Music-making for the Deaf: Exploring new ways of enhancing musical experience with visual and haptic feedback systems.

Richard Burn

Faculty of Arts, Design & Media, Birmingham City University, United Kingdom
Richard.burn@mail.bcu.ac.uk

Abstract. Musicians with hearing-impairment are able to exploit multi-sensory feedback produced by acoustic instruments, allowing them to perform to the highest of professional standards. However, Digital Musical Instruments (DMIs) generally fail to provide the same types of feedback, which limits their usability for the deaf. My research will build on related work to steer development of new haptic and visual feedback systems. These feedback systems will aim to represent the components of sounds produced by DMIs, delivering a multi-sensory experience similar to that provided by acoustic instruments. I intend to investigate how the senses of sight and touch are stimulated, build prototype hardware and software systems to replicate the missing feedback and test the resultant systems for efficacy. The overall aim of my research is to enhance the musical experience for deaf musicians who wish to play virtual instruments and expand their range of live performance opportunities.

Keywords: Human-Computer Interaction, Haptic and Visual interfaces, Ethnographic approach to interface design, Perceptual and cognitive issues.

Introduction

There has been relatively little research on how to optimise musical experience for deaf people (Nanayakkara et al. 2013) and the majority of existing research has concentrated on enhancing the passive activity of listening to recorded music. Where research concerning active music-making for deaf musicians exists, it tends to concentrate on enabling technologies, for example, providing haptic pulses to help musicians play together in time (Fulford 2013). There would seem to be an, as yet, unexploited opportunity to develop haptic and/or visual feedback systems that accurately represent or describe sound to enhance the playability of virtual instruments for deaf musicians.

There are a number of hearing impaired virtuoso musicians, such as Evelyn Glennie, who have mastered acoustic instruments, often describing a multi-sensory experience whilst performing (Glennie 1993). Of course, hearing players experience the same sensations but may perhaps, not rely on them to the same extent. However, it is generally accepted that players of computer-based, virtual instruments do not enjoy the same visual and tactile sensations as those experienced by acoustic musicians. In discussing the relationship between performer and instrument, Rebelo (2006) describes how haptic sensation allows a performer to “negotiate subtlety” and “recognise threshold conditions”, enabling the player to master the instrument. When playing DMIs, the musician is denied this “haptic space” and while the hearing player is less able to reach the highest levels of performance standards, the deaf player may be unable to play the instrument at all.

The objective of my research is, therefore, to explore new ways of providing meaningful multi-sensory musical feedback. This will be achieved by designing a system that provides an immersive experience for players of a wide range of Digital Musical Instruments (DMIs). An ethnographic study of the specific requirements and expectations of deaf musicians will be carried out to inform the development of innovative visual and haptic feedback systems taking into account their needs. This research should introduce a new level of inclusivity in the field of Human-Computer Interaction, while advancing knowledge in sensory replacement.

Related Research

Haptics

The majority of existing work on haptic feedback for software instruments focuses on issues not directly associated with hearing impairment; the haptic drum kit (Holland et al. 2010), designed to be a teaching aid, provides a guide to playing technique but does not attempt to convey any information about the sounds being played. Eagleman (2015) has devised a sensory replacement system designed to help the deaf hear the human voice with the aid of a dynamic haptic vest. By using an array of actuators activated by audio input, the vest provides real-time brail-type stimulation to the user's torso. It may be possible to adopt some of the techniques utilised in these types of system to physicalise audio data for digital instruments. Other systems, such as the Viblotar (Marshall 2005), seek to deliver a more immersive musical experience by providing vibro-tactile feedback, which is driven by the amplitude of the source waveform. The efficacy of this approach will be evaluated and be used to inform design decisions in the construction of resonant chambers or bodies. Drawing together elements from the systems described above will facilitate the development of a haptic display capable of describing both synthesised sounds and controller parameters. If successful, this type of display will empower deaf musicians, providing real opportunities for live performance using a whole range of virtual instruments.

Visuals

In discussing the appreciation of 'music alone', Kivy (1996) examines the subject of 'visual music', asserting that visual perceptual complexity is far superior to auditory perception. He describes how the brain attempts to make sense of what the eye sees, rather than merely seeing lines or shapes. Bruce, Green and Georgeson (2003) support this viewpoint and propose that the apparent superiority of the visual sense is an evolutionary response directly related to human survival. It should be possible to exploit this inherent natural ability to quickly assess visual cues when designing visual displays. Principles of abstraction, where complex images may be reduced to a few significant features, as observed by McCloud (2011), will inform the development of simple but meaningful pictographic icons, which could be used to represent various elements of sound.

Research Questions

How do deaf musicians interact with acoustic instruments? This will be addressed by researching how sensory information is exploited by virtuoso players, who are most likely to understand and be able to accurately convey this information. It is clear that the senses of sight and touch play a vital role in conveying the fine detail and components of sound. However, it will be necessary to examine in great detail how these senses are stimulated to reveal the subtle cues that expert players are able to resolve and interpret.

What types of visual and haptic feedback provide the most positive user experience? A review of relevant literature has revealed a wide range of research into haptic feedback with an equally wide discourse on the subject of visuals, albeit located mostly in adjacent fields. Principles and ideas will be incorporated into prototype systems and will need to be tested extensively in user trials. It will be important to consider all cognitive effects derived from the sense of sight to understand if additional or augmented feedback, such as lighting, may be useful. Care will be taken to ensure feedback is meaningful, rather than merely pleasing.

What physical limitations are necessary to ensure a good user experience? The overriding aim of the project is to develop an enjoyable and widely accessible system. Factors such as affordability, comfort, ease of use and physical size, amongst others, will need to be considered.

Aims and Objectives

The primary aim of this research is to address the needs of deaf musicians and afford them a better performance experience when using DMIs. In order to do this, it will be necessary to understand the visual and tactile elements missing from the musical experience of deaf people when playing electronic instruments. Deaf musicians exploit a combination of senses in cross-modal interaction in order to play acoustic instruments successfully. Observation of this phenomenon will inform the design of a multi-sensory feedback system that will enhance the overall performance experience but avoid the introduction of confusing or mis-judged feedback.

It would make sense to integrate any potential new system with existing systems that provide ease-of-use allowing the user to concentrate on creating music rather than complex software manipulation. The Birmingham Conservatoire Integra Lab have already developed musician-centred interfaces for live electronics; a logical further step would be in developing additional modules to provide enhanced capabilities for deaf musicians.

This research will be structured into three distinct phases:

1. Gathering of quantitative and qualitative data on the experiential elements considered to be missing when playing an electronic or digital musical instrument.
2. Investigate how new systems may provide the missing elements.
3. Carry out real-world evaluation of prototype systems.

The second and third phases will by cyclic in order to refine the systems based on user feedback.

The differences between acoustic instruments and DMIs, such as lack of expressivity in the latter, will be central concerns when considering how to reintroduce visual and tactile cues for those who are unable to hear the unusual sounds produced in modern synthesisers. Accurate representation of the sound will be vitally important if a deaf musician is to be confident in virtual instrument performance.

Research Methodology

This research will be conducted, using mixed methods. A series of questionnaires and interviews with virtuoso and high-level deaf musicians will generate qualitative data on sensory perception and exploitation. An extensive interview with Evelyn Glennie has recently been conducted, which revealed a wealth of information that will inform design direction. A mix of qualitative and quantitative methods will be used to gather data on how a much larger set of users, both hearing and deaf, react to the subsequent prototype system; the charity *Music and the Deaf*, were approached and have agreed to help identify suitable participants. Evaluation of the data will help determine the success, or otherwise, of the project.

Haptic and visual displays will be designed using a combination of hardware and software systems. The nature of these displays will be based on detailed research, development and testing. Ethnographic field studies will form a large part of the research with cyclic development based on interpretation of the user experience of individual musicians involved in testing. Participants will be asked to evaluate the prototype displays to determine how well they describe particular sounds; the subjective opinion of users are likely to produce variable results as they evaluate how well the visual and haptic feedback represents the sounds that they are playing. Creswell (2012) suggests that qualitative researchers should conduct their study with the intent of reporting the multiple realities of those individuals taking part. When compiling a phenomenology, it will be important to take a distilled view of the most popular experiences as described by the majority of people who evaluate the system, while also reporting on the differing views of individual users.

The focus of research will be on development of novel feedback systems exclusively; there is no intention to explore the development of new input devices or instruments. The aim is to increase accessibility to virtual instruments for hearing-impaired players using standard controller keyboards and commercially available software, such as Apple Logic Pro.

Impact

It is expected that this research will greatly enhance the experience of deaf musicians enabling them to enjoy the act of making live music with software and other electronic instruments. This will provide a similar degree of confidence and enjoyment as that experienced when playing acoustic instruments, which provide predictable haptic and visual feedback. The research will also add to the body of knowledge in the field of Human Computer Interaction (HCI) revealing a previously neglected area of how HCI can benefit hearing impaired musicians. The desire to reintroduce feeling in a DMI has been widely discussed and successfully implemented in a number of cases, however, very few systems have been directly concerned with sensory replacement. It is this gap in knowledge that this research also seeks to address.

By focussing on the needs of the deaf this research will conform with Inclusive Design principles, however the benefits of an immersive musical experience may be enjoyed by all and so the research will also conform to the principles of Universal Design as defined by the National Disability Authority.

Acknowledgements. This research is supported by the Midlands3Cities Doctoral Training Partnership (M3C DTP) and the Arts and Humanities Research Council (AHRC).

References

Bruce, Vicki, Patrick R. Green, and Mark A. Georgeson. 2003. *Visual Perception: Physiology, Psychology, & Ecology.* 4th ed. Hove; New York: Psychology Press.

Creswell, John W. 2012. *Qualitative Inquiry and Research Design: Choosing Among Five Approaches.* SAGE Publications.

Eagleman, David. 2015. 'Sensory Substitution'. http://www.eagleman.com/research/sensory-substitution.

Fulford, Robert. 2013. 'Interactive Performance for Musicians with a Hearing Impairment'.

Glennie, Evelyn. 1993. 'Hearing Essay'. https://www.evelyn.co.uk/hearing-essay/.

Kivy, Peter. 1996. *Music Alone: Philosophical Reflections on the Purely Musical Experience*. 3rd print. Ithaca: Cornell Univ. Press.

Marshall, Mark T. 2005. 'The Viblotar-a Big Box That Makes Noise (and Vibrates Too!)'. Technical Report (Unpublished), McGill University. http://www.marktmarshall.com/data/media/writings/viblotar_report.pdf.

McCloud, Scott. 2011. *Understanding Comics: The Invisible Art*. 39th print. New York: Harper Perennial.

Nanayakkara, Suranga Chandima, Lonce Wyse, Sim Heng Ong, and Elizabeth A. Taylor. 2013. 'Enhancing Musical Experience for the Hearing-Impaired Using Visual and Haptic Displays'. *Human–Computer Interaction* 28 (2): 115–60.

Rebelo, Pedro. 2006. 'Haptic Sensation and Instrumental Transgression'. *Contemporary Music Review* 25 (1-2): 27–35. doi:10.1080/07494460600647402.