Report of EU/JP Exchange Program

Osaka University
Kenichi Niinuma

1. Personal Data

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Home Institute

Institute: Osaka University
Faculty: Graduate School of Engineering
Department: Department of Manufacturing Science
Lab: Area of Advanced System, Chair of Advanced Manufacturing Systems (Arai Lab.)
Address: 2-1, Yamada-oka, Suita, Osaka, 565-0871, Japan
Supervisor: Prof. Eiji Arai

Host Institute 1

Institute: Delft University of Technology
Faculty: Faculty of Mechanical Engineering and Marine Technology
Department: Production Technology and Organization
Lab: Design and Life Cycle Engineering
Address: Mekelweg 2, 2628 CD Delft, The Netherlands
Supervisor: Prof. Tetsuo Tomiyama

Host Institute 2

Institute: Katholieke Universiteit Leuven
Faculty: Faculty of Engineering
Department: Department of Mechanical Engineering
Lab: Production Engineering, Machine Design and Automation (PMA) Section
Address: Celestijnenlaan 300, B-3001 Leuven, Belgium
Supervisor: Prof. Dominiek Reynaerts

2. Executive Summary

Recently Cooperation with people in the world is very important in every field

because not only a manufacturing industry but also industrial activity is internationalized. When the world comes to internationalization, we tend to think only of linguistic ability. But, in order to understand other people, it is important for us to understand their history and culture and to express our own opinion even if we don't have high abilities of speaking.

I applied for this exchange program to grow more and more as a man as well as improving communication ability, by talking with people with different ideas or ways of thinking.

In this program firstly I went to TU Delft in Netherlands and stayed four months to study design theory. When I was a bachelor student, I made a thesis titled, "Design Activity Analysis for the Design Process Model Which Can Express Design Intentions." Then I read some papers written by Professor Tomiyama Tetsuo of Delft University of Technology. So I was interested in his idea of design theory. I discussed it with him. This is a beginning for the master research and I hadn't had a concrete plan for it then. So in order to find a concrete theme which I will work on, I needed to read a lot of papers to increase the knowledge. It was better that I had prepared a concrete plan and what I work on, but the experience I suffered from and what I studied is important and it will help me in future work.

And I took some courses (Biomedical Engineering Design, Introduction Man Machine System and Design of Production System) in TU Delft. The English course and Dutch course of International Neighborhood Group was also available for us.

Secondly I went to KU Leuven in Belgium. I stayed there for one month. And I made a design of a flapping plane, ornithopter. I wanted to design actually because my experience of actual design was very poor and I only studied an armchair theory of design. In this term I studied TRES methodology, the method of inventive problem solving. TRIZ was developed in the former USSR on a grassroots basis, has become known to the West after the end of the Cold War, and is currently attracting much interests in industries and in academia. And then I analyzed the existing six ornithopters designed by bachelor student of KU Leuven to clarify the problem of those mechanisms. And I used the TRES methodology and made a solution of that problem.

3. Travel Schedule

1/9/2004-4/1/2005 Delft in Netherlands

5/1/2005-31/1/2005 Leuven in Belgium

4. Research or Lectures

4.1 TU Delft

4.1.1 Purpose of my research

Recently mechanical products get to have higher abilities and be more complicated. At the same time, more designers need to cooperate simultaneously. When plural persons work on the same task at the same time, it is desirable that they all have correct information about their task. Because of the same reason, designers also need to own sufficient amount of common information and we are trying to share design information among designers working cooperatively. But at the presence, the main information shared among designers is only about forms, dimensions and materials of products. It is not enough because designers need the information include the "design rationale" which enables them to understand "why and how the product was designed" in order to understand product and to work well. But existing system hardly realize sharing such type of information.

In my bachelor thesis I tried to clarify what is needed to express the design rationale. The method is shown below.

1. Analyzing a practical design protocol and making an information flow model. That model consists of a lot of nodes and arcs that express which information nodes are the grounds of an information node.
2. Adapting three design process model to IFM and evaluate how that design process model can explain the arcs.

After this analysis, I got the following conclusion.

1. The design process model which can transfer design rationale should be able to express the classification which depends on how detail the designer thought about.
2. The design process model which can transfer design rationale should be able to express the detail arcs between information nodes.

And I judged that existing design process models cannot express both completely.
So my purpose of this research is the system which enables us to understand design rationales and to elicit design information sufficiently by watching the design process.

In order to find a concrete theme which I will work on, I read papers and discussed with Prof. Tomiyama frequently. The personal meeting was held once a week and in addition to that the group meeting called DL meeting was held on every Friday. In DL meeting we take turns in presenting about each research. I have presented two times. The theme of first presentation is "The research of papers about design

rationale", and second is "The difference between Japan and Netherlands". The presentation was very good experiment for me because I have never presented in English.

In September and top of the October, from arriving TU Delft until first presentation, I studied the papers about design rationale.

In October and the top of November I study papers about Requirements Management to broaden my knowledge.

And from the middle of the November until the end of December I studied the book, "Human Behavior in Design", which Prof. Tomiyama lend to me. I studied the Papers which Dr. Kei Kurakawa wrote and papers written by members in Arai laboratory also. The contents I studied was written bellow.

And I took the three courses following.

4.1.2 Researches for design rationale

The classification of design rationale

(1)Model-based

Model-based approach is the way to explain design rationale by deep knowledge such as a function model, a physical structure and physical phenomena of a product. The systems which base on this approach all have the conceptual model which can express the designed object's information. For example, Baudin uses the conceptual model of function, structure, and behavior and proposes the method to get the design rationale. The strong point of model-based approach is high capability to express and reuse the design rationale. But it is troublesome for designers to translate their design process into a conceptual model. Designers need to make conceptual models during or after the design activity. It is very difficult because there could be information they can't remember after the design activity. This is the week point.

(2)Argumentation-based

Argumentation-based approach is the way to explain design rational by regarding a practical design as a rational process. Shpman proposes PHIDIAS based on the PHI (procedural Hierarchy of Issues), one of the Argumentation models. An argumentation model is expressed by graph which consists of "problem" and its "proposal" and its "argumentation" and the structure of consent and opposition of them. IBIS also is the famous Argumentation-based model. This approach enable us to get the design rational more easily than Model-based approach, but it is still troublesome for designer to write the structure of the argumentation when designer

is designing.

(3)Action-based

Action-based approach is a view that regards a raw design process express the design rationale already. Lakin propose the system, Electronic-Notebook, which is based on this approach. Electronic-Notebook system is connected with design support tools and records the log of the activities of the designer automatically. The Action-based approach is strong in the aim of getting the design rationale because designers' activity is already design rationale. But it is difficult to reuse the log a record. It is nothing more than a log record.

The classification from a viewpoint of the getting design rationale

Hu classifies design rationale researches into two approaches from a viewpoint of the getting design rationale.

(1)Automatic approach

Shipman's research stands on this approach. In this approach we need to prepare design knowledge. When designer input a text into the argumentation model, the system looks for prepared design knowledge automatically of which key-word accord with the text. And this design knowledge expresses the design rationale. In general such an automatic approach reduces the labor of designers but have problems too. But it is troublesome to prepare the knowledge and it is hard to get new knowledge.

(2)User-intervention

This approach is the way which expresses design rationale by the interaction between designers and design support system. The ADD system which Garcia developed is an example of this approach. In ADD system design object is expressed as a set of the parameters. The standards of the parameters are prepared in the system by using knowledge of each field. If a designer input a different value from a standards value, ADD requests the designer to input the reason of the difference. And the KID system which Nakakoji developed is an example of User-intervention approach also. In the system design knowledge is prepared in a form which express that a discussion approves or objects against a solution by using IBIS, which is one of the argument model. If a designer made a result which doesn't suit the prepared knowledge, the system presents the knowledge and requires him or her to modify it and get designer's knowledge. User-intervention approach can get unconscious knowledge but if its requests are too frequency, it is disturbance. That is a problem.

The research done by member of Arai Laboratory

In Arai Laboratory we have worked on development of the method of expressing design rationale. We need to understand design requirements, designer's intentions of an actual functional structure and how they are realized when we want to use an idea of design information which was made before. And these days it is very common to design cooperatively and concurrently. We need to hold design information in common with understanding how that information was leaded, designer's intention and design rationale.

Therefore our group has developed the method that can express a designer's intention by using the functions, behavior, mechanism and shapes. And we also describe the relation between functions and the shape by using events and replies. Designers can understand the design intentions when they see the model. These expressions are all model-based.

(1)Using functions, behaviors, mechanisms and shapes

This method expresses a designer's intention as unified design information which consists of functions, behaviors, mechanisms and shapes. The system which uses this method can refer to what requirement cause a function or behavior and how the function or behavior can be divided into sub functions or sub behavior. And it can indicate functions of the part of the mechanism you watch.

(2)Using the process and function

In actual design process, especially in big design team which have plural member of designers, it is necessary to express the design process and design intention clearly. So this research proposes the method to express the design information combined with the design process. This system deal with the process that designer analyze the requirement function and reach the behaviors.

(3)Using inputs and outputs of the mechanism

This research deals with the relation of a function and mechanism model which consists of elements, inputs and outputs. Designer can search examples of mechanism by the key word of function or operation and get the idea of how to realize the function. Designers can also check whether the mechanism is realizable or not. The models designer made through this system can transmit the designer's intention because that models have the connection with function designer thought.

4.1.3 Courses

I took this course because I wanted to take part in practical design activity. Actually I didn't have experience of practical design. I studied only theoretical part

of design. So I wasn't familiar with practical design and didn't understand real problems of designers.

Biomedical Engineering Design

In this course, we are given an assignment. In the assignment, we worked on the designing the voluntary closing prosthesis which is defined as the prosthesis of which the pinching force can be controlled.

Introduction Man Machine System

Introduction Man Machine System

This course showed introduction of the research field and section Man-Machine Systems, its mission and challenges, overview of the research projects. I studied study planning advices

Design of Production System

I studied CIM, design, process planning, production control & scheduling, system design, reference models, manufacturing, assembly, logistics, computer vision.

Language Courses

I took the two courses of International Neighborhood Group (ING). It was Advanced English Conversation Class and Introduction of Dutch.

4.2 KU Leuven

I made a design work based on the 6 ornithopters designed by students of KU Leuven and made a new design with the same specs (600 mm span, "spring" powered) applying the TRIZ methodology to this design process.

Ornithopter

An ornithopter is a machine that flies by flapping its wings - just like a real bird. All lot of people are surprised to hear that a machine can fly like a bird. It shouldn't be such a surprise, because bird and machine are subject to the same rules, which we call the laws of nature. This means that machines eventually can do anything animals can do: fly like birds, think like people, etc. Even though nature is far ahead in many areas, technology evolves much faster than plants and animals. We'll fly as birds do, and then we'll do it better than birds.

Many people want to know if it's possible to scale up an ornithopter to the size where it could carry a person. Early failed attempts at flapping wing flight, in the 1800s, convinced many people that humans could not fly by flapping wings. However, all it really proved was that they didn't yet have the technology to succeed at this difficult task.

Manned ornithopters are a great way to showcase flapping wing technology, but if birds could talk, they would tell you flight is not about carrying people from place to place. The main goal in our field is to mimic bird or insect flight more closely at its own scale. Current challenges include improved flight efficiency and learning to take advantage of the potential maneuverability that flapping wings can offer. Hobbyists and professional researchers alike can make important contributions to the study of flapping wings.

To see how an ornithopter or bird can fly, first you must understand how a simple airplane wing operates. As the wing moves forward through the air, it is held at a slight angle, and in some cases it has a curved shape. Therefore the wing will deflect the air gently downward. This causes air pressure to build up, beneath the wing. At the same time, the pressure above the wing is reduced, relative to the surrounding air. The difference in pressure is the lift force that keeps the airplane up in the air.

There is some drag, or air resistance, whenever any object moves through the air. This would tend to make the airplane slow down, and then there would be less pressure under the wing, and it wouldn't be able to stay aloft. There are two ways around this. An unpowered glider type aircraft can maintain its speed by going into a shallow dive. The wing is angled forward so some of the lift of the wing counteracts the drag on the aircraft body. You can also use an engine to keep the airplane moving.

The bird or ornithopter applies power in the downstroke of the wings. The wing in downstroke works something like a glider when it goes into a dive. The downward motion and angle of the wing cause a strong lift force with a forward thrust component. Unlike a glider, only the wing is going down. The body stays up.

airplane wing bird downstroke bird upstroke

The upstroke is tricky because the upward travel angle introduces a large drag component. This is the opposite of what happens in the downstroke, and it would

tend to slow the ornithopter down. The solution is to decrease the angle of the wing, relative to the airflow, so less overall force is produced. Birds also fold their wings somewhat, but ornithopters and insects prove that this is not strictly necessary. Throughout the upstroke, the part of the wing near the body has little upward motion, so it continues to produce lift just as a result of its forward motion.

Ornithopters have a stiff spar at the leading edge of the wing. This corresponds to the strong, hollow bones in the leading edge of a bird's wing. Otherwise, the wing is flexible, and in many ornithopters it's made like the sail on a boat. This ability to twist in response to the flapping motion allows each part of the wing to stay aligned with the local airflow.

When hovering, birds can beat their wings almost horizontally. In this situation, the outer part of the wing is "reversed" in the upstroke, meaning that pressure develops on what would normally be the top of the wing. However, the top of the wing is actually facing down now, so it produces lift. The outer wing feathers (primaries) separate and rotate to provide the extra twist needed for this maneuver.

TRIS Methodology

TRIZ was developed in the former USSR on a grassroots basis, has become known to the West after the end of the Cold War, and is currently attracting much interests in industries and in academia. "TRIZ" is the English spelling of the Russian abbreviation representing "Theory of Inventive Problem Solving", and is pronounced just like "trees" in English.

In 1946 in the former USSR, a young patent adviser in a Navy Office, G. S. Altshuller of age 20, recognized that among a huge number of patents there appeared similar ideas and analogous solutions in different areas, in different eras, and for different problems. And he realized that even "original" and "creative" inventions naturally had common patterns. Thus he thought that if we should extract the patterns of inventions from good patents and study them, every one could become an inventor. Such a study could help people become less dependent on trial-and-errors and incidental enlightenment.

He sent a proposal of his ideas to Stalin, and, as the result, was deemed being against the regime and was sent to a GULAG for five years. Later on, in spite of similar continuous suppression by the authorities, he studied the patent databases,

extracted principles of invention, and developed in a bottom-up, step-by-step manner a new view of technology and a methodology for solving technological problems. From 1970 to 1974 he was allowed to teach at a public institute every Sunday for training students, but during all other eras he had to conduct his research and training activities with his private grassroots organization.

He analyzed a huge number of patents and extracted "Principles of Invention" (i.e., essence of ideas in inventions), and devised procedural methods to think of such inventions (he called them "Algorithm of Inventive Problem Solving"), and further tested their usefulness by applying them to different problems. Such research was done all manually and experientially with his associates.

In 1990, associates and followers of Altshuller were teaching TRIZ in about 200 TRIZ schools (they were sometimes official laboratories/courses, whereas sometimes private groups) to about seven thousand students all over the former USSR.

As the results of the decay of the former USSR and the subsequent end of the Cold War, a large number of TRIZ specialists have emigrated to USA and Europe and brought TRIZ to the Western countries. Especially in USA, such Russian TRIZ specialists have developed PC software tools of TRIZ knowledge bases, and have conducted seminars and consulting to penetrate TRIZ to industries.

The solutions I reached by using TRIS methodology

1) To add the wings which lead edge suction.

The first solution I made is to add new wings below or under the flapping wings like a biplane. One couple of the wings generates the thrust force by flapping and another couple of the wings generates the lift force by leading edge suction.

2) To add the flapping wings at the tip of normal airfoil.

The second solution is a wing that consists of two parts. The root of wing is for lift and the tip is for thrust. This also may realise high efficiency of both thrust and lift.

3) To fold the wings when the wings stroke upward.

In order to increase the lift force, we can think of reducing the down force. To do so it is possible to reduce the ability to generate the wind only when the wing are stroking down by using the wing which allows the air to go through only one way. This function can be realised by the mechanism like blind you can see on the window in your room.

5. Exchange student life

5.1 TU Delft

Delft

Delft is small city that exist in the center of Netherlands. We can reach to Den Haag, the capital of Netherlands and Rotterdam in 15 minutes by train. And Delft has old history. It was capital of Netherlands in 16th century. There is grave of Royal Family of Netherlands in Delft.

Residence

I lived with Akio Morita, a member of EU/JP exchange student from Osaka University. We talked in English with each other because we wanted to exercise speaking English as much as possible. The distance between our room and the university was about 2 kilometer. We could go to school by bike in 10 minutes.

Bike

There are a lot of bikes in Netherlands. In the first meeting with our coordinator we are introduced second hand bike shop. I bought a cheap bike in the third day at the beginning of the life in Netherlands. Bike is useful because Netherlands is flat country. We could visit Den Haag and Rotterdam by bike in weekend.

Food

Eating at a restaurant was so expensive that we needed to cook by ourselves. Even student restaurant in university was not reasonable too. Fortunately some supermarket was near our residence. Materials in the supermarkets are cheap especially potato, onion and carrot. And my residence has good cooking equipments, four gas cooking stoves, a refrigerator and some pans. We didn't need to buy these equipments.

5.2 KU Leuven

Leuven

Leuven also exist almost center of the Belgium. We can arrive at Leuven from Brussel in 30 minutes by train. Leuven is not so big city. This surrounding is very good to concentrate study. Leuven is a city of student. Leuven has around 90,000 inhabitants. Add to this 35,000 post-secondary and 11,000 high-school students and it should come as no surprise that the streets are filled with young faces and that the city lives at a student's rhythm: hectic weeks at the beginning of the academic year and relative calm during vacation and examination periods. And

unfortunately when I visited Leuven, it is during examination periods.

Residence

I got a room in a dormitory of KU Leuven. In the dormitory there were about 15 members in same floor. These members in the same floor shared the bass room, kitchen and toilet. The distance between the Faculty of Mechanical Engineering and the dormitory is 10-15 minute by bike. I brought my bike from Delft to Leuven by train. We can get our bike into a train if we pay 12 Euro.

Food

The university restaurants provide a wide variety of meals. It was much cheaper than in Delft. But when I visited Leuven, it was during examination term, so some restaurant was closed. In the restaurant refills of mashed potatoes or French fried potatoes are free. I used these university restaurant for almost all supper. So I didn't cook except breakfast and weekend supper. The taste was very good in Belgium.

6. Suggestions to the Project

Language Course

On arriving EU, our English ability was not sufficient to communicate in English. At least for me it was hard to understand what our coordinator says because I had no experience to talk with foreign people. I paid effort to prepare for this program and study English a lot by myself, but I hadn't studied at all for two years, later half of the bachelor term. I didn't have the language course or opportunity to learn English. So it was hard work to get back English words.

A student who is going to attend this program needs to begin preparation of English earlier. And it is better that the program provides students an English lecture.

Housing

I heard that getting the room in short term was very difficult in Delft. As a result, I had gotten the share room with Japanese student. But it is not good because the aim of this program is to communicate with student in EU and make connection with them. It is better to live with a student with student from EU if it is possible.

Team Meeting

In TU Delft we held weekly team meeting. One of our members of laboratory presents in rotation and after presentation we discussed about it. I think it was very good system. In TU Delft and KU Leuven we didn't have the our room and I worked in common place. So this meeting was nice chance to talk with the member

of the laboratory. Other member of this program who didn't have such type of meeting complained that he had a few chance to communicate with friends form EU.

7. Summary

The stay in EU was valuable for me. I could communicate with students from all over the world. Especially the members of the laboratory of Professor Tomiyama were close. I had an opportunity to stay home of one of the member of my colleagues and to eat Dutch dinner. I appreciate him very much.

I took some courses which was much harder to get their credits than Japan. And I found many cultural and customary differences from Japan. It was surprising that European students Europe often throw out questions when a lecturer is speaking.

Talking about my research, it was failure not to decide concrete theme to cope with before starting this program. But reading papers and discussion are profitable experience. After go back to Japan I will use the knowledge which I studied in TU Delft and am going to analyze and compare existing design methodologies to clarify their advantages and disadvantages.

I believe that these experiences will help me in future.