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Creating a highly-realistic "Acoustic Vessel Odyssey" using Sound Field Synthesis with 576 Loudspeakers

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ABSTRACT

“Acoustic Vessel Odyssey” is a sound installation realizing the future of music by using Sony’s spatial audio technology called *Sound Field Synthesis* (SFS). It enables creators to simulate popping, moving and partitioning of sounds in one space. At the "Lost In Music" event, where we demonstrated “Acoustic Vessel Odyssey”, the immersive experience provided by SFS technology was further enhanced by a new, specially designed loudspeaker array consisting of 576 loudspeakers. The content was choreographed by sound artist Evala and is accompanied by a light installation created by digital media artists Kimchi and Chips. In this paper, we present the details of the system architecture as well as technical requirements of “Acoustic Vessel Odyssey”.

1 Introduction

Over the past few decades, sound artists and audio engineers have explored new styles of music representations, especially the manipulation of sound source locations in real space. However, conventional channel-based audio was insufficient to live up to their expectations and thus limited creators’ freedom to place sounds in space. Meanwhile, spatial audio technologies have evolved over time thanks to the tremendous effort done by academia and industries. In particular, physical model-based techniques such as Wave Field Synthesis [1, 2] and Higher Order Ambisonics [3] are favored techniques because both offer more freedom to control sounds in space. In [4], a virtual rock concert was designed by Wave Field Synthesis and the result was investigated with a listening test. We refer the interested readers to [5, 6, 7] for more details about sound installations and physical model-based techniques. In this paper, we introduce "Acoustic Vessel Odyssey", a sound installation which was recently exhibited at the "Lost In Music" event organized by Sony Corporation. The audio content of the installation was generated by Sony’s *Sound Field Synthesis* (SFS) technology.

The remainder of the paper is structured as follows. In Sec. 2, we briefly introduce our Sound Field Synthesis technology while omitting technical details. From Sec. 3 to 5, the technical requirements for building "Acoustic Vessel Odyssey" are described. The event summary is given in Sec. 6 before we conclude this paper in Sec. 7.

2 Sound Field Synthesis Technology

SFS technology enables content creators to control the position of multiple virtual sound sources in real space. Certain types of waves such as spherical waves or plane

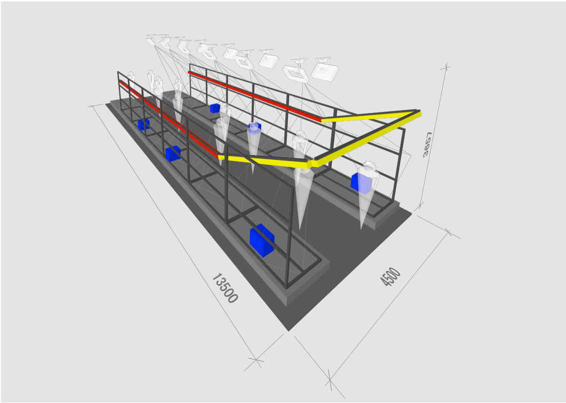

Fig. 1: Speaker layout of Acoustic Vessel Odyssey.

waves can be created by changing delays and gains of driving signals for individual loudspeakers. In contrast to traditional surround systems, SFS does not suffer from a sweet spot problem and is also not restricted to any specific loudspeaker layout. Moreover, compared with existing spatial audio technologies based on a physical acoustic model, e.g., Wave Field Synthesis, SFS has an advantage in terms of wave front reproduction accuracy, especially for high frequencies. This was achieved by incorporating the idea of Higher Order Ambisonics where the Ambisonic order is limited in the spherical harmonic domain to circumvent the well-known spatial aliasing problem.

3 Software

The spatial movement of sounds can be designed and controlled by a *digital audio workstation* (DAW), e.g., Nuendo, on a host PC. While a sequence of source locations is transmitted by *open sound control* (OSC) protocol, audio streams are delivered to the SFS player in the client server via a pair of *Multichannel Audio Digital Interface* (MADI). According to the source location, multichannel spatial filters are selected and convolved with the transmitted audio stream to create the loudspeaker driving signals.

4 Hardware

The design of "Acoustic Vessel Odyssey" is based on a line of 50ft-long corridor and a total of 576 loudspeakers are deployed on the left and right sides of the corridor as well as above the exit space located at the end of the corridor. Fig. 1 shows the actual speaker layout. The red bars on both sides of the corridor indicate two parallel loudspeaker arrays each with 192 loudspeakers. Their height matches the height of the listener' ear. The yellow U-shape bar indicates another array with 192 loudspeakers which are located above the listener's head in order to allow listeners to easily leave the listening area. The playback of each 192-channel loudspeaker array is controlled independently by a server equipped with the HDSPeMADI FX audio interface. For the left and right side arrays, the 192 channel signals are generated by a dedicated software in the SFS server and are delivered to twelve D/A converters supporting 16 channels each. The analog outputs are further amplified by a series of 12-channel amplifiers. The emission of sounds is achieved via loudspeaker arrays dedicated for SFS technology. Details can be found in the next paragraph. For the last 192-channel array located at the exit, six D/As and amplifiers supporting 32 channels each are used to feed the driving signals to the loudspeakers.

The loudspeakers for "Acoustic Vessel Odyssey" were specifically designed to improve the accuracy of the reproduced sound waves. A schematic of them can be found in Fig. 2. The key specifications are as follows:

- Configuration: 2-way
- Transducers: 10 mm dome tweeter, 40 mm woofer
- Enclosure: Closed-type
- Impedance: 4 ohm
- Frequency Range: 180 - 100 kHz

To create a highly immersive experience, we applied our latest transducer technology which was commercialized for Sony's flagship soundbar models. The woofer part uses a magnetic fluid structure, enabling both high efficiency and low distortion playback. It also supports a sturdy carbon fiber diaphragm providing a quick response to middle and high frequencies with low distortion. The tweeter part can cover the frequency range over 20 kHz. Apart from the dedicated loudspeakers, we provide sub-woofer loudspeakers to compensate the low frequency range below 180 Hz. Since SFS technology assumes that each loudspeaker emits a spherical wave, we took the following approaches to ensure that this assumption is met:

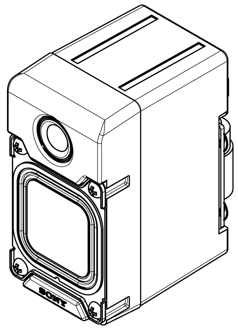

Fig. 2: Loudspeaker design for Sound Field Synthesis.

1. A closed-type enclosure to achieve a flat phase response in a low frequency range,
2. a flat diaphragm to reduce the interference of sound waves caused by its aperture, and,
3. a round shape edge of the baffle plate to reduce the diffraction of sound waves.

Thanks to the technologies listed above, the specially designed loudspeakers can successfully approximate an ideal spherical wave over a broad frequency range, thus improving the accuracy of the reproduced sound field.

5 Content creation

"Acoustic Vessel Odyssey" allows visitors to have a highly immersive listening experience by a unique combination of music, SFS technology and light installation that creates an illusory space. Enveloped in a dynamic wave of sound, visitors are taken on an audio voyage beyond time and space spanning cityscapes, lush forests, the depths of the ocean, and even the outer reaches of the solar system. In addition to a time based music composition, the spatial composition designed by the sound artist Evala made it possible to create an unreal experience by taking familiar sounds and reflecting them in a new way by exploiting the characteristics of SFS. The sound is accompanied by a light art installation created by digital media artists Kimchi and Chips. 576 tenuous threads, which is the same number of speakers, are activated by digital video projection which tightly match onto each individual string. They also created video projections that respond to the motif of sounds like water, forest birds, whisper voices, flying objects etc.

Fig. 3: "Acoustic Vessel Odyssey" demonstrated at "Lost In Music".

The combination of sound and light installation enables listeners to feel being in an unreal space beyond our physical world.

6 Event summary

Sony Corporation held its brand campaign, called "Lost In Music", which delivered novel music experiences to fans using Sony's latest technologies. The brand campaign consisted of live music events and Virtual Reality experiences enabling fans to immerse themselves in music. "Acoustic Vessel Odyssey" was first exhibited on 20th and 21st January in Los Angeles and from 10th to 16th (except 14th) March in Austin, US during SXSW in 2018. Fig. 3 shows a picture taken inside the installation.

7 Conclusion

In this paper, we showed how the highly-realistic sound experience "Acoustic Vessel Odyssey" could be realized using Sony's SFS technology together with a large loudspeaker array installation. We described the technical requirements of our system and also summarized the event "Lost In Music" where "Acoustic Vessel Odyssey" was first exhibited.

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