EU and Japan Pilot Cooperation in Higher Education Program

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Danmarks Tekniske Universitet (Denmark)

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Executive summary

This is a report in the exchange program. The report consists of my travel schedule, a report of my study in KUL, a report of my study in DTU and the summary.

Travel schedule

- From 1 September 2005 to 1 January 2006: KUL
- From 2 January 2006 to 31 January 2006: DTU

Research in KUL

Title: Wheelchair simulator with haptic feedback

Objectives

In this study, I developed two haptic applications. Firstly, in order to discuss general advantages of the haptic interface, I developed an application of planar reaching tasks. Secondly, I developed a wheelchair simulator with haptic feedback. In the wheelchair simulator, the Phantom is used for the human interface of the wheelchair simulator and the wheelchair has a sensor which can detect obstacles. Therefore, users can feel “obstacles” through the human interface. Finally, I discussed the advantages of using haptic human interface for the wheelchair simulator.

Method

Planar reaching tasks

I developed the planar reaching tasks as shown in Figure 1. In this application, a hand pointer and a center are displayed. Some random targets (8 positions) distribute around the center but they are not visible. The hand pointer moves to one of the targets. A user, then, operates the Phantom to guide the hand pointer back to the center. The time that the user needs to bring the hand pointer back to the center is measured. The radius of the circle where the targets appear was set 120 mm in the experiments.

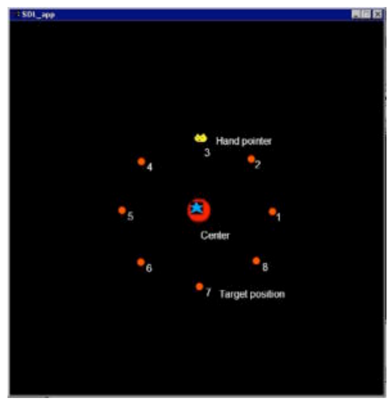
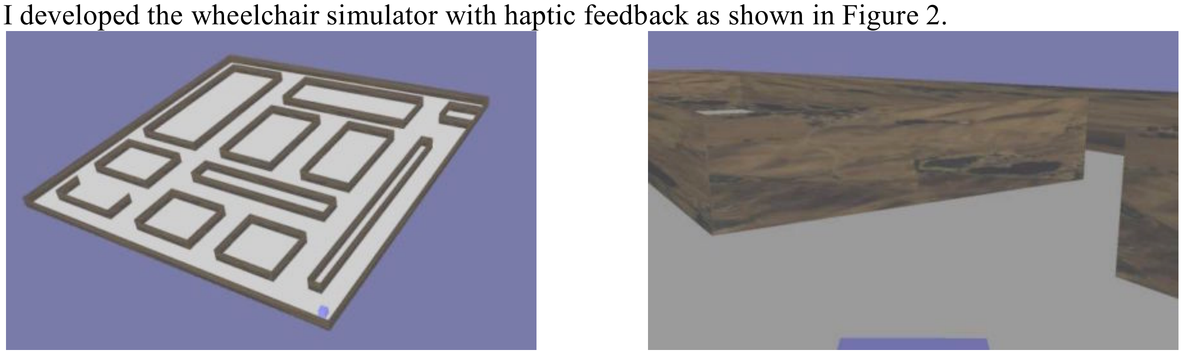


Figure 1 The picture of the planar reaching tasks.

Two ways of the planar reaching tasks were developed. In one way (planar reaching task A; visual feedback), only the graphic of the hand pointer moves to the target position while the Phantom remains at the same position. In the other way (planar reaching task B; haptic feedback), both the graphics and the Phantom move to a target position so that the user can feel the hand pointer moving to the target position.

Wheelchair simulator with haptic feedback

I developed the wheelchair simulator with haptic feedback as shown in Figure 2.



(a) An overview of the wheelchair simulator (b) A user’s view of the wheelchair simulator

Figure 2 Pictures of the wheelchair simulator with haptic feedback. A blue cube shows a position of the wheelchair. Blown walls are obstacles that the wheelchair detects by a laser

In the wheelchair simulator with haptic feedback, a user can drive the wheelchair by the Phantom moving. The linear speed (v) is calculated from the position (P_3) of the Phantom and the rotational speed (ω) is calculated from the position (P_1) of the Phantom. The linear and rotational speeds are given as follows:

$$v = K_{P3} P_3 \qquad \omega = K_{P1} P_1$$

I set the parameters $K_{P1} = 0.004$ and $K_{P3} = 0.004$ in experiments.

A model of the wheelchair and obstacles in simulator (Figure 3) is give, and the wheelchair has a laser scanner which detects the nearest obstacle and measures a distance (d) to the obstacle and an angle (α) between the direction of movement and it. When the wheelchair enters force fields of obstacles, a user can feel a reaction force (**F**) from the obstacles; otherwise they can move the wheelchair freely.

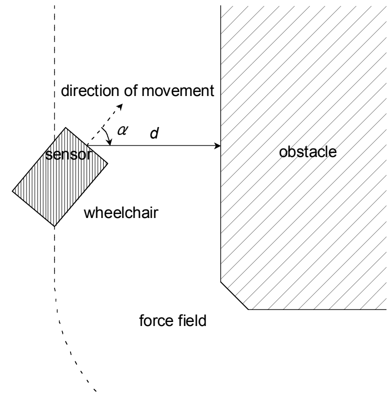


Figure 3 The model of the wheelchair and obstacles.

The simulator allows the calculation of a reaction force from the distance (d), the angle (α), gains (K1 and K3) and the velocity (v and ω) of the wheelchair. The reaction force is given as follows:

$$F_1 = K_1 \cdot \frac{1}{d} \cdot \cos(\alpha) \cdot \omega ,$$

$$F_2 = 0$$

$$F_3 = K_3 \cdot \frac{1}{d} \cdot \sin(\alpha) \cdot v$$

I set the parameters $K_1 = 0.005$ and $K_3 = 0.005$ in experiments.

Next, I developed two applications; the Phantom application and a wheelchair simulator application. The Phantom application has functions to control the Phantom and to send data concerning the positions (P_1, P_3) of the Phantom. The wheelchair simulator application has functions to simulate the wheelchair and to send data concerning the reaction force (**F**). These two applications are connected with a socket protocol. A flowchart of the two applications is shown in Figure 4. I used the Adaptive Communication Environment (ACE; version 5.4) for the socket programming.

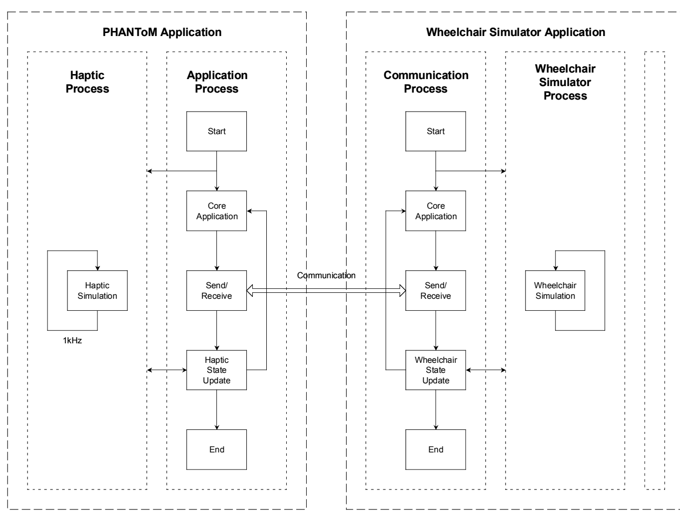


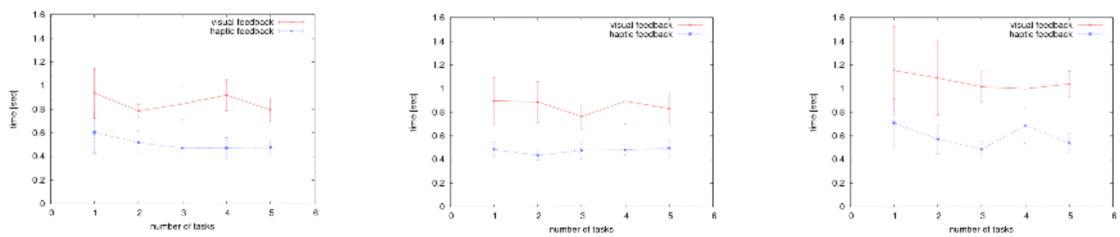
Figure 4 The flowchart of wheelchair simulator with haptic feedback.

Experiments

Experiments 1 (using the planar reaching tasks)

The experiments were conducted 5 times for 3 users (user 1, 2, 3) with the planar reaching tasks A

(visual feedback) and B (haptic feedback), and data concerning the time of the tasks were collected. Figure 5 shows the comparison of the mean times between task A and B.
The mean time with haptic feedback was shorter than the one with visual feedback.



(a) user 1 (b) user 2 (c) user 3

Figure 5 The mean time for 8 trials to bring the hand pointer back to the center.

Experiments 2 (using the wheelchair simulator with haptic feedback)

When the wheelchair goes at a constant linear speed, I measured moving distances and times from a start point to a goal point or a point where the wheelchair collide an obstacle (collision point). In these experiments, users cannot control the linear speed of the wheelchair, but they can control only its rotational speed. As shown in Figure 6, the start point, the goal point and obstacles were laid out and a route was set.

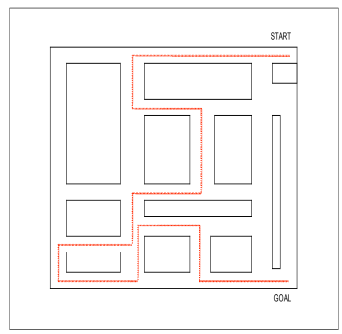
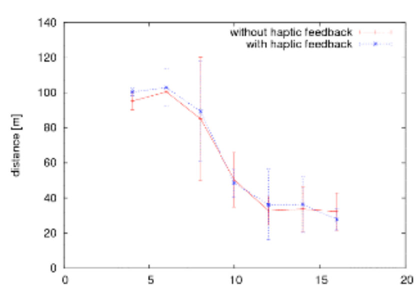


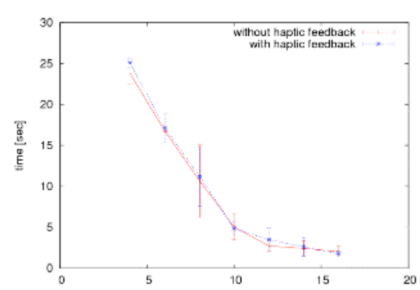
Figure 6 The route from the start point to the goal point for the experiments 2. A red line shows the route which users have to track.

I conducted experiments as follows:

- The linear speed was changed from 4 m/s to 16 m/s at intervals of 2 m/s.
- Before the experiments, I let users move the simulator about 5 minutes and be familiar with this operation of the wheelchair using the Phantom.
- The experiments were conducted for 4 users.
- I compared for the wheelchair simulator with haptic feedback and that without haptic feedback.

Results of the experiments are shown in Figures 7 and 8.





Discussion

Analysis of the planar reaching tasks

Figure 7 shows that adding the haptic feedback made shorter the time to bring the hand pointer back to the center. This result would be occurred by two reasons. First reason is that the time to notice changes of hand pointer's position is shorter in the application B than that in task A. The users were able to notice the changes by not only sense of vision but also sense of force in the task B; while they were able to notice them by only sense of vision in the task A. Second reason is the differences of the manipulaility in the workspace. But the radius of the circle where targets appear was set 120

Figure 7 The mean distance from the start point to the collision point

Figure 8 The mean time from the start point to the collision point.

mm, so that the workspace is 240 W x 240 H x 40 D mm. In the meanwhile, the maximum workspace of the Phantom is 381 W x 267 H x 191 D mm (documents of SensAble Technologies, Inc.). This means that the users moved the Phantom in the workspace where the manipulaility is good condition, therefore the difference of the manipulaility should effect very small. It appears that adding haptic feedback has a much greater effect on the shortening of the time to notice.

Analysis of the wheelchair simulator with haptic feedback

Firstly, I was able to check out the functions of haptic feedback. When the wheelchair moved along an obstacle, users felt little or no reaction forces from obstacles and they were able to move the wheelchair freely. On the other hand, when they turn around near obstacles, they felt reaction forces from the obstacles. This demonstrated that I have developed the wheelchair simulator with haptic feedback just as I intended.

Secondly, Figures 9 and 10 show that there was small difference between the wheelchair simulator with haptic feedback and that without haptic feedback. The reason I cannot obtain large advantages of the force feedback is because the Phantom has a large workspace and small back-drive frictions. The back-drive-ability is an important factor for the haptic devices, but the Phantom has too small frictions that it would be difficult to keep a pose of the Phantom. Because of the difficulty to control the wheelchair by the Phantom, users cannot get advantages of the haptic feedback.

Finally, I got some comments on the wheelchair simulator with haptic feedback as follows:

- It was difficult to control the speed of the wheelchair.
- It was a hard work to turn corners.
- It was difficult to keep a constant speed when users can control the linear speed of the wheelchair.

The reason turning corners were difficult would be because users hardly realize the initial position. The reason it was difficult to control the speed is because of the small back-drive frictions of the Phantom.

Conclusions

In conclusion, I developed two applications; the planar reaching tasks and the wheelchair simulator with haptic feedback. Firstly, the experiments of the planar reaching tasks show the advantages of the haptic feedbacks. Secondly, I cannot confirm the advantages of the haptic feedback using the wheelchair simulator with haptic feedback. But if standard-form joystick which can generate forces connected information of sensor can be used, it would be possible to have the benefits of the haptic feedback.

Lecture in DTU

Title: Autonomous Robot Systems

Objectives

A competition was hold and some tasks that robot had to carry out were given. We competed scores that were depending on tasks that our robot did. The robot was a small mobile robot (SMR) and we had some groups whose members ware consisted of 3 or 4 people.

Members of Team 5

- Kazuhiko Nakanishi
- Olafur Pall Einarsson
- Olafur Torvi Yngvason
- Thorsteinn Mar Arinbjanason

SMR (Small Mobile Robot)

The SMR is a small robot vehicle which has been built at AU in DTU. The SMR is sufficiently small so that they are safe and easy to operate yet have the full features found in larger mobile platforms. The computing power on-board is a standard PC giving able resources and making it easy to upgrade if needed. The communication is handled by a standard wireless LAN and the operating system used is Linux. The aim is to provide a platform that enable easy and safe experimentation and development of ideas and algorithms. The SMR is consists of (1) the computer, (2) motor and power amplifier, (3) power supply, (4) line sensor, (5) IR distance sensor (6) encoders and (7) wireless LAN.

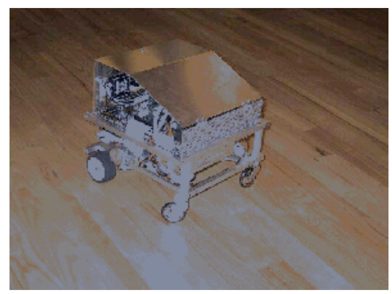


Figure 9 The picture of SMR.

Calibration of line sensor

To be able to follow a line a line sensor is needed. A number of LED's illuminate the surface under the SMR and photodiodes measure the amount of reflected light. The line sensor of the SMR has 8 photodiodes and a width of approximately 15 cm. At each sampling instance a vector of 8 values between 0 and 255 is returned and should indicated from no reflection to full reflection.
The calibration was done placing a black and a white sheet of paper under the line sensor and reading the value. A linear transformation can be determined making black 0 and white 1.

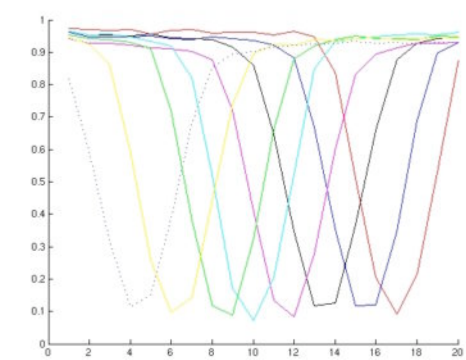


Figure 10 Calibration of line sensor

Calibration of IR sensor

The smr is equipped with infrared distance sensors capable for measuring at distances up to 60 cm. The method used is called triangulation. A beam of light is sent out and its reflections received by a

photosensitive chip. The chip is called a "Position Sensitive Device" (PSD) and is capable of determining the position of a light beam on its surface.
In Figure 11 the output of 3 different sensors has been measured. The front sensors was caribrated by taking the mean of 100 measurements of an obstacle at different distances from 15cm to 60 cm in steps of 1cm.

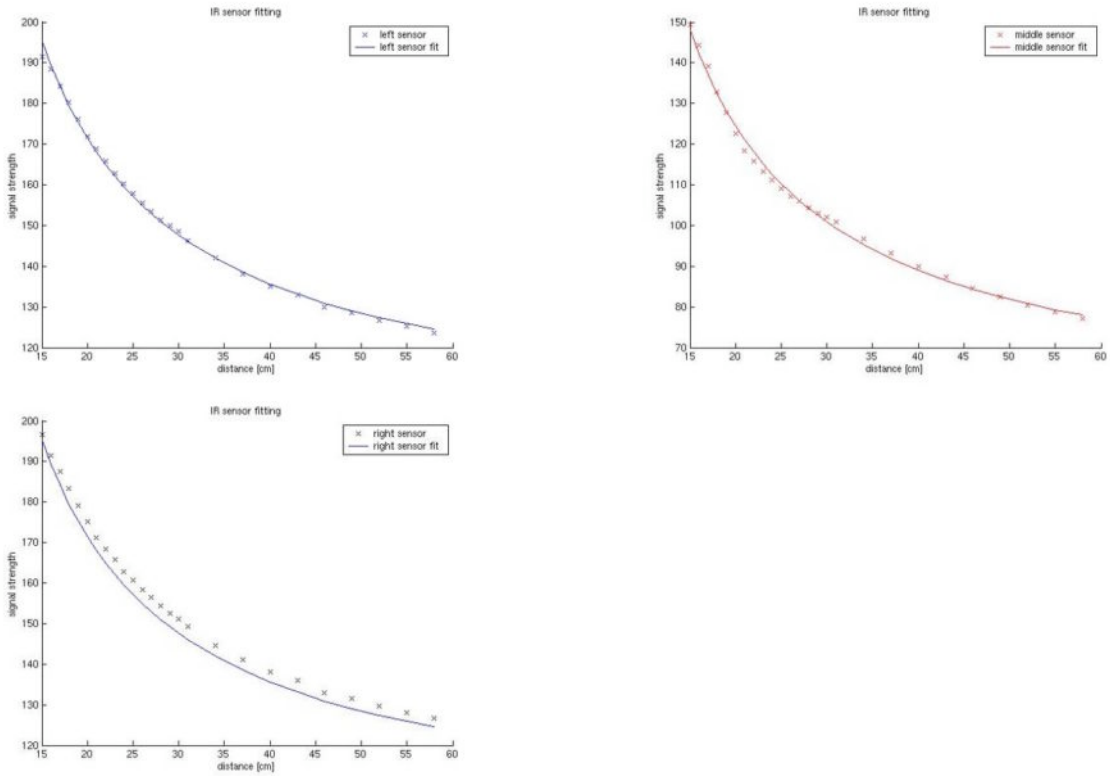


Figure 11 Calibration of IR sensor

Robot Competition

The SMR moved in a filed as shown in Figure *. The tasks and score were as follows:

1. Measure the distance from the start to a box on the track. (±7 cm=1 point, ±3 cm=2 points)
2. Bush a box out of the way and afterwards going through the tunnel. (2 point)
3. Find a gate to the left side of the SMR and going through it. (1 point)
4. Going through 2 gates with a wall inbetween. (2 point)
5. Follow a white line. (2 point)
6. Going though a gate without touching its poles. (1 point)
7. Finding the 'garage' and opening its door. (1 point)
8. Going into the 'garage' and stop. (2 point)

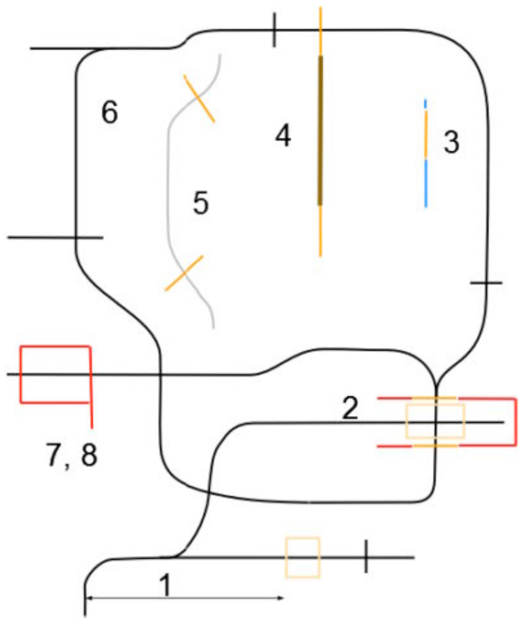


Figure 10 Task filed used in the competition

Results
Our team finished in first place. The score was 26/26 (100%).

Exchange student life

Belgium

KUL, I spent almost all my time in KUL. The KUL has a beautiful campus and buildings, and I enjoyed walks in the campus during a lunch break. Staffs in a laboratory where I studied were very kind, and they helped me not only my research but also something in dairy lives. A working time was about from a half pass 9 to 6. Almost all students in the laboratory didn't study so long but they concentrated on the study during the time. I felt a big difference in this style for study, and I tried to do like Belgium students as much as possible.

Foods, I sometimes cooked dinner by myself, and had lunch and dinner in a students-café "Alma" otherwhile. In the Alma, I was able to had some typical Belgian foods and know Belgian dietary habits. Frites, those are French potato with mayonnaise and very popular foods in Belgium, were very delicious and other foods also were good. And Belgian beers are very good and have many kinds of tastes so that I was able to meet new taste anytime. Anyway, I always had to take care not to eat too much.

Pangaea, is a space where international students can get together and had some interesting events. At the beginning, there were many events, such as a karaoke party, a dancing party and a travel, and I had chances to know other people. I had an "English conversation class". This was not a class with formalities, but a class where we were able to talk about some topics freely. Though the class, I was be able to not only make progress in English but also gain a better understanding of other countries.

Denmark

DTU, I spent almost all the time in DTU campus. My dormitory was a room of "Campus Village", that are located in the DTU campus, so that I didn't go out the DTU campus expect for shopping in weekdays. There were lots of international students in the dormitories, so I did enjoy communication with the international students. Sometimes I had a party with the students, and I and Japanese students cooked Japanese foods, otherwise we also had some other countries-meals.

Foods, I cooked all meals everyday. This was because of prices of meals in cafeterias or restraints. In Denmark, taxes are very high (25%), so my money was not enough to take a life in Denmark. It was really bad not to enjoy typical Danish foods, but I had no choice.

Summary

Through this exchange program, I spent five worthwhile months in Europe. I was able to have lots of great experiences that I could not have in Japan. Everything - communication with foreign people, grasp of foreign culture, many failures because of the gap of my knowledge and looking at Japan from Europe – is my treasure in my life. At last, I would like to thank everyone for helping my exchange life.