Practitioner Reflection

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Musical haptics for the listener: Reflections of a design practitioner

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Luca Turchet
Department of Information Engineering and Computer Science, University of Trento, Italy

Abstract

This short essay focuses on the author's reflections as a design practitioner in the emerging field of musical haptics. The reported perspectives relate to the fields of human-computer interaction and music composition and performance. Both ideas and concerns are presented, which are derived from the process of designing, implementing and evaluating hardware and software haptic devices to be used in musical settings with the aim of enriching the listeners' experiences. Finally, some final thoughts and future interventions are proposed.

Keywords

Musical haptics, Internet of Musical Things, multisensory interaction

Introduction

Digital communication has been one of the main objects of investigation of researchers in the Multimodality field, who have approached its study under the lenses of manifold perspectives, including social semiotics, corpus-based multimodality, systemic functional linguistics, and conversation analysis (Jewitt et al., 2016). From a different perspective, researchers in the domain of Human-Computer Interaction have investigated the use of multiple sensory stimuli digitally conveyed to users to produce novel technologically-mediated sensory experiences (Velasco and Obrist, 2020). Lately, a significant attention has been devoted by researchers to the study of digital touch, with a growing body of studies positioned at the confluence of Multimodality and Human-Computer Interaction (Price et al., 2022). In particular, an emerging area in this space concerns the use of the haptic sensory channel in artistic contexts.

Corresponding author:
Luca Turchet, University of Trento Department of Information Engineering and Computer Science, Via sommarive 9, Povo 38123, Italy.
Email: luca.turchet@unitn.it

The object of the present study concerns the sense of touch as a means of expressive communication in musical settings. Research on haptics has been applied to the musical domain, leading to the field of "musical haptics" (Papetti and Saitis, 2018). Musical haptics experiences are typically conceived for two categories of users, i.e. listeners and musicians, as well as for two categories of interactions of the user with the audio-haptic content, i.e. active and passive. This article is focused solely on the listener and passive interactions.

In this context, musical haptics practitioners have created hardware and software systems aiming at enriching the musical experience of passive listeners with a layer of haptic sensations concurrent to the musical sounds (Remache-Vinueza et al., 2021). For instance, Hayes (2015) created an installation where the audience member is asked to lie on a chaise longue, which provides both sounds and vibrations to the body thanks to vibrotactile loudspeakers placed underneath the piece of furniture. On the other hand, Mazzoni and Bryan-Kinns (2016) created a glove with embedded actuators and designed vibration patterns for it aiming at enhancing the affective state of music listeners in the context of cinematic experiences.

Therefore, endeavors in this space aim primarily at the creation of novel forms of musical expression as well as new kind of experiences for the end users. Two main lines of research have been investigated, i.e. offline and real-time. The former concerns the addition of a haptic layer to musical recordings, the latter to live music and has recently arisen within research about the Internet of Musical Things (Turchet et al., 2018). For instance, Turchet et al. (2021) created a system where musical features were extracted in real-time from the acoustic signal of a smart mandolin, which were sent to haptic jackets worn by audiences that provided vibrotactile sensations in response to the received messages.

In 2003 Gunther and O'Modhrain coined the term "tactile composition" to refer to the strand of music composition encompassing the sense of touch to enrich the listeners' experience (Gunther and O'Modhrain, 2003). Ever since, composers, installation artists, and researchers have explored the use of the body surface as a compositional parameter. However, the tactile composition repertoire is still very limited as only a handful of compositions and concerts have been performed for "skin and ears", most of which did not employ actual live music, but recordings. Examples of these artistic and technical efforts are reported in (Gunther and O'Modhrain, 2003; Armitage and Ng, 2015; Hayes, 2015; Turchet et al., 2021).

Nevertheless, to date still little is known about the actual experience of the audiences of these artistic works. Moreover, no guidelines are available to composers interested in adding a haptic layer to their music. A growing body of literature has investigated cultural perspectives about the various senses, including the sense of touch (Jewitt and Leder Mackley, 2018). Yet for the case of haptics in listening experiences much remains to be done. Therefore, for all these reasons, to progress this field positioned at the confluence of engineering and art it is useful to share with the musical haptics community not only the lessons learned, but also the matured perspectives.

It is worth noticing that the reported reflections are based on the author's background as a practitioner in the fields of Human-Computer Interaction and music composition and

performance. Therefore, the presented perspectives on multimodality relate more to approaches belonging to such fields rather than the sociological field.

Some considerations on the design process

Through my personal experience while working with musical haptics compositions and related problems, the results available in the literature, as well as the evaluation experiments I conducted with users, the following general considerations about the musical haptics design process emerged.

First, musical haptics design should obey to artistic considerations rather than the functional ones that occur in other domains such as virtual reality or rehabilitation. The point indeed it is not how to maximize a task efficiency or increase the degree of realism of an experience, but how to enhance the emotional reactions of users compared to the music alone. Designing for musical haptics for the listener is a process similar to that of music composition. The conception, creation and evaluation of the haptic stimuli needs to take into account the emotions to be elicited in the listener.

Second, a musical haptics designer first needs to define the haptic stimuli and their relation with musical attributes before starting to prototype. This necessarily calls for the definition of the body location(s) to be utilized and as a consequence the selection of the type of devices to be used (e.g. wearable or non-wearable). The more detailed such design choices are performed beforehand, the easier the upcoming steps are, and pitfalls and implementation delays can be reduced or avoided. This entails the creation of an audio-haptic vocabulary that can be effectively applied to the musical composition at hand. In this process, the knowledge of "crossmodal correspondences" may be useful, i.e. people's tendency of matching information presented in one sensory modality to that presented in another (Deroy and Spence, 2016).

Third, each haptic stimulus needs to be tailored for the musical piece at hand. It is not plausible that a general solution across multiple compositions, devices, and user groups can be defined. This entails ad-hoc design strategies and results in a highly iterative design process where concepts, prototypes, and stimuli need to be evaluated constantly in order to provide artistically meaningful experiences.

Fourth, unless the musical haptic device is intended solely for visually-impaired users, the visual component also typically concurs to the overall musical experience. Therefore, not only the sonic attributes but also the visual elements should be taken into consideration when designing the haptic stimuli (e.g. movements of performers, stage lighting conditions, visuals appearing on screens).

Fifth, user personalization for stimuli features and location is an important requirement because not all users appreciate haptic sensations a designer envisions. For instance, to avoid unpleasant vibrotactile sensations that some people may experience in certain parts of the body it is important to empower the users to adjust the intensity and the frequency of the vibrations, or even to deactivate some device motors impacting certain regions of the body.

Sixth, in general a time of adaptation to the haptic stimuli (e.g. vibrations) is needed by users before actually appreciating their added value in musical contexts. Therefore, it is

desirable that the audience of a concert or the listeners of a musical haptics installation get acquainted with the types of haptic stimuli they will experience when the music will start.

Seventh, the offline and real-time scenarios have different technical requirements which necessarily impact the design decisions to be taken as well as the design process. In the offline case, the haptic stimuli can be completely predetermined and triggered when appropriate. In the real-time case, the haptic stimuli need to be triggered at the moment in which the music is produced by the performers. This entails technical issues that are still not fully solved, including the accuracy and latency to extract musical features from the sound generated by the musical instruments as well as the latency to wirelessly transmit such features from the musical instruments to the receiving haptic devices used by the audience.

Some concerns

As with any field that is not yet established, the design of musical haptic experiences carries some issues and concerns that need to be addressed in order to progress the field in an optimal way, at both designer and user levels. The following concerns regard both design aspects but also more general aspects related to the musical composition practice. In part such concerns could be addressed taking into account the considerations made in the previous section.

In first place, designing properly for a musical haptics experience is without doubt a difficult task. This is due to the fact that such an activity requires both musical knowledge and haptics knowledge, which, as of today, is not common among composers or haptic designers. On the one hand a possible solution to overcome the difficulty inherent in the creation of musical haptics works is that composers work hand in hand with haptic designers. This necessarily entails a change of perspectives from both parties, which need to take into consideration the different requirements for art and technology, along with the agreement on a common language allowing them to properly communicate towards the achievement of the desired goals.

On the other hand, there is the need for a new class of music composers who are willing to gain knowledge about haptic experience design. To facilitate this process, it is necessary to progress the hardware and software tools available for the creation of haptic experiences, in a way that they can be accessed also by non-specialists. A related problem is that no guidelines are available to composers willing to approach musical haptics composition. Ultimately, the added haptic layer needs to be pleasing, harmoniously integrate with the music, and significantly alter the music perception in a positive way. Both artistic and perceptual research is needed to achieve the definition of useful best practices and an audio-haptic vocabulary that actually works and can be commonly used. One of the biggest barriers to consider is represented by the listener's cognitive load introduced by the haptic layer that is superimposed to the musical sounds. Musical haptics composers must carefully select their multisensory strategies in a way that they do not deteriorate the listeners' experience instead of improving it.

These practical issues, coupled with a not so commonly manifested interest by composers to explore the musical haptics opportunities, have resulted in a relatively low

number of musical haptics installations and concerts. As a consequence, the musical haptics repertoire is still scarce. Musical haptics devices have not been established yet and lack a practice tradition and a repertoire. Performing and composing for them is crucial for their longevity. Indeed, throughout the history, musical instruments have evolved from a stage to another not only thanks to technological progresses, but also thanks to the requests of new features by musicians and composers.

Relatedly, more aesthetical research should be conducted in the musical haptics field. For instance, future studies could focus on the design of haptic stimuli and on their perceptual assessment to investigate the role of haptic sensations in creating pleasant or unpleasant experiences concurrent with music. Audio-haptic aesthetic aspects would play a dominant role in choosing to attend a performance of a musical haptics composition. As pointed out by different authors (see e.g. Hayes and Rajko, 2017), the sense of touch remains largely under-explored within contemporary aesthetics, and this is even more true for the musical haptics domain. Critical reflections on such a topic would likely facilitate the interest of composers and audiences towards the field.

Final thoughts and future interventions

Musical haptics for listeners is an exciting emerging field and there is still much to be discovered. However, one of the biggest challenges and one of the main reasons why there are very few musical haptics applications for listeners available in both academia, industry, and artistic settings, is the lack of easy-to-use hardware and software tools as well as guidance for composers and designers.

Whereas much research has been conducted on audio-haptic perception, the specific perceptual relationship between music and haptics has been largely overlooked. Researchers have thus far made only tenuous links between haptic stimulations and listening musical experiences. To my best knowledge, almost all previous studies in this space concerned the use of vibro-tactile stimulations concurrent with recordings. Only one study, reported in Turchet et al. (2021) investigated actual live music settings. No study has involved thermal or pressure stimuli. The few studies available in the literature have shown that adding vibrations to musical content is effective in increasing the perceived quality of recorded music (Merchel and Altinsoy, 2018), may contribute to listeners' engagement with the recorded performance (McDowell and Furlong, 2018), and may enhance emotional responses during a cinematic audiovisual experience (Mazzoni and Bryan-Kinns, 2016). This suggests that vibro-tactile sensations may play a significant role in the perception of live music when appropriately designed.

It is worth noticing that opportunities for the creation of musical haptics experiences arise particularly for the hearing-impaired community, since the additional haptic layer has the potential to enhance music perception (Nanayakkara et al., 2013; Fletcher, 2021). Notwithstanding the potential benefits that musical haptics technological solutions can bring to such users, thus far this line of research has been scarcely addressed.

However, little is known about how to design solutions capable of effectively enriching the live musical experience of audiences. The studies mentioned above did not link musical parameters (e.g. beat, rhythms, mood) to haptic parameters (e.g. spatio-temporal

patterns, duration, or intensity of vibrations), nor systematic investigation of the corresponding perceptual spaces has ever been performed. Finding relationships between musical and haptic perceptual spaces would inform the design of effective musical haptic devices and provide composers with a palette of haptic stimuli that can enrich the musical experience. Crossmodal correspondences have been documented between many different combinations of sensory modalities and have been shown to affect human performances during various tasks. The music enrichment via crossmodal correspondences has been hypothesized by other scholars (see e.g. Walker, 2016). However, to my knowledge no study heretofore has investigated the role of audio-haptic crossmodal correspondences in inducing emotions in musical contexts, and just a few rigorous investigations have compared the listeners' responses to musical haptics stimuli compared to music alone.

Therefore, in my future work I plan to identify the relationships between the musical and haptic spaces via experimental methodologies established in the field of multisensory perception. This will enable the creation of a toolbox for composers that in my best aims should facilitate the adoption of musical haptics technologies. Moreover, this will be useful to address the current gaps in aesthetical research surrounding musical haptics. Furthermore, I plan to focus on the challenging topic of providing haptic sensations during live performances, which entails the issues of extracting in real-time useful features from the acoustic signal, wirelessly transmitting them in low latency to haptic devices for the audience, and effectively map them to haptic stimuli. These steps in my opinion are necessary to progress the musical haptics field towards new frontiers and unleash the unexplored potential that this still uncommon art form carries.

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