HARMONY OF THE SPHERES – COSMOLOGY AND NUMBER AESTHETICS IN 16TH AND 20TH CENTURY MUSIC FOR VIOLA DA GAMBA

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ABSTRACT

Harmony of the Spheres is a concert programme based on cosmology during the renaissance. Historic philosophical and astronomical concepts from ancient Greece until the modern age are accessed through the music of the 16th and 20th century. The five musicians of the ensemble ORLANDO*viols* play on violas da gamba of several sizes, but also employ the potential of electronics and digital signal processing to craft musical concepts in space. Low-delay real-time spatial processing is applied to the instruments and presented via a multi-channel speaker setup.

1. INTRODUCTION

Many astronomers and philosophers from ancient Greece up until the 16th century believed that all things in the universe, and most specifically the planets moving on the spheres around the earth, are in a great and universal harmony to each other [1]. Mathematical relations, number aesthetics and fear of God are aspects of this imagination, which together with their critical reflections can be found in the music of the renaissance as well as in many contemporary works [2]. A number of pieces following these concepts have been selected for the concert programme *Harmony of the Spheres*. In addition to the musical contents, the spatial dimension of the underlying concepts are emphasised, by both a unique isotropic setup around the audience, and electro-acoustic spatial processing of the historic instruments.

Violas da gamba are stringed, bowed and fretted instruments of several sizes, with six or seven strings. Their fine gut strings produce a delicate and, due to the concordance of the many fretted strings, a resonant sound. The sound processing is carefully tuned to the multifaceted sound qualities of the historic instruments. High quality sound reproduction with a flat frequency response, low distortion and moderate sound levels are essential for this electro-acoustic performance.

2. THE PROGRAMME

The programme *Harmony of the Spheres* is centred around the piece *In Nomine* of a little known Englishman of the 16th century, Mr. Picforth [3]. In this piece each of the five voices represents one of the five planets recognised throughout that time – Mercury, Venus, Mars, Jupiter and Saturn (see Fig. 1). All notes within one voice have the same length throughout the whole piece, but each part has its own duration, resulting in a pulse proportion of 12:8:6:3:4. The parts move like the planets on their trajectories to be once in opposition and then in conjunction. These trajectories are projected into the space of the concert hall: The sound of the instruments is not bound to a fixed place as it would be in a conventional concert, but moving in space as if the musicians are floating around. Since each planet has its own speed, the music is perceived from ever-changing spatial constellations. The trajectories are modelled after three different systems of celestial mechanics: The first system originates from the beginnings of ancient Greek astronomy. The planets are mounted on invisible spheres around the earth, thus moving in circles. The second system is attributed to Ptolemy [4], and was derived by careful observation of the planets. Although the earth is still thought to be in the centre of the universe, the planets are moving on more complex epicycles. The third system was proclaimed by Johannes Kepler [5]. He found that the planets move on elliptic paths around the sun (see Fig. 2). With the help of modern spatial presentation techniques the differences between these three models will become audible to the listeners.

The piece *Mirrors in the mirror* for violin and piano by Arvo Pärt was composed in 1978 following strict mathematical rules [6]. Although the piece is completely determined by a small set of simple rules it shows brilliant clarity and aesthetics. This piece has been specially adopted for viol consort for this programme. The spatial processing follows the same rules which were used for the composition of this work.

Musical content is often created by subtle deviation from rules and regularities in 20th century Minimal Mu-

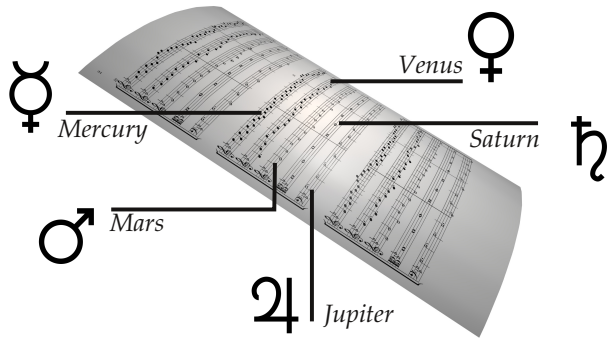

Figure 1: The five voices in the piece *In Nomine* by Mr. Picforth represent the five planets known at the time of composition.

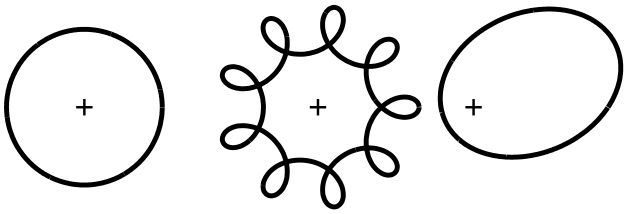

Figure 2: Schematic planet trajectories of the three cosmology models: Left is the first model with the planets moving on circular spheres, in the middle the planets follow epicycles, and on the right Kepler-ellipses are used.

sic. This is particularly obvious in the opus *Violin Phase* by Steve Reich, composed in 1967 [7]. This piece, originally written for violin and tape recorder or four violins, is played as *Viol Phase* for five violas da gamba. A short sequence, using six different notes, is repeated constantly throughout the whole piece. However, minimal tempo changes and the resulting time shifts lead to unexpected melodic motives. Despite the spacious presentation and large distances between musicians the precision of microscopic timing will be made audible through the electro-acoustic presentation.

Other composers of the programme are Christopher Tye (c. 1505-1572), Lee Santana (*1959), William Lawes (1602-1645) and John Cage (1912-1992).

3. SETUP

3.1. The Stage

For an optimal perception of the spatial effects in the programme *Harmony of the Spheres* an unconventional arrangement of musicians and audience is needed: The musicians play on the edges of a large regular pentagon. Within this pentagon is a 3rd oder Ambisonics system [8, 9] built from ten loudspeakers on a decagon. Within this circle sits

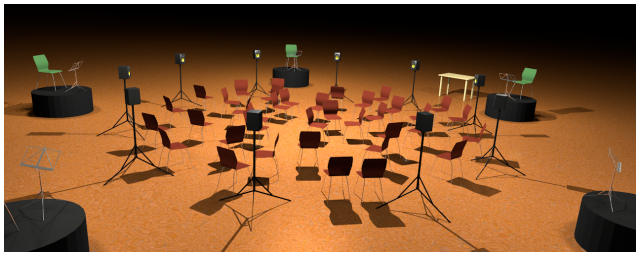

Figure 3: Simulation of a concert room.

the audience. Due to the isotropic nature of the arrangement of musicians and loudspeakers there is no distinct direction of the audience. The audience's chairs should ideally be placed randomly within the decagon. In this programme the reception of the individual musicians is ulterior to the spatial sensation of the whole ensemble. The lighting is preferably a discreet illumination of the musicians and their instruments in an otherwise dark room to shroud the visually dominant physical dimension from the audience. A typical concert room is simulated in Fig. 3.

3.2. Limitations

The precedence effect (also commonly known as "principle of the first wavefront") describes the fact that we can hear the direction of sounds even in reverberant rooms, despite the fact that reflections from many directions contribute to the received acoustic image [10, 11]. The precedence effect is relevant whenever the same sound comes from at least two different directions, with different relative delays. For short delays the sound is heard as one sound from the direction of the leading source. At moderate delays, the sound is still perceived from the direction of the leading source, but also an echo is recognised. However, if the lagging sound is much louder, it still can dominate the localisation.

For spatial presentation of acoustic sound sources, the audience will always hear the direct acoustic sound and the spatially processed sound simultaneously. To avoid a localisation dominance from the direction of the acoustic instrument due to the precedence effect, the musicians should be located so that the direct sound arrives later than the processed sound through the loudspeakers for all listening positions. Most rooms require minor exceptions, which can be accepted if the amplification is sufficient.

Other limitations are inherent to the Ambisonics playback system: The usable sweet spot at which the localisation is acceptable is limited [12]. Also the maximal radius of the loudspeaker ring is limited by echo effects for off-centre listening positions [13], and by the maximum power of the loudspeakers.

An ideal concert room offers space to fit a pentagon with 10 meters radius, and a loudspeaker ring with ap-

proximately 6 meters radius. This setup provides space for about 100 listeners. Non-orthogonal rooms with large room height and low reverberation are preferable. Within the loudspeaker array there should be no large obstacle like columns.

3.3. Signal processing strategies

The signal flow of the concert setup is schematically shown in Fig. 4. The sound of the five instruments is picked up by close microphones for signal processing and monitoring. These signals are converted to the digital domain and are processed on a personal computer running a Linux workstation optimised for low-delay audio processing. Besides applications specifically developed for this concert, many Open Source Software is used: Jack Audio Connection Kit (Paul Davis), Ardour (Paul Davis), AmbDec (Fons Adriensen) and Ambisonics-related LADSPA-Plugis (Fons Adriensen, Jörg Nettingsmeier and Richard W. E. Furse). After processing, the signal is converted back to analogue and sent to loudspeakers and monitor headphones. The direct monitoring for the musicians is routed on the audio hardware with 'zero' latency.

In all pieces, the signal of each instrument is passed into a trajectory generator, which creates the positioning information of the virtual sound sources. These trajectory generators differ between the pieces and are the heart of the spatial concept. The virtual trajectory controls an Ambisonics panning method with a reverberation-based distance effect [14, 15]. The signal rendered in Ambisonics format is fed in an Ambisonics decoder for the loudspeaker system, and into five combinations of static signal rotators with a binaural Ambisonics decoder for individualised monitoring by the musicians. Additionally, the direct sound is passed via a zero-latency matrix mixer for individualised direct monitoring with synthesised binaural level cues.

4. THE ENSEMBLE

ORLANDO*viols* is a viol consort, inspired by the historical context of consort music but also open to the sounds of our modern communication society. Although all members are successful as soloists, transparency and communication in polyphonic music and a common consort sound is of greatest importance to ORLANDO*viols*. The concept and realisation of the audio signal processing has been developed by Giso Grimm, who, besides being a musician also works as a physicist in the area of hearing aid research, with a focus on algorithm development and low-delay audio processing.

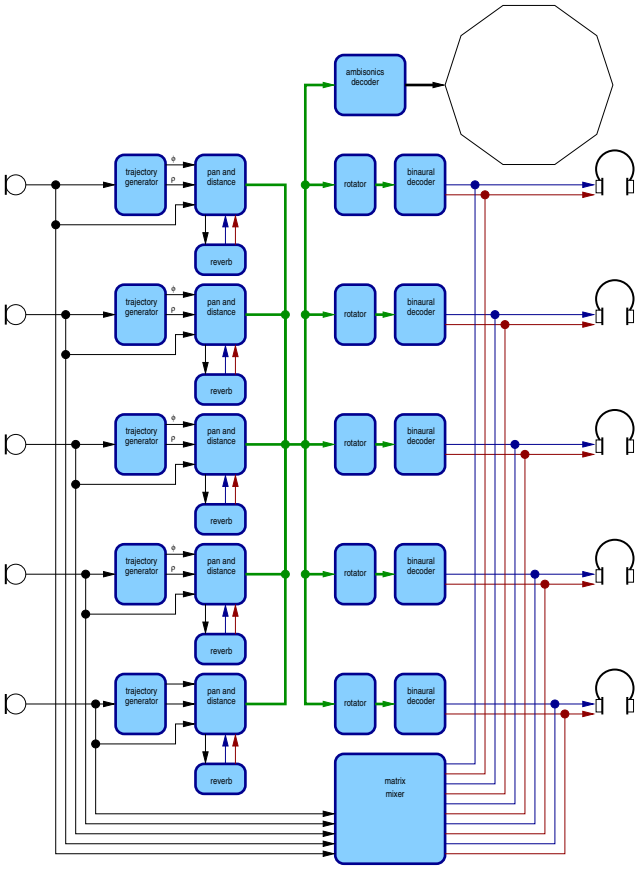

Figure 4: Schematic signal flow in the concert processing setup. On the left side are the five instrument microphones. The trajectories are rendered in the trajectory generators and used to control Ambisonics panning. The output signal is down-mixed in Ambisonics format, and routed to the loudspeaker and to an individualised binaural rendering for the monitor mix. Black lines denote monophonic signals, blue-red pairs are stereo signals, and green lines are used for signals in Ambisonics format.

Figure 5: ORLANDO*viols*

5. CONCLUSIONS

Harmony of the Spheres is a concert programme which utilises multi-loudspeaker setups for spatial presentation to

deliver cosmological concepts in music to achieve a unique listening experience for the audience. Modern technology and inputs from psycho-acoustic research have been considered during the planning and also production/performance of this programme. The sound processing has been carefully tuned to the multifaceted sound qualities of the historic instruments and aims to provide the audience a concert experience of unprecedented intensity.

6. REFERENCES

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