Sonification of Haptic Interaction in a Virtual Scene

Emma Frid
Roberto Bresin
Sound and Music Computing
CSC, KTH Royal Institute of Technology
Stockholm, Sweden
emmafrid@kth.se
roberto@kth.se

Jonas Moll
Eva-Lotta Sällnäs Pysander
Interaction Design
CSC, KTH Royal Institute of Technology
Stockholm, Sweden
jomol@csc.kth.se
evalotta@csc.kth.se

ABSTRACT

This paper presents a brief overview of work-in-progress for a study on correlations between visual and haptic spatial attention in a multimodal single-user application comparing different modalities. The aim is to gain insight into how auditory and haptic versus visual representations of temporal events may affect task performance and spatial attention. For this purpose, a 3D application involving one haptic model and two different sound models for interactive sonification are developed.

Keywords: interactive sonification, haptic feedback, spatial attention

1. BACKGROUND

Integration of haptic feedback in computer music applications, especially in the context of Digital Musical Instruments (DMIs), is a growing research field (see e.g. [1, 2]). Numerous studies have focused on how force feedback devices, i.e. controllers that read position information and provide continuous force feedback as a response to user movements, can be used in applications involving both sound and haptics [3, 4, 5, 6].

Audio-tactile and audio-proprioceptive interaction has been found to play an important role for spatial orientation in virtual scenes [7]. Moreover, it has been suggested that auditory and tactile signals are more effective than visual signals when it comes to drawing cross-modal attention to particular positions [8]. The current study is motivated by the fact that few previous investigations have focused on cross-modal links in spatial attention for sonified 3D haptic interfaces.

2. AIM

The purpose of this study is to investigate how visual spatial attention and haptic spatial attention correlate in a single-user application comparing combinations of different modalities. We aim to investigate how different representations of temporal events affect task performance by triggering a shift of attention. The following proposed hypotheses will be tested: 1) by providing auditory and/or haptic feedback a visual attention shift will be triggered, and 2) auditory feedback can elicit an increased sense of effort; a user’s gestures can be affected by ecological knowledge of sound producing events related to the implemented sound model.

3. METHOD

A SensAble™ Phantom® Desktop haptic device 1 is used together with eye-tracking technology to analyze how focus of attention is affected by combinations of different modalities. The haptic device has a pen-like stylus, attached to a robotic arm, which is used to haptically interact with objects in virtual environments. A 3D application based on a simple task where the user is supposed to throw a ball into a goal (see Figure 1) has been developed. The application provides haptic, visual and auditory feedback.

Eye-tracking data will be correlated with haptic tracking data in order to investigate hypothesis 1), i.e. if focus might shift from the ball to the goal depending on the provided feedback. Hypothesis 2) will be tested through comparison between the haptic and non-haptic condition.

Figure 1: Experimental setup with the SensAble Phantom Desktop, Tobii X2-60 eye-tracker and 3D application.

Experiments with first-year students from the Computer Science program at KTH Royal Institute of Technology will be carried out. Initially, pilot experiments involving vocal sketching [9] will be carried out. The pilot tests will provide ideas for design of two different sound models, but also serve as a first evaluation of the entire setup.

Copyright: ©2014 Emma Frid et al. This is an open-access article distributed under the terms of the Creative Commons Attribution 3.0 Unported License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

1http://www.sensable.com/haptic-phantom-desktop.htm
The subsequent experiments will contain auditory-haptic, auditory-visual, auditory-visual-haptic, haptic-visual and visual-only conditions. A between-group design will be adopted, where each group will solve the task in one of the conditions.

Subjects will be given a period of 5 minutes for practice before the actual experiment starts. After the practice trial, they will be instructed to try to throw the ball into the goal 40 times. Task performance, defined as a quota between 40 hits and total number of trials, will be computed for each subject. We define visual attention in terms of time that a user is focusing on a specific area of the screen.

3.1 Apparatus

The 3D application, based on the haptic software library Chai3D [10], is written in C++. As previously mentioned, a SensAble Phantom Desktop device will be used to provide force feedback. The sound models for providing auditory feedback have been developed in Max and sound synthesis is done on a separate computer. Communication between Max and the 3D application is done via OpenSoundControl (OSC) [11]. A pair of Sennheiser HD 433 headphones will be used for auditory feedback. Eye-tracking data will be recorded using a commercial X2-60 eye-tracker from Tobii Technology. The Morae software for usability testing will be used to set up, record and analyze study data.

3.2 Sound Design

A summary of different interaction events and suggested corresponding auditory feedback can be seen in Table 1. Most interaction sounds were designed as Earcons [12], since many of the sound-triggering events in the 3D application have no intuitive mapping to an auditory event. As for the sonification of the interaction with the haptic ball, i.e. the gesture where the user is aiming at the target, we compare two sound models: one simple model based on filtered white noise (simulating a whooshing sound), and one sound model designed using the friction preset from the Sound Design Toolkit [13].

The models are designed in such a manner that sound changes in terms of stereo panning and frequency depending on movements in the x- and y direction respectively. Velocity is mapped to volume and a specific mapping for movement along the z-axis is adopted for each sound model (see Table 1).

4. PRELIMINARY RESULTS

Pilot tests involving vocal sketching are being performed at the time of writing. Initial findings have led to conclusions regarding adjustments that are required in order to ensure robust behaviour and reliable interaction in the virtual 3D environment. Improvements on the application as well as sound models will be done in an iterative manner as the pilot tests proceed, until the setup is stable enough for the actual experiments to be carried out.

5. FUTURE WORK

As a continuation of this study, future investigations could involve assessment of how visual spatial attention could be affected by auditory and haptic feedback in a multi-user setting.

Acknowledgments

This work was supported by the Swedish Research Council (Grant No. D0511301).

6. REFERENCES


