

THE FUTURE DIRECTION OF SURROUND SOUND SYSTEMS

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ABSTRACT

Sound reaches our ears from all directions, not just one single point. Surround sound has been derived from mono and stereo which can not sufficiently reproduce the realism of perceived sound. It is probably good enough for listening to music from 2.0 stereo or a 5.1 surround sound system, which provide, horizontally, enough information or satisfaction of surrounded sound. However, visual image with sound, which is very close to our real life, needs more vertical direction. This paper will describe the limitations of current surround sound systems and the future direction of surround sound systems.

1. INTRODUCTION

Audio reproduction starts with mono which has a single reproduction source. After that it become stereo which has two reproduction sources that is expended left and right horizontally. However, mono and stereo audio reproduction techniques assume that the sound source is coming from the front, like a music stage, but unlike real life. Apart from a musical listening perspective, we cannot assume that sound is coming from front always. For example, if we are in the middle of a war combat situation, sound will come from all directions with different distances and levels. However, mono and stereo audio are not suitable for these kinds of sounds. Additional reproduction sources are required to create the illusion of war combat. When this illusion can be achieved, where the listener feels like they are in the middle of a war, surround sound will then be a big improvement over stereo. However, current 5.1 surround sound systems cannot perfectly reproduce the illusion of sound due to some limitations such as lack of vertical surround information, limited bandwidths of side phantom power image and ignoring early reflections in different rooms. 5.1 and 2.0 sound systems could be enough for music reproduction in which mainly sound coming from front horizontally. Sound on screen, however, which is most close to our real life listening, needs the directionality of the sound field, which is composed of spherical harmonic components, not just horizontally surrounded.

2. REVIEW OF PAST SURROUND SOUND SYSTEMS

After Bell laboratories invented multi-channel audio formats, including three-channel stereo (left, center and right), Walt Disney

engineers developed a technology called Fantasound in 1938. Fantasound stored three channels of audio and a control track on the film itself, with playback through the five channels. The main sound track is only three front channels. The rest of two rear channels were recorded on a separate reel of film. Arguably, this is the very first surround sound system, which attempts to surround the listener with the sounds for the movie "Fantasia". The speaker configuration of this system is very close to today's 5.1 surround sound system. Unfortunately, installing the Fantasound system in cinemas was too expensive to have commercial success. The 1950's Multi-channel Stereo and Early 1970's Quadraphonic sound systems also were unsuccessful due to financial problems.

3. REVIEW OF PRESENT SURROUND SOUND SYSTEMS

3.1. Dolby Stereo (analog)

[7] Dolby Stereo or simply Dolby Analog is the original analogue optical technology developed for 35mm prints and is encoded with four audio channels: left, centre, right (which are located behind the screen) and Surround (which is heard from speakers at the sides and to the rear of the theatre) for ambient sound and special effects.

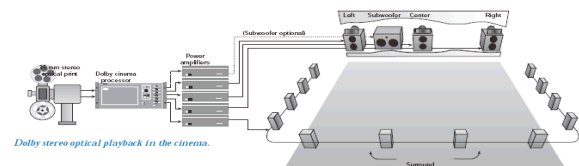


Figure 1. [1] *Dolby Stereo Optical playback.*

In 1976, Dolby Laboratories introduced Dolby Stereo. Two channels of sound reproduction are not adequate for movie stereo because movie screens are too wide for the left and right channel. A separate center channel and speaker is needed to localize dialogue for audiences and a surround channel is needed for ambient sound. These four channels of sound information and movie print are encoded to two physical tracks. (Even today, movie prints with digital soundtracks have Dolby analogue soundtracks to ensure compatible playback in all cinemas).

3.2. Dolby Digital (SR-D)

Dolby Digital (also known as AC-3 and SR-D) delivers digital audio via six clearly separate channels (referred to as “5.1”). The three front channels deliver crisp, clean dialogue and accurate placement of sound, while twin surround channels wrap around the audience and immerse them in the action.

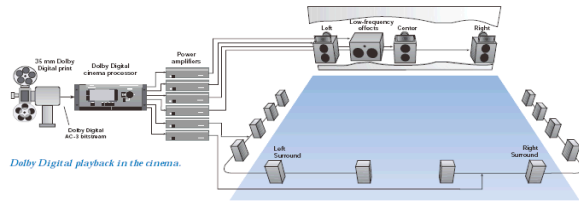


Figure 2. [1] *Dolby Digital playback in the cinema.*

In the late 1980s, Dolby Laboratories undertook the application of digital audio technology to 35mm film sound in response to growing interest from the film industry. In order to retain an analogue track so that release prints could continue to play in any cinema, it was decided that a separate new Dolby Digital optical track be placed. Six discrete sound channels were placed on the film stripes provided in 5.1 configurations which features five discrete full-range channels-left, centers, right, left surround, and right surround plus a sixth channel for those powerful low-frequency effects (LFE). As it needs only about one-tenth the bandwidth of the others, the LFE channel is referred to as a “.1”channel.

3.3. Digital Theatre System (DTS)

DTS is a multi-channel digital surround format used for both commercial/theatrical and consumer grade application. It is used for movie sound both on film and on DVD, and during the last few years of the format’s existence, several laserdisc releases had DTS soundtracks. The actual audio is recorded in compressed form on standard CD-ROM media at a bit-rate of 1103K bit/s. It should be noted, that Dolby Digital and DTS use different coding tools and syntax to perceptually compress audio, and therefore, the raw bit-rates of the two formats do not indicate an objective measure of sound quality. [8] DTS proponents claim that the extra bits give higher fidelity and more dynamic range, providing a richer and more lifelike sound. A DTS track is often louder with fewer hisses, even at the same relative playback volume.

3.4. Sony Dynamic Digital Sound (SDDS)

SDDS is a cinema sound system developed by Sony. Digital sound information is recorded on both outer edges of the 35mm film release print. [9] The System supports up to 8 independent channels of sound: 5 front channels, 2 surround channels and a sub-bass channels. This arrangement is similar to 70mm magnetic

sound format (see figure 4) and is useful mainly for very large cinema screens.

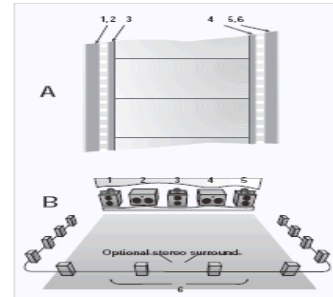


Figure 3. [1] *70mm magnetic-left, right and center channels (1, 3, and 5), one surround channel (6), and two low-frequency bass extension channels (2, 4).*

The SDDS system adds the potential for two more screen channels for a total 7.1 channels which are left, left centre, centre, right centre, left surround and right surround plus LFE.

4. LIMITATIONS OF CURRENT SURROUND SYSTEMS.

There are three prominent digital surround formats in use today: Dolby SR-D, Digital Theatre System (DTS), and Sony Dynamic Digital Sound (SDDS). They are similar in their print master requirements except for the number of channels. In all cases, the 0.1 channels designation refers to a separate low frequency channel with a smaller bandwidth requirement. These Surround systems have some limitations such as side phantom imaging works well only for limited-bandwidth material, because different frequencies image differently on the sides, leading in turn to the break up of sounds panned from front to rear. Also, the 5.1 system does not take into consideration early first reflections, nor does it simulate a sense of height.

5. FUTURE SURROUND SOUND SYSTEM

Present 2.0 and 5.1 reproduction systems have the same principle regarding the creation of phantom sound images between two loudspeakers or 5 loudspeakers. Future formats of surround sound systems also have this principle with more accurate and additional vertical phantom images. Another factor of future surround system could take account of early reflections which can recreate room acoustics. Current 5.1 and 2.0 reproduction systems works differently due to the room acoustic conditions. Also, the number of low frequency effect (LFE) channels increase to improve the envelopment of surround sound.

5.1.10.2 Surround Sound System

The 10.2 surround sound format was developed by THX creator Tomlinson Holman of TMH Labs. This is an extended version of the ITU 5.1 System and is actually a 12.2 system that uses a total of 16 loudspeakers.

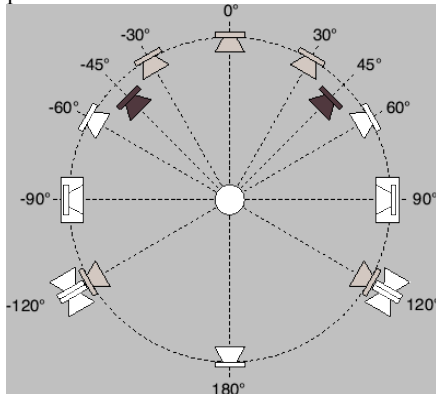


Figure 4. [5] *Extended version of 5.1 systems.*

The additional 6 channels can recreate the acoustics of nearly any location with astonishing realism. A weak point of current 5.1 systems is that the system does not take account the early reflections which is normally from reflective ceiling surfaces nor simulates the sound of height. Holman's new system simply fixes this problem with upper left and right channels, which can simulate a sense of height. Also, the placement of two upper speakers (45 degrees above and to the left and right of the audience) is the key that recreates early reflections, which reaches the ear at a slightly different time, allowing the brain to both localize the primary sound and compute the size of the room.

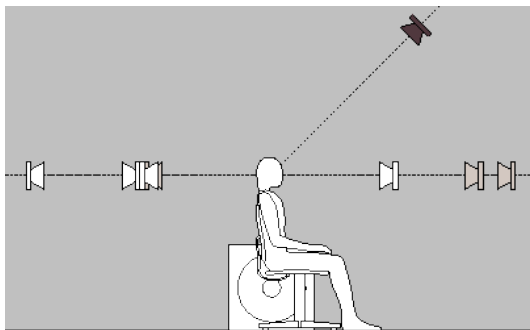


Figure 5. [5] *45 degrees upper front speaker.*

The other speakers can fill in the other major reverberations from the sides and off the back of the room, recreating a full acoustic signature. Wide fronts are added to simulate early reflections from the sidewall and by spreading out the sound in the front, clarity is also improved and more possibilities for envelopment are added. Separate side and rear speakers are also added to eliminate the compromise between envelopment and rear imaging along with a rear center channels so that hard rear pans are possible. Finally, two low-frequency channels are added for bass envelopment and improve spatial reproduction. Although low frequencies are not

very localizable, [2] it was found that splitting the bass on either side of audience increase the sense of envelopment.

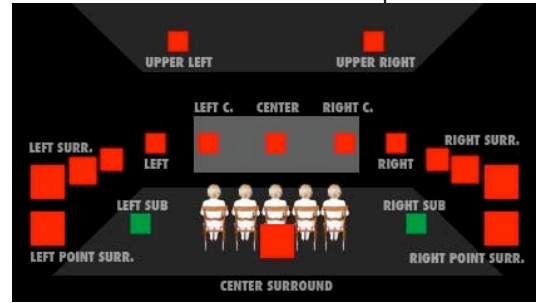


Figure 6. [4] *10.2 configurations.*

5.2. NHK 22.2 Surround Sound System

NHK has developed a 22.2 multi channel sound system for ultrahigh-definition video. The 22.2 multi channel sound system has three layers of loudspeakers: an upper layer of 9 channels, middle layer of 10 channels and lower layer of three channels.

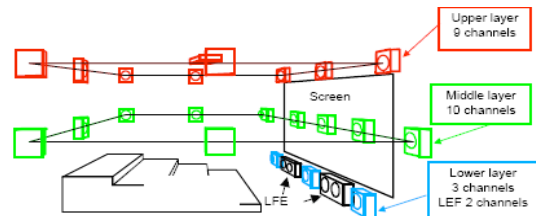


Figure 7. [3] *Three layers of surround sound system.*

This system can create an even more accurate sound image than 10.2. The three layers of sound system are ideally close to a spherical atmosphere. If new mixing techniques, which can pan up, down, left and right fully support this system, sound images could move in any location that the sound designer wanted. However, as the channels increase, more time consuming mixing is required because the designer must repeat various operations and also combine different effects for producing such surround sound effects. For the 22.2 multi-channel sound systems, further work is needed on creating vertical movement of a sound image and on creating a three-dimensional sound field.

6. SUBJECTIVE PREDICTION OF FUTURE SURROUND SOUND SYSTEM

The 5.1 Surround system was developed as a minimum number of channels for surround due to distribution and economical reasons. Two channel sound reproduction was easy enough to implement, back in the 1950s, even as filmmakers continued to regard four channels as the minimum amount necessary to create a life like sound-field. Perhaps the weakest point of the current surround system is that it does not simulate the sound of height. It makes it

very hard for a sound designer who wants to create the sound image such as the sound effect of an airplane flying over the audience. Considering a minimum amount of channels for future surround sound, two additional front channels (upper left and upper right) are necessary for simulating the sense of height. It is also essential to develop new mixing techniques to localize the sound source on spherical atmospheric sound reproduction systems. New mixing techniques can be used in situations which cannot use sound field sound recordings. The sound designer can record as mono and put or move the sound source anywhere around the spherical surround sound system if the mixing techniques (panning horizontally and vertically, determining the distance of source) were possible. For future surround sound systems more and more additional channels are required to achieve accurate sound source images. However, increasing the channels is not a simple matter. [2] Even the ITU 5.1 surround system is hard to install at home due to the location of furniture and limitations of room size and surface material. Also, high costs make it hard to distribute to consumers. 1940s Fantasound and 1950s quadraphonic failed due to the high cost of installation. About 99% of current cinema is installed with Dolby Digital, DTS or SDDS 5.1 channel configurations, therefore, future surround sound should be extended from these formats, rather than design completely new systems. This is one way to minimize the installation cost. From the sound designer's view, it is going to be time consuming to create extreme multi-channel sound reproduction. Also, additional mixing tools and techniques are required to produce multi-dimensional surround reproduction.

7. CONCLUSION

Increasing the numbers of channels is a very obvious future direction to make it possible to recreate the sense of height and room acoustics. However, more study of surround mixing techniques is required to support new generations of spherical multi dimensional surround systems.

8. REFERENCES

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