EU/Japan Pilot Cooperation
in Higher Education and Vocational Education and Training

DeMaMech

Design and Manufacture in Mechatronics

STUDENT REPORTS
2005

Preface

This book contains reports written by Japanese students who got chance to visit and stay at EU institutes under a pilot student exchange program between EU and Japan named DeMaMech. They spent several months on conducting various interesting researches at these EU institutes, which are summarized in this book. We highly appreciate that they had valuable experience to study advanced topics and to learn foreign cultures as well. We believe that the students must benefit from this valuable experience in their future career.

We would like to express our sincere thank to Prof. Tetsuo Tomiyama (TU Delft, the EU project leader), other EU coordinators and supervisors. This project is funded by JASSO (Independent Administrative Institution Japan Student Services Organization) in Japan.

Hiromasa SUZUKI
Japan Project Leader
Professor, The University of Tokyo
On behalf of all the Japanese coordinators
March, 2006

Contents

Project overview

Background

EU/Japan relations have developed steadily and continue to grow closer, resulting in the establishment of mutual links across the whole spectrum of relations. In 2002 a new action plan was adopted, in which the importance of strengthening links and exchanges between EU and Japan in the academic world was recognized to make every effort to promote international exchanges of students, teachers, researchers and administrators. The European Community and Japan launched a joint pilot project of multilateral, student-centred project/s with the potential to serve as a model for future substantive and long-lasting structural EU/Japan cooperation in higher education.

Pilot exchange program, DeMaMech

This pilot student exchange program, called *DeMaMech (Design and Manufacture in Mechatronics)*, is selected as one of the two pilot projects in the strategically important areas of design engineering, manufacturing engineering and mechatronics started in 2004 (to end in 2006). It coordinates student exchanges between four European and four Japanese universities in these areas. The European universities are *Delft University of Technology* (*TU Delft*, The Netherlands, coordinating institute), *University of Technology Berlin* (*TU Berlin*, Germany), *Catholic University Leuven* (*KU Leuven*, Belgium), and *Technical University of Denmark* (*DTU*, Denmark). All of these institutes have strong engineering programs and, in particular, they are currently strengthening the education and research in these areas. The Japanese partners are *The University of Tokyo* (*UT*, Tokyo), *Osaka University* (*OU*, Osaka), *Hokkaido University* (*HU*, Sapporo), and *Keio University* (*KU*, Yokohama).

TU Delft is the European coordinating institute and *Prof. Dr. Tetsuo Tomiyama* is the European project leader, while *The University of Tokyo* is the Japanese coordinating institute and *Prof. Dr. Hiromasa Suzuki* the Japanese project leader. Table 1 summarizes the faculties/departments from the four European institutes and four Japanese institutes that have participated in the project.

These institutes are highly respected for their education programs in many branches of science and considered one of the best in the country. They are also trying to strengthen the education and research in these areas. Their educational programs cover a wide range of topics and can be truly complementary to each other. And they put emphasis on the cross-disciplinary nature of the field and recommend, e.g., design engineering students to study not only design engineering and design support technologies of mechatronics but also manufacturing aspects, fundamental principles of mechatronics such as control engineering, and micro-nano systems applications. But they are not always able to offer the full range. This project aims at further strengthening these cross-disciplinary aspects of the participating institutions' programs by giving students opportunities for complementary international studies.

Project coordinators at the first meeting in Japan (Keio University, Japan. April, 2004)

Table 1. DeMaMech participating institutes

Inst.	Faculty/Department	Programs/Institutes	Specialties	Key person
TU Delft	Faculty of Mechanical Engineering and Marine Technology	Production Technology and Organization (PTO); Life Cycle Engineering (LCE); Advanced Mechatronics (AM)	Manufacturing Engineering, Industrial Organization, Design Engineering (PTO), Life Cycle Engineering (LCE), Mechatronics, Control Engineering (AM)	Prof. Dr. T. Tomiyama
TU Berlin	Faculty of Mechanical Engineering and Transport Systems –Institute of Engineering Design, Micro and Medical Technology (IKMM); –Institute of Machine Tools and Factory Management (IWF)	Engineering Design and Methodology (IKMM); Industrial Information Technology (IWF)	Engineering Design, Systematic Product Development, Product Development Methods and IT-Technologies, Design Automation, Manufacturing and Assembly Engineering, Life Cycle Engineering	Prof. Dr.-Ing. L Blessing Prof. Dr.-Ing. F.-L. Krause
KU Leuven	Department of Mechanical Engineering	Division of Production Engineering, Machine Design and Automation	Manufacturing Engineering, Design Engineering, Manufacturing Systems, Industrial Automation, Mechatronics, Robotics, Micro- and Precision Engineering	Prof. Dr. H. Van Brussel
DTU	Department of Manufacturing Engineering and Management	Industrial Production, Materials Technology, Environmental Engineering	Manufacturing Engineering, Industrial Management, Life Cycle Engineering, Design & Innovation, Micro/Nano Manufacturing	Prof. Dr. L. Alting
UT	Department of Precision Engineering	Digital Engineering; Micro- and Nano-Systems	Nano- and Micro-Systems, Design Engineering, Manufacturing Engineering, Life Cycle Engineering	Prof. Dr. T. Arai Prof. Dr. H. Suzuki
OU	Mechanical, Materials and Manufacturing Science Group, Graduate School of Engineering	Adaptive Machine Systems (AMS); Mechanical Engineering and Systems (MES); Computer-Controlled Mechanical Systems (CCM); Manufacturing Science (MS)	Robotics, Robotic Control (AMS), Design of Mechanical Systems, Manufacturing Technologies, Industrial Automation (MES), Control Engineering, Design Engineering, Manufacturing Technologies, Robotics (CCM), Design Engineering, Manufacturing Technologies, Industrial Automation (MS)	Prof. Dr. E. Arai
HU	Department of Systems and Information Engineering (SIE); Department of Electronics and Information Engineering (EIE)		Systems Analysis and Synthesis in Design and Manufacture (SIE), Knowledge and Communication in Knowledge Intensive Design and Manufacture (EIE)	Prof. Dr. M. Onosato
KU	School of Integrated Design Engineering	The Center for Mechanical Engineering and Applied Mechanics; The Center for Integrated Systems Engineering	Design, Manufacture, and Optimization through Universalized Engineering, Intelligent Machining Processes, Machine Tools, Manufacturing	Prof. Dr.-Ing.E.h. I. Inasaki

Implementations

Target students

This exchange program is meant for Master's course students who participate in lectures and/or research work, for either a five-months (one semester) or ten-months (two semesters) stay. They must be students of a participating university and at the time of exchange must be in the Master's course of the relevant studies.

Study program

Japanese students can take research work and lectures. Due to the two-institute requirement for the Japanese students, it was agreed that if they stay for 10 months, two European host institutes would coordinate research topics. In case of short term (5 months) students, since DTU organizes an intensive lecture period of three weeks in January, they can go to DTU to fulfill the two-institute requirement.

Selection criteria

Applicant students apply to their home institute by declaring their language ability, preference for visiting institutes, academic records with an essay to describe their wish and plan to study abroad in this project. Especially, it was recommended that Japanese students would try to obtain TOEFL/TOEIC certificates (although scores are removed from the acceptance criteria).

Support to the students

The selected European students receive 1,000 Euro as an airfare and 700 Euro/month during the stay in Japan (maximum 5 months for one semester students or 10 months for two-semester students). They also receive financial support to participate in the workshop at TU Berlin. The selected Japanese students are given a return ticket from Japan to Europe and receive 100,000 Yen/month for living during the stay in Europe (maximum 5 months for one semester students or 10 months for two-semester students). Tuitions at the host universities are exempted. Accommodations will be arranged by the host universities.

Exchange schedule

European students participated in a two-week workshop to be held at TU Berlin in September 2005 and subsequently left for Japan. Japanese students left Japan in September 2005 and stayed at two participating European Universities.

Statistics of student exchange

In 2004-2005, DeMaMech exchanged 16 Japanese students and 16 European students. In 2005-2006, a similar number of students will be exchanged. Tables describing details of these exchange students can be found below (Tables 2 and 3).

Table 2: Japanese students

Home university	Name	Months	Period	First host university	Second host university
U Tokyo	Koji. Tsushima	10	10/2004 - 07/2005	**TU Berlin**	**TU Delft**
	Tomoya Nakao	5	09/2004 - 02/2005	**KU Leuven**	**DTU**
Osaka U	Masaki Michihata	10	09/2004 - 07/2005	**DTU**	**TU Delft**
	Kenshiro Hida	5	09/2004 - 02/2005	**TU Delft**	**DTU**
	Akio Morita	5	09/2004 - 02/2005	**TU Delft**	**KU Leuven**
	Takumi Sakamoto	5	09/2004 - 02/2005	**TU Delft**	**DTU**
	Kenichi Niinuma	5	09/2004 - 02/2005	**TU Delft**	**KU Leuven**
	Hidenori Fujii	5	09/2004 - 02/2005	**TU Delft**	**DTU**
Hokkaido U	Keisuke Kameyama	10	10/2004 - 07/2005	**TU Berlin**	**TU Delft**
	Tetsuro Yamaki	10	09/2004 - 02/2005	**KU Leuven**	**TU Delft**
	So Horiuchi	10	10/2004 - 07/2005	**TU Berlin**	**TU Delft**
	Ryosuke Gotoh	5	09/2004 - 02/2005	**KU Leuven**	**DTU**
Keio U	Yu Kimishima	10	09/2004 - 07/2005	**KU Leuven**	**DTU**
	Yuka Mukaibo	5	09/2004 - 02/2005	**KU Leuven**	**DTU**
	Kazumasa Yokoo	5	09/2004 - 02/2005	**TU Berlin**	**DTU**
	Yusuke Hosomi	5	09/2004 - 02/2005	**KU Leuven**	**DTU**

Table 3: European students

Home university	Name	Months	Period	Host university	Host supervisor
TU Delft	Ewoud van West	10	10/2004 - 07/2005	**U Tokyo**	Prof. Yamamoto
	Casper van Strijp	10	10/2004 - 07/2005	**Hokkaido U**	Prof. Onosato
	Mark Lelieveld	10	09/2004 - 07/2005	**Keio U**	Porf. Maeno
	Reimer Hettema	5	09/2004 - 02/2005	**Keio U**	Prof. Mitsui
	Michiel Berkheij	10	09/2004 - 11/2004 (*)	**Osaka U**	Prof. Miyoshi
	Sander Pastoor	10	09/2004 - 07/2005	**Osaka U**	Prof. Takeuchi
	Sai Kit Liu	5	09/2004 - 02/2005	**Keio U**	Prof. T. Aoyama
DTU	Birgitte S.Jorgensen	5	09/2004 - 02/2005	**U Tokyo**	Prof. Kimura
	Elsemarie Knage-Rasmussen	5	09/2004 - 02/2005	**U Tokyo**	Prof. Kimura
	Nick Frederik Thomsen	5	09/2004 - 02/2005	**Osaka U**	Prof. Arai
	Jan Michael Munkeso	5	09/2004 - 02/2005	**Osaka U**	Prof. Arai
KU Leuven	Geert Packet	5	10/2004 - 02/2005	**Hokkaido U**	Prof. Kanai
	Jan Piot	5	03/2005 - 07/2005	**Keio U**	Prof. Murakami
TU Berlin	Christian Froelich	10	10/2004 - 07/2005	**U Tokyo**	Prof. Higuchi
	Tina Wilczynski	5	03/2005 - 07/2005	**Keio U**	Prof. H. Aoyama
	Paarthiban Purushothaman	10	10/2004 - 07/2005	**Keio U**	Prof. Ohnishi

(*) Aborted his stay due to a medical reason

The ten-month Japanese students stayed at two European universities for five months each. The five-month Japanese students stayed at the first university for four months then at the second for one months or less (in case of staying at DTU for a block lecture).

To become an engineer with a global view

— **Ryosuke Gotoh**, Hokkaido University

07 Sep 2004 - 01 Jan 2005 Katholieke Universiteit Leuven, Belgium
01 Jan 2005 - 31 Jan 2005 Technical University of Denmark, Denmark
31 Jan 2005 - 07 Feb 2005 (Leuven, Belgium)

Executive summary

I studied at Katholieke Universiteit Leuven (K.U.Leuven) from September to December 2004 and Technical University of Denmark (DTU) in January 2005 as a DeMaMech exchange student.

At K.U.Leuven, I worked on the mobile manipulator LiAS (Leuven intelligent Autonomous System). Through this research, I showed necessity to vary impedance of the manipulator during the task process or in each task condition and to quantify the operational feel. At the end of the project at K.U.Leuven, I handed in a paper and made a presentation entitled "Investigation into the subjective operational feel with a multiple-degree-of-freedom manipulator".

At DTU, I took an intensive course, "Laboratory Course in Process Simulation". In this course I learned how to use some of the most important computer programs for simulation of metal casting, die casting of plastics as well as mechanical forming of metal.

During this project, I enjoyed the European life style, that is I did my best when I had to do and I used my free time well when I took days off. Besides, I positively communicate with many people from various countries and travel around Europe. Through this precious experience, I realized that it's important to talk with people from different countries in person and to know their cultures.

As a suggestion to the project, I pointed to enough preparations for taking in students.
I hope this project will be expanded and more students can get precious opportunities to study abroad through this project.

Exchange student life

Leuven where I stayed from September to December 2004 is a beautiful city that has medieval atmosphere. Whole of the city is dotted with hundreds of facilities of Katholieke Universiteit Leuven where I studied, and I felt the city was in the university.

During my stay in Leuven, basically, I worked on my research in my laboratory weekdays, and I took days off on Saturday and Sunday. I loved this European life style, that is I did my best when I had to do and I enjoyed my fee time when I took days off.

In my laboratory, I belonged to the Mobile Learning Robots group and worked on a mobile manipulator with several co-workers of the group. When I worked on my research, autonomy was strongly required of me, i.e. I was told, "Do what you want when you want to do. " Of course, I discussed how I should improve my research with my co-workers, and they helped me kindly and gave me good advices when I asked them. The most important thing was, however, to think and to do by my self and express my own ideas. When I had a break, I chatted cheerfully and drank a coffee with my co-workers. Moreover, I sometimes introduced Japanese culture to my Belgian co-workers and also learned their culture and language. I really had a pleasant time with them.

Besides, K.U.Leuven is well-known that many students from various countries are studying, therefore I was surrounded by international atmosphere in the city. This city gave me a good opportunity to communicate with many international students and to learn the importance to accept the different cultures from ours. For example, at the beginning of the semester, I joined the international orientation days. During the orientation days, we learned how to live in the city, attended lectures on international awareness, introduction to Dutch and history of K.U.Leuven, and joined a party for international students. The international orientation days gave me a precious chance to make friends with people who have different backgrounds and specialties from various countries. Another example, in my apartment, many Arabic people lived there, so I could communicate with them in daily life. They were really kind and friendly to me. Chatting and having dinner with them, and being exposed to their culture that is quite different from ours, I felt in my bones that it's important to talk with people from different cultures in person.

In the evening, I sometimes went to cafes with my friends. Drinking Belgian beer – Belgium is famous for beer, and Leuven has Oude Markt that is called the longest bar in the world! – I shared pleasant time with them. Students of K.U.Leuven drink much and study well.

When I took some days off, I positively went out and visited other countries. Because Belgium is located at the heart of Europe, it was convenient for me to travel around. Visiting places that I had seen only in books, seeing glorious building, chatting with local people and looking at precious paintings in museums, I got interested in cultures and history of the countries I visited. Everything I saw, heard and felt there was fresh and exiting for me.

At the end of the program at K.U.Leuven, we handed in a paper and made a presentation about our research in front of our supervisors and co-workers. Writing a paper and making a presentation in English were arduous but challenging works for me, and thanks to this experience, I felt confidence in my English ability than before.

After finishing the project at K.U.Leuven, I went to Denmark in order to take an intensive course at Technical University of Denmark (DTU). The course theme was computer simulations of casting and forging process, and I worked on exercises in a group from morning to evening weekdays. It was really busy but fulfilling days.

During my stay in Denmark, I had a homestay in an elderly Danish lady's house. She was always gentle, and I had a really good opportunity to know daily life in Denmark through communication with her.

The day when we finished our project, we Japanese exchange students of this project in Denmark gathered and cerebrated the completion of our project. My sense of achievement was special. My five-month stay in Europe past in a twinkle, and it was a constructive, precious and dream-like life for me.

Suggestions to the project

I think the greatest advantage of this project is that we can study abroad, communicate with people from various countries and feel the outside world of Japan early on as an engineer. Through this project, I believe I could make a big step to become an engineer who has global view.

Besides, this project gave me an opportunity to communicate not only with many international students but also with Japanese students whose major is the same as mine from other universities. Communication with them was really stimulative and constructive. This is also a good point of this project.

My suggestions to the project are the following:

1. Host institutes should fully prepare for taking in students in terms of their research theme and experimental setup because their stay at the host institutes in Europe is too short if the preparation is not enough.
2. Their research theme should match their major, preferences and interests to the possible extent, or it should be decided as early as possible so that they can learn at least the background of their research in advance.

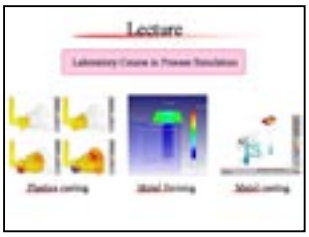
I hope this project will be expanded and more students can get precious opportunities to study abroad through this project.

Summary

In this project, I studied at two institutes, Katholieke Universiteit Leuven and Technical University of Denmark. At K.U.Leuven, I investigated the subjective operational feel with a multiple-degree-of-freedom manipulator in order to develop robots that move in human-centred environments. At DTU, I worked on the exercises in computer simulations of casting and forging process.

This project also gave me an opportunity to make many international friends, communicate with people from various countries and see thousands of interesting things.

I believe these experiences through the project will lead me to become an engineer who can contribute to society of the world widely in the future. Besides, I hope the cooperation between Japan and European Union nations will be promoted in the field of exchange students through this project.



Personal Data

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Supervisor	Prof.Dr.ir. Marnix Nuttin
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[Research at K.U.Leuven]

I. Introduction

In the recent past, to develop a human-centred system and a human interface is emphasised when computers and mechanical devices including robots are designed. In this context, as one way to develop robots that move in human-centred environments, the behaviour-based paradigm became rapidly very popular. When one further analyses these applications, one discovers a striking grab in the application area, namely manipulation. However, very few successful applications were devised using the behaviour-based approach. Therefore, the mobile learning robotics group of K.U.Leuven has implemented several behaviour-based controllers on the mobile manipulator LiAS (see Figure1).

On the other hand, in the social context of aging population and declining birthrate, behaviour-based robots which move in human-centred environments are expected to develop into robots which assist humans.
As a first step to develop robots that assist humans, we need to survey the operational feel or comfort when humans touch end effectors of robots.

In this study, I investigated operational feel based on variable impedance parameters in Skill-assist with the manipulator of LiAS. LiAS has a high-level behaviour-based system and the manipulator is well-controlled, therefore I believe that it is useful for developing robots in human-centred environments to try to evaluate operational feel of the manipulator in Skill-assist.

II. Impedance model of the manipulator

The industrial robot arm I used has a 6-degree-of-freedom (6-DOF) CRS manipulator (see Figure2). The impedance model which has a mass-spring-damper system shown in Figure3 is defined on joint level to emulate human manipulation in LiAS system. This model provides adjustable stiffness and basically implements a natural low-pas filter on the force action on the joint. Moreover, by adding an extra damper to the system, switch between velocity control and force control can obtained. If the mass is free to move, i.e. there is no contact, the source controls the velocity of the mass. On the other hand, if the mass is free to move, i.e. the mass is in contact, the movement of the source regulates the interaction force.

III. Experiments

III-1 Experimental conditions
As a pilot study, I surveyed characteristic of the operational feel based on various impedance parameters and I chose a standard combination of impedance parameters. Based on the pilot study above, I investigated the subjective operational feel in order to get a basic understanding of the relation between the impedance parameters and the subjective operational feel of maneuvering by asking the subjects i.e. Start up responsiveness, Controllability of the motion speed and Ease of positioning, to answer the questionnaire.

When I decided the desirable impedance parameters variation patterns in a positioning task in this study, I experimentally determined them. Here, to keep the model mechanically plausible, the mass m is taken constant. The variables k, c_1, c_2 are left to be used for control. The variable k can easily be used to achieve the desired stiffness and generally c_1 will be used to damp the mass-spring system. c_2 will be used to tune the velocity/force control. Therefore I fixed c_2 when I chose combinations of impedance parameters. To evaluate the difference of the operational feel clearly and easily, I temporarily classified the joints into 2 groups; joints which were used to move the manipulator in a longitudinal direction and up-down direction: Joint2, 3, 5 (Group1), and which were used in a transverse direction: Joint1, 4, 6 (Group2) when I changed the parameters.

The combination of impedance parameters(a) (Comb(a)) was a standard combination which was decided based on the results of the pilot study. Comb(a) had low c_1 and stiffness, but the manipulator were stable to some extent. In Comb(b), each joint had larger c_1 than in Comb(a). In Comb(c), Group1 had lager stiffness, and in Comb(d), Group2 had lager stiffness than in Comb(a). In all combinations of impedance parameters, the manipulator was stable to some extent. Besides, I asked the subjects to do the positioning task in the two types of motion speed i.e. Speed(1) - Operate the manipulator as fast as possible, Speed(2) - Operate the manipulator at a comfortable speed, because the operating speed relates to the operating efficiency deeply.

Therefore, the subjects had the eight experimental conditions that were combinations of the two positioning task speeds and the four types of joint impedance. In what follows, Experimental condition(a-1) means a condition which is combination of Comb(a) and Speed(1), and the other combinations are described by the same way. The subjects were asked to do a positioning task with the manipulator, i.e. a subject grasped the end of the manipulator, moved it and touched the circles on the targets with a brick that was fixed on it. The subject repeated the task. Experimental setup in this task is below (Figure4, 5).

III-2.Experimental results and discussion
The experimental results are shown in Table1 - 8. Comparing each result, I'll discuss the relation between the impedance parameters and the subjective operational feel. Distinctive trends that I could grasp from the tables are below.

(a) In set up responsiveness;
1. The operational feel didn't depend on difference in motion speed very much. I guess this is because the speed were almost the same both in Speed(1) and Speed(2) when a subject started the task.

(b) In controllability of motion speed;
1. The subjects felt better in Experimental condition (a-1) than in (b-1), however they felt good in (b-2). That is because they feel more resistance while they are operating the manipulator as fast as possible and they feel more comfortable when they operate it at a comfortable speed in the case c1 is large to some extent.
2. They felt good in (a-1), (c-1) and (c-2). This means it is easy to move the manipulator when c1 and stiffness are low.

(c) In ease of positioning;
1. The subjects felt bad in Experimental condition (a-2) and (d-2). This means Group1 needed a measure of stiffness when the manipulator was operated at a comfortable speed.

2. They felt better in (b-2) than (a-2). This means the manipulator is more stable in the case the joints had large c1 in Speed(2) when the end of manipulator touches the circle. Besides, I guess these two mentions above greatly depend on the stiffness of the environment (the targets) which the end of the manipulator (the brick) touches.

These results indicate the following.

1. Low values of damper and stiffness are not always comfortable for workers in the Skill-assist task, especially in the case the end effecter touches stiff environments.
2. It is necessary to vary impedance of the manipulator during the task process and in each task condition.

As I mentioned above, however, though there were some trends depended on impedance during the task, there were also differences in the operational feel among individuals. For example, in Experimental condition(b-1) and (c-2), some of them felt comfortable, the others felt uncomfortable in Ease of positioning.

Moreover, when a subject brings a heavier object or gets tired, he/she must feel more uncomfortable during a task in the same experimental condition. Considering these, we need to investigate the relation between the individual operational feel and impedance of the manipulator in more detail. To realize it, I believe that quantification of the operational feel is necessary.

IV. Conclusions

1. There are distinctive trends between impedance of the multiple-DOF manipulator and the subjective operational feel, i.e. it is necessary to vary impedance of the manipulator during the task process or in each task condition.
2. There are differences in the operational feel among individuals.

Figure1: LiAS

Figure2: CRS manipulator

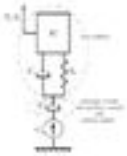


Figure3: Impedance model

Figure4: Experimental Setup- Front view

Figure5: Top view

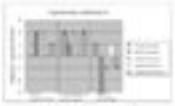


Table1: (a-1)

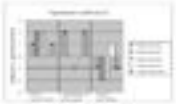


Table2: (a-2)

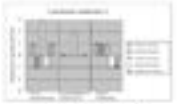
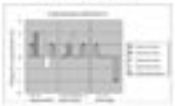


Table3: (b-1)



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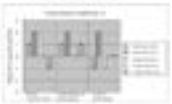


Table5: (c-1)

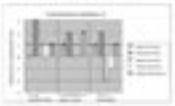


Table6: (c-2)

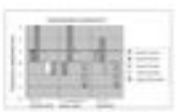


Table7: (d-1)

Table8: (d-2)

[Lectures at DTU]
Laboratory Course in Process Simulation

In this course, we learned how to use some of the most important computer programs for simulation of metal casting, die casting of plastics as well as mechanical forming of metal. This course was divided into three parts covering simulation of plastics casting, metal forming and metal casting.

1. Plastics casting

In this section, we investigated the filling pattern in the process of the plastics casting with a computer simulation program called "SIGMASOFT".

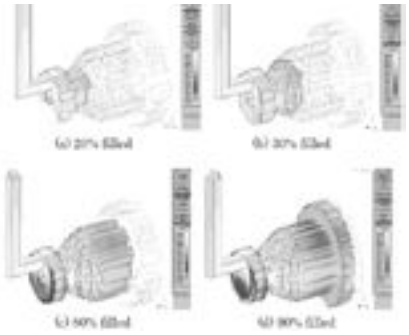
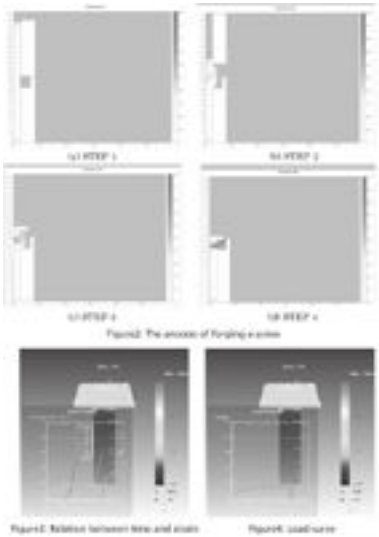


Figure1: An example of filling pattern

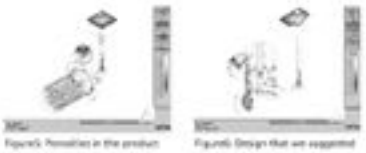
2. Metal forming

In this section, we tried to find a suitable process of forging a screw by investigating temperature, stress and strain of the product. The simulation program we used is "Deform". Besides, by using a 3-D simulation program called "Deform 3D", we checked up strain and the load curve in the process of forging a screw.



3. Metal casting

In this section, we investigated the filling pattern and how to reduce porosities in the product in the process of the metal casting with a simulation program called "MAGMASOFT". Especially we focused on the location and shape of the feeder, and we made a suggestion of a feeder design.



Exchange life in Berlin

—— **So Horiuchi,** Hokkaido University

03 Sep 2004 - end of Feb 2005 Technical University of Berlin, Germany
Feb 2005 - Delft, Netherlands

Executive summary

Research and Laboratory life:
I had belonged to Engineering Design and Methodology laboratory (Department of Mechanical Engineering and Transport Systems) and had researched. The theme of my research is "The research on user interface specification by using XIML and a state chart for usability assessment" and I'd researched about usability in product development process. In the laboratory, Dipl. -Ing. Bruno Gries had given me advices for the research and had taken care of me. Basically, I had a meeting for the research with Dipl. Gries a week and I wrote a report at the end.

Lecture:
I had two lectures. One is Systematic Product Design and the other is German course.
Systematic Product Design contains structure and life-cycle phases of technical product; product development process; methods for product planning, task clarification, concept generation and evaluation; development size ranges and modular products. Especially, the lectures about product planning, task clarification and evaluation are interested for me because they are related to my research area.
As for a German course, I had a beginner course of SKB (Die Sprach - und Kulturbörse der TU Berlin) in November and December. It was efficient for surviving in Germany. I still have big trouble in German but I could study its foundation and I got interested in it. Therefore I'd like to continue to learn German after going back to Japan.

Exchange life in Berlin:
At first, I had many troubles because I couldn't speak German at all. But there is buddy system in TU Berlin and my buddy helped me so much. The dormitory is near from TU and a kitchen and bath are shared. I met many students from many countries there and they also gave me a big help. I still keep in contact with some of them.
There are many attractive places and events in Berlin. While I had stayed there, there are Christmas market, New Year's Day, Berlin Film Festival and so on. And more, there is world heritage in the city, and we can see many kinds of operas, musicals and concerts in a very reasonable price.

Exchange student life

Dormitory:
Dormitory was near from TU Berlin (10 minutes from TU on foot). And there is near from S bahn station. So, the dormitory was good for going to both school and city. On my floor, there are more than 10 students who are from China, Turkey, Netherlands, Germany and so on. It was not easy to communicate with them because they communicate in German and some of them can't speak English. But it was fun and they helped me to live there.

University:
In the laboratory, I had researched in Computer room of the laboratory with another exchange student from Keio University. We received the room key, so we always could use the room. So we usually researched there and sometimes drank coffee with members of the lab in the morning and coffee time. We'd eaten lunch in the university or restaurants near the university.

The figure below is a picture of the Christmas party of the lab. This party was taken placed 19th December and after this, we had winter holiday.

TU Berlin Computer room of the laboratory

Christmas party

Berlin and surrounding:
In usual, I ate dinner in the restaurant. In Berlin there are many good restaurants. And more, there are many kinds of beers in Berlin and they really taste good. So I went to drink in almost every weekend.
In this 6 months, I went to many places in Berlin and surrounding. There is a world heritage in Berlin. The world heritage, the museum island is very beautiful. There are many museums in the island and all those museums are beautiful architectures.

Moreover, I traveled to Hamburg and Potsdam. There are also beautiful cities. But Berlin is a very big city enough to do everything for life. So it is not necessary to go to other cities. (On the contrary, it is not easy to live without going other cities here in Delft Netherlands)

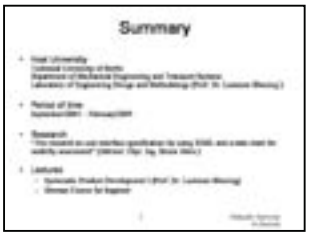
Berlin Zoo station Old national gallery

Suggestions to the project

When I applied for this project, one of my purposes was to do research in a different research environment. I could meet the purpose.
I got good environment to research and members of the laboratory always helped me.
So I could undertake a research and wrote a report of that. So I have no complaints about the environment. Only one problem for me is that academic schedule of those universities are little bit different. So many lectures of TU Delft are already started when I arrived at TU Delft.

Summary

This was my first experience to study abroad. I could experience different country, culture, university and laboratory. Everything was new for me and I could get many things in this 6 month. I have more 5 months in Delft. So I'd like to spend student life in Delft based on my experience in Berlin.



[Research at TU Berlin] The research on user interface specification by using XIML and a state chart for usability assessment

1. Background

Recently, digital devices have many functions and become more complex. Because of this, the awareness of the design for usability in the product development phases is strongly needed for companies and the User Interface (UI) becomes to have a big role of the product's quality. Reflecting such a situation, ISO13407 (Human-centered design processes for interactive systems) was established. That means the difference of the UI gives big difference to the product's usability. Actually, there are many devices which have almost same tasks but different UI like a mobile phone. Therefore, the usability assessment of the UI in product development process is becoming very important.

In the current development process, the user test (which makes subjects to operate a mock-up) is mainly applied for the usability assessment. But it has problems about time, cost and objectivity. So developing the products in low cost and in the short period with considering the usability is required in order to satisfy the needs of customers and companies simultaneously.

The usability assessment of digital devices consists of the assessment from physical aspects (operability of the buttons, visibility of the displays) and the assessment from cognitive aspects (understandability and efficiency of the UI operations). Therefore the assessment from both aspects on one mock-up simultaneously is desirable for enough usability evaluation. Fig. 1 shows the typical mock-ups and UI embedded mock-up in the existing development process in order to evaluate the usability of a UI. Mock-ups are categorized in 3 groups (the mock-ups which can be assessed usability

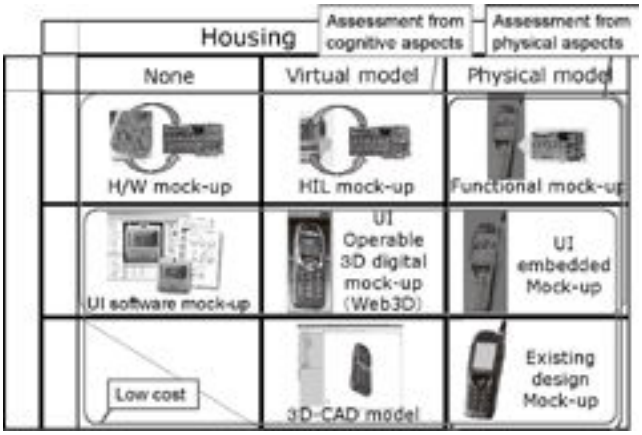


Fig.1. Mock-ups in the development process

from cognitive aspects, the mock-ups which can be assessed usability from physical aspects and the mock-ups which can be prototyped in low cost). It shows no existing mock-ups realize the assessment from both aspects in a low cost and in the early phase of the development process. To realize the mock-up which satisfies all conditions, we proposed the UI embedded mock-up.

When usability assessments by using above mock-ups are undertaken, the specification data of the UI has also important role. In order to apply a specification data for the designing and the usability testing, it should include the information for the usability assessment and is easy to be redesigned based on the results of the usability assessments.

2. Purposes

In order to realize above conditions, we proposed UI embedded mock-up. In this research, we propose the UI specification method which is applicable for the user test by using UI embedded mock-up. The conditions required for the specification are that

- it is easy to be described
- it has both UI's structural information and behavior information
- it is easy to be diverted for other products.
- it is applicable for the user test
- it is applicable for the simulation test before the user tests
- it is easy to be re-designed based on the results of usability tests

The structural information describes the UI's components and construction and the behavior information describes the superficial behavior of the UI.

Additionally targeted products of this research are handheld digital devices which have at least one display and some of push buttons and slide switches (e.g. mobile phone).

We combine the existing UI specification techniques and propose the UI specification method which satisfies the all above conditions.

3. Existing UI specification techniques

In order to propose UI specification which satisfies above conditions, we researched existing UI specification technique. Table 1 shows the result.. Each criterion is rated between 1 and 5. This table shows the state chart diagram and the XIML get high score and they have complementary characters each other. From this result, I decided to propose the UI specification technique which consists of the state chart and XIML in order to satisfy all requirements.

Table 1. The characters of the methods

	State chart	Use case model	XIML
Versatility of specification	1	1	5
Understandability of diagram	4	4	1
Adaptability of describing UI	4	3	4
Ease of applying its data to usability tests	3	3	4
Ease of redesigning	1	2	4
The description of detail of tasks	5	3	2
Ease of manipulation by the computer	5	1	4
total	23	17	24

- **Versatility of specification:** the specification data can be reused for latter similar products.
- **Understandability of diagram:** the diagram can be understood easily.
- **Adaptability of describing UI:** the technique is suitable for describing UI (because some of them are proposed not only for UI).
- **Ease of applying its data to usability tests:** the specification is applicable for usability test (especially for user test).
- **Ease of redesigning:** the specification is changed any part of them easily.
- **The description of detail of tasks:** the specification has detailed information about detailed process of functions.
- **Ease of manipulation by computer:** the data is suitable for being manipulated by computers.

4. User Interface design with XIML and matrix algebra

In this method, the designer describes the UI specification as the XIML model. The XIML model basically consists of the Task model, the Domain model, the Dialog model and the Presentation model. Therefore designer can define the abstract tasks, the information which is viewed and manipulated by the user, the operations which the user can operate to realize the UI's task and the appearance of the UI.

However the XIML model is not good for describing the behavior of the UI. Therefore we use the state chart to describe the superficial behavior of the UI at the same time. The problem of the state chart is that it needs time and effort to describe. Because of that, we don't want to describe the state chart directly by hands. (When we undertake usability tests and redesigning many times, we need to describe the state chart many times in order to reflect the changes.)

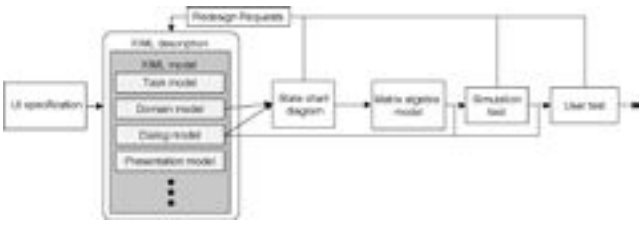


Fig. 2. The data flow in the UI designing

Therefore, we propose the algorithm to translate from the XIML model to the state chart. By applying this algorithm, we can get the state chart from the XIML model. And when the designer wants to re-design the specification, he only needs to change the XIML model. The outline of the data flow is shown in Fig 2. At first, the designers describe the XIML model based on the results of product planning. At that time they have to write at least the Task model, the Domain model and the Dialog model. And when they describe the state chart, they apply the algorithm for the Domain model and the Dialog model and create the state chart. When they redesign the specification, they can get the redesigned state chart by changing the XIML model.
In the next section, I explain about the conversion algorithm.

5. The algorithm of the conversion

When we consider the state chart of the interactions between the user and the UI, the transition arrows mean user's actions to UI and the states mean the states of interaction information of UI. Therefore, it can be made from the XIML dialog model (which represents user's actions to UI) and the domain model (which represents information of interactions between the user and the UI).

In this algorithm, the fundamental rule is that the <DIALOG_ELEMENT>s become the transition arrows, and the <"pre" CONDITION>s and the <GOAL>s of <DIALOG_ELEMENT>s become states.

6. Conclusion

We proposed the UI specification method which consists of XIML and the state chart. In order to realize that, we invented the algorithm that converts a XIML model to the state chart.

This specification contains both UI's structural information and behavior information, and can be diverted a part of the specification for the other products (this comes from the XIML's character). And we can describe the state chart diagram systematically following to the algorithm. So we can say the effort for describing the state chart is decreased.

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Discovering new cultures and my own culture

— **Keisuke Kameyama**, Hokkaido University

20 Sep 2004 - 23 Feb 2005 Technical University of Berlin, Germany
Feb 2005 - Delft, Netherlands

Executive summary

I stayed in Berlin between 20 September, 2004 and 23 February, 2005 and studied at TU-Berlin as a DeMaMech exchange student. This is my first visit to Europe. Therefore everything was new and exciting for me. I couldn't speak German at all and had a hard time at first. But I had a "buddy" who is German and always helped me. I learned German later. So I could spend a good time in Berlin.

My research theme is the NLP in Japan. This is very different from the Mechanical Engineering. To realize the most possible synergies as the main research subject the topic of finding the way to support computer aided design with natural language was suggested. And I took three lectures. There were held in English. But it is hard to find them because most lectures are held in German. Finally I got knowledge about the product development through them.

Besides studies, I had a lot of experience in Germany. I present some of them.
Firstly, I learned German. I didn't have any knowledge of German. But classes are held in German. It was unbelievable for me at first. But I gradually found that it was the best way to acquire a language. It's a great experience for me.
Secondly, I played volleyball with German people. I couldn't make myself understood well in German. But it is universal to play sports. So I could communicate them through playing volleyball without words. I had a very nice time.
Lastly, there are a lot of cultural facilities like theaters, cinemas, museums and so on in Berlin. I could feel European culture through them. All of them are much cheaper than Japan. I could have a lot of opportunity to experience them.

I offer some suggestions about this exchange program. I hope that it's going to be better. Through my exchange life, I could get really a lot of things and realize myself again. My English ability is still not so good. But it is better than it was before stay in Berlin. Fortunately, I have another opportunity to stay in Delft as an exchange student.
So I use my previous experience in Berlin to advantage. I believe I also have valuable experience in Delft.

Exchange student life

I stayed in Berlin from September, 2004 to February, 2005. I had never visited European countries before I stayed in Berlin. So it was greatly fantastic to stay in Berlin at first. Everything was new for me and completely different as compared with Japan. But I also had a really hard time to live in Berlin because I didn't know German at all at that time. I've heard in Japan that many young German people can speak English. Of course it's true. Most people, who are young and work at restaurants, hotels and post offices, can speak English. But quite a few people even some international students cannot speak English. It was much troublesome that many administrators of TU-Berlin offices and city-hall where I registered my stay in Berlin couldn't speak English. So it was really hard to progress my enrolment.

There are two institutions of language teaching at TU-Berlin. One is called SKB and the other ZEMS. SKB offered an intensive German lesson for foreigners before beginning a semester. I wanted to take it. I asked them by email whether I could take it or not though I hardly studied German. Their answer was "You should have knowledge of German as you studied it about 100 hours at least". I couldn't take it. But I should study German. So I went to the private German school during first one month. It was really useful for me. After that I took lessons held by SKB. Those lessons by SKB were not intensive and were held twice a week. I feel good that I could learn German in Germany. It was incredible at first. But it was reasonable to acquire the language fast.

TU-Berlin has a "buddy" system. The "buddy" helped and guided me. My buddy is a German man who studies computer science at TU-Berlin in those days. He really likes Japan and has learned Japanese for two years. So he can speak Japanese a little. We could exchange our language, culture and knowledge between Japan and Germany. This system was really good. At first I don't have any friends. But I had a buddy. He always helped me when I had a trouble even didn't have. I greatly appreciate his kindness.

There are a few lectures in English at TU-Berlin. But most of all are held in German. This situation is not so good for me. But Berlin is a truly big city. Therefore even international students can speak German. I was asked many times "why do you come to Germany though you cannot speak German?". When I took lectures, I felt that European people and other national people insist themselves. And they like debating on their problems. Japanese people don't do like that. But it's very important. We have to follow them.

There are some completely difference between Japan and German in my daily life. One of them is that European people greet very often even stranger. When I bought some-

thing in a supermarket in weekend, they said "Have a nice weekend!". It's really comfortable. In addition, I had some chances to be asked something. When they found me Japanese, they told me their knowledge about Japan. The other is that the transport is well arranged. I bought a season ticket called "semesterticket" for students at TU. It cost only about 150 euro for 6 months. It's really cheap. Then I could transfer anywhere in Berlin by bus, train, underground or tram. In weekend the trains run through the night. And it's not so crowded beside Japan. I could almost find a seat. It's so convenient.

In my exchange life in Berlin, it's very impressive to play volleyball with German people. There are many sports activities for everyone not only students by ZEH (central institution for sports at the university). It's very hard to communicate with my teammate at first because position names, technique names and the sense toward playing volleyball are completely different. Besides they speak German. But I could become used to these surroundings through playing volleyball. When I played volleyball one day, I realized I'm shortest in my team. As you know, the height is advantageous for playing volleyball. I'm not short in Japan. But all of my teammates are over 180cm. So I had to make up for the disadvantage of my height with my skill. It's really exciting for me.

Berlin has a lot of cultural facilities like theaters, cinemas, museums and so on. They are so interesting for me. I sometimes enjoyed listening to a concert, watching an Opera and visiting museum. They were much cheaper than Japan. The "BERLINALE" which is a big international film festival was especially spectacular. It held on 10. _20. 02. 2005. I watched various countries' films. I could also watch Japanese films. Most movies which are showed in cinemas are often dubbed into German in Germany. So I couldn't understand them. But there were many films which weren't dubbed and had subtitles in English. So I could enjoy them. And there were many directors and actors. Then they were often on the stage after their film was showed and they talked about it. It was a precious experience.

Thus I had gotten a lot of valuable experiences through my exchange student life in Berlin. I felt European culture, attitudes, custom, climate and so on. I also realized how Japan is. I could find Japan is closed again. It has both good aspect and bad one. And my English ability is not so good yet. But I got courage to speak English and a little German. So I believe I'll be able to spend my other exchange life more usefully in TU-Delft.

Suggestions to the project

It is most big problem that I couldn't get a scholarship until end of October. I needed much money at first. Of course I prepared enough money to stay in Berlin. But I didn't know when I could start to get a scholarship. It made me anxious. That's why it is important to know when I can start to get a scholarship. And I can expect how much I have to prepare until I get a scholarship.

I appreciate the "buddy" system. My buddy always helped me. I couldn't often make myself understood in German. So he came with me and translated German into English. If I hadn't had any buddies, I wouldn't have succeeded my exchange life in Berlin.

I had to prove my health insurance in Germany. I join Japanese health insurance. But it isn't valid because it's not famous in Germany. So I had to join German health insurance. Next exchange students should be known which insurance companies, also exist in Japan, are valid in Germany.

I'd got many documents from TU-Berlin and the administration of my dormitory. Most of them are in German. I had trouble because I couldn't understand them exactly. So I hope we can get them in English.

Summary

I stayed in Berlin from September 20, 2004 to February 23, 2005 and studied at Technical University of Berlin. I had a lot of precious experience in Germany. Through studying, traveling and living in Germany, I felt European culture, attitudes, custom, climate and so on. I also recognized Japan and myself again. It is greatly useful for me.

As I mentioned above, I had a hard time in Germany because of the lack of my German knowledge. However, German people are warmly. When I just said "Hallo" or "Dank schön!", they gave me their smile. It made me happy. Then I think if I could speak German well, I had communicated with them and my exchange life in Germany would have been much more wonderful. If I had used only English, I have never thought like this. So I recommend for my junior to stay in Berlin without fear.

[Research at TU Berlin]

I belonged to the laboratory of Prof. Krause in TU-Berlin as an exchange student. In this laboratory they are doing applied research in the area of industrial product development. I have researched about the Natural Language Processing (NLP) in Japan. It is the aim of researching the NLP that you will be able to make approaches to your computer as you will be able to make approaches to another person. For that purpose, we really need to deal with the language processing, that is to analyze the natural language and to modeling the linguistic constraints and to find the statistical characters, and to apply these results for the applications. This is very basic oriented informatics research. So it is difficult to apply for the product development directly now. Then I was suggested the topic of supporting computer aided design with natural language. The main aspect of it is not to understand the human language but to find the way of combining it with CAD-Systems, both on a technical, an organizational and a social side. I haven't thought the Natural Language from such a point of view.

The product development has a tremendous impact on the economical success of industrial companies due to its responsibility for costs, time, quality and degree of innovation. An efficient product development process requires a goal-oriented planning of activities, from which all effects and states occurring within a process can be derived.
This planning task has to be supported by appropriate methodologies and tools. The product development process is characterized by a high amount of activities, which are connected and strongly depending from each other. Product development processes are much more influenced by creative elements and uncertainly. So they can not be planned in detail but have to be handled flexibly.

To meet these requirements, an approach of a Design Process Language has been developed at the IPK-Berlin. The Design Process Language is an artificial language but intends to have some natural characteristics. Its syntax and grammar is intelligible described by the Backus Naur Form [BNF], an already existing meta-language for the specification of languages. The BNF is based on an alphabet, which basic elements are called terminal symbols. From the alphabet, non-terminal symbols can be generated by the use of production rules.
Following the Extended Backus Naur Form (EBNF), the Design Process Language is structured by words and links (Figure 1). If words and links are replaced by non-terminal symbols, representing a determined group of attributes, non-terminal expressions can be built, describing all process-building elements in a universally valid form. The connections of non-terminal symbols are defined and thus resulting in a general process model. By the assignment of concrete attributes (terminal symbols), the non-terminal are changed into terminal expressions.

Figure 1: Syntax of the Design Process Language.

Thus the product development processes are described by the Design Process Language, based on quasi natural-linguistic terms. If real Natural Language is used for this purpose, it will be more flexible to be adapted to the specific demands and used for the development of optimization functionally.

Statistical values are often used in the area of Natural Language Processing. Quite a lot of data are needed to get more precise statistical value. If the aim of use them is wide range, it is very hard to get excellent statistical data. Moreover personal data always have bias. Therefore it is difficult to apply these data to other cases. But in this case, it is specified the product development. And all companies have huge quantities of their own data concerning the product development processes. So it is possible to get excellent statistical data. The data is analyzed syntactically and semantically. It makes many rules to represent new product development processes.

The EBNF is one of the languages that represent the syntax formally. But it doesn't provide semantics. For example one of the famous syntactical analyses is called "Chart Parsing" [2]. A chart is a form of well-formed sub-string table (wfst). It consists of a collection of vertices, one between each word of the input, connected by edges, labeled with grammatical information. Both of them are suited to describe the Context Free Grammar (CFG). The CFG is a formal grammar in which every production rule is of the form. It is composed of generation rules. "Chart Parsing" can describe any CFG. But in this case, EBNF is effective to describe the Design Process Language because EBNF is used to specify the syntax rules of the programming languages. The Design Process Language is not a programming language. But it also needs to describe the processes systematically. Then the semantic is represented in a general process model, where non-terminal symbols are connected with each other in a way, that process elements and their dependencies are described universally valid. In case of instantiation, the semantic can be interpreted for instance for the generation of the course of activities. Furthermore, attributes can be connected with arithmetical links to complex expressions, representing evaluation and optimization algorithms. Semantic analyses take great deal of time even the area of the NLP. So this representation may be applied to the area of the NLP.

Thus it has high potential to combining the NLP with CAD-system not only the area of the product development but also the NLP. I studied about the product development wide range with searching this topic and lectures. I think it's just superficial. And I considered about combining the NLP with product development. The field of the NLP needs to apply universally. Therefore it's difficult to get high rate of collect answer. But if we use the NLP for the specific field like the product development, the results of applying the NLP is much better. I'll do my master's thesis in consideration for this topic.

Reference

[1] F.-L. Krause; R. Heimann; C. Kind, 2001,
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[2] Doug Arnold,"Chart Parsing",
http://www.cs.ualberta.ca/~lindek/650/papers/chartParsing.pdf

[Lectures at TU Berlin]

I took three lectures, "Industrial Information technology II", "Systematic Product Development I" and "Supply Network Planning and Scheduling" because I wanted to get knowledge for the "product development". First two lecturers provided me with essential knowledge and the present condition of the product development. Last one gave me more concrete idea with some numerical expression and charts.

All of them were held in English. There are some lectures held in English at TU-Berlin. But of course, most lectures are held in German. It is very hard to find lectures held in English because the syllabus is also in German. Its thickness is about 3 cm. There are all lectures held during one semester. A syllabus of a lecture in English is also written in English. However it's not easy to find them. The syllabus provides information of a lecture, its name, schedule, place, professor and summary. But a schedule and place are sometimes changed or not indicated yet. So I have to check its website to confirm them. They also provide the syllabus on web site. But I couldn't use it properly because of German.

Prof. Dr.-Ing. F.-L. Krause:

Industrial Information Technology II

This lecture supplies knowledge, information and technology concerning the product development that reached widely. Its contents are CAD/CAE-Technology, Simulation, Use and selection of software systems, Information Technology for Quality management, Production Planning, Process Management and E-Business and so on. This lecture is based on industrial aspect. So it is very interesting to know not only German companies but other companies.

Prof. Dr.-Ing. L. Blessing:

Systematic Product Development I

This lecture presents the product development from the systematic point of view. Its contents are structure and lifecycle phases of technical products, product development process, methods for product planning and task clarification, finding, evaluating and selecting solutions, size ranges and modular products, design for quality, design to standards, modular products and design for minimum cost and so on. The materials of this lecture are provided on website by PDF file. They are methodical. So they are really useful to prepare and review the contents of lectures.

The examination was an oral test. I had never experienced an oral test. Professor asked me some questions about the lecture. Prof. Blessing holds this lecture. This lecture lasts until summer semester. So there is usually no examination in winter semester. I really appreciate her kindness.

Prof. Dr.-Ing. H. -O. Günther, Dr. Martin Grunow:

Supply Network Planning and Scheduling

This lecture offers the Supply Network Planning. Its contents are fundamentals of production planning and control (PPC) systems, Functional building blocks of PPC-Systems, Advanced planning systems, strategic network design and design planning and so on. There are many exercises to confirm the contents, e.g. coding the physical structure of items according to a network representation of the Bill of Material (BOM) database, the Winters Exponential Smoothing Procedure for Trend-Seasonal Demand that is one of the forecasting methods.

This lecture is active because teacher asks us many things to confirm whether we understand contents or not and students also often ask him questions without restraint. So it is really useful to understand them and recognize what is incomprehensible for other students.

The examination is the written test. The test questions are some explanations of the systems or functions and a little calculation.

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Short stay in Leuven but valuable experiences

— **Tetsuro Yamaki**, Hokkaido University

20 Sep 2004 - 02 Feb 2005 Technical University of Berlin, Germany
04 Feb 2005 - Delft, Netherlands

Executive summary

In the travel schedule, I write about trip plan from Chitose to Leuven and from Leuven to Delft. It takes more than 12 hours to go from Chitose to Leuven. And so, I was very tired.

In the Research section, I write the topic in Leuven. This topic is based on Neural Networks. This back ground is the realization of the autonomous machine by using Spiking Neural Networks. First of all, I need to study about Neural Networks, especially Spiking Neural Networks. And, I investigate what another university and research organization done in the world. Next, I examine some simulators about Neural Networks. And then, I choose 1 simulator and simulate on the base of the data from an autonomous invalid chair sensor. At last, we can indicate the superiority of the specific neural network to compete each other by the simulation.

In the Exchange life, I explain living in Leuven. First of all, I introduce my residence. This was very nice residence. And I have precious experience there. Next, I describe the laboratory life in the weekdays. And then, I showed what I have done in the weekends. At the last paragraph, what I have felt about the prices is written. Some of them are expensive, but most of them are cheap.

In the Suggestion for the project, I wrote my opinion towards the students who will apply for this project and organizers. First of all, I thank to participate in this project. But, it is too short time to research and stay. It's better to stay long time in one university. And I also write about scholarship. It is enough for me. I can enjoy my Leuven life with the amount. And I explain about Belgium. What it is usual in Japan is unusual in Belgium. I have got a lot of culture shock.

Exchange student life

First of all, I want to introduce my surroundings. I lived at the apartment. In this apartment, many international students lived. There, a shower, a kitchen, and a toilet are shared with the inhabitants. So, I met them at the kitchen every day. And I was able to make some friends and sometimes went to a bar with them or exchanged the typical dinner of own country. So, though I lived in Leuven which is far away from Sapporo I don't feel lonely at all.

Next, I explain the laboratory. It takes 15 minutes from my residence by bike. This laboratory is very big to compete with the Japanese laboratory. Some professors work there. My supervisor is Professor. Nuttin. He had me do what I want to do. But, this laboratory does not have private computers enough to use whenever I want. So, I need to bring my lap top computer every day.

In weekdays I go to the laboratory and in weekends I and my friends meet and sometimes travel a Belgium city or drink at a bar or eat dinner. A lot of international students from all over the world come to Leuven for study, internship and so on. People from Spain are more than those from any other countries except for Belgium. And I thought 2nd biggest community is Chinese community. By the way, Leuven is very small city so, whenever I went out, I certainly met a friend. It was very interesting and exciting thing. And, most of inhabitants in Leuven are students. Their age is very similar to my age. So, I can easily make friends and get along with each other.

The prices of the most things in Leuven are lower than those in Japan. For example, I can buy a sandwich for 2.5euro at a student restaurant. On the other hand, cloths, shoes, and computers are more expensive than the products which I can get in Japan. An exchange student usually cannot do a part time job. So, I get all my money from only this scholarship. But, it is enough. The residence fee costs 285 euro per month. The food expenses cost approximately 10 euro per day. And, when I go to Brussels in the weekend, it costs 4.6 euro to buy the weekend ticket: the return ticket which you can use only on Friday, Saturday, and Sunday.

Suggestions to the project

- It is not enough time to stay in Leuven for only 5 months. The research was finished in the way. So, I hope the students for long period stay in 1 university for long time next year.
- When I talked with foreign students, they definitely asked about Japan. For example, Japanese attitude toward United States, traditional cloths, history and so on. So, the students should know much about Japan.
- A semester of Europe usually starts in September. Before a semester starts, here is an orientation days: To help you get settled during your first few days in Leuven, a special program with useful tips and information, and opportunities to meet your fellow students. And so, in order to attend that, the students should go to Leuven before starting an adjustmental meeting.
- I needed a lot of money during first few days in Leuven. This amount is almost 100,000 yen. So, I suggest the stu-

dents get the first scholarship before going abroad.

- When I do anything, I need to speak in English. So, the English skill is highly necessary. If possible, the students should study Dutch spoken in Leuven. And so, they can communicate with Belgium people more.
- I looked for a residence after arriving at Leuven. Because it was told that I could find a residence easily. But, it is difficult to find a cheap place. At first I went to International Housing Office, this is an organization of KULeuven for the accommodation. But, they told me that rooms they have are already full. Next, I went to another private office of housing. But, they also told me same things. In the end, I got a room from a poster in the university. So, the students are strongly advised to come to Leuven as early as possible in order to arrange their permanent housing.
- When I went to Belgium for study, I needed to get a visa. In order to obtain a visa, I needed some documents and a passport. It takes at least 1 month to prepare these things. So, if the students are decided, they should behave earlier as long as they can.
- In Leuven most of shops and restaurants are closed on Sunday. And there is no convenience shop which is open for 24 hours every day. So, the students need to buy something to eat before Sunday. Otherwise they have trouble.

Summary

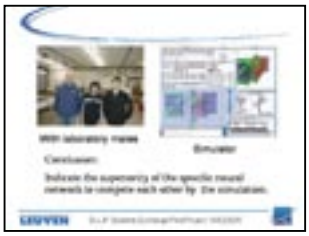
I stayed 4 months and 2 weeks in Leuven. It is definitely precious time for me. And so, I want to thank to this project, coordinators, supervisors, and my laboratory mates.

When I arrived to Leuven, I felt what an old town is! It looks like a one scene in a movie of the Middle Ages. Actually, Leuven has many old buildings of world heritage and is surrounded by walls like a ring.

But, at the same time I felt culture shock. In the weekends all the shops are closed. It was very inconvenient for me. Because it is first time to live abroad and to go to Europe, and I got used to the Japanese style which some shops are always open every day. So, I always worried about the meal of the weekends, especially Sunday.

The research topic is a little different from the topic in Japan. At first, my topic was about reconfigurable robot. I researched at this topic for a while, and it was getting more and more boring topic more for me. And so, I talked with my supervisors and they permitted to change the topic. This new topic is about Neural Networks. And I am more interested in Spiking Neural Networks. So, I researched at this topic, but I could not simulate by using Spiking Neural Networks. I regret that thing.

Many international students from all over the world live in Leuven. And their age is very similar to my age. So, I could easily make friends and get along with each other. It is very fun and valuable experience. And I was able to know their culture, for example, traditional cooking, clothes, events and so on. I think I also know what Japan is seen by the foreign countries. They told me Japan is rich, high-technology country, very funny behaviors foe Europeans and so on. Actually, it is difficult to know real Japan in Europe. Because it is very far away and broadcast stations hardly make a program of Japan. But, I also felt I don't know much about Europe. What they, European are usual is not usual for me. I think if you live abroad you can get it. So, it is an irreplaceable experience.



[Research at K.U.Leuven]

In Neural Network, there are many kinds of network. For example, Perceptron, Recurrent network, Hopfield network, Kak networks, Spiking Neural Networks etc... Among all of them, Spiking Neural Networks are similar to human real brain and, not complicated but easy to compose. So, we can apply that to vision recognition or some functions of the brain with ease. Furthermore, we can embed that to portable devices (for example, Khepera, blimp) and make new machine like the autonomous air-plane which Dario Froleano have made. For the purpose of that first of all, we need to know how neural networks works, what kinds of simulators are published. Next, we use simulators of these and compare another Neural Network. And, in the future we will use real machine to solve a problem.

First of all, I had to study about neural networks: Recurrent networks, especially Spiking Neural Networks. The Spiking (or pulsed) Neural Networks (SNNs) are models which explicitly take into account timing of inputs. The network input and output are usually represented as series of spikes (delta-function or more complex shapes). SNNs have an advantage of being able to continuously process information. SNNs are often implemented as recurrent networks. Networks of spiking neurons - and temporal correlations of neural assemblies in such networks - have been used to model figure/ground separation and region linking in the visual system. And I also choose another Neural Networks to compete with SNNs. These are Back propagation and SCG.

The former is the most popular algorithm. This is a technique used for training neural networks. It is most useful for feed-forward Neural Networks (networks that have no feedback, or simply, that have no connections that loop). The term is an abbreviation for "backwards propagation of errors".

$$\Delta_{w_{ij}} = \eta \delta_j o_i$$

$$\delta_j = \begin{cases} f_j'(net_j)(t_j - o_j) \cdots if\ unit\ j\ is\ an\ output - unit \\ f_j'(net_j)\sum_k \delta_k \omega_{jk} \cdots if\ unit\ j\ is\ a\ hidden - unit \end{cases}$$

η : learning factor eta(constant)
δ_j : error (difference between the real output and teaching input) of unit j
t_j : teaching input of unit j
o_i : output of the proceeding unit i
i : index of a predecessor to the current unit j with link ω_{ij} from i to j
j : index of the current unit
k : index of successor to the current unit j with link ω_{jk} from j to k

The latter is also a supervised learning algorithm for feed-forward Neural Networks, and is a member of the class of conjugate gradient methods. They are general purpose second order techniques that help minimize goal functions of several variables, with sound theoretical foundations. Second order means that these methods make use of the second derivatives of the goal function, while first-order techniques like standard back propagation only use the first derivatives. A second order technique generally finds a better way to a (local) minimum than a first order technique, but at a higher computational cost. Like standard back propagation, SCG iteratively try to get closer to the minimum. But while standard back propagation always proceeds down the gradient of the error function, a conjugate gradient method will proceed in a direction which is conjugate to the directions of the previous steps. Thus the minimization performed in one step is not partially undone by the next, as it is the case with standard back propagation and other gradient descent methods.

Next, I investigated what they have done about SNNs in the world. And, I also analyze the simulators for Neural Networks. In the end I choose one simulator among what I have researched and I simulate Neural Network. This simulator is SNNS. SNNS (Stuttgart Neural Network Simulator) is a simulator for neural networks developed at the Institute for Parallel and Distributed High Performance Systems (IPVR) at the University of Stuttgart since 1989.

And so, we analyzed those data for the simulation of autonomous machine. When the invalid chair goes on a road which sometimes has obstacles, that one needs to pass over. If the driver can control that chair, we don't need to think about this. But, if the driver cannot make that move at all, people have to help them. However, people do not stay together all time. And so, that chair has to judge. The purpose of an autonomous invalid chair is to get round a barricade by itself. We use neural network to get a solution of this problem.

This data comes from an autonomous invalid chair sensor. The data has 36 values (1 value is time, another is from sensor) as an input. And this has 1 output. The output returns 0 or 1. The input values are not 0 or 1 but numbers less than 10 including minus.

There are many possibilities which how many units are appropriate. For example, this should be the number same as the input units, the output units, the average of the input units and the output units and so on. How to decide the number of hidden layer is not established certainly. This is almost determined by an experience. But, in this Simulator pruning functions are available. So, at first, we prepared same units as an input layer for a hidden layer. And we tried to make neural networks smaller and more effective.

We use two algorithms for pruning. One is called "non-contributing units" and another is called "Magnitude based pruning". The method of the former uses statistical means to find units that don't contribute to the net's behavior. The net is subdivided into its layers, the output of each neuron is observed for the whole pattern set and units are removed that

- don't vary their output,
- always show the same output as another unit of the same layer,
- always show the opposite output of another unit of the same layer.

The Later is the simplest weight pruning algorithm. After training, the link with the smallest weight is removed. Thus the saliency of a link is just the absolute size of its weight. Though this method is very simple, it rarely yields worse results than the more sophisticated algorithms.

And, we prepare these data;

- Input 35 units (B:39, D:30)
- Hidden 35 units(temporarily)
- Output 1 unit
- Pattern file A : 2074 pattern
- Pattern file B : 4336 pattern
- Pattern file C : 1634 pattern
- Pattern file D : 1353 pattern
- learning cycles for first training : 1000

And, from those data we can get those results;

The number of units after pruning

	"Non-contributing units"		"Magnitude based pruning"		Note
Pattern file	Input	Hidden	Input	Hidden	
A	35	19	31	30	
B	35	24	35	35	*
C	35	22	35	35	*
D	35	23	30	10	

*: In "Magnitude based pruning", we cannot get the number in hidden layer because the simulator can not generate those values.

The value of MSE after training by learning function

Pattern file	Standard Back Propagation	SCG
A	0.00079	0.00291
B	0.00818	0.00415
C	0.00185	0.00123
D	0.00237	0.00030

MSE is defined as a next equation. $MSE = \frac{SSE}{n-p}$

- n = Number of observations (sample size)
- p = Number of parameters, to be estimated (weights)
- SSE = Sum of squared errors

First of all, B and C have many various patterns. And so, about "Magnitude based pruning" they cannot be settled. On the other hand, D has many similar patterns. So, they can make neural networks easily and the number of the hidden layer becomes very few. But, about "non-contributing units" the number of hidden layer of A is less than that of C. So, though, some of them cannot settle the number of units, others can decrease the number of units. About learning function, the value of B is most in all the patterns. This depends on too many patterns. Only "Standard Back Propagation" of A has more MSE than "SCG". "SCG" of D is most suitable learning function. But, you can see all the patterns get a good result.

But, we were also going to simulate SNNs and compete with another Neural Networks. However, we could not do it because of less time. So, in the future we can do it.

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Think by myself and act by myself

— **Yusuke Hosomi**, Keio University

15 Sep 2004 - 02 Jan 2005 Katholieke Universiteit Leuven, Belgium
02 Jan 2005 - 31 Jan 2005 Technical University of Denmark, Denmark

Executive summary

The first thing I was said from my teacher at K.U. Leuven was "think by yourself and act by yourself". This was of course applied to my research activity, but was required all through my stay in Europe. Since I didn't have any friends in Belgium and this was my first time in Europe, I had to gather information all by myself. This means that if I didn't make any action to what I want to get, I would end up with nothing. It was very interesting to act in an environment where I couldn't use my mother tongue.

The research was operated in a team who had a similar topic for their researches. Since the topic of my research was new to me, I had to start from gathering information about the topic to understand what is done in the recent researches. I had to determine how to run my research by considering the remaining time and estimating what I could do from the research environment in that time. The most difficult thing was to understand and to adjust my research environment like reserving the experimental machines. It didn't work out first and I think I did waste some time. The problem was the lack of communication with the technicians in the workshop and the tight scheduling of my research which came from the unfamiliarity to the research environment there.

The life it self was very important during my stay in Europe too. The scenery and buildings were totally new to me and the culture in Europe was my first experience. I had very nice experiences by traveling a lot of places, by going to the party or pubs to drink Belgium beer, going out with my friends and etc. Since the time of my stay in Europe was limited, the most important thing I felt was to open myself and to challenge to various things to experience a lot efficiently.

Exchange student life

This was my first time I went to Europe. The first city I stayed was Leuven, Belgium. The first thing I noticed was the good driving manners of the drivers. When I intended to walk across the street, the cars and even the trucks stopped to let me cross the street. The reason may be that Leuven is a small city and people are not so busy and crowded, compared to the big cities. Leuven is indeed not a big city but has everything inside. You can find almost everything you want in the main shopping streets. And since Leuven is a city where Katholieke Universiteit Leuven is located, the city has a lot of young people. There are a lot of bars where you can find very nice Belgium beer.

The first week was the orientation week. There were lots of events for the new students and international students such as party, day trip to the other cities and etc. The events of this week provided me a lot of chance to make new friends.

After the orientation week, my research started. It was a very new topic for me and I started from gathering the information about the topic. The most important thing was the scheduling of the research. I had to determine how to run my research by considering the remaining time and estimating the progress of my research. The largest problem was to adjust my research environment such as booking the experiment machines and materials I needed. It didn't work out first and I think I did waste some time. The problem was lack of communication between the technicians of the workshop and my tight scheduling of my research which I made myself. After the reason was clear, it was quite easy to solve but it needed some time to get use to the environment.

The time for the research was only about 3 months. Since the deadline of the submission of the report was fixed, I had to get some results through experiments and write the report during this period of time. It was very hard for me to start from learning a new topic to write a report in this time of period, but it was really good time for me.

In the weekends, the laboratory was closed. So I had some time to go out for a trip to look around some cities in Belgium and Europe. Since Leuven is located in the center of Belgium, and Belgium itself is not such a big country, it was easy to visit some cities in Belgium by train. And also Belgium is located in the center of the west Europe, the big cities such as Paris, London, and Amsterdam was near by. I went to these cities by bus and train. The countries in Europe lays next to each other and this could not be imagined in the island country like Japan. Since this was my first time in Europe, I was curious about the difference between the countries in Europe. Even the boarder of the countries contacts one another, the type of people, language, food, customs, cultures, and types of buildings differ from north to south and east to west. It was very nice for me to have a chance to see these differences.

The second county I went was Denmark and stayed at Denmark Technical University at Copenhagen. The day length was only about 8 hours and this was my first experience. I took a 3 week concentrated course of simulation using FEM in casting and forging. Even though I had never done these productive processes, it enabled me to understand the prin-

ciple and the flow of the process. FEM does consume time to acquire results, but from the term of its accuracy, I believe it is useful. My undergraduate research was about proposing a method of simulation in milling process and the main aim was to minimize the calculation time. So it was set up against the FEM analysis. Since I haven't actually studied the FEM deeply before, this was a good chance for me to study FEM and experience the advantage and the weak point of the FEM.

As mentioned above, my life during the exchange program consisted of mainly two factors such as research and student life. My time was meaningful since both of them were very new and precious experience to me.

There are two things I felt during this program. The most important thing to success my research in this short time of period, is to understand and be able to use the environment around me as fast as possible. And the most important thing for my life is that I should not hesitate to try new things and just do it. I believe this is most important to experience and feel a new environment.

Suggestions to the project

I will mention about few things I noticed during my stay. I know this project has just started, but there are some points which should be modified.

- The information about the project was not announced equally to all the Universities. After I met some Japanese who belong to this program, we noticed that there was some gap in the information. This should be corrected before the announcement of this program next year.
- The accommodation was very difficult to find. In case of K.U. Leuven, Belgium, the minimum period of rent in most of the accommodation was 6 months. So the accommodation office could not be able to help me. I stayed in a hotel for few days to find the accommodation myself.
- It is quite difficult to make a research and get some results in such a short time like 3 months. The schedule is quite tight. So I think it is nice to have an option to stay in one country to make a research during their whole stay, or to stay in two countries to experience several environments.

Summary

I joined the short term program. It was actually not a long time to do the research. Even the long term program, it only allows 5 months for the research in one university. So I think this program is not so good for a participant who wants to focus only on the research. But since there is a chance to see two universities in two countries, there is a chance to see and experience the education system based on their culture. Since this was my first time in Europe, everything was new to me and exiting. From the viewpoint of experience new things, joining this project was meaningful to me since I believe I could not have experienced such a lot of things if I stayed in my home university during the same period of time. And since the period of time of my master course is limited, my aim is to grab the chances which are open for the master course students to experience many things as possible. When I first heard about this program, I felt it will match my aim and it actually did. I believe this program will satisfy the demand of students who wants to experience various of things during their master course. Since Japanese is an island country, it will be a good chance to compare the Japanese culture and education system and Japan itself to European countries.

[Research at K.U.Leuven]
Basic Study on Forming Cranial Implants by Incremental Sheet Forming

1. Introduction

In recent years, the need for small lot production has arisen to satisfy the changing market demands. In case of sheet metal forming, the major current method is press working but it costs time and money to adopt in small lot production. To solve this problem, the forming method called incremental forming has been proposed to form sheet metal[1]. Incremental forming is a method to develop sheet metal into three-dimensional shapes, only by moving a tool relatively on the sheet metal. It doesn't need a die or specific tool during the production process and this characteristic enable to meet the market demands of small lot production from the view point of cost and time of the production process.

The demand of small lot production is not only from the industrial engineering, but also from medical engineering. There are demands of forming metal membranes for bone reconstructions. The metal membranes are custom made for each patient because the desired shape differs between the patients.

The aim of this study is to form the skull implant part by using existing technique of single point incremental forming, and to improve the accuracy of skull implant part by modifying its tool path. Several tests have been made to verify the usefulness of the tool path modifications.

2. CAD Model Design

The geometrical data of the skull part is shown in figure 1. In this study, two CAD models were created to create tool path in incremental forming. One is created by covering the outer shape of the model since the skull part is convex shape, and other is by NURBS surface from the point cloud. These two models are shown in figure 2. Table 1 shows the geometrical accuracy of the two CAD models compared to the original STL data. From table 1, CAD model using the wrap command was chosen to create the tool path.

Figure 1. geometrical data of the skull part

(a) wrapping (b) NURBS surface from point cloud

Figure 2. created CAD models

Table 1. Geometrical error of the two CAD models

	average [mm]	maximum [mm]
Wrap	0.091	0.38
NURBS	0.42	2.02

3. Tool Path Design

From the created CAD model, tool path was created. The 2D contour tool path was used. The spiral tool path was not used for the first tool path because it was difficult to control the vertical pitch of the tool path in this complicated model. In this study, 4 types of tool paths were tested to compare the geometrical accuracy.

- Type 1
  Normal 2D contour tool path was created. This tool path is used to check the usefulness of other tool paths.
- Type 2
  After the 2D contour tool path, spiral tool path was adopted. In type 2, the spiral tool path was created from the outer boundary to the center of the model.
- Type 3
  After the 2D contour tool path, spiral tool path was adopted. In type 3, the spiral tool path was created from the center to the outer boundary of the model.
- Type 4
  2D contour tool path was created according to the measured data formed by type 1 tool path. The correction algorithm is shown in figure 3. After the skull part was created by the 2D contour tool path, the shape was measured and "deviation vectors" pointing from a set of points on the CAD data to the corresponding points on the actual geometry are determined. These vectors are inverted and scaled by a correction factor c, yielding a new trial tool path to produce a further part. In this study, the value of 0.7 was used for the correction factor c which was determined by the earlier studies[2].

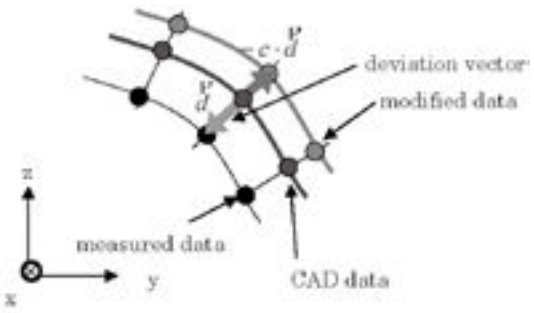

Figure 3. Correction algorithm

4. Results

The measured error considering only the skull part is shown in table 2 and the error map of the whole sheet is shown in figure 5. The positive and the negative error are defined in figure 4. The distance perpendicular to the measured data to the CAD data is defined as error. Especially when the CAD data is higher in z direction than the measured data, it is defined as positive error, and negative error is defined when CAD data is lower than measured data in z direction. This is important for the error map shown in figure 5.

From the figure 5 and table 2, the most useful tool path considering only the skull part is the type 3 tool path. When considering the whole shape, type 4 tool path has the best result.

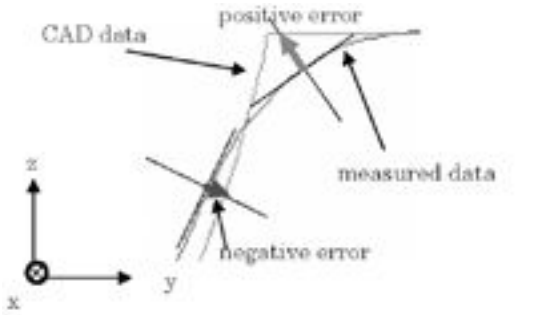

Figure 4. Definition of positive and negative error

Table 2. Comparison of the geometrical error in the skull part

test type	average [mm]	minimum [mm]	maximum [mm]	range [mm]	RMS [mm]
type 1	-0.288	-1.393	0.379	1.773	0.199
type 2	0.811	0.143	1.418	1.275	0.277
type 3	0.344	-0.293	0.909	1.202	0.138
type 4	0.407	-0.523	0.906	1.429	0.171

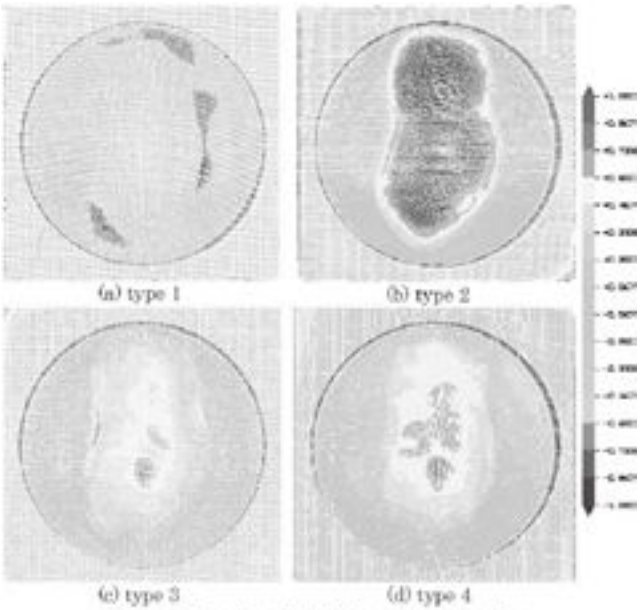

Figure 5. Results of the tool path modification

5. Conclusion

The main results achieved in this paper are summarized as follows:

1. The design method of creating a CAD model which includes the skull implant data was investigated in case of single point incremental forming.
2. Basic tests were carried out and the skull implant part was created by single point incremental forming.
3. Methods to improve the geometrical accuracy of the skull part was investigated and verified through tests.

6. Reference

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Wonderful days meeting completely different cultures

— **Yu Kimishima**, Keio University

10 Sep 2004 - 09 Feb 2005 Technical University of Denmark, Denmark
10 Feb 2005 - 11 Jul 2005 Katholieke Universiteit Leuven, Belgium

1. DTU

Executive summary

I started my studying abroad on September 10th 2004. My research was about configuration system of a clock company. I did process analysis of the company, I did product analysis of the clock, I did Object Oriented Analysis, and I made a configuration system. About my student life, first, I could not enjoy my life in Denmark. Because I could not participate in introduction week of DTU, I was unknown about DTU and I could have few friends. But I made friends little by little, I improved my English little by little, and I enjoyed my life little by little. Finally, I can say that I totally enjoyed my exchange student life in Denmark. And with that mind, I left Denmark on February 9th 2005.

Exchange student life

Introduction week of DTU was took place in August, so I could not join that. It was very big problem for me because I did not know everything about DTU and Denmark, and because I had no friends when I came to Denmark (Introduction week is good chance to make friends). Also I was not good at speaking and hearing English, and it makes my student life very hard. So, actually, I could not enjoy my exchange student life during first 1 month. But I improved myself little by little. I made friends, I learned English and I got used to living in Denmark. Now I can say that to make friends is the best way to enjoy student life. If I have many friends, I can have many chances to speak English, I can have much information and I can learn various way of thinking. DTU has parties for international students every week, and it allowed me to make friends easily. Also, because I lived in private house with other 2 guys, I could make friends with them. I went to Copenhagen every weekend with them to enjoy concerts and drinking beers and etc. As such, I made friends, and my exchange student life turned to be very fun.

After I started to enjoy my life, I joined basketball team which is official team of DTU. Practice was 2 times a week, and I joined almost all practice. Sometimes, we had a match against another team. Because basketball is not so popular as football in Europe, team mates were not so many, but it was very nice team. Playing basketball in English is also good experience for me. Because I am a small guy, coach of the team did not accept me and did not allow me to join the match. But I continued to join practice, and finally the coach accepted me and I could become starting member of the team. I was very happy with it.

Also I started swimming once a week. Owner of my house drove me and other 2 house mates to the pool every Friday, and we enjoyed swimming. After swimming, we took a sauna just to relax ourselves.
So, my usual life was going to university to study around daytime, doing sports in the night and going to Copenhagen at the weekend.

During the Christmas vacation, I could travel around Eastern Europe. It was also very good experience for me, and I think I will have not so many chances to do like this in the future.

Then, I will describe about my research. Actually I had studied about Object Oriented, but the field was almost new for me. So I read many theses about the fields. To read English theses was very hard for me in the beginning, but I got used to it little by little.

Now, I will mention about DTU. DTU has huge campus and it is not easy to move from one building to another building without bicycle. (Actually, I did not have bicycle.) Big buffet is located in 101 building, and many students go there to have a lunch. In same building, there is a bar which is opened every week day. In the bar, international students party is took place every Tuesday, and also big party is took place every Friday. It made me easy to make friends. In some building, there are rooms called "Data Bar" in which we can use computer connected to internet. With student card of DTU, Data Bar is available for 24 hours. DTU has a huge ground to play football or basketball for free, and it has also many gyms where we can play a lot of inside sports (but it is not for free). In my department building, I had a small room sharing with other 2 Danish guys. There is a nice kitchen in the building. The kitchen provides us free coffee and I often enjoyed coffee break with my friends.

Then, I will mention about Denmark. My first impression of Denmark is that "Denmark is a country of kind people". Every time when I have some trouble, someone spoke to me saying "Can I help you?". It seldom occurs in Japan, especially in Tokyo. Also, many of Danish people are very cheerful and most of Danish can speak English fluently. So there was no problem of communication except my English skill.

Copenhagen is very beautiful and lively city. Especially in the weekend, there are many parties, concerts and other events. I went to Copenhagen almost every weekend with

my friends, sometimes just for drinking beer and sometimes for joining in the event.

Denmark is expensive country, so I had to cook my dinner almost every night. It was sometimes cumbersome, but because I had never cooked before, it was also a good experiment for me.

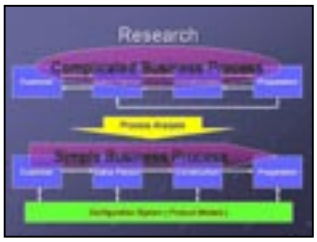
Through these exchange student life, I could get a lot of experiences. I could get lifelong friends, I became better of speaking English, I learned different way of thinking, and I learned how to enjoy my life in Europe. And these experiences must be great help for the next 5 month life in Belgium. I may not feel difficulty which I felt at the beginning of Denmark life. And, I hope I can get more and more good experiences through the life in Belgium, too.

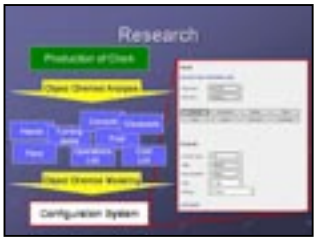
Suggestions to the project

As I mentioned above, that the Project does not allow us to start studying abroad from August is big problem. Introduction week is very big event for international student, I think. So, I suggest that the Project should be more flexible about starting day.

Summary

Both studying and living in Denmark were totally new for me. So I got lost first period. But I could solve all of these problems by myself. Now I can say that "I can live everywhere". That kind of vitality is one of the biggest things I obtained through this project. Also, I could understand the fact that I am unknown man about outside of Japan. Because I have lived in Europe, there are many races of people. And of course each of them has different way of thinking. When I was in Japan, I had little chance to talk with foreigners. So this was also good experience for me. Finally, I am sure that next 5 month in Belgium will be also very nice days.





2. K.U.Leuven

Executive summary

My studying place was changed from Denmark to Belgium on the beginning of February 2005. At the K.U.Leuven, I studied about cut directions of 5-axis milling machine. In this research, 30 degrees, 45degrees, 0 and 90 degrees cut direction millings are examined. Previous research calculated Preferred Milling Direction. So this is examined, too. Result of milling is analyzed and compared with the result of another cut direction milling. From this, how the cut direction effects the surface is examined. Tool paths of each cut direction milling are made with drive curve method or drive surface method. So difference of these drive method is also discussed.

Student life in Belgium was so fun. I lived with many Arabic people and we always eat and drink together. I could also enjoy trips around Western Europe in the weekends or certain vacations. And in the beginning of July 2005, I came back to my country saying farewell to friends and European countries.

Exchange student life

My living place in Leuven was same building as other Japanese friends who lived in Leuven anterior half period with DeMaMech project, so I could make so many friends quickly not like in Denmark. Furthermore, almost all the friends were Arabic people that rarely can be made friends with in Japan. This meeting is one of the most valuable issues in Belgium. Although I could not find other Japanese in Belgium, I did not feel lonely. Because my English skill had been proved through the life in Denmark, conversation did not matter. The stories of the Arabic people were totally new for me. For example, stories about last Iraqi war talked by Iraqi (Kurdish) people stroke me. Because I had heard about Iraqi war only through with Japanese media, I did not know how the central players feel and what was really going on. And it drove me to feel shame my ignorance about the world. Also I could feel big difference of culture between Arabic countries and Japan.

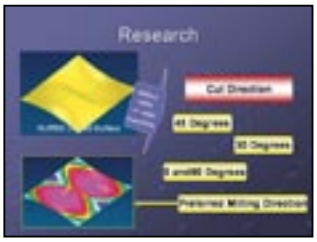
My life in Leuven was always same. I woke up in the morning, stayed and studied in the university until evening, cooked and ate my dinner, and play with my friends until midnight. On the weekend, I sometimes went on trips to other cities in Belgium, and also went to France, Germany, Netherlands, or so. Because Belgium is surrounded by big countries, I could enjoy my trips easily, not like when I was in Denmark. Through these trips, I could feel European cultures, I could meet many back-packers from several countries, and I could see historical cities. When I did not have a trip on the weekend, I went to discotheque or my friends' rooms and enjoyed until midnight or next morning. Then, Monday came and almost same week started. Although the life was something like routine, I really enjoyed the life.

When I was in Denmark, I have to go to big cities like Copenhagen using trains or buses if I want to do something with my friends. But in Leuven, there is almost everything and I did not need to go to other cities. If I want to drink beer, I can find bar within 10 minutes on foot. If I want to eat something, I can find restaurants and supermarkets within 10 minutes on foot. It was very convenient. Of course I like my life in Denmark as well but from the point of view of

convenience, life in Leuven is superior to Denmark, for me. Another good thing in Belgium was season. When I was in Denmark, first 1 month was summer and it soon turned to cold winter. So daytime was very short and just walking around in Denmark was hard work. In Belgium, it became hotter and daytime became longer day by day. Because Belgium is on a higher latitude than Japan, daytime in summer is much longer than I have ever experienced. That is why I could enjoy my life even when I have a study until late.

I will mention about diet in Belgium. K.U.Leuven has several school cafeterias and they sell nice meals with low price. The school cafeterias open until evening so I could eat not only lunch but also dinner in the cafeterias. Usually I used cafeterias for lunch and I cooked for dinner. Sometimes I took place Bar-B-Q party with my friends and it was so nice. Also Belgian sweets were delicious. I could get nice chocolate with very low price and if I walk around Leuven, I could find hot waffles.

Through all period of my life in Europe, the most important thing I have got is confidence and courage that was missing in me. I could get them getting over many problems all by myself. Now I can say that I can get over almost everything because I have experienced so many unusual things in Europe. And such confidence provokes me courage saying "I am sure that I can make it so I will try it". I am sure that this mind will be continued forever. So, I appreciate that I could have chance to live in Europe from all of my heart.



Summary

By virtue of the experience of life in Denmark, I could start my life in Belgium smoothly. So I could concentrate on both of my research and life. Through this studying abroad, I achieved following things;

1. Confidence and courage
2. Whole life friends
3. Knowledge of configuration system
4. Knowledge of 5-axis milling
5. Experiments of European cultures
6. English skill
7. Cooking skill.

[Research at DTU]

The purpose of my research is to make a configuration system for a clock company.
Present process of the company has some problems of lead time and quality. Therefore, process analysis must be done to optimize the process. Figure 1 shows present procedure. As it can be seen, there are many getting backs and it makes mistakes and long lead time.

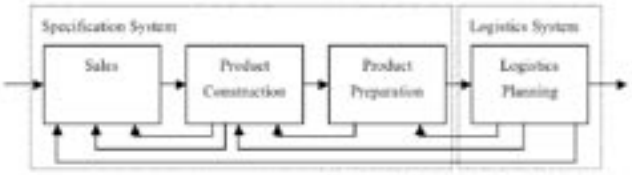


Figure 1. Flow chart of present procedure

So, it is necessary to get rid of these getting backs doing process analysis. Figure 2 shows desired procedure. Because the configuration system has every data of current process, getting back can be eliminated. It allows short lead time and few mistakes.

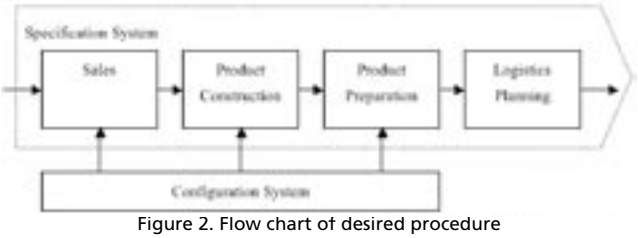


Figure 2. Flow chart of desired procedure

Table 1 shows gap analysis, which illustrates how much improvements can be expected with introducing a configuration system.

Table 1. Gap analysis

	Goal	Present	Gap
Lead time for quotation	1 day	7 days	6 days
Lead time for delivery	1-2 weeks	3-4 weeks	2 weeks
Mistakes in quotations	0%	25%	25%
Mistakes in list of parts and operational lists	0%	20%	20%

After finishing the process analysis, product analysis is done to specify all of the variants. The result of product analysis is illustrated in Figure 4 as Program Variant Master (PVM).

Figure 4. Program Variant Master

Then, object oriented analysis is done. First, class-diagram is made to define classes and relationships of classes. Figure 3 shows class-diagram of the configuration system. There are 6 classes corresponding to 6 subparts which can be seen in PVM. Console, face, clockwork and hands can be seen as components of a big console. In this case, this big console class is named "_Console" to separate from "Console" class which is a class of small console. The configuration system also needs classes of displaying operations card and cost list. Inheriting a class of operations card, a class which can calculate time of operation is made, and inheriting a class of cost list, a class which can calculate price of material is made.

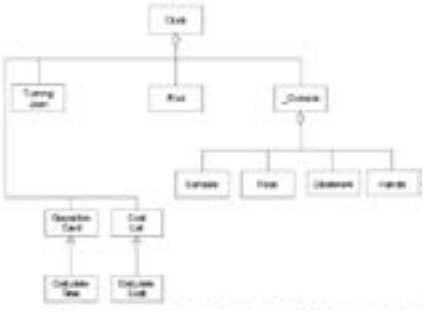


Figure 3. Class-diagram of the configuration system

To specify each classes, CRC(classes, responsibilities, collaboration) Cards are made. The number of CRC Cards is same as the number of classes which can be seen in Class-diagram above. In a CRC Card, there are descriptions like class name, responsibilities, aggregation, generalization, sketch, calculations, definition, etc. This must be made regarding to both of Program Variant Master and Class-diagram.

Using software *iBaan E-Configuration*, the configuration system is made. Because all of data is described in CRC Card, what the programmer has to do is just input the data into the software. The software checks errors, and if there are no incoherencies, a configuration system is created automatically as JAVA program.

Finally, using the same software, user interface is designed so as to user can use the configuration system easily. Figure 4 is a screen shot of created configuration system. The user interface page has 2 frames, Menu page and Contents page. Upper half of figure 4 is Menu page and the other half is Contents page. As figure 4 shows, there are some buttons in Menu page, such as "Console", "Clockwork", etc, and if a user pushes the button, corresponding page appears in Contents page.

Figure 4. User interface of the configuration system

Because the contents are categorized following to the Class-diagram, user can set variants easily. And if all the contents are displayed in same page, it will be very complicated interface, so this structure makes the interface simple. In Menu page, there are 2 windows to display total price and total time. With these windows, user can see total price and total time immediately after setting all variants.

Conclusion of this research is thus;

1) Doing process analysis, usability of the configuration system was shown. It is obvious that the process after implementing the configuration system is better seeing flow chart shown in figure 1 and figure 2.
2) Configuration system for clock company was made. To make the system, it starts with product analysis making PVM, and it also contains Class-diagram and user interface as object oriented modeling.

[Research at K.U.Leuven]

1 Introduction

The increasing complexity of parts of products makes the importance of 5-axis machining grow. During the last decade, much progress has been made, mainly with respect to multi-axis machines, machining technology, and CAM. However, the complexity of 5-axis milling machine still demands more research to put it into practical use.

Previous research at the K.U.Leuven calculates the Preferred Milling Direction (PMD) for each region divided from a surface. This indicates that there is necessity of considering cut direction when using multi-axis machine.
Although many pieces of CAM software are developed, all of them have no function which enables flexible cut direction. One of the reasons is that nobody has proved whether the milling considering cut direction is useful or not so far.
The aim of this research is to examine whether the some cut directions improve the quality of the surface comparing to the other cut directions.

This paper describes difference between several cut directions. Same NURBS surface is milled with 30 and 45 degrees cut directions. Also the surface is milled with multiple cut directions like 0 and 90 degrees and PMD for each region. These operations are done using drive curve method and drive surface method. So the difference between these 2 drive methods is also mentioned.

2 Creating CAM Operations

In this research, aluminum cubes are going to be milled to make the surface like NURBS curved surface shown in Fig.1.

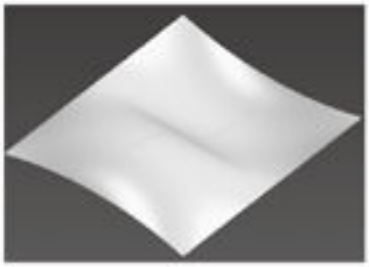


Fig.1 NURBS Curved surface

This NURBS surface is milled by cut directions of 30 degrees, 45 degrees, 0 and 90 degrees and PMD. Drive curve is applied for 30 degrees milling and 0 and 90 degrees milling as drive method while drive surface is applied for 45 degrees milling and PMD milling. With these 2 drive methods, tool paths are generated for each cut direction milling. And the generated tool paths are verified using a function of CAM software. If the result of the verification is satisfied, the tool path is converted into NC-program using post processing function of CAM software and the NC-program is applied for real milling machine to be milled.

3 Analysis

The milled surfaces are measured and compared with ideal surface. In Fig.2, there can obviously be seen gouging around

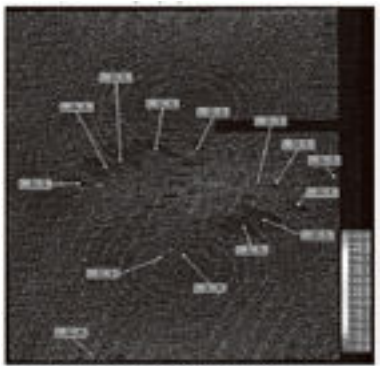


Fig. 2 Analysis of 30 degrees cut direction milling

the center. Since these gouging cannot be seen in the verification of tool path, this may be caused by post processing. To examine the post processing, simulation of the NC-program is done with CAM software. Figure 3 shows the result of the

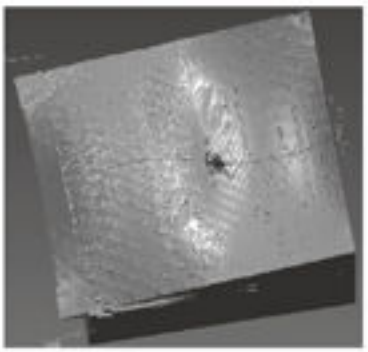


Fig. 3 Simulation of 30 degrees cut direction milling

simulation. Because of bug of CAM software, this result looks not clear, but still there can be seen errors same as figure 2. This means that even if there are no errors in the verification of tool path, errors may be appeared in the result of milling because of the bug of post processing function. So it can be said that errors is caused by post processing error. Now, post processing error will be discussed. Post processing function converts the tool path into NC-program. The structure of NC-program is continuous data of tool position and tool angle. And the milling machine implements between one position and the next position automatically. But because the implementation does not depend on the shape of the part, sometimes there occurs gouging. To solve this problem, the value of lintol should be set smaller.

Fig.4 shows the result of comparison of 45 degrees milling. There can be seen many large areas with 0.2mm or 0.3mm errors. Although these errors cannot be seen in the result of verification, tool path errors are still to be suspect because the surface is smooth as mentioned above. So I tried to compare the measurement of the surface and the result of verification of tool path. The result of comparison between

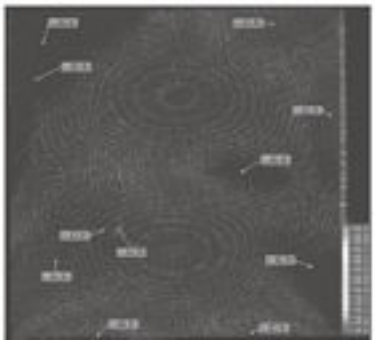


Fig. 4 Analysis of 45 degrees cut direction milling

measurement data and STL data looks same as Fig.4. It means these errors are not caused by tool path error. Measurement error is also examined measuring twice but it does not matter, neither. Remaining issues to be suspected is post processing error, but because of the bug of CAM program, it cannot be examined. Thus, these errors still need investigations.

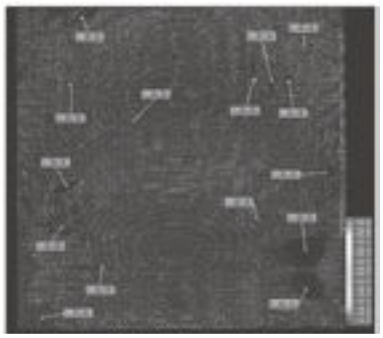


Fig. 5 Analysis of 0 and 90 degrees cut direction milling

Fig.5 shows the result of comparison of 0 and 90 degrees milling. There can be seen many errors. First, both of 0 degree cut direction and 90 degrees cut direction area has scallops with 0.2mm or 0.3mm height. Furthermore, there can obviously be seen gouging and uncut areas around the corner of the surface with 0.2mm or 0.3mm errors that cannot be seen in the result of verification. The colors of these areas are changed acutely unlike figure 4.5. It means the surface around the error is not smooth and bad quality.

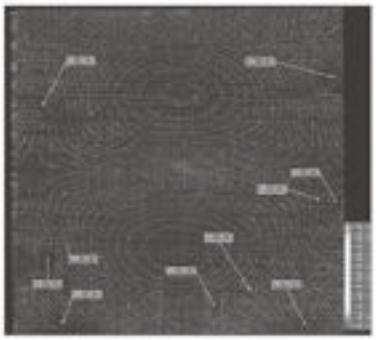


Fig. 6 Analysis of PMD milling

Fig.6 shows the result of comparison of PMD milling. Same as the result of verification, scallops exist only on the convex region. Between convex region and surrounding saddle regions, there can be seen acute color change, meaning not smooth surface. Although these errors cannot be seen in the result of verification, it cannot be said that these errors are not caused by tool path because the errors are not so big. So I tried to compare the measurement of the surface and the result of verification of tool path, same as 45 degrees milling. Fig.7 shows the result. This result seems to have less

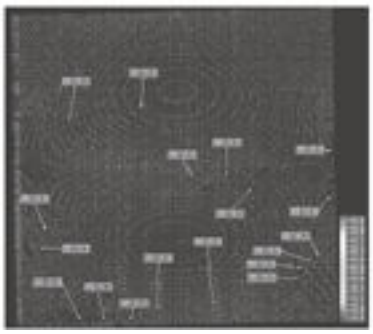


Fig. 7 Analysis between measured surface and the result of verification

error than figure 6 especially around the boundary between convex region and saddle regions. So it can be said that errors are caused by tool path error from this result. In this case, PMDs are applied only for convex and concave regions and not for saddle regions. Thus, errors are concentrated on saddle regions. This indicates adversely the usability of PMD.

Remaining gouging area on the convex region can be eliminated by setting the scallop height small.

4 Conclusion

This paper examined how the cut direction effects to the result of the surface and whether the some cut directions improve the quality of the surface comparing to the other cut directions. From the result of examination, following things are suggested:
1) Usability of Preferred Milling Direction
2) Superiority of drive surface method

On the other hand, there remain problems that need more investigations as follows:
1) Errors on 45 degrees cut direction milling
2) Preferred Milling Direction of the saddle regions

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Learning more than was taught

— **Yuka Mukaibo**, Keio University

13 Sep 2004 - Katholieke Universiteit Leuven, Belgium
02 Jan 2005 - Technical University of Denmark, Denmark
28 Jan 2005 - 08 Feb 2005 (Leuven, Belgium)

Executive summary

This report documents the experience and achievements as a participant of the EU/Japan Pilot Student Exchange Program from September 2004 to February 2005.

Research at KU Leuven. "A Practical Implementation of Virtual Fixtures for Robotic Surgery". The research consisted of;

- **Literature study on related research** Problems of past studies was considered and the purpose of the research was clarified
- **Experiments** Virtual graphical fixtures were made and experiments were conducted in order to find out how mechanical properties of the fixture surface affected the performance of an operator. The results suggested. Experiments consisted of path following tasks and reaching tasks in a virtual environment, and sensory evaluation was done using questionnaires.
- **Proposal of novel interface** The results suggested properties of the virtual fixtures affect feelings of fatigue and stability for the operator, and showed there was also difference in performance. Based on the analysis, a surgical operation interface was proposed, which would enhance safety and operability.

Student life in;

- **Belgium** Living in a room of a family home, life was mainly going to and from the laboratory. Much of the time was spent on research, and I also attended classes twice a week. Also enjoyed the Belgian food and weekend excursions.
- **Denmark** With only less than a month to stay in Denmark, life there was mostly spent on campus. Assigned a room in a "mostly Danish" student residence just minutes from the classroom, I enjoyed living with and getting to know other students of the residence.

Looking back at the experience, I suggest this program consider;

- **The program period** The three and a half month period was too short for research. If students decided to take courses, the workload could become considerably large.
- **Housing arrangements** Many students had difficulty finding appropriate housing for the short period of stay in Leuven. (It was not a problem in Denmark)
- **Requirements from the Program** Participants were not really aware of what was expected of themselves prior to the program (e.g. if there was to be a presentation, if we were to put together a thesis).

Exchange student life

Life as a student in both countries was extremely comfortable and enjoyable. In either county, I was very impressed to know that most of the people I met spoke English very well and I never felt the frustration for not being able to communicate. People were always friendly and willing to help which made my stay ever more fruitful.

Belgium
In Leuven, I stayed at a family home, with a 57 year old lady who rented out rooms that she had free after her children had grown up and left. She had three rooms to rent and the kitchen, bathroom and toilets were shared, but I never experienced having to wait for my turn since there was usually only one other than myself (apart from the landlady). Rent was 300/month, a little expensive compared to the other students, but it was worth every cent. Thanks to the landlady, the house was very tidily kept but always warm and cozy. The rent included electricity and water, etc., but there was no internet access or a common television in the home.

To get around the city, I rented a bicycle for the three and a half months there. It was necessary since the department of mechanical engineering was about 2km from where I lived. Bike rental for students was operated by a non profit organization called 'Velo' which was very inexpensive. Students of KU Leuven were also granted access to the bus network within the Leuven area, which was useful especially in bad weather.

Food in Belgium was very good, and inexpensive. During the week, I would have lunch at the university cafeteria with my colleagues. Breakfast and dinner I usually prepared at home, with occasional kebab and frites.

Weekdays would start by getting up at around 8:00am. After preparing I would have breakfast and take a quick look through the newspaper (I subscribed for the International Herald Tribune for three months), and leave for school between 9:00 and 9:30, arriving at the lab within 10 to 15 minutes. After working on my research in the assigned corner in the lab, I would go for lunch with the other Japanese students, and sometimes with a Belgian student. Research continues in the afternoon, until 6:00 to 7:00 pm, sometimes

later. Usually one of the Japanese students would suggest going home, and we would go home together. If I didn't have any special plans, I would drop by a supermarket on the way home and be home between 8:00 and 9:00pm. I then would prepare myself something to eat and spend the rest of the evening reading or doing assignments from class.

In the weekends I often got together with other exchange students since Belgian students would usually go home to spend the time with their families. There were many students from a variety of countries, so I had no problem finding someone to spend some time with. I sometimes went out with my landlady, and she took me out on her car to places hard to reach by train or bus.

I also enjoyed the many activities the university provided in the evenings, which I could attend after I was done with my work in the lab. For example, there was a lecture by key personnel of the Court of Justice or the European Communities on the challenges of the EU, which was particularly interesting for me since the EU had just expanded to 25 countries, and the issue of Turkey was gaining much attention. There was also a lecture on post development which was equally interesting.

Denmark

The life in Denmark was a little different compared to Belgium. To start with, the international affairs office found me a room in a student residence on campus, a five minute walk to the classroom. The room had a shower and toilet, and only the kitchen was shared with 24 other residents. The residence was apparently very popular, and I was very lucky to have been able to find a vacancy there. Most of the other residents were Danish, which was good for me to get to know some Danish students, since I would only be staying in Denmark for less than a month. The kitchen was more like a common room, very spacious with a television and even a darts board and soccer game. There was internet access in my room, and also a telephone line, but I had no phone.

There were no bike rentals as there was in Leuven, and since the campus was far from the station to walk, weekdays were mostly spent on campus.

Food I took mostly at home except for the weekends. There were many reasons for this. One would be because everything was so expensive in Denmark, even in the cafeteria. Secondly, there weren't many places to eat near the university, and the closest would be going to the station. Days were short (I was there in January) and nights could get very cold, which kept me from leaving the warmth of my room, saving time and energy.

Since I took a course in Denmark, and the class started at 8:30, I had to get up earlier than I did in Leuven. There would be lectures from 8:30 to 12:30 with usually 3 coffee breaks. After the morning lectures, I would go home to cook myself lunch. There were never lectures in the afternoon, but the professor always had assignments for us to do, which were done in groups of two to three, so we would get together in the afternoon, at 1:00 or 2:00pm in the library or the computer room (known as the DATABAR) to discuss and put together a report for the assignment. Usually this would go on until 7:00 or 8:00pm. After that, I would either stay at the library or DATABAR a little longer to read and answer emails or go home to eat. During my stay at DTU, I had a lot of work to do concerning classes at KU Leuven and from my home university, so after dinner I would usually be facing my computer to work on the assignments.

Suggestions to the project

1. The period of the program

After my 5 month experience, I strongly felt that the three and a half months at KU Leuven was too short to do research and to achieve a certain amount of results with substance. If the student was already well aware of the field of study and had started with the research before going abroad, I believe the situation would be different. I did have contact with a PhD student concerning my research, but I hardly had time to prepare for the research, since it was very different to the study I was doing then at my home university. I recommend the students be given more time if they are to focus solely on research. If that is not impossible, I suggest that the supervisor of the host university and the student thoroughly discuss the theme of research before the program so that the student has at least a brief idea of how the research would commence. I regret not reading through papers of related studies before the program since that took much of my first couple of weeks in Belgium.

I also attended two lectures, "Introduction to Management", and "Behavioral Decision Making", and attended Introductory Dutch classes for the first two months, but the workload was too much, I dropped out of the Dutch class after two months. But I strongly recommend students to try to attend a course. Research can be pretty individual, and you spend a lot of time on your own. But if you follow a course, especially a course with which involves much interaction among the students, you really get to experience how differently things are taught and I definitely benefited from the courses and was able to make many friends.

2. Housing arrangements

Although I was lucky and found a place to stay after one day of searching, many of the students had trouble finding a place to stay at Leuven. I strongly recommend a system that secures a place to stay for the students prior to arrival. This also concerns the lack of information provided, which is mentioned later.

I also suggest the program encourages students to stay in a room with shared kitchens and bathrooms. I think that such accommodations provide a good opportunity for students to communicate with different people from other countries, and especially since the students will only be living there for a limited period of time, they should cherish the time they are given to enjoy cultural exchange. In Belgium, I lived in a family home, I was privileged to experience a typical Belgian home. In Denmark it was very different, where the kitchen was shared with 24 other students, and it was great fun to be able to communicate with other students. I enjoyed every moment of it. This was my first experience to live alone, and in the beginning I wanted to live in a studio, with a private bath and kitchen, but I am so glad I didn't.

3. Requirements of the program was unclear

We were not told in advance what exactly was expected of us in this program. In my case, it was not until there was a meeting with the professors and other exchange students in the beginning of October, that I knew we were to make a final presentation at the end of my stay to share the achievements of my research, and was also to hand in a thesis. Concerning the intensive course at DTU, we were not told when to apply or which courses to choose from, and had it not been for my colleagues, I may not have been able to

apply in time. Since I had applied for a very popular course (apparently over 100 students applied for the course which had only 40 places available), I may have ended up on the waiting list, or not have been accepted at all.

4. Confusion of Information

There seemed to be a lot of mix up during the whole program. I guess it was because the program itself was new, but with the time difference between Japan and Europe, such mix-ups could sometimes take a while to clear. First it was concerning housing. I have mentioned earlier that it was difficult. In the beginning, I was told "a standard student room which normally comes free from students leaving Leuven to study abroad" would be reserved for me. But it turned out no such room was prepared and I had to go find a room after arrival. Then it was concerning the scholarship. Some students were told to send a facsimile to their home institutes to prove they were participating in the program while other students were told to just send an email. There was a lot of different information concerning the return flight. I was first told I could only return to Japan from Copenhagen, while a student following the same schedule as me from Hokkaido University was allowed to return from Brussels. In the beginning I was told to return to Japan within 5months (which was by February 12th), where as later, I was told to return within the first week of February.

I suggest information is more thoroughly discussed among the different universities to avoid such confusion. None of the problems I experienced was vital that it affected my research or my life, but things may have progressed more smoothly had I been given more reliable information from the start.

Summary

To be blunt, the five months that I was able to spend in Europe was a great experience I will treasure for life. I enjoyed every moment of it. Probably because I was brought up abroad, in the U.A.E., I feel extremely comfortable living in a multi-cultural environment, and working together with people of the same age from various countries. And this program provided me with precisely that.

While at KU Leuven, I was able to spend quite some time on my research, and managed to reach a conclusion with what I was working on. But the time was far from enough for my thesis to reach the quality I would have liked. As I may have mentioned earlier, I regret for not having started working on the theme in advance had I the time to do so. But I do not regret having spent time taking courses. All the classes I attended was very beneficial, and since I deliberately took courses not directly connected to my field of study, much of what was being said was new to me, which I found intriguing. Classes gave me an opportunity to speak with other students from different faculties, which was something I also looked forward to. I was amazed at how we could come up with such different solutions to the same problems. The classes are bound to influence my ways of thinking in my career.

Time at DTU was more relaxed, since the schedule and exercises of the course were clearly stated at the first lecture, including the time expected to spend on the assignments etc. Assignments themselves were also pretty straight forward. Since exercises were done in groups, it was another opportunity to get to know other students of other countries.

I have learnt much more than just what was being taught in the courses and what was written in the papers I read. So much was different from what I had known and was used to in Japan. It was a while since I last lived abroad, but it surely has brought back the senses and has strengthened the curiosity toward cultures other than my own. This experience is sure to influence my future, and I hope that I can reap the benefits of the five months. I have made many friends that will surely cherish them.

I would finally like to take this opportunity to express my gratitude to the organizers and professors who made this program come true. I did not expect to experience so much in such a short period of time, and although I would have liked to stay longer in Europe, the five months have been truly meaningful I hope many students will follow in years to come to enjoy the program as much as I did.

[Research at K.U.Leuven]
A Practical Implementation of Virtual Fixtures for Robotic Surgery

My research at KU Leuven was on "A Practical Implementation of Virtual Fixtures for Robotic Surgery".

1. Background and purpose of the research

Minimally invasive surgery is widely used and well-known within the medical community. More automation or the aid of robotic devices currently gets major attention. With technical aid, faster operation or extension of the application to micro scale can be made possible. However, only a few studies focus on creating intrinsically safe systems when conducting surgery. Although in recent years more robotic systems are in development, commercial applications are still few.

In a surgical procedure, the operator will have control of the operation manipulating the master device in a 3-dimentional space within predetermined constraints. In order to diversify possible types of operations, the system must also be applicable to soft tissue surgery. Past methods predetermined constraints based on CT scan images, but this would not always be appropriate since there is no assurance that the tissue would be in the same place before and after the CT scanning. Therefore, a simple graphic interface is proposed through which the operator can define the constraints from visual information through laparoscopes without having to move the patient. This approach allows the surgeon to define constraints real time in the actual space where the operation is to be held. Therefore traditional procedures in which limbs or body parts, usually bones, were either secured or markers were placed in order to obtain the same axes to work on would become unnecessary. The operator, or surgeon, may create multiple constraints with a hierarchical relationship, determining the degree of constraint for each graphical constraint. Thus allowing to create an active space in which certain areas would be either impenetrable or the surgeon would feel a certain constraint but still have control to move beyond the predetermined wall, or feel no constraints at all.

This research was conducted to evaluate and determine the appropriate properties for the virtual fixtures to enhance safe and more practical master/slave manipulative surgical systems. As a master device, the haptic device PHANToM of SensAble Technologies (Fig.1) is used owing to its dexterity and large degree of freedom.

Fig.1 PHANToM haptic device

2. Virtual Fixtures and experiments

Different levels of constraints are known to be necessary during a surgical procedure [Davies 2003]. During a surgical operation, if the organ subject to surgery is adjacent to other organs or vital arteries,

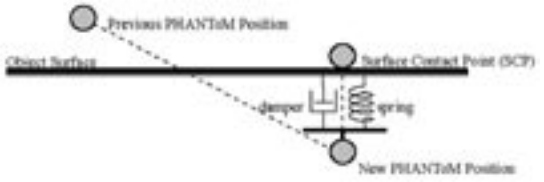


Fig.2 Surface Contact Point of PHANToM

Table 1 Parameters of Impenetrable Surfaces

	Spring Constant	Damping Constant	Static Friction	Dynamic Friction
Case1	0.8	0.0	0.2	0.2
Case2	0.2	0.0	0.2	0.2
Case3	0.8	0.0	1.0	1.0
Case4	0.8	0.003	0.2	0.2
Case5	0.8	0.003	0.2	0.2

virtual fixtures should assure the instrument does not harm its surroundings. Therefore, the surface of the fixture should be impenetrable. However, in some cases, for instance trying to cutting through tissue, virtual fixtures could provide virtual force feedback just to assist the process. Creating penetrable virtual fixtures could also be useful as a warning that the surgeon may be working in an area which requires precaution. In this study, virtual fixtures have been divided into impenetrable surfaces and viscous volumes.

Using Ghost SDK software, virtual geometric shapes were created as examples of virtual fixtures to conduct the experiments. Three parameters were considered in this study; spring coefficient, damping coefficient, and viscosity. Spring and damping coefficients were set based on the surface Contact Point model of PHANToM shown in Fig. 2.

Two types of experiments were conducted on test participants; path following within a virtual tube path with impenetrable surfaces, and reaching movements within a viscous volume. Five cases with different properties were provided for the impenetrable surface experiments as shown in Table 1. Test participants conducted the path following tasks with limited visual information; the subject had to move along the path based on the tactile feedback applied by the haptic device. After each task, the participant was asked to answer a questionnaire concerning level of comfort, stability, accuracy, fatigue and stress he/she felt during the task execution. For the path following tasks, time was also measured to see how performance improved among the different cases. All participants were unfamiliar with PHANToM, and were given five minutes prior to the experiment with sample programs to get used to maneuvering the device.

Examples of the path following task execution time are shown in Table 2. All subjects had faster results when the spring constant was high, meaning the surface was stiff. The average of time shortened here was 28.5%. This meant large spring constant values are effective in areas that require fast execution.

Table 2 Path following execution time

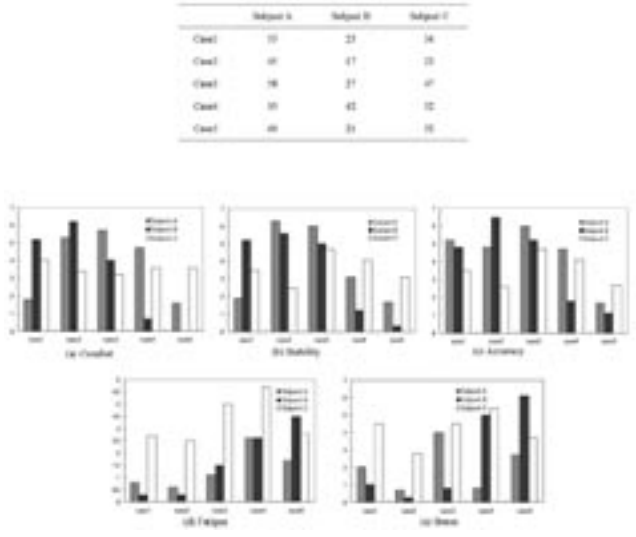
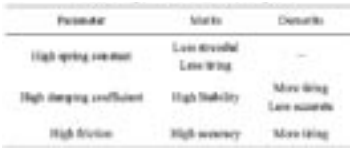


Fig.3 Sensory evaluation (Impenetrable

Table.3 Experiment results analysis



Execution time was also shortened in cases where friction coefficients were small, in this case, by 30.5%. However, no significant results could be obtained from changing the damping constant; therefore we can consider damping does not directly affect the execution time of a task.

Results for the sensory evaluation of the path following task are as shown in Fig.3 A summery of the results are given in Table.3 The perception of "comfort" varied among the different participants, therefore results provided no noticeable characteristics. However, the evaluation of fatigue factors was clear; high spring coefficients proved less tiring, where as high damping coefficient and high friction both made tasks more tiring. Although damping and friction were disadvantages when arguing fatigue, damping gave operators a greater feeling of stability, and high friction enhanced the feeling of accuracy.

Results of the viscosity experiments show that implementation of virtual viscosity to a workplace could be beneficial. Although, a majority considers the viscosity as more tiring, users feel more stable and can get a strong feeling of accuracy and control during the operation. Indeed, during the reaching tasks, people tended to exceed an aimed point where there were no virtual constraints. However, when viscosity was implemented, the reactive force that is applied to the user through the master device helped compensate for the extra energy and led to more stable and accurate manipulation.

3. Proposal of Surgical Assistance Interface

Based on the results, I proposed the fundamental structure of a novel surgical interface consisting of three types of virtual fixtures; forbidden areas, tube passageways, and viscous volumes.

(i) Forbidden areas
When wanting to define an area which is forbidden for the surgeon to enter, the surgeon can implement geometric fixtures or walls that are impenetrable. From the experiments, results have shown that with an impenetrable fixture, the spring coefficient should be set at a high value to effectively avoid the area. The damping coefficient of the surface could also be set high to maintain stable manipulation during the operation.
The surgeon may set the spring coefficient low if the position and shape of the forbidden area is not important to the operation. Setting too many highly stiff fixtures may restrict the workspace, thus reducing effectiveness.

(ii) Tube passageways
When the surgeon has to move from one place to another frequently, the tube passageway could be implemented. These are tunnels that are impenetrable from the inside, and assures the surgeon fast and safe access to the other end. In such cases where the end effecter moves from one place to another, the surface parameters of the tubes should be set so as to realize fast movement. Therefore, spring coefficient are set high, damping low, and dynamic and static friction coefficients set low.

(iii) Viscous volumes
Experimental results showed that implementing virtual viscosity helped stable feeling during the execution of a task. Viscosity also enhanced the feelings of accuracy, which means that the surgeon can move the manipulator more instinctively. Therefore, in the proposed interface, the surgeon can define volumes that display viscosity inside. Primitive geometric shapes can be inserted to the workspace in places where the actual operation takes place, and where caution is necessary in executing tasks.

Different types of fixtures can all be implemented into one scene to create a safe surgical environment with layers of virtual fixtures. The surgeon may define a hierarchical relationship depending on the priorities of the operation, thus avoiding interference among the different fixtures.

Reference

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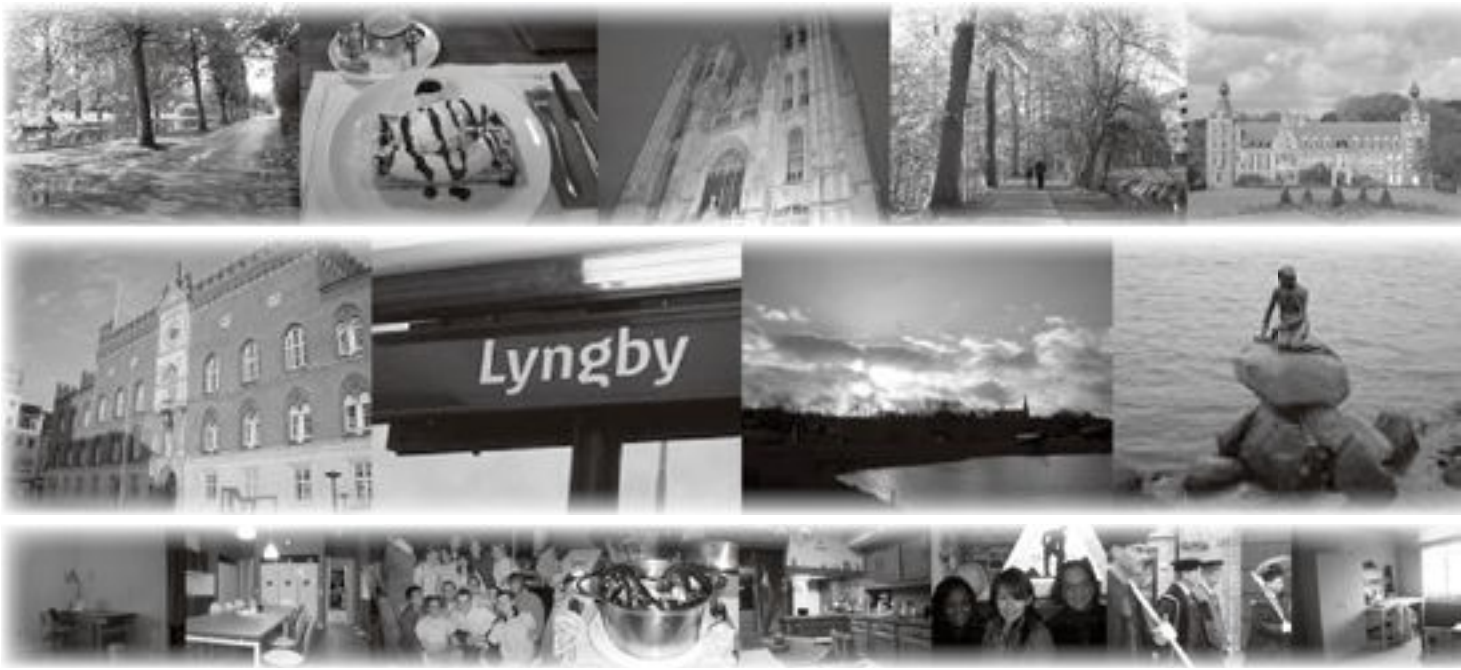

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Valuable experience as exchange student

— **Kazumasa Yokoo**, Keio University

15 Sep 2004 - 23 Dec 2004 Technical University of Berlin, Germany
Jan 2005 Technical University of Denmark, Denmark

Executive summary

Technical University of Berlin:
Studying of Design Methodology and
Designing of a Fixture and a Tool
Downsizing devices is one of the most interesting themes in engineering field because it is expected to reduce environmental impact, to realize small space and high efficiency. Therefore, components in micro or nano accuracy are necessary in order to build these devices. In this work it will be focused on the manufacturing process to make a micro chip which is used for analyzing the DNA and so on, and tried to develop the micro processing machine for that. In this research the design methodology was studied and a fixture and a tool for micro processing machine with help of the design methodology was designed.

Technical University of Denmark:
Investigation of Lubricants and
Extreme Pressure Additives in Ironing
Pick up and galling due to lubricant film breakdown is a severe limitation in cold forming of difficult metals like stainless steel and aluminum. This is leading to investigations in how changes of additives in lubricants influence lubricant film breakdown on the several conditions. It was found that the viscosity effect has a great influence for lubricant. In addition, it was also found that the lubricant including chlorine as a compound in a mineral oil lead to a longer threshold drawing length at the high temperature before galling occurred. This matter implies that there are some effects in the lubricant film which could be explained as an effect made by the chemical additive at the high temperature.

I studied not only researches but also English, culture and the way of living strange country. And I made many friends not only European but also American, Asian and Japanese.

I went to ten countries and around thirty five cities to do sightseeing. This exchange program was very good experience for me. If I have a chance, I'd like to go again.

Exchange student life

I was not good English speaker before I went to Berlin. That's why I was afraid of going there as an exchange student. After I was selected as an exchange student, I studied English very hard. Of course I don't think I can speak English frequently now. However, I could get courage that I am not afraid of speaking English and strange places.

I studied not only English, research and culture but also the way of living strange country, which mean that there are not any people whom I can be counting on like family and friends. And I made many friends not only European but also American, Asian and Japanese.

Germany:
I got many culture shocks in Germany. I will describe some of them.

One of the most surprising things is that there are some people who can't speak English. And people who live in German don't like to speak English. Before I came to Berlin, I heard from my seniors in my laboratory who went to Germany (not Berlin but Hannover) last year that they never used German. Therefore I had thought that I only studied English. However, if I tried to talk to somebody in English, I got a cool reception. For example, when I went shopping to buy foods for dinner and asked a shop assistant where the articles are in English, he spoke to me in German. But I couldn't understand German. After all, I had to seek them by myself. Everybody talked to me in German in spite of my appearance is not German. Therefore, I studied German and I felt that I had better study German before I came to Berlin.

One month ago before Christmas, Every city in Germany became hot city like Japanese Festival. It called "Weihnachtenmarkt". A Vienna sausage was very good. And Illumination of trees, streets and houses were very beautiful. However, Every shops were closed in December 24th and 25th and Everybody went to a church. Christmas is sanctity for European.

Weihnachtenmarkt in Stuttgart

The institute staffs in KTEM were very kind. They helped me not only in the advice about my research, but also in my private life. Every coffee break and lunch time, they asked me whether I go to café or restaurant together. I really appreciate their help.

Farewell party in TU Berlin

Denmark:
In Denmark, I could speak English. That is the most different point. And prices were very expensive. So everyday I made lunch box and dinner.

The research in DTU was for three weeks. I thought firstly that this class was only lecture because of shot time. However, it was study including making a report and presentation. Therefore, the class was hard schedule and we could not get the desired result. Moreover, I could not manage the research procedure.

The last lecture in DTU

I went to ten countries and around thirty five cities to do sightseeing. In the travel, I could see many old buildings and natures. They were very beautiful.

Charles Bridge in Praha　　Aurora in Rovaniemi

This exchange program was very good experience for me. If I have a chance, I'd like to go again.

Suggestions to the project

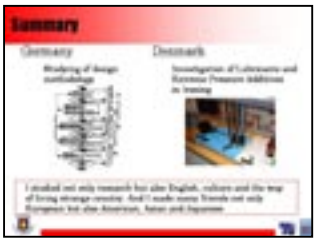
- I went to two institutes in spite of short time exchange program. Therefore, I could not finish and satisfy my researches, especially in DTU because of only three weeks lecture. I think that it is better to go only one institute in the case of short time study.
- I had a problem that I could not get a student ID card first because of lack of a paper in TU Berlin. In the guide book for an exchange student, it was not said that we need the paper. I asked to send the paper to International office, and finally I could get ID card. I thought there were too many steps to get something in spite that I went studying. I wanted a condition to study smoothly.
- I think it is better to study German before if we go to the Germany. I went there without studying German. Thus I could not understand at all. We need a marginal skill for daily life before we go there.

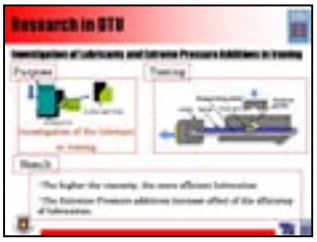
Summary

"Studying of Design Methodology and Designing of a Fixture and a Tool" was done while I belonged to Department of Mechanical Engineering and Transport System in Technical University of Berlin. And "Investigation of Lubricants and Extreme Pressure Additives in Ironing" was done while I belonged to Department of Manufacturing Engineering and Management in Technical University of Denmark. Prof. Dr. -Ing Lucienne Bressing who gave me a great opportunity in TU Berlin and Assistant Prof. David Dam Olsson who gave me it in DTU are thanked heartily.

This exchange program was very good experience for me. I really appreciated anyone who helped me. Thank you very much.

At last, I appreciate Prof. Dr. Tojiro Aoyama in Keio University and his laboratory staffs, and my parents who permitted my invaluable studying abroad.





[Research at TU Berlin] Studying of Design Methodology and Designing of a Fixture and a Tool for Micro Processing Machine

I. Introduction

Downsizing devices is one of the most interesting themes in engineering field because it is expected to reduce environmental impact, to realize small space and high efficiency. Therefore, components in micro or nano accuracy are necessary in order to build these devices. And MEMS (Micro Electro Mechanical System) technology is focused and actually used. On the other hand, the analyzing system called micro TAS (Micro Total Analyze System) with a very small device is focused, and MEMS technology is also made available to build up this device. However, it needs much time to make it and unconventional/heavy equipments or tools to build a microscale structure are required because conventional processing method puts to use institute unique technology. In my research, it will be focused on the manufacturing process to make it, and tried to develop the micro processing machine for that. Especially the emphasis targets in this paper are that the fixturing device and the cutting tool for the micro processing machine were designed with help of the design methodology.

II. Design methodology [1]

A design process can be divided into four stages, such as "Clarification of the task", "Conceptual design", "Embodiment design" and "Detail design". Figure 1 shows this process step by step. Every process can be fed back and it can return to previous steps as described figure 1.

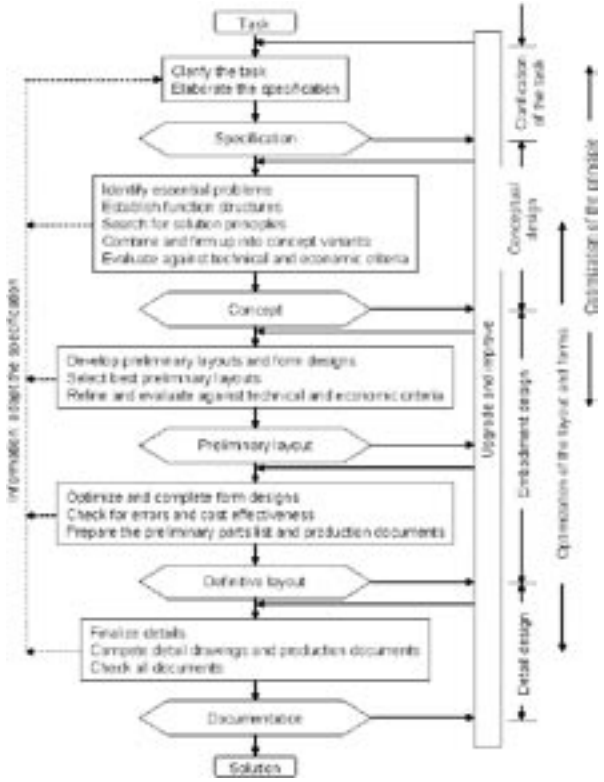


Figure 1 Steps of the design process

1. Clarification of the task

The designer's work starts with a particular problem. Every task must be fully understood whether the optimum solution is to be found. Therefore, the task must be defined as fully and clearly as possible so that amplification and corrections during designing can be confined to the most essential. To realize the clarification, a specification (requirements list) should be drawn up and consulted. In requirement list, only the required function with the appropriate inputs and outputs and the task-specific constraints should be specified at the start because the solution of the task or concrete ideas often have an adverse effect on the final outcome. Therefore, it is essential to state whether the individual items are demands, which are requirements that must met under all circumstances, or wishes, which are requirements that should be taken into consideration whenever possible, when making a requirement list.

2. Conceptual design

Conceptual design is that part of the design process in which, by the identification of the essential problems through abstraction, by the establishment of function structures and by the search for appropriate solution principles and their combination, the basic solution path into concept variants is laid down through the elaboration of a solution concept. A successful solution is more likely to spring from the choice of the most appropriate principles than from exaggerated concentration on the finer points.

(1) Abstracting to identify the essential problems

The clarification of the task with the help of a specification will have helped to focus the designer's attention on the problems involved and will have greatly increased his particular level of information.

(2) Establishing the function structures

We need a system with a clear and easily reproduced relationship between inputs and outputs (See figure 2).

Figure 2 Task or function described on the basis of inputs and outputs

Depending on the complexity of the problem, the resulting overall function will be more or less complex. Just as a technical system can be divided into sub-systems and elements, so a complex or overall function can be broken down into sub-functions of lower complexity. The combination of individual sub-functions results in a "function structure" representing the overall function (See Figure 3).

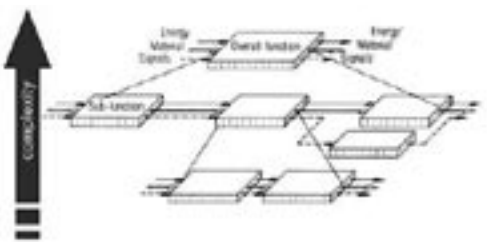


Figure 3 Establishing a function structure
by breaking down an overall function into sub-function

(3) Searching for solution principles to fulfill the sub-function
Solution principle has to be found for the various sub-functions. It should be important that the step of searching for solution principles is intended to lead to several variants in each sub-function (a solution field).

Figure 4 Basic structure of a classification scheme with the sub-functions of an overall function and associated solutions

In order to seek for solution principles, conventional methods like Literature, textbooks, journal, magazines, internet, solution catalogues, professional information, patents, analysis of natural system, analysis of existing technical system, analogies, measurements and model tests, heuristic operations, are available. In addition, methods with an intuitive bias or with discursive bias are much helpful.

(4) Selecting and combining solution principle
After searching solution, it is necessary to select suitable solution principles from function structure and to elaborate overall solutions from the combination of principles. The basic of such combination is the established function structure which reflects logically and/or physically possible or useful associations of the sub-function.

(5) Firming up into concept variants
The principles elaborated in 3 and 4 are usually not concrete enough to lead to the adoption of a definite concept variant. Before concept variants can be evaluated, they must be firmed up which, as experience has shown, almost invariably involves a considerable effort.

(6) Evaluating the concept variants
In the next step, the solution proposals must be evaluated so as to provide an objective basis for decisions. There are special evaluation procedures to fill this need. One of them will be introduced.
The first step in any evaluation is the drawing up of a set of objectives from which evaluation criteria can be derived. Then we must first assess their relative weighting to the overall value of the solution. A weighting factor is a real, positive number. It indicates the relative importance of a particular evaluation criterion. The next step is the assessment of values and hence the actual evaluation. These 'value' derive from a consideration of the relative scale of the previously determined parameters, and are thus more or less subjective in character. The values for every variant having been determined, the overall value must be calculated.

3. Embodiment design
During this phase, the designer, starting from the concept, determines the layout and forms and develops a technical product or system in accordance with technical and economic consideration.

4. Detail design
This is the phase of the design process in which the arrangement, form, dimensions and surface properties of all the individual parts are finally laid down, the material specified, the technical and economic feasibility re-checked and all the drawings and other production documents produced.

III. Designing of a fixture and a tool

A fixture and a tool for micro processing machine are actually designed with the help of the design methodology. The followings are results of conceptual design.

- A workpiece is put into a micro processing machine manually before processing and removed from there manually after processing (according to the requirement list).
- The machine is not equipped with any sensor to recognize the workpiece shape.
- The machine has a locating point which is defined by three locators. Locating method is "2:1 locating system".
- Two clamper moves the workpiece to the locating point which is defined by the locators.
- The clampers were located on the opposite side of the locators, and positioned between the locators.
- The processing stage can move in the ±X and ±Y direction (according to the requirement list).
- The tool can move in the ±Z direction (according to the requirement list).
- Process technology is "water-jet".

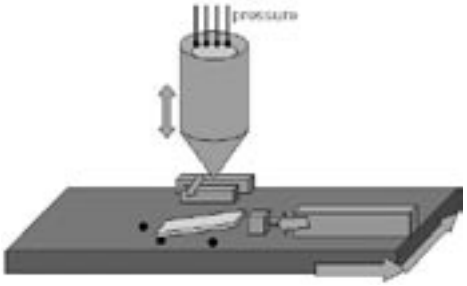


Figure 5 Designed fixtures and a tool

IV. Conclusion

The design of a fixturing device and a tool for micro processing of glass or plastic was performed through the design methodology. The result is a conceptual design. Through evaluation of solutions, Figure 5 was the best overall solution. However, the control method of cutting depth is necessary to realize the require process by the water-jet technology.

V. Future works

It is necessary to finish the design work with the embodiment design and the detail design. A prototype model should be build up. Moreover, the arrangement, form, dimensions and surface properties of all the individual parts should be finally firmed.

VI. Reference

[1] G. Pahl, W. Beitz, Edited by Ken Wallance (1984), " Engineering Design", The Design Council, pp.41-132

[Research at DTU] Investigation of Lubricants and Extreme Pressure Additives in Ironing

I. Introduction

Sheet material processing is one of the most interesting themes in the engineering fields because sheet materials are available in car industry, cans making industry and so on.

In the sheet material processing, ironing is one of the tribologically most severe processing owing to the high surface expansion and normal pressure at the tool-workpiece interface. Therefore, lubrication between tool and workpiece is very critical when forming metal parts. A major problem in this processing is the tendency to lubricant film breakdown resulting in pick up of workpiece material on the tool surface and subsequent scoring of the workpiece surface, the phenomenon normally referred to as galling. This problem is especially pronounced in deep drawing at the die entry radius, in draw beads in drawing as well as in stretch forming operations and in ironing. In order to avoid galling, chlorinated Paraffin oils normally have to be applied. However, these oils are expected to be abandoned in near future because of environmental problems. Therefore, implying that substitute lubricants needs to be developed and tested. For this reason, knowledge regarding the sustainability of a lubricant is very vital which means that prediction of when a lubricant fail is very important. The parameters which have the largest influence on the failure of breakdown of a lubricant are known to be the ones which relate to the tool/workpiece interface:

- Contact pressure (Reduction)
- Temperature of contact point

Thus a lubricant film breaks down earlier in a process if either contact pressure or temperature (or both) increases.
Earlier studies have shown that the breakdown of a lubricant can be predicted by identifying a critical temperature by preheating the tool to different temperatures. At this critical temperature the lubricant has reached a viscosity which thins the film to such a degree that the tool and workpiece topography come in close contact leading to direct metal-to-metal contact and subsequently total lubricant failure.

As mentioned above, the lubricant film break down is a problem in industry and the method to predict when the lubricant film breakdown occurs has been developed. But how the characteristic of lubricants influences on the lubricant film breakdown is not still clear. Then in this paper, the influences have been investigated by conducting the strip reduction test.

II. Experiment condition

In the present work the limits of lubrication have been studied applying a strip reduction test, simulating the tribological conditions in ironing (See figure 1).

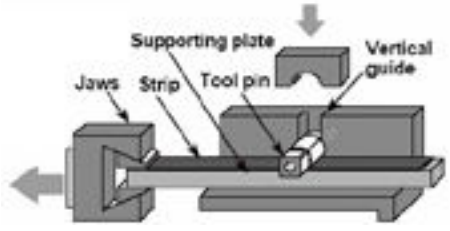


Figure 1 A strip reduction test

The following test procedure has been applied in this experiment.

(1) The tool is disassembled. (2) All tool parts are cleaned thoroughly in an ultrasonic bath with naphtha. (3) The equipment is also cleaned to remove the lubricant that is used for the previous experiment. (4) A thin lubricant film is applied to the workpiece with a hand. (5) If necessary, the top plate to adjust the reduction is changed. (6) The workpiece with a thin lubricant is set on the supporting plate and the tool is assembled in the vertical guide. (7) In the case of pre-heating experiment, the tool is heated with a heater. And tool temperature is measured. When the temperature is reached to the wished one, the heating is stopped. (8) The strip reduction test is conducted. (9) The workpiece is removed from the equipment and cleaned. (10) Steps (1)-(9) are repeated with a new test workpiece. (11) The length of drawn workpiece surface before any visible scratches appear on the surface is taken as a measure of the threshold sliding length before the onset of pick-up and galling.

III. Result

1. The influence of viscosity

First, the experiment for investigating viscosity dependence on lubricant film breakdown has been conducted. Lubricant samples are described in Table 1. The experiments have been carried out on the following condition; reduction-30%, tool temperature- 20°C. The results are shown in Fig 2.

Table 1 Code and description of the tested lubrication

Code	Description	Viscosity [cst] (40℃)
CR5	Pure Mineral Oil	660
125P	Pure Mineral Oil	125

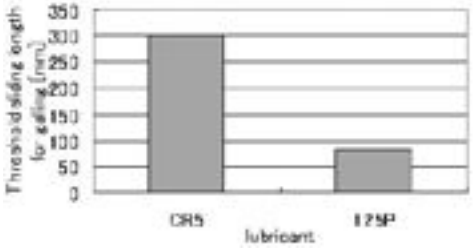


Figure 2 Comparison between CR5 and 125P

It is found that the threshold sliding length for galling of CR5, which has higher viscosity than 125P, is longer than that of 125P in Fig 2. Both of CP5 and 125P are pure mineral oil. Only the viscosity is different between these two lubricants. Thus it is found that the lubricants that have higher viscosity show better results.

2. The influence of additives

Next, the influence of containing additives has been investigated.

2-1. Difference of additive

Table 2 is a detail of sample lubricants to investigate the influence of additives. Viscosity of these lubricants is almost same.

Table 2 Code and description of the tested lubrication for

Code	Description
125P	Pure Mineral Oil
TDN81	High additive mineral oil with chlorine based EP additive. [Containing Chlorinated Paraffin consisted of 40% Cl]
CP15	125P (85%) + CP3179 (15%) [Containing Chlorinated Paraffin consisted of 7.5% Cl]
CP3179	Pure Chlorinated Paraffin consisted of 50% Cl

TDN81 is most widely used in industry and it is known that TDN81 contains Chlorinated Paraffin composed from 40% chlorine as an additive. Therefore especially the experiment for investigating influence of Chlorinated Paraffin containing chlorine has been conducted. The experiments have been carried out on the following condition; reduction-30%, tool temperature- 20°C. The results are shown in figure 3.

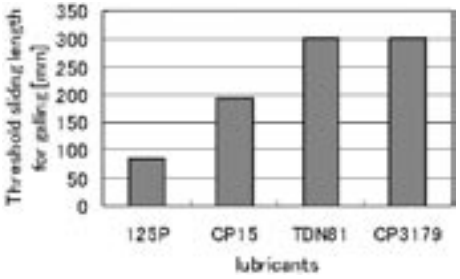


Figure 3. Comparison among 125P,CP15, TDN81 and CP3179

It is found that the threshold sliding length for galling becomes longer according to the following order: 125P, CP15, TDN81 and CP3179. The percentages of chlorine in 125P, CP15, TDN81 and CP3179 are 0%, 7.5%, 40% and 50%. Thus the pure Chlorinated Paraffin and the lubricants containing more chlorinate as an additive show better results. It is obvious that chlorine contained in Chlorinated Paraffin in lubricant influences the threshold sliding length for galling strongly.

2-2. Investigation of CP15

CP15 is the appropriate lubricant to investigate the effect of Chlorinated Paraffin containing chlorine on the several conditions because CP15 includes only the Chlorinated Paraffin (7.5% of chlorine) as EP additive and shows a lubricant film breakdown at the above condition in Figure 3. That's why the characteristic of CP15 has been investigated.

The experience in the following condition: reduction-20%, 30% and 40%, preheated tool temperature-20°C, 40°C and 80°C was done. The result is shown in Figure 4.

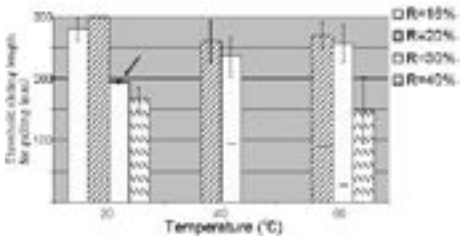


Figure 4 The result for investigation of CP15

Compared with the CR5 result [1], the same result is found in the case that reduction is focused. However, in the case that initial temperature of tool is focused, the different result from CR5 one is found when the reduction is 30%. Therefore, it could be said that some chemical effect on the workpiece or the tool surface works actively with this lubricant when the initial temperature is high. It means that the additive included chlorinated paraffin leads some chemical effect easily on the workpiece or the tool surface (or both) in high temperature and prevents occurrence of pick-up (See Figure 5).

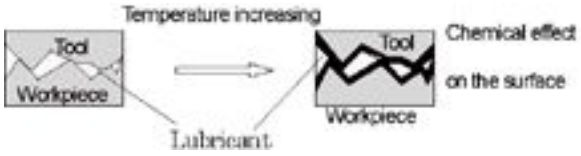


Figure 5 The sketch of chemical effect on the surface

IV. Conclusion

Different mineral oil lubricants with different viscosity were compared and it was found out that the higher viscosity oil works as the more effective lubricant.

EP additive has an increasing effect on the possible drawing length in ironing. Since there is only one additive in CP15, It can be said that the improvement of the lubricant is due only to the effect of the Chlorine Paraffin and not to a synergic effect between different EP additives.

V. Future work

It is found that high viscosity lubricants work more effectively than low viscosity lubricants in low temperature. In addition, it is also found that chemical additives make quality of a workpiece surface better in high temperature. Therefore, it is expected that a high viscosity lubricant with some chemical additive works effectively in any temperature conditions.

VI. Reference

[1] D.D. Olsson, N. Bay, J.L. Andreasen "Prediction of limits of lubrication in strip reduction testing".

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Overcoming communication difficulties

— **Hidenori Fujii**, Osaka University

Sep 2004 - Dec 2004 Delft University of Technology, Netherlands
Jan 2005 Technical University of Denmark, Denmark

Executive summary

I went to the Netherlands from September 2004 to December 2005 and Denmark in January. My research topic at TU Delft is Ankle actuation for dynamic bipeds. We analyzed Passive Dynamic Walking and walking on a flat floor by using the model which has two legs connected to foot with ankle joint. It is described in Technical report section.

At TU Delft I took three lectures 'Control Theory', 'Optimization in System and Control' and 'Biomedical Engineering Design'. The lectures at TU Delft were very different from those of Osaka University. They were not only taking lectures but also some group assignment or making a presentation. The contents and style of these lectures is described in Technical report section.

At Technical university of Denmark, I studied about hexapod robot. This robot will be used for micro manipulation. So I summarized its limitation and possibility.

In the next section, I describe my actual life during studying abroad. I could do many kinds of experiences I could not do in Japan. One of these experiences is living with a Danish person. Because of this, I could get to know a lot of foreign students.

At last, I summarize what I could get and review throughout my foreign life in the Summery section.

Exchange student life

I stayed in the Netherlands for four months from September to December. Because studying abroad in this project was first experience of living overseas for me I was worried about not only communications with foreigners in English but also gaps in culture and custom between Japan and Europe at first. Moreover I had an accommodation with a Danish person. That's why I was more concerned about my life in the Netherlands than I expected for. However, because I would go to Denmark after staying in the Netherlands, I thought that it was very good chance to get some information about Denmark. I thought I could improve my communication skill by conducting daily conversation with him in English. And while I was living with him, I didn't have a problem so much about communication with him thanks to his concern about my being poor at English conversation.

Because he had many friends from other countries, he usually invited some of his friends to our house and drank with them weekend. So I joined it and conversed with them much in order to improve my English communication skill. Moreover, we had a party in my house once a month and Japanese group cooked some Japanese typical food and Danish group cooked Danish traditional food. So my life with him was very useful and enjoyable.

First, what I spent most time in the Netherlands were lectures and my research in TU Delft. The lectures at TU Delft were very different from those of Osaka University. They were not only taking lectures but also some group assignment or making a presentation. That's why I could understand their contents in detail. In respect to my research I think I gained very valuable experience. That's because TU Delft is very famous for researches of a walking machine, which I am studying in Japan, and I have wanted to watch some robots there and to get some useful information for the walking machine which is being constructed in Japan before. In fact, I was surprised that the robots could walk I have seen with the video on the flat floor more easily than our robot. And I thought that I could not fail to try to study the technical know-how of a walking robot. However, I could not make my research a breeze more than I had expected because of lack of communication skill. When I went to meet my supervisor in the Netherlands, I had to explain my research in Japan. But I had difficulty in telling it exactly because of lack of technical terms. And I had a meeting once a week in order to report the result and to get detailed advice from my supervisor. First I could not understand what he said exactly for a short time. So I had him draw some pictures. But I could understand what he said and say my thought gradually at last. So I think I brought trouble to my supervisor much. However, I could get a result of my research because of his careful explanation. That's why I am very satisfied with my research in TU Delft. So I want to refer to this result for the research in Japan.

In actual life, when I passed a holiday I was struck by the cultural differences. Some shops are closed on weekend differently from Japan. So I cannot enjoy shopping on weekend. And I felt inconvenienced because of no convenience store open for 24 hours. However, after one month, I got used to these customs. And I could find my daily rhythm, so I didn't feel uncomfortable.

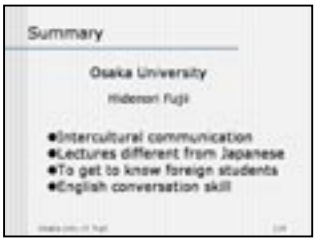
Because I could do various experiences not only in my university life but also in my daily life as mentioned above, this project was very meaningful for me.

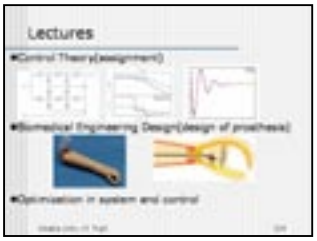
Suggestions to the project

Countries in Europe are on the border with next countries differently from Japan. So we can see people coming from various countries. However, because of lack of my communication skill, I could not get across my thought to them exactly. Communication skill is one of the most important things in this project the purpose of which is intercultural communication. I think it is necessary to practice English communication in order not to be struck during conversation.

Summary

I think that I gained very valuable experience abroad because I could study and take some lectures abroad and get to know people from foreign countries as mentioned above, which is the experiment I cannot gain in Japan. Because of this experiment, I could know various concepts of value and look at Japan from a different point of view. So I could see myself again before getting a job. I want to make use of these experiences not only for my university life and also for my job.





Technical report

Hidenori Fujii

[Research at TU Delft]
Ankle Actuation for Dynamic Biped

Introduction

Recently much research have been performed on robotic walking locomotion such as ASIMO (HONDA) or QRIO (SONY). These robots can walk with two legs. However, the locomotion that is realized by these researches need to be refined and further developed to achieve higher energy efficiency and more natural movement resembling human features. Passive Dynamic Walking has been used as a starting point of the walking theory. This theory is that a simple knee-less biped structure walks down a slightly inclined walkway with no external energy input, in other words, the swing phase is completely ballistic. Passive Dynamic Walking showed that a biped structure itself has a potential to operate locomotion although there is a restriction to a corresponding slope angle and initial angular velocities of each legs. Most recently, the biped robot has been developed based on Passive Dynamic Walking. It has knees, hips and an upper body. But, It doesn't have ankle. we think that it lose high energy at foot contact if it doesn't have ankle. So we propose the model that has legs and flat feet connected to legs with ankle joint. With the addition of ankles the energy efficiency and stability can be improved.

Model

In this section we will explain the model which we treat. The model consists of two rigid legs and two feet connected with ankle joint which is shown in Fig. 1 and Fig. 2. In order to simplify the simulation, we will study a two-dimensional model. We will make the following assumptions to keep the simulation manageable.

1. The legs and feet suffer no flexible deformation.
2. The contact between the foot and the floor are modeled as an instantaneous while the heel strike impact and toe strike impact.
3. The heel strike impact and toe strike impact are fully inelastic impact where no slip and no bounce occur.
4. The floor is assumed to be a rigid and flat.

There is one problem due to oversimplification of the model. Contrary to humans who have knees, the legs of the model cannot extend or retract, which inevitably leads to foot scuffing at during the leg swinging. In the simulation, we will simply assume that there is no interference between the floor and the swing foot under certain conditions.

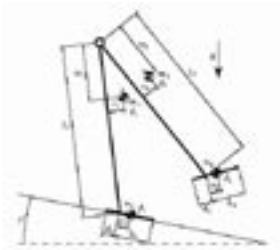


Fig. 1: Parameters of the simulation model

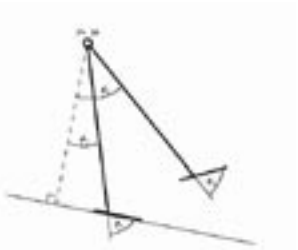


Fig. 2: Six degrees of freedom of the simulation model; the position of hip, the absolute leg angles and the relative foot angles.

Stability

In this section, we describe the stable walking of this model. Its stability is the most important characteristic in order to analyze the walking. As said before, walking should be regarded as a continuous passive fall with intermittent changes of foot contact. And the stable walking is that the stride pattern repeats itself. In other word, the end of a successful step is the start of a new one, and so some points in the graph map to some others. This is called 'Poincare mapping'. If we can find this function, the walking of this model become cyclic motion, which is called limit cycle. However, the Poincare mapping of this model is nonlinear. Therefore we made this function linear around fixed point. This equation is the following.

$$v_{fp} + \Delta v_{n+1} = S(v_{fp} + \Delta v_n) \simeq S(v_{fp}) + J\Delta v_n$$

If the eigenvalues of the Jacobian J are between -1 and 1, errors decrease step after step and the walker is stable. The eigenvalues of this model are 0.5799+0:152i, 0.5799-0:152i 0.359, 0.0000, so the model is linearly stable.

Results of simulation

First, we considered Passive Dynamic Walking of this model. Using a Newton-Raphson iteration we could find an initial condition to make the walking of this model a limit cycle. The result of this simulation is shown in Fig 3.

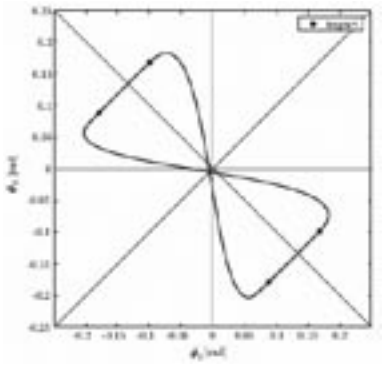


Fig3. The simulation of Passive Dynamic Walking

Next, we considered about the walking on the flat floor. When this model walks down a slope, there is no external input. That's because the energy lost by the impact is provided by the potential energy generated by the slope. However, when this model walks on the flat floor, the potential energy isn't generated. So it needs external input. So, we considered about ankle actuation as the external input such as

- Impulse input to ankle
- Change natural angle of ankle spring
- Change ankle stiffness

The method of changing natural angle is to change the natural angle of foot spring between toe strike and toe lift. The smaller the natural angle is, the larger energy the model is given. The method of changing ankle stiffness is also to change the stiffness of foot spring between heel strike and toe lift. The larger stiffness is, the larger energy the model is given. However, as a result of simulation, even if we made the input larger in any type of ankle actuation, it was impossible to keep the footstep. Therefore it is difficult to find a limit cycle in the walking with only ankle actuation. So we need more actuation in order to find limit cycle. This method is a hip actuation. So, finally, we considered about the walking on the flat floor by ankle actuation and hip actuation. We chose 'Change natural angle of ankle spring' as an ankle actuation. The hip actuation is to change natural angle of hip sprig. By using this method, this model can walk on a flat floor. The result of simulation is shown in Fig 4.

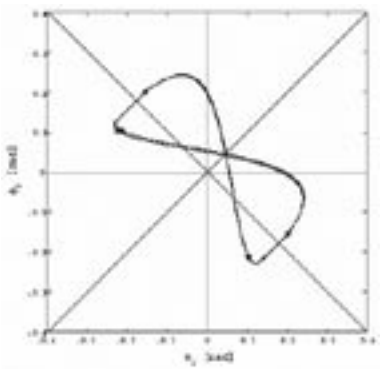


Fig 4. The simulation of Ankle and Hip actuation

[Lectures at TU Delft]

Control Theory

The topic of the lecture 'Control Theory' is the following.
Control engineering: basic theory. State space description of linear dynamic systems. Realization of transfer function models by state space models. Controllability, observability, minimal order. Parallel and series connection, pole-zero cancellation, relationship with controllability and observability. Controllability and observability canonical forms. Jordan canonical form. Stability theory, frequency domain analysis. Dynamic response, relationship with pole and zero locations in the complex domain. Loop shaping for dynamic response, robustness indicators. Multi-input and multi-output systems. Pole assignment, design of state feedback. Linear observers, Kalman filter. Design of observer. Control design and separation principle. LQ regulator and LQG theory. Algebraic Riccati equation, choice of performance criteria. Asymptotic analysis, LQ control system design, dynamic compensation. Disturbances and reference signals, modelling of exogenous variables. Internal model principle, design of tracking control systems, servomechanism design.
And there is an assignment for real system by using Matlab. In this assignment, we apply the contents of lectures to real system.

Optimization in Systems and Control

Essentially, almost all engineering problems are optimization problems. If a civil engineer designs a bridge, then one of the main objectives is to obtain the cheapest design or the design that can be implemented most rapidly, where of course several specifications and constraints such as size, strength, safety, etc. have to be taken into account. When developing a new type of engine, we look for the most economical design, the cheapest design, or the design with the highest performance. A process engineer wants a production unit to deliver a final product of maximal quality, with minimal expenditure of energy or with maximal output flow. When composing a portfolio, a financial engineer tries to maximize the expected profits, subject to the given risk constraints. So we encounter optimization problems in almost every engineering field. How can we solve such an optimization problem? That is the topic that will be addressed in this course. We will consider both the transformation of real-world design problems into a more mathematical formulation, and the selection of the most efficient numerical algorithms to solve the resulting optimization problem.

The examples and case studies of this course are primarily oriented towards systems and control. In preceding courses you have already studied modeling, identification and control of systems. However, the examples in these courses were usually limited to simple or small systems, and more complex systems were often dealt with by saying that they can be tackled using optimization. And that is what we will do in this course: you will not only learn how you can identify models and design controllers for complex systems using numerical optimization, but also how this can be done in the most efficient way. This course is divided into two parts:
1. optimization techniques
2. applications in systems and control

In the first part we study several classes of optimization problems and we discuss which algorithms are the best suited for each particular problem. In the second part we show how a controller design problem can be recast as an optimization

problem and we use the results of the first part to efficiently design the controllers using numerical optimization.

Biomedical Engineering Design

Various types of prosthesis are currently on the market for the patients who lost a part of their body such as elbow. However, there are some problems such as functionality or controllability to be solved in order to meet requirements of patients. We receive the explanation about various type of prosthesis or its inner mechanism. After lectures, we discuss a new mechanism of prosthesis in a small group and make presentations at last as an assignment.

[Research at DTU]
Robotic Manipulation of Micro Parts

Because of technological achievements many products are continuously becoming smaller and smaller. This trend is especially clear in a broad range of manufacturing industries such as for instance the hearing aid industry. Many components used in high-tech products have reached a size where handling and assembly is becoming the main limitation in the utilization of new technologies.

When we process micro components, it is important to get a relative positioning accuracy between tools and part. For that purpose, it is important not only to improve the accuracy of mechanism between tools and components but also to stabilize the frame of manipulators statically and dynamically. However, the mechanism and the frame change shape by various causes such as disturbances and loads of process. Therefore a relative positioning accuracy between tools and components become worse. In order to avoid these deformation, an accuracy of mechanism had been improved by increasing cross-sectional or and second moment area. However, if the volumes of components become large then we cannot ignore the deformation by its weight.

In order to resolve these problems, a parallel mechanism has been used. A parallel mechanism is a mechanism that actuators are disposed in parallel with end-effectors. Contrary to serial mechanisms the inverse kinematics of parallel mechanisms is usually rather straightforward. Furthermore, the larger the degree of freedom of tools becomes, the easier it is to process components. In 3-dimensional space it needs 6 degrees of freedom. And if the tools are connected with cable, the tools are affected by cable. So, the summaries of requirements for manipulator of micro components are the following.

- Lower Inertia
- Better Dynamic Behavior
- Smaller Package Size
- Higher Stiffness
- No Accumulation of Position Errors
- Reduced Runout Errors
- No Moving Cables: Better Repeatability and Reliability

In order to satisfy these requirements as many as possible, a hexapod robot was proposed. Because of its structure, it has high rigidity and 6 degrees of freedom movement of the tool.

To enable precise control of robots, encoders are usually embedded in the actuators, but due to the small size of the hexapods such encoders are not used in this case. Instead, two custom made sensory systems are deployed to ensure proper functionality. In the surroundings of the hexapods, a number of optical sensors are placed. Visual servoing is a technique used for servoing a robot on the basis of image data from one or more cameras observing work cell, and thus relevant for the control of the hexapod.

However, in order to put these types of hexapod robots to practical use more, there are a lot of things to improve. In the respect of actuators, step motors are used so that we can control a hexapod easily. Therefore we cannot control the angular momentum. So it is difficult to perform tasks such as assembly. A DC servomotor enables us to control a hexapod dynamically.

The hexapod robot has six degrees of freedom. However its motion is limited to narrow range because of its structure. So if we process complex components, we need more hexapod robot. In micro scale a steady state error or an overshoot is not more negligible than in macro scale.

The measuring method of absolute coordinates of current hexapod robot is a camera which is fixed outside. However if we can calculate the position of tool geometrically by loading sensors into each actuator, we can make the robot smaller. And, for example, we can use it for some medical operation.

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A lot of surprise! A lot of fun! A little bit accidents...

— **Kenshiro Hida**, Osaka University

01 Sep 2004 - 27 Dec 2004 Delft University of Technology, Netherlands
27 Dec 2004 - 31 Jan 2005 Technical University of Denmark, Denmark

Executive summary

In this project I studied at two universities in Europe. In this report I am going to introduce which universities I chose and how long I stayed there. Next I am going to describe about how I felt and studied. Finally I am going to make suggestions based on my experience.

Exchange student life

I studied at TUDelft in September to December. I took lectures and did a research there. Next I studied at DTU in January. I took a three-week intensive lecture. I could experience many things which I haven't eve done in Japan through this exchange program. But, of course, there were a lot of troubles that I couldn't imagine at the beginning. The first problem was to talk in English. Before going to Netherlands, I did not have enough experience to speak and hear English in Japan. Therefore I struggled to get accustomed to communicating in English during first several weeks. In addition, there were a lot of differences in lifestyle, traffic rule and so on. Unfortunately I met traffic accidents and I was injured and treated in Hospital. I was very surprised at many troubles. However I've got used to new life in Netherlands and become to enjoy fresh life naturally. In the following section, I am going to write about my precious experience at TUDelft and DTU.

Firstly I am going to write about the lectures in Europe. Both universities, which I stayed, focus on international exchanges. Thus many lectures are conducted in English. It was very good for me because there were a lot of students whose nationalities are different and I could talk with them. The lecture contents in both countries are not widely different from that in Japan. But there are many group work in which several students progress the same project together. Actually at DTU I did group works with foreign students and make one presentation and report together. So I could discuss with them and I could get touch with many different ideas. It was very impressive for me that many foreign students always enjoy studying and always express their thinking clearly. And I find that there is a difference in curriculum. In Japan master students take lectures and do research at the same time. On the other hand, in Europe master students only take lectures at first grade because they focused on getting wide knowledge to adapt to rapidly changing technological needs. Now, in the world, it is highly demanded for us to be generalist. So Japan might need to import European style in the near future. While taking lectures, I also find that it is very important for understanding lectures not only to hear English but also to be familiar with technical terms. I think that we should learn many technical terms daily to communicate with foreign engineer in the future.

Secondly I am going to write about my research in Netherlands. I did the 4 month closed research which was different from my research in Japan. Then I was surprised at the difference of research style between in Netherlands and Japan. In Japan I belong to a laboratory and there are some professors and a lot of students. I always progress my research discussing with professor and colleague. On the other hand in Netherlands master students follow to one PhD student as an assistant. And they always progress their research discussing each other. Both of style has unique advantages. The style in Japan has the advantages to get many different ideas because there are many persons to discuss. On the other hand, the style in Europe has the advantages to get practical knowledge deeply from the PhD student because they always discuss on each step in detail. I was very interested in this difference because I felt that the style in Netherlands reflected their nationality to focus on their individuality. And many researches in Europe are conducted cooperating with companies. So the research themes are very practical and reasonable. Actually experiment set-up I used was the form which could be introduced to the factories instantly.

Of course, I could make foreign friends whose nationality is different because both of universities highly welcomed international students. After school, most students go to the parties organized by students or bar in the town because European students really like talking and beer is very cheep in Europe. Most of the opportunities to meet with many foreign students were commonly at parties or bar. As I go to the parties or bar, I could have some friends with whom I can talk more deeply. Sometimes I cooked dinner and played soccer with them. And in the weekend I often go to the disco because it was the most popular spot to excite their soul in Europe and I could feel European spirits directly. To meet and talk with many foreign students was the most precious experience for me. Each topic, which we talked each other casually, remains my memory deeply.

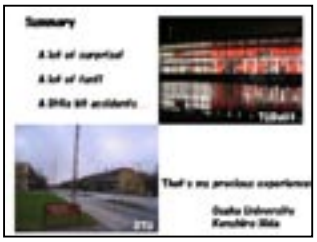
I wrote about what I felt thorough studying abroad and what I could know. My exchange experience could be summarized as the following; "the exchange life was full of surprise and fun". I believe the experience in foreign countries would be my confidence in the future.

Suggestions to the project

Suggestion 1
In both countries I lived with only Japanese students. But It is not good to live with Japanese. It is better to live with foreign students because it is very good chance to live with foreigner for the sake of getting in touch with foreign custom. So next time please arrange to live with foreign students.

Suggestion 2
In this program I had no choice to write my master thesis at Host University. But I think it is very attractive to write thesis in foreign university. So please give us the chance to write master thesis during our staying.

Suggestion 3
I go to two countries for five months. But I think we don't need to go two countries necessarily. Usually the lecture term takes five month in Europe. But we have to leave one university for four month at least. Therefore we couldn't take lectures witch we really want to take. It is problem. The system should be changed more flexibly.



Summary

Thorough this exchange program I could experience many things that I haven't ever done in Japan. Now I think that this program was a good chance to know the world and it was good for me to study in Europe. In the future I will take initiative in the world as an engineer. Finally thank for everyone who supports me.

Technical report

Kenshiro Hida

[Research at TU Delft] Generation of the Surface Structures by Micro-Abrasive-Blasting

Background

Recently micro-electro-mechanical-system (MEMS) has been developed by various techniques such as etching. But conventional techniques are expensive. Now industry requires the economical technique for MEMS. We propose a Micro-Abrasive-Blasting as an economical technique for MEMS especially composed from brittle materials such as glass and silicon. This technique has been widely applied to the technique to produce a television flat screen in industry because of its economical efficiency. This technique realizes economically viable MEMS. The overview of Micro-Abrasive-Blasting is shown in Fig1.

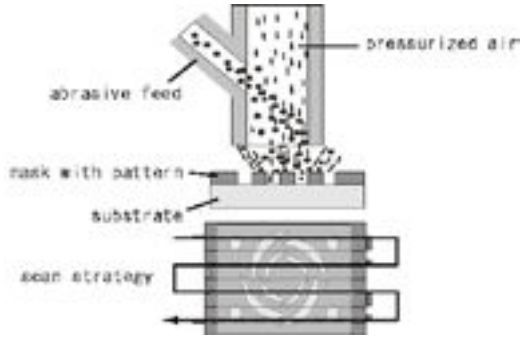


Fig1 Overview of micro abrasive blasting

This technique is based on the erosion of a brittle substrate by a high-velocity particle beam. On this technique the substrate is covered with mask pattered with the desired contour instead of direct blasting and the mask pattern is transferred to the substrate by blasting. The mask determines the accuracy of the dimensions in the plane of the desired structure. The mask size and scan speed directly influence the machining speed. So the scan strategy is of great importance for generating an arbitral shape.

Experimental set-up

All experiments have been conducted on the abrasive blasting set-up shown in Fig2. A SS-White Airbrasive unit, model HME (a) mixes dehumidified compressed air (b) with abrasives and feeds it to the blasting chamber (c). A CNC (d) five-axis guiding system (e) with a working area of 600mm×600mm×300mm realizes the scanning motion of the nozzle (f). A cyclone type air filter (g) evacuates abrasives from the hermetical closed blasting chamber.

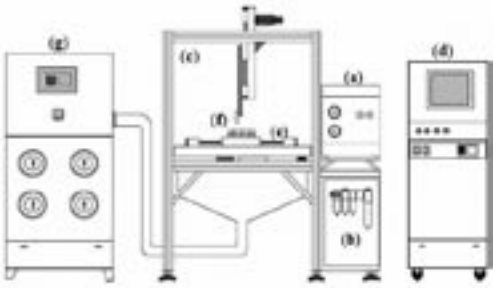


Fig2. Schematic abrasive blasting set-up

Results

To generate an arbitral shape, the scan strategy needs to be constructed. Therefore relation among hole width, hole depth and machining speed need to be obtained. Then the experiments that the glass plate is machined with several machining speed against circle and square mask has been conducted.

In the above experiment it is found that the relation among hole width, hole depth and machining speed could be formulated into the following equation.

Equation for circle mask

$$V = 0.72D^{-0.88} - 0.18W^{-1.73} \quad (1)$$

Equation for square mask

$$V = 0.88D^{-0.73} - 0.17W^{-1.55} \quad (2)$$

To verify the constructed scan strategy the experiment to machine with constant depth 0.1mm has been conducted (see Fig3).

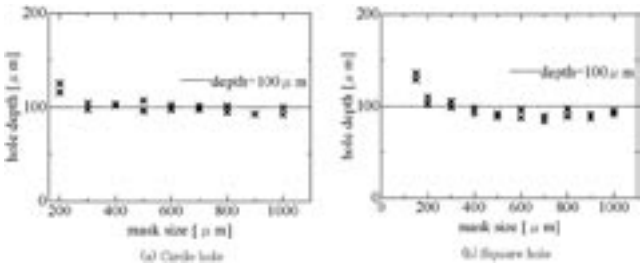


Fig3. Results of machining with constant depth 0.1mm

As the results of above experiments, it is found that the circle holes can be machined with the average depth 0.101mm and the standard deviation 0.00825mm and the square holes can be machined with the average depth 0.0987mm and the standard deviation 0.0131mm by using the constructed scan strategy.

Conclusion

In this report, the relation among hole width, hole depth and machining speed has been formulated into the equation to generate an arbitral shape. The constructed equation has been verified by the experiment to machine with constant depth.

[Lectures at TU Delft]

Control Theory

This course serves as an introduction to the concepts and techniques currently used in basic modern control theory. This course requires the development of the technical skills involved in state space system theory. It also extends the notions of control system design towards time-domain techniques based on pole placement and linear optimal control using quadratic performance criteria. The exercises in this course stress the use of a computational linear-algebra environment (Matlab or similar) for linear control system design. The exercises familiarize the student with model-based control design, supported by modern computational tools for dynamic analysis, simulation and control performance assessment. The remark of this course was evaluated by the examination and exercises.

Biomedical Engineering Design

This course gives an introduction in the field of prostheses and orthoses, and presents a design philosophy and a design method, illustrated by a presentation of the entire design process (system components) of several prosthetic/orthotic products. The goal of this course is to provide knowledge and understanding of the design process based upon system theory and control theory. The remark of this course was evaluated by a conceptual engineering design project.

Design of Production System

The topics of this course are the following; CIM, design, process planning, production control, production scheduling, system design, reference models, manufacturing, assembly logistics and computer vision. The goal of this course is to get the knowledge of modern flexible manufacturing methods and conditions; being able to recognize and use paradigms of automation technology in factory design. The remark of this course was evaluated by a written open book examination.

[Lecture at DTU]

Project Course in Process Technology

This lecture is consisted from literature study, planning of experimental investigation, theoretical and experimental work, data acquisition, analysis of experimental results, conclusion, reporting and presentation. In this lecture I did a group work on the following experiment theme with foreign students. I made a report on the theme.

Experiment theme:

Investigation of lubricant and extreme pressure additives in Ironing

Background

The major role of the lubricant film in metal forming is to ensure the separation of the contacting workpiece and tool surface. The limit of lubrication is understood as the threshold at which the lubricant film breaks down leading to the direct contact between the tool and the workpiece surface, which is normally fatal to a production, because it means that the tool surface pick-up the workpiece material. The picked up workpiece material becomes very hard and brittle when oxidized and causes scoring of subsequent workpiece surfaces being formed by the damaged tool surface. industry and the method to predict when the lubricant film breakdown occurs has been dev This effect, known as a galling, leads to a poor product quality and a severe stressing of the tool.

As mentioned above, the lubricant film break down is a problem ineloped in the past research. However how the characteristic of lubricants influences on the lubricant film breakdown is not still clear. Then, in this paper, the influences have been investigated by conducting the strip reduction test.

Experimental conditions

In the present work the limits of lubrication have been studied applying a strip reduction test, simulating the conditions in ironing, see Figure 1.

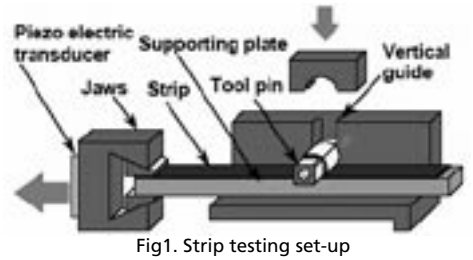


Fig1. Strip testing set-up

The thickness of the strip is reduced between a non-rotating hardened tool pin simulating the conical die and a supporting plate simulating the cylindrical punch in ironing of a cylindrical can wall. The strip and the supporting plate are clamped together at the front end with a set of jaws. Ironing is performed by drawing in the direction of the arrow. The two ends of the tool pin are machined with square cross-sections in both ends fitting into two vertical guides allowing the gap and thereby the reduction to be varied.
In the experiment, the following lubricants shown in Table1 were used.

Table1. Code and Description of tested lubricants

Code	Description	Viscosity(cSt)(40℃)
CR5	Pure Mineral Oil	460
125P	Pure Mineral Oil	125
CP15	125P (85%) + CP3179 (15%)	134
CP3179	Pure additive, Chlorinated Paraffin (containing Cl)	-

Results

Firstly to investigate the influence of viscosity on lubricant film breakdown, the strip test using CR5 and 125P, only the viscosity of witch is different, has been conducted. The experiments have been carried out on the following condition; reduction-30%, tool temperature- 20°C. The result is shown in Fig2.

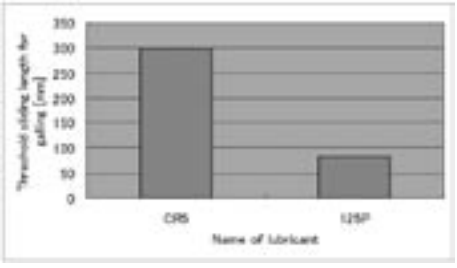
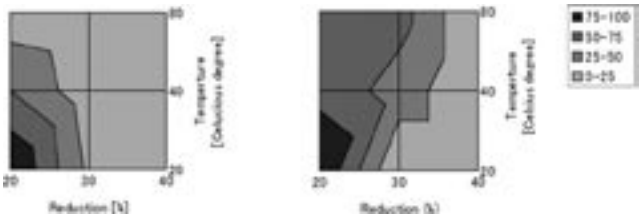


Fig2. Comparison between CR5 and 125P

It is found that the threshold sliding length for galling of CR5, which has higher viscosity than 125P, is longer than that of 125P in Fig2. Both of CP5 and 125P are pure mineral oil. Only the viscosity is different between these two lubricants. Thus it is found that the lubricants that have higher viscosity show better results at the condition; tool temperature is equal to 20 degree Celsius.

Secondly to investigate the influence of additive on lubricant film breakdown, the strip test using CP15 containing 15% CP3179 in 125P has been conducted on the several conditions (temperature[20,40 and 80°C]-reduction[20,30 and 40%]). More than three times experiments have been conducted on each condition. In order to see the result more clearly, the distribution which shows the success rate on each condition between reduction and initial temperature of tool was made. Success rate means the percentage of samples which don't have any galling in 300 mm drawing on the more than three times experiments. Comparison between expected result and CP15 one is shown in Fig3. The expected result was made from the previous research that shows a lubricant film is broken down earlier in the processing if either contact pressure or temperature increases. Fig3 (a) is not an exact graph. But, it shows that the success rate is decreasing if the reduction is increasing, and also it shows that the success rate is decreasing if the initial temperature of tool is increasing.



(a) Expected result (b) Result using CP15
Fig3. Comparison of success rate between expected result and one using CP15

In the case that initial temperature of tool is focused, the different result from expected one is found when the reduction is 30%. And it is also found that success rate is decreasing rapidly as reduction is increasing when the initial temperature of tool is 20°C, but success rate is decreasing slowly when the initial temperature of tool is 80°C.
The difference between expected result and result using CP15 could be lead by only the existence of chemical additive in lubricant. It means that the Chlorinated Paraffin leads some chemical effect easily on the workpiece or the tool surface (or both) in high temperature and this chemical effect work to prevent the occurrence of pick-up.

Conclusion

In this report, the influences of lubricant viscosity and chemical additive on lubricant film breakdown have been investigated. It has been found that the result become better as the viscosity of lubricant increase. And also it has been found that the lubricant containing chemical additive shows better results on sever conditions than one not containing chemical additive.

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Study in different environments

— **Masaki Michihata**, Osaka University

Sep 2004 - Jan 2005 Technical University of Denmark, Denmark
Feb 2005 - Jun 2005 Delft University of Technology, Netherlands

1.DTU

Executive summary

I studied at Technical University of Denmark (DTU) for 5 months from September 2004 to January 2005. During the period, I was doing one project, 2 regular courses and one extra course (English course).

During whole the period, I was doing one project under my supervisor at DFM which is based on DTU and IPL which is one department belonging to DTU. My topic is deeply related to Atomic Force Microscopy (AFM). AFM has been already a matured tool for investigation in a field of nano/micro technology. However, it's still held some problems. One of the most serious problems is convolution of a tip shape of AFM cantilever and sample surface topography. My study aims to extract the contribution of the tip shape to AFM image. For that purpose, two kinds of samples called tip characterizer were used. These samples have sharp peaks on them, which have potential to reveal tip shape accuracy up to around 30nm from the end of the tip edge. So the images of those characterizers were analyzed by using two kinds of methods, Blind Reconstruction and Direct Estimation, according to situations with commercial computer software, Scanning Probe Image Processor (SPIP). The conclusion is such as the following. The AFM tip seems to have an extremely small radius of curvature in a range from the very end of tip to around a few nanometers, approximately 20 nm radius of curvature in the range between 5 nm to 15 nm from the tip edge and straight line upward form that.

In the period from September 2004 to December 2004, which means the period of fall semester, I was taking two regular courses, Introduction to industrial environmental management, CAD/CAM, and extra course, English course. In both of regular course, I had group works. Group work is sometimes quite effective, but sometimes quite troublesome, as you can image. So we could learn many things from group works. Each course has exercise every week either. So we had to study constantly, otherwise it's impossible to catch up with the lecture proceedings.

As my study environment, my accommodation was a student dormitory located inside of the campus. This dormitory accommodates about 100 foreign students. This accommodation was pretty good place for making friends and learn communal life, because we must have shared same equipments such as kitchen, shower room, and toilet for 10 people. For solving some conflict, we needed to talk often and understand each other. It was good experience to me. As other activities, I could enjoy parties, sports and sightseeing, etc.

Exchange student life

My life at DTU was completely different from one in Japan. Only same thing is to go to school everyday.

First of all, I describe my room in Denmark as life environment. My room was inside of a Campus, called "Campus village". Campus village is consists of ten buildings (it's just container), and about 100 students live there, that is, each container includes around 10 people. We had to share a kitchen, shower room, and toilet for 10 people. Since I'd never lived alone before coming to Denmark, almost all things such as cooking, washing my clothes were special for me. But many students were same situation as me, so we often helped each other when we had some troubles. Of course we have some trouble with each other because many people live together and we were not only unfamiliar with each other at the beginning, but also different nationalities people. In case of our container, there were Chinese, Spanish, Turkish, Pakistani, Italian, French, Bulgarian and, of course Japanese, totally 8 countries. For enjoying our exchange life and knowing of each other, we sometimes had parties, and then cooked own countries' dishes and showed off them to others.

Basically, I was taking 2 courses and English course, and doing one project. So all weekdays of daytime and evening until 6 or 7 o'clock were occupied by them. In the evening, normally I did study, cooking, chatting with friends, sports, going to parties etc. In DTU, there were parties at least one or twice a month. Some of them were organized by DTU or PF, which is also organization in DTU. In their parties, there were concerts, bars, disco, and so on. Usually many Danish students, International students and foreign exchange students joined it. Perhaps, I can say it's the biggest party in DTU. Some other parties were organized by some communities. For example, there were Spanish, Korean, Italian, and French parties during that semester. They invited a lot of students and prepared their own countries' foods or dishes for guests. We could enjoy many different countries taste there. But it was unlikely to have Japanese party although many friends requested me to organize it. For foreigners, the most famous Japanese foods is "sushi" definitely. It's too expensive, because I have to prepare for it for about 50 people at least, beside there were not many Japanese students in DTU (There were 7 Japanese in DTU as far as I know and they didn't know of each other). Most of the others were held with people who knows each other. Actually

these were not really parties. We just cooked for our friends and ate together. Then I often cooked Japanese foods such as "Temaki-sushi" or "Okonomi-yaki" for my friends. Except parties, we hung out a bar, which is inside of DTU. Especially, Tuesday was referred as international night. So many international students came to the bar to meet some friends. I think that to go to parties or bars is one good way to make friends. Then we could share useful information there.

As other activities, sports can be mentioned. In my case, I often played soccer. There is a huge ground for soccer or rugby. Students can use those fields freely as long as it's not occupied. Many people were playing there, international students and Danish football team as well. Sometimes I joined Danish team. In Europe, soccer is the most popular sport, as you may know. So in August, there was one competition called "DTU world cup". This was organized by PF and for international students. All international students can attend it. And then we made one team which is consisted of many nationalities people, about 8 countries. Other team was like Italian team, Spanish team, Czech team and French team. It was very excited, because they really like to play football and most people were good players. In this time, French team won, it's just like real World cup in 1998. Our team lost against Italian team. In winter, we could not play football at out door fields any more due to too cold temperature. So we moved to indoor fields. DTU offers many sports opportunities, such as football, badminton, tennis, climbing, and so on. People can enjoy sports inside of DTU. But just nearby DTU, there is also one place where we can play some sports. But we have to pay because it's not part of DTU.

Suggestions to the project

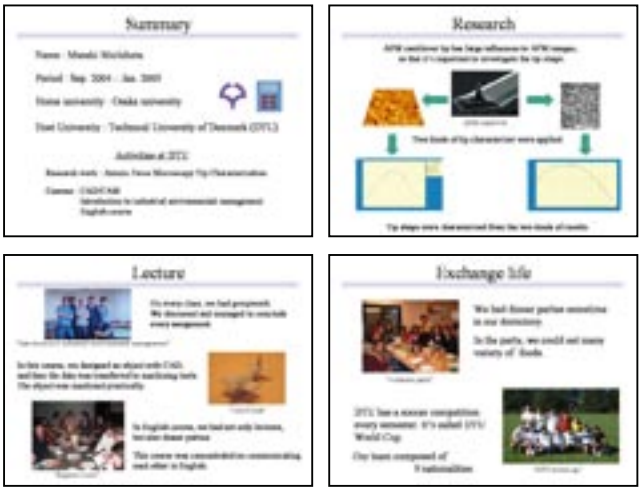
I am satisfied with this exchange program except the following only one thing.
DTU has an event called introduction week for international students before a semester. It for fall semester was held on the end of August. And also the semester started the end of August. Nevertheless, I was not allowed leaving Japan until September 1st. I think it's not good. So I hope we can choose the date of departure more flexibly, which means both way going to Europe and returning to Japan according to a schedule of each university.

Summary

Studying at DTU was quite good experience for me.
I studied hard and tried to understand with different nationalities students, resulting in having many friends in Denmark. I learned many precious things included academic knowledge, knowledge of life and so on from the university and all of friends there.

About my project, this project was very interesting for me, but not easy task. I used approximately 1 month among 5 months for grasping how to use instruments, software and understanding what my project is. And so I could use only 4 months to investigate the topic, this was not enough periods to conclude it. However, I think the most important thing is not conclusion, to study about it, experience of studying there, and discuss with my Danish supervisor are more important.

In terms of study, each class was not easy, which means that not only we had to understand the contents of lectures (in order to catch up with lecture, we normally needed to spend own spare time to study by myself), but also we managed to work out group work. DTU is enthusiastic about having us address group work. On many courses, group work is compulsory. We had to do cooperate with other nationalities people.



2.TU Delft

Executive summary

I studied at TU Delft in the Netherlands for 5 months from February to June 2005. During that period, I have done 4 lectures and one small project.
The lectures are 3 technical courses, Fundamentals of material removal process, Measurement theory and praxis and Electromechanical systems, and one English course. Measurement theory and praxis and English course were held for 5 months, other two courses were held for 2 and half months. Every courses required us final exam at the end of the period of these courses.

As small project, I conducted research about development of micro-gripping with electrostatic force. This work was started from literature investigation, studying of electrostatics and studying how to use software package ANSYS. And after that, as analytical approach, simulations were done by using ANSYS. In parallel, experiments were implemented. And last an half month was spent for writing a report. As a conclusion of the results, it was confirmed feasibility of electrostatic micro-gripping. And it was proved that necessity of insulation layer wrapped conductive core, reliability in terms of temperature at range from 27.2 °C to 37.4°C. And differences between theoretical and experimental results were shown, and these reasons were given. Last conclusion was that experiments have shown that bi-pole gripper could pick up a part at lower applied voltage than mono-pole gripper.

About exchange life, regularly I went to school every weekdays for research work and lectures. But it was difficult to find good spaces to study at mechanical faculty due to some noise and many people. I was sorry that I could not get my space to concentrate on studying there. On Tuesdays and Thursdays, I went to practice soccer from 8:30 after studying. Other weekdays and even weekend, I had practices for the marathon. Every time, I ran about 8 km. And on Wednesday's night at around 11:30, international students started to gather one bar to meet their friends. So I went there often, otherwise we were not likely to have any communication with international students, because my accommodation was isolated each other with residents there. Equipments of accommodation was so fine, every thing was new and the room has own kitchen, toilet and shower room. On the other hands, this made me lonely.

Weekend I went traveling about the Netherlands, for example, Amsterdam, Rotterdam, Scheveningen and Den Haag. And I had a chance to see soccer matches at Kerkrade, and moto GP at Assen. We felt that it was easy to travel around the Netherlands because of good traffic system. But sometimes they had constructions and strikes that result in big inconvenience to transport.

Exchange student life

Here, the Netherlands is second place for me in this exchange program. I stayed here for 5 months and several days.

My accommodation was located near a campus of TU Delft and it is called normally "Roland Holstraan" from students. This room has own shower room, kitchen, toilet and internet connection. This internet connection is branch line from the university, so we could download papers from many journal sites. This was one of good respects of Roland Holstraan. On the other hand, this accommodation may complete too much for exchange students. In our diary life, we don't see neighbors usually. Many of exchange students including me want to communicate with as many people as possible, but people in Roland Holstraan is too isolated each other. I think that this problem is going to be improved by TU Delft. This idea is based on TU Delta, which is newspaper published by one organization in TU Delft. I read article in the Delta about this problem many times. This problem is one reason why I got fewer friends in the Netherlands than in Denmark.

I wanted to achieve something in the Netherlands for unforgettable memory. Then I decided to try in a marathon because of one Japanese Ph-D there. He asked me to do it. I though it was nice of me. But at that time, I had not been trained anythings for 7 or 8 years. I started to prepare for the marathon since two days after I arrived at Delft. Concretely, I ran about 8 km distance around Delft city or the university 3 or 4 times a week as long as I didn't have muscle pain, often with Ph-D student. After 2 months training, I participated Rotterdam marathon with other 4 friends. This was first time for me to run in the marathon. As many people said so, after 30km it was so hard to keep running. Fortunately I could finish the marathon and the record was 3 hours and 45 minutes. Totally, I participated in the marathon twice, one was in Rotterdam and another in Copenhagen.

There is a sport center, where students and people related to TU Delft can use for training and playing many kinds of sports. I joined Dutch soccer team "Ariston" there. Every Tuesday and Thursday we enjoyed playing football for about 2 hours each time. And this team has games on Saturday for league matches. But I didn't join the game, just enjoy training with them.

In school, I was not given may space for small project studying. This is normal in TU Delft, particularly at mechanical department. There, normally master students in mechanical are not given their own space for research work. This fact was totally difference from Japanese system. So it took time for me to make do it. And building of faculty is normally close at 10:00. At the beginning, I was suffering to find my space for studying. There are a lot of computers in the building and this space can be for studying to students. This means that there are many students using these spaces, even bachelor students. I felt that they made a noise a lot, so these were not good place for me to study. And everyday I had to look for the available space. As far as I see, many Dutch students need music while they are studying. Furthermore, when we are using such a public space, always we have to take care of our stuffs, because our stuffs may be stolen while go to lunch even a toilet. So that, when we go to somewhere, we have to carry all stuffs every times, otherwise, it might be disappeared after you back there.

In weekend, I went to many places in the Netherlands, for example, Amsterdam, Rotterdam, Scheveningen, and Den Haag. It was easy to travel around, because the Netherlands is not big country. So I could go to see football matches from Youth championship twice at Kerkrade, where is in southern Holland and motorbike race, moto GP at Assen where is in northeast Holland. And there is a big beach in Scheveningen. You could do bungee jump there and also trumporing, shopping etc.

Every wednesday, foreign international students gather at one bar at cented of Delft. Here is place to see other international students. I went there sometime. But I think that it is not easy to build real friendship at a bar if you don't have

common interest with them.

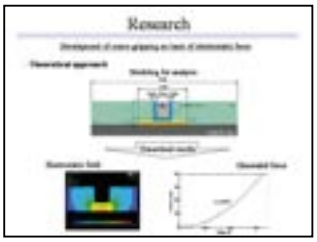
Suggestions to the project

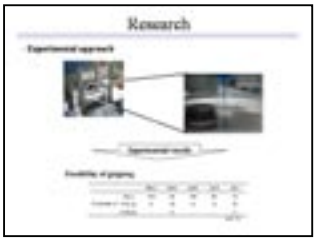
Just let us make sure earlier when we can come back to Japan. We have to inform the date when we leave our room one month before the date to accommodation agent. As a matter of fact, I got the ticket of airplane 5 days before I was going to leave the Netherlands. As a common sense, it is too late. Furthermore, travel agency told me that my coming flight is on 10th of July by a email, nevertheless, the ticket is valid on 11th of July. I noticed it after I got the ticket.

Summary

I could enjoy my life at Delft, but also I got many compliment or difference from Japanese systems. I mostly suffered from a space for studying, because we could not be given space in their laboratory. This is not good to do research work, because I could not have sufficient meeting and discussion with my supervisor.

In TU Delft, there were many Japanese people and they were integrated well. This environment seems not good for practicing English. But it was wrong, I think. Maybe we tend to speak Japanese, but if you really want to speak English, you have a lot of opportunities to do that. For me, it was nice to see them there, simply because I am not likely to meet them in Japan, and I could learn lots of precious things for my future, study and so on from them. I really appreciate this exchange stay there.





[Research and lectures at DTU]

In Denmark, I was doing one project and 3 courses. The project was done under my supervisor of Denmark. 3 courses were 2 regular courses and one English course.

My project was done at DFM. On weekday, I studied my project there at from 10 to 5 except time for classes. Content of my project is such as the following.
Under invisible scale technology or atomic scale technology called the Nanotechnology, at present many kinds of technology have been developing. One of key technologies is absolutely optical technology. Its physical scale of components has been already reached the scale much less than light wavelength.

It is always necessary to measure geometrical parameters such as dimension, roughness, etc. for guaranteeing functionality or performance of products or components. However, it is not an easy task to evaluate the accurate shapes at nanometer scale, especially when they have complicated shapes like an undercut structure, a high aspect ratio and so on.
Atomic Force Microscope (AFM) was utilized in this study, which has a high resolution and adaptabilities with many kinds of samples. Here the principal of AFM is explained. As the name indicates, AFM uses the atomic force between the end of the AFM tip and sample surface. AFM cantilever, which consists of a substrate and a very sharp tip, is oscillated (in case of tapping mode) and getting close to a sample surface, and then the atomic force caused by Van der Waals attraction works between the tip and the sample when the distance between them is adequately small. The Atomic force influences a condition of cantilever oscillation, that is, its amplitude, frequency and so on are shifted. The shift can be detected as shown in the following figure. The incident light (typically laser) hits a back face of the cantilever substrate, and then reflects. Reflected light enters a detector. The light path would shift with the change of cantilever oscillation.

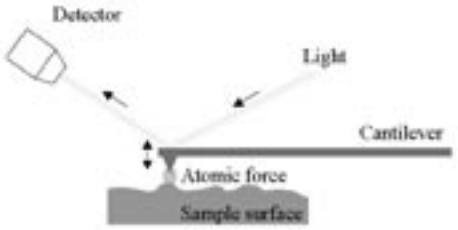


Fig. 1 The principal of Atomic Force Microscope.

AFM has already matured in some ways, but still has some problems, one of which is a convolution of the tip and a sample surface. Figure 2 depicts concrete situations.

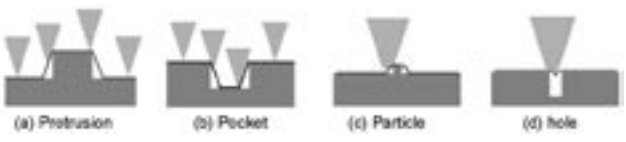


Fig. 2 Influences of tip - sample convolution.

Figure 2 (a) and (b) show influences risen a finite tip shape. An artificial AFM tip cannot vanish, so that these problems are unwanted company. Due to specific cone angle of AFM tip, the tip cannot reach roots of protrusion or bottom corners. Figure 2 (c) and (d) show cases that sample surface has smaller structures than the radius of curvature of AFM tip. In (c), tip cannot trace the small particle because the particle is too small. In (d), the tip cannot be go into the hole due to small width hole. In this case, AFM is able to detect that there exist a something. This problems cause a distortion, bluer of AFM images. The images involved such kinds of problems cannot be reliable images. So the problems must be solved. The only way to solve them is to know the tip shape exactly. Therefore, in order to obtain as accurate images as possible, the tip shape has to be known. As a result, after taking AFM images, the tip shape can be extracted from the AFM images.

Thus in this project, the AFM tip characterization was deeply focused on as preparative study of measuring practical structures such as optical components.

Tip characterization was implemented with two kinds of tip characterization sample, called TipCheck and NioProbe, by using two kinds of method, called blind reconstruction and named direct estimation. Two characterization samples are called tip characterizers. Necessaries as a tip characterizer are hardness, sharp peak, and random orientation. Tip check and NioProbe can meet these requirements, because they are made of hard crystal. From the images of them shown in figure 3, it's known that they have completely random oriented peak. And according to the company which makes these samples, peaks on NioProbe sample have less than 5 nm radii. Thus, TipCheck and NioProbe are regarded as appropriate tip characterizer for AFM tips. The AFM images were analyzed based on two kinds of methods, Blind reconstruction and direct estimation. Blind reconstruction is a mathematical method that takes into account all peaks or valleys over the image, so that all processes are carried out with a computer software called SPIP (Scanning Probe Image Processor). SPIP works out a tip image estimation by using blind reconstruction.

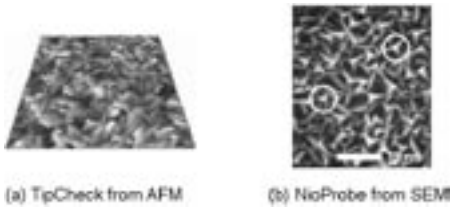


Fig.3 Tip characterizer.

It was expected that tip shape could be evaluated up to 30 nm from the end of tip.

As a conclusion, each tip has been revealed the shape from both characterization samples although its value includes specific uncertainly. And each tip has each shape, which may be not able to be assumed as a simple model by being evaluated at a nanometer scale. Direct estimation is simple method. As you can image from figure 2 (c), when a tip traces a small part, the radius on AFM, $R_{profile}$, image is made from a radius of a tip edge, R_{tip}, and a radius of a sample peak, R_{sample}. This relation can be express simple formula such the following,

$$R_{profile} = R_{tip} + R_{sample}$$

Based on abovementioned principal, experiments and analy-

sis were implemented.
Figure 4 shows one result from TipCheck sample, an estimated tip shape based on the image by using blind reconstruction, and its cross-section profile.

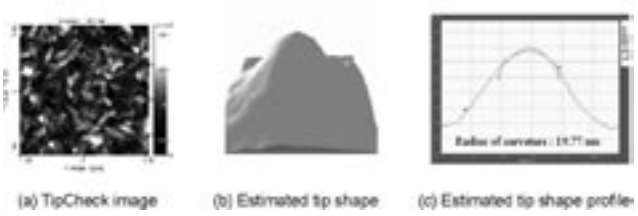


Fig.4 One result of TipCheck sample.

Figure 5 shows one result from NioProbe. (a) is full image from AFM. Numbers and squares means picked up peaks, because the five sharpest peaks were referred as presenting peaks among all of peaks in an image. (b) is one of peak and (c) show the profile.

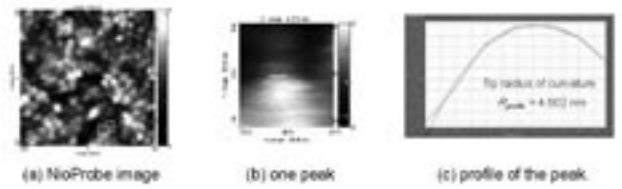


Fig.5 One result of NioProbe smaple.

From those results, tip shape was investigated. But tip shapes are no longer same with all other tips, because the domain has reached nanometer scale. So each single tip has to be evaluated in cases of developed investigation. Now this study is still basic study, so that the shapes were tried achieving normalization. Figure 6 is the conclusion.

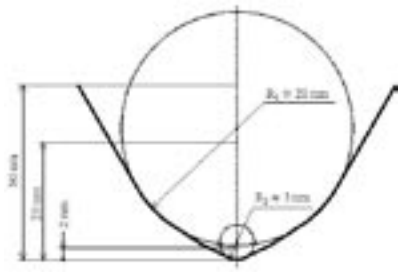


Fig.6 Result of analysis.

From figure 4, it's seen that a tip has approximately 20 nm radius of curvature in the range between 5 nm to 15 nm from the tip edge and has straight line upward form that. From figure 5, tip has an extremely small radius of curvature in a range from the very end of tip to around a few nanometers. These data were combined and result in figure 6.

About courses, I was taking two regular courses although any credits are not necessary for me as a matter of fact.
One of them is CAD/CAM course which is for foreign students and students without previous experience in Pro/Engineer. This course was held from 8 to 12 on Thursdays and was composed of Lectures and exercises. All of exercise were done with group of two students.
In this course, I learned to create models of machine parts and assemblies of these using a CAD-system and a graphical workstation and use computer aided systems (CAD/CAM systems) in process planning. In terms of contents, as exercise for CAD system, there were geometric modeling, solid modeling, surface description, Boolean operations on solid models, transfer to drafting programs, dimensioning, programming in CAD-systems, and assembly of solid models to systems, and as a part of CAM or practical task by using machining tool, there were exercises such as introduction to numerically controlled machine tools, CAM and NC-programming, computer aided process planning (CAPP), reverse engineering and rapid prototyping and tooling. Especially, we made a model of LEGO human for CAD exercise.
After finishing all of exercise, we started to work on final report which is consist of theoretical part and practical part. Our theme was CAPP.

Another is Introduction to Industrial Environmental Management. This course was held from 13 to 17 on Tuesdays and consisted of lectures and project. The Projects were based on groupwork.
In this course, I learned planning, implementation and control of the environmental and work environmental activities in a company and obtained knowledge and skills enabling them to develop and implement environmental and work environmental management, apart from knowledge of structural elements in industrial environmental management. Besides, we dealt with how it can be integrated as a part of other activities in the company.
As final project, we made a report that is about comparing Danish 4 companies in respect to strategic management and formulation of environmental and work environmental strategies, design and implementation of environmental and work environmental management, and certification and audit of environmental and work environmental management systems.

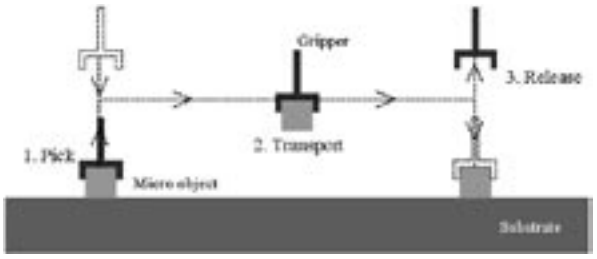
The last is the English course. This is not regular course and is opened for foreign students who want to improve their English. I took this course from 5 to 8 on Mondays and Wednesdays.
This course was concentrated on speaking English. Contents of the lecture were vocabulary, pronunciation, grammar, reading, and discussion. This course is not for any credits, so that there was no examination, no evaluation.

[Research and Lectures at TU Delft]

In TU Delft, I have done one small project and 4 lectures.

The small project was titled "Development of micro-gripping on basis of electrostatic force". This is following project of previous one that is done by other students. Previous one showed a possibility of the electrostatic micro-gripping, and this time, development of the gripper was aimed.

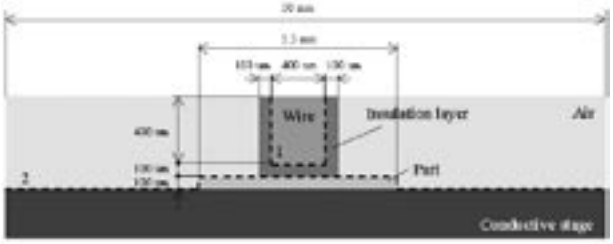
Today two kinds of systems can be found in the micro domain, one of them is the system composed of only a few or one components such as MEMS, and another is the system composed of some parts as elements of functions, which is called micro-system. MEMS has been developed and has precision structures usually on nanometer order, but it is still hard to be built 3-dimensional structure by using current fabrication techniques. On micro-system, ways of building 3-dimension structure different. In order to establish more functional systems, the elemental parts or modules tend to be assembled, although micro-assembly that includes manipulation, gripping and placing is also not an easy task due to unpredictable phenomenon. So micro-assembly plays an important role in micro-system. In terms of micro parts, overall part and product dimensions are in the range of about 0.5 - 30.0 mm, parts in the range of 100 - 5000 mm, and high accuracy in the range of 0.1 - 10.0 mm is required.

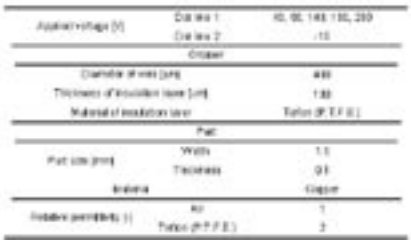


In this project, only the gripper was focused on. Robotic systems such as robot arm or sequences to manipulate were not taken into consider. Main functions of a gripper are to pick up, transport and release an objective part. In general, releasing is most difficult operation on micro-gripping due to unwanted forces like surface tension force or Van der Waals force.

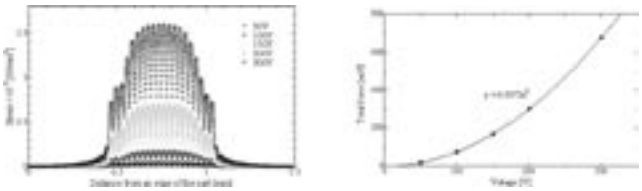
Electrostatic force is useful for the micro-gripping. This force is attractive force and also repulsive force corresponding to properties of electrons. In case of positive against positive, generated force is repulsive: of positive against negative, generated force is attractive force. These forces help effectively to picking process and especially releasing process. What's more, electrostatic force is controllable with changing specific parameters. Important parameters are applied voltage, material of insulation layer (relative permittivity of insulation material), thickness of insulation layer and so on.
On this research, investigation was approached from two ways, theoretical method and experimental method. As theoretical way, Finite Element Method (Fem) was implemented on commercial software package ANSYS. In this method, a continuous problem is first broken in to a discrete physical representation consisting a finite number of regions or finite elements. The governing equations for the discrete representation of the continuous problem are formed by combining the stiffness matrices and load vectors for the individual finite elements. These equations are then solved to produce an approximate solution for the continuous system. As a result, ANSYS evaluates how much the electrostatic force is generated. As experimental way, electrostatic gripping is done practically. At first, required setup was built including electrical circuit, and electrostatic grippers were made. For later comparisons, two kinds of insulated materials were used. Teflon (P.T.F.E.) (relative permittivity $\varepsilon_r = 2$) and trichloroethane ($\varepsilon_r = 7.5$). And the grippers could be classified with the number of electrodes. One has one electrode and another had two electrodes. Each experiment was done at least 10 times, and percentages of possibilities represented evaluation of the parameters. Finally, theoretical and experimental results were compared. These comparisons typically showed difference between ideal and practical situation.

Here one analytical model and their result are shown. It is about applied voltage variance. The analysis model are depicted in the following figure. Considered area was 10mm (600μm. Diameter of a wire was 400μm long and totally the gripper's diameter was set 600μm. Thickness of insulation layer was 100μm, which is from measured thickness of Teflon firms used in this research. The objective part has 1.5mm width and 100μm thick and is made from copper, which means that it is highly conductive. It was assumed that the end surface of the gripper and the top surface of the part had complete contact without any gap or contamination, and insulation layer was Teflon, that is, relative permittivity is 2. relative permittivity of air was set 1. Applied voltage was changed from 50V to 300V. That voltage were applied on the dot lines in the figure. One is on a surface of wire and another is on the stage and on the part.





The generated force on the top surface of the objective part was shown in the following figure. Horizontal axial is corresponded to the top surface of the part.



The resultant data is stress and data have waves. This may be due to FEM. This method deals with the analyzed area as divided small elements. The number of waves is equal to the number of elements. So they must have relation. Total generated forces are integral of the stress. From these results, 100 voltages should be enough to pick up the part.

Experiments were done and the following table shows the results.

		300V	200V	150V
Possibility of	Move	100	100	0
	Pick up	90	60	0
	Release	67	50	-

unit : %

Move means that gripper could move the part but could not pick it up eventually, Pick up means that the gripper could pick it up successfully, and release means that gripper could release the part deliberately.

From this result, picking task need 300V, and 200V seems not enough. When we look at releasing task, the possibilities are higher than picking up task. But still 200V is not enough. This also shows that picking up is more difficult that releasing. This experiment showed that practical gripping needs about 3 times high voltage than theoretical model. These reasons are suspected that exist of influences from other forces and positioning error between the gripper and the part. It could be possible that imperfectness of gripper due to mistake of making and damages during experiments.

The conclusions are briefly shown such as the following.

- Experiments proved that the electrostatic gripping to conductive parts is feasible with this setup. And a comparison between with an insulation layer and without an insulation layer has proven that the electrostatic gripper needs insulation layer in order to pick up a part in the air.
- The electrostatic gripper could not generate enough forces to pick up a part at such a voltage that is sufficient in simulating. This discrepancy in required voltages was suspected to come from other disturbing forces influence, influence of mutual position between a gripper and a part, and imperfectness of the electrostatic gripper.
- Experiment has proven that temperature changing at range from 27.2 °C to 37.4°C does not give any influence to the electrostatic gripping system.
- Experiments have shown that bi-pole gripper could pick up a part at higher possibility than mono-pole gripper, or bi-pole gripper could pick up a part at lower applied voltage than mono-pole gripper.

Here lectures are explained.

The course, Fundamentals of material removal processes was opened in English every Tuesday from 10:00 to 12:30. Students can be given 3 ECTS (European Credit Transfer System) credit points if they can pass an exam.
Detailed description of topics is about Classification of material removal processes, processes with geomtrically well-defined cutting edges (turning, drilling, milling, etc.), processes with geomtrically non-defined cutting edges (grinding, honing, lapping, etc.), other processes, tool characteristics, process parameters, recent developments, state-of.the-art machine tools. Learning goals are gaining knowledge about fundamentals of material removal processes, technological comparison of different manufacturing possibilities, limits of technology.

The course, Electromechanical systems was opened in English every Tuesday from 8:30 to 11:30. Students can be given 4 ECTS credit points if they can pass an exam.
As learning goals, students who followed this course, should be able to use the terminology used in electromechanics, describe the operating principles of motors (magnetic circuits, magnets, induced voltage), deal with the important limitations and characteristics (losses, safe operating area, cogging, magnets, amplifiers), distinguish between the different construction forms of DC motors, choose a motor for a certain application (given a load profile, ambient conditions, heat), be a good partner of a specialist who designs electromechanical actuators, and describe the operating principles of magnetic levitation and propulsion of magnetic levitated objects.

The course, Measurement theory and praxis was opened in English every Thursday from 8:30 to 10:30. Students can be given 3 ECTS credit points if they can pass an exam.
In this course main attention is paid to measurement of mechanical magnitudes especially for servosystem application. Some topics are General performance characteristics of instruments. Input-output configuration of measuring instruments. Input impedance, correction methods. Static and dynamic behaviour, transfer functions. Amplitude modulation, Measuring devices for motion, standards and callibation. Displacement, velocity acceleration - measurement devices for both linear and angular motion, Force torque pressure sensors, Strain gauge principals, Temperature: thermoelectric sensors and radiation methods, Signal conditioning, manipulation and transmission, and Filtering, noise suppression.

The English course was opened every Wednesday from 5:30 to 7:30. Students can be given 3 ECTS credit points if they can pass the course. Students are evaluated though final exam, final report, small assignments, presentation and attendance. Though this course students could learn sense of English rather than grammar or writing English by using their own materials.

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Division	Faculty of Mechanical Engineering and Marine Technology, Department of Production Technology and Organization
Supervisor	Ir. J, J, L Neve

Knowing Europe through study and football

— **Akio Morita**, Osaka University

01 Sep 2004 - 02 Jan 2005 Delft University of Technology, Netherlands
03 Jan 2005 - 31 Jan 2005 Katholieke Universiteit Leuven, Belgium

Executive summary

I studied in Technical University of Delft from 1st of September 2004 to 3rd of January 2005. I worked on the research about "Design of a compensation mechanism for voluntary closing hand prosthesis". Though I worked alone till the beginning of October, Emanuele Antonucci, an Italian exchange student, cooperated with me to deal with the same project from the middle of October. Since then, we worked together and gave presentation about our work for 4 months in the monthly meeting of Man-Machine-Systems on 21st of December 2004.

Besides this research, I took several courses in TU Delft, "Introduction Man-Machine-Systems", "Biomedical Engineering Design" and "Intermediate English Course". In the course of Introduction Man-Machine-Systems, the researchers or PhD students introduced their research. I could broaden my knowledge about various kinds of applications. Biomedical Engineering Design consists of two parts of lectures. In the former, the teachers just gave us the lecture, and we had to design a specific prosthesis with group mates in latter part. We gave the presentation of our idea about the prosthesis twice.

Apart from study, I played football as a member of an official amateur team in the Netherlands. I played every weekend and did training every Tuesday and Thursday. Since I should communicate with the local Dutch people with Dutch language, I took Dutch language course once a week from ING group. ING Group is an international community in Delft.

I stayed in Leuven from 3rd of January to 31st of January. I belonged to the department of production engineering, machine design and automation. I studied about Electroactive polymer actuator there. On arriving at Leuven, the University registration office was closed because it was still in holiday. I worked on the design a setup for the measurements of the simple characteristics of IPMC (displacement and force). And I tested whether the actuator is promising or not.

Apart from study, I stayed with foreign exchange students in the same flat for the first time. I could get knowledge of other culture people not only in Belgium but all over the world.

Exchange student life

Football is one of the most popular sports in Europe. I wanted to communicate local people in the Netherlands, so I decided to take part in a local football team. I was a member of the football team of Osaka University, so, the difference between teams of Osaka and the Netherlands is also my interest. Anyone can play football in any club teams in the Netherlands. There are no official school teams different from Japanese school.

TU Delft has a sport center, where everyone can enjoy many kinds of sports. If you are a student, you can play more than 40 sports after paying 50 euro for one year. I belonged to one football club in the sport center, Ariston80's, which has seven teams and one woman team. This club is now at the 4th class in national amateur league in the Netherlands. I played the official match every Saturday and did training every Tuesday and Thursday from 20.00 o'clock. Many of the teammates have their own work and therefore we always do training in the evening. The most different part of football in Japan and in the Netherlands is an environment. The facilities for sports in the Netherlands are very good, for instance, I played always football on the grass ground, while on the soil ground in Japan. Not only the field where the Netherlands is better than Japan, but also that there are locker rooms, shower rooms, and a bar next to the every soccer ground. Why can they keep them being good conditions? The reason is that every team has its own sponsors. You can see a lot of advertisement of the sponsors in the pitch side of the ground, on the uniform, bag and so on. Dutch people really like a football.

I could play official amateur football league. I had a lot of opportunities to communicate with Dutch people. From these experiences with Dutch teammates, I am describing the personality of Dutch people. Dutch people are very lively and always talk to someone even he/she is a stranger. With such character of them, I could play with them easily as soon as I got to the Netherlands. Other character of them should be that they have unyielding opinion. The Dutch people always did their best performance earnestly for everything though they play only the small game, running, and training. Thus, they are very excited in the official game. They sometimes have a very big quarrel with opponents in the match of football. They really wanted to win.

If we win the match, they are very excited. The atmosphere after winning the game was very good. The Dutch people try to enjoy everything truly. There is a specific Dutch word "gezellig". The meaning is something like cozy. It is not completely same. I could experience "gezellig" through the

football. The atmosphere in locker room after training or the match was very comfortable. The football in the Netherlands was my precious experiences.

Suggestions to the project

It was too short that to complete one task for the project. I arrived at Leuven on 3rd of January 2005 though the school was opened in the daytime; the registration office was closed because the New Year's holiday was till 10th of January. I suggest that I should have made my plan more clearly before coming to Leuven. If you make plan to go to Leuven as a second University for short time, you should consider about registration. And all students of Leuven are very busy because they have to take examination in January. I couldn't spend much time with Belgium students. Most of the students studied in their own home or library, so that the opportunities which I can communicate with Belgium students.

There are a few constant working spaces for the master students in Delft. The system of laboratory in Europe is different from Japan. I often saw some students who wrote master thesis in the shared computer room. However, you have a lot of opportunities for discussing with foreign students. There are many courses as group works.

Summary

From 1st of September to 31st of January, I studied in TU Delft and KU Leuven. The research theme was different from my research in Japan. However, thanks to supervising from Prof. Plettenburg in TU Delft and Prof. Reynaerts, and also the discussion about design of compensation mechanism with my research fellow, Emanuele Antonucci, I could study a lot of knowledge for mechanical engineering.

[Research at TU Delft] Design of a Cosmetic Glove Compensation Mechanism

Introduction

In prostheses design three key requirements play fundamental roles: comfort, controllability and cosmesis. The voluntary closing hand prostheses which are dealt with in this research have the main advantage over external powered devices; intuitive controllability. However, the voluntary closing hand prostheses are not still common in the market of this application because of poor cosmesis. For example, the Lite Touch hand by TRS (shown in Fig. 1), company from United States, made the voluntary closing hand of which the hinge and the operating cable are visible. For attacking this issue, flexible covering, and cosmetic gloves are needed in order to improve their appearance. Implementation of them does not come without further problems. In facts, these gloves counteract the movement of the prostheses fingers with non-linear force that make trouble with the proprioceptive feedback with the prostheses. Therefore design for the mechanism which can balance the elastic part of the glove counteraction is to be the purpose of the present research.

We, from now on, define the glove characteristic as the moment of the elastic force from the glove with respect to the thumb axes as a function of the thumb opening angle. The problems of glove characteristic are the non-linearity of their own hysteresis and different characteristics.

Fig.1 Voluntary Closing Hand (TRS)

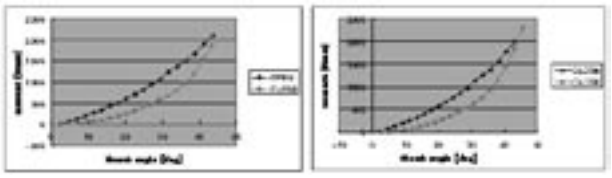

Fig. 2 Glove characteristics which we must design torque and angle of thumb

The statically balanced system is supposed to be sufficient for compensation mechanisms. Especially four bar linkage with spring mechanism should be useful because this mechanism is able to generate the torque which increases progressively.

Four bar linkage

(1) Concept of four bar linkage for compensation mechanism

The four bar linkage which we deal with for compensation mechanism is shown in Fig.3 schematically. We should point out that several methods exist for the synthesis of four bar linkages, from the historical Hrones & Nelson book to modern computer techniques. Nevertheless, all these methods are oriented to problems different from the one we are willing to solve. The classifications of the methods are; function, motion, and path synthesis methods. None of the categories fulfilled out needs, thus a different approach should be taken for analysis of four bar linkage. What we have to do is to find the configuration for fit with the glove characteristics.

Due to the various restrictions (position, spring stiffness, length and so on), we find the configuration by trial and error.

Fig.3 Four bar linkage for compensation mechanism

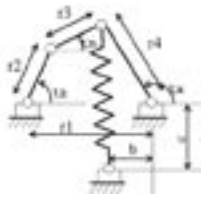

Fig.4 Four bar linkage

(2) Analytical calculation

The four bar linkage is shown in Fig.4. Each joint of the four bar linkage is defined as 1, 2, 3, and 4 counter clockwise from left bottom point respectively. The joint 1 is connected with the thumb, thus the moment of the link between joint 1 and 2 (M) should be calculated. Note that the spring is not ideal spring, but real spring. M is

$$M = k \cdot (l - l_0) \cdot \frac{\sin(\theta_4 - \beta)}{\sin(\theta_4 - \theta_3)} \cdot \sin(\theta_2 - \theta_3) \cdot r_2 \qquad (1)$$

where k is spring stiffness, $\beta = \arctan[\frac{c + r_4 \sin\theta_4}{b + r_4 \cos\theta_4}]$, $l = \sin\alpha \frac{\sqrt{b^2 + c^2}}{\sin(\theta_4 - \beta)}$, l_0 is initial length of spring.

The moment M can be calculated based on two angles θ_3 and θ_4. These two angles can be calculated with Newton-Raphson method. The vector loop equation of the four bar linkage provides the set of functions that defined the two unknown link angles θ_3 and θ_4.

$$\begin{aligned} f_1 &= r_2\cos\theta_2 + r_3\cos\theta_3 - r_4\cos\theta_4 - r_1 = 0 \\ f_2 &= r_2\sin\theta_2 + r_3\sin\theta_3 - r_4\sin\theta_4 = 0 \end{aligned} \qquad (2)$$

where f_1 and f_2 are vector loop equations.

Design the mechanism

(1) Space constraint

The dimensions of the operating mechanism are very important factor for design. Roughly measurement on an existing closing hand prosthesis for toddlers resulted in an area of about 40mm and 30mm. And the presence of the real spring is also is to be considered. The real springs are standardized and have rest length and the limitation to be taken into account. Therefore the range of the spring is depended on the configuration as shown in Fig. 5.

The real extension spring can be selected from Tevema's catalogue.

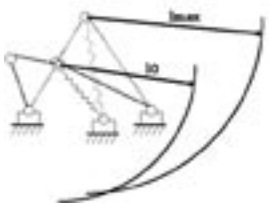

Fig. 5 Limited area for spring attachment

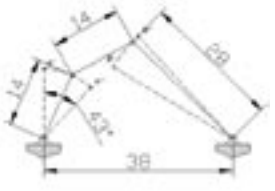

Fig.6 The selected mechanism

(2) Selected mechanism

From the afore-seen considerations, Fig. 6 shows the selected

layout for the mechanism in the initial and final positions and the dimensions of the mechanism. The mechanism should be as simple as possible, to meet the dimensional constraints and of course to make possible the match between the glove characteristics. Our approach is based on considerations on the glove characteristics and on the simulated characteristics for the balancing mechanism.

(3) Regulation
In order to adjust the compensation spring characteristic to the glove, we should know how the regulation parameters can influence the characteristics of compensation mechanism. The length of linkage, the attachment position of spring, and can be regarded as the regulation parameters shown in Fig.6.

(length of linkage)
We change only r2 and r3 when the total length (r2+r3) is constant 28mm. The moment of the thumb is shown in Fig.7 when r2 changes from 12mm to 15mm. The largest moment is when r2 is 15mm.

(stiffness of spring)
With the catalogue of extension spring from Tevema, we selected the three springs. These springs' stiffness (k) are 5.27N/mm, 24.56N/mm, and 30.06N/mm. The moment is shown in Fig.8. The largest moment is when k = 30.06N/mm.

(position of spring)
Fig. 9 shows the moment when the position attached with linkage changes; horizontal line on linkage1 (b = 8, 10, 12 mm), and vertical line on linkage1 (c = 8, 10, 12 mm). The largest moment is when b (and c) is 12mm

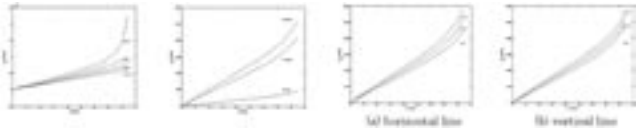

Fig.7 length of linkage Fig.8 spring stiffness Fig.9 Position of linkage

Decision of final configuration

The sum of the two lengths of linkage remain constant, that is to say r2+r3=28 mm. The final configuration of the mechanism is kept the same as above. When regulating the mechanism, the overall potential energy required to compensate for the glove elasticity is calculated. This will be equal to the area beneath the characteristic curve. Once done that, a configuration of the r2/r3 links is selected in order to provide the same amount of energy through the scope of the mechanism. Finally, the attachment point of the spring is positioned along a rail in order to match the torque required at the top of the curve.

The rail is shaped in such a way that the potential energy provided by the four bar through is motion is independent from the attaching point of the spring, as long as this point lies on the rail.
Fig.10 compares the simulated resultant torque from the compensation mechanism with the given glove characteristic.

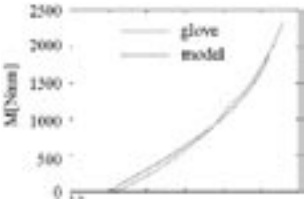

Fig.10
Simulated torque and glove characteristic

[at K.U.Leuven] Electroactive Polymer Actuator experimental data

Introduction

In recent years, Electroactive polymers are investigated by many researchers because they have a lot of attractive characteristics. They are lightweight, inexpensive and soft, and have low excitation voltage. Since they behave similar to biological muscles, they are called 'artificial muscles'. The aspects of EAPs which is similar to that of animals and insects can lead to design some innovative applications in medical and engineering area.
Generally, EAPs can be classified into two categories based on their activation mechanism: electronic and ionic. The electronic polymers require high activation fields (>150V/μm). However, they can be made to hold the displacement under activation of DC voltage, so that they are useful for robotic applications. For instance, piezoelectric polymer (PVDF and PVF2) can be obtained commercially. On the other hand, the ionic polymers require drive voltage only 1-5 V. However, it is needed to be in wetness.
IPMC (Ionomeric Polymer-Metal Composites) is focused on in this report. IPMC bends in response to an electrical activation as a result of mobility of cations in the polymer network. A relatively low voltage is required to stimulate bending in IPMC, where the base polymer provides channels for mobility of positive ions in a fixed network of negative ions on interconnected clusters. There are two types of base polymers which are used to form IPMC: Nafion (erfluorosulfonate) and Flemion (perfluorocarboxylate). This report focuses on the IPMC which consists of Nafion membrane and Platinum as electrodes on its surface. Measurements are performed to find out how the IPMC can be applied for many kinds of applications. In order to know the characteristics of IPMC, at first, the bending displacement and the force were measured under a low voltage. Subsequently, the time dependent behavior of IPMC was measured simply.

Ionic Polymer-Metal Composites

IPMC as bending actuators and sensors are referred to as 'soft actuators-sensors' or 'artificial muscles'. IPMC consists of a polymer membrane and metal electrodes plated on both faces. The polyelectrolyte matrix is neutralized with an amount of counter-ions and to balance the charge of anions fixed to the membrane. When an IPMC in the hydrated state is stimulated with a small voltage, both the fixed anions and mobile counter-ions are subjected to an electric field. Only the counter-ions are able to diffuse toward one of the electrodes charged negatively. As a result, the composite undergoes a bending deformation toward the anode. The schematic principle of such a bending mechanism of IPMC is shown in Fig.1.

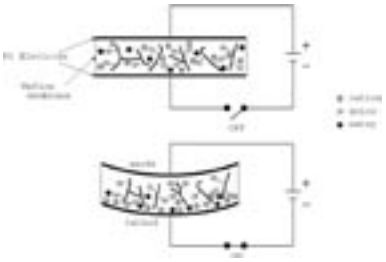

Fig.1 Schematic of bending model with migrating cations due to an imposed electric field

The IPMC strips were composited with a Nafion membrane and Platinum as electrodes. Nafion is a perfluorinated polymer that contains small proportions of sulfonic or carboxylic ionic functional groups.

Experiment (static situation)

In this section, the aspects of electroactivation of IPMC are presented. The displacement and the force of a sample IPMC of Enivironmental Robots Inc. are measured when this polymer responds to applied voltage. These experimental data are shown in this section as a fundamental characteristic of IPMC.

(A) Theory

(1) Displacement

IPMC bends when it is subjected to a voltage between the electrodes. The displacement is divided into two parts, electroactivation and IPMC's own weight. The displacement from only electroactivation can be measured as the difference between the current position and the initial one without any voltage.

(2) Force

The force is calculated by the mass which can keep shape of IPMC staying initial position as $F_e = Wg$ where F_e is the force fro electroactivation, W is mass of loading weight and g is gravity.

(B) Experimental setup

In order to determine the aspects of electroactivation, IPMC strip was set up as a cantilever-shaped actuator. IPMC bends when subjected to a voltage between its electrodes, and then the tip displacement can be measured by the ruler. On the other hand, the force can be measured when loading weight keeps the tip of IPMC strip staying the initial position. In this experiment, I measured all data every 30 seconds after applied voltage changes.

This IPMC of which thickness t is 0.3mm and width w is 6.5mm has parameters of $I_y = \frac{wt^3}{12} = 14.6 \times 10^{-15} mm^4$ where Iy is the second axial moment of IPMC.

(1) Young's Modulus

Young's Modulus of IPMC can be calculated from experimental data. The displacement is measured directly based on some weights without any applied voltage. The displacements were measure 5 times by 5 kinds of weight.

The displacement with a single load f_w is derived as $f_w = \frac{Wgl^3}{3EI_y}$. Thus, the difference between two displacements Δf can find Young's Modulus of IPMC as described $E = \frac{(F_1 - F_2)l^3}{3\Delta f E I_y}$.

where F_1 and F_2 are the force when loads are W_1 and W_2 respectively.

The Young's Modulus are calculated by the difference of displacement between neighbors as shown in Table 1, where $l = 25.4mm$.

Table1 Young'sModulus

E1-2	418.3 [MPa]
E2-3	763.9[MPa]
E3-4	702.8[MPa]
E4-5	798.6[MPa]
Ave E2-5	755.1[MPa]

$E_{1\text{-}2}$ is especially different from others. All data were measured by the ruler of which resolution is 1.0mm. I calculated the Young's Modulus as the average of data except $E_{1\text{-}2}$.

(2) Result

The experimental data are the distribution of 5 measurements.

(a) Displacement

The tip displacement of IPMC is shown in Fig. 12 when applied voltage changes from 0V to 4V.

(b) Force

The force was measured with loading weight which kept IPMC straight. The force is shown in Fig. 13 when applied voltage changes from 0V to 4V.

From Fig.13 the biggest force was 10mN. Therefore, the applications need to be designed accordingly and limited.

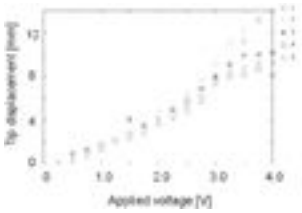

Fig. 12 Tip displacement vs applied voltage

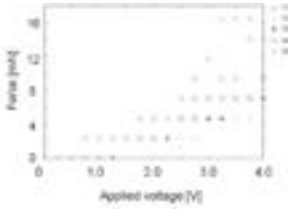

Fig.13 Force vs applied voltage

Experiment (dynamic situation)

Fig. 14 shows how the tip displacement changes for 3 minutes after input voltage 4V is applied. The experimental data include 3 measurements.

The slow movement of the tip displacement are observed and there is no relaxation after bending toward anode. Herewith, the counter ion should be a large cation. The tip of IPMCwas still bending 3 minutes after the applying voltage. The material of which response is very slow is not useful for applications.

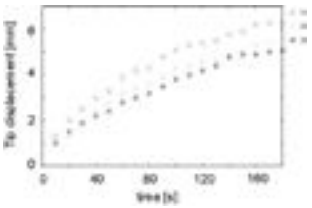

Fig.14 The response of IPMC

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Experiences to help me in the future

— **Kenichi Niinuma**, Osaka University

01 Sep 2004 - 04 Jan 2005 Delft University of Technology, Netherlands
05 Jan 2005 - 31 Jan 2005 Katholieke Universiteit Leuven, Belgium

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.

Exchange student life

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.

2. K.U.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.

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.

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.

[at TU Delft]

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.

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 sys-

tem. 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.

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
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.

[at K.U.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.

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Big differences in the way of studying between Japan and Europe

— **Takumi Sakamoto**, Osaka university

01 Sep 2004 - 27 Dec 2004 Delft University of Technology, Netherlands
27 Dec 2004 - 31 Jan 2004 Technical University of Denmark, Denmark

Executive summary

I stayed Nederland from 1st September 2004 to 27th December 2004 and Denmark from 27th December 2004 to 31th January 2004.

I researched "New algorithms to solve BMI problem" in TU Delft. It will be a part of graduated thesis. I took 3 lectures in TU Delft and 1 lecture in DTU. Level of lectures in TU Delft and DTU are not so different from that in Japan. I only had a problem to write my answer in English. But I could get all of the grades. I also took 2 English lectures a week though I could not be allowed to get the grades. One is a lecture in TU Delft and the other is in ING that is a private organization. I think that they are very effective to improve English because I had opportunities to speak and hear English and also the lectures were very enjoyable.

I found some big differences between Japan and Europe. I write down them as follows.

- There are many practices and the maneuvers in European lecture.
  In Europe we cannot get the unit by only attending the class and taking the test. In order to get the credit, we need to attend the class, to submit reports that are made from the maneuver and to take the test. I think these systems are lack for Japanese university.
- European student's motivation is different from Japanese one.
  In Europe whenever the teacher questions during the lesson, someone positively answers the question in Europe. I wonder why Japanese students choose the lectures by judging the ease of taking the credit. I think this idea of Japanese students is very dangerous.
- There are many group works.
  I was surprised at an interesting lecture of designing by the group work. In the lecture the teacher explained only the outline of the lecture, and then we have to design what we were given in our groups. I thought that I hardly took such a interesting lecture in Japan. This lecture enabled us to strengthen debate and presentation and so on.
- There are unpalatable foods and bad service in Europe.
  I had problems to have a meal in Europe because the food in restaurant is very expensive and the lunch in TU Delft is not delicious. During the stay I missed Japanese foods. In addition European clerks are not polite compared with Japanese one. They often made me a little bit annoy.

Exchange student life

What was most astonishing for me was that universities in the Netherlands, for example, TU Delft were not accessible on weekend. When I asked about it a professor at the university, he answered "Here is Holland. Why don't you enjoy your life?". Then I realized that almost all the shops in the Netherlands were closed by 18:00 and TU Delft was not accessible on weekend. They spend their time on their leisure activities with their family. I found this culture is quite different from that of Japanese. Before I went to the Netherlands, I took it for granted that most professors and students come to laboratories and do their studies or work even on weekend. However, such ideas are very new to me and broadened my mind.

Actually I did not have any serious problems in the life in the Netherlands. However, one problem for me was the food. The food does not suit my taste. In addition when we had meals in a restaurant, each meal costs around 1500 yen.
The food in a restaurant in TU Delft is also expensive for students. Therefore, I had to go back my dormitory during lunch time and make a meal by myself.

In 4 months' stay in the Netherlands, I made friends with many other students through football and having a drink almost every weekend. Such activities let me relaxed and helped me to make progress in English. Moreover, I attended ING: a private organization for events, and then I was able to take an English lecture and have a Christmas party. I felt something familiar to the culture in the Netherlands greatly.

Since in Denmark I stayed only for one month and took three weeks' lectures at the university, I was very busy and was not able to spend time like I did in the Netherlands. I woke up early morning, went to university, took three weeks' lectures, studied by myself and went back to my dormitory. I repeated this cycle for three weeks. In the three weeks' lectures four Japanese students including me have to do some tasks together. Therefore, I did not have to use English.

In Denmark I had troubles about a bicycle and the expensive cost of living. DTU was a large university and it took twenty minutes to go to DTU from my dormitory. Then I thought it was necessary to have the bicycle for comfortable life. I borrowed a bicycle from a friend. However, the tire of the bicycle got punctured three times for one month. This was unbelievable for me. Even thought I complained about that

at a bicycle shop, they were not willing to help me at all. I was surprised at their attitude and came to realize the differences of services between Japan and Denmark.

Suggestions to the project

- In Holland I lived with Japanese guy. So I could not speak English in my house and make foreign friends. So I wish I lived with foreign people.
- I think there are a lot of foreign people in Osaka University. So before going to Europe, we should have had the opportunity to talk with them.
- In September we could not get money. So I think that the time when we can get money should be announced in advance.

Summary

This project enabled me to have quite good experiences. I felt something familiar to European culture in the Netherlands and Denmark and other foreign countries by talking to friends in the countries, and then I gained precious experiences thorough this project.

I considered that going abroad was a special experience before I went to Europe. However, actually this exchanging project made me find out that it was not extra ordinary experience all over the world. Now I think Japanese students are abnormal. For example Japanese students choose lectures by judging the ease to take the credit and there are few lectures where students can do many practices and the maneuvers. I consider that we should head toward international levels. Otherwise I think Japan will lose the competition of international companies.

Owing to this project I could grow more greatly than I was in Japan. I could find the crisis of Japanese students, lectures and the abnormality. I also found the better points in Japan than in Europe. I think I could not realize these things without going to foreign countries. I think these concepts will be needed if Japanese lead this world.
I really thought it was worthy for me to participate in this project.

[Research at TU Delft]

Introduction

In this project we considered algorithms for H_∞ optimal static output feedback problem based on sequential LMI optimization.

H_∞ controller synthesis is an attractive model-based control design tool. It allows incorporation of modeling uncertainties in control design. One of the reasons that H_∞ controller has not yet been widely used in industry is the high order of the resulting controller. H_∞ synthesis without additional complexity constraint yields in general a controller order equal to n the order of the dynamical model plus the order of the weighting functions. The computation of the controller action in implementation on systems with a very high sampling rate, the need for low-order controllers is obvious. But this problem is BMI problem which is not easy to solve.

In order to solve this problem we apply a method based on Finsler's method for this BMI problem. Moreover we considered the existing methods (XK-iteration, Path-following) which solve BMI problems. In order to speed up the calculation time, we combined them with a dedicated solver for LMI problems arising from the KYP. By using these methods, we solved the H_∞ static output feedback problem for a system with McMillan degree 4 and compared the results.

Problem formulation

Consider the system depicted in Fig.1. $P(s)$ is given by

$$\begin{bmatrix} \dot{x}_p \\ z \\ y \end{bmatrix} = \left[\begin{array}{c|cc} A & B_1 & B_2 \\ \hline C_1 & D_{11} & D_{12} \\ C_2 & D_{21} & 0 \end{array}\right] \begin{bmatrix} x_p \\ w \\ u \end{bmatrix}$$ and K is static output feedback gain.

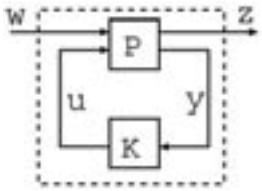

Fig 1. Generalized plant

In this case, we have the closed-loop systems as the following state space representation:

$$\begin{bmatrix} \dot{x}_p \\ z \end{bmatrix} = \left[\begin{array}{c|c} A + B_2 K C_2 & B_1 + B_2 K D_{21} \\ \hline C_1 + D_{12} K C_2 & D_{11} + D_{12} K D_{21} \end{bmatrix} \begin{bmatrix} x_p \\ w \end{bmatrix}$$
$$= \left[\begin{array}{c|c} A_{cl} & B_{cl} \\ \hline C_{cl} & D_{cl} \end{bmatrix} \begin{bmatrix} x_p \\ w \end{bmatrix}$$

Here we consider H_∞ controller static output feedback problem: The purpose of this problem is to obtain the stabilizing controller which minimizing H_∞ norm from w to z. This problem is equivalent to finding $X > 0$, K and

$$\begin{bmatrix} A_{cl}^T X + X^T A_{cl} & XB_{cl} & C_{cl}^T \\ B_{cl}^T X & -\gamma I & D_{cl}^T \\ C_{cl} & D_{cl} & -\gamma I \end{bmatrix} < 0$$

such that the above equation holds. Note that A_{cl}, B_{cl}, C_{cl}, D_{cl} depend on the controller K.

Application

In order to solve this H_∞ problem which is BMI problem, we considered 5 methods: Finsler's method, XK iteration method, Path-following method and 2 combined methods. We propose Finsler's method. This method can deal with larger class than BMI. On the other hand the number of LMI is larger than that of other methods. XK iteration method and Path-following method are used for BMI solver so far. We remark KYP method which is known as the more efficient solver than LMI solver and combined it with XK iteration method and Path-following method. These are combined methods.
Here for the convenience of space, I explain only KYP method.

KYP method

In this method, we can efficiently solve LMIs with a special structure. This method solve

$$\text{Find } X, \text{ s.t.} \begin{bmatrix} A_{cl}^T X + X A_{cl} & XB_{cl} \\ B_{cl}^T X & 0 \end{bmatrix} + M < 0.$$

In terms of H_∞ problem, we can obtain the form of KYP as follows.
First we apply a shur complement for H_∞ problem. Then we get

$$\begin{bmatrix} A_{cl}^T X + X A_{cl} & XB_{cl} \\ B_{cl}^T X & -\gamma I \end{bmatrix} + \begin{bmatrix} C_{cl}^T \\ D_{cl}^T \end{bmatrix} \left(\frac{1}{\gamma}\right) \begin{bmatrix} C_{cl} & D_{cl} \end{bmatrix} < 0.$$

Then we multiply γ to the above equation and recast $Y = \gamma X$ and $\beta = \gamma^2$. Thus we obtain the following KYP form.

$$\text{Find } X, \text{ s.t.} \begin{bmatrix} A_{cl}^T Y + Y A_{cl} & YB_{cl} \\ B_{cl}^T Y & -\beta I \end{bmatrix} + \begin{bmatrix} C_{cl}^T \\ D_{cl}^T \end{bmatrix} \begin{bmatrix} C_{cl} & D_{cl} \end{bmatrix} < 0.$$

Note that this method can solve LMI efficiently but Y is not always positive matrix. So we have to be careful for Y.

Numerical example

We denote the result of solving H_∞ problem by using "Finsler's method", "XK-iteration method", "Path-following method", "XK-KYP method" and "Path-KYP method". We compared the CPUtime and the H_∞ norm which is obtained by each methods. We use the objective plant of the model of logitudinal motion of VTOL helicopter. Then we got the following result.

Table.1 : The comparison of each method

	Finsler's	XK iteration	Path following	XK KYP	Path KYP
H_∞ norm	0.173	0.176440	0.154457	0.176440	0.154456
CPUtime	2655.4	14.5610	5.157	24.195	17.4150
Iteration	48	47	24	44	23

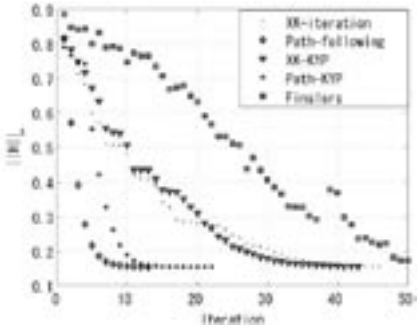

Fig.2 : Iteration v.s. H_∞ norm performance

Table.1 shows the comparison of H_∞ norm, CPUtime, iterations and Fig.2 shows one example of the relationship between iterations and H_∞ norm performance in each method. We can find that the movements in Path-following and Path-KYP is similar and the movements in XK-iteration and XK-KYP is as well. We also find that Path-following method is better than other solutions.

Finsler's method takes much time compared with other methods, because we have to deal with larger matrix and larger number of variables in Finsler's method than in other methods. But in this method we can obtain the controller which has almost same performance as one in other methods. It is very good results. Because in Finsler's method, we can deal with larger class of problems that can not be solved by using other methods.

Summary

Finsler's method takes much time compared with other methods. It is because we have to deal with larger matrices and larger number of variables in Finsler's method than in other methods. But in this method we can obtain the controller which almost has the same performance as with other methods. Furthermore Finsler's method can be applied to a much larger class of problems.
We guess that the combined methods (XK-KYP, Path-KYP method) can get a controller faster than Path-following method because KYP solver is more efficient than LMILAB solver. However we got the results that Path-following method is faster than the other methods. We have to investigate why it occurs.

[Lectures at TU Delft]

1. Control theory

This course serves as an introduction to the concepts and techniques currently used in basic modern control theory. The course requires the development of the technical skills involved in state space system theory. It also extends the notions of control system design toward time-domain techniques based on pole placement and linear optimal control using quadratic performance criteria. The exercises in the course stress the use of a computational linear-algebra environment for linear control system design. The exercises make us familiar with model-based control design, supported by modern computation tools for dynamic analysis, simulation and control performance assessment.

2. Optimization in systems and control

This course is divided into 2 parts. One is optimization techniques and the other is applications in system and control. In the formal part we studied various techniques to solve optimization problem. For example Linear programming, Quadratic programming, nonlinear optimization, global optimization methods and so on. In the latter part we consider the Multi-Criteria Controller Design and solve it in a exercise.

3. Biomedical engineering design

In this course we study the various mechanisms which are involved in medical engineering. In my case we designed the new mechanism of a prosthesis. In order to do it, we decided the problem definition and think about a lot of conceptual solutions and then find the most effective solution.

[Lecture at DTU]

1. Laboratory course in Process Simulation

The course is divided into three parts covering simulation of metal casting, plastics casting and metal forming. Each part starts with an introduction to the process followed by an exercise where the process is simulated. A small report must be delivered in the end of the course. There are 2 main objectives in this course. One is to make us familiar with some of the most important computer programs for simulation of metal casting, die casting of plastics as well as mechanical forming of metals. The other is to enable us to make simple computer simulations with these programs.

[The differences in the way of studying]

I took only four lectures in Europe. I think this is enough to realize the differences between Japan and Europe. I have 3 main opinions about the differences. First I was surprised to do many practices and the maneuvers. I cannot get the credit by only attending the class and taking the test in Europe. In order to get the credit, we need to attend the class, to submit reports which are made from the maneuver and to take the test. Especially, one class needed that I had to discuss reports with the teacher in order to check whether I could really understand the lecture. Although I spent on studying the lecture, I think I made progress by this lecture policy. Secondly there is a difference of student's motivation. Whenever the teacher questions during the lesson, someone positively answers the question in Europe. I wonder whether the Japanese students who choose the lecture by judging the ease of taking the credit, is really good. Thirdly I was surprised at an interesting class of designing by the group work. In the lecture the teacher explained only the outline, and then we have to design what we were given in our groups. I thought that I hardly took such a interesting lecture in Japan. The lecture enabled us to strengthen debate and presentation.

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Experience from short term exchange program

— **Tomoya Nakao**, The University of Tokyo

06 Sep 2004 - 02 Jan 2005 Katholieke Universiteit Leuven, Belgium
02 Jan 2005 - 21 Jan 2005 Technical University of Denmark, Denmark

Executive summary

I stayed in Leuven, Belgium and went to Katholieke Universiteit Leuven from September to December. Then I did a research and took lectures (but did not take exam). My research was a part of MEMS project in Belgium. It was about a micro turbine and my part was fabrication technique for a rotor of a micro turbine. Before I left Leuven, I succeeded making in making one blade. Students (PhD) are independent and professors do not usually instruct students each time. So they need to think about their research way by themselves.
Leuven is a town for the university. Buildings of the university spread out in whole town. The town is full of students. So it is good atmosphere for students there. Buses are free for students.

I stayed in Lyngby, Denmark ant went to Technical University of Denmark for 3 weeks in January. Then I took a 3 weeks intensive course. The course I took consisted of lectures and exercises. Each week we took a lecture on Monday and did exercises after the lecture to Friday. Teacher made some groups and did exercises in group and wrote one papers in group at the end of each week. Course title is Laboratory Course in Process Simulation. I studied about computer programs for simulation of metal casting, die casting of plastics as well as mechanical forming of metals.

In Denmark things are so expensive because tax is so high. So many students cook their meal by themselves at home. Some of buildings are locked so early. I think the reason is sunrise is late and sunset is early in winter there.

Both countries English is spoken well. Even if we can speak only English, it is fine for us to live there.

I had some suggestions which I want to be solved in the same project next year.

Exchange student life

Life in Katholieke Universiteit Leuven
Katholieke Universiteit Leuven has many foreign students. Most of them are exchange. So most of them stay in Leuven for about 1 year. They come from all over the world. For example they come from Europe, Asia, North and South America, Africa and so on. Normally they can not stay in student residence. It is only for full year academic students. Exchange student usually rent a room in Leuven city. Accommodation office can help them to find a room. There are 2 type of rooms. One is just a room and the other is studio. The former is a room with own basin and shared kitchen and bathroom. It costs about 200 to 300 euro. The latter is a room with own basin, kitchen and bathroom. It costs about 250-400 euro. Most of them has internet points. Some of students live with Belgium family.

At the beginning of semester there is guidance for exchange students. It consists of welcome speech for exchange students, instructions about life in Leuven, which are about supermarkets, sport centres, traffic systems, traffic rules and so on. It is not obligation. It does not matter if students go or not.

The university also has exchange student centre, which is called "Pangaea". It is for exchange student. It has language class, not only English also other languages. Students have to pay fee, but it is very cheap. The centre also has a coffee room. If students pay 5 euro, they can use this room. Students can drink coffee for free there. A lot of students gather in this room. If students use this room, it is easy to find international friends. The centre also helps students who have problems, for example they have homesick, they can not make friends and so on. The cantre have events as well, for example tours to some cities. I took the tour to Brugge. The tour price is included a bus and a guide.

There are some parties for international students. Normally canteens are used for parties. Students can meet many other international students there. Usually it starts from 9pm and finish until when they want finish!

Students can rent a bicycle for cheap price. The university has this non-profit facility. Computer rooms are available for 24 hours and students can eat good and cheap food in a canteen. 2nd bite French flies are free! So Students never get starve.
There also many parties in bars. Parties usually take place on Thursdays because students whose hometown is near Leuven go back to their hometown on Fridays.

Students can have free bas card from the university. They can use bus in Leuven city and around Leuven for free.

Life in Denmark Technical University
There are residences only for foreign students. They are in university. It is a room with shared kitchen and bathroom. It also has laundry facility. Students can wash and dry their

clothes. Accommodation office can introduce host family or other building to international students. Some of students live there. In Denmark eating out is very expensive. So many students cook their food at home. There are canteens and small supermarket in the university. This market is not so big, but it is convenient because even closest supermarket is a bit far from the university.

International student office can help students who have problems. Computer rooms are available for 24 hours with their student card and account. They can also connect their own lap top computer with internet there. There is also bar in the university. Tuesday is only for international students.
I have heard that there is a system, which is that Danish students help international students. Before students arrive in the university, they can send form to international student office.

Not so many bars are near the university. So students go to Copenhagen for parties, disco. There are night bas systems in Denmark. So students can go back home late even though it is twice as expensive as day bus.
This country English is spoken very well. So it is fine if we can not understand Danish.

Suggestions to the project

All universities should keep places where students live during their stay. In our case some of us could not get a room because accommodation office said that we stayed in Leuven for only 4 months (Usually students stay for more than 1 year. Most of landlords want to rent out a room for more than 1 year.), but we sent a accommodation form about more than 3 months before our arrival.

If students want to do some research there, they should apply for long time course and students should go to only 1 university instead of 2 universities. To do good research students had better be used to living and studying there. If students go to 2 universities, it takes some time for them to get used to living and studying there. In addition, if students get accommodation problem (as I wrote above), it is more difficult. Besides, students focus on only one subject instead of doing 2 researches in 2 different universities.

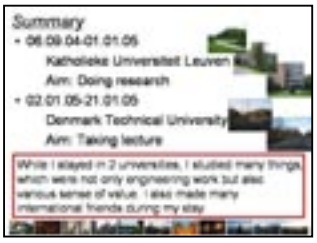
For short term students if they are wanted to do research, they should go to only 1 university instead of 2 universities as well. In my opinion 4 months are too short to do some research. If they are wanted to get good experience, it is ok for them to have to go to 2 different universities. Students can get different lectures, culture, friends from 2 different countries.

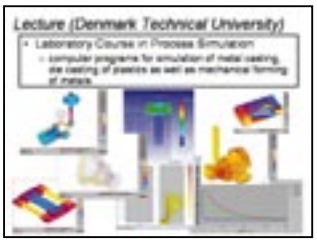
When we asked coordinators some questions of this project, some case they answered so late or did not know about the project well. If even coordinators do not know the project well, students get confused easily.
Students should not only study but also travel or make friends to get good experience. Because students are in different country which has different culture, people and etc, they should try many things which is difficult to do in Japan.

Summary

I went to Katholieke Universiteit Leuven to do a research for 4 months and went to Denmark Technical University to take course for 3 weeks. The subject I did was slightly different from my research in Japan. So it was difficult to do it. Besides, I had only 4 months to do it. I made some outputs at least, but I do not recommend applying for this project for short term if students really want to focus on research and to make a very good output such as thesis, academic paper. If student want to do it, they should apply for long term one. However, I do not deny the short term one. From the short term one students can get good experience for short time. They can feel different atmosphere and meet many people and make many friends. I am sure that it can widen their world.

To conclude, this project is good for students. I would like to recommend it to my junior, but in my opinion it has some problem which should be solved to make the project better.





[Research at K.U.Leuven] Electro-Discharge Machining for a Method of Fabrication for a Rotor of a Micro Gas Turbine Unit

1 Introduction

1.1 Situation

Miniaturization portability is nowadays trend. Many portable devices, systems and etc have been developed these days. It could be wireless and be desired to work in difficult places to get power. Therefore several groups are working on the development of micro power generator based on fuel cells, thermo-electronic device, Stirling engines and etc. A miniature gas turbine also is required in those situations. Therefore Micro turbine is under development that generates electrical energy from fuel. The main parts are compressor, turbine, combustion chamber and generator. How to make parts of a miniature gas turbine is one of the most difficult aspects of this study. There are several ways to make micro 3-dimension structure such as etching, LIGA, laser micromachining, focused ion beam machining, powder blasting, microstereolithography, moulding etching and micro EDM. From Jan Peris's study Kersit 601 (Si3N4 + TiN) is chosen as a material of a rotor because of its high thermal shock residence. Therefore we use EDM to machine a rotor because Kersit 601 is too hard to be machined by conventional fabrication technique and EDM has some advantages to machine this material.
However, there is a big problem in EDM process, which is electrode wear. Overcoming this problem can make it possible.

1.2 Aim

Machining a very small rotor (approximately diameter is 10-30 mm) is not easy. Some fabrication techniques for making a micro structure are available all over the world. However, only few fabrication techniques can be used in K.U. Leuven at this moment. For long time research we can think about all fabrication technique. On the other hand, for short time research we should think only fabrication techniques which are available in K.U.Leuven now. In previous research 2-dimension turbine rotor is machined by die-sinking EDM [8]. The aim of this study is to make strategy to machined 3-dimension complex shaped micro turbine rotor with available methods of fabrication techniques in K.U.Leuven.

2 Method of fabrication

2.1 EDM

Electro-Discharge Machining (EDM), or spark erosion, is a mature machining process in the tool making industry, and is especially applied for the machining of hard materials which are difficult to machine with conventional manufacturing process. In EDM process requirement is just that both workpiece and tool electrode are electrical conductive. EDM has developed itself and made variety EDM process such as die-sinking EDM and wire EDM. EDM has become economical machining process to make complex components of any electrically conductive engineering materials.

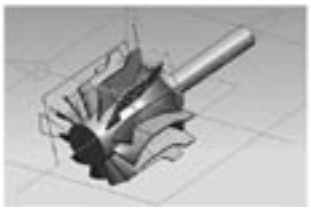
2.2 EDM process

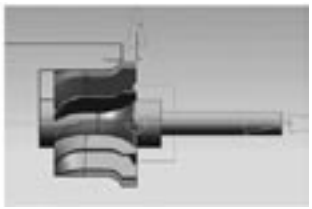
Electro-Discharge machining is an electro-thermal machining process which removes workpiece material by the erosion action of electric discharges. The discharges are created between a tool electrode and a workpeice electrode. Both electrodes are immersed in a dielectric fluid and separated by a small working gap. When a voltage is applied between the electrode and the corresponding electric field in the working gap exceeds the dielectric breakdown level, a discharge is created. The applied voltage is generally pulsed at a predefined frequency, creating successive discharge. Each discharge melts and evaporates a small amount of material on both tool and workpiece electrode. The evaporated material and a portion of the melted material are removed by the electric fluid. The remaining material resolidified and creates a crater-like surface on both electrodes. By applying a large number of sparks, large material volumes can be removed. The material removal on the tool electrode can be kept an order of magnitude lower than the material removal on the workpiece by an appropriate selection of electrode materials and by appropriate machining setting.

The first phrase is the preparation phrase of the discharge channel which is initiated at the moment the generator applied the necessary voltage between the electrodes. When a critical electric field is exceeded between a spot on the workpiece, conduction paths grow at microsecond speeds through the dielectric fluid, in the form of branched trees, called streamers. These streamers are precursors of the effective dielectric breakdown. In a second phrase the electrodes are locally melted by the discharging spark. The discharge consists of a plasma channel surrounded by a gaseous mantle. The plasma channel, consisting of free electrons and positively charged ions, is characterized by high pressure and high temperature. The free electrons accelerate towards the anode and heat up the anode during impact, while the ions strike and heat up the cathode. On both electrodes, material is melted and evaporated by the high power concentration of the plasma channel. It is found the diameter of the plasma channel at the cathode side remains constant, while the plasma channel enlarges at the anode side. This means that the current density at the anode side decreases. When the generator cuts the electric current at the end of the discharge pulse, the plasma channel disappears and the corresponding pressure drop cause the melted electrode material is ejected into the surrounding dielectric fluid. With this action the cycle of a single discharge is finished. When the dielectric is sufficiently deionized, another pulse can be applied in order to produce the next discharge.

3 Rotor

In this research I used NX3 Unigraphics (UGS Corp.) to design a rotor. I designed it using examples of photos of rotor of Smart. This time I did not design with hydrodynamics and thermodynamics. Size of a rotor (only a rotor part not included a pole part) is diameter 26.2mm and height 20mm, which is smaller than examples.





4 CAM

According to the design I also made CAM data with NX3

Unigraphics. Figure 6 illustrates its simulation. It shows that I mill only one groove between blades beside Z-axis because only 3-axis milling machine is available. The groove of this part can be perfectly cut by even 3-axis machine. I made simulation many times and I changed design each time case by case. In those figures I put 2 cylinders in front and back of the rotor to reduce movement of an electrode.
One program is to make only one groove just beside Z-axis. Therefore I need to rotate the workpiece and repeat the program 12 times to make all blades.

5 Experiment

5.1 Programs
Unigraphics can make PTP program. However, I had to consider wear compensation. So I needed to change program with consideration of tool electrode wear. A postprocessor program was made to change PTP program to the program that can calculate tool electrode wear. This post processor we can choose wear ratio. Wear ratio is given with how long electrode moves to cut workpiece, not with volume of removed material from the workpiece.

5.2 NC programs
In the program the most important elements is NC programs. I used three kinds of NC programs. They are main NC program, technological NC program and geometrical NC program.
The mail program only contains the NC command successively load the technological NC program for the machining cycle. The technological NC program contains all technological machining parameters and successive calls for the geometrical NC programs for the different layers. The geometrical NC programs basically contain the tool path vectors together with wear compensation and feed limitations.

5.3 Setting
I used ROBOMILL200 (CHAMILLES) for milling EDM. NC program was sent to EDM machine through the computer because EDM can not load whole program due to its data capacity. Figure 11 illustrates milling EDM machine.
Copper was used as electrodes. The outside diameter of the electrode is 2.0mm and the inside diameter of the electrode is 1.2mm.
Stainless steel is used as workpiece because Kersit 601 is expensive to use test. The workpiece had been machined to the starting shape by conventional cutting operation. To hold workpiece I used the clamp, which can rotate workpiece each 15 degree accurately.

6 Result

After machining two grooves I got one blade (Figure 14). Table 3 shows machining time and tool electrode wear. However, some parts of the bottom of the groove were not machined well.


I measured roughness of the surface with Form Talysurf Series 120L (Taylor-Hobson). I did not do finish machining because of lack of time. Therefore roughness is not good enough for rotor. The smoothest part is outside of the blade. The reason why this part gets the smoothest surface is this side was machiened pertically. The roughest side is machined not pertically. But even the smoothest surface is not good enough for a micro turbine rotor.

7 Conclusion and direction for future works

With milling EDM I made one blade, which means that I can make a rotor although material is not Kersit 601 (desired material for a micro turbine rotor at this moment), but stainless steel. Kersit 601 is possibly supposed to be machined by milling EDM.
Roughness of the machined rotor is too rough to use as a real micro turbine rotor. We need many machining steps to obtain desired shape and roughness. Only one process can not make it.
To conclude Milling EDM is one possibility to make a micro turbine rotor.

[Lecture at DTU]

1 Course guidance

42250 Laboratory Course in Process Simulation
Danish title: Øvelseskursus i processimulering
Language of instruction: English Credit Points (ECTS): 5
Type: B.Eng. Mechanical Engineering
M.Sc
Taught under open university
Recommended semester: B.Eng. 5th semester
M.Sc. Intermediate part of M. Sc. Programme
Scope and form: Exercises
Duration of Course: 3 weeks
Date of examination: No exam
Evaluation: Evaluation of experiments and reports
Evaluation: pass / not pass, internal examiner
Qualified prerequisites: 42301 / 80001, Production Technology I
Optional prerequisites: Computer user knowledge
Participants restrictions: Maximum: 16
Aim/objectives:
To make the students familiar with some of the most important computer programs for simulation of metal casting, die casting of plastics as well as mechanical forming of metals.
To enable the students to make simple computer simulations with these programs.
Content:
The course is divided into three parts covering simulation of metal casting, plastics casting and metal forming. Each part starts with an introduction to the process followed by an exercise where the process is simulated. A small report must be delivered in the end of the course.
Remarks:
First og middle part of study.
Responsible:
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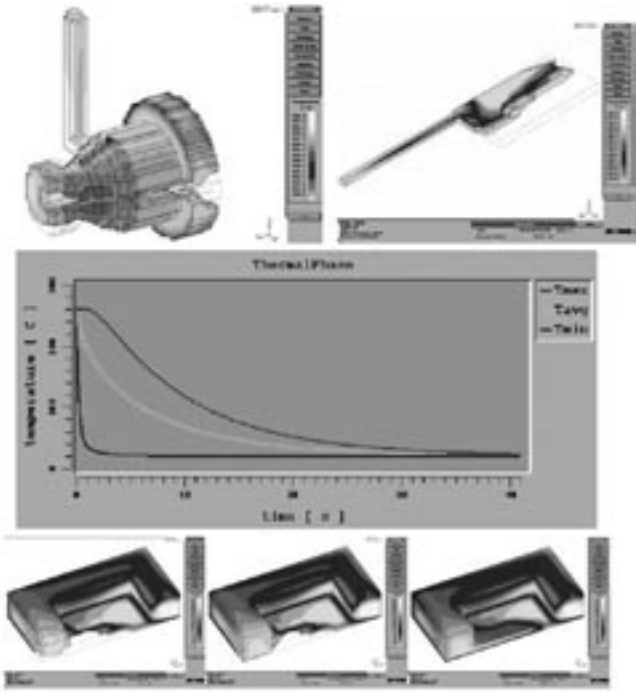
Key words: Numerical modelling, Process analysis, Plastics processes, Control volume method, Finite element method

2 Course description

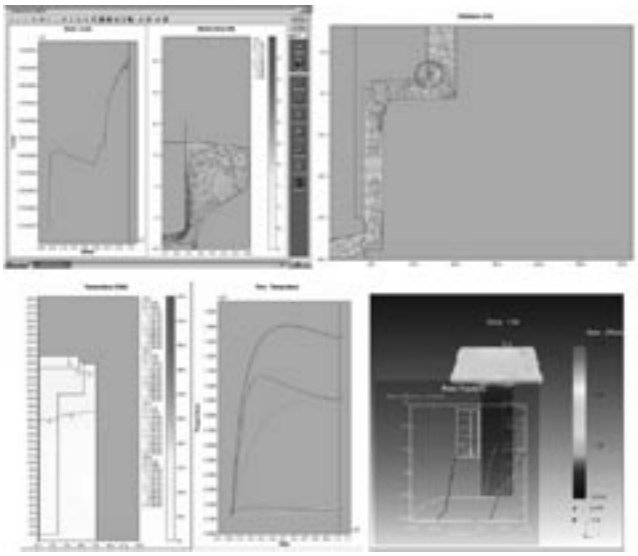
2.1 1st week
We made some computer simulations of die casting of

metals and plastics with SIGMA soft. We talked about some problems in simulation such as welding line, filling time, position of runner and so on.



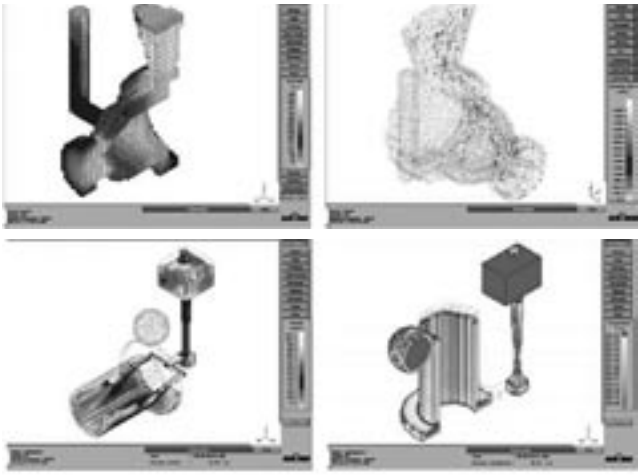
2.2 2nd week

We made some computer simulations of mechanical forming of metals. We observed stress curve, strain curve and temperature curve. Then we discussed problems in simulations such as forging cross, die deflection and so on through simulations.



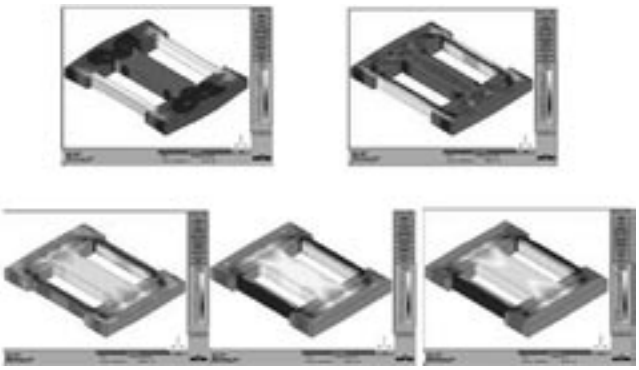
2.3 3rd week-1

We made computer simulations of die casting of plastics with MAGMA soft. MAGMA soft is similar with SIGMA soft. This time we discussed feeder, cooling process and so on.



2.4 3rd week-2

We made some computer simulations of cooling process, especially about shrink problems. We discussed about that and analyzed some data and compared analytical data and simulation data.



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