User Performance and Haptic Design Issues for a Force-Feedback Sound Editing Interface

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Abstract
This paper describes current work on the design and development of haptic interfaces for use with digital sound editing software. Current systems rely on computer keyboards, mice, and sometimes passive knobs for user input and graphics and audio for feedback. The addition of haptic feedback will improve the user experience because of the additional mode of feedback received through touch. This work is focused on using a design methodology, including need finding, user observations, prototyping, and user testing to develop haptic sensations effective for manipulating sound.

Keywords
Haptics, audio, sound editing, design methodology

INTRODUCTION
As any performer of acoustic musical instruments will confirm, the sense of touch is vital to effective control of the instrument. A musician relies not only on hearing, but also on haptic feedback when performing music. This physical relationship to the manipulation of sound is lost in many computer-based musical activities [2]. Musicians no longer receive pertinent haptic information that is generated in conjunction with the sound waves coming from the instrument. This gap in physical intimacy now exists in many computer-based tasks, from electronic performance to sound editing systems.

In current digital sound workstations, the GUI attempts to replicate interfaces commonly found in a sound studio. These include graphical knobs, sliders, buttons, and a waveform representation of the sound. However, the user must use the mouse and keyboard to access the GUI widgets on the screen. New physical interfaces have been developed that utilize physical knobs, sliders, and buttons that correspond to the graphical ones on the screen, but these are passive and do not provide haptic feedback related to the sound.

This work, however, suggests that greater improvement can be reached by incorporating input devices with haptic-feedback capabilities. As we know, the haptic senses are very important to musicians but traditionally have been undervalued in the development of interfaces. A sound editing system with haptic feedback would achieve two primary goals. First, it would allow for greater efficiency in sound editing tasks due to the addition of haptic feedback to the existing aural and visual channels. Second, it would allow for the creation of haptic icons that do not exist in acoustic or analog environments, but may contribute not only to the efficiency of the interface, but also to the artistic and aesthetic gratification of using the interface.

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GOALS
This work has two primary goals. The first goal is to show, through a series of experiments, that the addition of haptic feedback is beneficial to typical sound editing tasks. The second goal is to address design issues specific to the creation of haptic sensations related to sound manipulation.

Effectiveness of Haptics
The first goal of this research is to show that the inclusion of haptic feedback will improve user performance in basic sound editing tasks. This will be accomplished through a series of experiments providing quantifiable results in task time and performance error. These experiments will focus on the task of locating edit points at the onset or offset of a sound.

The initial experiment will use a haptic knob as the input device. This will allow the user to scrub through a sound in a familiar manner. The user will be tested for locating the onset of a sound with the presence of haptic effects and without the presence of haptics. In the case with haptics, a detent will be generated at the location of the onset. In both cases, the user will be able to hear the sound while scrubbing through it.

Further experiments will be designed based on the above model with the purpose of studying user performance given more complicated haptic effects such as:

- Spring-loaded knob
- Various levels of damping
- Various sizes of detents
- Ramping forces for gradual onsets and offsets
- Use of haptic textures to describe a sound

Additionally, tests may be designed to determine the effectiveness of haptics in conjunction with visual feedback compared to the use of haptics as a replacement for visual feedback.

Design Issues

The second goal of this work is to utilize a formal HCI design methodology in the creation of haptic sensations to be used in the system. The hope is to gain knowledge on how to map appropriate haptic effects to specific events and parameters in the sound. Great care must be given during the design process to ensure that the provided sensation produces the best feedback for a given action. For example, a spring must not only feel like a spring, it must feel like a spring suitable for a specific situation. Other sensations such as pops, walls, or detents also must be crafted carefully to provide appropriate feedback. Furthermore, custom effects may need to be created due to special needs that exist in musical interfaces that are not needed elsewhere [3].

This will lead to a set of guidelines and a catalog of musical haptic effects to benefit future work. In order to do this, the work will be based on the large body of existing knowledge related to HCI design methodology. As described in many sources, the first step is to uncover user needs through observations and interviews with users at work on current sound editing systems. The haptic sensations can then be designed to fulfill these needs.

The next step is to design prototypes to satisfy user needs. Again, many sources describe methods for creating scenarios and fictional user profiles as a way of designing for different situations of use. In this case, scenarios of various sound editing tasks will be useful in the design of haptic sensations appropriate for specific tasks. Next, prototypes of the designs will be implemented so that they can undergo user studies. Because of the nature of this research, the user studies must measure both subjective experience as well as quantifiable results. Although subjective success often correlates with quantifiable success, there may be discrepancies. For a sound engineer, efficiency may be the primary goal, but for a composer, the aesthetics of using the interface may be more important than its efficiency. After results from these user studies are analyzed, the process of scenarios, design, prototyping, and user studies is repeated until satisfactory haptic effects are developed.

PRIOR WORK

Currently, the field of haptics in music is young and sparsely populated. Cadoz [1] and Gillespie [5] provide contributions to the development of force-feedback keyboards and programmable piano actions. Their work, however, concentrates on the engineering issues of haptics rather than the user experience or interaction design of interfaces. The work of O'Modhrain is more user-centered and focuses on perceptual issues of using haptics specifically within a musical context [7].

Despite the limited body of work detailing haptics and music, useful information can be found in work investigating general haptic perception and haptic relationships to non-musical auditory stimuli. For example, Gescheider [4] found that the presence of simultaneous tactile and auditory stimuli did not effect perceptual processing, but had an effect on higher level cognitive processes. Because of the distinctive properties of music cognition, findings such as this may be relevant to the way people combine touch and hearing when working with music.

STATUS

At this moment, preliminary user observations have been performed and a basic prototype has been built. The observations have revealed a number of distinct needs such as better mechanisms for zooming and grouping. The current prototype consists of sound navigation software that can be controlled with a vibrotactile mouse or with a haptic knob. Simple haptic sensations such as pops, detents, and springs have been implemented.

TECHNICAL COMPONENTS

The technical components used in this research are haptic mice, a haptic knob, and a simple custom sound editor. The development software is written in C++ for Windows 2000 and contains a library of programmable effects such as detents, springs, wall barriers, damping, and pops [6].

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