutions in Taiwan.

The speakers were not only with strong research backgrounds but also ambitious goals. For the speaker Dr. Larry (Nanlei) Wang, he overviewed the world startup ecosystem and recent trends by the use of his previous academic and practical experience as well as rich network resources. For the speaker Jordan Huang, he combined his expertise and interest to invent brand manufacturing new music players especially for swimming sports. For the speaker Dr. Chien-Jung Li, he stated that his various experience from the past led to the foundation of Sivann Inc, which offers IoT full stack development solution. For the speaker Dr. Richard (Ting-Yueh) Chin, he extended the research topic during his PhD study as his startup product. He shared his idea about the innovation and its breakthrough in indoor positioning technology based on phased array radar.

(Continued on page 7)

Activities *(Continued from page 6)*

For the speaker Dr. Wen-Tron Shay, he shared his specialty in terms of microwave measurement and its new application at the detection of breast cancer. For the speaker Dr. Hung-Wei Wu, he talked about his career transition from a laboratory researcher to a startup founder, with his novel techniques for screening cancer cells. For the speaker Sheng-You Tian, he offered paths for researchers to use their patents and laboratory resources to turn the research results into the profitable business of innovative products, which connects academic and industrial sectors.

With this seminar, the potential to transform electromagnetic expertise into practical business models was revealed, as well as the experience of managing a startup. The combination of academic and practical professionals would create optimistic opportunities for the industry's advancement.

Corner of Student News

Article by Mathis Zamboni

Mathis Zamboni came from France and he got Master Degree in 2017 July by joining double degree program via a collaboration agreement signed by NTUGICE and INPT-ENSEEIHT.

This article deals with the difference between my day life in NTU, Taiwan and my previous day life in ENSEEIHT, Toulouse. A lot of things have changed and most of the time in a good way, this is the reason why I wanted to share this with you.

Firstly, let's talk about something Taiwanese and French care about a lot: the food. France is known to have one of the best quality foods in the word with its cheese, beef, viennoiseries... things I really like. Before arriving in Taiwan I was scared about the food I was going to find there, the collision with Asian strange meals was imminent but in fact, it was not the case. Fried chicken legs, fried pork ribs,... for a meat lover as me it is the heaven. The food is good, healthy and cheap, what can you ask more?

The good thing is that in Taipei you have a lot of little restaurants that propose traditional plates, most of the time meat with rice and vegetables, for approximately 3 euros. Yes 3 euros, so you can eat every day in restaurants for just 3 euros a meal. The time where I had to eat pre-cooked food as nuggets, ham and cheese escalopes or pizzas is finished. Now I can eat a varied and healthy meal every time. When I am hungry I don't need to cook anymore, the fact is I don't even have a kitchen in my room. I told you about traditional Taiwanese plates but the best thing, I think, is that you can find restaurants with food from all around the world. Italian restaurants, Japanese restaurants, French bakeries (yes) , you just have to choose and most of the time they are very good. Sometimes the language can be an obstacle because in some restaurants the menus are all written in Chinese, but thanks to the kindness of Taiwanese people, they will find a way to communicate with you.

(Continued on page 8)

Corner of Student News *(Continued from page 7)*

A second statement about living in Taipei is the attitude of the people around you. Everybody is quiet, smiling and friendly. It is very far from French city where you always feel that other people are looking at you, analyzing your comings and goings. For instance, the MRT or subway is a strong illustration of these different states of mind. Taipei MRT stations are all clean; users are respectful inside and take care of each other. Once more, this is far away from the Parisian subway which is famous for its dirtiness and the bad habits of its users. This is so good to live in a peaceful environment, you feel more free and capable of developing yourself.

Graduation ceremony

Finally, if my life here is different this is mostly due to a big difference of university. The National Taiwan University is a very big university compare with my previous engineering school. The number of student in my French engineering school only represents the number of exchange students in NTU, which counts more than thirty thousand students. There are also a lot of convenience stores, food restaurants, and green spaces and sports facilities on the campus. To my mind NTU is more than a campus, it is a little village in a big city. I have passed a beautiful year here at NTU. I received a lot of support from the GICE department and I want to thank you all. Now it's time for me to come back to France with a lot of memories. Who knows, one day I may be back to Taipei!

Afternoon at the skating rink with lab members.

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