FLEXIBLE SPATIAL DESIGN FOR DANCE PERFORMANCE

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ABSTRACT

The role of spatial design in music has become more prominent in recent years mostly because of the affordability of powerful software and hardware tools. Spatial design tools for electroacoustic and computer music are widely used nowadays in studio and concert environments with very few examples of applications for dance and theatre performance. An innovative wireless body worn loudspeaker system for dance performance is proposed including original features for cabinet design, frequency response and power performance taking into account acoustical and artistic considerations for performance. Future developments of the designed system are outlined considering the possibility of expanding it into an extended integrated performance platform.

1. INTRODUCTION

As shown by a recent survey, the availability of cheaper and more powerful spatial design tools has encouraged composers to develop more refined and ambitious approaches to the use of space in their compositions [Otondo 1]. In most cases, spatial tools used by electroacoustic and computer music composers in their works are conceived for very specific purposes within studio, concert or site-specific frameworks [Normandeau 2, Otondo 3, Stefani 4]. There seem to be very few recent examples of compositional projects where simple or complex spatial tools have been effectively integrated within dance or theatre performance environments [Ghettoblaster orchestra 5, Hahn and Bahn 6, Ukiyo project website 7]. Motivated by the idea of developing an interdisciplinary approach to the use of spatialised sound in the performing arts, the current project aims to develop a mobile loudspeaker platform to be used as a flexible tool to explore spatial relationships between dance and experimental electronic music.

2. MOBILE SYSTEMS FOR DANCE THEATRE PERFORMANCE

2.1. Initial tests with portable radios

The first ideas for this project incorporated the use of mobile sound sources to be used by singers and actors as part of a hybrid multi-channel system for the performance of the dance theatre piece *To have done with the judgment of Artaud* at the 2007 Edinburgh Fringe Festival [Otondo 8]. The music for the piece was composed as a large-scale four-channel composition using portable radios that were manually synchronised with the PA system of specific theatre venues. Figure 1 shows an example of the use of the four-channel hybrid system during the performance of the piece where two performers carry mobile sound sources (channels 1 and 2) and the main stereo PA system at the venue plays a stereo mix (channels 3 & 4). The advantage of this system was the simple nature and flexibility of the technology used but its clear limitation for performance was the need for manual synchronisation between the fixed and mobile sources during performance [Otondo 9].

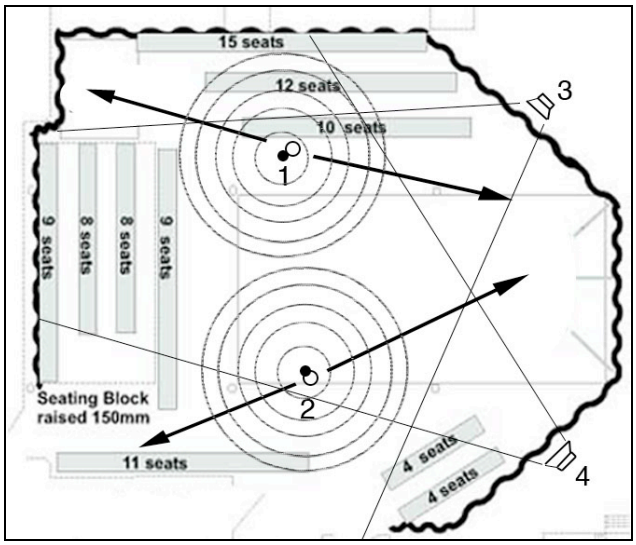

Figure 1. Four-channel mix played through two wireless mobile sources and a stationary stereo system at the 2007 Edinburgh Fringe festival.

2.2. Initial tests with commercial wireless loudspeakers

Due to the synchronisation problems of the portable radios mentioned above a similar approach was tried in performance with two performers carrying commercial wireless loudspeakers [Rimax 10]. Initial tests with this hybrid system showed that the use of synchronised sources as part of an overall multi-channel system allowed the possibility of a good interaction between the composer and the performers carrying wireless sources, as successfully shown by the pioneering work of Henry Brant with travelling instrumentalists in the 60s [Brant 11]. The use of wireless technology also opened new possibilities for using sound in performance in much more flexible and effective ways allowing the option of easily adjusting the composition's spatial design to different venues and seating configurations. Figure 2 shows an example of trials carried out at the Jack Hylton concert hall at Lancaster University using an 8-channel mix played through a fixed quad system surrounding the audience (channels 1 - 4) and four wireless loudspeakers carried by the performers on stage (channels 5 - 8).

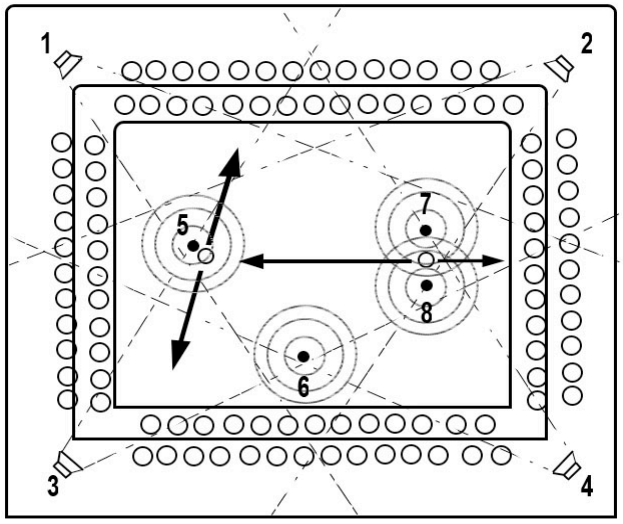

Figure 2. Example of tests using an 8-channel mix played through a fixed quad system and four mobile loudspeakers carried by performers.

2.3. Limitations of commercial systems

The use of synchronised wireless loudspeakers allowed the possibility of creating a flexible environment where performers could take an active role in the implementation of the spatial design for a specific devised work. The limited frequency range, the poor sound quality of the speaker units and recurrent interference problems with the wireless system during performances contributed to the decision of developing an original wireless loudspeaker system that could be used in performance to professional standards.

3. BODY WORN SPEAKER DESIGN

3.1. Proposed system

The goal of the project was to create a reliable and robust wireless body worn speaker system that could easily be adjusted to the requirements of performers in different circumstances and performance environments. Following a series of discussions with engineers from the company Green Light Audio Visual the basis for a prototype design was agreed [Green light Audio Visual 12]. The original idea for the prototype included two loudspeaker units to be placed on the front and the back of the torso of the performer fed by independent audio channels, and a professional wireless platform following the highest professional audio standards within the industry. Figure 3 shows the first examples of the loudspeaker prototypes during pilot tests with the performer Vicky Harper at Lancaster University.

3.2. Cabinet and speaker design

One of the more challenging aspects of the project was to design small speaker cabinets that could be flexible enough to be used by performers and at the same time provide a good sound quality. The basic goal was to provide a complete speaker package including two housings, connections and supports that could be adjusted for each performer. Each loudspeaker was built using rigid materials such as fibrous wood and plastic. The rear of the housings was curved in order to offer a reasonable fit for performers within a range of sizes. In order to do this the speakers had a small amount of adjustment to the curvature of the chest and the back. The speakers were covered in light black fabric to minimise the visual impact of the housing. Both speakers were supported by flexible straps over the shoulders and round the torso. Several tests were carried out with the performer to establish the best solution for width, elasticity and adjustment of the straps.

Figure 3. Prototypes of the body worn loudspeaker system worn by the performer Vicky Harper.

3.3. Speaker power and receivers

The loudspeaker amplifiers chosen for the project were class D digital amplifiers which offer very high efficiency and reasonable quality. In this case, the efficiency does not only extends battery life but also minimises the heat output of the amplifier. After several initial tests it was decided to host the amplifier units on the power belt carried by the performer. In order to keep the size and weight of the speakers to a minimum the battery pack, power controller and radio receivers were mounted on the belt to be worn around the waist or hips. The belt contains a power control circuit, radio receivers, a removable battery pack plus the two digital amplifiers. Considering the setup mentioned above the battery packs should last for a target time of approximately 60 minutes of continuous operation. Later tests with the system showed that this time could be extended to several hours in most performance situations.

3.4. Signal routing, processing and transmission systems

The base station for the mobile system will consider a mixer with two available channels for the performer's mixer. The two channels to be played will be processed at two stages before transmission. The first stage will include filtering and delays in preparation for a full range signal to be sent to the performer and low frequency elements to be sent to one or more bass drivers on or near the performance area. The second stage will involve equalisation of the signal before being sent to the performer. The limited volume of the speaker housings are likely to require a low frequency boost and adjustment of high frequencies for best performance. This will be done using a graphic equaliser which will be set up considering the measured frequency response of the speaker outputs in a semi-anechoic environment.

The transmission systems considered for the project will be a 2.4 GHz digital transmission links and UHF analogue transmission which should allow a suitable bandwidth as well as reducing the size and power consumption of the receivers.

4. PILOT TESTS WITH PROTOTYPES

4.1. Frequency response

The first tests with the performer using the prototypes of the body worn speakers focussed on testing the quality of the frequency response of the body worn speakers as well as the acoustic power to be used in different types of acoustic environments. The initial frequency response tests of the speakers done with the performer in different venues showed that there were some undesired colouration produced by the shape and features of the cabinets used. After several tests in a semi-anechoic environment done by *Greenlight Audio Visual* staff these colourations were reduced considerably. It was important to take into account in all the tests and trials with the prototypes that the frequency response of the speakers does change dramatically when attached to the body of a performer which adds a rigid support to the back of the speakers making the sound projection more clear and stable than when testing the portable speakers independently.

Figure 4. Dancer wearing the final version of the designed body worn loudspeaker system.

4.2. Power performance

Another important aspect of the tested system was that the power performance of the speakers would be suitable. It was therefore very important to confirm that the body worn speakers would be powerful enough to perform in different kinds of circumstances and acoustical environments. Initial tests with the prototypes showed that the power performance was adequate for most venues and when carefully balanced with the venue's PA system the body worn speakers can respond very well. Several test carried out with different models of PA loudspeaker in different positions of the room showed that, when levels were adjusted correctly using small equalisation adjustments, the portable system can have an optimum performance. Figure 5 shows tests with the performer in a concert hall using the body worn system and various PA systems playing different kinds of sound material.

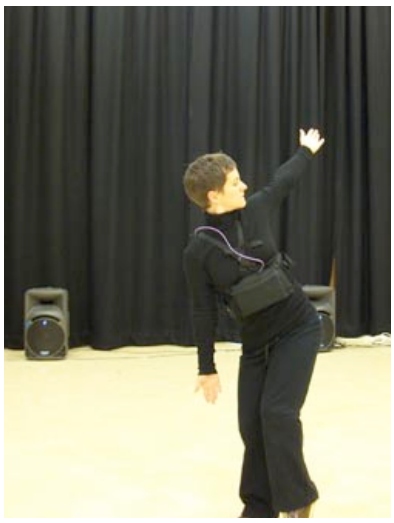

Figure 5. Dancer testing the body worn system within a multi-speaker system rig.

4.3. Tests at different venues

Initial tests with the system in two different performance spaces suggested that the wireless system could be adapted to different room shapes and acoustics by carefully balancing sound levels (Dance and music project blog 13). It was also shown that by using simple signal processing techniques like equalisation and delays, the body worn speakers could be effectively used in connection with different types of multi-channel systems. Considering the size of the speaker units on the cabinets of the portable system, the system's quality of sound reproduction tends to be more prominent in the middle and high frequency range in large space like the one shown in Figure 5. This also implied that the directivity of the speaker units is prominent for high frequency sounds and should be taken into account when devising performances in different venues. The acoustic contrast between front and back speakers in performance also provided an interesting contrasting tool that can be effectively used for dramatic effects in different kinds of venues and audience configurations. Tests also showed that effective intimate and distant dramatic effects could be created by carefully balancing the sound of the wireless system in relation to a sound reinforcement system.

5. CONCLUSIONS AND FUTURE WORK

The designed body worn loudspeaker system presented here proposes a new flexible approach to the use of spatialised sound for dance performance. Initial tests with the designed system suggest that, by using synchronised mobile acoustic sources in connection with a different types of multi-channel systems, interesting complex spatial relationship between movement and sonic material can be established. Future developments of this project will explore the idea of devising a combined creative approach for dance and music using mobile technology as an active tool to adapt and implement devised works in different kinds of performance environments.

6. REFERENCES

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