A Design Approach to Engage with Audience with Wearable Musical Instruments: Sound Gloves

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ABSTRACT
This paper addresses the issue of engaging the audience with new musical instruments in live performance context. We introduce design concerns that we consider influential to enhance the communication flow between the audience and the performer. We also propose and put in practice a design approach that considers the use of performance space as a way to engage with the audience. A collaborative project, *Sound Gloves,* presented here exemplifies such a concept by dissolving the space between performers and audience. Our approach resulted in a continuous interaction between audience and performers, in which the social dynamics was changed in a positive way in a live performance context of NIMEs. Such an approach, we argue, may be considered as one way to further engage and interact with the audience.

Keywords
NIME, wearable electronics, performance, design approach

1. INTRODUCTION
NIME is an area in which one can continuously explore technical and aesthetic design challenges. While technical requirements have sometimes been the central focus in contributing to new musical instrument design and electronic music development, when the novel instrument is presented in a live performance context, the challenge to engage with an audience becomes a concern. Especially the abstract and unique input/output coupling between the performer's action and the produced sound, may pose questions in audience perception and understanding [6]. Thus, presenting a new musical instrument in live performance context raises the difficulty level in communicating with an audience. Inspired by one of Perry Cook's artistic principles, "make a piece, not an instrument or controller" [1], we believe that apart from the technical improvement for interface and instrument design, other relevant factors, such as the musical concept and performance approach, are just as important and should be taken into account. This approach should be considered throughout the design and development phases.

In this paper, we highlight the design factors that address the issue of engaging with the audience. We propose a design approach, focusing on the notion of designing an engaging performance by exploring the use of performance space. We positioned ourselves to consider composing music "performance" with an audience in mind, rather than starting the focus on instrument design. The design intention was to dissolve the distance between the performer and audience by extending the "performance space" beyond the front stage, and technology facilitates such an idea. Thus, the process of realising the performance concept and the design of the instrument inter-influence each other and shape the outcome of the creative work. Furthermore, we argue that by considering the performance space or stage in the design approach is one way to further engage and interact with a passive audience.

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2. ENGAGING WITH THE AUDIENCE
The issue concerning the engagement between performer and audience in electronic music performance is not new [13]. To approach this concern, the design process of new musical instruments should include considering the relationship between audience and performer. Base on the discussion on a Digital Musical Instrument evaluation framework in which multiple stakeholders involved in the design process was pointed out [9], we also believe the design decisions should be approached from various perspectives; including the instrument designer, performer, composer and audience, as they are all involved in the process to carry out a performance.

One concern raised in performing with new musical instruments has been whether the audience could understand the performer's intent, as the perceivable relationship between required gestures and the way sound is produced has changed significantly. Schloss suggests that the visual/corporal aspects of the performer's physical interactions and the mapping decisions of gesture and sound should be carefully considered with an audience's view in mind, in order to make a convincing performance [13]. Fels et al. also suggests a transparent mapping approach that intended to improve the performer and audience' understanding of the process of sound generating by applying metaphor [4]. Paine also emphasises that new musical instruments should serve to increase not only performability, but also communication with the audience [11]. These suggestions show that having an audience in mind in the action-sound mapping process is crucial to engage with an audience.

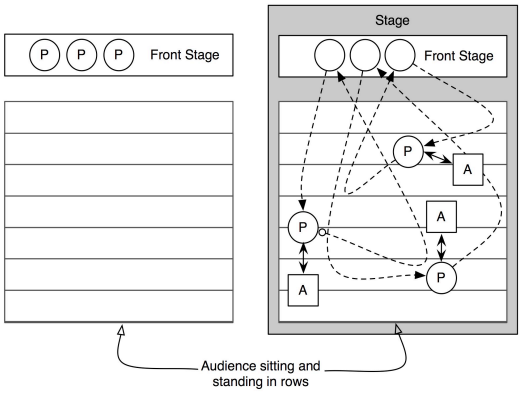
This concern of engaging with audience can be also considered from the performer's perspectives by mastering performing techniques. The importance of virtuosity was also brought up for discussion by Michel Waisvisz in NIME conference in 2006 [17]. His musical instrument, *The Hands*, established a virtuosic quality as a physical controller [16]. He also reminded us that the attempt to design and redesign the instrument not only would change the instrument's response, but also stop people to be a virtuoso of the instrument [3]. Also, Dobrian and Koppelman point out that virtuosity facilitates expression, and the mastery control of the instrument by the performer enable the mind to focus on the listening and expression [2]. This process of articulating expressivity in performance can be recognised as one effective way to communicate with the audience.

Another, perhaps a more artistic, view in thinking of how new musical instrument design can be approached is by starting the design process with a performance concept in mind. Apart from the inter-relationships between instrument, performer and audience, the way a performance is *presented* could also influence the overall audience experience. One way to take performance element into new instrument design could be based on the use of the space, and consider how technology could facilitate the exploration of space in relation to engage with audience. While there are many different types of venues, such as concert hall, club and gallery, been used as performance space, a typical setting of performance space is divided into two sections: the stage and seating area (Figure 1a). If the performer intends to communicate with the audience, this division of the stage and seating area makes the communication slightly more challenging, as the performer and audience are distanced. An often-discussed method to enhance the communication focuses on the movements of the performers, as many performances are "immobile" and restricted to a smaller movement space like concert stage [7]. Nonetheless, the media, mobile and wearable technologies have facilitated a new way of thinking of the performance stage space, which have been applied to our design approach.

3. DESIGN APPROACH

There are at least two ways to explore the use of stage in a physical space: first, the technologically augmented stage space; second, the deconstruction of the traditional idea of stage with mobile and wearable technology. The augmented space here refers to a stage that incorporates elements such as images, video, and text that the responds to performer's gesture with an interactive system. This has been explored more in the fields of theatre and dance [8, 15]. The second idea of exploring the stage space extends from the idea of the movement space. The movement space of a performer is dependent on the portability of the musical instrument, as the shape, size and the "wires" of electronic musical instruments have limited the potential performer's movement, so the performance is usually carried out in a fixed space such as front stage. However, providing a portable electronic instrument without the constraint of external cable connection would enable the performer to freely move. An example demonstrating such an idea is Greg Schiemer's Pocket Gamelan, purpose-built mobile instruments, in which its composition, *Mandala 3,* was performed at Passage Beslay, an outdoor venue in Paris in 2006 [12]. Standford's mobile phone orchestra, MoPhO, also experimented with a different stage setup for their mobile music concert in which the performers walked around with mobile phone instruments amplified the sounds with wearable speakers [10].

In a performance, continuous interaction and communication among the performer, instrument, and audience. Sustaining the "communication flow" is an important consideration in our design approach, and in particular this flow needs to get through to a rather passive audience who observes in a live performance. Although designing a scenario that invites audience to actively participate in a performance could also be an interesting way to engage with them, however, it is our intention to focus on addressing this issue with a more typical concert music performance audience, whose role is rather a passive one. This led us to consider several factors in our design, including the physical form of the instrument, the gesture and actions to play the sound, and most importantly, a performance concept. Our performance was initiated with focus on the concept of the deconstruction of the traditional idea of the stage as discussed earlier. We commenced the design process with this concept in mind to allow an inter-influence development to occur between the instrument design phase and the development of the performance structure, in which it resulted in the *Sound Gloves* project.



(a) **(b)**

Figure 1. (a) A traditional idea of the performance space; (b) the deconstruction of the traditional idea of stage. "A" refers to audience; "P" refers to performer.

4. SOUND GLOVES

The *Sound Gloves* project was carried out as a collaborative effort between project members from various backgrounds including media technology, textile design, art, and music performance. We applied the proposed design approach and resulted with three different pairs of gloves instruments, *Touch Sound Gloves*, *Castanet Gloves*, and *Theremin Gloves*.

4.1 Concept

We intended to make wearable musical instruments that would provide an option for the performer to freely walk around and engage with a rather passive audience by dissolving the distance between the performer and the audience and position sound close to some of the audience members (Figure 1b). We approached that by making three pairs of gloves as musical instruments to facilitate such an idea. The main reason in choosing gloves as the form of the instrument was that we intended to provide the performers with an intuitive feel when making sounds, and hand movements could be argued as one of the most expressive gestures. Thus, we were motivated to integrate our performance idea with the design of gloves, a suitable medium to pick up hand movements' data with embedded electronic parts. In fact, glove interfaces and instruments have been quite popular in past years [5, 14]. However, for our gloves, we wanted to avoid the notion of the sound coming from remote speakers, thus small speakers were embedded on them. This setup enabled the sound to co-locate with the performers' action, and it also allowed the sound to travel with the performer's location. Although the advance on mobile phone technology could also be considered for this purpose, the necessary gesture of holding a phone in the hand seemed to constrain our intention to explore other potential movements with the hands, as well as the possibility to interact with the audience directly. To reinforce the intuitive quality of the instruments, the design of the instruments was based on natural movements and gestures of hands, such as touching and scratching surface, lifting up and down, and moving forwards. In addition to that we also considered performing gestures borrowed from playing other musical instruments.

4.2 Technical Detail and Interaction

The electronic parts in *Sound Gloves* are used in simple configurations, and the parts include piezoelectric contact microphones, an accelerometer sensor, an ultrasonic range finder sensor, potentiometers, thin Mylar speakers, LilyPad

Arduino Simple Boards, 1000mAh Polymer Lithium Ion batteries, Lithium coin cell batteries, audio power amplifier circuits with LM368[1]. Each pair of gloves used different electronic parts to facilitate one kind of performing gestures. We attempted to use conductive threats mostly and sewed them to the glove fabrics to connect the electronic parts, to maintain the softness of the glove instruments, but with two exceptions: the connection between the two gloves of the same pair (*Castanet Gloves*); and between the amplifier and the speakers, as the use of conductive threads gave too much resistance to power, thus caused output volume to decrease.

4.2.1 Touch Sound Gloves

For *Touch Sound Gloves* (Figure 2), the sound was directly amplified with performer's actions such as scraping and tapping, which were similar techniques in playing percussion instruments. The two gloves in this pair were made with the same material and electronic parts. Two piezoelectric contact microphones, in which one of them (index finger) was soldered with a thin wire, were incorporated. These were connected to the amplifier with a small potentiometer and a thin speaker placed on the top. The amplifier circuit was powered with four coin cell batteries in serial configuration to supply 12-volt power. The circuit was hidden on the topside in the inner layer of the gloves, and the speaker, connected with metal buttons, was left on the outer layer to prevent the sound been muffled.

Figure 2. *Touch Sound Gloves*.

4.2.2 Castanet Gloves

In *Castanet Gloves* (Figure 3a), the two gloves in this pair were made with different parts, and connected together with long wire. The right-handed glove consisted an accelerometer sensor and a LilyPad attached to the top of the glove, as well as a Polymer Lithium Ion battery placed in a pocket hided in the inner layer. The gestural idea to control sounds with this pair of gloves came from playing castanets, which requires similar gesture like tapping with middle finger and thumb. Thus, the contact points were made with conductive threats sewn onto the middle fingers and thumbs on both gloves. By connecting these contact points, the sounds would be enabled. Hence, the similar performance gestures like playing castanet were required to generate sound. The x-axis of the 3D accelerometer was sending continuous data to two Pulse Width Modulation (PWM) outputs of the LilyPad, and the data was mapped to change two different frequency ranges.

4.2.3 Theremin Gloves

The design of the *Theremin Gloves* (Figure 3b) was inspired by the performing gestures in playing the Theremin. We used a small ultrasonic range finder sensor to measure distance, and it was connected to the LilyPad. The distance range data selected for mapping was between 20 to 80 cm, and it was mapped to continuous frequency changing, which was sent to a PWM output connected to a speaker. All the parts were placed on the right-handed glove. The sensor was placed on the palm side, the LilyPad was hidden in the inner layer, and the speaker was placed on the outer layer. The one-to-one mapping of action-sound for this pair was applied as we intend to keep it simple and transparent. The playing gesture of this instrument is to position the right hand towards any surface to change the frequency of the sound.

Figure 3 (a) left: *Castanet Gloves* (b) right: *Theremin Gloves*.

5. Performance: *Sound Gloves Impro 1*

The first public performance, *Sound Gloves Impro 1,* was carried out by three performers in a gallery space, filled with around eighty audience members, as part of a wearable electronics performance event. The duration of the performance was approximately seven minutes. The performance space used was the whole front gallery exhibition space, which included the front 'stage' area with a setup table and a record player, as well as the audience sitting area. This performance was organised into two parts as a structured improvisation. It began with one performer walking up to front area picked up and wore the *Theremin Gloves*, followed by playing a solo. The second performer joined her playing with the *Castanet Gloves,* followed by the third performer, who was tapping and scratching parts of clothing with *Touch Sound Gloves*, joined from the end of the gallery space, and walked through the audience area to make her way to the front stage. Once the three performers were united, they exchanged the gloves one by one to proceed to the second part of the performance, in which they moved into the audience area and began to interact with the audience. With the *Theremin Gloves*, the physical presence of the audience could have an influence to the process of sound production. When the performer changed the distance between the gloves and the audience member, the pitch would immediately change. For *Touch Sound Gloves*, the performer was applying scratching and tapping actions onto various surfaces such as audiences' chairs, and occasionally to the audience member's shoulder lightly. With *Castanet Gloves*, although the way to produce sounds was limited to solely one performer's action by connecting fingertips, the performer was still able to interact with the audience by moving hands that changed the location of sound, in which it provided new sonic experience to the audience. This improvisation ended with three performers standing on the front area with one performer positioning the index finger of the *Tocuh Sound Gloves* on the running record player. It functioned as the record player's needle, and the vibration of the record was amplifed.

[1] http://www.alldatasheet.com/datasheet-pdf/pdf/

6. DISCUSSION

The freedom of being able to move around not only on the 'stage', but also into the audience area, allowed direct and physical interaction with the audience members. The performers were able to make eye contact and exchange smiles with the audience, and it was surprising that some audience members even initiated the interaction by positioning their hands close to the performers' gloves as an attempt to interact in the process of making sound. The observed situation indicated that the audience became closer with the performer, and the communication flow was enhanced. The performers felt that these simple and subtle interactions made the performance experience and interaction more inviting and engaging.

In "the use of space" aspect, we presented a similar stage setting like MoPhO as discussed. However, the main difference was that the instrument we made enabled us to have different bodily gestures in the performance, in which it furthered the performer-audience interaction. Although there was a limitation in sound quality, the direct human-human interaction has enriched the communication flow in a performance context. In particular, in performing with *Touch Sound Gloves*, the "passive" audience played an important role, as occasionally they became the sound sources when the performer tapped and touched their shoulder. Although the idea to move around in performance space is not new, and even possible to be achieved with acoustic instruments, the notion to turn the audience into musical objects through considering the use of space, is rather different. This was made possible with the use of technology.

In virtuosity aspect, *Sound Gloves* were not difficult to achieve the mastery control of the instruments with practices, as one of our design decisions was applying natural, expressive and simple performing gestures for *Sound Gloves*. This allowed the performer to focus on interacting with the audience. Also, the designed performing actions required the performers to constantly moving their hands to produce sounds, and that enriched the visual aspects of the performance.

A casual group discussion by the artists and producers, involved in the performance event, was carried out after the first performance. This group of twenty people, who were also the audience, were in the discussion to comment on each other's works. Although the purpose of this discussion was not meant to be a formal evaluation of any work presented including *Sound Gloves,* we were able to receive comments. Some people felt the *Sound Glove* performance was interesting as the performers were carrying and moving the sounds with them. One person pointed out the walking in the performance space somehow changed the social dynamic in a positive way.

Sound Gloves project began with an intention to consider a performance work that has an audience in mind since the beginning of the conceptual development. By integrating media technology in a contemporary performance context, this project demonstrated an approach that brings the performers and audience closer as part of the interaction design. The performance outcome showed an enhancement of the social interaction in a performance context. In addition, the collaborative effort was also a valuable experience as we could learn from one and another.

7. CONCLUSION

Our design approach, made with a performance concept in mind throughout in developing phases of the new musical instruments, shaped the outcome of the work as intended. This enabled an inter-influence nature between the performance and the instruments. Future works include exploring other methods to improve sound volume and timbre variations. Finding an appropriate evaluation method is also highly desired as the current result of the discussion between the performers and the audience was too informal to provide constructive findings. Thus, for future study of the performer-audience interaction and performance outcome, an improved evaluation method will be investigated. However, we still find the design process to be a challenging, but rewarding experience.

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