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# Haptic Human-Computer Interaction

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# Preface

## Haptic Devices

Haptic devices allow users to feel their interfaces and interactions. This has the potential to radically change the way we use computers. Haptic interaction is interaction related to the sense of touch. This could be based on force-feedback or tactile devices. We can take advantage of our powerful sense of touch as an alternative mechanism to send and receive information in computer interfaces. Haptic technology is now maturing and coming out of research laboratories and into real products and applications. We can therefore begin to focus on its application and general principles for its use rather than just the hardware and technology itself. Important questions are: what are haptics good for? What kind of information can be successfully presented via touch? Do haptics actually improve efficiency, effectiveness, and satisfaction? Arbitrary combinations of information presented to different senses have been shown to be ineffective so how should sight, hearing, and touch be combined in truly multimodal interfaces? We do not want to end up with haptic interfaces that are in fact harder to use than standard ones. Haptics may become just a gimmick for computer games, rather than the key improvement in interaction technology we believe it should be. We felt that it was therefore time to concentrate on *haptic human computer interaction*.

There are other conferences that discuss haptic hardware, but so far there has been little discussion of how haptics can be effectively used to improve the usability of human-computer interactions. There is currently no unified place to present research on general haptic human-computer interaction and so one aim of the workshop was to provide an information resource for those interested in the topic. Because this was the first workshop in the area and we wanted to ensure that we covered a wide range of the ongoing research, we planned to accept work on any aspect of haptic HCI. As it happened we had a very healthy turnout of 35 submissions and after a reviewing process, where each submission was reviewed by two reviewers, this resulted in 17 papers and 5 posters. The workshop took place at the University of Glasgow, UK from the 31st August to 1st September, 2000. We had over 75 attendees from Europe, the USA, and Japan.

## Workshop Content

The workshop began with a keynote presentation from Bob Stone of MUSE Virtual Presence giving an overview of the history of haptics. This proved to be an excellent start assuring that all of the attendees (who were from a wide variety of diffent backgrounds such as psychologists, computer scientists, textile designers, sculptors, toy manufacturers, mechanical engineers, and games designers) got a good foundation

and knew how we reached the current state of development in haptics research. The rest of the workshop focused on five main themes:

1. Haptic interfaces for blind people,
2. Collaborative haptics,
3. Psychological issues and measurement,
4. Applications of haptics
5. Haptics in virtual environments.

## Haptic Interfaces for Blind People

The first paper on this theme is by Challis and Edwards. They propose a series of principles for designing tactile displays that they developed from the results of experiments on Braille music notation. Three of their key principles are: consistent mappings should be kept between the visual and haptic representations; the tactile representation should focus on static data; and height should be used as a filtering mechanism. Penn *et al.* describe a series of investigations into the perception of text, object size, and angularity by blind and sighted users. One interesting aspect of their paper is the comparison of results of similar experiments on different haptic devices (a PHANToM and an Impulse Engine 3000). As the area of haptics is still in its infancy there is little work comparing different devices and the effects that this might have. Van Scoy *et al.* and Yu *et al.* both address the problem of presenting line graphs to visually impaired users. Van Scoy *et al.* focus on the presentation of haptic models of mathematical functions, Yu *et al.* report an experiment on the comparison of two different line modeling techniques to see which was the most effective at making graphs usable. Continuing the topic of education, Wise *et al.* present the results of an investigation into the benefits of haptic feedback in allowing blind students access to college and high-school physics curricula.

## Collaborative Haptics

There are three papers in the collaborative haptics section. The first is by Oakley *et al.* who are looking at how haptic effects can be used to help users of collaborative editors synchronize their work and gain awareness of others. Users of collaborative editors work in a restricted environment and there are many problems with awareness. Other researchers have looked at audio or graphical solutions to the problems but no one has really yet considered the possibilities of haptics. Sallnäs looks at a similar problem – collaborative manipulation of objects in a three-dimensional desktop virtual environment. Her results show that when the two users have haptic feedback, collaborative manipulation of objects becomes more successful. The final paper in this section is by Hikiji and Hashimoto. Their paper discusses the design of a system that allows the collaboration of a human with a robot that could provide haptic feedback. The robot could grasp a user's hand and lead (or be led) through a path, avoiding obstacles.

## Psychological Issues and Measurement

In the psychological issues and measurement section Jansson and Ivås present two studies: one on practice effects using the PHANToM and the other on exploration modes. Results of the practice effects experiment show very significant improvements in exploration times and accuracy over time. This is important for the design of future experiments. An appropriate amount of training is needed if results are to be robust and reliable. Results of the exploration modes suggest that certain grasps can be more beneficial than others when using the PHANToM. Pollick *et al.* investigate two-fingered grasp of objects to understand the contact forces users apply. Their results can be used for facilitating grasps of objects in virtual environments. There are two papers on texture, and in particular, roughness perception. The first from Wall and Harwin, combines haptics and graphics to investigate the interactions between the two. The second, from McGee *et al.* is about the combination of haptics and audio. The aim here is to investigate congruent and incongruent multimodal cues that might create different illusions of roughness.

Keuning-Van Oirschot and Houtsma discuss the design of a cursor trajectory analysis system for use in future haptic desktop computer interfaces. Other research has shown that individual targets with haptic effects added can improve performance. However, if you have to move over one of these targets on the way to something else (as would happen in a real interface with multiple potential targets) then the haptic effects could obstruct and disrupt your interaction. This paper presents setps towards a trajectory analysis system that could predict the target at which the user is aiming and so only haptify that and none of the others passed on the way to it.

Bougilia *et al.* use a new $3m^3$ workspace haptic device called the scaleable-SPIDAR (described in a later chapter) in an investigation of whether haptics can improve depth perception in VEs. Users can have problems with depth perception in such environments, even when using stereoscopic visual displays, as cues in other senses are often missing. Bouguila *et al.* report an experiment where haptics recombined with a stereoscopic display to allow the manipulation of virtual objects.
Kirkpatrick and Douglas provide benchmarks for evaluating the usability of haptic environments for shape perception tasks, with conclusions for future haptic environments.

## Applications of Haptic Technology

Crossan *et al.* are investigating the use of haptic technology to aid the teaching of difficult palpation techniques to veterinary students. Medical simulators have used haptics for some time but this has mostly been in the area of minimally invasive surgery training. This paper looks at how haptics can teach skills where the veterinarian's (or doctor's) hands are on the patient, which brings up a new set of haptic challenges. Finally we present two studies on the use of haptics in aircraft cockpits. Van Veen and van Erp show that pilots are heavily visually loaded and under high G-loads visual perception can become severely degraded. Is tactile perception affected in the same way? If it is degraded then it will not be a useful

alternative to visual feedback. Van Veen and van Erp present an experiment that shows that tactile perception on the torso is resistant to high G-loads. Van Erp presents an experiment to investigate the use of haptics for navigation in virtual environments. He describes an array of tactile stimulators that might run across the torso and provide directional information.

### Haptics in Virtual Environments

Bouguila *et al.* present a new $3m^3$ workspace haptic device called the scaleable-SPIDAR. The paper describes the design of the SPIDAR and an experiment to test its effectiveness. Stevens and Jerrams-Smith describe the use of haptics in projection-augmented displays. In their display haptics are coincident with information projected on an actual physical model. They propose the concept of 'object presence' – do users feel that an object actually exists in the display? Their hypothesis is that a combined haptic and visual display should increase object presence. One area in which haptics are beginning to take off is in computer games. In the *Lumetila* project Leikas *et al.* have developed a game that uses the player's whole body and body movements for control.

Dillon *et al.* are focusing their work on the use of haptics to present the 'feel' of virtual fabrics for the textiles industry. It is important for clients to be able to sample potential materials over the Internet and haptics can help with this. Dillon *et al.* investigate how factors integral to the fabric selection process, such as weight, thickness, shearness, drape, and stretch, could be presented using a haptic device.

## Conclusions

One reason that we decided to run the workshop was that haptic research at Glasgow was new and we wanted to make some contacts with others interested in the same area so that we could discuss ideas. We had no idea how many people would be interested in coming along. In the end we had over 75 attendees from many different countries and with a wide range of backgrounds. We had not anticipated anything like this degree of interest. It seems like haptics is a growing area of importance within the HCI community, but as yet it has had little impact on the mainstream HCI conferences.

One issue that came out of the workshop was that much of the research presented focused around the PHANToM device from SensAble Technologies (the other main commercial device represented was the Wingman force-feedback mouse from Logitech). The PHANToM is very effective for many kinds of interactions, but is not so good for others. Its cost also prohibits its wide use for research and its take-up by ordinary users in ordinary day-to-day situations. The field should try to broaden the use of technology, as we do not want to become restricted in our research to doing only the kinds of things that the PHANToM device supports. Wall and Harwin's work is a step in this direction as they are developing extra end-effectors for the PHANToM to allow it to give more cutaneous feedback. We believe that one thing

the field would benefit greatly from is a wider range of devices that can give haptic feedback at a lower cost. This provides a useful link from this workshop to others devoted more to the development of haptic hardware. We need to make sure that our requirements for devices are fed back to the hardware developers so that the next generation of haptic technology will be able to do the things that users need at prices they will be able to afford.

The workshop showed that lots of interesting work is going on using haptics in human-computer interaction. However, the area is still in its infancy in terms both of the hardware and software available and in what we use haptics for. Some key areas for further research that came out of the workshop are: we need more analysis of human haptic abilities and limitations in an HCI context; we must identify the fundamental issues in haptic HCI design; we need an understanding of what kinds of information can be successfully presented in touch and to understand the links between our sense of touch and the other senses as interfaces will inevitably use other media in addition to touch. Answers to the questions in these areas will help provide suggestions for future usable interfaces, yet to be implemented. It is also important to synthesize the results of the studies done into some design guidance that we can provide to interface designers (most of whom currently probably know almost nothing about haptics) so that they know what to do with this new medium in order to use it effectively to improve human-computer interaction. From the work presented in these proceedings we can see that haptics has a lot to offer HCI, the challenge is to make it happen.

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For more information, please refer to http://www.dcs.gla.ac.uk/haptics

March 2001

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