3D classical piano studio production, Brahms in 13.1 and the au3Dio microphone array

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Abstract

The late piano work of Johannes Brahms, very intimate and brittle, has been recorded and mixed in 13.1 in a way, that the sound supports these qualities of the music. The listener is almost getting the sound impression of the players' perspective, in this case Bernd Grill. Christian Vaida, the producer of the record and owner of cvmusic film/ton, shares his experiences with this recording: choosing the instrument, the listening format, monitor speakers, 3D monitoring rig, microphones and preamps, miking, mixing in 13.1 and, of course, there is a demo of the final mix and a comparison between 13.1, 11.1, 9.1, 7.1, 5.1 and stereo.
Also, after several experiments with different stereophonic 3D arrays, Christian Vaida presents his proposal for such a system, the au3Dio microphone array.

Introduction

I'm the owner of the recording studio cvmusic film/ton, established in 1999. In 2015 I converted my studio into a 3D studio and conceived the brand name au3Dio for 3D services, built a 3D-rig which can handle all channel based standards up to NHK 22.2, installed the then apparently most promising format 13.1 and tried all kinds of recordings with different stereophonic 3D arrays.
The pianist Bernd Grill wanted to record a CD and I asked him for a cooperation to produce the album also in 3D audio. This paper is about all the aspects of the album and in the second part about the au3Dio microphone array, which I developed recently.

The terminology

The terminology is not standardized, so I must explain some confusing terms. Firstly I use the channel naming and labelling of NHK 22.2 as used in the following document on page 4: http://www.nhk.or.jp/strl/publica/bt/en/fe0045-6.pdf because they have all the channels that the smaller channel based formats also have. Some angles are different, but the the channels' positions are mostly clear. When I talk about front left and right I mean the two speakers in the middle layer at ± 30°. NHK named the speakers at ± 30° front left center and front right center while their front left and front right are at ±60°. That's a little confusing, but otherwise their naming is clear.

Formats and layers

Dolby Atmos has two layers, a channel based 7.1 bed and a layer for audio objects. Auro 3D has three layers (middle, height and top (voice of god)) and NHK 22.2 has four layers (lower, middle, upper and the top center which, although higher than the upper layer, is declared as part of it).
When I talk about the top layer I mean Auro's height and NHK's upper layer. In Dolby Atmos this layer must be embedded as audio objects at the corresponding positions.

The instrument

Right after the musician, the instrument is the second most important factor of a recording. The author tested hundreds of instruments, recorded 55 of them always with a similar microphone position and the same song and chose it in a blind test. The best grand pianos in my opinion (I'm a piano player myself), are by Fazioli, no matter which model. This brand builds the highest possible quality, but also at the highest prices. Most other pianos don't come even close, but very surprisingly the 218 concert grand from Wendl & Lung (Figure 1) in Vienna, now Feurich, was in the ballpark and sounded just great, especially considering its relatively low price.

Figure 1: Christian Vaida checking different 3D setups with his Wendl & Lung 218 concert grand at cvmusic film/ton.

The listening formats

In 2014, when the project was started, Auro 3D seemed a promising format for music production and 13.1 seemed to be the most versatile and future proof. As it turned out, that was right. It is of course compatible with all Auro 3D formats, but also with Dolby Atmos 7.1.4 and 9.1. A real Dolby Atmos setup is unaffordable for our studio and has a flaw for music production, it has only a top layer, no height layer, whereby the immersion suffers because it loses the connection to the middle layer. With 30° to maybe 40° there is still a connection and thus a good immersion, but if the speakers are up in the ceiling, there is no coherence in the soundfield, especially for music. In cinema this is not a problem.

Voice of god

It turned out Auros' voice of god channel (the top layer) is not well received in home cinema and fortunately it's also not too important for the immersion in a music production, although I liked it.

The center channels

The top center didn't survive either and is non-existent in 7.1.4 and 9.1, so most setups will not be able to play back my original 13.1 mix, but the 7.1.4 version will sound very similar.

The center channels in 13.1 are rather counterproductive in a stereophonic context, because they are too close to the left and right channels, which causes phase issues. Otherwise, in an object based production like pop music, the center can be used for all kinds of things, like voice, bass, snare etc.

In cinema, when the basis from left to right is very big, omitting the center often creates a hole. In this case I would encode left and right to MS (mid side), put the mid signal on the center channel and subtract the mid signal from the left and right channels. That way one can use the center without phase issues.

The 3D monitoring rig

The monitor speakers

The first step was to find thirteen monitor speakers that are suitable for mixing in 3D. That means not only a flat frequency response, a wide dynamic range etc., but they must also play full range, so that there is no bass management involved and the subwoofer serves only as LFE channel. Also, they had to be affordable. So a test with lots of monitors in the price range up to 1000 € apiece was carried out at gkg-mastering with Ludwig Maier. Only speakers with very good reviews were tested and the big surprise were the Nubert nuPro A-300. They have all the above mentioned qualities, play from 22 kHz down to 30 Hz (± 3dB), cost only 525 € apiece and are much better than most other speakers costing even twice as much.

The rig

There were and still are several 3D formats out there and so a rig (Figure 2) was built that could handle all channel based setups up to NHK 22.2. It was specifically designed for the Nubert nuPro A-300s, so that the alignment towards the listener is 100 % accurate. The inclination of the height layer is 30° as standardized as minimum in NHK 22.2 and as recommended by Auros' Winfried van Baelen. The immersion with this inclination is very good.

The steel pipes were filled with sand, so that the rig doesn't resonate, an invaluable tip from Andreas Silzle.

Figure 2: The au3Dio 3D rig for setups up to NHK 22.2 with the Nubert nuPro A-300, designed by Michael Mack.

Microphones and preamps

I have tested lots of microphones on the grand piano and the best sounding were the MBHO MBP 603. Unfortunately, my preamps and converters (SSL XLogic Alpha Link, SSL 9000, Telefunken V672, DAV, TLaudio and others) which are very good for stereo recordings, have too much noise for 3D recordings, because the noise of so many channels sums up a lot, especially in piano/quiet sections. So I searched for a solution and found the Sennheiser and Neumann digital microphones, the noise of which was about 20 dB lower than that of my setup. Georg Neumann GmbH were so kind to lend me ten of their microphones, Synthax GmbH digital preamps and interfaces from RME while Steinberg contributed a Nuendo 7 license and Nubert the nuPro A-300 speakers for this recording. The only problem was, that the microphones just didn't sound as nice with the piano as the MBHO microphones, the sound became harsh. Today I would recommend analog mics with preamps and converters that have very low noise, because soundwise it is the most flexible solution if you can select the proper microphones.

Miking

My first tests with orchestra and choir (Figure 3) were based on INA 5 with thirteen microphones, seven in the middle layer, five in the upper layer and one facing upwards as top layer. The distances between the mics as well as the lower and upper layer were about 1 meter. The recordings sounded pretty good, but localization was not so good. To make a long story short, a 3D stereophony did not work with the grand piano in the studio and it is obvious, that this doesn't even make much sense in a studio environment without reverberance. Because of the brittleness and intimacy of the

music the artist and I decided to record in the dry studio, a big concert hall was not necessary.

Figure 3: The first test setup with 13 cardioid microphones.

The basis for the microphone setup (Figure 4) was the elaborate stereophony of the piano that an assistent and I worked out in a soundcheck that lasted one complete week! This effort was made, because the great sound in the room didn't translate on the stereo speakers during a normal soundcheck and, as part of the studio, the piano should sound excellent. Different microphones, setups and positions were tried and the most promising was a setup that was adopted by Al Schmitt. He put down the piano lid and miked it from the left and right side in an AB setup for a Diana Krall recording and it was a great sound. This AB setup was moved in 2 cm increments and hundreds of recordings were made and compared. There was one position, where the piano translated beautifully and that was the starting point for the 3D setup as middle layer left and right channels. The microphones were small condensers with cardioid capsules that were facing each other. That way the near miked piano sounded full and though direct not harsh at all.

Figure 4: The 3D microphone setup for the grand piano in the studio. In the foreground the back left microphone, at the curtain the right side microphone.

For the upper layer, the AB was doubled one meter above the middle layer, but with cardioids showing up to the ceiling to get a more diffuse sound. That was the best idea then and it sounded pretty good, but there was too much direct sound, so the piano sounds bigger than it should. A figure of eight with the null towards the piano would have sounded much more diffuse, but I didn't have the idea then.

The back microphones were in the back of the room, pointing away from the instrument. All microphones were placed by ear, listening in the control room while moving them. A Sennheiser MD 441 was placed under the piano for the LFE channel. That turned out to be a great sounding solution. This signal was used very conservatively, but brought some extra fullness, that lets one feel something in forte sections.

As mentioned before, the center channels were not used as they introduced phase issues, so a total of twelve microphones were used: front left, front right, top front left, top front right, side left, side right, back left, back right, top back left, top back right, voice of god and LFE, all cardioids, except MD 441, super-cardioid.

The resulting sound is unusual, it's from the players' perspective, very close, intimate and realistic. It pulls one into the music – an overwhelming experience.

Mixing in 13.1

The monitor setup

The 13.1 setup of Auro 3D, which was then used for the mix, is a bit special, as it has a top center channel and a voice of god channel which both turned out not to be used in home cinema today, which is the main target of music production in 3D. The next most compatible format is 7.1.4, which is the current setup in my studio, with the front channels at ± 30°, the side channels at ± 90° and the backs at ± 135°. The top channels are directly above the front and back channels.

Delay

All microphones were time aligned with the front. That sounded very homogeneous, so much so, that one didn't even have a 3D sensation, even with the back speakers louder than the front – just boring. So I delayed the back speakers and could so adjust the impression of the room size. Without enough time-of-arrival differences, stereophonic recordings sound small and unconvincing to me, even with these uncorrelated signals we had.

Reverb

The microphone signals were very dry, as the reverb time in the studio is 0.25 s, so of course we had to use artificial reverb. We got the most natural and good sounding result with several different impulse responses of real rooms from the Waves IR1. What was surprising was that the same room, although with different settings on the different stereo pairs, didn't sound neither pleasing nor convincing. I had to find the perfect room for the respective pair, building up the sound image from front to back to height. Especially the sides sounded very odd, probably because they point directly

at the ears. To get them right was difficult and the reverb had to be rather special to fit in the whole picture. It was similar with the voice of god, but not so crucial.

Comparisons

13.1 The voice of god channel covers the sound field nicely, but it's not essential.

7.1.4 The top center is absolutely unnecessary in the stereophonic context, so I would consider 7.1.4 as an optimal setup for music reproduction at home, at least among the available setups. Especially in context with my au3Dio microphone array, this setup has one big advantage that I'll describe later.

9.1 or 5.1.4 is the smallest convincing 3D setup, but for music reproduction in the stereophonic context absolutely convincing and thus sufficient, except the same objection applied for 5.1.

7.1 is a big improvement over 5.1 when placed evenly in 60° increments (± 30°, 90° and ± 150°), but even with the common max. of ± 135° for the back. If the sides (± 90°) are only added to the 5.1 rear speakers (± 110°) this brings no improvement at all, only phase issues again.

5.1 has the disadvantage of the ± 110° rear speakers. To my ears the sound of these speakers comes mostly from the sides and very little from behind, so the sensation of immersion is very restricted.

Height channels bring a lot of immersion to the table and when switching from 9.1 to 5.1 most people are extremely surprised about the quantity of the difference.

The au3Dio microphone array

After as many listening sessions as I could attend, for example at the previous ICSAs and lots of test recordings by myself, I figured out a new stereophonic 3D microphone array (Figure 5) that I have already tested in a cave concert – it worked just great, even better than I imagined.

A stereophonic approach is always indicated when you want to authentically reproduce a sound field. This is normally the case when a homogeneous sounding ensemble like an orchestra or a choir play in a good sounding room like a church or a concert hall. Usually you place your stereophony at the reverberation radius or simply where it sounds good and that's it. That was of course not the case in the previous piano recording, but the cave concert was a perfect test scenario.

The listening format of 7.1.4 was the basis of my idea. First I'll explain the setup for the middle layers' 7.1 or better 7.0 format.

As we all know 60° is the optimal angle for stereo reproduction on two speakers. With ± 30°, 90° and ± 150° we would therefore have a perfect 360° coverage on the middle layer with six times 60°. But even with the backs at ± 135° we are pretty close. The center is obsolete, as I described before.

The idea concerning the middle layer is simple: six cardioid microphones in 60° angles, perfectly covering the complete compass of 360°. To calculate the proper basis between the microphones, which is exactly 62 cm for cardioids, I used a tool by Eberhard Sengpiel (www.sengpielaudio.com) which calculates the microphone basis, the microphone angle and the recording angle in relation to each other, dependant of the polar pattern and even shows the ratio of time-of-arrival to intensity stereophony. In this case it's about 80 % time-of-arrival stereophony. I usually prefer equivalence stereophony, like in this case, as this gives me a good mix of spatiality and localization.

Why cardioids?

Omnis usually are not working for me. I know they sound fantastic, the spatiality is unsurpassable, but the localization is poor. For me that's a quality criterion. When I listen to an orchestra, I want to hear where the oboe is coming from. If localization was irrelevant, for example like background music in a film, I would use omnis, too.

Figure of eights are of course unsuitable, as they record also to the back and one gets a big part of the sound that is recorded from the opposite microphone, thus again degrading localization, very similar to the omnis.

Super cardioids or hyper cardioids suffer from the same problem but in less extent.

The microphone pattern with the best reverse rejection is the cardiod with -25 dB, while wide cardioid has -11.7 dB, hyper cardiod -6 dB and the figure of eight as well as the omni have 0 dB reverse rejection (www.sengpielaudio.com - MonoAufnahmebereichMikrofon.pdf).

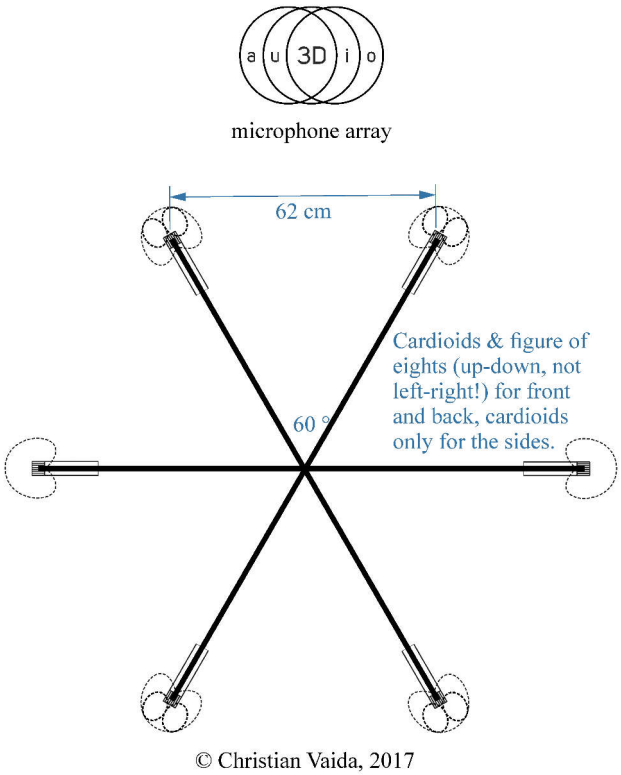

Figure 5: The au3Dio microphone array. The figure of eight microphones face up-down, not left-right.

The upper layer

When I recorded the upper layer with cardioids, the localization did suffer, but even more of a problem was the fact that the sound stage became too high, as some direct signal came from the top, too. I looked for a way to get a more diffuse sound field from the top layer, as we usually have the impression of the direct sound coming from the front middle layer and reverberation coming from the top layer and the back.

Cardioids or even hyper cardioids showing 90° upwards from the middle layers' cardioids is not bad, but as the mono recording angle of cardioids is 131 ° and that of hyper cardioids 104.8° (www.sengpielaudio.com – MonoAufnahmebereichMikrofon.pdf) there is still some overlapping. The best rejection of all polar patterns is that of the figure of eight to its sides. So, as the cardioids are pointing to the sound source and align with the figure of eights' sides, the overlapping signal and thus the correlation is as small as possible. The icing on the cake is, that you can now even MS encode these signals, splitting them up into up and down, omit the down signal, which usually records noise from the audience, subtract the mid signal again and get only the rewarding, most uncorrelated up signal, giving you a beautiful reverb with the least direct sound. For stereo 3D recordings with good acoustics and players positioned only on the ground and not on a gallery as well, that's a great sounding solution. I'll gladly demonstrate that with my cave concert recording. The localization as well as the immersion is great, I was at the exact point of the microphone setup and it really sounded like it sounds on the record.