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Environment Adaptive Sound Localization for Multi-Channel Surround Sound System

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Abstract

Recent development in multi-channel surround is emerging in various formats to provide better stereoscopic and sound effects to consumers in recent broadcasting. The ability sound localize the sound sources in space is most considerable design factor on multi-channel surround system for human earing perception model. However, this paper propose the change of the sound localization according to the spacing of the speakers, which is not covered in the existing research focus on sound system design. Presently the sound system uses the position and number of the speakers to localize the sound. In the multi-channel surround environment, the proposed design uses the sound localization is caused by the directional characteristics of the speaker, the distance between the speakers and the distance between the listener and the speaker according to the directivity is required. The proposed design is simulated using virtual measurement with MATLAB simulation environment and performances are measured.

Key words: *Multi-channel surround, Sound System Design, 3D TV, UHDTV surround, Surround Speaker System Optimization, Sound Localization, SPL*

1. Introduction

The multi-channel surround system used in UHD TV (4K, 8K) and high-capacity multimedia storage media system follows different auditory system standards like Blue-ray, : NHK22.2, TTA / USC10.2, AURO10.1, etc. The Blue-ray standard provides 5.1 / 7.1 channel capacity and the NHK22.2, TTa / USC10.2, AURO10.1 standards provides channel horizontal surround audio system has more than 10 audio channels [2, 3].

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The sound localization in auditory system most important criterion to perceive the auditory signal without distrusting human auditory system on multi-channel surround system. Sound localization involves psychological acoustics, physiological acoustics, artificial intelligence and high performance computing (HPC) system. In general, the human listeners can localize a single sound source accurately but auditory system built with multichannel need more attention toward to location to give better auditory perceiving factor without getting distraction from other channel auditory signal perceived by the listener.

The multichannel auditory system uses different sound source parameters for localization, including time and level differences between both ears, spectral information, timing analysis, correlation analysis, and pattern matching. The speaker installation layout for any space needs to be planned according to the size, shape, and intended use of the space in order to supply sufficient sound pressure level consistently throughout the listening area. Of course the performance of the speaker systems used is important, but positioning and layout are critical in achieving high-quality sound.

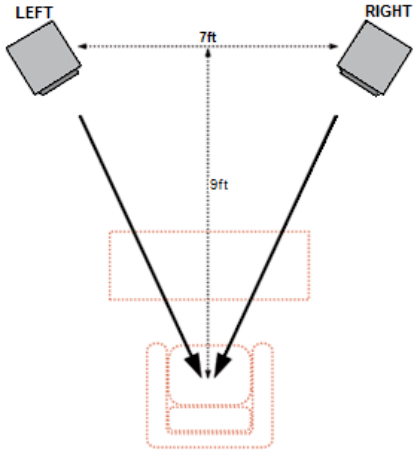

Figure 1. Stereo Channel Speaker Localization

The change of the sound image of the surround system moves along the imaginary line connecting the point and the point. When the directional sound source and the non-directional sound source are used, the distance between the speaker and the speaker and the distance between the speaker and the celadon are different [5]. In this paper the multichannel sound localization simulated analyzed based directional and non-direction sound system positioning model using Virtual Measurement Space and MATLAB. The analyzed results added as part of result and conclusion to prove the proposed sound localization method.

2. Multi-channel surround system

The modern sound system are designed with multichannel capability to give effective audio perceptual feel to the listener. The multichannel audio system capable of handling multiple audio channels to rebuild the sound on a multi-speaker setup. The surround sound is used to describe a type of audio output in which the sound appears to “surround the listener” by 360 degrees and this technology gives the impression that sounds are coming from all possible directions. Surround sound is a way to provide a more realistic and engaging experience. The Figure 2 shows latest 22.2 multichannel surround System to understand multichannel sound system model.

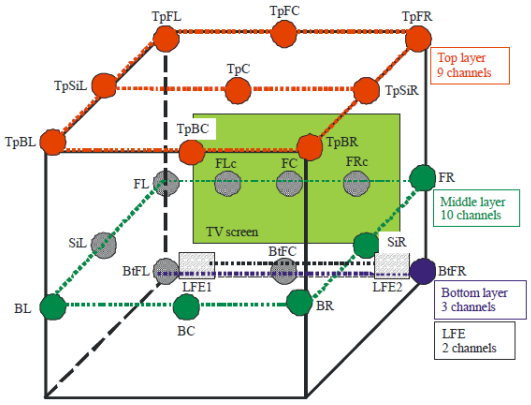

Figure 2. 22.2 Multichannel Surround System [1]

The surround sound works with multiple audio channels are received through speakers that are positioned at various locations in the room. This sound system configuration programmed into the source and the sound tracks are decoded when the source is played. The multichannel system represent by two digits separated by a decimal (.) point (2.1, 5.1, 7.1, etc.) are used to classify the various kinds of speaker set-up, this number basically depending on how many audio tracks are used. All multichannel surround system works with sound localization principles.

3. Environment adaptive sound localization

Sound localization is nothing but a listener's ability to identify the location or origin of a detected sound in direction and distance. The sound localization technique appeared with the considerable progress that has been made in acoustic simulation techniques and allows us to localize the acoustic sources by modeling a sound field that contains one or several sources. The directional or non-directional are the two types of localization used in sound system localization.

Non-directional localization the speakers are positioned throughout the listening area so as to achieve equal sound pressure level at every listening position called as "distributed speaker systems" which used in broadcasting announcements and background music. Directional localization the speakers are facing in about the same direction, and may even be clustered together in one part of the space used in live events and other situations in which directionality is important, and where the listeners will be seated or remain in a limited area.

If a directional speaker is used, it must be combined at the point where the sound source is synthesized through the speaker alignment, so that it is possible to avoid the waviness and comb filtering of the sound pressure at the position of the listener. However, even if a combining zone is formed by speaker alignment, it is difficult to expect a positive effect on the sound image change in a surround environment instead of music appreciation.

When a directional sound source is used, the sound source is recognized outside the coverage of the speaker which are distance from the moving path of the sound source, so that the sound source movement in the real environment cannot be perceived. Moreover, if the sound source is moved to the listener, the listener will be in the coverage of the speaker in a certain period, and suddenly the sound pressure will rise. For this

reason, in the case of multi-channel surround using a directional sound source, natural sound image changes cannot be felt.

As an alternative, when the omnidirectional sound source is used, the listener perceives the sound source regardless of the coverage of the speaker even if the user is far away from the sound path of the sound source. Unlike a directional sound source, which is heavily influenced by speaker coverage, a multi-channel surround environment designed as a non-directional sound source allows the user to feel natural sound changes regardless of the position of the listener.

4. Simulation and analysis

The proposed sound localization method simulated on 5 Channel linear speaker arrangement model to evaluation directional and non-directional localization evaluation in a room with virtual measurement space as shown in Figure 3. The performance evaluation method analysis implement on x64 Windows 7 PC using MATLAB. The directive sound sources were placed in virtual space and the response characteristic of each speaker was measured at the listening position, when the listening position deviates from the directivity characteristic of the speaker, the response characteristic was significantly lower than that in the directivity characteristic.

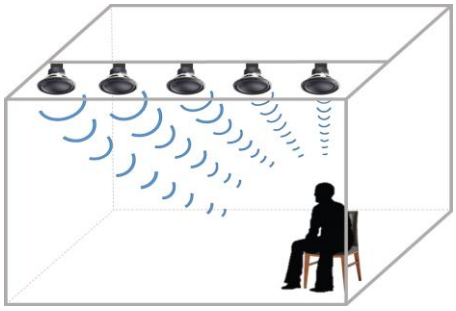

Figure 3: Virtual measurement space

To evaluate the performance, the Sound Pressure Level (SPL) is measured in the 1 kHz ~4 kHz band from the listener position and the graphical representation of characteristic influenced on the clarity on directionality of the source is shown in Figure 4.

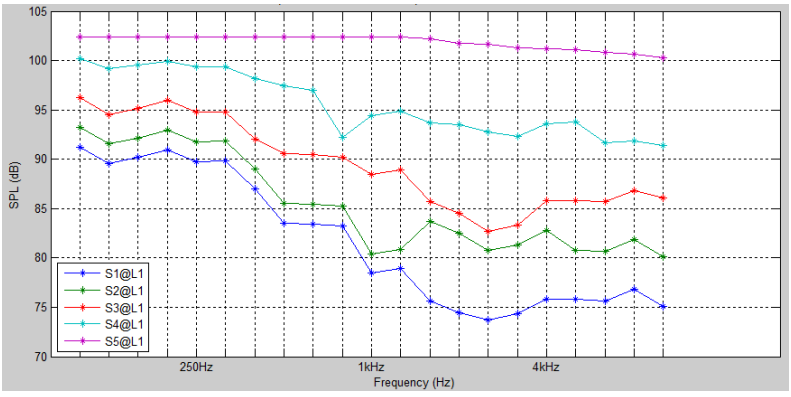

Figure 4: Response characteristics of S1~5 measured at L1

From the graphical representation in Figure 4, the sound pressure (dB SPL) in the 1 kHz ~ 4 kHz band increases as the sound source approaches from the listener position.

5. Conclusions

It is required to design a surround sound system considering the relationship between the non - directional sound source and the directional sound source, and the relationship between the sound source orientation and the direction of each sound source. In this paper, it is expected that the design of the surround speaker system will be optimized one by one according to the change of the sound localization according to the orientation pattern and the arrangement interval of the speaker.

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