DeMaMech 2007

Exchange student report

A. van der Heijden

Host university: Tokyo University
Home university: Delft University of Techology

Personal data:

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Host university

Name:	Tokyo University
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Home university

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Supervisor:	Prof. Dr. T. Tomiyama, Dr. ir. Hans Langen

Travel schedule:

Departure
April 8, 2007

Amsterdam (Schiphol)	->	London (Heathrow), by plane
London (Heathrow)	->	Tokyo (Narita), by plane
Tokyo (Narita)	->	Tokyo (Ueno station), by Keisei train

Return:
October 7, 2007

Tokyo (Funenokagakukan)	->	Tokyo (Narita), by car
Tokyo (Narita)	->	London (Heathrow), by plane
London (Heathrow)	->	Amsterdam (Schiphol)

Executive summary

In October 2006 I have read an announcement on the university's BlackBoard system about the DeMaMech exchange program to Japan. In a reflex I deleted it instantly but then, out of curiosity I recovered it to see what is was about. I got interested and decided to join the information meeting. The meeting was very interesting and I decided to try and join. I was very lucky to be accepted by assoc. professor Akio Yamamoto to the Advanced Mechatronics Laboratory, run by him and professor Toshiro Higuchi.

As a preparation to my stay in Japan, I was given a number of papers on the lab's various research topics. Upon arrival in Japan I entered the research field of electrostatic actuators, one of the lab's main research fields, of which I had hardly any knowledge at the time.

The goal of my research would be to work on an electrostatic rotational device that provides haptic feedback to the operator. To get more into the topic, I was given access to the vast amount of papers and articles the Laboratory had already published before and I saw some demonstrations of electrostatic actuators.

After a lot of reading I started by programming a controller for a linear type of electrostatic motor, because the rotational device did not exist yet. And later I designed a rotational type setup to realize the haptic device.

I had no experience in using typical laboratory equipment like dSpace and oscilloscopes and I was surprised that all the needed equipment was readily available in the laboratory. In Japan the focus is more on experimenting than on modeling, an approach that I really liked.

The life outside the lab was very exciting as well. Although I thought the language barrier could cause some problems, I have had hardly any. Although most Japanese don't speak english so well, they are always really friendly and very willing to help. Tokyo offers many interesting things to see and I have met many nice people to hang out with. My home was on Odaiba, one of the artificial islands in the Tokyo bay area. I was living in the Tokyo International Exchange Center, which provides housing to all kinds of international people for many universities and schools. Living in an international environment was good, because it is nice to share your experiences with others. Especially during the first couple of weeks.

My stay in Japan was a very exciting period in my life and I never regretted it. I have learned very many things, both in the field of my study and in dealing with different cultures, languages and habits. I believe the past six months were a very valuable experience.

Assignment

The Advanced Mechatronics Laboratory in Tokyo focuses on the field of electrostatic actuators. The research I have done is about designing a rotational haptic device that uses electrostatic actuation to give feedback to the user. Possible applications for such devices are in microfactories, where (micro scale) forces have to be presented to an operator (for example tightening micro bolts without breaking them). Another application is in scrolling car audio menus while keeping an eye on the road. The haptic device could provide feedback on a selected option by giving a tick-sensation, dependent on the angle of the knob.

Introduction:

An electrostatic actuator typically consists of two thin films (0.2 mm) with embedded three-phase electrodes. One layer functions as a stator and the other as a slider. The electrode configuration on both sheets is comb-like, with a very small pitch p of 200 μm. A sinusoidal wave is then applied to each phase, with a phase shift of 120°. Before feeding the signal to the electrode sheets, it is first amplified to obtain a high-voltage (500 - 1400 Volt) potential distribution. Both the stator and the slider are connected but in reversed order. The principle is illustrated in fig. 1

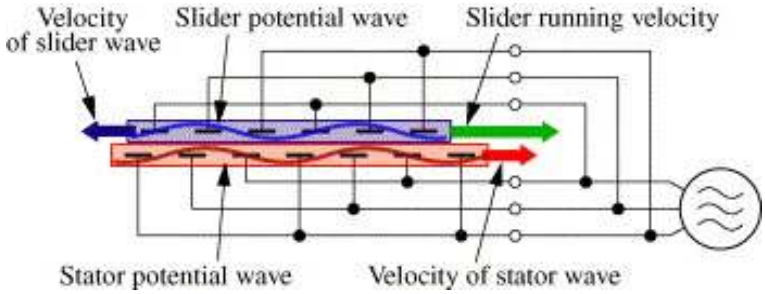

figure 1: Electrostatic actuation principle

When applying the driving signal with frequency f, the potential distributions will run with the same velocity v thru the sheets, but in opposite direction. When the phase-difference between the two potential distributions is kept stable, the electrostatic interaction between the two distributions will cause the sheets to move, with a velocity $v = 2*p*f$. The maximum thrust force of the actuator is proportional to electrode area, and can be easily increased by stacking multiple pairs of electrode sheets on top of each other. An advantage of electrostatic actuation is that its force/volume ratio is very good.

The structure shown in figure 1 can also function as a position sensor. By applying three-phase signals (150 kHz) to only one sheet, the capacitance over the terminals of the other sheet varies when it is moved. By sensing this capacitance change, a measure for the traveled distance is obtained. This is a big advantage, because the same components can be used for both driving and sensing.

Experimental setup

After a lot of reading and experimenting with a linear type electrostatic actuator I designed the rotational device for the test setup. One big issue is misalignment. Only a small misalignment between the electrode sheets, in the order of micrometers, disturbs the phase difference between the two electrodes, causing the actuator to lose all power. In my setup I used five pairs of sheets for driving and one for sensing. This provided for a torque in the order of 0.01 Nm, which is enough for giving the user appropriate feedback. Figure 2 shows a photo of the experimental setup.

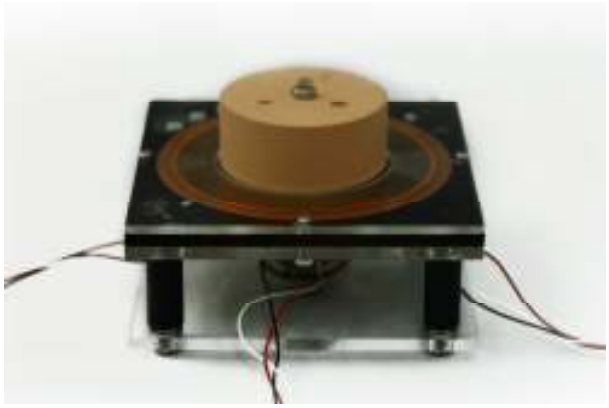

Figure 2: experimental setup

Electronic circuitry

The second part of my experimental setup consists of electronic circuitry for generating high frequency sensor signals. To obtain a three-phase signal in the order of 150 kHz, I designed an oscillator. For the sensor output to be useful, it is important that the phase difference between every phase is as close to 120° as possible. Therefore I designed a circuit for adjusting phase and amplitude as well.

The circuit for generating the three-phase high frequency signal uses three operational amplifiers (Op-Amps). These Op-Amps are connected in series and the output of the last one is the input to the first. Connected this way, the signal is integrated twice, yielding the three-phase signal at the three Op-Amp outputs. The schematic is shown in figure 3.

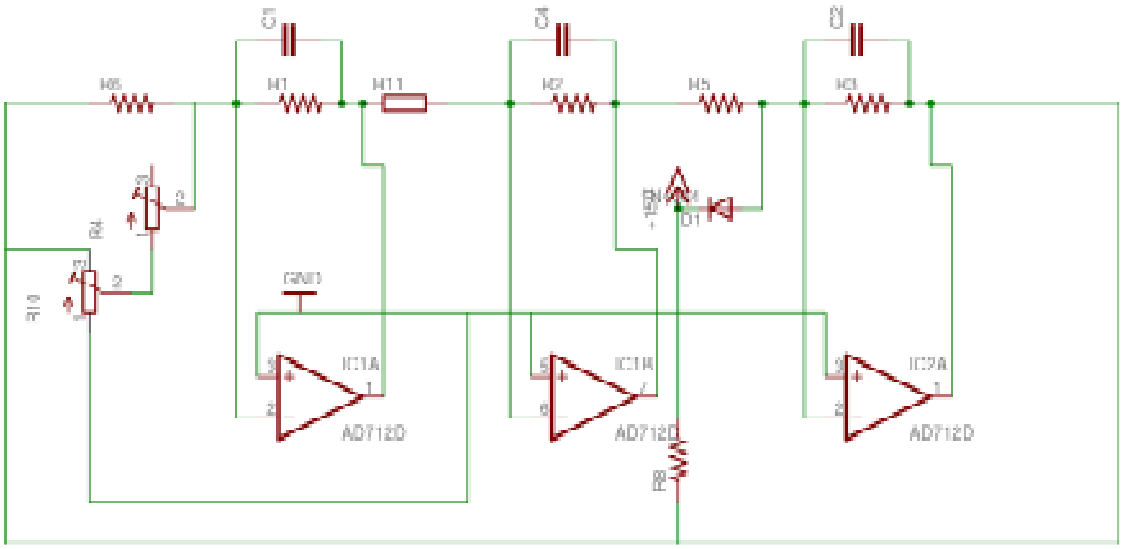

Figure 3: Oscillator schematic

Unfortunately the shown schematic is quite sensitive to loads and has some unwanted phase-shift. Therefore buffer circuitry was added and I designed a circuit for adjusting phase.

Results

In order to test both the actuator and the sensor I let the actuator follow a sinusoidal motion profile and measure its displacement. If the measured signal matches the motion profile, both actuator and stator perform well. The result of this experiment is shown in fig. 4.

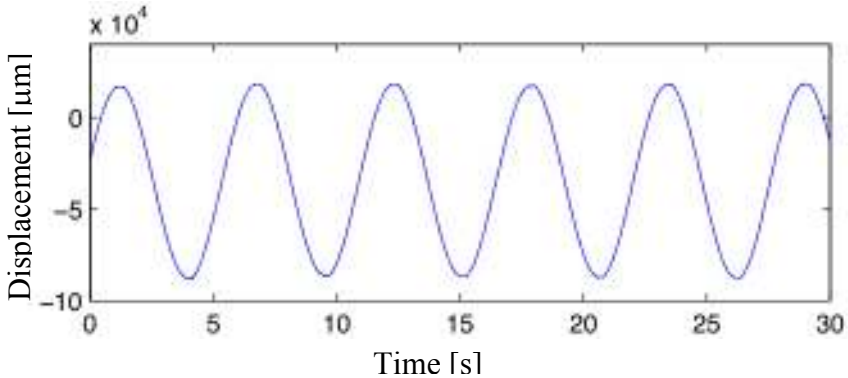

Figure 4: Driving the actuator with a sinusoidal motionprofile and sensing the motion

It is readily checked that the sensed signal matches the driving signal so both driving and sensing work fine. This research can be used to further develop the haptic knob.

Exchange student life

To show me around Tokyo and to help me settle I was assigned a very helpful tutor. He picked me up from the train station, showed me around the laboratory and introduced me to many people. In the first couple of days many administrative things had to be taken care of, for instance opening a bank account and getting a mobile phone.

At my first day in Tokyo I went to dinner with some of the labmembers and I was exposed to Japanese cuisine straight away: a lot of raw fish, wasabi and even raw egg. A couple days later they organized a welcome party for me to get to know everybody. Although the level of english is not very good in Japan in general, I was very well able to communicate with most of the labmembers, although it takes some time to recognize the funny Japanese english pronounciatiion ('engrish').

One thing that surprised me very much is the Japanese willingness to help and the effort people take to understand your problem. As an example, my metro commuter pass was swallowed by the ticket gates (at 11:00 PM), and another passenger helped me for thirty minutes to get it back.

Also I attended a beginner's course in Japanese language. Of course it is not possible to master the language in only six months time, but it helped in reading some words and having small conversations, like asking for directions. In general, the Japanese respect any efforts to speak their language and enjoy talking in Japanese to foreigners.

When it comes to business hours, Japan differs very much from Holland, as a normal salaryman's workday lasts from 8 in the morning until 10 at night, six days a week. Luckily the lab is a bit milder to its employees, and a typical day is from 10 to 9, having weekend-days off. When having deadlines however it is not uncommon to stay until 11 or even stay at the lab overnight. Taking into account that getting to and from university takes two hours in total every day, one can imagine that sightseeing and other activities usually take place in the weekends.

Daily life is not difficult to manage on your own in Tokyo. My lodge was equipped with washing machines and there was a big kitchen available to the residents. At the ground floor of our building there was a convenience store located that stocks all kinds of products. It is really advisable to learn the Japanese Katakana character set as soon as possible, as many foreign (english!) words are written in this character set. With a bit of training it is for instance fairly easy to distinguish shampoo ('shi a n pu') and conditioner ('ko n di shi a na'). If I had learned it a little earlier, maybe I would not have tried to fry my food in vinegar instead of oil.

When it comes to money, Japan is not the end of the world. Although things like public transportation, drinking in bars and dining at fancy restaurants tend to be relatively expensive, one can very easily live on the money supplied. Typical expenses are E 225,00 for room rent, E 60,00 for a commuter pass, E 12,00 for breakfast, dinner and lunch, E 30,00 for mobile phone usage and E 90,00 for a one way ticket on the Shinkansen (bullet train) from Tokyo to Kyoto (600 km).

Apart from the sometimes overwhelming culture differences, most of the normal social rules apply. Treat people like you want to be treated and act like you would normally act, and most people will feel at home quite easy. It is rarely unforgivable if you forget to take off your shoes when entering somebody's house.

In the past six months I have learned very many things. I worked on a breaking-edge technological project, made valuable Japanese and foreign friendships and I sampled one of the worlds most interesting and rich cultures. I believe I will stay connected with Japan for a long time, and I am looking forward to going back some day.

As a final word I would like to thank the following people:
Professor Higuchi and associate professor Yamamoto, for offering me the opportunity to come to Tokyo and taking such good care of me in the laboratory. Professor Tomiyama and Dr. Hans Langen for giving me the possibility to join the DeMaMech program. Aiko Kato and Ewoud van West for being very nice friends, I will miss you!