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Virtual Presence and the Six Cardinal Rules of Sound Acquisition

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Overview

You will find no revelations or new discoveries in this paper. What you will find is, to paraphrase the patent law, “a novel and unique application of existing ideas and technology.” In an attempt to clear the accumulation of gizmos, gadgets, and gear that has gradually crept in to the field of recording and brought a layer of obfuscation to the bright light of music.

I’ve had a number of experienced audiophiles question various aspects of this treatise to wit: “If you have time alignment, the speakers need not be equidistant” and “Room acoustics are critical to imaging” and many more excellent points. However, these things are well beyond the scope of the six cardinal rules. An eminent physicist commented “I don’t know anything about audio, but the physics are beyond dispute.” The reader should understand that I am not attempting to define the rules for successful surround recording universally, but only locally and mainly for purely acoustic space-time events. An amateur with a pair of Revelation soundcards and four microphones can follow these rules and achieve Virtual Presence when “experienced” audio engineers with half a million dollars worth of mixers and gear fail to do so. That is important, and empowering. Acquisition and publishing has long been the playground of High Priests and deep pockets. With the failure of the large publishers to understand the trends in the industry, the mantle has fallen on the shoulders of “mom and pop” and garage studios to provide acoustic and classical material to a hungry 21st century audiophile and music-loving class dissatisfied with the over engineered and “cleaned up” offerings of traditional studios. I am simply saying “PLEASE, try this at home! The Six Cardinal Rules will guide you to a simple, pleasant musical experience and a way to persevere accurately a space-time audio event from a single perspective. Let me state this clearly and categorically:

Nothing I have written here should be construed as suggesting that satisfying musical experiences cannot be obtained by other methods. Proof this is not the case resides in my own listening library. David Hafler obtained a degree of Virtual Presence 40 years ago in his DynaQuad sampler LP, though the effect was quite localized to a “sweet spot” and variable over the disk. Others have succeeded to some degree or the other using various approaches up to and including Dolby ProLogic II. However, other methodology relies on decades of experience, luck, good karma, and a variety of other things one may or may not have access to or possess. For the beginner, or the experienced audio engineer wishing to simply “capture the moment,” the Six Cardinal Rules offer a methodology that guarantees a recording with Virtual Presence. Also, note that if you use microphones other than the PZMs, you must have an in-depth understanding of their pickup patterns and interactions with each other in order to approximate or match the 360° pickup

of the SoundCube. The same caveats go for variances in speaker type and placement. Happy recording and listening!

Virtual Presence

“Virtual Presence” is the process of providing the human brain with precisely the information required to recreate the original soundfield. Today, highly complex and sophisticated circuitry attempts to, and in some cases, succeeds in, creating an involving, immersive, and sometimes even relatively accurate soundfield. However, many times it also fails, and fails miserably. Experience suggests that the reason for this is that modern circuitry, even at its best, is no match for the human brain. You just can’t fool Mother Nature.

Six Cardinal Rules of Sound Acquisition

It was a visit to the laboratory of the late “Legend in Sound” Paul W. Klipsch in the early 1970’s that ignited my quest for Virtual Presence. For that reason, I don’t believe he will begrudge using his “Cardinal Rules” descriptor to attempt to describe for acquisition what he did for reproduction.

- 1. Conventional “Stereo” is simply dual channel mono and is incapable of delivering Virtual Presence.**
- 2. To achieve “Virtual Presence,” 4 identical microphones must cover 360° with seamless overlap.**
- 3. Mixing = editorializing, no matter how well it is done and prevents the achievement of Virtual Presence.**
- 4. The simplest possible signal path from microphone to storage must be used.**
- 5. There must be a minimum delta from master to distribution copy and the ideal is none.**
- 6. Reproductive conditions must be as close as possible to the inverse of acquisition, and the ideal is to simply reverse the transducers.**

1. Conventional “Stereo” is simply dual channel mono and is incapable of delivering Virtual Presence.

In recent years, home theatre systems with their 5 or more channels have rapidly become ubiquitous. This has produced renewed interest in surround audio. Many in the audio world eschew anything beyond stereo as unnecessary and gimmicky. On the other hand, we heard exactly the same thing from their fathers and grandfathers when stereo debuted. Both they and their fathers/grandfathers were correct. Early stereo WAS gimmicky and full of “Hey! Listen to this ‘Ping-Pong’ effect.”

In fact, it is not possible to record certain events with any degree of reality in only 2 channels. I have rarely ever used more than two microphones for stereo, and the most often asked question in the field was always “Why only two microphones?” My stock answer was always the same: “I have only two ears!”

That answer was, and remains true, for simple 2-channel stereo. However, it does not apply to “Virtual Presence” where 4 microphones are the required. The reason that 2 microphones cannot provide a realistic soundfield when 2 ears can is simple: no brain. In the 1970’s, attempts were made to fix this with what amounted to “artificial brains.” The first, simplest, and possibly the best was David Hafler’s “DynaQuad” system, which used passive circuitry (unnecessary to get into the theory here) to extract out-of-phase information from normal stereo recording and route it to the rear. At its best, the impact was marvelous, and I have Hafler circuitry in my stereo even today as it adds much to stereo sources. However, there is a fundamental flaw in this approach when re-creating a “Virtual Presence” as true to the original soundfield as possible: it is in no way comparable to the natural “Hafler circuitry” built into our brains. The point is this: Give your brain the data points it needs and let it do the work.

2. To achieve “virtual presence,” 4 identical microphones must cover 360°

By placing 4 microphones in the “best seat in the house” you provide the brain with the data points it needs to triangulate the origination point of every sound in the acoustic space-time event. In order to test this concept, I developed the MBS SoundCube. The SoundCube is based on the Crown PZM (Pressure Zone Microphone) microphone. The PZM is the only microphone design aside from the ribbon and the omnidirectional to have a “natural” pickup pattern. While many different microphones have been developed with a wide variety of pickup patterns, all of them rely on phase cancellation to achieve the desired performance. While effective for news people, moviemakers, and the CIA, they are not the best choice for Virtual Presence. Of the 3 “natural” pickup patterns, I have experimented with ribbon microphones (figure of 8 pickup pattern) and the PZM (semi-circular pattern). The SoundCube is the result of my experiments with the PZM, and the easiest to use in this explanation of Virtual Presence.

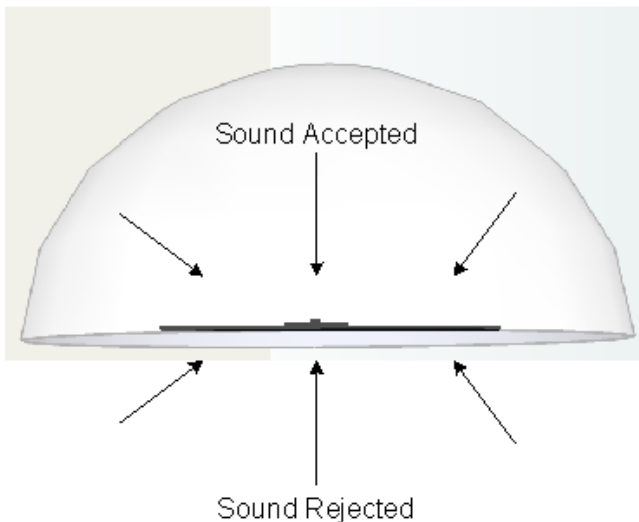


Figure 1 A PZM captures precisely 180°

mike overlap perfectly to record surround sound. If the overlap is imperfect, the human brain will interpret this as spurious directional information.

The diagram at the left shows the natural 180° pickup pattern of the PZM. Omni’s and ribbon mikes pick up sound reflected from the walls, floors, and other objects in a room. For stereo, and with the mikes properly positioned, this doesn’t impact the recording too much. However, these out of phase signals impact the accuracy of the signal and confuse the extremely sensitive direction finding capabilities of the human brain. Further, it is extremely difficult to perfectly overlap conventional microphones such that the areas covered by each



Figure 2 SoundCube test

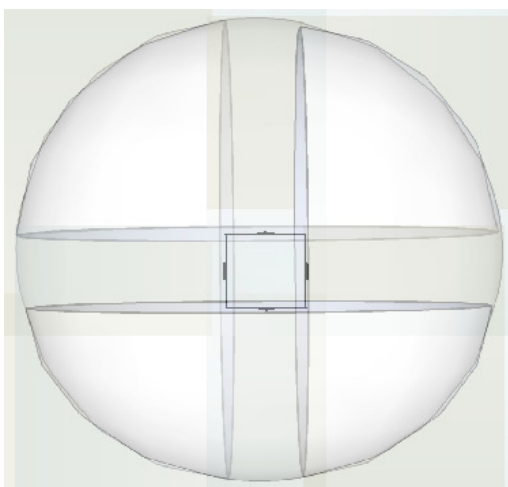


Figure 3 SoundCube 360° coverage

I developed SoundCube in an effort to address this issue. SoundCube consists of 4 square boundaries facing the 4 cardinal directions. Each square has a hole in the center for mounting a PZM microphone with a butterfly nut. This arrangement provides all the data points required by the human brain to recreate Virtual Presence with 4-180° zones with a 90° transition zone yielding the requisite seamless coverage.

Nothing in the above should be taken to suggest that only PZM microphones are capable of achieving Virtual Presence. I have achieved Virtual Presence with ribbon microphones, which are my personal favorite microphones for acoustic instruments and natural sounds. All audio engineers have their bias and preferences in microphones, and despite my personal dislike of phase-based directional microphones, it is possible to achieve virtual presence with them if they are properly deployed in accordance their design specifications and the above principles. However, the use of PZMs in the SoundCube configuration reduces the highly complex task of microphone configuration and placement to that of simply locating the “best seat in the house” and placing the SoundCube there as a proxy for the listener.

3. Mixing=editorializing, no matter how well it is done and prevents the achievement of Virtual Presence.

As a media producer, I love great mixers. They do yeoman work in a wide variety of creative production and the world of production would not exist without them. However, in the quest for Virtual Presence, they have no place. For one thing, they violate one of the cardinal rules, that dealing with the simplest signal path being the best, but most importantly, they represent editorializing. What it means is that the audio engineer does not believe it possible to deliver a quality recording without tampering with the soundfield. For Virtual Presence, this is never necessary. The mystery of microphone placement is reduced to simply finding the best seat in the house and putting the SoundCube there. The brain will take care of the mix. A noted professional photographer once told me one of his secrets. “Leave the zoom alone.” If you need to get closer, MOVE THE CAMERA.” The same is true for recording. You need to move the microphone(s) or the musicians if the mix is not correct instead of using a mixer to “fix” it.

4. The simplest possible signal path from microphone to storage must be used. The mantra of many audiophiles is “The perfect preamplifier is a straight wire with gain.” While this goal is, at present, unattainable, the criterion it represents is something all recording engineers should strive for. Modern audio processing circuitry is frightfully good, but every issue it seeks to address in the acquisition of acoustic music in fine environments can be eliminated by following the rules as stated so far. Therefore, only the essential paths should be followed: microphone to preamp, preamp to Analog to Digital (A-D) converter, thence to storage. Even modest microphones, preamps, and A-D converters used within this framework can provide a more satisfying Virtual Presence than 6 figures worth of gear passing through endless processes, mixing, and conversion.

Now, all you have to do is deliver it.

5. There must be a minimum delta from master to distribution copy and the ideal is none.

At this point, we run into a bit of a problem. To date, every MBS recording has been a master. That is, recorded either at the 16/44.1 resolution of CD to begin with or at exactly twice that rate so that reduction yielded no change in the data. Since no mixing, processing, or any other alterations of the original file takes place, each CD was identical to the original master. This is how it should be, and as such, exceeds even the legendary “direct to disk” LP’s of old in that the analog disk reproduction processes made delivery of a master to the end user impossible. However, Virtual Presence requires 4 channels and a delivery medium. The ideal method would be to deliver the files as raw data, but few listeners have either the skills or the equipment to replay these. There are only two commercial delivery media with the potential to deliver Virtual Presence that are available to any significant numbers of people, SACD and DVD-A. SACD is a fine medium, but the costs and complexity of creating them are beyond (some say intentionally) those of us in the “mom and pop” category. However, DVD-A production is not significantly more complex than that of producing a CD. On the other hand, you have to follow the rules. That means transcoding via industry standards so that Joe and Jill Consumer can be sure it will play in their unit. Yuk. Transcoding. Well, there it is. I’d rather not, but great recordings are no good if no one can play them. Something is lost in this process no matter what algorithm you use. The good news: If you follow all the other rules, you lose less violating this one than any of the others.

The good news is that the 1 bit, 2.8 or 5.6 MHz technology behind SACD is now becoming available to “mom and pop.” My experiments with it suggest that mastering with this format produces a file that can be transcoded nearly transparently to any PCM format. Finally, we have a universal format for high resolution digital.

6. Reproductive conditions must be as close as possible to the inverse of acquisition and the ideal is to simply reverse the transducers.

The ideal playback is as close to the inverse of the original 4 microphones. That is, four identical speakers equidistant from the listening point. Microphones are transducers. They turn sound into electricity. Loudspeakers are also transducers that turn electricity into sound. Therefore, the perfect listening situation to

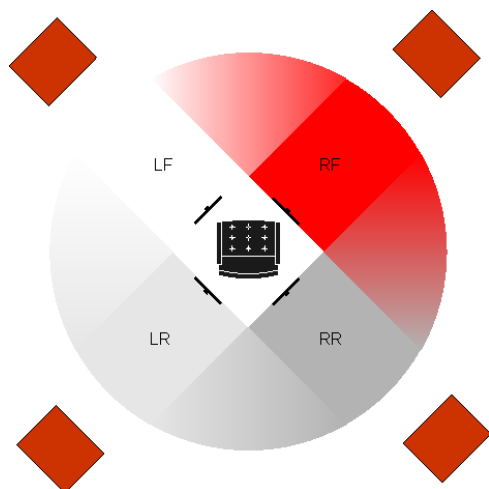


Figure 4 Seated in the “sweet spot” of four identical sound sources at identical levels, the listener experiences Virtual Presence.

experience a recording made according the 6 Cardinal Rules is a simple reversal of the transducers.

Figure 4 shows a reversal of the transducers, with 4 identical speakers facing towards the listener instead of four identical microphones facing away from the listener. If the principles have been followed so far, then a person sitting dead center in this array should have an uncanny sense of “Virtual Presence.” They are now positioned as if they had been at the original event sitting where the SoundCube was. In other words, a visual representation of rule number 6.

A brief anecdote from my SoundCube experiments illustrates this phenomenon. I did some test recordings with the SoundCube on my front porch. During the recording, I went outside to check on something or the other and as I went out, the wind caught the front door and slammed it pretty hard. When I played the recording back on 4 identical Frazier Mark IV loudspeakers, the environment was very convincing and involving. Then the door slammed. I immediately jerked around and looked towards the door to see who had come in, as my brain was completely fooled and I fully expected to see someone entering the room. I did not realize what had really happened until I got up and verified that no one was present. I repeated this with several other people, and all behaved exactly as I did. I got a lot of laughs from this. More importantly, it proved the point: Realistic reproduction must be the inverse of the source recording: reverse the transducers.

CONCLUSION

Consider the pipe organ. The space housing the instrument is very much a part of it. A pipe organ sitting out in the open would not sound very good at all, nor does a fine instrument housed in a poor space. The amount and manner of the return reverberation of the sound is very much a part of the overall experience. Four microphones producing 4 discrete channels of information from a single point, preferably the best seat in the house, are required to approximate the experience. This is even more important for antiphonal instruments or bombarde divisions. It is very strange to hear bombarde division emanating from the front! Of course, the same is true of live performances, environmental recordings, and many other sources. Doesn't the idea of hearing audience noise emanate from the performers strike you as, well, wrong? Are they applauding for themselves or what? The enjoyment of such recordings is a learned experience, much like the “realism” of the flat-as-a-pancake video and film we enjoy even though it won't fool my cat.

Here is one more example before closing. Many environmental recordings have been made over the years, and sold quite a few copies. However, the public appetite gradually faded. This is not because people do not want to experience the ambience of the beach, forest at night, or a Texas thunderstorm up close and personal, but because of the two dimensional nature of stereo. Today's home

theater systems are ideal for this, and the unique “SoundCube” provides the perfect perspective to experience these natural symphonies.

Virtual Presence offers no use for the center channel. Nor is the “.1” or bass management necessary for the vast majority of the repertoire if you have speakers capable of covering the musical spectrum. Fortunately, the specifications for DVD and DVD-A media neither require the use of those channels nor any intervention from the user to adjust for the use of 4 channels only.

With 4 identical full range loudspeakers spaced equidistant from the listening point and material recorded in compliance with the Six Cardinal rules, you will find yourself in another time, and another place. Hopefully, you will want to return there often.

Addenda

Nearly 4 years have passed since my first experiments in Virtual Presence with so many things happening in my life that little further progress was made. However, that is changing now. I will soon be doing my first live musical performance using “SoundCube Jr.” SoundCube Jr. is identical to the original SoundCube except that the cube measures .5 meter on a side instead of 1 meter. The reason is both practical and acoustic. Only the largest pipe organs and events like thunderstorms produce bass in the very lowest octave and the natural filtering of this is desirable in spaces where the only sound in this octave is Air Conditioners or traffic rumble from a nearby freeway. The half-scale SoundCube covers all the instruments for the vast majority of musical events and does so in a smaller, less conspicuous form. Of course, I’d use the original if I felt it necessary to the event.

The musical event is a performance of the complete Beatles “White Album” with a variety of singers and musicians with orchestra backup. Some of these instruments are non-acoustic, but the event is a purely acoustic experience which I intend to capture from the “best seat I can get” perspective.

But wait, there’s more! A concept that has been bouncing around my head since the early days of these experiments appears to be proving correct. If so, it may produce the first practical means of producing Virtual Presence from a common 2 channel CD using only equipment found in every home surround system. I hope to have some results to share with readers of this paper before this year (2008) is out.

NOTE: “SoundCube” and “Virtual Presence” copyright 2004 by David A. Mallette.