Contents

1. Personal Data

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2. Executive Summary

I participated in the DeMaMech EU-Japan exchange program in 2005/06. I went to the University of Tokyo where Professor Dr. Akio Yamamoto was my host professor. During five months I worked on a single project in this laboratory.
The research was regarded as my internship. The goal was to develope a haptic device with two degrees of freedom connected with two acctuators.
I was able to work with a very new film motor which could work in a magnetic filed without being disturbed by it. The environment of research is very interesting itself.
The research program in Japan is different from my home university, but I learned many things in both research approach as personal development.
During my time in Tokyo I had many opportunities to get to know the city. The place I lived was the International Komaba Lodge on the Komaba campus, in Tokyo. Trips to other areas include the Takaosan, Kamakura, Yokohama, and suburbs of Tokyo.

Life in Japan is very different from Europe:

- The level of English is very low of the average student. But at my laboratory the level of English was good enough for communication

- At the beginning students don't help you or give you suggestions unless you ask them a specific question. After two month they asked me and talked to me on their own. I had to initiate most of the conversations and be active and communicative on my own.

- Without a decent scholarship living costs in Tokyo can be expensive. You have to know where to shop.

- The University of Tokyo is always open. Normally students arrive in the morning and leave at night. When necessary they stay overnight.

Living in Japan showed me that many things can be different in the way of living, social life and safety. In Tokyo are many foreigners. I had no problems to get to used to the every day life.

3. Travel Schedule

Berlin – London	4.10.05
London – Tokyo	4.10. – 5.10.05
Tokyo – London	19.2. – 19.2.06
London – Berlin	19.2.06

4. Research

In this research project the goal was to develop a human-machine interaction/collaboration systems that can physically assist or cooperate with human operators utilizing mechatronic sensors and actuators. The system was a two degrees of freedom haptic device connected to two sensors and using an actuators (electrostatic film motor). The goal was to building up the prototype and testing it with simulink.

4.1 Background -Electrostatic motor

The basic structure of the electrostatic motor used in this work is shown in Fig. 1. In its simplest configuration, the motor consists of a pair of thin plastic films that are fabricated using flexible printed circuit technology. Each film contains three-phase parallel electrodes that are aligned at regular 200μm intervals. Glass beads with diameter of 20 μm are inserted between the films to reduce friction. The motor is typically driven by high voltage three-phase signals such as I to 2 kVo-p to generate practical thrust forces. Since such high voltages cause electric discharges of the air, the motor is typically immersed in dielectric liquid. For practical applications, stacked configurations shown are often used for greater force generation capability.

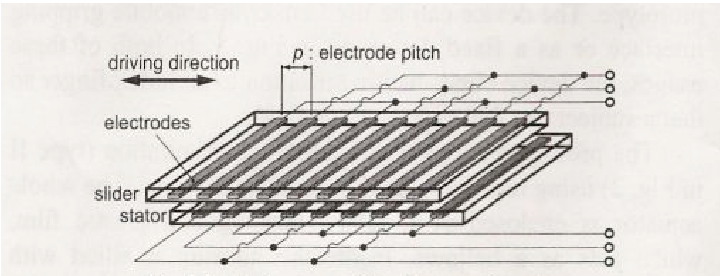


Fig. 1 Basic structure of the electrostatic motor

4.1.1. Principle & Structure

The motor is a synchronous linear motor driven with two sets of three-phase sinusoidal voltages. By applying voltages , travelling voltage distributions are excited on both the stator and the slider. The electrostatic interaction keeps the relative position between them to be constant, and, in turn, the slider runs in a speed relative to the frequency difference between the stator three-phase voltage and the slider one. The slider displacement is proportional to the difference between excitation phases of the two voltage sets Fig. 2.

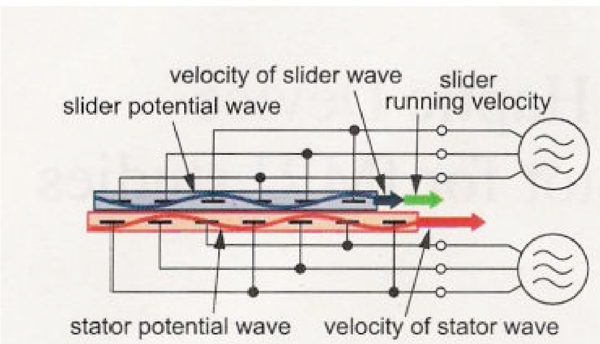


Fig. 2 Driving principle

4.1.2 Possible application (control lever of aeroplane)

In the 70's the fly-by-wire architecture was developed, starting as an analogue technique and later on, in most cases, transformed into digital. This architecture is based on computer signal processing: the pilot's demand is first of all transduced into electrical signal in the cabin and sent to a group of independent computers (Airbus architecture substitute the cabin control column with a side stick); the computers sample also data concerning the flight conditions and servo-valves and actuators positions; the pilot's demand is then processed and sent to the actuator, properly tailored to the actual flight status. The flight data used by the system mainly depend on the aircraft category; in general the following data are sampled and processed: pitch, roll, yaw rate and linear acceleration. As observed, the current tendency in flight control is to install hydraulic actuators and mechanically or electrically signalled control valves to operate the actuators.
With the advent of fly-by-wire and fly-by-light systems coupled with advances in controller technology, interest in sidestick controllers has increased substantially. The use of a sidestick has many advantages over the conventional centerstick controller. A major factor in the renewed interest in the sidestick has been the industry's acceptance of the use of electrical commands as the primary or sole means for a pilot to control the airplane. As a result, the use of a small displacement controller, such as a sidestick is feasible. The use of a sidestick with electrical commands, nonlinear gains, command pre-filters, response feedbacks, and signal shaping gives a designer a large number of parameters to manipulate to achieve good flying qualities.

4.2. Prototyping of Joy-stick type haptic device, Overall design

An electrostatic motor does not require magnetic field for its operation, it is expected to be MR compatible. In fact,Yamamoto *et al* investigated MR-compatibility of a highpower electrostatic motor and proved that the motor is safe in strong magnetic field of MRI and that the motor is compatible with MR imaging under certain conditions. In this work, a two-DOF haptic device using electrostatic motor is developed. The haptic device is designed for investigating human motor control of a performed task with the hand, which is one of the most dexterous parts of human. First the basic design of the device is described. Then, experimental results of measurements of reaching movements of a hand are reported.

Fig. 3 shows the appearance and usages of the developed prototype. In these usages, the device elicits haptic sensation to user so that a subject can feel various force fields.
The prototype adopted the stacked configuration using pairs of slider and stator films. The whole actuators are enclosed in a plastic housing and plastic film, which acts as a bellows. Inside the housing is filled with dielectric liquid, Fluorinert FC-77 (3M). The sliding part is equipped with a force sensorand. With Matlab Simulink different force fields are applied to test the device and the behaviour.

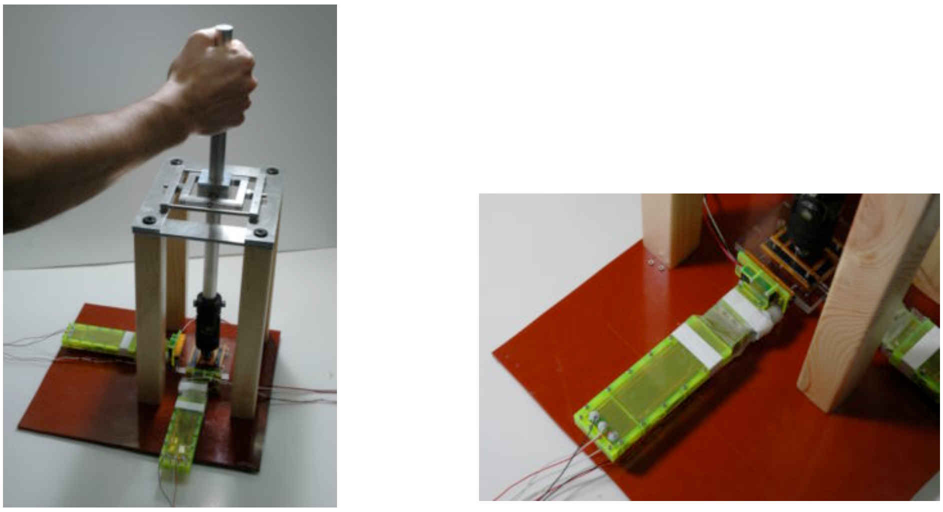
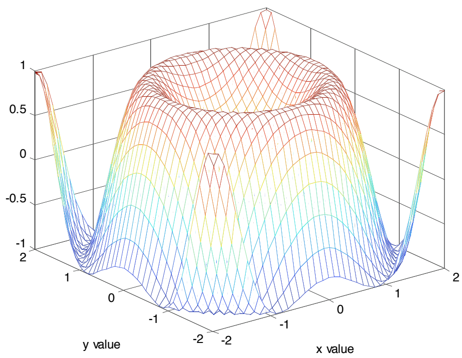


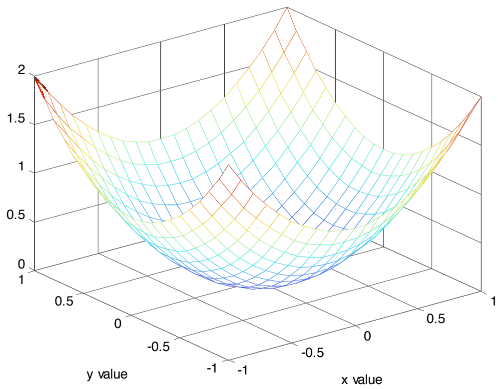
Fig.3

4.3 Test (2 or 3 results) 3d graphic representation of applied force (potential) field
Motion trajector

The generating force of the motor is proportional to the overlapping area of the slider and stator films. In the stacked configuration used in the prototype, the overlapping area changes as the sliding part moves. This leads to that the force generation capability changes depending on the position of the sliding part. In the most contracted state, where the actuator possesses the maximum force generation capability, the maximum holding force was measured to be more than 20N at 1.4 kV.
Two major control modes are known for haptic displays. One is impedance control mode and the other is admittance control mode. In an admittance control mode the input to a controller is force and the output is position or velocity . A system based on admittance control mode measures interaction force by a force sensor and calculates velocity or position, which the end effecter should follow, based on an internal dynamics model. Our controller adopts the admittance control mode together with open-loop position control.

Applied potential fields:





5. Exchange student life

The student life in Tokyo is quite eventful. There is plenty of sightseeing to be done and many places to go to enjoy oneself. The University of Tokyo arranges events and parties for the exchange student, which are good to attend.
I stayed at an international dorm with students from all over the world and the life outside the
University was very active. There are plenty of opportunities to do sports at the campus foe example volleyball, swimming and basketball. The spare time have been
used by for going sightseeing: Yokohama, Kamakura, and suburbs of Tokyo are very nice to visit. The Tokyo nightlife is famous especially at Roppongi and Shibuya. Exploring the different kinds of food and cultural events was a nice activity.

There is also a lab-life. The system is very different from my home university. One professor has one laboratory with its students. They all share the same space in office style.
Each of them has his own desk and laptop. While sitting all together in the same room everybody is doing his own research or doing experiments in the test lab.
When present in the lab they are not always working. Social contact between the students is very easy when sitting with each other in one room. Except everything is in Japanese. The level of English of the students was acceptable and my Japanese just not enough to talk. My experience is neutral. Social contact has to come from yourself, since the students don't even try to speak with you, but when yourself initiate a chat they are always very happy to talk to you.

6. Summary

The stay 5 months in Japan Tokyo have been very nice, although also looking forward to coming home, I have not got any regrets about leaving. The international office of the university helped with translating, with bank accounts, and everything
necessary for staying in Japan over a longer period of time. It has also been necessary, since you feel quite helpless sometimes, when your not able to speak Japanese.