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Exploratory microphone techniques for three-dimensional classical music recording

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ABSTRACT

At McGill University's Redpath Hall, a conventional stereo recording array was augmented with additional microphones in both the horizontal and vertical planes, yielding a fourteen channel surround sound recording, featuring seven discrete height channels. Based on existing multichannel recording models, microphone placement was designed to prioritize listener envelopment. Preliminary evaluations of the recordings by the authors and fellow researchers from the Graduate Program in Sound Recording at McGill University found that these 3D recordings have an increased sense of envelopment and realism as compared to traditional 5.1 surround sound. The authors have identified several areas to be further investigated through future recordings and listening tests.

1. INTRODUCTION

Common music playback formats, stereo and 5.1 surround, offer a decidedly two-dimensional listening environment, recreating sounds only in the horizontal plane. Three-dimensional audio formats featuring height channels, such as Japan Broadcasting Corporation's (NHK) 22.2 Multichannel Sound [1] offer the potential to recreate musical performances with an unprecedented sense of depth and realism.

1.1. Historical Context

Classical music and the concert hall are strongly linked: the venue creates sonic reflections and reverberation that envelop the listener, while also informing the musicians' performance. Numerous recording techniques have been developed to capture an ideal and realistic balance of music and reverberation for stereo and/or 5.1 surround. However, few such techniques have been discussed or developed for 3D audio formats, leaving a large gap in the current knowledge base of music production. NHK's 22.2 surround sound features a scalability that easily allows for down-mixing audio content to any other multichannel system [1] [2],

making it an ideal research tool for developing versatile 3D recording techniques. However, the small number of publications that specifically address recording for NKH 22.2 have mostly dealt with topics such as live sports broadcast [3] or ambience recording for television specials [4].

1.2. Motivation

Research has shown that the addition of vertical "height" channels to 5.1 surround sound improves a number of subjective listening attributes, such as depth, presence, envelopment, intensity and naturalness [5] [6] [7]. The authors created an experimental fourteen-channel double layer microphone array, with the hope that the resultant recordings would yield a better understanding of what steps need to be taken to improve music recording for 3D playback systems. At this stage, the authors are not concerned with developing "definitive" microphone arrays (such as a Decca Tree). Rather, the focus of this investigation is to determine what sonic information yields the best listening experience in terms of envelopment and realism.

2. METHODOLOGY

The recordings took place in McGill University's Redpath Hall (Fig. 1). The hall measures 27.8m in length by 13m wide, with a height of 13.35m; the RT60 is approximately 1.7sec. The musicians (a small baroque ensemble) were setup in a “quasi-concert" positioning that was determined ahead of time by the group leader and recording producer as being one that would deliver ideal sonic depth and stereo imaging.

2.1. Recording Methodology

Typical of many commercial recordings, the sessions were split over two days. For the first day, the recording team focused only on stereo capture. The main stereo array consisted of two DPA 4006TL omnidirectional microphones, spaced 60cm apart, 2.51m high (from the floor to capsules), and at a distance of approximately 1.15m from the ensemble leader (violin). Spot microphones were also placed near each instrument for additional detail: *Violin:* Royer SF-24, *Cello:* Neumann m149, *Theorbro:* Schoeps MK4, *Harpsichord:* two Schoeps MK21, and *Portative Organ:* two Neumann U87i. (Fig. 2)

Figure 1: Redpath Hall during recording sessions

Figure 2: Baroque Ensemble

On the second day of recording, an extended setup period allowed for the addition of a number of microphones, for both horizontal surround and discreet height channels. At the same height as the main pair were added two cardioid DPA 4011s facing outward +/- 90°, and two more DPA 4006s fitted with 50mm Acoustic Pressure Equalizers as surrounds. (A Sennheiser MKH 30 was added as a centre channel pickup, but was not used in the mix.) For the height array, a combination of four omnidirectional Neumann KM 183s (L, R, LS, RS), and two DPA 4011s (LL and RR) were employed, all at a height of 3.72m. An additional DPA 4011 was placed in the centre of the height array, facing upward, capsule height 4.07m (see Fig. 3, 4). All microphones were connected to a Merging Horus audio interface. Audio was recorded to a Pyramix workstation at 96kHz/24bit resolution. Monitoring took place in a nearby control room featuring seven Focal Audio loudspeakers, arranged for playback as: L, C, R, LS, RS, L Height and R Height.

2.1.1. Methodology of Microphone Placement

A great deal of literature exists on microphone techniques for 5.1 surround, many of which could easily be adapted to expanded 3D recording arrays. In this case, the authors chose the microphone positions for the surround array largely based on their personal experience in recording classical music. Recording techniques by Hamasaki [8], Fukada [9], and Polyhymnia were also re-examined. Microphone type and placement choices for the height array were largely experimental, and focused on capturing a variety of sonic information. The decision to include "lateral" microphones in both the main and height arrays was based primarily on research showing the importance of lateral reflections for listener envelopment [10].

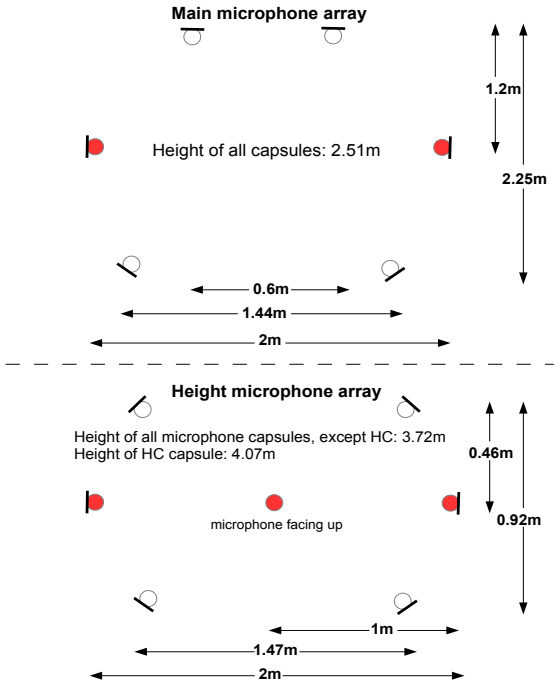

Figure 3: Microphone Arrays as seen from above

2.1.2. Playback Methodology

The authors, along with several other McGill Sound Recording faculty and researchers, evaluated these recordings in McGill University's Studio 22, a purpose-built multi-channel listening room with up to 28 channels of discreet audio playback via *M-25* speakers made by Musikelectronic Geithain GmbH, powered by Flying Mole digital amplifiers. The evaluated mix featured the following playback elements:

Main Level: L, C, R, LL, RR, LS, RS

Height Level: L, R, LL, RR, LS, RS, and Above Head Centre channel.

Figure 4: Microphone Arrays setup for recording

3. RESULTS

All listeners agreed that the addition of discreet height channels to the main playback level yielded a significant increase in the envelopment and realism of the recordings. There was also a general consensus that the four height channels that used omnidirectional microphones (L, R, LS, RS) likely contained too much direct sound and not enough decorrelated or diffuse sonic information. This was especially noticeable in the 2 front height channels, which had a tendency to “pull”

certain elements of the image upward. In general, it was found that the height channels needed to be balanced fairly high in the mix in order to create enough "impact" for the listener. The lateral height channels were deemed to have the best mix of decorrelated and diffuse sound, which is understandable, given that those microphones were cardioid pattern and facing away from the ensemble. The main level lateral channels were also thought to increase envelopment, though they too suffered from the problem of containing not enough diffuse, decorrelated information, and were at times somewhat disruptive to the frontal image.

Several listeners who took the time to perform a more detailed analysis of the individual components of the height channels observed that when only adding pairs of height channels (eg. L+R or LL+RR) to the main level, the addition of the Above Head Centre channel increased the overall cohesion and envelopment of the sound, which is consistent with Oode et al.'s findings on the importance of an Above The Head speaker to reproduce spatially uniform sound [11].

4. DISCUSSION

Based on existing research, as well as our own experimental recording, the authors believe that the addition of discreet height channels to classical music recordings significantly increases listener envelopment. What remains to be seen is exactly what components of height information are the most important to achieving this increased envelopment and realism. This test recording has already given the authors several ideas for further studies that would benefit from formal listening tests, including creating recordings that achieve similar sonic results using less height channels, as well as looking at improving the spacing and placement of lateral microphones for the main playback layer. Also of interest to the authors is whether or not listeners prefer certain polar patterns for height array microphones. 3D music recording is still very much in its infancy: hopefully this and additional studies will result in techniques and/or recommendations that can benefit the audio community at large.

5. ACKNOWLEDGEMENTS

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