HSP v2: Haptic Signal Processing with Extensions for Physical Modeling

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HAID10 Program and Papers

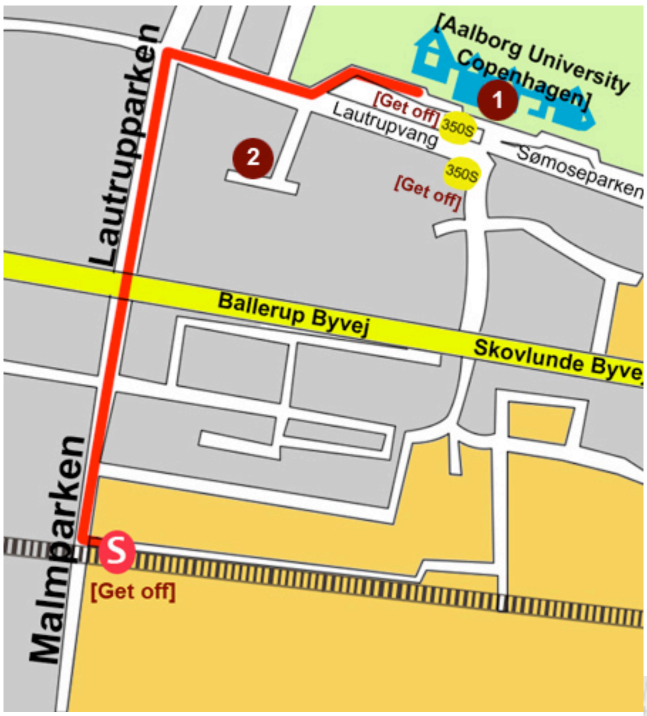
September 16th - 17th, Copenhagen, Denmark

How to find us…

Our address:
Aalborg University Copenhagen (Copenhagen University College of Engineering)
Lautrupvang 15,
DK-2750 Ballerup

The conference will take place at Lautrupvang 15, numbered as 1.

Lunch will take place at Lautrupvang 2, numbered as 2.



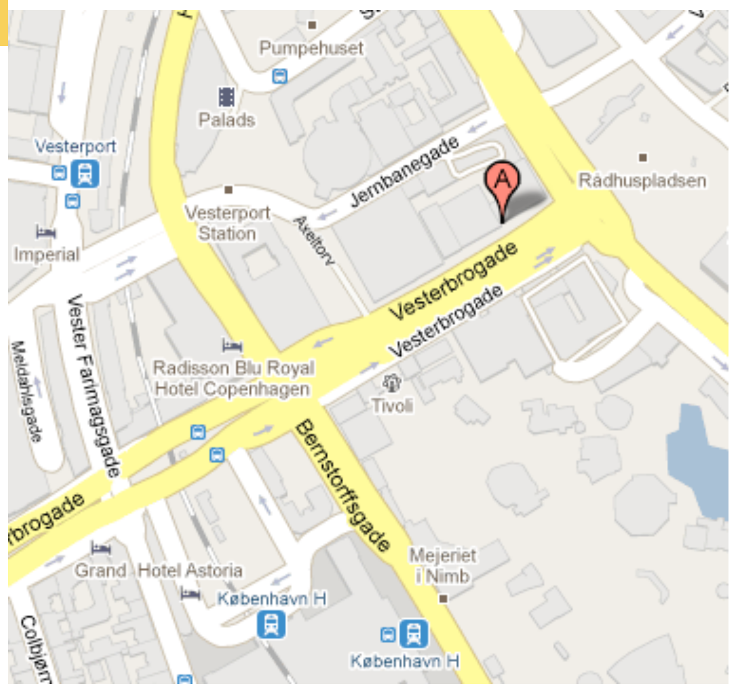
By train:
From Central Station of Copenhagen take the train, route C (direction Ballerup/Frederikssund), and get off the train at Malmparken. From Malmparken you can take the bus 350S(direction Syndbyvester Plads or Dragør Stationsplads) directly to Copenhagen University College of Engineering (5 minutes) or walk (20 minutes).

Bus from Nørreport train station
From Nørreport Station you can take bus 350S (direction Ballerup) directly to Copenhagen University College of Engineering (40 minutes).

Social dinner…

Social dinner takes place at Vesterbro Bryghus, Vesterbrogade 2B (close to Town Hall-Rådhuspladsen), 1620 København V

You can reach Vesterbro Bryghus by foot from Vesterport st, København H (Main train station) or Rådhuspladsen (Town Hall).



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HAID10 sponsors:

Sonic Interaction Design

natural interactive walking

Welcome to HAID 2010!

Dear participants,

A very warm welcome to Copenhagen and the fifth International Workshop on Haptic and Audio Interaction Design (HAID).

The aim of HAID10 is to bring together researchers and practitioners who share an interest in finding out how the haptic and audio modalities can be used together in human computer interaction. The research challenges in the area are best approached through user-centred design, empirical studies or the development of novel theoretical frameworks.

HAID10 is a direct successor to the successful workshop series inaugurated in Glasgow in 2006, in Seoul in 2007, in Jyväskylä in 2008 and in Dresden in 2009. This year we have been able to gather a program of 20 talks and 18 posters that we very much look forward to. We hope that you will enjoy two days full of interesting talks and demonstrations!

We are looking forward to a fruitful conference and wish you all a pleasant stay in Copenhagen.

Local Organizing Committee:

Sofia Dahl, Kristina Daniliauskaite, Rolf Nordahl, Stefania Serafin, Bob Sturm, Niels Böttcher, Steven Gelineck, Jon Ram Pedersen and Niels Christian Nilsson

AALBORG UNIVERSITY COPENHAGEN

Scientific Program

Thursday, September 16th

8:30 - 9:00	Registration
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9:15-10:15	Keynote *Vincent Hayward, Professor at* UPMC, France.

Session: Multimodal integration

10.15 – 10.35	*Merchel and Altinsoy.* Cross-Modality Matching of Loudness and Perceived Intensity of Whole-Body Vibrations
10.35 - 11.20	COFFEE BREAK (around posters)
11.20 – 11.40	*Tuuri, Eerola and Pirhonen.* Leaping Across Modalities: Speed Regulation Messages in Audio and Tactile Domains
11.40 – 12.00	*Altinsoy.* The Effect of Spatial Disparity on the Integration of Auditory and Tactile Information.
12.00 – 12.20	*Yoon, Perry and Hannaford.* Parametric Study of Virtual Curvature Recognition: Discrimination Thresholds for Haptic and Visual Sensory Information.
12.20 – 12.40	*Altinsoy and Merchel.* Cross-Modal Frequency Matching: Sound and Whole-body vibration.
12.45 - 14.00	LUNCH
14.00 - 15.00	Keynote *Davide Rocchesso, Associate professor at* IUAV, Italy

Session: Tactile and Sonic Explorations

15:00 – 15:20	*Melzer, Kindsmuller and Herczeg.* Audioworld: a Spatial Audio Tool for Acoustic and Cognitive Learning.
15:20 - 16:00	COFFEE BREAK (around posters)
16.00 – 16.20	*Bakker, van den Hoven and Eggen.* Exploring Interactive Systems Using Peripheral Sounds.
16.20 – 16.40	D*elle Monache, Hug and Erkut.* Basic exploration of narration and performativity for sounding interactive commodities.

	Kuber, Yu and O'Modhrain.
16.40 – 17.00	Tactile Web Browsing for Blind Users.
	Gonzales, Garbaya and Merienne.
17.00 – 17.20	Reducing Reversal Errors in Localizing the Source of Sound in Virtual Environment without Head Tracking.

Friday, September 17th

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10:15 – 10:35	*Turchet, Serafin, Dimitrov and Nordahl.* Conflicting audio-haptic feedback in physically based simulation of walking sounds.
10.35 - 11.20	COFFEE BREAK (around posters)
11:20 – 11:40	*Magnusson, Rassmus-Grohn and Szymczak.* The influence of angle size in navigation applications using pointing gestures.
11.40 – 12.00	*Papetti, Fontana, Civolani, Berrezag and Hayward.* Audio-Tactile Display of Ground Properties Using Interactive Shoes.
12.00 – 12.20	*Civolani, Fontana, Papetti.* Efficient Acquisition of Force Data in Interactive Shoe Designs.
12.20 – 12.40	*Srikulwong and O' Neill.* A Comparison of Two Wearable Tactile Interfaces with a Complementary Display in two Orientations.
12.45-14.00	LUNCH
	Session: Prototype design and evaluation
14.00 – 14.20	*Zappi, Gaudina, Brogni and Caldwell.* Virtual Sequencing with a Tactile Feedback Device.
14.20 – 14.40	*Andresen, Morten Bach, and Kristian Ross Kristensen.* The LapSlapper – Feel the Beat.
14.40 – 15.00	*Ferrise, Bordegoni and Lizaranzu.* Product design review application based on a vision-sound-haptic interface.
15.00 – 15.20	*Vanacken, De Boeck, and Coninx.* The Phantom versus The Falcon: Force Feedback Magnitude Effects on User's Performance during Target Acquisition.

15:20-16:00 COFFEE BREAK (around posters and demos)

Session: Gestures and Emotions

16.00 – 16.20 *Cooper, Kryssanov, and Ogawa.*
Building a Framework for Communication of Emotional State through Interaction with Haptic Devices.

16.20 – 16.40 *Wilhelm, Roscher, Blumendorf and Albayrak.*
A Trajectory-based Approach for Device Independent Gesture Recognition in Multimodal User Interfaces.

Abstracts of Plenary Talks

September 16th

10:15 - 10:35 Cross-Modality Matching of Loudness and Perceived Intensity of Whole-Body Vibrations

M. Ercan Altinsoy and Sebastian Merchel
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In this study, two experiments were conducted to determine the point of subjective intensity equality (PSE) of pure tones and sinusoidal whole-body vibrations (WBV) at various frequencies (50 Hz,100 Hz and 200 Hz). In these experiments, sounds and vertical vibrations were simultaneously presented to subjects using circumaural headphones and a flat hard seat. In total, 10 participants were subjected to tones with a fixed loudness level (40 phon, 60 phon, 80 phon and 100 phon). The participants were asked to match the intensity of the vibration to the loudness of the tone, using the method of adjustment. In the first experiment, the participants were subjected to a vibration and tone with the same frequency. Alternatively, in the second experiment, the frequency of the vibration was maintained at 50 Hz, while that of the tone was varied.
The results revealed that a 20 phon increase in loudness level resulted in a 5-6 dB increase in matched acceleration level at loudness levels greater than 40 phon. This result was reproducible with small intra-individual variations; however, large inter-individual differences were observed.

11:20 - 11:40 Leaping Across Modalities: Speed Regulation Messages in Audio and Tactile Domains

Kai Tuuri[1] , Tuomas Eerola[2] , and Antti Pirhonen [1]
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This study examines three design bases for speed regulation messages by testing their ability to function across modalities. Two of the design bases utilise a method originally intended for sound design and the third uses a method meant for tactile feedback. According to the experimental results, all designs communicate the intended meanings similarly in audio and tactile domains. It was also found that melodic (frequency changes) and rhythmic (segmentation) features of stimuli function differently for each type of message.

11:40 - 12:00 The Effect of Spatial Disparity on the Integration of Auditory and Tactile Information

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Spatial origin is an important cue for humans to determine whether auditory and tactile signals originate from the same event/object or not. This paper addresses spatial factors involved in the integration of auditory and tactile information. Perceptual threshold values for auditory-tactile spatial origin disparity were measured using tactile information and sound such as those generated by touching (scraping) an abrasive paper. The results of the study show that the minimum angle subjects need to notice that the locations of the auditory and tactile events do not coincide is 5.3°. Simultaneously presented tactile stimulation enlarges the auditory localization blur in the horizontal plane. The results show that the perceived location of auditory stimuli is influenced by tactile stimulation.

12:00 - 12:20 Parametric Study of Virtual Curvature Recognition: Discrimination Thresholds for Haptic and Visual Sensory Information

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The senses of vision and touch are vital modalities used in the discrimination of objects. In this research effort, a haptic device is used to determine thresholds of curvature discrimination in visual-haptic experiments. Discrimination thresholds are found for each sense independently as well as for combinations of these with and without the presence of conflicting information.
Results indicate that on average, the visual sense is about three times more sensitive than the haptic sense in discriminating curvature in virtual environments. It is also noticed that subjects seem to rely more heavily on the sense that contains the most informative cues rather than on any one particular sense, in agreement with the sensory integration model proposed by Ernst and Banks. The authors believe that the resulting thresholds may serve as relative comparisons between perceptual performance of the sensory modalities of vision and haptics in virtual environment.

12:20 - 12:40 Cross-Modal Frequency Matching: Sound and Whole-body Vibration

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Interest in human responses to whole-body vibration has grown, particularly due to the increasing usage of vehicles, e.g. cars, trucks, and helicopters etc. Another reason for

growing interest in recent years is the importance of the vibrations generated by the performance of music for multimedia reproduction systems. There is a strong relationship between the frequency of the auditory stimulus and the frequency of the tactile stimulus, which simply results from the physical processes that generate the stimuli. The recordings in different vehicles or in different concert situations show that the whole-body vibration signal is like a low-pass filtered audio signal. The spectral contents, particularly low frequencies, are matched with each other. This correlation plays an important role in our integration mechanism of auditory and tactile information and in the perception of an immersive multimodal event.
In this study, psychophysical experiments were conducted to investigate, if subjects are able to match the frequencies of two different sensory modalities with each other. In this experiment, sinusoidal sound and vibration signals were used. The auditory stimuli were presented to the subjects via headphones and the tactile stimuli were presented through a vibration seat. The task of the subject was to match the frequency of the whole-body vibration to the frequency of the auditory stimuli. The results show that the subjects are able to match the frequency of both modalities with some tolerances.

Session: Tactile and Sonic Explorations

15:00 - 15:20 Audioworld: a Spatial Audio Tool for Acoustic and Cognitive Learning

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The present paper introduces Audioworld, a novel game-like application for goal-oriented computer-supported learning (CSL). In Audioworld, participants localize sound emitting objects depending on their spatial position. Audioworld serves as a flexible low cost test bed for a broad range of human cognitive functions. This comprises the systematic training of spatial navigation and localization skills, but also of verbal skills and phonetic knowledge known to be essential in grammar literacy, for example. The general applicability of Audioworld was confirmed in a pilot study: users rated the overall application concept novel, entertaining, and rewarding.

16:00 - 16:20 Exploring Interactive Systems Using Peripheral Sounds

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Our everyday interaction in and with the physical world, has facilitated the development of auditory perception skills that enable us to selectively place one auditory channel in the center of our attention and simultaneously monitor others in the periphery. We search for ways to leverage these auditory perception skills in interactive systems. In this paper, we present three working demonstrators that use sound to subtly convey information to users in an open office. To qualitatively evaluate these demonstrators, each of them has been implemented in an office for three weeks. We have seen that such a period of time, sounds

can start shifting from the center to the periphery of the attention. Furthermore, we found several issues to be addressed when designing such systems, which can inform future work in this area.

16:20 - 16:40 Basic exploration of narration and performativity for sounding interactive commodities

Stefano Delle Monache[1] , Daniel Hug[2] and Cumhur Erkut[3]
[1]IUAV - University of Venice, Italy
[2]Zurich University of the Arts, Zurich, Switzerland
[3]Aalto University, Dept. Signal Processing and Acoustics, Espoo, Finland
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We present an exploration in sonic interaction design, aimed at integrating the power of narrative sound design with the sonic aesthetics of a physics-based sound synthesis. The emerging process is based on interpretation, and can represent a novel tool in the education of the future generation of interaction designers. In addition, an audio-tactile paradigm, that exploits the potential of the physics-based approach, is introduced.

16:40 - 17:00 Tactile Web Browsing for Blind Users

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[3]Queen's University Belfast, University Road, Belfast BT7 1NN, UK
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Recent developments in tactile technologies have made them an attractive choice to improve access to non-visual interfaces. This paper describes the design and evaluation of an extension to an existing browser, which enables blind individuals to explore web pages using tactile feedback. Pins are presented via a tactile mouse to communicate the presence of graphical interface objects. Findings from an evaluation have revealed that fifteen participants were able to learn the tactile HTML mappings developed, and were able to perform a range of web-based tasks in a less constrained manner than using a screen reader alone. The mappings presented in this paper, can be used by web developers with limited experience of tactile design, to widen access to their sites.

17:00 - 17:20 Reducing Reversal Errors in Localizing the Source of Sound in Virtual Environment Without Head Tracking

Vladimir Ortega-González† , Samir Garbaya, and Frédéric Merienne
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This paper presents a study about the effect of using additional audio cueing and Head-Related Transfer Function (HRTF) on human performance in sound source localization task without using head movement. The existing techniques of sound spatialization generate reversal errors. We intend to reduce these errors by introducing sensory cues based on sound effects. We conducted and experimental study to evaluate the impact of additional cues in sound source localization task.

The results showed the benefit of combining the additional cues and HRTF in terms of the localization accuracy and the reduction of reversal errors. This technique allows significant reduction of reversal errors compared to the use of the HRTF separately. For instance, this technique could be used to improve audio spatial alerting, spatial tracking and target detection in simulation applications when head movement is not included.

19.00 SOCIAL DINNER, Vesterbro Bryghus

We welcome you to a social dinner at Vesterbro bryghus.

This microbrewery is situated on Vesterbrogade 2B (just by Rσdhuspladsen), an area that traditionally has hosted many breweries.
Along with the good food, we hope that you will taste and enjoy some of the high-quality beers brewed here.
The restaurant is just next to Rådhusplatsen (Town Hall), on walking distance from train stations Hovedbangården (Central train station) and Vesterport (see map on page 1).

September 17th
Session: Walking and Navigation Interfaces

10:15 – 10:35 Conflicting audio-haptic feedback in physically based simulation of walking sounds

Luca Turchet, Stefania Serafin, Smilen Dimitrov, Rolf Nordahl
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We describe an audio-haptic experiment conducted using a system which simulates in real-time the auditory and haptic sensation of walking on different surfaces. The system is based on physical models, that drive both the haptic and audio synthesizers, and a pair of shoes enhanced with sensors and actuators. Such experiment was run to examine the ability of sub jects to recognize the different surfaces with both coherent and incoherent audio-haptic stimuli. Results show that in this kind of tasks the auditory modality is dominant on the haptic one.

11:20 -11:40 The influence of angle size in navigation applications using pointing gestures

Charlotte Magnusson[1] , Kirsten Rassmus-Gröhn[1] and Delphine Szymczak[1]
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One factor which can be expected to influence performance in applications where the user points a device in some direction to obtain information is the angle interval in which the user gets feedback. The present study was performed in order to get a better understanding of the influence of this angle interval on navigation performance, gestures and strategies in a more realistic outdoor setting. Results indicate that users are able to handle quite a wide range of angle intervals, although there are differences between narrow and wide intervals. We observe different gestures and strategies used by the users and provide some recommendations on suitable angle intervals. Finally, our observations support the notion that using this type of pointing gesture for navigation is intuitive and easy to use.

11:40 – 12:00 Audio-Tactile Display of Ground Properties Using Interactive Shoes

Stefano Papetti[1] , Federico Fontana[2] , Marco Civolani[1] , Amir Berrezag[3] and Vincent Hayward[3]
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We describe an audio-tactile stimulation system that can be worn and that is capable of

providing the sensation of walking over grounds of different type. The system includes miniature loudspeakers and broadband vibrotactile transducers embedded in the soles. The system is particularly effective at suggesting grounds that have granular or crumpling properties. By offering a broad spectrum of floor augmentations with moderate technological requirements, the proposed prototype represents a solution that can be easily replicated in the research lab- oratory. This paper documents the design and features of the diverse components that characterize the prototype in detail, as well as its current limits.

12:00 – 12:20 Efficient Acquisition of Force Data in Interactive Shoe Designs

Marco Civolani[1] , Federico Fontana[2] and Stefano Papetti[1]
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A four-channel sensing system is proposed for the capture of force data from the feet during walking tasks. Developed for an instrumented shoe design prototype, the system solves general issues of latency of the response, accuracy of the data, and robustness of the transmission of digital signals to the host computer. Such issues are often left partially unanswered by solutions for which compactness, accessibility and cost are taken into primary consideration. By adopting widely used force sensing (Interlink) and analog-to-digital conversion and pre-processing (Arduino) components, the proposed system is expected to raise interest among interaction designers of interfaces, in which the reliable and sufficiently broadband acquisition of force signals is desired.

12:20 – 12:40 A Comparison of Two Wearable Tactile Interfaces with a Complementary Display in Two Orientations

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Research has shown that two popular forms of wearable tactile displays, a back array and a waist belt, can aid pedestrian navigation by indicating direction. Each type has its proponents and each has been reported as successful in experimental trials, however, no direct experimental comparisons of the two approaches have been reported. We have therefore conducted a series of experiments directly comparing them on a range of measures. In this paper, we present results from a study in which we used a directional line drawing task to compare user performance with these two popular forms of wearable tactile display. We also investigated whether user performance was affected by a match between the plane of the tactile interface and the plane in which the users drew the perceived directions. Finally, we investigated the effect of adding a complementary visual display. The touch screen display on which participants drew the perceived directions presented either a blank display or a visual display of a map indicating eight directions
from a central roundabout, corresponding to the eight directions indicated by the tactile stimuli. We found that participants performed significantly faster and more accurately with the belt than with the array whether they had a vertical screen or a horizontal screen. We

found nowith the map display compared to the blank display.

Session: Prototype Design and Evaluation

14:00 – 14:20 Virtual Sequencing with a Tactile Feedback Device

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Since the beginning of Virtual Reality many artistic applications were developed, showing how this technology could be exploited not only from a technical point of view, but also in the field of feelings and emotions. Nowadays music is one of the most interesting field of application for Virtual Reality, and many environments provide the user with means to express her/himself; our work follows this direction, aiming at developing a set of multimodal musical interfaces. In this paper we present a first simple virtual sequencer combined with a low cost tactile feedback device: some preliminary experiments were done to analyze how skilled musicians approach this unusual way of making music.

14:20 – 14:40 the LapSlapper - Feel the Beat

Mads Stenho j Andresen, Morten Bach, and Kristian Ross Kristensen
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The LapSlapper is an inexpensive and low-technology percussive instrument with a digital interface. In a tactile and embodied manner it allows enhanced control and promotes expressive creativity when operating with percussive elements in digital environments. By using piezo-microphones, mounted on a pair of gloves and connected with a stereo signal to a runtime-version of a Max/MSP patch, intuitive haptic properties are achieved with simple means. The LapSlapper improves the physical feeling of playing digital rhythm instruments but the concept holds furthermore the potential to promote exploration and innovation of new, digitally founded rhythmical structures and aesthetics.

14:40 – 15:00 Product design review application based on a vision-sound-haptic interface

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Most of the activities concerning the design review of new products based on Virtual Reality are conducted from a visual point of view, thus limiting the realism of the reviewing activities. Adding the sense of touch and the sense of hearing to traditional virtual prototypes, may help in making the interaction with the prototype more natural, realistic

and similar to the interaction with real prototypes. Consequently, this would also contribute in making design review phases more effective, accurate and reliable. In this paper we describe an application for product design review where haptic, sound and vision channels have been used to simulate the interaction with a household appliance.

15:00 – 15:20 The Phantom versus The Falcon: Force Feedback Magnitude Effects on User's Performance during Target Acquisition

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Applying force feedback applications in a therapy environment allows the patient to practice in a more independent manner, with less intervention of the therapist. Currently however, high-end devices such as the Phantom or the HapticMaster are far too expensive to provide a device per patient. Recently Novint launched a low-cost haptic device for the gaming market: the Falcon. In this paper we report on an experiment that we conducted in order to compare the Falcon and the Phantom, based on a Fitts' law targeting task. We deduced physical parameters such as inertia and damping, which were found to be different for the devices. Although from a velocity analysis these differences can be clearly seen, it turns out that the influence of different forces does not show significant differences when taking completion time and error rate into account. From a sub jective experiment, we can learn that users allow the Falcon to produce slightly higher forces than the Phantom before forces are judged as too strong.

Session: Gestures and Emotions

16:00 -16:20 Building a Framework for Communication of Emotional State through Interaction with Haptic Devices

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Brief and high speed semantic communication, such as through texting and e-mail, leaves users without the ability to fully comprehend emotional content and vulnerable to emotional misunderstanding. The need to communicate emotional states, or to elicit sympathetic response in the receiver is evident in emotive icons and other relatively new applications of existing modes of communication. Haptic interfaces offer users a non-verbal way to communicate remotely, opening the door to a richer vocabulary and greater accessibility in emotive and affective communication. The studies described here investigate a possible framework for communication through haptic interface devices using existing models of emotional state. The semantic studies offer a look at users' naïve understanding of the emotive content of haptic sensations. Further experiments with haptic devices show that while communication through these modes can be implemented, the range of possible responses depends as much on the type of interaction used as on the users' understanding of emotive content.

16:20 – 16:40 A Trajectory-based Approach for Device Independent Gesture Recognition in Multimodal User Interfaces

Mathias Wilhelm, Dirk Roscher, Marco Blumendorf, Sahin Albayrak
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With the rise of technology in all areas of life new interaction techniques are required. With gestures and voice being the most natural ways to interact, it is a goal to also support this in human-computer interaction. In this paper, we introduce our approach to multimodal interaction in smart home environments and illustrate how device independent gesture recognition can be of great support in this area. We describe a trajectory-based approach that is applied to support device independent dynamic hand gesture recognition from vision systems, accelerometers or pen devices. The recorded data from the different devices is transformed to a common basis (2D-space) and the feature extraction and recognition is done on this basis. In a comprehensive case study we show the feasibility of the recognition and the integration with a multimodal and adaptive home operating system.

Abstracts of Keynote Talks

Professor Vincent Hayward
UPMC, France.

Haptic devices can take many forms and operate from different principles. Some of these devices can be very simple indeed, but to be effective they must always be respectful of the haptic sense in the same way acoustic transducers must be designed as a function of the sense of hearing. The presentation will cover some recent advances in the design of haptic interfaces and discoveries about the haptic sense that were made possible by these new designs.

One pushes, all hear: Sonic Interaction Design is Social

Associate professor Davide Rocchesso
IUAV, Italy.

Having absorbed the fashion of ubiquitous projections (of images on screens, of sounds in space), having experienced the trend of gestures-in-air followed by the tide of gestures-on-surfaces, we register a steadily increasing interest into the objecthood of everyday things and environments.
Interaction with many everyday objects is largely tactile and kinesthetic, inherently intimate and almost inscrutable. However, sound can make the qualities of interaction manifest and sharable. Sonic Interaction Design is about the qualities of objects in use, where sound is the principal mediator between human and object, as well as between humans through the object. The design practices that are being explored in Sonic Interaction Design are, therefore, intrinsically social, based on sharing experiences of creation, manipulation, performance, interpretation, and understanding.

The relative importance of visual, auditory, and haptic information and identification of perceptual attributes of the user's experience of mechanical switches

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Abstract: While the use of hand tools and other everyday manually controlled devices is naturally accompanied by multisensory feedback, the deployment of fully multimodal virtual interfaces requires that haptic, acoustic, and visual cues be synthesized. The complexity and character of this synthesis will depend on a thorough understanding of the multimodal perceptual experience, including the interrelations between the individual sensory channels during manual interaction. The results of two studies will be reported. In the first 70 participants were asked to rank the manual operation of ten electromechanical switches according to preference. In the second study the Repertory Grid Technique was used to identify the perceptual attributes of the user's experience of the switches use in the first study. A between subject design was used in both studies to assess seven sensory presentation conditions. These conditions comprised six bimodal and unimodal sensory combinations created by selectively restricting the flow of haptic, auditory and visual information, plus one condition in which full sensory information was available. In both experiments PCA analyses suggest that the primary dimension is related to the haptic channel and the magnitude of feedback. The second dimension is related to those conditions in which the haptic cues were impeded and the quality of the feedback in those channels.

Poster Papers
(HAID10)

Using Tangisense for a collaborative exploration of a sonic textures space

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ABSTRACT
We present here a musical tabletop experiment, inspired by the metaphor of the navigation in a sonic space, using *Tangisense*, a new tangible interface designed to sense objects equipped with Radio-Frequency IDentification (RFID) tags.

TANGISENSE, A NEW PLATFORM FOR INTUITIVE AND COLLABORATIVE INTERACTION

Tangisense is a platform for intuitive and collaborative interaction using an interactive table coupled with tangible objects. This new interface relies on RFID technology (Radio-frequency IDentification), which enables the users to manipulate tangible objects equipped with one or several RFID tags. The current prototype of Tangisense is composed of an array of 1600 RFID antennas The surface of the interactive area is about 1m^2 enabling the detection of more than 60 tangible objects moving simultaneously on the table with a spatial precision of 1.25 cm. In terms of temporal resolution, the 'sampling rate' of the table is 20 Hz, that is the position of a tangible object is refreshed every 50 ms. One of the main advantages of RFID-based technology, compared to camera-based tabletops is that *Tangisense* is not sensitive to lightning conditions, and does not require any preliminary calibration step before utilization. Tangisense allows users to interact with two kinds of objects: *tangible objects*, which can be found in the context of everyday life, and are physically accessible and easy to grasp by the user, and *virtual objects* displayed on the table using LED diodes. The original software architecture of Tangisense is written in Java, but a bridge based on the OpenSoundControl protocol has been implemented to allow the table to communicate with a series of OSC-compatible programming environments such as Max/MSP, Pure Data, or Processing.

RELATED WORKS ON MUSICAL TABLETOP

Since a couple of years touchable and tangible interfaces have been widely used for musical expression From pioneer works, such as *Audiopad* [5] or *Reactable* [3], to the most recent ones like *Bricktable* [4], artists and researchers have highlighted the possibilities offered by such interfaces for musical expression and performance.

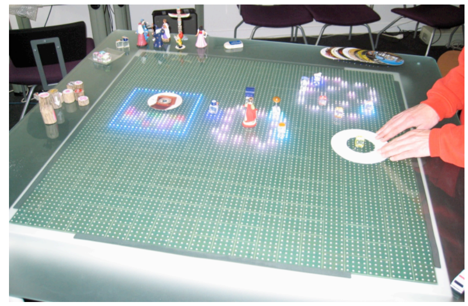

Figure 1: Tangisense used for interactive sonification

Tangisense has already been used in the context of sonic interaction design (Fig. 1) for controlling the sonification of a cellular automaton [1] or classifying a set of sonic textures [2] through the use of tangible objects. In the following section, we describe another musical tabletop experiment recently designed by the authors, where performers explore a sonic space by manipulating various types of tangible objects on the interactive table.

INTERACTIVE EXPLORATION OF A SONIC SPACE WITH TANGISENSE

A gravitational sonic space

For the design of this musical tabletop experiment, we considered the surface of the tangible table as a sonic space populated by n '*sonic attractors*', which are virtual objects associated to specific sounds. This can be though as a "geographic map" of a sound territory (see Fig. 3).

These attractors exert an attraction influence on '*sonic actuators'* (tangible objects) depending on their relative distance to them. So each actuator generates an audio track composed of the weighted mix of the n sounds associated to the attractors that are present in the space. The weight of each sound in the mix depends on the forces exerted by the corresponding attractors on the actuator. This musical experimentation was developed under Max-MSP and partly relies on interpolation tools provided by Todoroff et al [6].

Interaction with the tangible table

The exploration of the sound space is performed by manipulating three kinds of tangible objects[1] (Fig. 2):

[1] A video demonstrating this musical tabletop is available online : http://www.tele.ucl.ac.be/~jjfil/HAID10.html

sixteen cubic '*tangible sound objects'* that modify the sonic attractors, six hemispheric '*tangible* '*sonic actuators'*, and one '*tangible rubber*'.

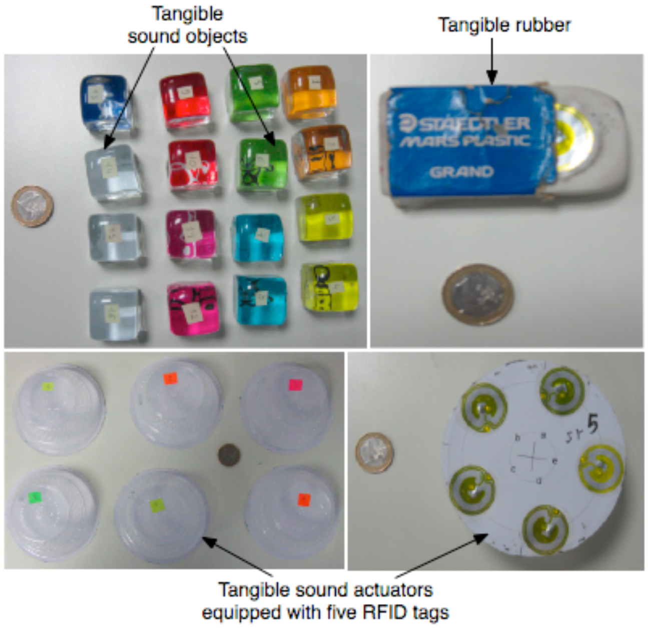

Figure 2: The three kinds of tangible objects used for exploring the sound space

The performer has the ability to freely design, populate and modify the sonic space, by placing '*tangible sound objects*' (Fig. 2 top left) on the table. '*Sonic (virtual) attractors'* are this way represented by illuminated areas on the table. To prevent a cluttering on the table and facilitate the navigation into the sonic space, attractors are persistent, which means that they keep their position in the sonic space even if the corresponding *'tangible sound objects'* are removed from the table. A *tangible rubber* (Fig. 2 top right) is placed at the disposal of the performer to remove any unwanted sonic attractor.

The '*tangible sonic actuators*' are tangible objects that are used to physically navigate in the sonic space. These objects are hemispheric and equipped with five RFID tags (Fig 2 bottom). That, beside increasing the robustness of the detection, allows to provide information related to the rotation of the object on the table. We chose to map sound granulation parameters, i.e. grains length and triggering, to the rotation of the actuators.

Evaluation of the sonic interaction

This musical tabletop application constitutes one of the first attempts to control real-time sound processes using the RFID-based tangible interface. The mapping between gestures and sound parameters designed in this application allows the performer to interact with sound through a large range of musical gestures: while a seamless navigation in the sonic space is made possible by sliding the tangible sound actuators along the table, drawing actuator trajectories through rapid gestures allows to shape the sound matter intuitively. Multilayered soundscapes can be composed by fixing the position of some actuators in specific areas of the sonic space while moving around other actuators in different regions of the table.

Figure 3: Collaborative exploration of a texture sonic space by two performers

The exploration of a sonic space by several performers is also possible (Fig. 3) and demonstrates the potential of such kind of interfaces for collaborative musical improvisation.

ACKNOWLEDGMENTS

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Realtime synthesized sword-sounds in Wii computer games

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ABSTRACT

This paper presents the current work carried out on an interactive sword fighting game, developed for the Wii controller. The aim of the work is to develop highly interactive action-sound, which is closely mapped to the physical actions of the player. The interactive sword sound is developed using a combination of granular synthesis and subtractive synthesis simulating wind. The aim of the work is to test if more interactive sound can affect the way humans interact physically with their body, when playing games with controllers such as the Wii remote.

Author Keywords

Interactive sound, realtime sound synthesis, computer game sound, mapping of human gestures to sounds, physical computer games.

ACM Classification Keywords

Design and human factors

INTRODUCTION

A few years ago new interfaces to control computer games started to show up. This includes interfaces such as the Nintendo Wii controller[5], the Nintendo DS[4] and others. These devices usually contains a variety of sensors, microphones and cameras. It is possible to analyze sound input, detect motion, retrieve sophisticated information about acceleration, 3D orientation and such.

More advanced devices utilizing even more sophisticated features are soon to be presented on the commercial marked as well.

The new possibilities of controlling the games opens up the possibility to involve the players in a much more bodily physical way, compared to the traditional joypad, mouse or keyboard solutions. As it is today, in most computer games and virtual environments, pre-recorded samples are commonly used to simulate sounds produced, when a user acts in a scenario by moving his body, swinging a weapon, hitting an enemy or similar diegetic action sounds. This approach has several disadvantages, and one of the main problems is that sampled sounds are repetitive, and do not capture the subtle nuances and variations which occur, when objects interact with different forces, velocities and similar. This is usually overcome by the use of randomization of several samples and simple processing of the recorded sounds, in order to achieve more variation and realistic sound.

With the huge advances of game controllers, and a much more natural human computer interaction, it seems obvious to design more interactive sound, that is utilizing the detailed information available from the sensors in the game controllers. Most of the detailed information about the physical user input, such as acceleration as an example, is not at all utilized to its full potential.

One solution to this could be the use of realtime sound synthesis instead of sample based sound.

RELATED WORK

Realtime synthesized sound for virtual environments is not a new topic and several people have been working within this field.

Andy Farnell has developed a collection of procedural audio models, especially designed for computer games and interactive applications[2],[1]. Perry Cook has made some very important work within the field of realtime synthesis for interactive applications[6]. In[9] a very precise and realistic physical sound model of aerodynamic fluids for sword sounds is presented. Work has also been made in integrating sound and motion in the game engines. In[3] a so-called timbre tree is presented, where it is described how the physical parameters affecting the visualizations are re-used to affect and generate the audio. In[10] physically based contact sounds are modeled using the informations from the texture map of a game engine. Another important and related project to mention is the sounding objects project[7],[8], where the aim, among other things, was to develop a series of sound models being responsive to physical interactions, and in the same time being easily matched to physical objects.

ON THE DEVELOPMENT OF INTERACTIVE SWORD SOUNDS

In order to test the effect and perspective of interactive sound synthesis an interactive sword sound, especially designed for the Nintendo Wii controller, has been developed.

Looking at the work carried out within interactive sound for virtual environments and computer games, most of the academic work tend to focus on the simulation of natural and realistic sounds. In computer games however, it is very common to use highly enhanced and in some cases cartoonized sounds - far away from realism. In games it might be more important to emphasize the affordance of the objects rather than simulating the actual physical properties. If a wooden stick is used as a weapon to hit other people, it should probably sound more like a weapon than a real natural wooden stick moving through air.

A great deal of the academic work put into the interactive sound models, could be applied to the modern computer games, but perhaps some of this work, needs to be moderated and re-thought in order to be integrated well with the games.

A MAX/MSP SWORD SOUND PROTOTYPE

During the development of this work, many different synthesis techniques and prototypes have been tested. Subtractive synthesis, granular synthesis and modal synthesis are the main techniques that have been utilized so far. The most convincing technique during this work, has been granular synthesis .

In the current version of the sword sound model, a combination of granular synthesis and subtractive synthesis is utilized. The granular synthesis is used to scrub through a simulated sword sound recording. The acceleration of the Wii remote is mapped to the amplitude as well as the location of the scrubbing through the sample. The end of the sample contains a high pitched sound simulating a hard acceleration with the sword. This point of the sample is never reached if the user is not swinging the Wii remote hard enough.

The granulized sword sound is then mixed with a filtered version of itself, running through a subtractive synthesized wind model simulating the air and giving more randomization and realism to the sound.

By pitching the sample either up or down a larger or smaller weapon can by simulated.

A WII CONTROLLED UNITY-MAX/MSP SWORD GAME PROTOTYPE

In order to test the effect of the interactive sound a simple sword fighting game has been implemented in the Unity game engine. The game is using a first person shooter camera view and the player can simply move around and swing a wooden stick in the air and against simple objects. The design of the game it self, and the visual parts, is currently work in progress. In order to utilize the sound generated in Max/MSP data is sent back and forth between the two platforms via local host.

FUTURE WORK

The main motivation for the development of this work, is to test weather the closer connection between physical motion and sound could change the physical body movements of the players, when playing and interacting with the game.

During the development of the prototypes some indications

Figure 1. The first person shooter view of the wooden stick-sword in the Unity game.

of different physical behavior from the users was observed. This is to be tested in the future when the interactive models and the corresponding game is fully developed. The idea is basically to compare a sample based game, with a game including realtime synthesized sound on the diegetic action sounds.

It is the aim to apply a motion capture system in order to retrieve data about the exact body-movements of the people playing the two different versions of the game. This could be information such as movement patterns, variations, which body limbs the test persons move, how much, how far and similar.

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Realtime Interaction Analysis of Social Interplay in a Multimodal Musical-Sonic Interaction Context

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ABSTRACT

This paper presents an approach to the analysis of social interplay among users in a multimodal interaction and musical performance situation. The approach consists of a combined method of realtime sensor data analysis for the description and interpretation of player gestures and video micro-analysis methods used to describe the interaction situation and the context in which the social interplay takes place. This combined method is used in an iterative process, where the design of interactive games with musical-sonic feedback is improved according to newly discovered understandings and interpretations of joint user action.

Author Keywords

Multimodal interaction, sound feedback, musical and sonic games, interaction analysis, joint user action.

ACM Classification Keywords

Socio-musical interaction, joint user action, user attunement in social games.

INTRODUCTION

In the research reflected through the conferences IDC (Interaction Design and Children), TEI (Tangible Embedded and Embodied Interaction), NIME (New Interfaces for Musical Expression), SMC (Sound and Music Computing) and ICMC (International Computer Music Conference) there has been several examples of prototypes of new multimodal interfaces that have mapped user gestures to sonic and musical content. Blaine and Weinberg have discussed mapping of joint user action in networked interfaces.[1][2] Interfaces in relation to gestural and full body musical interaction have been discussed by Bongers and Veer [3]. An example of realtime gesture recognition for the learning of musical performance is presented by Fléty et al.[4].

This research uses the above knowledge as a starting point for the formulation of new design methods for musical and sonic games. The design methods can be used in the design of mainstream game applications with physical interfaces for the learning of musical expression in an ensemble context. Current examples of this are the Iphone® musical applications, Guitar Hero® and Rock Band®. For this study, two commercial interfaces, the Nintendo Wii® and the Wacom Tablet® have been chosen for experiments with joint user action. This is to minimize usability issues that often appear in sensor technology prototypes where hardware design and positioning of sensors in a physical layout can be somewhat questionable. Test applications for the Wii-mote and Wacom Tablet interfaces support the idea of 'socio-musical expression'. By 'socio-musical expression' is meant a type of musical performance where the focus is on the social interplay among players rather than 'correctness of action' in terms of being in tune / in time with precomposed music. The sonic-musical game applications do not include a screen interface, because it makes direct eye contact between players difficult. Haptic feedback along with the sonic feedback has been considered, but not yet implemented.

EXPERIMENTS THAT ENCOURAGE 'SOCIO-MUSICAL EXPRESSION'

Experiments with individual and joint user action consist of sound applications designed in the high-level programming environment Max MSP. Two musical-sonic game concepts have been implemented. They will be tested with users in the Fall of 2010. The experiments are inspired from improvisation techniques in Music Therapy and Central African polyphonics and polyrhythmics.[5][6] Through fine and rough motoric movements two users jointly manipulate musical-sonic content. In a 'push-pull relationship' two users either support or work against each other. For example, users can direct the flow of a melody or a rhythm and jointly influence parameters of a soundscape. With similar movements, they amplify, accelerate and add regularuty to musical-sonic content. With different or opposite movements, two users obtain irregular, perhaps atonal musical-sonic results. Users obtain more complex musical-sonic results with relational movements.

A COMBINED APPROACH TO THE UNDERSTANDING OF 'SOCIO-MUSICAL EXPRESSION'

In order to analyse the social interplay amongst two players a combined method of sensor data analysis as well as video micro-analysis is used. The involvement of these two methods makes it possible to create an understanding of joint user action that can help to formulate design parameters for the mapping of individual and joint user action to sonic-musical feedback.

Realtime Gesture Analysis

In musical-sonic game experiments two users are introduced to sound material and musical content that they manipulate jointly with rough motoric (Wii-mote) and fine motoric (Wacom Tablet) gestures. The gestures generate sounds according to realtime gesture analysis that has no or very little delay. In order to secure a direct and immediate musical dialogue between the two players it is central that the sound feedback is as immediate as possible. The gesture analysis for both interfaces is relatively simple. Gesture characteristics are recognized within 100 to 200 milliseconds. The gesture analysis for the Wacom Tablet recognizes characteristics of continuous drawing: draw area, stroke direction (360°), change of pen direction and stroke qualities such as line smoothness, curvature, circular movements and line angle. The Wii-mote gesture analysis is focussed around shaking patterns: shaking direction in 3D and shaking volume, shaking speed in terms of detected peak points. With the time lapse between peak points it is possible to detect if the two players synchronize when they shake the Wii-mote back and forth, or if there is a temporal relationship. By detecting shaking direction from two players it is possible to detect mirroring- or parallel movements. The action of 'shaking the Wii back and forth' has been chosen as a main sound control action, because it is visual and because it has been discovered in early experiments that players rely on visual cueing before they understand any sonic-musical feedback.

Data Logging

During an experiment with a musical-sonic game application the sensor data from the two interfaces is logged. Furthermore the realtime gesture analysis is logged in order to see how the gesture analysis functions with the raw sensor data values. The logged data is registered every 20 milliseconds and when the gesture analysis allows registration.

Video Micro Analysis

One video camera films the two participants from the side. It is placed roughly 1 1/2 meter from each participant. In this way participant postures, gestures and eye movements are documented as a whole. In video micro-analysis eye contact, synchronization, mirroring of gestures is noted along with any other gesture relationships. Furthermore, the context behind the user situation is analyzed according to social cues such as participant utterances, sign/signal-related gestures, full body postures and proximity. Sections where the two participants have a specific social relationship are noted in order to compare to the data-logged information.

RESULTS OF LOGGED DATA AND VIDEO CAPTURED USER PERFORMANCE

The results from the two types of analysis provide two perspectives of the user situation: The video micro-analysis provides information about the continuous interaction situation, while the logged data provides information about specifics in the individual and joint user actions that were present at any moment in the interaction situation.

Social Relationship Detected in Logged Data

The logged data reflects what kind of musical and sonic expression the two players shared at any given moment. The question is if a particular musical and sonic expression reflects a social dialogue between the users. Logged sensor signals can reveal individual player styles, synchronization, mirroring, opposite movements and temporal relationships. It is assumed that the video micro-analysis will reveal that players are more aware of each other if gestural relationships are found in the logged data. Findings in the video micro-analysis may help to evaluate the digital interpretation of individual and joint actions and the mappings from actions to sound.

DISCUSSION

In this paper, a combined method for the analysis of social interplay between two users is presented. This analysis is used in an iterative design process, where games that encourage 'socio-musical expression' are continueously developed and evaluated. The question is: how do users understand and interpret the digital interpretation and sonic reaction/adaptation to joint user action? One could claim that the digital interpretations of joint user action and gesture/sound mappings are successful, if users actually obtain joint awareness and a meaningful musical-sonic output is reached as a result.

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Response Time to Auditory Feedback in a Motor Task

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ABSTRACT

Concurrent augmented feedback has been found to enhance learning of complex motor tasks. As in most motor tasks visual perception is highly loaded with processing essential information of the environment, augmented feedback might rather be displayed in another modality in order to prevent cognitive overload. Therefore, we designed and evaluated concurrent error sonification based auditory feedback for a 3D-rowing-type movement. We found that participants could follow the target oar by moving a real oar with only auditory feedback. However, the participants lagged the target oar, most likely due to their naturally given response time. Therefore, in this study, 11 participants tested feedbacks designs with four different compensations of the response time. The compensation was based on the sonification of the deviation between the own oar position and a target oar position that was in advance to the actually desired target oar position. We found that response time compensation is effective, and considering a response time of about 200ms was optimal in order to reach highest precision in the investigated task. The results encourage us to further develop augmented auditory and also audiovisual and audiohaptic feedback for complex motor tasks.

Author Keywords

Augmented auditory feedback, concurrent (real time) feedback, motor learning

ACM Classification Keywords

H.1.2 Human information processing, H.5.2 Auditory (non-speech) feedback

INTRODUCTION

Concurrent (real time) augmented feedback, i.e. information about performance during task execution and additional to intrinsic feedback, has been found to be rather detrimental to learn simple movements, but beneficial for more complex movements [4]. To provide concurrent augmented feedback, visual displays are limited since in many complex motor tasks, visual information has to be processed by the performer in order to succeed. To prevent perceptual and cognitive overload, it is therefore reasonable to provide concurrent augmented feedback acoustically. Auditory alarms were already reported to enhance learning of dancing skills [2] or movements on a pommel horse [1]. In precision shooting, mapping pitch to the deviation to the target was also successfully applied [3]. However, learning of complex motor tasks may even more benefit from continuous feedback than from a discrete alarm, and from feedback about multiple variables.

We have developed and evaluated different concurrent auditory feedback designs on multiple variables of a rowing-type movement. Participants which were naïve to the task could follow the target movement with the applied feedback designs sonifying the movement error. Additionally, we observed that in general, the participants lagged on average 344ms behind the target movement. Humans need time to process and respond to the feedback. We hypothesized that mapping the auditory feedback to a position in a certain time in advance helps the participants to correct the movement more adequately. Thus, we tested four feedback designs differing in response compensation time in order to evaluate the benefit of considering the time to process and respond to the feedback.

METHOD

Participants, apparatus and task

Eleven healthy non-rowers (25 to 32 years old) participated and agreed the guidelines of the local ethics commission. They were familiar with the task and related designs of auditory feedback due to the participation in another study.

The participant was seated on a chair next to a real but trimmed oar that the participant could easily move with the right hand and arm in the required range (Figure 1). The ranges of the target oar movements were 35° (53cm) in horizontal direction, 27° (41cm) in vertical direction, and 90° around the longitudinal axis. The task was to follow a virtual target oar by moving the real oar. One movement cycle lasted 10s. Three wire potentiometers (Micro-Epsilon, WPS-1250-MK46) were used to compute the oar angles. Kinematic data was recorded at 30Hz. Auditory feedback was provided by common headphones (Creative, HQ-1400; 20Hz ~ 20kHz, update rate ~30Hz).

Feedback designs

Concurrent auditory feedback displayed the deviation of the participant's oar to the virtual target oar, i.e. the current error of the movement. The deviation angle from the target oar in the horizontal plane was continuously mapped on stereo balance, in the vertical plane continuously on pitch. In addition, the signal volume represented the absolute deviation, i.e. angle between the oars, whereas a smaller deviation resulted in lower volume (but it was never silent). The feedback always indicated the direction whereto the participant should move the outer end of the oar in order to decrease the deviation, e.g. a louder signal on the left ear meant to correct to the left. As only two orientations of the oar rotation around the longitudinal axis are functional in

Figure 1. Setup. Arrow: rotation around longitudinal axis

rowing (0° and 90°), coincidence and no-coincidence of the oar orientations was mapped to two timbres. Different response compensation times were chosen for the four feedback designs: T_0 = no compensation; T_{200} = 200ms; T_{400} = 400ms; T_{600} = 600ms. Response compensation meant that the displayed feedback about the actual angular error was displayed in relation to a target oar that was the time T in advance to the actually desired target oar position.

Procedure

The participant performed three pretests to re-familiarize with the feedback. In the two 1D-pretests (6 cycles), the target moved only horizontally, and in the second pretest only vertically in a sinusoidal way. In the following 2D-pretest (12 cycles) the target moved with constant speed on a circle shaped trajectory. The feedback was given corresponding to the dimensions of the target movement of the specific pretest. In each of the four main test, i.e. 3D-test (18 cycles), the target oar moved with constant speed on a bean-shaped target trajectory. The target trajectory was unknown to the participant and rotated by 15°, 165°, 195° and 365° in order to minimize learning effects while keeping the task difficulty level constant. The target oar rotated around the longitudinal axis at two points on the target trajectory, from 0° to 90° or vice versa. Each participant tested all of the four designs. The order of the designs was balanced and randomized.

RESULTS

Statistical analysis of the main tests was done with a repeated measures ANOVA ($p < .05$). The first cycle and the last two cycles of each test were excluded from the analysis. The mean deviation, i.e. angle between oars, was not significantly different within all designs, but lowest for the 200ms compensation design: T_{200} (4.2) < T_0 (4.7°) < T_{400} (5.1) < T_{600} (5.6°) (Figure 2). Movements with T_0 showed a mean lag of 191ms, the movements with the other feedback designs were in advance to the desired movement (T_{200}: -14ms; T_{400}: -250ms; T_{600}: -367ms). After subtracting these lags or leads, the mean deviation angles were 4.3° for T_0, 4.1° for T_{200}, 4.6° for T_{400}, and 4.2° for T_{600}, and did not differ significantly. The longitudinal oar rotation was generally too late (T_0: on average 555ms; T_{200}: 271ms; T_{400}: 106ms), but in T_{600}, too early (on average -155ms), whereas only T_{200} and T_{400} did not differ significantly.

DISCUSSION AND CONCLUSION

In this work, the goal was to evaluate the effect of auditory feedback designs considering the response time in a

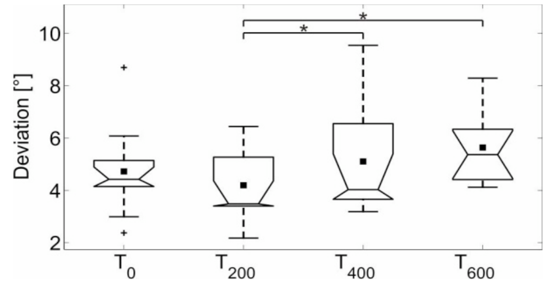

Figure 2. Angle between oars: ▪mean, *significant difference

complex, rowing-type 3D-movement. Response time compensation was found to be effective, whereas 200ms seem to be close to optimal. Based on the presented results, the feedback to induce oar rotation should be given even earlier, around 500ms in advance. This is rather surprising if we assume that the binary, alarm-type feedback is easier to interpret than the continuous feedback about the other variables. It might be that participants tend to rate the horizontal and vertical movement more important than the longitudinal rotation. Participants' performance was found to be at a similar level after subtracting the remaining lags or leads of the movement. However, if participants get more familiar with the feedback and more skilled, excessive response compensation would be detrimental as it would induce skilled participants to shorten the target trajectory at certain sections. We assume that including response compensation in concurrent auditory feedback helps to better time and follow irregular shapes or turnings.

FUTURE WORK

Auditory feedback designs with different polarities, or in combination with other modalities, i.e. audiohaptic and audiovisual feedback, will be evaluated. Finally, the effects of concurrent augmented unimodal and multimodal feedback on learning complex motor tasks must be compared to other feedback strategies, such as terminal feedback.

ACKNOWLEDGEMENT

Special thanks go to Jürg Schellenberg for his large effort on designing and programming the auditory feedback.

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Haptic Sensation in Organ Playing

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ABSTRACT

This paper presents a new research project, which aims to reveal the elements of haptic sensation in playing pipe organ with mechanical tracker actions. In order to reach this goal sets of experiments will be carried out. Layout of these experiments are (1) measuring manual key signatures and analyzing them together with the interviews with expert organists to study the extent they can feel and communicate key properties, (2) measuring dynamical properties of key action, recording sound and recording organist's movements simultaneously during performance, and (3) running psychophysical experiments on expert organists using an experimental keyboard where key action can be simulated and altered. The outcome of this research project will contribute to organ building and documentation and new class of haptics-enabled digital musical instruments.

Author Keywords

Pipe organ, tracker action, haptic feedback.

INTRODUCTION

Musical instruments do not only provide auditory or visual information but they also provide tactile feedback to the performer. String instruments convey information through the performer's fingers, wind instruments through fingers and lips. Also, vibrations in the instrument body can be felt through contact. If pipe organs are taken as an example, during performance organist hears the pipes sounding as well as the contribution of room properties; sees manuals, pedals and stop knobs; smells the instrument (e.g. oak) and the room, and feels the manual and pedal action properties through his/her fingers and feet. Thus, one can claim that similar to the fact that perception of most objects and events are multisensory, sensation and perception of instrument playing is also multisensory. A model showing the multisensory nature of instrument playing could possibly look like the one in Fig. 1. Using haptic channel, which combines both cutaneous and proprioceptive information, performer both acts on the instrument and receives feedback from it.

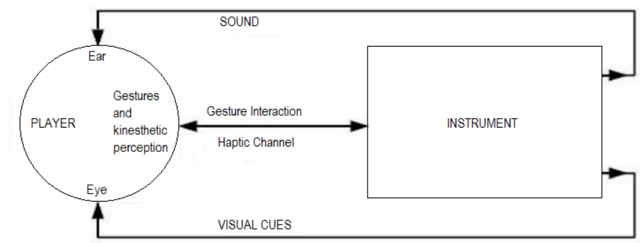

Figure 1. Player-instrument relationship (Recreated from [1]).

In a new research project we aim to investigate the importance of haptic feedback for organ playing and also to characterize key action properties both objectively and subjectively. We are aware of the existence of different types of key actions in different organ building periods and traditions. In the current project we focus on mechanical tracker actions. Outcome of this project will improve the current knowledge in the fields of organ building, restoration, conservation and documentation; organist-organ interaction; haptically enabled digital instruments and basic haptics research.

MECHANICAL TRACKER ACTIONS

Tracker action refers to mechanical connection between pedals and keys at the console and the valve (or pallet) that lets the air flow through pipes (Fig. 2). It consists of several mechanical components like trackers, stickers, levers, rollers, etc [2, 3]. In Fig. 2, one can see a simplified illustration of tracker action where the keys are balanced at the end opposite to where organist plays, and pulling action is carried to the pallet by means of trackers. In order to convey motion in vertical directions rollers are used (Fig. 3). All these mechanical components contribute to the force feedback that organist feels at the keyboard. Main components of this force are, (1) force from the spring keeping the pallet closed when key is not pressed, (2) force needed to accelerate moving parts of the action, which depends on inertia and friction forces, and (3) flow forces acting on the pallet. Due to the mechanical construction of the key action, forces that organist feels are different during attack and release of the key. During attack organist has to overcome flow and spring forces and mechanical friction, whereas during release flow forces have a different

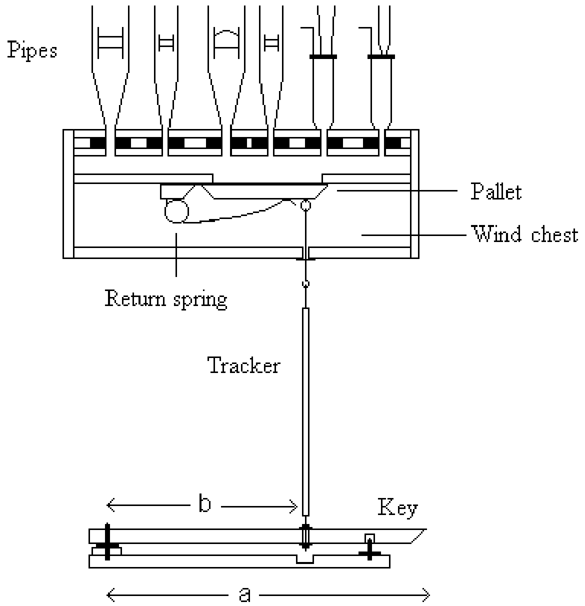

Figure 2. Illustration of mechanical key action [4].

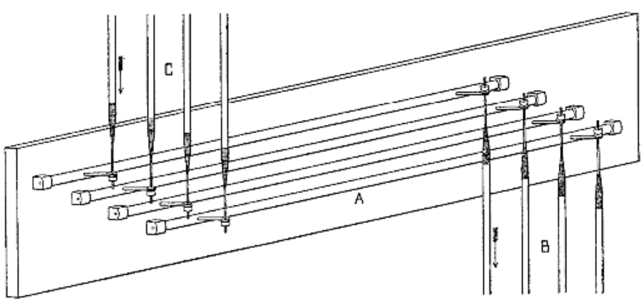

Figure 3. Rollers (marked A) are used to convey motion in vertical direction [2].

character and force from spring is in the same direction with the motion, thus it opposes to friction.

Since organ building is mainly formed by traditions, builders might not have a clear image of how these different properties affect overall quality of the instrument as well as performance and preference. Also, once the instrument is built, it is virtually impossible to achieve dramatic changes. Thus, objective and subjective characterization of key action can help organ builders.

PROPOSED WORK

In order to understand how all these different parameters affect the performance three different sets of measurements are planned. First, key signatures will be measured. By key signature we mean force that is felt by the organist at the keyboard as a function of key position and velocity during both attack and release. A typical key signature is illustrated in Fig. 4. Flow forces against the pallet dominate the early part of the attack. Once these forces are overcome, force feedback is dominated by spring force and friction. During

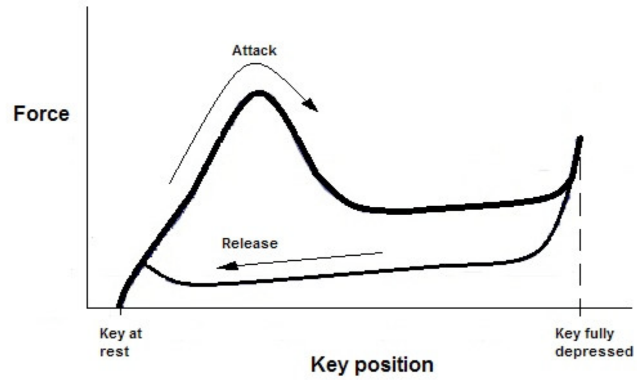

Figure 4. Force profile at the keyboard during attack and release.

release, forces felt on the keyboard will be somewhat lower compared to the attack. This is due to the fact that during release friction forces will oppose to the spring force. At the end of release there is a slight increase in the overall force which is due to the flow forces that sucks the pallet upwards. Even though this is the expected characteristics of a key signature, the effect of key velocity during attack and release are not fully captured. Thus key signature measurements will be done using a controllable linear actuator which will press keys with different velocities. These measurements are planned to be made on a number of historical pipe organs with mechanical action in Gothenburg. Moreover, interviews with expert organists will be made in order to investigate the haptic sensation of organ playing. Next step would be to compare the results of the measurements and interviews, and analyze what extent of these key signatures could be felt and communicated by organists.

One should be aware of the fact that even though these measurements will reveal a great deal of mechanical properties of the system, they might not completely depict what happens during performance. Thus, second part of the study will contain measurements of the dynamical properties of key action during performance practice with minimum interference to performer’s perceptual field. In order to achieve this, measurements will be taken inside the organ, since, pipe organ key actions are visually decoupled from the console. Moreover, performers’ actions will be recorded during performance, and short interview sessions will take place after each performance. The aim of the first two sets of experiments is to characterize the physical properties of the system both subjectively and objectively.

In the last part, we plan to build an experimental keyboard where one can adjust physical properties of the key action. This will be used in psychophysical experiments using expert organists in order to investigate the contribution of the properties of key actions to the haptic sensation of organ playing.

CONCLUSION

This study aims to investigate the haptic sensation of organ playing, and focuses on mechanical tracker actions. We aim to study key movement characteristics and relate them to subjective sensation in order to reveal salient sensory properties of mechanical key action. The outcomes of this work will not only help improving organ building and documentation technologies, but it will also create new possibilities for haptically enabled virtual musical instruments.

ACKNOWLEDGMENTS

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Physical Modeling Modular Boxes: PHOXES

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ABSTRACT
This paper presents the development of a set of musical instruments, which are based on known physical modeling sound synthesis techniques. The instruments are modular, meaning that they can be combined in various ways. This makes it possible to experiment with physical interaction and sonic exploration, thereby possibly extending the potential of the physical models.

Author Keywords
Physical Modeling, Physical Interfaces, Musical Instruments, Exploration, Creativity, Electronic Music.

ACM Classification Keywords
H5.5. Sound and Music Computing: Modeling. H.5.2 User Interfaces: Input devices and strategies. H.1.2 User/Machine Systems: Human Factors.

INTRODUCTION
The PHOXES modular instruments have been developed in order to investigate what happens when physical modeling sound synthesis algorithms are controlled in an environment, which encourages creativity and exploration. The physical control of the models plays a large part in how the sonic potential of the models is perceived – on both a lower level (e.g. which physical gesture must the user perform to excite a certain model?) and on a higher level (e.g. how do different control structures let users explore the sonic potential of the models?).

In order to investigate the impact of the higher level control structures a set of modular electronic instruments have been developed. The goal has been to extend the creative use of physical modeling sound synthesis by focusing on exploration. The HCI research area that deals with *creativity support tools* suggests that in order to support the kind of exploration that is crucial for creative work, one must design for *low threshold, high ceiling, and wide walls* [1]. In other words there must be a balance between how intuitive the system is *(low threshold),* how powerful it is *(high ceiling)* and how well it encourages exploration, letting users keep finding new ways of combining /controlling elements or movements *(wide walls)*.

The proposed system tries to balance the intuitive causality inherent in the physical modeling technique with a flexible

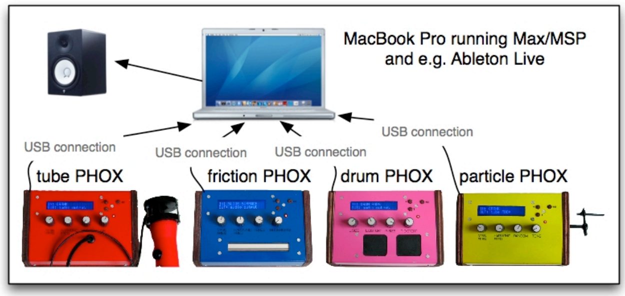

Figure 1. The PHOXES send control data through USB to Max/MSP, which is rewired to the DAW of your choice – e.g.Ableton Live.

exploratory system that provides freedom within the boundaries of the individual elements (each PHOX acts as an instrument on its own and is naturally constrained, but because they can be combined in a modular fashion, they also provide the sense of freedom).

PHOXES MODULAR SYSTEM
At present time four PHOXES have been developed: tube PHOX, particle PHOX, friction PHOX, and drum PHOX. Each PHOX implements a different physical model and consists of a unique excitation controller, intended to naturally relate to that model. For instance, the tube PHOX implements a physical model of a tube and a flute-like excitation controller. Each PHOX also consists of four knobs for adjusting model parameters, three buttons for controlling the mapping involved in combining the PHOXES and an LCD screen for displaying mapping settings. We felt that it was important that all input/output functionality was built into the PHOXES themselves so focus could remain solely on the instruments while exploring them (as apposed to also focussing on controlling some parts using a laptop).

The physical models are written as Max/MSP[1] externals and the system is developed in the Max/MSP environment. The idea is that the PHOXES are powered through Max/MSP but the sound is rewired to for instance Ableton Live or Logic so eventual test subjects can explore the PHOXES' potential in a familiar environment. Inputs and outputs from the PHOXES are handled by a PhidgetTextLCD with PhidgetInterfaceKit 8/8/8[2] embedded in each of the

[1] a graphical programming language (http://cycling74.com/)

[2] from http://phidgets.com

PHOXES - See Figure 1 for an overview of the system.

Physical Models

The physical models which have been implemented present a variety in complexity, sonic fidelity, and physicality (the type of excitation gesture they naturally propose). The physical models used are:

- **tube PHOX** – turbulence model based on [2].
- **particle PHOX** – particle model based on Physically Informed Sonic Modeling (PhISM) [3].
- **friction PHOX** – friction model based on the elasto-plastic friction model [4].
- **drum PHOX** – drum model based on 2D waveguides [5].

Excitation Controllers

Each PHOX implements a physical controller, used to exert energy into the model. The controllers have been chosen to naturally extend the physical models they by default are connected to. The modularity of the PHOXES system then lets the user play around with exciting any of the physical models using any of the excitation controllers from the different PHOXES.

The excitation controllers used are listed below, together with the excitation gestures that they afford. They are all used to measure velocity, which is mapped to the amount of energy injected into the system.

- **tube PHOX** – flute controller implementing an amplified low pressure sensor (1INCH-D-4V from All Sensors). The user blows into a small tube attached to the sensor, which senses how hard the user blows, giving the user the feeling of blowing into something similar to a recorder.
- **particle PHOX** – crank attached to a multi-turn rotational potentiometer (Model 357 from Vishay). The user turns the crank to produce energy. The rotational speed is measured and used as excitation. The crank gives the user the capability of experimenting with both continuous and instantaneous excitation gestures.
- **friction PHOX** – friction slider implementing a ribbon sensor (SoftPot from Spectra Symbol). The sensor lets the user slide a finger back and forth on a horizontal flat surface. The velocity of the back and forth sliding gesture is measured and used as excitation.
- **drum PHOX** – two drum triggers implementing piezo transducers (PSG100 from Kingstate). The drum triggers detect the occurrence of a hit (finger tapping gesture) and the velocity of that hit.

Modularity

Two or more PHOXES can be combined by choosing how energy is put into any given PHOX. Energy can either come from an excitation controller (it is possible to use any of the available excitation controllers embedded in the PHOXES to control any of the physical models), or it can come from the sound produced by a different PHOX – similar to [6], where sound is used to drive the excitation mechanism of the physical models. This means that there are a couple of challenges when developing the physical models. Each of the models must 1) be able to respond to energy from different types of excitation gestures (continuous or instantaneous [7]) and 2) have a way of mapping sound to input energy.

When each PHOX is played on its own using its own excitation controller there is a natural mapping metaphor, which makes the relationship between gesture and sound intuitive and natural (for instance making squeaky friction sounds by sliding your finger back and forth, or making flute sounds by blowing into a tube). But the naturalness of the metaphors change when an excitation controller from one PHOX is used to excite a physical model from a different PHOX (when for instance using a crank to make flute sounds or when blowing a drum). Although unnatural, it seems that the mapping is still perceived as being intuitive. Because of the nature of physical modeling there is a natural causality relationship between the amount of energy you put in and the sound you get out. If the amount of energy does not change (only the gesture one uses to produce that energy changes), we believe that the mapping is intuitive. By presenting the user with a variety of physical gestures for controlling the same physical model, we open up for a physical, more embodied exploration of the sonic potential of the models.

Goto `http://media.aau.dk/~stg/phoxes/` for details about mapping, videos, pictures and additional development information.

CURRENT STATE AND FUTURE DEVELOPMENT

An early pre-test was conducted where an experienced electronic musician borrowed the PHOXES for a duration of 10 days – see Figure 2. The goals were 1) to get a first impression of how well the system encouraged exploration and whether the system was creatively inspiring and motivating, 2) to explore the evaluation methods involved in testing such a complex set of instruments in as natural an environment as possible, and 3) to see if the build and functionality of the PHOXES would withhold such a long test period without our interference. Further details about the test can be found in [8].

The early impressions have shown that in order for future test subjects to be able to use the PHOXES in their natural working environment (where they integrate them in their normal setup with mixers, effect-racks, other controllers,

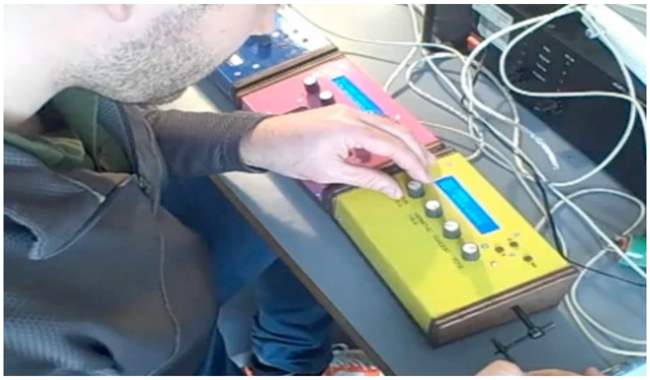

Figure 2. User playing the PHOXES. Here he is playing the particle PHOX on its own. Energy is exerted into the model by rotating the crank.

computer running their favored DAW, etc.) improvements should be made to the efficiency of the code. Some of the synthesis models are quite computationally expensive and are currently run on the test subject's own computer. This means that it is not possible to run large DSP-heavy projects at the same time as playing the PHOXES. This puts an undesirable limit to the potential use of the PHOXES. We want the test subjects to be able to work on projects exactly the way they are used to, in order to see how the PHOXES integrate in a natural environment.

Another issue was that the test subject did not get to explore parts of the modular system. This might have had to do with the mapping functionality being presented in an overly complicated way or because the test period was not long enough, and the test subject simply did not get to some parts.

The pre-test also showed that the test subject was highly motivated and stimulated by the PHOXES. He especially noted the balance between the familiar form factor of the instruments (familiar to an electronic musician, that is) and the naturalness of the physical interaction. It made him feel like he was playing an acoustical instrument, but in an electronic music setting. He found the PHOXES very durable and easy to set up. He found the physicality of the controls very inspiring and lastly he said that the sounds they made were amazing.

Before conducting a larger scale longitudinal evaluation with more test subjects, improvements will be made to the PHOXES regarding computation and in the way that the combination mapping is controlled. Hopefully the large scale evaluation can tell us if the success of the pre-test was a matter of novelty alone, or if developing for this kind of physical exploration does in fact improve the creative use of physical modeling sound synthesis.

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An Audio-Haptic Mobile Guide for Non-Visual Navigation and Orientation

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ABSTRACT
People who have visual impairments may have difficulties navigating freely and without personal assistance, and some are even afraid to go out alone. Current navigation devices with non-visual feedback are quite expensive, few, and are in general focused on routing and target finding. We have developed a test prototype application for Android in which a user may scan for map information using the mobile phone as a pointing device to orient herself and to choose targets for navigation and be guided to them. It has previously been shown that scanning for and pointing at potential points of interest and receiving information about them works, however, there is still an issue about how to combine direction information with overview information, particularly in a non-visual use situation.

Author Keywords
non-visual, interaction, navigation, GPS, compass, audio-haptic

ACM Classification Keywords
H.5.2 **Information interfaces and Presentation**: User interfaces: *Input devices and strategies, haptic output, voice output* K.4.2 **Computers and Society:** Social issues*: Assistive technologies for persons with disabilities*

INTRODUCTION
The use of navigation devices based on GPS information increased with 100% between the years 2006 and 2009 [5]. Nowadays (2010) many mobile and smart phones are delivered with pre-installed navigation applications. By combining GPS data with the information from an electronic compass (magnetometer), directional information can be displayed to a user when a device is aimed in the direction of a point of interest (POI). So far the bulk of this work focuses on adding visual information on the screen of the mobile device, of which Layar is one example (layar.com). However, there is also recent research showing how to make use of non-visual feedback, for example [1, 4, 2,6].

The SoundCrumbs [2] application demonstrated that the non-visual feedback received when pointing with the device and scanning with it in different directions provided sufficient information to the user about the direction to a target. The SoundCrumbs application was an application mainly for creating trails (hence the "crumbs") and following them, and therefore independent of map data. The display of map data in a completely non-visual use case becomes increasingly complicated with increasing numbers of map features to display. But as pointing and scanning with a navigation device could potentially aid users who have limited eyesight and give them a means for orienting themselves and navigating in unknown places, we are developing a prototype for evaluating such use.

THE POINTNAV PROTOTYPE
The PointNav application is a multi-purpose test application with the possibility to adjust the vibratory feedback, load point of interest lists (via .gpx files) and choose between sound file or speech feedback. The main functionality from the user's perspective is the non-visual touch-screen interaction, the environment scanning by pointing, and the speech feedback. In the scanning mode, the user points the device in the desired direction, and if the device points at a POI within a certain distance range she will get a short vibration followed by the POI name and distance (by speech feedback). The scanning angle (see figure 1) is currently 60 degrees, and if several POIs fall into a sector, there are a number of behaviors that can be chosen. Either 1: the one closest to 0 degrees bearing will be displayed, or 2: the one that is closest to the user (in that sector) will be displayed, or 3: a list of POIs can be displayed. The scanning can serve as a reference to the user, if she finds known landmarks within the POIs that she points at. Alternatively, the scanning can provide more detailed information about single POIs, and can be used to select the next desired target to be guided to.

The guiding mode behavior is similar to that of the PocketNavigator (pocketnavigator.org) which guides the user by applying a vibration pattern that is relative to if the user is facing the direction of the goal, or needs to turn left or right to face the goal. The user may also receive this information in speech, or in speech only. Also when the user is guided by the application to a desired goal, the user may want to be informed of POIs along the route. However, since there is a potential risk of information overload, the application has two separate modes (guide and scan), which the user can switch freely between also while navigating to a target.

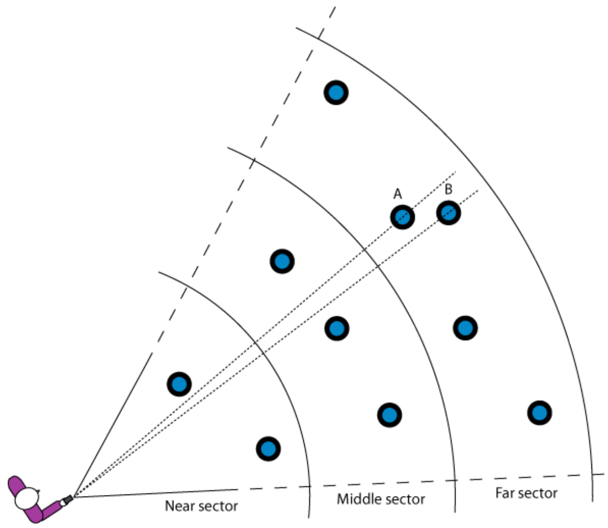

Figure 1. Scanning angle and sector ranges. The points signify POIs, and the POIs A and B in the same sector are close to each other in angle.

The PointNav software is based on Android 1.6, and runs on a Google Developer phone.

PILOT RESULTS AND DISCUSSION

The testing has been done iteratively during the development process, and several design solutions have been discarded or altered, and some are still in the process of being altered. The touch screen interface is one issue that is under revision and evaluation. At the moment, the layout is based on a 3 by 3 grid of buttons (see figure 2), which trigger a soft vibration when they are touched. The user can glide with her finger over the virtual buttons, and feels the transition between buttons. When resting on a button, it will speak its function, and when releasing a button, it will be selected. The center column buttons are for selecting the "listening distance" see figure 2, and although they are depicted like buttons, they need not be seen as buttons, but rather like a listening range which is chosen by a finger. This listening range could also be divided into smaller sectors ranges, with 5 sub-ranges, or more. However, it may be harder to select a specified range with too many "buttons". The maximum scanning range should also be possible to adjust in the future. There are options both to do the adjustment automatically (e.g. based on the number of points in a sector) or by user request.

We have been testing with POIs that are close to each other in distance and/or angle. Since speech information about a POI takes time to display, there is in this respect, the question about how to handle the speech queuing. If the TTS is allowed to finish speaking single POIs, the user might get the wrong impression about where a POI is placed, if she has moved away from pointing directly at a POI. On the contrary, if the speech is interrupted by new speech requests, GPS and/or compass jitter will be noticeable if POIs are very close in angle and falling into the same sector range (see points A and B in figure 1), and disturb the user experience. We do, as yet, not employ any signal filtering strategy, and although we want to minimize processor usage, some filtering strategy might need to be adopted in a later stage.

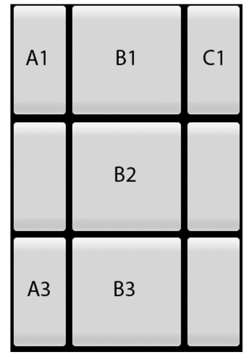

FIGURE 2. The button layout on the touch screen. B1, B2 and B3 are used to select the scanning distance, A1 selects guiding mode, C1 scanning mode, and A3 the POI to be guided to.

CONCLUSIONS AND FURTHER WORK

We are aiming at designing a stand-alone, usable combination of a non-visual scanning and guiding application, where the user can receive either overview information or information about the direction to a target. In the process, we have found several design issues to be crucial, both regarding direct manipulation of the touch screen, and the pointing gestures in combination with speech synthesis and unstable data (GPS and compass jitter). We will continue refining the scanning ranges and the touch screen interface, as well as vibration and audio feedback for the different use cases. Additionally, we will refine the scanning angle, which, particularly in the mode that displays a list of POIs in the specified sector range, has been found to be too wide. It seems, that for guiding purposes, as has been shown by [3,7] that 60 degrees is an appropriate angle that is neither too narrow nor too wide and handles compass and GPS jitter well. However, for scanning, a more narrow angle may be found to work better, although this needs to be tested in context. The behavior in the PointNav application, selecting the POI that is closest to 0 degrees has the effect that the scanning angle is variable, but never wider than the maximum (currently) 60 degrees.

ACKNOWLEDGMENTS

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Linking Motion Sensors and Digital Signal Processing for Real-Time Musical Transformations

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ABSTRACT
In this paper we propose some practical applications linking motion capture and real-time music transformation via the gestural control of digital signal processing (DSP) algorithms dedicated to sound / music processing. The use of a specific accelerometer / magnetometer sensor and related real-time signal acquisition and processing device is described. The presented applications provide some examples of original ways to control musical features such as tempo, volume or notes management. This work feeds the media interaction interfaces field with a new approach based on rhythmical gestures and modulations mapped gestures. It also underlines the user dimension which has to be considered in the application design. This work is extendable to new interactions in the areas of gaming and entertainment.

Author Keywords
Motion capture, real-time human interaction, user-centered design, gestural control, accelerometer, magnetometer, MotionPod© sensors, musical transformation, digital signal processing (DSP), phase vocoder, tempo, rhythm, graphic user interface, "Max / Msp / Jitter"© software.

ACM Classification Keywords
Information systems, information interfaces, sound and music computing, signal analysis synthesis and processing.

INTRODUCTION
Motion capture is taking advantage of miniaturization and democratization of sensors like accelerometers and magnetometers. New types of real-time interactions are emerging [7] using such devices in the multimedia area, as illustrated by the success of Wii© and Iphone© systems. Although more and more application areas may benefit from this technology in the near future, it is crucial that applications should be designed with consideration of the user. Gestures are socially constructed as a real embodied culture including the experience of technical objects.

Physical, social and cultural dimensions have to be considered as a way to design and implement relevant movements matching relevant effects. In the present paper we present some practical applications that connect motion capture and real-time sound / music transformations via the gestural control of digital signal processing algorithms. This work aims at exploring new types of user control on music playback / transformations [6]. It also aims at promoting a specific motion capture technology, the MotionPod© system, as an appropriate technology for such applications. DSP algorithms are implemented with the Cycling'74 Max© software and can be adapted to other systems like iPhone© or Wii© controllers. We expose different applications like rhythmic movements controlling a phase vocoder [3], a tap-tempo, a mixing interface, a zoom and rotation control on video media, and a first step on expressive control of air percussion which emphasizes a specific technology. These applications illustrate how limitations / constraints imposed by the system and users gestures can affect the design of DSP algorithms in the quest to produce relevant effects. This paper also provides a description of the exploratory designed gesture for each application, a two steps test protocol on two populations and a discussion about changes in relation to their feedback.

HARDWARE AND SOFTWARE

MotionPod© by Movea
The MotionPod© system (see Figure 1) is an electronic wireless goniometric device commercialised by the French start-up Movea [4].

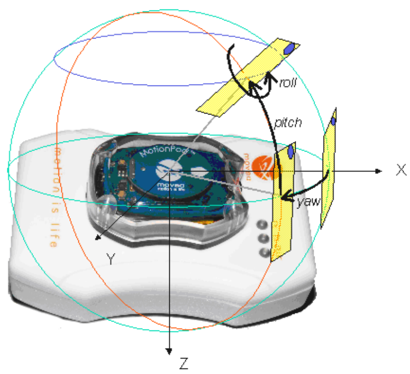

Figure 1. The Motion Pod© system.

It is composed of two devices:

- The MotionPod© sensor / transmitter which is a small autonomous motion sensing device worn on the body as a watch.
- The MotionPod© Controller which is a small box connected to a computer. It enables reception of the measurements using wireless link (Bluetooth Band 2.45 GHz). It is also used as the battery charger for the MotionPod©.

The system provides acceleration values along three axes (Ax, Ay and Az) and magnetometer values as well (Mx, My and Mz). This leads to the calculation of angles values named "Yaw", "Pitch" and "Roll".

Max / Msp / Jitter© by Cycling74

This software is an interactive graphical programming environment for music, audio, and multimedia [2]. Max is the graphical programming environment that provides user interface, timing, communications, and MIDI support. MSP adds up real-time audio synthesis and DSP. Jitter extends Max with video and matrix data processing.

System Configuration and Processing Chain

The complete system is composed of a computer (2.26 GHz, 2Go RAM), stereo speakers and the MotionPod© system (two sensors). Processed music is stored in 16-bits PCM / 44100 Hz audio files (.wav or .aif.).

The chain starts with gestures captured by MotionPod© sensors. Resulting gesture data are sent to Max through the controller and an Open Sound Control (OSC) server (adjustable sampling rate from 25 Hz to 200 Hz). Finally the User Datagram Protocol (UDP) and Max carry out the signal processing and mapping tasks.

Accelerometer values are adjusted to trigger sequences of events (by comparing the sensor data flow with an adapted threshold). Debounce filters are used to prevent unexpected triggering due to uncontrolled movements. Magnetometer / angle values are adapted to control continuous parameters control. An adapted mapping is tuned to enable an accurate control of effects, volume, balance, pitch and tempo.

USERS NEEDS AND FIRSTS GESTURES IDENTIFICATION

This study is mainly explorative and aims at emphasizing the possibility to develop applications which allow users to express themselves on a given musical flow. Users can be found among musicians and electronic music community members and followers who are desirous to find new ways of expression / interaction. They can also be found among general public, these applications being adaptable to gaming mobile area such as iPhone©, Wii© and now iPad© technologies. Needed applications can be time control, musical flow modification (tempo or pitch) and real time effects like volume control or balance switching, panoramic effects, spatialization and filters management.

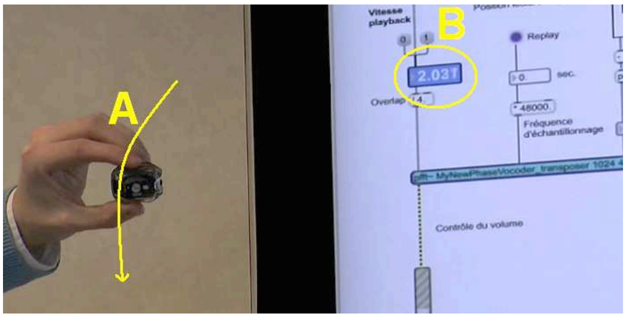

Figure 2. Control of playback rate with roll movement.

Applications have to be designed considering the user (see *test protocol and feedback* part) but a first choice of movements has to be done to set the foundations of Max© algorithms. Broadly speaking the most intuitive gesture is firstly chosen to build up the application (i.e. a wrist rotation to rotate a video). It is firstly tested among the laboratory researchers part which show some interest for this kind of musical applications. Test protocol and users feedback influences are described in the last part of this paper.

PRACTICAL APPLICATIONS OF MOVEMENT / SOUND INTERACTIONS

Phase Vocoder (PV) Basic Controls (Tempo and Pitch)

The Phase Vocoder is an efficient and widely-used frequency-domain technique (often implemented using Fast Fourier Transform) that enables basic speech / music transformations such as time stretching / compression or pitch shifting [1] [3] [5]. In our application, the playback rate ('B' in Figure 2) is controlled by the rotation of one sensor ('A'). The other sensor independently controls pitch shifting either via acceleration or by mapping the Yaw parameter to the desired range of transposition.

Phase Vocoder Linked to Tap Tempo

Linking the MotionPod© system, the Phase Vocoder and a Tap-Tempo method leads to another expressive control. Here the user can control the tempo of the original audio file with rhythmic movement (four regular hits in a row) using (Az) acceleration values. The resulting tempo is represented on a screen with circles of proportional size (See Figure 3).

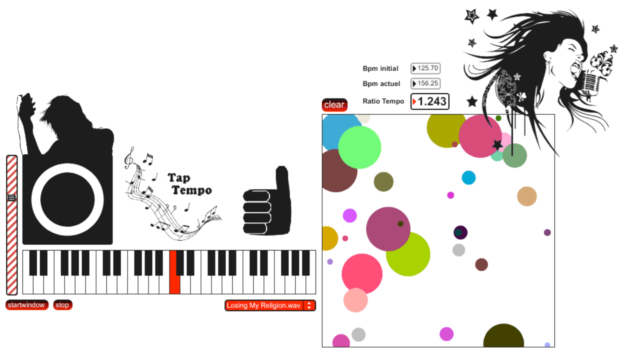

Figure 3. Rhythmic application of the PV (max screenshot).

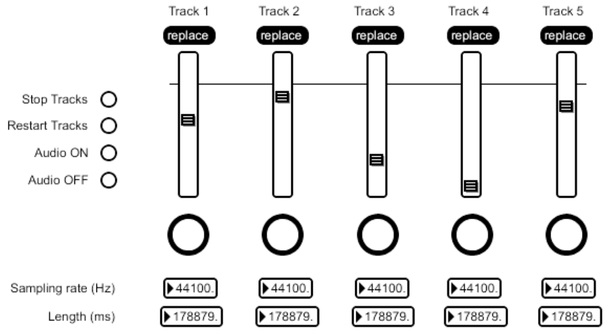

Figure 4. Mixing interface for separation of sources (max screenshot).

Mixing Interface for Separation of Sources

Here is a program interface for tracks mixing (see Figure 4). One sensor controls the tracks volume through Roll angle; the other selects the track through acceleration triggering on Z axis. It is well adapted to tracks obtained after sources separation.

Another Media: Video Control

It is also possible to control image or video processing. For example the user can rotate / zoom in pictures or videos with one sensor. At the same time it is possible to play / rewind videos with the other sensor through angles mapping. Here the rotation of the left wrist controls the rotation of the video. The rotation of the right wrist allows the user to zoom in / out the video (See ‘A’ and ‘B’ on Figure 5).

First Step of Expressive Control for Air Percussion Musical Scores

Here the idea is to give the possibility to play back a given musical score with one or two sensors with rhythmical gestures working on Ax and Az accelerations. It aims at being as expressive as possible that is to say controlling speed with arm rhythm, volume with the hits strength, etc. Hits are provided by an up to down movement like a drums player. This movement matches the need to give an expressive control on air percussion musical scores as it uses the real movement of the musician.

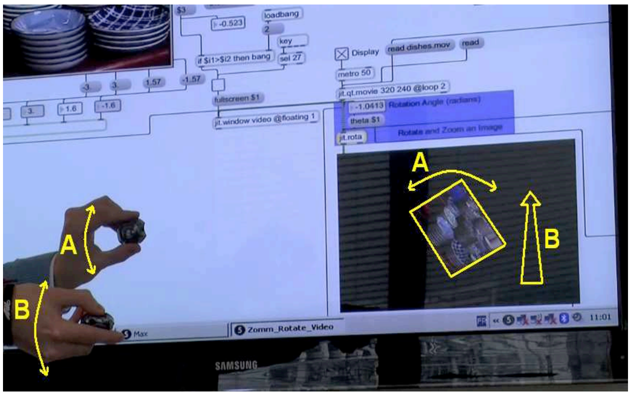

Figure 5. Zoom and rotation on a video display.

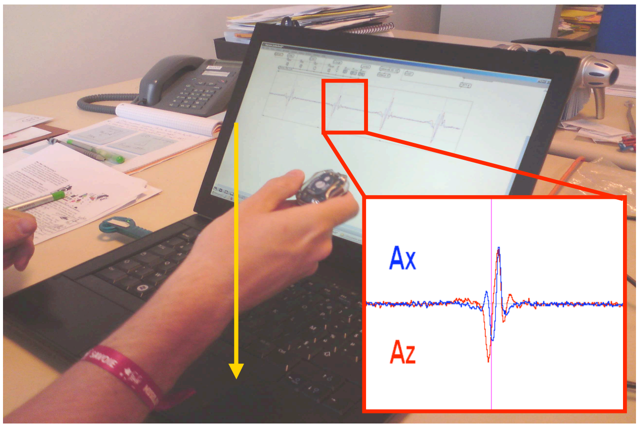

Figure 6. Hit detection on accelerative gesture on Z axis.

Data are real time processed (centered and low-pass filtered) and displayed on a screen which shows a pink vertical line when a hit is detected (see Figure 6). An audio feedback is available and produces drum samples at an audio level corresponding to the hit intensity.

TEST PROTOCOL AND FEEDBACK

Even if the study is explorative for the moment, user tests are planned in the future to confront users’ gestures to initial ones. Here is a proposal for the test protocol and feedback considerations (see Figure 7):

The test panel would be composed of two populations: Musicians from various horizons and general public. For each application and each population, the tests would be launched on two stages:

- It would be asked to users for a Spontaneous Gesture (S.G.) which could match the musical transformation designed in the application.
- Then it would be asked to them to execute the gesture initially imagined by the programming team (E.G. for Expected Gesture).

Gesture / comments sessions would be filmed in addition to the data / curves storage. The tests analysis would confirm the initial gesture or underline a new gesture depending on the users’ attitude when confronted to the two stages. If the same gesture often occurs within the application it might replace or modify the initial one. Then algorithms would be modified in order to consider the users feedbacks.

Application i^{th}			
Population 1		Population 2	
S.G.	E.G.	S.G.	E.G.

Figure 7. Test protocol on application i for 2 populations. (S.G. and E.G. standing respectively for Spontaneous and Expected Gestures).

CONCLUSION

Practical applications for the control of music transformations were implemented by first combining the MotionPod© system with the Phase Vocoder. Hence motion capture was used as an “instrument” for real-time music modification. This work aims at providing the user with expressivity allowing the choice of specific movements, instead of listening to music without interaction. As described current extensions of this work deal with the control of a remixing interface for multichannel music (possibly combined with source separation algorithms), the control of video media and an intuitive and expressive control of musical scores for air percussion. Even if an initial gesture has to be chosen by the programming team to work on these applications, the design has to consider the user dimension. A test protocol has been proposed in addition to a discussion on users' feedbacks. The initial gesture might be the most relevant to match the application but the tests would also reveal new gesture based on users intuition and spontaneity. Algorithms can be real-time modified during workshops or redesigned after test sessions and retested during upcoming workshops. Gestures are socially constructed as an embodied culture and the relevance of their mobilization appears in the design process resulting in a real continuity between gesture and an innovative user-friendly application.

ACKNOWLEDGEMENTS

We would like to thank the CEA and LITUS Laboratory for supporting this work and MOVEA for lending the sensors.

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Spectral Discrimination Thresholds Comparing Audio and Haptics

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ABSTRACT

Previous studies have been carried out concerning the ability of individuals with normal hearing to discriminate auditory stimuli which have the same fundamental frequency but different spectral content [5]. This study concerns to what extent is it possible to perform the same differentiation considering vibratory tactile stimuli. Being aurally able to distinguish between an A3 note played by a flute and the same note played by a clarinet, the question posed is whether or not it is possible to observe a similar ability in terms of vibratory tactile stimulations. In trying to address these questions, a research project is currently ongoing consisting of a series of perceptual tests to be carried out in an attempt to compare discrimination thresholds in terms of spectral differences between auditory and vibratory tactile stimulations.

Author Keywords

Audio, haptic, tactile vibration, haptic-audio transfer function, spectral discrimination threshold.

ACM Classification Keywords

H.5.2 [Information interfaces and presentation]: User interfaces - Haptic I/O. H.5.2 [Information interfaces and presentation]: User interfaces - Auditory (non-speech) feedback.

INTRODUCTION

This paper presents an ongoing research collaboration between LIMSI-CNRS (Orsay, France) and the Fused Media Lab (DMU, Leicester, UK) based on perceptual studies for comparing detection thresholds for spectral differences of auditory and vibratory tactile stimulations. The cooperation between these two laboratories has already been presented through a series of conference publications in the same research field between 2009 and 2010 [2][3]. In the following sections a brief overview will be carried out of the objectives of the project and of the procedures for the tests that will be performed, illustrating possible guidelines for the analysis of data resulting from the experiments, and possible outcomes.

OBJECTIVE

Within multimodal rendering applications, in order to be able to use the same models and algorithms for the haptic feedback that are used for audio, it is essential to understand how these two modalities are perceived in terms of amplitude, frequency, time and spectrum. The main objective of the current project is to acknowledge how spectral variations are perceived within a tactile vibratory stimulation, and to compare these results with those measured for auditory stimulations. This will possibly bring to light the identification of a series of differences between auditory and tactile vibratory perceptions; differences that could then be used for the implementation of transfer functions to be applied in order to directly use an auditory stimulus as a haptic one.

BACKGROUND

It is well known that differences in the frequency content and spectral envelope in auditory signals are often perceived as timbre variations, allowing for the differentiation between stimuli with the same fundamental frequency, loudness and duration, while having different spectrum [5]. But, is it possible to observe similar abilities via the perception of vibratory tactile stimuli?

Previous studies have shown the distinction between different tactile vibratory stimuli and perceived intensity: in [8] the subjective perceived intensity as a function of the vibration frequency have been studied and compared in relation to contact area. In [9] studies on frequency and amplitude discrimination for tactile stimuli have outlined the differences between tactile and auditory perceptions. In [6], vibration detection thresholds were compared using different haptic devices. The ability to discriminate between different signals and design parameters for the generation of tactile feedback has been investigated in [4].

Nevertheless, basic studies, performed using pure and/or very simple tones, and comparing the discrimination thresholds for spectral variations between audio and tactile stimuli, have not be found in the literature.

EXPERIMENTAL PLAN

The experimental apparatus will be composed by a software component, a computer, an audio interface, an audio amplifier and two 8” loudspeaker woofer drivers: one of these will be modified by removing the actual cone, and leaving only the magnet and the coil. A coupling system will be created in order to transfer the vibrations of the coil to the hand, possibly using a small rigid flat surface on which the fingers of the subjects will be placed. Using exactly the same hardware and software for the delivery of the auditory and haptics feedback will allow the comparison of results to be made with greater precision, and should allow for more reliable outcomes.

During the following experiments, subjects will be asked to place a hand on the coupling device for testing the haptic modality, and to place their head at 1 meter from the driver for testing the auditory one. All tests will be performed with all participants for both the rendering modalities.

Range Calibration test

A first preliminary test will be performed in order to establish the frequency and loudness ranges for the two modalities. In the *background* section it has been stated that studies have already been carried out in terms of frequency and amplitude subjective perception both for the auditory and tactile stimuli. It has nevertheless been considered important to repeat such tests with the equipment designed for this experiment, in order to take into consideration protocol and hardware limitations, such as the frequency response of the reproduction and coupling systems.

Performing a simple up-down 2 dB step adaptive procedure test, as is typical when measuring an audiogram [1], a threshold study, for both modalities, will be performed using a series of pure tones at different amplitude and frequency become detectable. From the results of this test, it will be possible to establish the frequency and loudness ranges for both modalities. Using these ranges the values employed for the following tests will be scaled both for the auditory and haptics feedbacks.

Simple Signal Comparison Test

The subjects will be asked to discriminate between three types of simple signals: a pure tone, two concurrent pure tones (not in harmonic relation) and broadband noise. The test procedure is elaborated considering the signal detection theory [7], and the outcomes will establish if and to which extent the discrimination between the three signals is possible both for the auditory and haptics modalities (it is of course expected that this task should not be problematic for the auditory stimuli).

Two Tones Detection Test

Using a simple up-down 2dB step adaptive procedure, the detection threshold will be determined for a stimulus composed of two concurrent pure tones (not in harmonic relation), changing the amplitude and frequency of the second tone. The subjects will be asked to discriminate between the two stimuli, one composed of a simple tone of frequency f_1, and another composed of two tones of frequencies f_1 and f_2, changing both the frequency value and the amplitude of f_2. The subject will be therefore presented with groups of two stimuli: initially the two will be the same, and in a second instance the second stimulus will be modified as explained previously (changing frequency and amplitude of f_2). Subjects will be asked when a difference can be heard between the first and the second stimulus.

Spectrum Detection Test

Using a simple up-down 2 dB step adaptive procedure, the discrimination threshold will be measured between a tone with all harmonic components (such as the sound of the flute) and a tone with only odd harmonic components (such as the sound of the clarinet), gradually reducing the amplitude for even harmonic components of the first tone.

DATA ANALYSIS GUIDELINES

Different analysis will be carried out on the results coming from these tests. It is nevertheless important to underline that the evaluations will always be performed considering comparatively the results of two rendering modalities.

CONCLUSIONS

The proposed experimental method will allow for the estimation of the differences between auditory and tactile renderings in terms of spectral discrimination thresholds. These differences could be exploited in the future for the implementation of transfer functions to be applied in order to directly use an audio signal as a haptic one.

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Virtual Navigator: Developing A Simulator for Independent Route Learning

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ABSTRACT
We present the initial design and development of Virtual Navigator - a virtual haptic and audio training simulator for route navigation. Virtual Navigator allows blind and visually impaired cane users to practice navigation skills and route learning in the built environment. Currently route training is supplied on a one-to-one basis causing it to be limited and expensive. We hope that development of Virtual Navigator will allow such training to be augmented with self taught sessions and be made more widely available.

INTRODUCTION
Navigation in the environment is a vital skill in allowing an individual to lead an independent life. For blind and visually impaired people however, such trips are challenging and require specialised training to learn routes as short as walking from home to the local shops. In the U.K., this training is usually provided by the local government authority and involves a mobility training officer developing a route between the two locations a user would wish to walk. The routes developed involve the user piloting between multiple landmarks that exist in the built environment (such as post-boxes, drain-covers or lamp-posts). These routes are chosen to be safe and may therefore not be the most efficient or shortest routes available. Over several one-on-one sessions, the mobility officer trains the visually impaired user on the route. As the routes are complex, multiple sessions may be required and there is often a waiting list for training. Additionally, each individual will learn only a few routes. Therefore in cases where a primary route may be blocked (e.g. due to road works), the visually impaired person will not have an alternate route to navigate.

RELATED WORK
The problem of navigation by visually impaired people is not a new one and several research attempts have been made to allow independent navigation in the environment. Primarily these have consisted of satellite navigation (GPS) based systems to guide the user dynamically in the environment. GPS based systems offer the possibility of navigation without a visually impaired person needing to pre-learn a route (in a similar way that car GPS systems negate the need to read the map) [1]. However, as noted by Strothotte *et al.* [2], such navigation requires piloting between close together, small landmarks. Such landmarks are often much smaller than even high quality GPS accuracy, so might be missed. Walker and Lindsay's SWAN system [3], which uses audio beacons to navigate a route, recommends a position accuracy of less than 1m. Something that is not currently available.

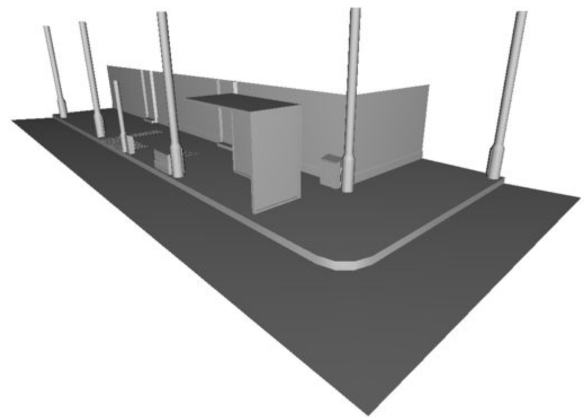

Figure 1. A model of the test environment used in the current version of Virtual Navigator.

DESIGN OF VIRTUAL NAVIGATOR
To overcome many of the problems identified, we have begun to develop an application called Virtual Navigator. Virtual Navigator is designed to augment the training supplied by mobility trainers and allow blind and visually impaired cane users to develop basic navigation skills and learn routes in safety. We do not argue that the use of Virtual Navigator will replace mobility trainers, but rather allow more opportunities for a learner to experience a route and thus make better use of limited training sessions that are available. We are developing Virtual Navigator in a participatory design manner, with feedback from users being incorporated into future versions. The version discussed here is based on initial interviews with, and observations of, mobility trainers and discussions with visually impaired users.

Virtual Navigator allows a user to interact with a virtual 3D model of a test route (see Figure 1) via the use of a haptic force-feedback device and spatialised auditory feedback. This allows many of the physical aspects of the environment that are used as landmarks to be simulated. The user explores the environment in a first person perspective (similar to a 3D "shooter" computer game). Figure 2 presents a screenshot of the visual interface of Virtual Navigator. The model is generated at a prototypical size as this most closely matches the world. I.e. a meter in the built environment is a meter in the real world. Our current models represent a fairly small environment so doesn't take very long to move through. In longer environments, such as prototypical routes, it remains an open question if the model scale could be reduced so that the route could be covered in less time with-

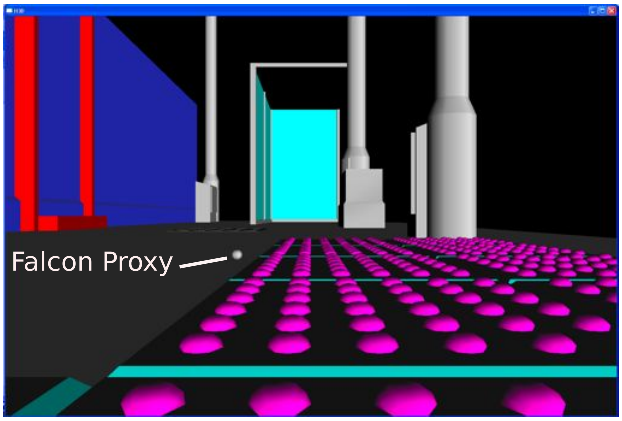

Figure 2. A screenshot of Virtual Navigator showing a simple street model with buildings on the left and a road on the right. Tactile paving, a bus shelter, lamp-posts as well as the point representing the Falcon proxy in the environment are also shown.

Figure 3. A picture of the NOVINT Falcon force feedback device used to allow haptic interaction with the environment.

out comprising learning. The model used in the simulator is currently produced via the Milkshape 3D (http://www.milkshape3d.com) modelling package. Future work will investigate automatically creating the model from both online map data and a toolkit of pre-built objects (such as post-boxes or lamp-posts) that can be dragged and dropped into the environment by the trainer.

Movement in the environment is achieved by using the directional cursor keys on the keyboard. Pressing the forward or backward keys cause the user to take a step in the corresponding direction. The sound of footsteps (one step sound per step taken) is used to provide an indication of distance travelled. The left and right arrows cause the user to turn 45° in the appropriate direction. As users are conventionally trained to turn on the spot to change direction and to pilot in straight lines, such a mechanism is more appropriate than stepping left or right.

Virtual White Cane Interaction

A NOVINT Falcon (www.novint.com) (see Figure 3) is used to act as a virtual white cane. The Falcon, as with many other force-feedback devices, works like a 3D mouse. As the user moves the end-effector around, a proxy object in the virtual scene moves (see Figure 2). When this proxy is determined to have come into contact with an object, a resistive force is applied providing the impression of a physical object. The Falcon provides a fairly limited workspace and only allows exploration of the scene with a single point of contact. In many applications this has been argued as a disadvantage of virtual haptic devices. However, in this case, it is very similar to the way in which a white cane acts when exploring the world.

Because of the impoverished nature of the feedback provided by a white cane, identification of landmarks is usually undertaken by sound caused by the interaction of the white cane on a landmark. Virtual Navigator deals with this by providing both contact sounds and movement sounds when the Falcon proxy comes into contact with the landmark. Both are important, as landmarks can take many different forms. Some, such as a post-box, will be identified through both physical forces stopping the cane moving, as well as the contact sound of appropriate pitch and timbre to indicate a hollow metal tube. Other landmarks, such as a manhole cover or tactile paving, will be identified via vibration and the repetitive striking sound as the user moves the cane over the surface. We used FMOD (www.fmod.org) to allow for low latency playback of recorded sounds when the user taps a feature in the virtual environment, or moves the proxy object over the surface.

The sounds used were generated by a visually impaired cane user tapping and scrapping surfaces made of different materials in the built environment. The sounds were recorded using an iPod Touch with microphone attachment and were processed in the WavePad software package. The sounds are triggered if the user touches or moves the Falcon along a surface in the virtual environment. We have found that combining these simple categories of sound with realistic physical models of the tactile paving and manhole covers in Virtual Navigator, naturally generate composite sounds in our environment that closely mirror the sounds of interacting with real world objects.

Auditory Clues

Whilst piloting between landmarks is the primary means of route navigation, other transitory features of the environment called clues are also useful. These are features of the environment that may or may not be available when navigating. If they are available, they provide useful indication that the correct direction is being taken. Whilst clues may be physical (such as a table outside a cafe), they are more likely to be auditory based. The way that sound changes on a street between rush hour and night time, or when walking under a tree lined avenue rather than an open street, can all be used to provide additional clues to the cane user that the correct direction is being followed. Virtual Navigator supports such clues by incorporating an environmental soundtrack that can be modified through FMOD to reflect the environment the user is passing through. So far we have included a simple reverberation to the environmental and footstep sounds as the user moves through more enclosed features of the environment - such as under a bus shelter.

DISCUSSION

So far, we have carried out qualitative evaluations with two late blind cane users on a simple street model and employed a mobility training officer to provide comments and guidance for improvement. In all of these evaluations Virtual Navigator was seen as a positive addition to route training and was felt to provide a useful ability to learn a route. However several key areas of improvement were identified before it could be practically useful. Firstly, was the use of the virtual white cane. In the initial system we modelled the cane as a single point. However as the user is sweeping left and right in the environment and walking at the same time, it is possible to miss small landmarks such as lampposts and simply sweep behind them. As the cane is modelled as a point, no indication that this occurs is currently provided. Our future work will change this model so that the virtual white cane is modelled as a stick, and contact at any point of the stick will cause haptic and auditory feedback. A further comment raised by the mobility trainer was that clues can be formed of multiple different modalities, of which haptic feedback and sound are only two. She noted that smells, such as a florist or chip shop could also be used as clues to allow a participant to orient his or herself in the environment. We intend to incorporate such feedback here using devices such as the Dale Air Vortex (www.daleair.com). In such a way Virtual Navigator will be able to provide a much closer set of landmarks and clues to those of the prototypical environment. We believe that with further development, Virtual Navigator can provide a useful augmentation for visually impaired and blind users in the important skill of environmental navigation.

ACKNOWLEDGMENTS

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Nonverbal communication of intention and attention while playing a game

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ABSTRACT
This poster abstract describes first part of a series of experiments on using the individual's gesture, grip and direction of face, to infer intentions and attention during interaction with technology. The experiment recorded here studies these patterns of nonverbal communication in order to explore how they can be used in an activity-aware setup that seeks adjusts to the individual's intentions and attention. Results indicate that basic patterns of facial direction, grip and gestures are correlated with intention and/or attention.

Author Keywords
Human-Technology Interaction, Activity-Aware Technology, Ubiquitous Computing, Multimodal Interaction

ACM Classification Keywords
H.1.2 [Model and Principles]: User/Machine Systems. H.5.2 [Information Interfaces and Presentation]: User Interfaces, Theory and Methods.

INTRODUCTION

As technology becomes a part of many different environments, studying new ways of making interaction easier and more seamless has become a more relevant than ever before [1, 6]. One aspect of interest in this area is the possibility of making technology automatically adjust to the individual's intentions and attention without having to receive specific commands [3]. In order to do this technology must be able to sense expressions of intentions and attention and so it becomes interesting to study how nonverbal communication can be used as an objective indicator of these aspects. Based on previous research it is hypothesized that gaze, grip and gesture are highly correlated with intentions and attention [2, 4, 5] and that it is necessary to study the exact expression of these, if we wish to design technology that can adjust to this. This abstract presents a study on what patterns exist in the expression of intentions and attention through facial direction/gaze, gesture and grip while playing a game. It is first part of a larger study with this part focusing on exploring what patterns are present and the second part focusing on how technology can adjust to these patterns.

METHOD

The experiment was setup as a video game with 3 stations, in which the participants had to hit mosquitoes and slugs using a Nintendo Wii remote. The bugs could appear on one of the 3 clearly numbered stations (Figure 1). In station 1 and 2 content was presented both visually on the displays, and auditorily via loudspeakers, but on station 3 only auditory content was available via loudspeakers. The Nintendo Wii remote was modified and given an ergonomic extension that would invite more different types of grip than the original wiimote.

There were 4 game scenarios for catching the mosquitoes and the slugs. In some scenarios participants had to use a gesture and in some they had to use a button on the Nintendo Wii remote:

1. Use the button to catch the mosquito
2. Use the gesture to catch the mosquito
3. Use the button to catch the slug
4. Use the gesture to catch the slug

Only 1 bug appeared at a time and the bug only appeared at one station at a time. All of the 4 game scenarios could be presented on station 1 and 2 (display and speakers), while only game scenario 1 could be presented on station 3 (speaker only).

Figure 1. The game setup. Station 1 to the right, station 2 in the middle and station 3 to the left.

Participants played 36 game scenarios each, ordered in a latin square design, so that each station was used 12 times, in different orders.

Between each game scenario participants put down the remote and were given instructions for the next game scenario, e.g. “Number 1. Use the button to catch the mosquito”.

So before each scenario the participant would be told on which station the bug would appear and if they had to use the gesture or button press to catch it. Before participants could interact with a station they had to choose the right station by pressing a button from 1-3, corresponding to station 1-3.

The instructions were made in order to create an intention to interact in a specific way before the participants gripped the remote again or turned in a new direction. Participants were asked to choose a station before interacting, to ensure that they knew where to interact, and so that we knew where they intended to interact before they turned.

12 employees at Bang & Olufsen (age 21-60, 3 female, 9 male) participated in the experiment.

Data collection

To record frontal face a web camera was placed at each station, and a facial recognition algorithm implemented by the computer vision library OpenCV was used. The three stations were placed at a 90 degree angle from one another (Figure 1), so that participants had to turn 90 degrees in order to gaze at them. This was done to ensure that participants had to be frontal to the station in order to gaze at it, ensuring that gaze and frontal face were highly correlated. The raw accelerometer data (x, y, z) were collected from the Nintendo Wii remote approximately 100 times each second. It was also automatically registered when a game was won or lost, when a target was missed, which scenario was being played, and which station had been chosen on the foot pedals. All automatically collected data received a synchronized time stamp in milliseconds, and for each time stamp the system also registered the state of all other variables. The experiments were videotaped from 4 angles, 3 showing each station and 1 showing a control display, with the same time in milliseconds as the automatically collected data, so that these could be compared. The participants grip was analyzed based on the video recordings.

RESULTS

Face/gaze and grip were analyzed using a crosstabulation of how face/gaze and grip correlated with what the participant intended to do in the game. This showed that participants were registered as facing the station they had chosen for 97.9% of scenarios on station 1, 100% of scenarios on station 2, and 91% on station 3. This implies that participants gaze at the station they wish to interact with, regardless of whether the station contains visual feedback or not. Participants use a precision grip, with one finger on the button, 100% of the time when they have to use a button, and they use a power grip, with all fingers wrapped around the handle, 93.1% of the time when they have to use a gesture. While they obviously have to use a precision grip to be able to press the button, they could still chose to use the same grip while performing the gesture. That this was not the case indicates that participants gripped the remote according to how they intended to interact with it. The gesture analysis is currently being performed both on video and accelerometer data, but preliminary qualitative analysis show that it is possible to identify patterns of gesture behavior that seem to be connected to intention to perform at gesture, frustration and impatience. The patterns found have a large inter-interpreter reliability, and can be found both in video and in acceleration data.

DISCUSSION

As expected the results of the experiment shows a high correlation between basic patterns of nonverbal behavior and intentions and attentions while playing the game. To some extend this seems to be independent of the modality of the stimuli presented, participants also gaze where they intend to interact, when only auditory feedback is available. This has the limitation that some visual information was still present via the speaker and the station number in itself. This was unavoidable as part of the experiment was that the participant had a location or an object to interact with, and this will obviously always contain some form of visual information.

The grip patterns found cannot be understood separately from the design of the modified Nintendo Wii remote. This was designed so that different types of grip were possible and felt pleasant to the hand. To be able to study aspects of nonverbal communication it is necessary to set up an experiment that entices the relevant nonverbal communication, and of course the results cannot be understood separate from the set up. This may bias the results in that participants could possibly be reacting to the unusual circumstances they find themselves in, rather than communicating in ways that would normally occur when interacting with technology. This is a condition that cannot be avoided, and it has been sought to set up the experiment so that participants had alternative ways of communicating, other than how it was hypothesized by us.

The experiment is embedded in a specific context which means that the results can be generalized into contexts with similar attributes, but that they may not be universally valid. This context was set up so that participants had to interact with multiple stations to imitate situations with more than one product available for interaction e.g. a TV and a music player. The game was created so that their primary focus would be on interacting with the game, not on the interaction itself, similar to everyday interaction with products.

This experiment confirms some very basic patterns of nonverbal behavior. Like activity in general, nonverbal expressions should be understood multimodally and future analysis of this experiment could look into how these patterns can be understood when analyzed multimodally instead of one at a time.

The results show that it should be possible to make technology adjust to the nonverbal behavior studied without receiving specific commands, and the next experiment will test this hypothesis. In doing this there are of course many other factors that must be taken into account, such as how the nonverbal behavior changes in different contexts and how the technology gives feedback when adjusting to nonverbal behavior. It may be relevant to give feedback when a station senses that the user has turned towards it, either visually or auditorily. It may also be relevant to give haptic feedback through the Nintendo Wii remote of how the participant should grip it or feedback of different gripping possibilities. How this feedback should be designed so that it best matches the participants nonverbal communication is a matter that requires further studies.

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Wheel matters – Pseudo-haptic approach in designing enhanced touch screen wheel widget

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ABSTRACT
In this paper a design of a general purpose, touch screen based control wheel is introduced and evaluated. The aim was to combine the robustness and feel of control of a physical wheel within the limitations of a touch screen interaction, utilising pseudo-haptics instead of any haptic actuator technology. The design also aims at providing an equal controllability for both the fine and rough adjustments. A pilot evaluation indicated success in fundamental design ideas and helps in the further development of the wheel.

Author Keywords
touch screen, user interface design, pseudo-haptics

ACM Classification Keywords
H.5.2 Information Interfaces and Presentation (e.g., HCI): User interfaces

INTRODUCTION
Touch screen interaction is based on an illusion of direct manipulation of objects. This study focuses on the design and implementation of a virtual wheel controller, utilising the opportunities of touch screen technology. This vertically oriented widget is aimed to be a general purpose controller for adjusting context-specific parameters. The wheel was opted to substitute the current physical wheel of the target product, thus providing with the flexibility and other advantages of a virtual solution.

An ideal controller would combine the strengths of the physical and the virtual. The clearest disadvantage of virtual control elements, compared with hardware-based ones, is the shortage of physical interaction. When using a physical wheel, the essence in the emergence of feel of immediate control is the haptic experience of the wheel and its mechanical properties. Therefore the virtual wheel design aims at triggering such ”missing” haptic experience. The intention, however, is not just to simulate a hardware wheel. The potential of virtualisation is in flexibility, as virtual tool-objects are not necessarily dependent on fixed schemes based on hardware controllers. A physical wheel controller is ideal for making fine adjustments robustly. However, it is not well suited for making big leaps along the available scale quickly. Therefore our design concept of a ”wheel” is enhanced to enable both fine (and robust) and rough (and quick) adjustments.

Touch screens rarely incorporate haptic actuators. However, the lack of actuators does not prevent haptic design. Rather than conceiving *haptics* as a mere input for touch sensation, we see it as a much broader perceptual apparatus [1], by which the subject actively ”picks up” information about the environment. For instance, there is evidence suggesting that haptic system effectively integrates action-related information from other senses [2, 3, 4]. Haptic experiences should thus be evoked, for example, when user's motor activity on the touch screen gets perceptually coupled with the directly related ”non-haptic” (sonic/visual) feedback. Such pseudo-haptic illusions [5] refer to physical properties, such as textures or inertia.

WHEEL DESIGN
Design and implementation of the widget progressed in tandem by iterative prototyping done with *Adobe Director* version 11.5 and *EloTouch* 1739L touch screen display. Firstly, in the visual appearance (see Figure 1) we focused on a general affordance of ”rotateability” and a smooth and responsive wheel movement. Contrary to the hardware counterparts, the wheel functions even when finger is sliding over its visual boundaries. The wheel embodies evenly spaced horizontal notches which represent points in the wheel where a change in a scale value ”snaps into”. The feel of going over notches is pivotal for user's ability to make fine adjustments, but the texture of consecutively crossed notches also affects the general mental image of the wheel as an object.

The elements of the pseudo-haptic wheel design relate both to *inertial model* (how wheel behaviour manifests inertial properties) and to *texture* (how wheel notches manifest an action-related texture). Elements relating mainly to the inertial model are:

- *Force dynamics*. A simple model that manages the increment and decrement of the Force value according to the rotation effort directed towards the wheel.
- *FreeWheel*. A mode where, after releasing the finger, the wheel keeps on spinning while enough Force is present (see below) or until the wheel is being touched again.
- *Notch friction*. A factor for decreasing the Force value at each notch crossing while the wheel is in the free spinning. Consecutive notches thus gradually slow down the spinning. When the Force value decreases below the pre-

determined threshold of minimum force, the next consecutive notch stops the wheel movement.

In fine adjustments, it is important that no free spinning accidentally starts at the wheel release. This matter can be managed by fixing the force dynamics, notch friction and the threshold of minimum accordingly.

Elements mainly relating to the wheel texture are:

- *Notch sound*. A short sound sample (200 ms) with acoustic features appropriately illustrating ”snapping into a notch”. Different kind of samples can function as textures that refer to different materials (e.g., wood, metal, plastic or rubber) but also to property dimensions such as sharp/dull, hard/soft, solid/tenuous or bright/dark.
- *Notch bump*. Visual bump of the wheel intensifies the sound feedback of snapping into a notch (small displacement forwards and backwards). The effect is noticeable only at slower rotating speeds.
- *Force-based filtering* (for notch sound). A spectral slope of the notch sound is varied as a function of the Force value (from negative to positive trend). There is also a subtle change in sound intensity in accordance with the Force. The purpose of this real-time filtering is to illustrate the rotation force of the wheel in the notch sound. The spectral slope has previously been associated, e.g., to the perceived speed of rubbing movements [6].
- *Scale-based filtering* (for notch sound). A center frequency of narrow-band filter boost is varied as a function of scale value. Such a moving resonant frequency (between 162-3240 Hz) is used for illustrating the relative location and direction of movement in the scale continuum. This element extends the object-related texture conception towards the ”subject matter” (i.e., scale value) being manipulated. The acoustic nature of this effect can also evoke metaphorical associations about the manipulation, such as ”pouring water” into a bottle (amount of fluid) or ”tightening” a spring (amount of tension).

For faster transitions in the scale position we utilised two alternative enhancement paradigms in the wheel prototype:

- *FlyWheel* mode is based on intensified operation of the FreeWheel mode. It modifies the free spinning of the wheel by using significantly reduced Notch friction until a wheel stoppage. FlyWheel is automatically enabled when the wheel is revolved with a Force exceeding a specified force threshold value. The enablement is visually indicated to the user by a colour change of the wheel’s borders. The user can rapidly move along the scale with a hard single spin and then stop the wheel as appropriate by touching it.
- *GearWheel* mode is based on intensified rotation rate (multiplied by 5:1 ratio) of the wheel when enabled. The usage of this mode presupposes that the FreeWheel mode is disabled, thus the wheel only rotates when being dragged. Identically with the FlyWheel mode, GearWheel mode is automatically enabled or disabled in terms of the used force and a specific threshold value, and the enablement is visually indicated. As the dragging out of the wheel boundaries is allowed, the user can navigate along the scale by varying the speed (thus enabling and disabling the GearWheel) and the direction of a continuous dragging.

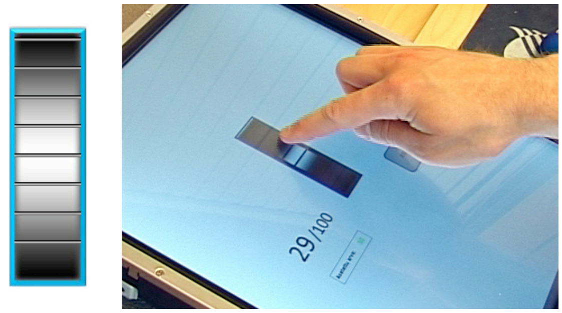

Figure 1. On the left, the visual appearance of the wheel. On the right, a subject is performing an adjustment with the prototype.

PILOT EVALUATION

The current prototype was exposed to a pilot experiment in which 8 subjects tested it in pairs. The experiment had three phases: 1) getting familiarised with the basic wheel (with no other enhancements than Notch sound), 2) getting familiarised with all available enhancement options and 3) choosing the favourite combination of features. In the second phase subjects were able to switch on and off FreeWheel mode (with adjustable friction), Notch bump, both audio filters, and both speed enhancement alternatives (with adjustable Force threshold). During the free testing, pairs discussed about the features. After phases 1 and 3, all subjects performed a timed sequence of 20 adjustments (within 1-100 scale). Each adjustment was confirmed with an OK button. The favoured options were used in the second sequence.

The wheel concept was rapidly adapted and liked, despite some early difficulties experienced due to somewhat ”stiff” responsivity of the resistive touch screen. Already the very first comment in the experiment was about the pseudo-haptic effect: a subject stated that ”. . . it feels just like a real”. When first trying with the basic wheel, many subjects complained the lack of free wheel and were relieved when it was included as an option in the next phase. Most subjects liked the idea of scale-based variation in sound (included in favoured set by 2 pairs) and gave expressions such as ”. . . sounds engaging” or ”. . . you feel at once the direction you are going to”. However, some were concerned about a possible irritation in long term use. The illustration of force in sound was also found useful by one pair due to its subtleness and the feedback it provides for perceiving the force threshold. Audio filters were seen as either-or options, although one pair did not choose either. The Notch bump effect was generally considered quite non-significant.

All four pairs opted for either speed enhancement in their favourite wheel (2×FlyWheel, 2×GearWheel). Discussions and arguments were mainly about the preference between them. The adjustment sequences were performed much faster with the favoured wheel. The performance difference across average times per adjustment is statistically significant in paired t-test, t(6) = 8.35, $p < .001$. Mean decrease in times was 23.6%. One subject was excluded from analysis due to a technical error.

CONCLUSION

The pilot study suggested that the design objectives have been reached. It indicated success in the fundamental design ideas and helps in the further development of the wheel towards implementation in the target system.

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The Effect of Haptic Feedback in Vocal Sketching Experiments with a Graspable Interface

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ABSTRACT
Tactile feedback has been a primary aspect of much of the gesture-based control/interaction projects and the importance of it has been addressed often in multimodal interaction context. This paper presents a study where a vocal sketching is used as a prototype method to investigate expectations for the sonic characteristics of a graspable interface and the effect of haptic feedback in sound-gesture coupling. We identify vocal sketching as a practice suitable for exploring the possible effects and expectations in early stages of designing multimodal interaction. At HAID'10, we will present our findings based on material collected in user inquiry sessions.

Author Keywords
Sonic interaction design, gesture-sound coupling, haptic feedback, mobile interface.

ACM Classification Keywords
H.5 HCI, H.5.2 User Interfaces, Haptic I/O, H.5.5 Sound and Music Computing, methodologies and techniques.

INTRODUCTION
Touch between two humans conveys a big amount of emotional information that is impossible to express in words [1]. A simple hand shake, which may seem a predictable and formal gesture, contains number of cues from the person. For example, skin moisture, muscle tremor and tension, grip force or movement amplitude and duration may reveal emotional states of the person such as nervousness, aggression or excitement. We are actively investigating emotional aspects in communication and seeking ways to exploit novel emotional sensing models that can result in improving interactions. In this context, we are focusing on human touch as a sensory input/output model in designing new ways of interaction.

Conventional button-based interaction is discrete and occurs step by step. On the other hand touch and gestures make the interaction continuous and dynamic. In this interaction process, continuous feedback is needed and it can be provided with multimodal channels; a continuous auditory and vibrotactile can be used for augmenting gestural movements [2][3]. In addition to haptic modality, audio modality provides a wider spectrum of information to present with recent technologies. The whole perceivable audio spectrum of the human ear can be produced with current audio speakers and headphones. Moreover, novel synthesis technologies provide an attractive set of tools for processing the sensory input. Therefore, it is well justified to investigate the possibilities in combining audio and gesture modalities, touch and grip for the purpose of emotional interaction.

Following our research process, we first explored user expectations for the sonic characteristics of our prototype device. We conducted a user inquiry to study the preliminary expectations and the effect of haptic feedback in sound-gesture coupling. We identify *vocal sketching* as a marginal prototyping practice, suitable for exploring the creative use of sonic interaction. In this paper we present our inquiry sessions and findings with future directions.

VOCAL SKETCHING
When the sound design ideas for the prototype device were initiated, it was obvious that there would be a variety of possibilities for developing sonic characteristics of the device. Therefore, before the actual design phase, we decided to conduct a user inquiry among 14 participants in different backgrounds to identify the preliminary expectations for the sonic characteristic of a graspable, tangible interface. Our goal was to study how the participants would describe/sketch the sounds that they would like the prototype device to make in use of certain tasks. We wanted to further observe how haptic feedback improves the interaction in this process. Vocal sketching, as one of the means of using voice, was also considered as a prototyping method in earlier projects and workshops by other scholars [4][5].

SOUND-GESTURE WITH HAPTIC FEEDBACK
User inquiry sessions focused on participants' performing particular tasks in relation to two different short scenarios. Scenarios intended to reflect the possible use case context of the prototype device. While the first scenario aimed to investigate a form of interaction based on the given communication task, the second scenario included musical gestures - *"You are on the stage before the audience and you will play the prototype as a musical instrument, improvising a short session. While you are making the musical gestures, you will also sketch your instrument using non-speech vocal sounds "*.

Figure 1. Certain gesture types (shaking, rolling) with vibrotactile feedback aid the bodily interaction.

Participants were initially asked to hold the device in hand with no further restrictions on the use of the device. The prototype device was functioning its all features; however with no supporting sound output mechanism. Once the task based on the second scenario was completed, the vibrotactile feedback function of the device was activated and participants were asked to perform the same task again. Numeric data of the accelerometer, gyroscope, pressure and touch sensor was recorded. Each session included a video recording and verbal feedback from the participants. Figure 1 shows the main gestures observed.

Data Analysis and Results

We used combination of qualitative and quantitative data analysis to find out the results of the user inquiry sessions. In the analysis of the second scenario task, we identified the aid of haptic feedback in producing diffuse bodily movements with a graspable interface. Recorded gyroscope, accelerometer and pressure sensory input data shows that conditions with the tactile feedback in the second task provide higher energies comparing to the same task, which involved no tactile feedback. Figure 2 illustrates the signal energy levels. We can state that tactile feedback makes the system more responsive and thus influences bodily interaction, although the calculated signal energy levels and observations can be interpreted as early promising results. In addition to the haptic feedback, the specific affordances of the device also employs whole-body movement for interaction – participants grasped and moved around within dynamic hand or arm movements.

Shaking, dropping down, squeezing, rolling, circular movement, pointing to a direction, lifting up, scratching were the most common expressive gestures observed. Participants changed the pitch of the sounds from lower to higher frequencies as they moved the device in vertical direction. Wave type of circular movements and rolling gesture in horizontal direction resulted in continuous pitched sounds. The shaking gesture also coupled with high or low frequency percussive sounds. Participants mainly sketched real world (elevator, wind, etc.), synthetic (electronic, sound effects, etc.) and abstract sounds.

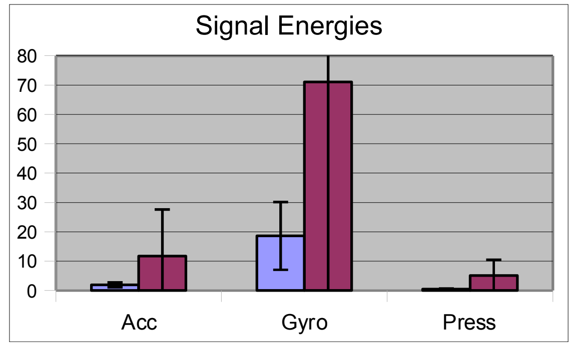

Figure 2. Blue (lighter) bars indicate the energy levels with no tactile feedback, and red (darker) bars with tactile feedback.

CONCLUSIONS

Vocal sketching is a marginal prototyping practice, providing alternative opportunities for combining haptic - audio - gesture modalities in interactive contexts. It enables us to explore the possible expectations in early stages for designing multimodal interaction. Our findings demonstrate that functional prototype of the device provided an optimal sound and gesture expectations. Moreover, haptic feedback improved the interaction in this process. The specific affordances of the device embodied in the gestures and such gestures are necessary components of the prototype device. The goal of vocal sketching sessions has been to elaborate this argument and explore it in detail before the actual sound design phase. It is a complementary task to conduct similar type of user inquiry sessions in the evaluation phase, in order to investigate what forms of our design decisions meet the expectations of the sketching experiments. We aim to present our findings in detail at HAID'10.

ACKNOWLEDGMENTS

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D-Jogger: a multimodal music interface for music selection based on user step frequency

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ABSTRACT

Modern mobile media players have sensors embedded in their hardware, allowing new ways to interact with the device. We build upon D-Jogger, an application that uses an accelerometer and gyroscope to analyze body movement in order to dynamically select music and adapt its tempo to the users' pace. Choosing the correct music during training sessions can have a positive effect on the performance, possibly due to the entrainment effect. However, the user control remains an issue: during a run session for example it is impossible to navigate in menus. For this, we propose a method of gesture recognition on a touchscreen for simple user input and feedback, making D-Jogger a multimodal media player.

Author Keywords

Multimodal interface, BPM aware playlist, pace detection, gesture recognition, entrainment

ACM Classification Keywords

H5.2. Input devices and strategies.

INTRODUCTION AND RELATED WORK

Thanks to recent developments in mobile music players, many people walk or run on music. During such a workout session it can be cumbersome to manually pick the best music; therefore the use of predefined playlists is common. However, this can lead to situations where the music is not adjusted to the users' actions, for example a slow song when running at a high tempo. In our previous work, we introduced D-Jogger [1]; a music interface that matches the tempo of the music (beats per minute, BPM) with the walking tempo of the user (steps per minute, SPM), switching songs when appropriate. This method however has a disadvantage over the use of traditional playlists because user preferrence is not taken into account. We propose the use of gesture recognition on the touchscreen for user feedback on the musical choice.

The idea of a system that adapts its music to the movement of the user is not novel in itself. Yamaha was the first to introduce BODiBeat[1] (2007), followed by Philips Activa[2] (2010). Elliott et al. introduced SynchStep[3], an iOS application for recent mobile Apple devices. SynchStep is based on the prototype PersonalSoundtrack, presented in [2]. These devices use a traditional menu-driven interface and are focused on selecting music to optimize workout performance, depending on the users' pace or heart rate.

D-JOGGER

D-Jogger distinguishes itself from the before mentioned devices because we use an alignment algorithm that time stretches the music depending on the users' pace. This allows for optimal alignment between steps and music without having to change songs when small gait tempo variations occur. A proof of concept was presented by Hockman et al. in [3].

The prototype of D-Jogger was build using Max/MSP, a graphical programming environment for real time audio processing that uses objects as basic building blocks. Objects developed for Max/MSP by third parties are called externals. D-Jogger consists of several externals, connectable in different ways to create a highly flexible framework for the rapid development of applications involving movement analysis and dynamic playlist generation. Figure 1 provides an overview of the system.

The alignment algorithm acts as the 'moderator' of the music: it decides whether the tempo of the current song should be adapted and whether a new song should be chosen. We present the Dynamic Song and Tempo (DSaT) algorithm, consisting out of 2 phases:

- Song Selection: DSaT starts by choosing a song with a BPM close to the SPM value, taking optional user rating into account. If no suitable song is found, the SPM value is doubled and the search restarted. This feature is used with very low SPM values (SPM < 90), because very few songs with a low BPM are available [4].

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[1] http://www.yamaha.com/bodibeat/
[2] http://www.usa.philips.com
[3] http://www.synchstep.com

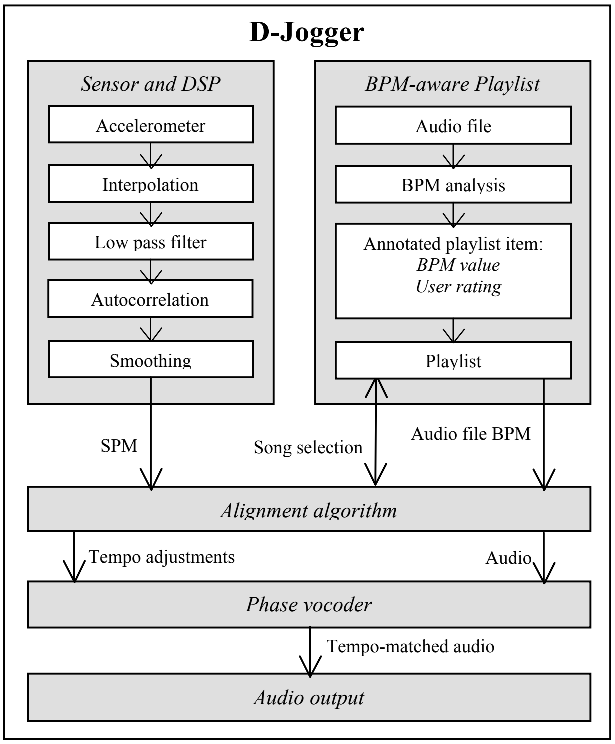

Figure 1. Overview of D-Jogger components

- Dynamic Tempo: the required tempo adjustment for the song is calculated by dividing the SPM value by the BPM value. When this adjustment falls outside predetermined boundaries for more than 5 seconds, a new song is selected.

The prototype has been used in several experiments, using a treadmill and an accelerometer placed at the users' ankle for reliable pace detection. There are some interesting conclusions about the users' entrainment to the beat. Entrainment is the synchronization of a system with a variable frequency to an external frequency [5]. The study showed that when SPM and BPM are sufficiently close to each other, users tend to align their steps to the perceived pulse of the music. Surveys also indicated that users reported feeling more motivated when in sync with the music [1]. The concept of D-Jogger can thus be used as a tool for assisting the user in music selection during workouts.

MOBILE D-JOGGER

A mobile version of D-Jogger is being implemented on a portable device. The main goal of this version is to perform experiments to indicate the users' entrainment in a less constrained environment. However, programming D-Jogger on mobile devices poses several challenges. Because the user has several options to place the device during a workout, for example the upper arm, the belt or in a pocket, pace detection is not as straightforward as in the prototype. Step and pace detection algorithms have to adapt to their location on the body to produce reliable results. A comparative study of pace detection algorithms and sensor locations is being performed. Results will include the best performing algorithm for each typical location. Preliminary data shows promising results for both upper arm and pocket sensor locations.

MULTIMODAL INTERFACE

Controlling a device during a workout session is a challenging task for the user. In most cases it is necessary to temporarily stop the session in order to navigate through a menu-based interface. D-Jogger minimizes the need to manually control the device, but a basic feedback loop is necessary to cope with user preferences. Basic controls include a positive and negative rating of the current song. A negative rating implies that D-Jogger automatically switches to the next song and avoids the song in the future, while a positive rating results in the song being played more often. The mobile version is implemented on a device featuring a touchscreen. This allows us to develop a user-friendly, gesture based rating system. We propose the following gestures:

- Swipe gesture means a negative rating. This common gesture represents throwing away a song.
- Double tap for a positive rating

The proposed system makes it easy to give feedback to the system during a workout, without interrupting the session. We plan a study in the near future to evaluate the design.

CONCLUSION

Building upon the prototype of D-Jogger, a mobile version was proposed featuring a multimodal interface. Music selection is based upon walking or running tempo of the user, while intuitive gestures on a touchscreen are used for user feedback on song selection. This combination leads to easy media player control during workout sessions.

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WiiCane Demo

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ABSTRACT
We will demonstrate WiiCane, a new commercial product that helps blind pedestrian walk straighter without veering, and provides practice in several other aspects of cane technique in safe, indoor environments. *WiiCane* combines precision motion tracking with real-time audio and vibratory feedback to produce a tool for training blind pedestrians to be move about with greater confidence and control as they navigate. The technology being developed also shows promise for creating immersive gaming environments where one or more players moves along a linear path of any length.

Author Keywords
Blind, Wii, Mobililty, Cane, Sensors, Education,Training.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

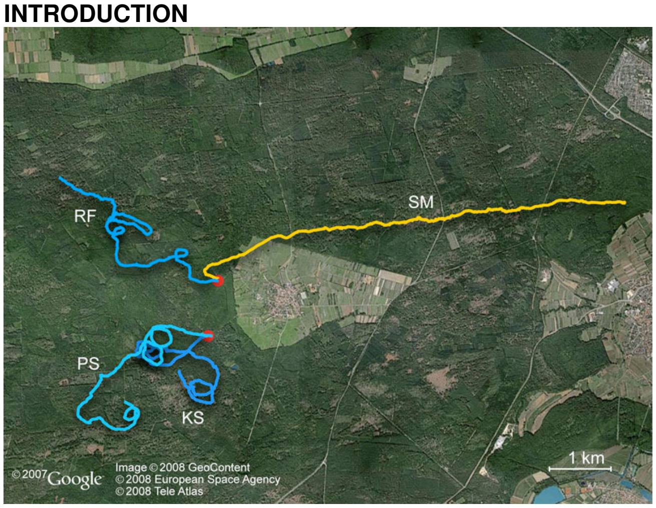

Figure 1. Path of test subjects attempting to walk straight. Yellow = sunny day, Blue = cloudy day. (Souman, 2009)

Deprived of visual and auditory cues about their immediate environment, humans tend to be unable to walk in a straight line for any significant distance. This phenomenon is familiar to anyone lost in the woods on a cloudy day: inevitably, the lost individual trying to maintain a straight-line path will veer in one direction or the other, and this tendency often leads hapless hikers to walk in circles, getting really lost in the process. This is illustrated in figure 1, where the yellow line shows the path of a hiker asked to walk straight through a featureless landscape on a sunny day, and blue lines show the convolutions of other (confused) subjects attempting to go straight on a cloudy day (Souman, et al, 2009).

For blind pedestrians, it is of the utmost importance to be able to walk in a consistent direction, often for long distances, in situations where audible or tactile reference data is not available (Blasch and LaGrow, 1996). The most obvious case is in street crossings, where a curb or building line is not present to trail with the cane, and veering is common. Orientation and Mobility trainers work with students to overcome their tendency to veer. According to David Guth, whose research in this area is of particular interest to the *WiiCane* developers, repeated spoken corrections delivered during attempted straight-walking exercises can help people veer less, even for months after the training has ended (Guth, 2009). *WiiCane* virtually walks behind the person, tapping them on the shoulder when their veering causes then to step outside a predefined threshold for perpendicular displacement from the line connecting the start and end points. *WiiCane* attempts to teach a user what it "feels like to walk straight" over a prolonged distance in the absence of any auditory or visual clues about the physical environment.

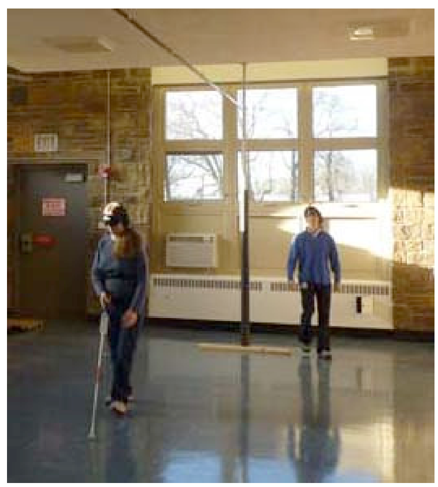

Figure 2: A trainee walking the course as her instructor looks on.

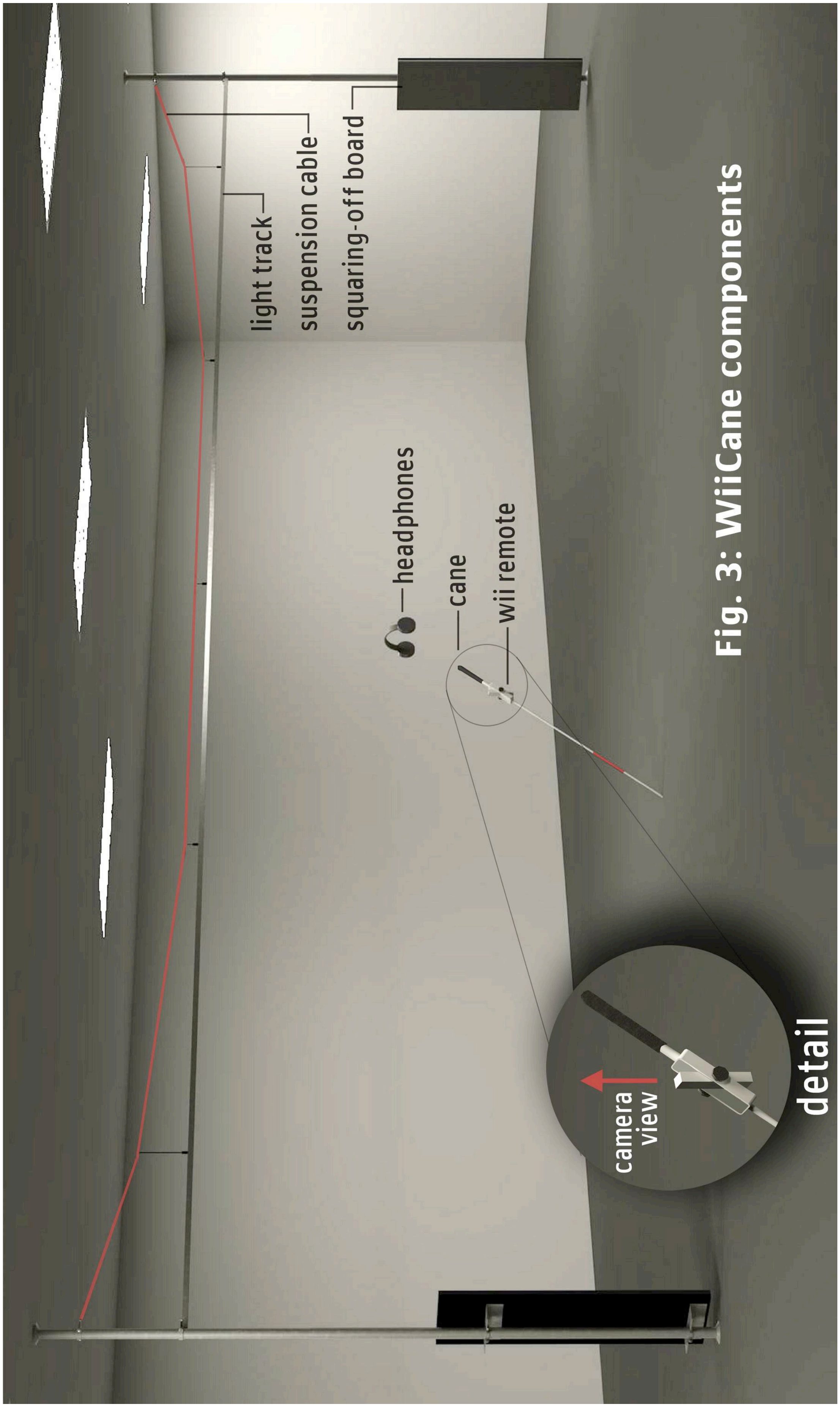

Fig. 3: WiiCane components

TECHNOLOGY

WiiCane consists of the following components

- An overhead track with individually controlled IR LEDs at 6" spacing. The light track is modular, and can be any length. It is either suspended on a cable structure or mounted to the ceiling like track lighting (see figure 3 on previous page).
- A telescoping mobility cane with roller tip and aluminum fixture for holding a standard Wii remote so that its light sensor is pointing at the overhead track. (see figure 4).

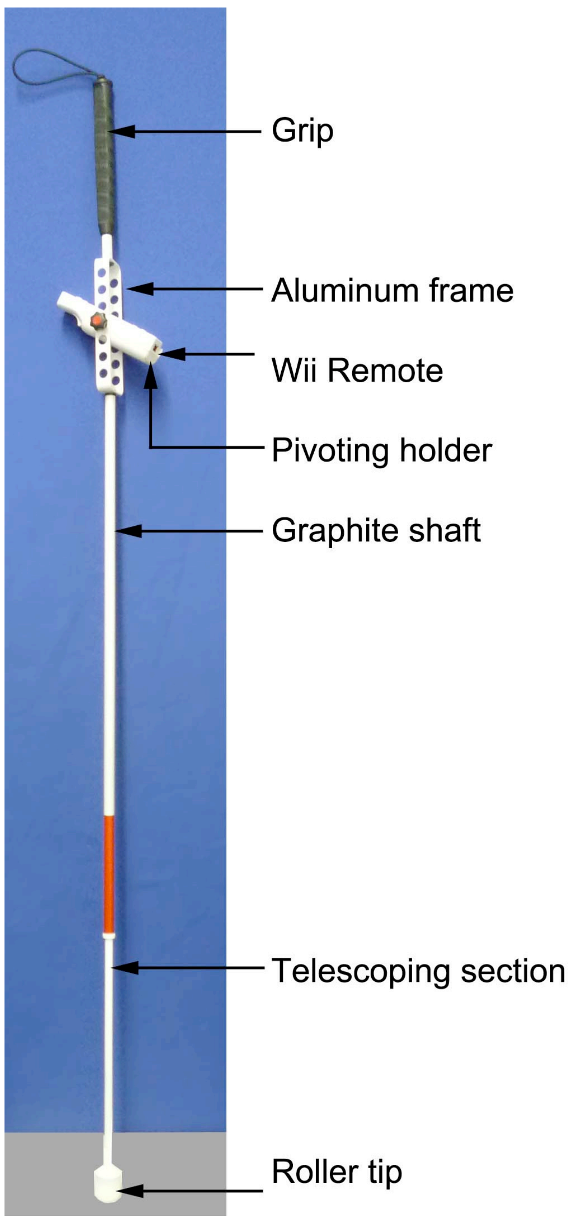

Figure 4: A standard telescoping mobility cane with Wii remote mounted in a pivoting fixture.

- A PC with Bluetooth radio mounted somewhere within 30 feet of the walking course.
- Wireless headphones for occluding the hearing of the trainee while providing real-time audio feedback.
- A Java program to manage the Bluetooth radio connection with the Wii device, control the LED's on the light track, send feedback to the trainee on several aspects of their cane technique via headphones and the rumble motor on the Wii remote, and capture find-grain data on movement and performance to see if performance improves over time.

In its current configuration, *WiiCane* observes movement and provides corrective audio and vibratory feedback on:

- *Veering.* Users hear a single tone every few seconds when their veering does not exceed a threshold. When veering is detected, they hear "go right" or "go left" spoken in their right or left ear.
- *Wrist roll.* The cane's grip vibrates when users fail to hold the cane straight. If they do not correct this behavior, they hear "Correct wrist roll", and all other feedback stops.
- *Arc width.* The system speaks "too wide" or "too narrow" if the angle of the cane's swing is inadequate to ensure complete coverage of the body during travel.
- *Rotation.* Users are asked to turn in precise 90 and 180 degree increments. When the system detects that they have stopped rotating, they receive feedback as to their accuracy in rotating.

NEXT STEPS

While the *WiiCane* project is intended for the specific purpose of training visually impaired independent travelers to use their long canes in a safe and efficient manner, the developers are considering a number of other possible uses for this apparatus. The main difference between *WiiCane* and other movement-based activities intended for the Wii platform is that the 12" long sensor bar that sits on the user's television in typical Wii set up is replaced by a variable length overhead light track in *WiiCane*. This means that the user is not constrained to remaining within 15 feet of the television, but can move anywhere along the track's length (within about 7 feet from either side of the light track depending on height of the lights above the Wii remote's IR sensor). Some possible activities include: pole vaulting, fencing, throwing and catching a virtual ball between two players, and many other competitive or individual games that include movement along a path. These will be investigated and demonstrated in future phases of this project.

WiiCane is currently in development, and is undergoing user testing at multiple sites in the United States. The company plans to introduce the product commercially in January of 2011.

ACKNOWLEDGMENTS

Wiicane is being carried out under a Steppingstones of Technology grant from the United States Department of Education, Office of Special Education Research Services

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Sonifying Social Networks: Maintaining an Overview of Online Activities

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ABSTRACT
Social networks have changed the way people communicate. They provide tools for users to share pictures, videos, text or music widely. There seems to be an almost constant stream of information between friends and acquaintances, so that it becomes increasingly difficult to stay on top of what is happening online. We have developed a mobile auditory display that allows users to maintain an overview of activities on different online platforms. The application runs on a mobile device and creates a spatialised soundscape around the user's head that reflects current online activities and also allows users to spot activity peaks. We conducted a series of user studies looking at the application's appropriateness for activity monitoring, peak activity recognition and users' performance during distraction tasks. Results show that our application provides an effective way of monitoring overall activity levels and allows users to identify activity peaks with 86.1% accuracy, even when mobile. Findings from this user study were used to derive design guidelines for feed monitoring via audio.

INTRODUCTION
Social networks are increasingly used for disseminating information to large groups of people. Platforms like Twitter and Facebook provide a variety of tools to facilitate communication among people. RSS is widely used for receiving news updates on topics of interest. Thanks to these tools, information travels the globe in almost real-time with contents ranging from private chat to time-critical updates on catastrophic disasters. Mobile devices now allow users to access this information and send updates, often from where important events are happening. By monitoring feed messages, which we call *social feeds*, people can stay on top of topics currently being discussed in the online world. However, huge amounts of information being shared and distributed in real-time cause information overload for users. This means that they have to spend too much time looking at their devices and can get in the way of other activities. New methods are needed to provide ways of maintaining an overview of social feeds in a lightweight way along with spotting activity peaks that might be important to attend to. To address this social feed overload problem we built an ambient, auditory display that allows users to monitor their feeds non-visually while on the go. We use spatialised sounds in order to create a 3D soundscape around the user's head that reacts to the activity levels on Twitter and Facebook, and to RSS updates (Fig.1). Sounds are conveyed through stereo headhones and allow users to maintain an overview of online activities and to spot activity peaks through an auditory display that runs on a mobile device in this case an Apple iPhone.

Figure 1. Spherical platform placement: Facebook (left), Twitter (front), RSS (right)

RELATED WORK
Using audio to convey alarms and notifications has been common in mobile devices for some time, but often they are attention grabbing and the challenge remains to develop a rather subtler system, that allows users to remain focused on a primary task but monitor the general state of an application. Sawhney and Schmandt [3] have looked into scaleable auditory techniques to provide timely information and built a contextual notification system for wearable audio messaging called *Nomadic Radio*. We pick up the idea of adaptive notifications and apply it to social feeds and their current activity levels. Another approach for audio notifications has been undertaken by Butz and Jung [1]: They developed a method for notifying users with the help of auditory cues in an ambient soundscape by embedding subtle cues in form of musical instruments and motifs into the auditory environment. Garzonis *et al*. [2] examined mobile service notifications and created design guidelines for auditory cues in terms of intuitiveness, learnability and memorability which we applied to the soundscape design in our system.

IMPLEMENTING A FEED MONITORING SYSTEM
We specifically designed our system for a mobile setting where users might not be visually able to monitor online activities due to other ongoing tasks. This implies that notifications from the system should not require the user to fully focus attention in order to gain an overview of the system's activity. Rather than forcing the user to understand each incoming message, our system was designed to convey a comprehensive overview of activities in the social feeds and to allow the user to spot specific peaks of interest. To access individually relevant information streams, feed messages are retrieved from the online platforms Facebook and Twitter, as

Facebook (water)	Twitter (forest)	RSS (abstract)
Inbox Message (splash)	Friend Feed (chirping)	CNN (didgeridoo)
News Feed (bubbles)	Direct Message (crow)	BBC (zither)
Notification (pouring)	Reference (junglefowl)	TechCrunch (wind chime)
Friend Request (drops)	Hashtag (canary)	University News (pan flute)

Table 1. List of message event types that are retrieved and sonified

well as from RSS feeds. If there is an activity spike where a lot of people talk about an item of interest then the rise in activity is displayed by increasing the density of sounds in the soundscape. We incorporated in total 12 unique sounds representing different kinds of online activities as shown in Table 1. Thereby we tried to assign distinct sounds to corresponding message events according to more or less obvious mapping. Feed messages are retrieved from each platform's servers in regular intervals and the current soundscape around the user's head is adjusted according to the incoming event types. Each incoming message is assigned to a platform and a specific message type which determines the displayed sound. We use *OpenAL* on the iPhone to spatially position the sounds around the user's head. Facebook items are presented on the left of the soundscape, Twitter in the centre and RSS on the right. Each platform has an overall sound (Facebook: water scenery, Twitter: forest scenery and RSS: rather abstract instruments) and within that each event type has a particular sound (see Table 1).

USER STUDIES

In order to evaluate the sound design as well as the application's effectiveness for feed monitoring, we recruited 15 university students as participants (10 men, 5 women be- tween the ages of 20 and 28) who reported normal hearing abilities. In total we conducted 3 user studies. The first study focused on the learnability of the sound cues. Participants had to assign the 12 sounds to the three platforms and twelve message types correctly before proceeding to the next part of the study. If, after a short training session, they could not respond with at least 80% accuracy they went through the training again. On average participants needed 2.2 (SD 1.3) training sessions to learn the sounds . After the training, participants were able to assign a sound to a platform with 94.1% accuracy. In the second study we examined the conditions under which a sound event was most likely to be noticed and how soundscape density (the number of sounds playing) affected the user's ability to monitor activities before becoming overloaded. Participants listened to 10 soundscapes that differed in the overall quantity of sounds being played and the number of sounds overlapping each other. Results showed that the more overlapping activity there was, the more events passed through the system unnoticed. But at the same time, recognition of types of events remained relatively stable as complexity increased. The data confirmed that it was easier to spot the unique occurrence of an event type than counting the total number of messages of that type. So, even in a highly dense soundscape where many online activities were displayed at the same time, users could still easily distinguish between different message types. In the third study, participants listened to 5 soundscapes of differing complexity that contained various activity peaks. While walking along a designated figure of eight path, we asked participants not to focus on single incoming messages, but rather to maintain an overview over the activity levels of the soundscape presented and to report any peaks in activity on a social platform. The overall ability to identify unique message event types remained good even while walking, which requires attention and concentration. Peaks of activity were noticed with 86.1% accuracy and correctly assigned to the related platforms. 53.6% of the presented peaks were correctly assigned to the corresponding message event type. Results confirmed previous observations: When the quantity of messages increases, single messages may go unnoticed, but they contribute to peak recognition performance. Overall, the identification of unique messages remained rather stable.

DISCUSSION AND CONCLUSIONS

We developed a novel way of monitoring social feeds by applying auditory display techniques and sound design. Our application allows users to maintain an overview of activity levels in social feeds like Twitter, Facebook and RSS while on the go. We conducted a user study examining performance in message type allocation and peak activity recognition. So far, results indicate that using our system allows users to maintain an overview of activity levels in social feeds. We were able to confirm that spatial sound positioning supports learnability, memorability and allocation performance. Furthermore, we did not find any correlation between participants' usage patterns of social media and their performance in the study, which suggests that this kind of auditory display could be applied to other scenarios as well, where there is a need to monitor activity levels of other kinds of data sets. Our current system runs on the iPhone, but can be adapted to any mobile platform with similar spatialised sound capabilities. We are planning to integrate more sophisticated sonification techniques such as using physical models to modify the soundscape and display online activities. Furthermore, we will conduct a longer-term user study to investigate usage and user preferences over time.

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HSP v2: Haptic Signal Processing with Extensions for Physical Modeling

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ABSTRACT
The Haptic Signal Processing (HSP) platform aims to enable musicians to easily design and perform with digital haptic musical instruments [1]. In this paper, we present some new objects introduced in version v2 for modeling of musical dynamical systems such as resonators and vibrating strings. To our knowledge, this is the first time that these diverse physical modeling elements have all been made available for a modular, real-time haptics platform.

Author Keywords
Haptics, physical modeling, Cordis-Anima, digital waveguides, Max/MSP, and robotics.

ACM Classification Keywords
H5.2. User interfaces: Haptic I/O; H.6.5 Model Development: Modeling methodologies; I.2.9 Robotics: Operator interfaces.

INTRODUCTION

In Max/MSP 5, it has become possible to set the signal vector size to one in the *DSP Status* window. This feature allows audio signal objects to be interconnected with as little as one audio sample of delay around feedback loops. As a consequence, physical models can be easily and elegantly created directly in Max/MSP by connecting audio-rate filters with one another. We have used these models to control Falcon robotic arm haptic devices, which are currently available for as little as US$150 [1].

MASS, SPRING, AND DAMPER MODELING PARADIGM

It is possible to model any linear driving-point impedance or admittance using masses, springs, and dampers, so it could be argued that these are the most fundamental modeling elements [3]. Consequently, HSP v2 includes Max/MSP subpatches that model virtual masses, springs, dampers, and nonlinear elements that can vibrate at audio rates. For instance, any audio signals received in the inlet of the `mass~` object are interpreted as forces in Newtons, and the output from the `mass~` object is the resulting position [3,5]. In contrast, because both damper and spring objects can receive positions as inputs, they can be combined together into a single `link~` object. Consider the example shown in Figure 1 (upper left), in which a mass m of 0.05kg is connected by way of a spring with stiffness 4000 N/m in parallel with a damper with coefficient 0.0002 N/(m/s) to mechanical ground g.

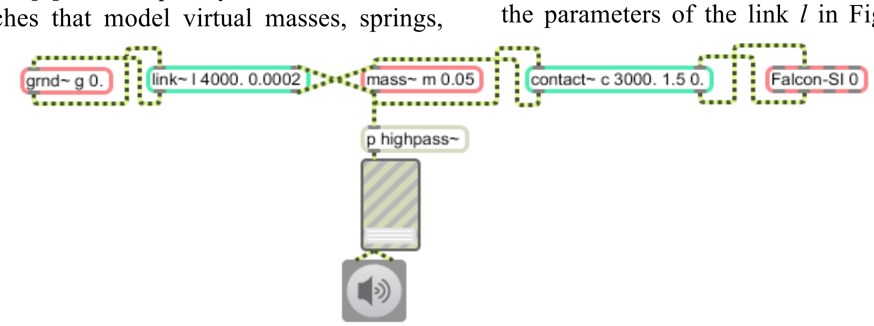

Figure 1. Example patch in HSP showing the signal flow

Model Implementation Details

The physical modeling objects in HSP v2 discretize the differential equations for the laws of motion of continuous-time masses and links according to the Cordis-Anima method. In particular, the mass dynamics are discretized using the second-order central finite-difference scheme, while the damper dynamics are discretized using a backward Euler difference [3,7].

The advantage of the schemes presented in this paper is that the virtual elements are modular [3,5]. Consequently, they can be interconnected in multitudinous configurations that all have physical meaning. In fact, the interconnections shown in the graphical user interface illustrate not only the audio signal flow, but also the physical relationships between the virtual objects. (While the pmpd library implements a subset of this kind of functionality, its sampling rate is much slower than the audio sampling rate, making it difficult to directly synthesize high quality sound using pmpd [5].)

Naming of Elements

Another advantage of modularity is that each element can be assigned a name as the first argument in the object box in Max/MSP [5]. Objects can be addressed by their names using the `send` object in Max/MSP. For instance, to change the parameters of the link l in Figure 2 to 8000 N/m and 0.0005 N/(m/s), the message “l 8000 0.0005” can be sent from any subpatch. Naming is especially useful when models become more complicated. For instance, naming makes it much easier to change the pitch of a mass-spring model of a string incorporating 19 identical mass elements and 20 identical link elements (not shown).

Real-Time Force-Feedback Haptic Interaction

The Falcon force-feedback robotic arm can be accessed using the `Falcon-SI` object, which specifies the index number of the Falcon. We have tested controlling up to five Falcons connected simultaneously to a MacBook Pro with a 2.4GHz Intel Core 2 Duo processor. The primary function of `Falcon-SI` is to serve as a three-dimensional mass. It has force inputs in Newtons in the x, y, and z axes, and it outputs position in the x, y, and z axes in meters.

Because the Falcon object behaves essentially like a mass, it can be connected to virtual masses (or other `Falcon-SI` masses) by way of links. Figure 1 (right) shows how the y-axis of the Falcon is connected to the virtual mass by way of a `contact~` link named c with stiffness 3000 N/m and damping coefficient 1.5 N/(m/s). This type of contact link behaves like a spring and damper that only exert forces when the Falcon grip is pushed beyond or "inside" the virtual mass m. HSP v2 supports other kinds of contacts such as `contact-pluck~`, a plectrum-like link with hysteresis, and `contact-attract~`, which is similar to `contact-pluck~` but does not incorporate hysteresis.

Choosing Parameters

The physical interpretation of the elements' parameter values is useful in many contexts for designing models. For instance, a virtual mass can be chosen to have about the same mass as the Falcon grip. However, in some other contexts, choosing parameters can be less straightforward. For example, the resonance frequency of a simple mass-spring-damper oscillator depends on the mass, stiffness, and damping parameter. For this reason, we have created the `resonator~` object. Internally it contains a mass and a link, and it adjusts their parameters to approximately achieve a specified resonance frequency, decay time, and mass. In this sense, `resonator~` approximates the behavior of the CEL object in Cordis-Anima [4].

Digital Waveguide Modeling

An alternating mass-spring model (not shown) of a one-dimensional waveguide is not perfectly harmonic when the masses are identical and the springs are identical [6]. For this reason, it is more straightforward to construct one-dimensional waveguide models using digital waveguides [8]. Thus far, we have created the following objects in HSP v2 for digital waveguide modeling:

• `DWG-end~` implements a one-dimensional waveguide with a termination at one end, where the termination incorporates some damping at higher audio frequencies.

• `ex-junct~` implements an explicit digital waveguide junction [2]. When connected to two `DWG-end~`'s representing velocity waves, the junction provides a position output and a force input. Hence, `ex-junct~` provides for a single point of interaction and can easily be connected to `Falcon-SI` using objects such as `link~` or `contact`-type objects.

FINAL WORDS

The physical modeling extensions to HSP v2 make it easier to create new haptic musical instruments, which provide force feedback to the performer. This release[1] of HSP v2 includes example models of instruments that we are incorporating into live music performances. Further in the future, we plan to not only create many more models, but also to provide support for additional haptic devices, enabling a broader suite of force-feedback interactions. For example, an external could be written for Max/MSP and/or Pure Data to interface with any devices supported by the Chai3D environment.

ACKNOWLEDGMENTS

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Tactile Belt gives valuable information to Tug Boat Pilot

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ABSTRACT

A vibrating belt has been tested for assisting a tug-boat pilot in the very demanding job of tugging large ships in severe conditions. The test was carried out in a large ship simulator system. The results are promising and further test are planned. Also other types of controller jobs could be assisted using vibrating belts.

Author Keywords

Guidance systems, tactile, tactors, user interface.

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

INTRODUCTION

A tugboat pilot is mentally fully loaded when tugging a large ship in a harbor basin. He is using primarily visual clues as distance, relative speed and obstacles and secondly aural clues from radio communication and sounds from the engine. Thirdly the kinesthetic senses are used to feel the movement of the tug boat and sometimes also vibrations from the motor.

The visual clues are dominating and this means that bad visual conditions like fog and heavy rain often can lead to canceling of tugging.

The is a need for additionally informations on possible obstacles or targets around the actual tugboat pilot without just adding more visual or aural clues. Thus inspired by a succesfull setup for helicopter pilots [1] using a tactile belt DELTA decided to do a test for tugboat pilots.

Several references shows possibilities for navigation assistance using tactile displays like vibrating belts [3].

TEST SETUP

A belt with 8 small vibrators (tactors) [2] may give valuable clues about some of the relevant parameters for controlling a tugboat when the sight is reduced or even not existing like in heavy rain/snow or fog.

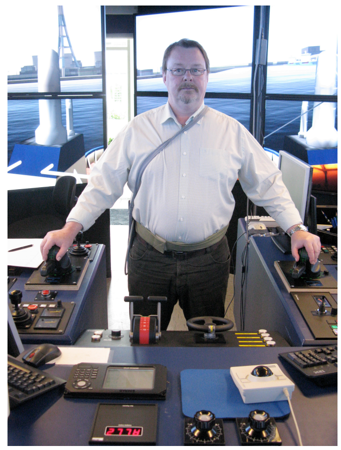


Figure 1. Simulation setup with tugboat pilot using a tactile belt

DELTA has in cooperation with FORCE carried out a simulator test which shows the possible benefits and ideas for further developments. The project is finished and it leads to projects for other types of working situations where information given by a tactile belt may be efficient.

Hardware.

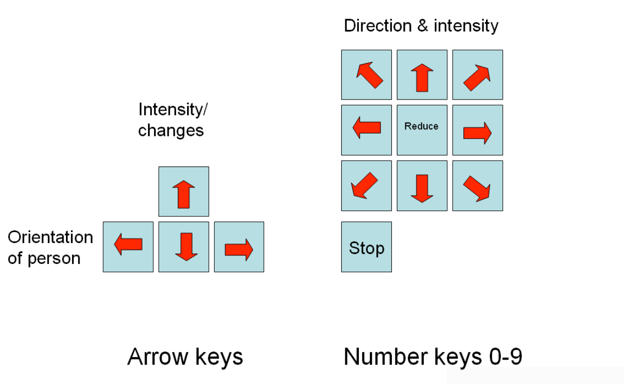
We used a flexible vibrating belt with 8 vibrators (tactors) equally distributed around the waist of the test person. [2] It is for the test controlled manually by a 'simulator person' using a relatively simple PC interface and a wireless connection to the belt. This made it possible to test different strategies without heavy programming. In a later version signals from relevant sensors may be controlling the output from the belt.

Testing in a large ship simulator

An experienced tugboat pilot carried the tactile belt in a large simulator at FORCE. Difficult tugging situations were tested using the vibration signals from the tactors in the belt to inform the pilot about direction and distance / speed towards the closest obstacles in a harbor basin. Different Different types of vibration signals (frequency, modulation, time patterns etc.) were tested. There may be a need for different combinations of these parameters depending on the persons individual preferences and the actual situation. This can be done in the software.

In the actual test four levels were defined by a combination of vibration pattern, two frequency combination and intensity. The zero level meaning no signal was off course default when turning the system on.

Layout for control-simulator keys on 'standard PC'.



The PC-based control system has an intuitive layout, where the numeric keypads are used for setting direction and intensity of the signal to one of the 8 tactors. A correction for the test person's orientation relative to the tug boat is implemented. The display shows actual direction and level.

SURVEY TEST USING ACOUSTICAL DISTURBANCE

The tactors used emit a weak humming sound at a low level, which may be totally masked by the engine sound etc.

In order to evaluate possible additional clues from the tactor sound a test was carried out for five persons. Here music was played back using headphones and a prerecorded sequence of tactile inputs was used for all tests. The actual chosen combination of frequencies, modulation and intensity was kept.

The test person was instructed to 'copy' the sequences felt from the tactile belt by tapping a computer keyboard like the control simulator keyboard. By logging the exact time and key ID when hitting a key a comparison with the original prerecorded sequence was made. The time delay, and the detected direction and intensity (0-4) were compared for each key hit.

On figure 1 and 2 are small examples of logging the control signals and three times the detected signals. The duration was 90 seconds. Figure 1 shows detection of direction, and Figure 2 the detected level.

This showed for the chosen setup that some of the persons were not much disturbed by the music and the 'missing' aural clue from the tactors, while others were disturbed and often did not feel the vibrations at lowest level.

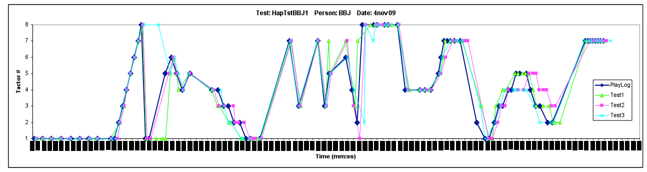


Figure 1 Detection of direction.

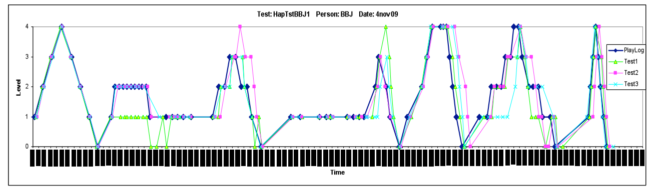


Figure 2 Detection of level (0 – 4)

After some more training the fault rate in general was reduced, but the lowest level (level 1 of 4) was often not sensed and thus interpreted as level zero. The different vibration pattern for the four levels helped some of the persons, while others mostly relied on the intensity level of the tactor. Thus some optimization is relevant.

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CONCLUSION

The simulation test using a tactile belt for assisting a tugboat pilot in navigating in a harbor shows many promising aspects. Individual settings for the vibration of the tactors can improve the persons capability of identifying the level. Challenges ahead are the coupling of measured parameters like distance and direction to obstacles or targets with the tactile signals sent to the tactile belt used by the pilot.

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