

AVE Absurdum

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Abstract

Auditory Virtual Environments (AVEs) are used to simulate audio environments in real spaces. As room in room reverberation system (RRR) they augment the acoustics in spaces, e.g. in concert halls and music theaters. Why not utilize them for theater music as acoustic stage design and therefore as a playable instrument ?

Even more, tune them to extreme configurations, so that absurd acoustic situations can be realized, absurd in the sense of not normal or possible in real physics and using distortions in time, space, frequency and signal domains.

This paper discusses the conceptualization and design of an artistic research project using AVEs for a theatre and some of the new aspects of these ideas are discussed. For the multi-space theater production “the Trial” from Franz Kafka for actors, singer, choir and stage design at the Art University in Graz networked AVEs have been realized, utilizing Ambisonics systems in concert halls and movable acoustics instruments on open spaces.

Keywords

Auditory Virtual Environment, acoustic, stage design, computer music, Ambisonics

1 Introduction

An auditory virtual environment (AVE) is a virtual environment (VE) that focuses on the auditory domain only. It sees itself independent from other modalities like vision. Nevertheless an AVE could also be combined with the visual domain. Depending on the application, the user may be either a passive receiver or be able to interact with the environment. Three different approaches for implementations of AVEs are listed in Blauert’s book “Communication Acoustics” [Novo, 2005] from Novo:

1. Authentic reproduction of real existing environments.

The virtual room should evoke in the listener the same percepts that would have

been evoked by the corresponding real environment. He should have same spatial impression moving through and perceive his own movement inside the environment as well as the movements of sound sources.

2. Reproduction of plausible auditory events
This approach tries to evoke auditory events which the listener perceives as having occurred in a real environment. Here only those features are implemented which are needed for a specific simulation situation.
3. Creation of non-authentic plausible auditory events or environments.

The virtual room doesn’t evoke percepts in the listener which are related to a real acoustic environment, evoking auditory events where no authenticity or plausibility restraints are imposed, targeting pure virtual environments like computer games.



Figure 1: physical adjustable acoustic for Beat Furer’s music theater FAMA

1.1 the setting

For the music theater production based on the novel “Der Process“ (engl. ”The Trial”), written by Franz Kafka from 1914 to 1915 for actors, singer, choir and stage design, an experimental theater music composition should be done:

The hopeless search of the main character “Josef K” for the reason of his arrest is the grandiose template for a inter-institutional project: a play with perception, a sensual journey through existential abysses and absurdities of the bureaucracy with students and lecturers of the institute stage design / acting / singing, song, oratorio / electronic music and acoustics, choir of the Kunstuniversität Graz.

The production was roughly spread in three parallel played scenes at three subsequent places with an collective intro at the foyer and collective finale at the concert hall:



Figure 2: Ligeti hall stage design with big moveable blocks

Gyorgi Ligeti hall 400m² concert hall constructed for virtual acoustics.

theatre in the Palais (TIP) 200m² theatre hall constructed traditional acoustics.

courtyard between these houses with a Peepshow construction as stage design.

After the “Intro” in the foyer, the audience was divided into 3 groups, each group attending a 30 minute performance in one of the places and have been guided from one place to the other within the intermissions.

1.2 the compositional approach

Additional constraints for the musical acoustic composition has been made to concentrate enforce the ideas of the piece:

One main idea was to use signal processing for the experimental theater music composition for the play “Der Process” on live signals only and do not use any pre-produced sound material. All material should be based on live recorded sound signals using different microphones at the

places; to construct virtual soundscapes for different audio reproduction systems and virtual acoustics as a main instrument within these sceneries.

Another constraint that all places should be treated as networked AVEs.



Figure 3: TIP stage with big hole in the middle, traditional chariot-and-pole-system

1.3 the experimental approach

The a artistic research question have been: can a non-plausible non-authentic AVE, applied as a complex music instrument for theater music, produce a varying plausible acoustic sceneries.

As an extension, the AVE should use distortions in space, time, spectrum and signal domain and should therewith produce an distorted AVE, which is still perceived as acoustics, an absurd acoustics, Therefore the production was titled “AVE-Absurdum”. With this concept the category of AVEs should be extended to a fourth category of AVE, let us name it “absurd AVE”, which is non-authentic but plausible in an absurd way of reception and in respect to the visual domain. This AVE does evoke percepts in the listener which are related to a real acoustic environment and the live sound produced. by the actors and other real sound sources.

As a common audio 3D sound representation Ambisonics should be used, also to allow simulations of these AVEs at development phase prior the first rehearsals.

Ambisonics was chosen, not only because of already implemented Ambisonics system at the concert hall, which has been the very well tested in previous productions like “Pure Ambisonics”, but for streaming the acoustical impact of one room to another. Therefore spatial recordings and mixes as 3D audio streams was used, so spatial information of the audio signals can be

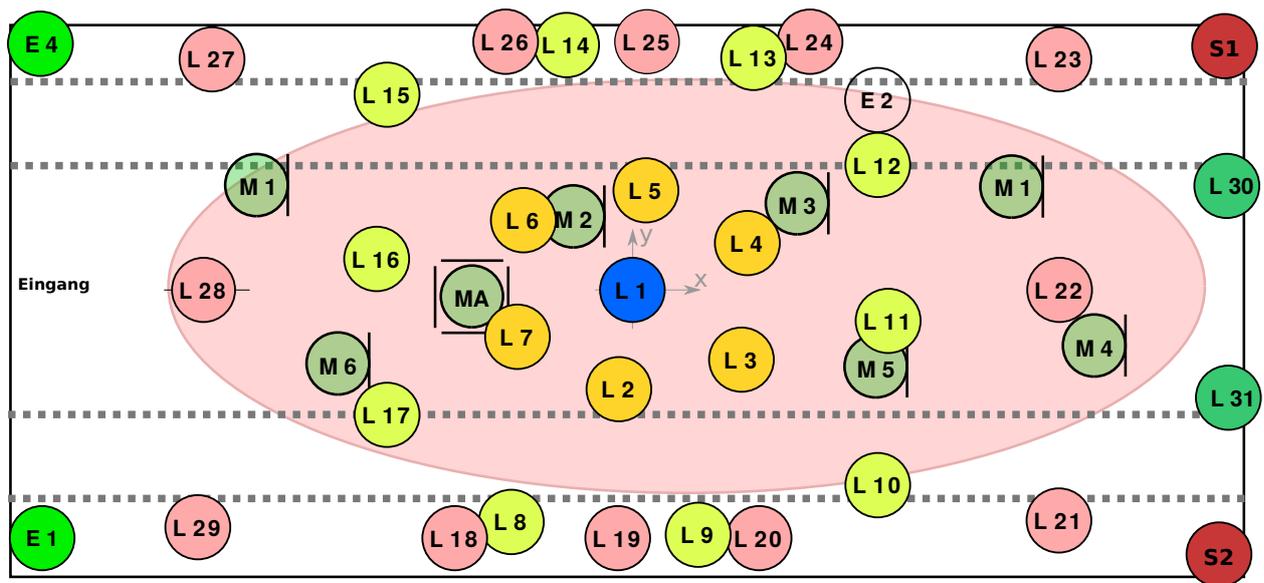


Figure 4: loudspeaker in Ligeti hall: Ambisonics L, subwoofer S, extra E, and microphones M. The heights of the speaker increases to the middle from 2m to 8m.

used in other spaces. Also Ambisonics can be used in directional speaker system, used for the move-able acoustics in between the spaces.

As a stage design using processes as backdrop, like an additional layer on the theater music itself, as an big invisible ensemble of signal processing algorithms, the generated sound environment represent a complex machine. So from another perspective these AVEs can be seen as part of the “theater machine” in the meaning of Gilles Deleuze concept of machines[Raunig, 2004; Deleuze and Guattari, 1977].

2 AVE Absurdi

For the three spaces, three different implementation of Ambisonics has been designed:

Ligeti-Saal Ambisoncis 4th order with 32 ambisonics speakers and 2 subwoofer, 7 directional microphones hanging from the ceiling, 2 headsets for main actors, 2 pickups on the floor and 2 on the blocks of the stage design.

Theater im Palais (TIP) ambisonics 2D ring on the ceiling, subwoofer, 2 Mikrofonen for Reverberation, 2 microphones for enhancement of special plaxes, 1 headset for trigger only.

courtyard between two houses Movable spherical directional loudspeaker driven by embedded linux computers connected to multichannel amplifier and a directional

microphone, powered by batteries and played by actors.

The order used in the different places is normally defined by the amplification system, but here we work also with Ambisonics streams and virtual microphones detecting different signals, the maximum is limited by the encoding system.

The Ambisonics system at the TIP, since the stage was designed as proscenium stage with the audience at one wall, was not satisfying and canceled by the director there, who wanted a purely stereo frontal speaker system. Anyway streams from other places has been used for the sound environment.

In the following the space in the Ligeti hall and the movable acoustic will be discussed.

2.1 AVE in Ligeti concert hall

Varying playable acoustics has been developed as an acoustician for Beat Furer’s music theater FAMA. As a stage design a real room in room with rotate-able wall elements, one side absorbers one side reflectors, for 200 listeners was build like a huge machine. One restrain was to use no electro-acoustic element. Unlike this physical adjustable acoustics, electro-acoustic AVEs should be implemented.

Since the already installed Constellation Acoustic System from Meyer Sound[Sound, 2010] with circa eighty of small speakers and about twenty microphones in 5 meter heights as a closed system was not in any way flexible

enough to fulfill the requirements of the idea of an “AVE absurdum”.

The speaker used for the 3D Ambisonics system are shown in figure 4. 31 active Klings & Freytag speakers have been used, where the first 29 of them are mounted on pantographs, which can adjust the heights and direction of each speaker individually as presets. The L22 speaker has to be adjusted higher, because of the blocks from the stage design and has been second by two others L30 and L31 on stands on the floor to lower the acoustical horizon. Additional two sub-woofer left and right in the front corners for enhancing the Ambisonics sound and used for special subsonic effects have been placed.

The Hemisphere was slightly expanded as ellipse and stretched to the front to increase the “sweet spot”. With this number of speaker a 5th order Ambisonics system could be realized. But since all the obstacles and additional movable blocks using a 3th order Ambisonics had smoother results on moving sources, increased spatial continuity and avoided to spatial aliasing errors over the room which resulted in a bigger “sweet spot”.

As an decoder the standalone decoder of the AmbiX plugin suite [Kronlachner, 2013] was used, for which Matthias Frank from the IEM calculated an suitable Allrad-decoder [Zotter and Frank, 2012]. For preproduction of effects and the development of the AVE in a studio or over headphones the binaural decoder with the special set of impulse-responses, measured in the Ligeti-Hall, was provided.

The decoder was fed with Ambisonics signals from applications within the Linux computer and over a MADI-Audio Interface input routed through the Lawo Mixing console from other computers, using “jackd”. Therefore three computer musicians were able to play in parallel using the same AVE system over one central decoder feeding the speaker. The sub-woofer management has been done in the Mixer, using the Ambisonics signals and an additional a subsonic effect channel for special effects.

The AVE-Absurdum has been implemented with Puredata [Puckette, 1996] running patches on different computers connected over MADI Audio Interfaces. The main computer implemented an Ambisonics Mixer with the room in room reverberation system (RRR), derived from the CUBEmixer [Ritsch et al., 2008] development of previous years and the “acre”

Pd extension library with the therefore developed Ambisonics Toolbox module for Pd: “acre-amb” [Ritsch, 2016] using “iem-ambi” external library.

“acre-amb” is a collection of high level Pd abstraction, to implement Ambisonics functionality for Ambisonics mixing and processing of multichannel signals and controls to be used in compositions and effects. Also a goal was to easily integrate Ambisonics encoder, decoder with calibration and speaker distribution, providing also connection and processing targeting fast prototyping of new Ambisonics algorithms.



Figure 5: consoles (from left): Lawo Mixing Desk, Controller for effects, Computer Console with Pd Patch and AmbiX Decoder, Controller for time machine and memory player, Spectral Ambisonics, with notebook as controller

2.1.1 Room in Room Reverberation for acoustics

The core of the RRR system is a multichannel reverberation system with 6 Inputs and 12 early reflections and 6 late reverb channels to be spatialized in the 3D space of the AVE.

It was not possible within this production time to hire a choir with 110 singers, especially because they move sometimes erratically in the room. Adjusting to limited rehearsal time, we had to find a solution where the actors and choir can play with different absurd acoustics, utilizing the conductor and movement-director to explore and fixate these effects within their re-

hearsals, starting within the very first rehearsals and eliminating the need to track the movement of the choir and actors for the composition.

The solution that was chosen was enabling “active zones”, areas under microphones, where choir, actors and audience are enhanced and encounter different acoustics feedback. These effects can be switched or cross-faded for each scene. Also actors can be in an different acoustical spaces parallel to the choir or audience:

Therefore the RRR was driven directly by microphones in 3-4m heights, enabling the different playable acoustics from small garage reverb, long tunnels with scatter echoes to big halls, even further to echoes like from surrounding buildings, mountains, allowing $> 200ms$ early reflections. This allows to build non-plausible acoustics, like increasing energy on reflections and/or different acoustical rooms in one room: an absurd AVE.

Additional to limiting the output, especially decreasing feedbacks of the reverb, each microphone got an feedback suppression EQ for the 3 most resonant frequencies of the room.

2.1.2 Distortion in Space

Within the RRR spatializing early reflections from only one direction or placing all late reverb to the other side, the acoustical space can be shaped: eg. imaging a big room in one direction and a wall in the other. This can be done dynamically, with a sudden appearance of a late reverb from one side. Since a changing acoustics can be perceived better than a static one, since change of size of rooms, normally does not happen, are drawing more attention to listeners than static ones.

An overlap of one acoustic space over another seems to be more unnatural, but since most singers and actors use reverb on stages, the audience is used to this effect.

2.1.3 Distortion in signal

Another effect was inserting processing of the microphone signal path. Within this project three types have been tested:

spectral Resonances and filters

dynamics Limiter, Compressor and Expander.

shaping Waveshaping: tubes, metal strings, noise (cut) and also string simulator, metal plate.

Spectral filter have same effects as different spectral properties of reflection material and

is therefore only spectacular, if really applied strongly. Changing this dynamically changes the whole “sound color” of the scenes.

Dynamics have been mostly applied on singer and actors. Nowadays audience is widely familiarized with these effects for solo performers, but doing it extreme, which means silent passages become loud and loud voices decrease the volume is a strong effect, but is something singers do not like. Therefore it was used to increase the struggle of the actor against the environment, here acoustics. The drawbacks are that it was really hard to control without feedback at silent phases and can be perceived as an mistake in the performance very easily.

A really strong effect is the distortion especially of the early reflections in the reverb: A tube shape make the room a warm sound and using nonlinear shapes introduces noise. Additional metal distortion like ring-modulator with 2 inputs signals within a parallel dialog can produce really scary rooms. As drawback the feedback is again an issue, so mostly limiters has to be used.



Figure 6: Choir surrounding the audience and actors behind a transparent curtain

2.2 Distortion in Time

We called it “artistic time-stretching”, which is an ongoing research project done by Manuel Planton on the IEM, where time-stretching should be applied in live situations. time-stretching and realtime is clearly a contradiction, since stretching leads in the past, which means the signal is not within the realtime constraints.

There has been three different phases in perception experienced:

- time-stretched signal within the early reflections delay $< 80ms$
- echos up to $300ms$

- a playback of a detached recording of the signal $> 1sec - inf$

Playing within this phases is the artistic approach, where voices has to be slowed down first and then speed up again. Doing this, the sound is amplified first, than scattered and becomes then a dialog with the live signal, which is a very thrilling effect, even more it seems like a replay like a “deja-vu” experience. It turned out to be a thrilling effect, which actors liked to play with. It was used on solo pieces on actors and repetition phases of the choir. Introducing feedback loops of the signal to the time-stretcher optionally combining with pitch shifts, expands the possibilities of this effect even further. So it was used solo for some scenes and the effect signal spatialized independently from the position of the source.

For the implementation a own Pd external was written, using the rubberband library and additional an overlap and add (OLA) algorithm. Considering the limited rehearsal time and the big parameter space, the time-stretcher has to be played interactively, observing the actors by an additional electronic musician. As an own instrument the Pd-patch was run on an separate computer with own controllers, mixed in via a Ambisoncis bus signal.

2.3 Spectrum processing

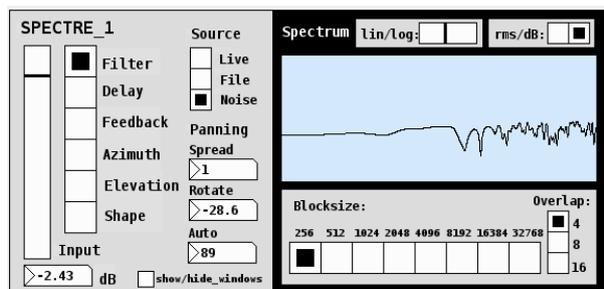


Figure 7: Spetcre Pd GUI

Another special effect has been the spectral distortion over space, we named it “spectre” developed and played by Christoph Ressi. With an special patch using small FFTs/IFFTs, the spectral information was split into several channels, which have been spatialized in the 3D space. High frequencies could be played from another direction than low ones and spread over the hemisphere. Drawing tables controls the movements and spreading. Also a feedback loop to within the effect was introduced, so it can

do a kind of spectral freezing. This development was used to audio-process the choir input signals and distribute them in the space. The choir chant tends to be a acoustical environment with itself, especially if the choir is surrounding the audience. On transient signals with fast glissandi elements like shouting, clapping and stamping the effect is audible like a rapid movement of the sound in the room. On long notes especially accords, the rooms begin to feel like stretched and softened walls, because it is hard to hear any dimension, since reflections are masked by direct sound. The effect was used on a one scene as solo acoustic performance and frozen during conversions.

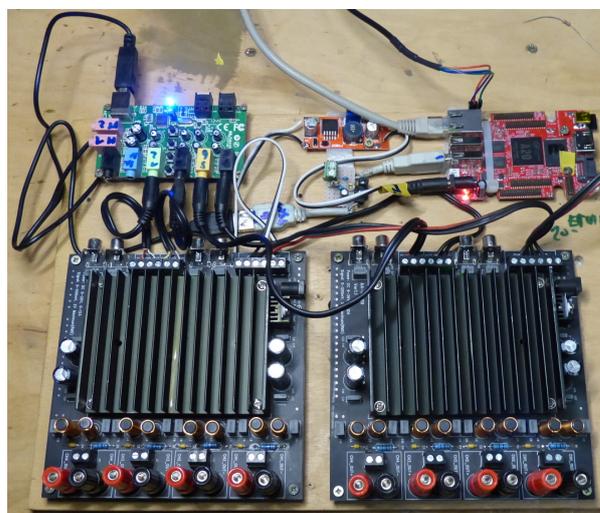


Figure 8: development prototype for linux player with 8x100W for 2 tetrahedron-speaker: decoupled USB 2/8channel, dc/dc, olimex-A20, 2x class-D amplifier to be powered by 12V battery

3 Movable Virtual Acoustics



Figure 9: agent with microphone playing 2 directional speaker

For virtual acoustics in the courtyard, where no speakers and fixed installation was available, a special concept of moving acoustics was conceptualized. Operated by electronic musicians as “agents” in the play, the movable acoustics instrument with AVE-function and stream rendering features, were integrated in the play by the director:

Using spherical loudspeaker arrays allows us to beam sound to many directions utilizing Ambisonics signals. With walls of buildings and rooms around in the courtyard, reflection can be induced, which triggers a kind of surrounding sound. The simplest of the spherical geometries the tetrahedron, which has been used before in a performance enhancing the room acoustics of a church [Robert Iepenik, 2014]. The Tetrahedron loudspeaker have 4 wideband speaker mounted on each plane and can be placed on an portable stand. The electronics consists of a $4 \times 100W$ class-D amplifier, supplied by an 12V12Ah rechargeable battery, driven by an “Olimex ARM-A20” embedded computer with a hacked multichannel USB audio interface, a phantom power microphone-preamp, speaker cable and an microphone over XLR cable. The agents can carry the whole electronics in their bags and hold the microphone and speaker.

A directional microphone has been chosen for interaction with the surrounding, so the agents can focus and play with the sound input of the environment using a kind of AVE-patch. Receiving the Ambisonics streams from the other spaces, using an additional virtual microphone, they can select signals from other performances to be combined in the audio scene.

The whole signal processing was done by a Pd patch including different effects like feedback with reverb, pitch shifting, delays etc. to realize a movable AVE. This work was named “AVE-tetrahedron” and experimental explored before on the campus.

To play this instrument small controllers mounted to the arms have been used.

4 Ambisonics network

Streaming Ambisonics was developed for the COMEDIA project [Ritsch, 2010]. Using this technique, the 3D acoustic signal of an room can be delivered to other spaces, broadcasting eg. the 25 channel Ambisonics signal from Ligeti hall to others. The receiver can choose the AVE and place virtual microphones inside, using controllable Ambisonics decoder.

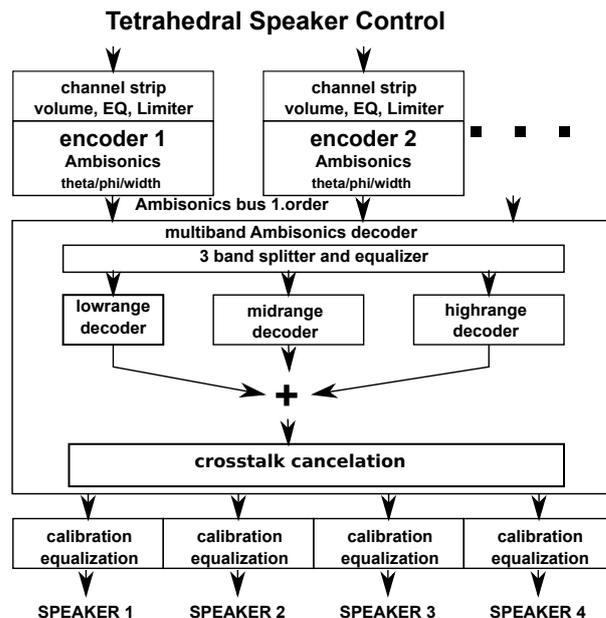


Figure 10: tetraeder drive for AVEs

For streaming scripts for “gstreamer” has been written as transmitter and receiver connected via “jackd” to Pd. This allows a adjustable and acceptable latency with a sufficient buffering for different situations.

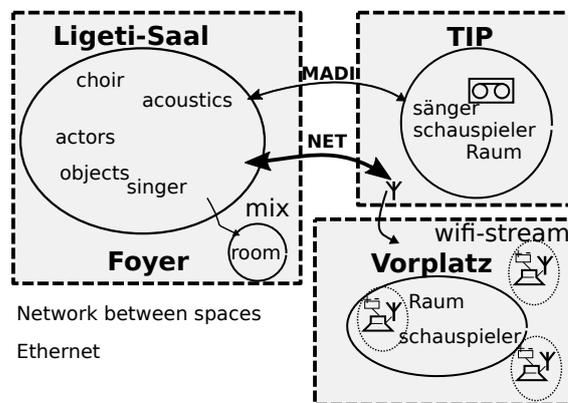


Figure 11: Network of AVEs

5 Conclusions

The whole production was a big success from the reaction of the audience and the participants. The AVE concept was accepted, after some persuasiveness, explaining the concept to all participants. Because of the limited time, there was not much space to criticize and overthrow the concept, so even it was very tight we tried to stay as close to the concept as possible or drop it, like within the TIP.

To focus on transformations and not so much

on sound-effects was a very wise decision, since effects brings to much additional parallel content and are not so invasive to support the idea of Kafka's absurd world.

The concept of AVE absurdum as a playable instrument has been proven in the Ligeti-hall. The movable acoustics instruments works nicely in small areas. Simple effects like distortion in time work surprisingly well. Imprinting other acoustics of one room in the other also works fine in most situations, but since listeners are used to it in media perception, are not spectacular.

6 Acknowledgements

Thanks go to all the participants of the play, more than 80 for support and being open minded to accept new concepts. Also to the university with greatly supported this production beyond the normal effort for workshops and lectures. Especially thanks to the Sabine Pinsker from the stage design department for organizing the whole project and the general director Horner for his encouragements to enter new path for theater music. For the development, Atelier Algorhythmics which provides the Tetrahedron-player with embedded linux systems and other hardware.



Figure 12: Winfried Ritsch conduction pantographs in ligeti hall

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