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Report on the short-term overseas study program for KU Engineering students Graduate School of Engineering, Kyoto University

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1. The Beginning of the Program

The program began with an e-mail in late March from Professor Ohsaki, who is my supervisor at my laboratory. It said something like, "If you are interested in studying abroad in the U.S. for a month, please contact me." I had been interested in studying abroad for long time, but I had almost given up on the idea of studying abroad during my master's program because I did not have enough time or money to do so. The e-mail came at such a time, so I was very attracted and immediately applied for the program.

2. Preparation before the Departure

I had a hard time because there were many things to do by myself for this program. I had to arrange flight tickets, purchase travel insurance, and even make my own arrangements for the laboratory where I would be studying and decide where to stay in the U.S. In terms of the laboratory where I would be staying, I contacted Prof. Caitlin Mueller at MIT, who had helped my senior lab member (who is now an assistant professor at Kyoto University) several years ago, and she agreed to accept me for a one-month stay at her lab. The most difficult part was finding a place to stay, since I could not stay at the dormitory of MIT because of the short period stay and had to find one by myself. I could not afford to stay in hotels, so I decided to keep costs down by sharing a room or staying with a host family. It was also important to find a safe place to stay, as the culture is completely different from Japan and the language barrier is significant. The location near MIT may be good, but it was quite expensive and there were few hosts, so I finally decided on a house about an hour commute away from MIT. It was 10 days before my departure that I finally decided where to stay. The host family was a house with a mother and three children all of whom are adult, but the two older children had already left home, and the youngest child seemed to be on a long-term trip to Europe, so I spent one month with my mother.

3. Research and Laboratory

For this program, I decided to conduct the research that I have been working on since the beginning of my master's program. My research theme is related to topology optimization of continuum structures with the aid of machine learning. Topology optimization is a type of structural optimization,

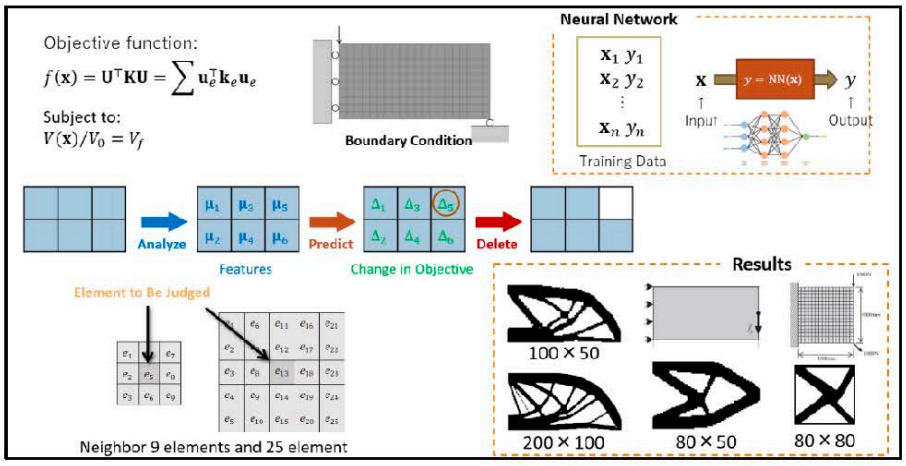

Figure 1. Summary of My Research

which is a method to find a material arrangement that achieves a stronger structure with less material. Topology optimization, which is a more flexible optimization method, is compatible with 3D printers, which have been rapidly put into practical use recently, and is attracting attention as one of the methods to design architectural and industrial products with less environmental impact. In my method, the optimal arrangement of elements is obtained by repeatedly deleting elements predicted to be unnecessary for the structure and adding elements predicted to be necessary for the structure, starting from an initial state in which a uniform element density is placed over the entire design domain. In the optimization process, machine learning is used to predict the amount of change in the objective function when elements are deleted. Supervised learning such as support vector regression or neural network is used for machine learning. This is to learn the correspondence between input vectors and output scalars. The input vector is the mechanical information of the element to be judged whether to be deleted or not and its neighbor elements, and the output is the change in the objective function when the element is deleted. By using this machine learning, the number of analyses can be reduced by predicting the gradient and deleting elements in succession, thus enabling highly accurate optimization in a relatively short time.

The way to proceed with the research at MIT was to introduce the research to the professor and students in the laboratory where I was staying, to interview students about their research, and to discover issues in my research and obtain new ideas through repeated discussions with Prof. Mueller. Meetings with her were held approximately once a week, for a total of five times during the stay. In the first meeting, I showed slides introducing my research, explained the method I was using, and answered questions from the professor. Even though this was the first time for her to see my research methods, she pointed out many sharp and thought-provoking suggestions. For example, when I showed her some animations of how the optimal structure is obtained by repeatedly deleting materials, she suggested that if we look at it as a reverse process, it could be utilized in construction, like a 3D printer, and from the perspective of structural reinforcement, she suggested that we could learn which parts of an existing building structure could be reinforced to make it more structurally advantageous by adding elements to the existing structure. From this advice, I could learn some unexpected way to apply my research.

I joined Building Technology Lab (BT Lab). About twenty people are enrolled in the BT Lab, which is divided into the Digital Structures Group led by Professor Mueller and Sustainability Design Lab directed by Prof. Christoph Reinhart. There were several professors, and each student seemed to be

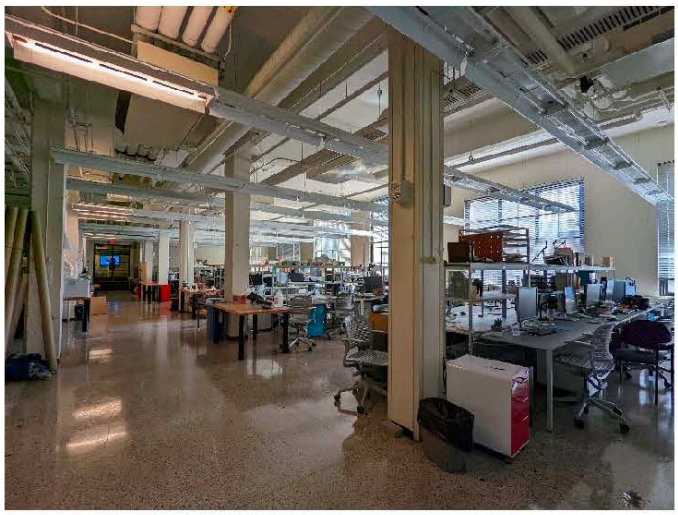

Figure 2. BT Lab

advancing their own research while having regular meetings with one or two professors as supervisors. There is a seminar presentation once a week, and one or two students give a presentation each time. The seminar was held during lunch time (12:00 to 1:00), so we all had lunch together after the seminar. For lunch on Wednesdays, we ordered pizza in the lab and ate it with the assembled members (this seemed to be discontinued from this fall semester due to budget constraints). The lab members consisted of PhD and Master students. I was impressed by the flat conversation between PhD and master, starting from "How's it going?". There were also visiting students who were participating in the similar program to mine, and I thought there was an atmosphere of easy collaboration since various people were in the same lab. The lab also has many international projects, and they told me that they completed a concrete slab project in India recently and they are currently working on a project in Mexico.

4. Conclusion and Acknowledgements

I am very happy that I could spend a month in a stimulating environment during the last year of my master's degree. I think I got to understand my weakness points, such as my small voice (low self-assertiveness) and my English-speaking skill (to make sure I convey what I want to say). I will grow these attitude and skills by having time to practice English or communicate with foreign people.

Figure 3. MIT Building

Figure 4. Downtown Boston

Finally, I would like to thank all those who have helped in this program such as people at the ER Center, Prof. Ohsaki, who recommended and supported me, and Prof. Hayashi, who introduced people at MIT and shared his experience at MIT. I would like to make the best use of this experience and work hard at my study.