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Supervisor:
Prof. T. Maeno

Executive summary

I traveled to Keio University in Japan at 15 September 2004. After a warm welcome of the Bio-Robotics Laboratory of Prof. T. Maeno, I spend some days for acclimatizing and getting used to the new circumstances as far as was possible.

After starting at the laboratory, I had to specify my research topic, which took until October 2004. The research topic that was chosen was determined after a thorough inventory of the needs of the Laboratory of Prof. T. Maeno and in accordance with the educational goals of the Technical University of Delft. The research title is "Design and Development of a 4 DOF Wearable Haptic Interface for the Finger with Multi-Point Passive Force Feedback."

In the research the design and development of a 4 degree of freedom (dof) wearable haptic interface for the index finger for a wearable master hand with 20 dof is presented. Master hands are used as haptic interfaces in master-slave systems. A master slave-system consists of a haptic interface that communicates with a virtual world or an end-effector for tele-operation, such as a robot hand. A human finger has 4 dof and therefore a human hand has 20 dof. So far, no 20 dof master hands have been developed that can exert a perpendicular force on the finger phalanges during the complete bending and stretching motion. The systematic Pahl and Beitz Design Approach is used as an iterative design method. Important design requirements are; perpendicular forces on finger phalanges, low friction mechanism, easy to control, no backlash, high back drivability and lightweight. A passive force feedback system is presented for simulating virtual hard contact surfaces.

The time spend in Japan was an intensive time that I will never forget. It contributed greatly to my personal development and gave me a broader view. I am very thankful for this given opportunity. I certainly will gain my advance in the future out of this experience. Maybe I will be able to work or start a career in Japan. I really hope so.

For this experience, I want to thank all the persons involved for making this possible.

Doomo arigato gozaimasu.

Travel schedule

Amsterdam Schiphol Airport – Tokyo Narita Airport	09-15-2004
Tokyo Narita Airport – Seoul Incheon Int'l Airport	06-22-2005
Seoul Incheon Int'l Airport – Tokyo Narita Airport	06-26-2005
Tokyo Narita Airport – Amsterdam Schiphol Airport	08-18-2005
Amsterdam Schiphol Airport – Berlin Tegel Airport	08-21-2005
Berlin Tegel Airport – Amsterdam Schiphol Airport	08-28-2005

Research

This research topic is determined after an inventory for the needs of the bio-robotics laboratory of Prof. T. Maeno and in accordance with the educational goal of the Technical University of Delft. The research title is “Design and Development of a 4 DOF Wearable Haptic Interface for the Finger with Multi-Point Passive Force Feedback.” In this research a master device was designed and developed that could be used for operating a complex robot hand. The Laboratory of Prof. T. Maeno developed a 20 dof wearable robot hand with 4 dof per finger like the one the human finger has. So far no master hands were developed that could operate such a 20 dof wearable robot hand with a high accuracy and that was capable in exerting perpendicular forces on all finger phalanges of the operator during the complete bending and stretching motion.

The systematic design methodology of Pahl and Beitz is used as approach for the design problem. Important design requirements are; perpendicular forces on finger phalanges, low friction mechanism, easy to control, no backlash, high back drivability and lightweight. The abstraction for the design problem is: “Design a wearable force feedback device for the human hand, in such a way that the device is easy to control and exert safely sufficient perpendicular feedback forces on finger phalanges for all degree of freedom, for laboratory research.” A function structure is determined by the design requirements and gives the relationship between the inputs and outputs of the device. Solutions that are likely to be used are presented to fulfill the sub functions and are placed in a morphologic matrix. Concepts are generated with this matrix and selected with a value analysis method. The chosen concept is firmed up into a realistic design and designed more in detail, this is called the embodiment design phase.

An experimental study showed that cable friction for the remote actuators were excessive high and not constant which is not allowable. Therefore, it can be concluded that cable transmissions as discussed above are not usable for haptic devices. Hence, a passive force feedback system is presented that uses a mechanical break system located at the exoskeleton. A separate actuator module that can be portable or non-portable with a cable transmission is used for remote actuating the breaking mechanism. Rolling-link mechanisms are used for following the fingers’ phalanges motion and to exert perpendicular forces on the finger phalanges. Rolling-link mechanisms have the characteristics to have low friction, roll smoothly and rotate without stick or slip. A photo of the designed and developed master hand and the graphical user interface (GUI) is shown in figure 1. An evaluation showed that the important stated design requirements could be fulfilled and perpendicular forces could be exerted.

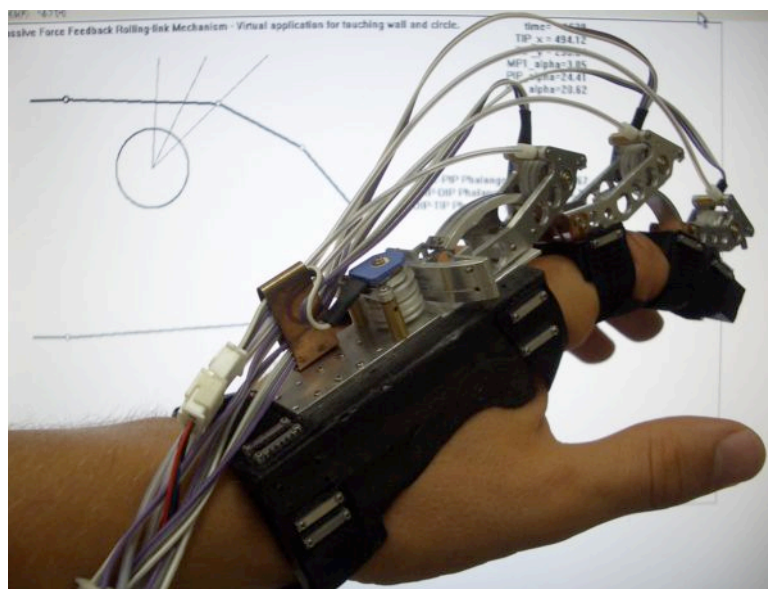


Figure 1. Photo

of the

designed and developed master hand with the GUI.

Exchange student life

The exchange student life in Japan is very interesting and wonderful experience and a big contribution to my personal development. It was a fascinating educational environment at the laboratory of Prof. T. Maeno of Keio University. The daily life beside the study is especially interesting, because of the big differences between the Japanese and Dutch culture.

The apartment and other arrangements were perfect organized by the international center of Keio University. The introduction to all new facilities was also very well arranged. The Japanese language classes were possible to follow, although we only had one-hour lessons a week, which was rather short. At the beginning of the year there was an intensive course, we had to pay for ourselves, which would take one complete month of intensive language training. It was not possible to combine with the research and therefore the language lessons had to stop, which was a disappointment. The English level in my laboratory was more than sufficient and even better than expected.

The working environment in the laboratory is different than we are used to in The Netherlands. The Japanese approach of doing research is a more an experimental approach than the theoretical Dutch approach. The Japanese approach made it possible to realize the suggested design with all the necessary available equipment.

The working times at the laboratory shifted slowly from the Dutch schedule to the Japanese schedule. Due to friendly working environment it was no problem and even comfortable.

Although the long days at the laboratory, there was time to spend for sight seeing and doing sports. Especially in the weekends, there was time for going to all the tourist spots.

During a small holiday with my visiting family, I could see Hiroshima, Osaka, Kyoto and Mt. Naeba. 10 Months is not enough, because only Tokyo prefecture could be enough to fill one year sightseeing in the weekends. Every event was one not to forget.

In June 2005, I was able to give a presentation of my research at a conference in Seoul Korea with my laboratory. It was a great experience.

Most friends consist of my laboratory members and people I met during going out and sightseeing. Due to these friends, it was possible to really learn more of the Japanese culture and mentality and see Japan from a different side. Actually, from these contacts I learned most from Japanese cultural habits. Not to forget all the friendly people you meet everywhere.

All these facts lead to a new personal view of Japan. It is really truth what I heard before I went to Japan, "Japan is everything what you don't expect of it!"

Suggestions to the project

I would like to suggest continuing this program in the future. It was worth every effort. The situation of housing and the university were very well arranged. Learn as much as Japanese language as possible before going to Japan. This will be a big advance.

Watch your budget. It is possible to cover your basic needs with the given budget. Although when you want to see more of Japan, be prepared to spend more money.

Summary

I have done my master thesis research at the bio-robotics laboratory of Prof. T. Maeno of Keio University for a period of 10 months. In this period, a haptic interface is designed, manufactured and evaluated. It was one of the most interesting and personal development periods in my life until now. The experimental and practical approach of the laboratory was

fascinating. I was able to present my research in Seoul Korea and maybe again at future conferences.

Besides the intensive research period, it was possible to learn more about the Japanese culture. I made many new friends and got numerous of new impressions.

I hope I will be able to start my career in Japan.

Doomo arigato gozaimasu.