Sound vest for dance performance

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ABSTRACT

The importance of spatial design in music has become more noticeable in recent years mostly due to the affordability of improved and powerful software and hardware tools. While spatial audio tools are extensively used nowadays in different kinds of musical applications, there are very few examples of mobile sound systems especially conceived for the performing arts. An original sound vest prototype featuring original costume design, a hybrid full-range loudspeaker array and an improved acoustic response was designed and implemented using data gathered from anechoic measurements and interviews with performers and audiences. Future developments of the system will consider the implementation of an extended multi-channel platform that will allow the possibility of exploring sonic and spatial relationships generated by several mobile sound sources on stage in connection with a multi-loudspeaker diffusion system.

1. INTRODUCTION

The development of cheaper and powerful software and hardware tools has allowed the topic of spatialised sound in music to gain a considerable momentum in recent decades [1, 2, 3]. The use of multi-channel sound systems for films, site-specific installations, videogames has increased awareness among audiences and artists about the creative possibilities of spatialised sound [3, 4, 5]. In recent decades the use of spatial audio tools has expanded to the performing arts, whereby performers, composers and technology developers have started to integrate mobile sound devices as organic components of music and dance projects [6, 7, 8]. While there has been some innovative dance projects involving mobiles sound systems, there is still a lack of flexible software and hardware tools that will allow artists to effectively relate creative features of music composition and dance choreography in collaborative projects. In this paper, the design, implementation and optimization of an original body-worn sound system is discussed, taking as a point of departure an interdisciplinary research approach which involved choreographers, performers, technology developers and musicians.

2. WIRELESS BODY-WORN SOUND SYSTEM

2.1 Design and implementation

Different kinds of artists and technology developers have carried out various kinds of projects involving the design and implementation of mobile sound systems [9, 10, 11]. Hahn and Bahn designed and implemented an original interactive platform for dance that included a 'sensor-speaker performer' interface, which located and reproduced sounds directly from the performer's body using two independent audio channels to feed the system [12]. From the documentation available about the system it is evident that the large size and shape of the system´s interfaces constrained considerably the movements and flexibility of performers on stage [13]. In recent years Johannes Birringer and Michèle Danjoux at DAP-Lab at Bruynel University in England have also designed and implemented different types of wearable mobile sound systems for various performance projects [14]. Aiming to enhance relationships between physical and virtual spaces, they designed and implemented original sound costumes and portable sound props to be used by performers as part of different kinds of multi-media productions. Possibly their most ambitious work involving mobile sound devices was the piece *UKIYO*, premiered in November 2010 at the Sadler's Wells' Lilian Baylis studio in London [15]. The piece was conceived as a site-specific multimedia installation where 'dancers and musicians perform simultaneously with digital objects that mutate; garments are custom-built for sound in motion' [8]. During the performance of the piece a singer and a dancer worn sound vests especially designed for the project while an actor carried two portable loudspeakers on a yoke. In the opinion of the author, the mobile sound systems used for the piece revealed during the performance technical and practical problems that constrained considerably the artistic potential and flexibility of the work. The first noticeable issue identified was the fact that the body-worn systems used by performers were large and had to be connected to a power supply, posing obvious limitations for actors, singers and members of the audience in the performing area. A second problem identified during the show was the limited acoustic power of the sound devices worn by performers. During the performance the projected sound by mobile sound sources was frequently masked by the voices of actors and sounds radiated by the PA system in the room. Taking into account some of the acoustic and practical limitations of mobile sound systems described above, it was decided to design an original wireless body-worn prototype to be tested and implemented with dancers in-situ [16]. The main objective of the project was to develop a robust and acoustically reliable system that could be adjusted to the requirements of performers in different kinds of artistic situations. The designed system had to be capable of effectively radiating sound in small and medium-size performance venues and flexible enough to allow dancers to carry out conventional movements in both standing positions and on the floor. The system considered two loudspeaker units located in the front and back of the performer's torso, a two-channel *Maxim* 25 Watt amplifier fed by 12 Volt batteries and a two channel 2.4 GHz Bluetooth transmitter with receiver set. One of the main challenges of the prototype design was the construction of small loudspeaker cabinets that will not impede dance movements and at the same time provide enough sound power to effectively radiate sound across a medium size venue.

2.2 System adjustments

Different types of tests to assess the flexibility and robustness of the body-worn system were carried out with dancers in a studio. After various trials performers were overall satisfied with the design of the system, but had certain concerns regarding the position of the back torso loudspeaker. One dancer noted that this loudspeaker restricted considerably the range of body movements, especially for actions taking place on the floor. In order to increase the control over radiated sounds by the performer, the dancer suggested to include loudspeakers attached to the arms of the performers. These suggestions were taken on board and it was therefore decided to modify the original architecture of the prototype by removing the rear speaker to include a pair of small speakers on both forearms of the dancer. As a way of finding the most suitable pair of loudspeakers for the performer's forearms, several kinds of 2-inch full-range loudspeakers units were tested and measured in an anechoic chamber. Frequency response and sensitivity measurements showed that the loudspeaker unit with the best overall acoustic performance was the *Vifa NE65W* [17, 18]. The next step in the optimization process was to find suitable cabinets for the chosen loudspeaker unit, focusing on two main design criteria. The first criterion was to maximize the acoustic power and frequency response of the *Vifa NE65W* units for small and medium size dance studios. The second criterion was to make the size of the cabinets as small as possible in order to allow the performer carry out regular dance movements in standing positions and on the floor. Anechoic measurements of the *Vifa* NE65W loudspeaker mounted on different size cabinets showed that for volumes below 250 cm^3 the variations in the frequency response and sensitivity of the loudspeakers were minor. In order to optimize the size of the forearms loudspeakers it was therefore decided to build the smaller cabinet size that would fit the *Vifa* NE65W speaker units. The volume of this cabinet was 100 cm^3 and the measured sensitivity of the loudspeaker system with this cabinet unit was 79.9 dB (1m/1W), within the range of the sensitivity of small conventional home studio loudspeaker systems and within the original expectations for the system. In order to improve the overall performance of the wearable application other aspects of the system were also modified. Regular commercial rechargeable battery units of the prototype were replaced with lithium-ion batteries, which extended the functioning duration of the system in 30 minutes and were significantly lighter than conventional commercial rechargeable batteries. Another improvement of the optimized system was the increased power of the built-in electric amplifier. A new more powerful amplifier with 30 Watt RMS per channel was added. This especially designed amplifier could easily drive two more extra loudspeakers, allowing the possibility of expanding the capacity of the current system in the future. Figure 1 and 2 show a dancer wearing the optimized body-worn system during tests in a dance studio in Valdivia, Chile.

Figure 1. Frontal view of the body-worn loudspeaker system during a dance demonstration.

Figure 2. Rear view of the body-worn loudspeaker system during a dance demonstration.

3. TESTS WITH PERFORMERS

An early demonstration of the system took place at the IX Ibero-American Congress on Acoustics in Valdivia, Chile. During the event a short dance improvisation was performed by a dancer wearing the system in a 200 m^3 dance studio. During the presentation the dancer exemplify numerous kinds of movements while the system played a two-channel mix created using different types of sounds materials. After the demonstration several members of the audience were asked about their impressions regarding the acoustic performance of the wearable sound system. Responses showed that the expressive character of the application, as well as the striking effect of the embodiment of movement and sound on and off stage, impressed most respondents. Quizzed about the acoustic power of the system, most participants considered that the application was easily capable of covering the size of a small and medium size dance studio. Questioned about the quality of the vest's reproduced sound, most respondents were positive about the overall functioning of the system, but noted that, the quality of the reproduced seemed to be very dependent on the type of sound material played [8, 15]. Another interesting aspect of the system mentioned by several respondents was that when the dancer performed in close proximity to the audience, the body-worn system was capable of creating a very intimate and subtle acoustic experience. The dancer was also questioned about his experience using the sound vest system. A considerable improvement in terms of flexibility and weight was noted in comparison to the original prototype, mostly obvious in regular movements in standing and floor positions. The performer also noted that, when in close proximity to the public, communication with the audience seemed to be enhanced by the use of the body-worn system and the possibility of being able to radiate sounds through his arms. As in similar dance projects where performers had control over sounds on and off stage, in this case the performer felt that he could play a more important role in the implementation of the piece by conceiving his artistic role as blend between a dancer and a musician [7, 18, 19].

A second demonstration of the system took place during a residency with dancers and choreographers that took place in the city of Valdivia. The demonstration was done by a dancer using the system playing synthesized tones in a dance studio. A discussion with dancers and a choreographer took place after the demonstration where various aspects of the application were examined. Initially it was agreed by most participants that the system provided a subtle sonic component to the dance, which was very dependent on the kinds of sound materials used to feed the system. It was also noted by the choreographer that it was evident the type of sound materials reproduced has a direct impact on the performer's response to the dance. Considering a new situation where the performer is no longer only a dancer, but also a musician projecting sounds through his/her torso and arms, it was clear that there has to be a process of reflection by the choreographer, performer and composer involved in the project in order to understand the new role of the dancer in the piece. When demonstrating the system it also became clear that single raw sound materials worked much better than textures of sounds that had been carefully crafted forehand. The complex shape and architecture of the system on the body of the performer and the important influence of the movement on the perceived sounds requires clean and transparent sounds that can be easily shaped during performance.

4. DISCUSSION

The aim of this study was to design and test a robust and acoustically reliable mobile sound system that could be easily adapted to the requirements of dancers in different types of performance environments. The main challenge of the project was to balance artistic, technical and practical specifications of a body-worn sound system suitable for contemporary dance practice. Early tests and demonstrations showed that sound wearable devices are very effective tools to establish close links with audiences during performances [20, 21]. Further studies with the designed system will explore ways of assessing this impact in different kinds of performance scenarios using suitable evaluation methods like listening tests with trained panels [22], context-methods surveys [3] or perceptual studies exploring spatial features music performance in concert halls [23, 24]. The impact that the sound vest has on the way performers conceive their role in a dance or music piece is also an important aspect to be investigated in future research activities. Evidence shows that performers that participated in projects involving the use of mobile sound devices consider that the use of these systems has a positive impact in a piece's artistic process, enhancing creative relationship between the choreographer, performers and the composer [7, 8]. Following developments of a related research project with students from various artistic backgrounds, further studies will explore different kinds approaches for successfully integrating compositional and choreographic strategies by relating specific body movements with sonic spatial attributes in a dance piece [20, 25]. By integrating corporeal and sonic movement, the body-worn sound system allows the composer, choreographer and dancer to investigate aesthetic relationships that go beyond the traditional associations found in dance and music performance. An interesting challenge for future performance with the system implemented in this study will be to develop a suitable framework where particular spatial and timbral features of multi-channel electroacoustic music performance can be successfully translated into a dance performance environment. Some of the early pilot tests mentioned above showed that this is an intricate issue because sound materials reproduced through stationary speakers are perceived by listeners in a very different way when they are projected through sound sources attached to a moving body. The performer's body drastically shapes the input to the sound system, making the acoustic output a complex modulated sound shaped by dance movements of the performer and the position of the loudspeaker units in the body of the performer. This implies that in order to make mobile systems work effectively in different kinds of performance environments; it is important to try out sound materials in a realistic performance environments rather than in acoustically treated spaces. In this context it is important to understand that when using the system in most dance performance situations, raw sounds, with little or no timbral and spatial processing, will work better in mobile sound systems than carefully composed sound materials, which is normally obscured by spatial and timbral modulations derived from the performer's movements.

The use of several performers wearing sound vests on stage linked with a multi-channel loudspeaker sound reproduction platform could be a natural development of this project. Early tests with two pairs of commercial wireless loudspeakers carried by actors synchronized with a four-channel fixed system revealed the potential of mobile sound sources to effectively enhance various performance features of multi-channel electroacoustic music that are normally lost in most concert situations [1, 20]. Trials with 8-channel hybrid systems as the ones mentioned above showed that by means of blending and contrasting multiple real and virtual sound sources on stage a greater sense of intimacy for audiences can be achieved, as well as an effective spatial counterpoint between travelling sounds sources on stage and projected sounds through a fixed sound reinforcement system. The artistic, perceptual and practical implications of such hybrid arrangements will be studied in future developments of the project presented here.

5. REFERENCES

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