3D Audio and Soundscape Composition

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ABSTRACT: Each 3D-audio composition creates a sonic landscape. Understanding 3D-audio as an autonomous means of expression leads deep into the field of acoustic ecology. The significant terminology provides a system of parameters for conceptualizing and composing within 3D-audio environments and therefore clarifies the narrative power of soundscape as a concept. The workshop identifies parameters and outlines an approach to 3D-audio design, including aspects of the practical implementation and production logistics within object-based production systems like the SpatialSound Wave System (SSW) by the Fraunhofer Institute (IDMT). The workshop refers to the observations of an ongoing research project at the Soundscape- and Environmental Media Lab (SEM-Lab) of the UAS Darmstadt in Germany, led by Prof. Sabine Breitsameter, within the frame of the master´s degree program International Media Cultural Work (IMC).

1. 3D-audio as acoustic holography

It has been an artist's wish for centuries to place sounds in acoustic space and create a virtual sonic landscape, in which sounds come across as acoustic holograms. 3D-audio technologies like the SpatialSound Wave System (SSW) allow to locate and treat sounds as three-dimensional, virtual sound sources in space. This enables to simulate tangible soundscapes and bring virtual space-sound-concepts to live. The acoustic space can be experienced in a multi perspective way in 360°, as a three-dimensional space with x, y, and z axis.

2. Object-based production format

The basic technical idea of the SSW relies on Wavefieldsynthesis (WFS). The Fraunhofer IDMT though created algorithms that allow to create virtual soundscapes with a smaller setup than WFS. Another benefit of that approach is the object-based production format. Unlike stereo, surround or other channel-based setups, sounds are not assigned to a certain speaker, but to an object – a virtual sound source object with a concrete position in acoustic space.

3. Acoustic holograms and acoustic topography: virtual soundscapes

The concept of *soundscape* refers to the appearance of all sounds in a room, place or landscape that envelope us up to the quietest and thinnest sound. Based on the term and concept of *soundscape*, as its basic gestalt of listening & figure of concept, 3D-audio constitutes an autonomous aesthetical concept, that necessitates three-dimensional, acoustic design-motifs as genuine means of expression. Referring to the soundscape concept, 3D-audio conceives the occurence of sound in art, everyday life and media as a concrete and sculpturally located, acoustic topography. Thus, the terminology, that is associated to the soundscape concept can be used to increase dramaturgical expressiveness of spatialization. As the spatialization can reduce the masking effect, polyphonic textures and figures acquire a sophisticated manifestation, allowing to suspend a predetermined hierarchy of "signal" and "noise" and to create unheard sonic choreographys. Think of a soundmark, as an unique sound of a place or peoples community, which often has a cultural and historical importance. Or the keynote which is heard, but often ignored, as a constant sound in the background. What if the soundmark surprisingly disappears? What if the keynote slightly changes – or moves? Isn´t this a non-verbal indicator for a change and herefore a powerful element of acoustic communication?

4. Conceptual thoughts & artistic strategies

The core of 3D-thinking, from the technical point of view, as well as from the conceptual perspective: Every sound has a spatial context. Where is the sound source located and how is the sound extending in space? Is it small, is it big, is it moving? What is the spatial relation to the listener and to other sound sources? The virtual sonic landscape is perceived as a 360° and three-dimensional sphere. Therefore, *the role of sound* is not longer reduced to the appearance of its acoustical representation. In fact, each sound must be treated as a 3-dimensional phenomena in acoustic space. From this, it follows, that the *role of the listener*, and the *role of the listening* is altering, too: the frontal stage disappears and the auditory becomes the stage itself. As the focus of attention is not predetermined by a stage, the auditory perception becomes an omnidirectional experience and an interactive process: the listener has to orientate himself acoustically in space and find out, or – decide – which sound(s) he focusses on, like an explorer of the acoustic environment. In order to get familiar with the appearance of sound in spatial context, sound walks are a highly-recommended method to prepare for a 3D-audio composition.

There is no predetermined limitation of application possibilities to a certain genre or aesthetic concept. Indeed, a wide range of artistic strategies are supported through the new way of audio reproduction and the tangibility of sound, that can be achieved with 3D-audio technology. On the one hand, tangible phenomena appear as "real" and "true". Such a naturalism can intensify the illusion of an immersive "reality". On the other hand, 3D-audio is best suited to design disruptive, contrasting, torn and collage-related forms, as opposed to homogeneous-illusionary experiences. 3D-audio also allows simultaneity of contradictions, so that the "sculputural" positioning of sound in space can also be a method of deconstruction, thus a concept, which is diametrically opposed to an illusionary realism.

5. Technology and production format

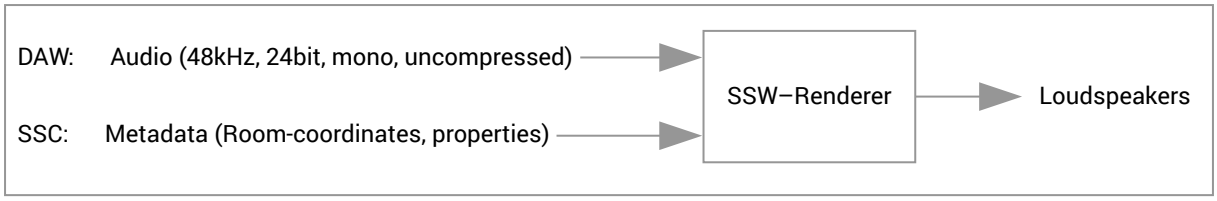
The SSW provides a user-friendly working environment. Each audio signal is assigned to an `object` (analogue: virtual sound source). Objects are graphically visualized and operated with the *SpatialSound Control* (SSC) production app. Stereo files are treated like two mono signals and assigned to two objects. Positions, movements and properties of the objects are applied with the SSC, a web-based production app with a graphic interface for the spatialization, that runs within the google chrome web browser. Objects are featured with certain *properties*, that effect the acoustic appearance of the corresponding sound files:

Point Source (default setting) || Plane Wave: Objects appear punctual at a precise position (Point Source) || Objects appear wider and broader and are roughly locatable (Plane Wave)

3D Source (default setting) || Lower Source: Objects occur further up (3D-Source) || Objects occur at a lower position (Lower Source).

Minimum Delay: Reduces movement artefacts.

Technically, the shift from the channel-based to the object-based environment means, that each object consists of signal (audio file) and meta-data (room-coordinates and other properties). The SSW-renderer gets audio signals from a digital audio workstation (DAW) and room-coordinates from the SSC.



The renderer accepts mono audio signals in 48 kHz and provides 32 objects. The audio signals are assigned by routing the audio-tracks to the outputs of a common MADI – Interface (Output 1 → Object 1; Output 2 → Object 2, (...), Output 32 → Object 32). The SSW-renderer processes the incoming audio files into signals for each speaker of the actual speaker setup, according to the positions and movements (metadata), that are defined with the SSC. Thus, object-based productions can be played back via different speaker setups without losing the intended spatial arrangement impression. The SSW supports a multitude of freely positioned loudspeakers and allows integration of interactive settings.[1]

6. Design approach and material concept

The idea for this research program and the workshop derives from the wish to compose, design and to create new forms: un-heard soundscapes, that never had been able to realize before. To make use of the new possibilities of spatialization in such an extent, the program focusses on the composition of virtual sound-scenarios, consisting of particular sounds. This approach requires a thoughtful *spatial concept* and an elaborated *Material concept*.

From a technical point of view, each audio signal can be played back with the SSW. From an artistic view point, a more differentiated consideration is needed. Therefore, an understanding of the object-based production is crucial: Every sound in an audio file will be synthesized as one virtual sound source. Overlapping sounds of a recording can not be spatially separated – only “isolated” sounds can be positioned individually.[2]

1. Room-coordinates can be delivered from all kinds of devices in the format of a common OSC-protocol.
2. If sounds are not overlapping, they can be seperated with conventional editing.

The microstructure, as the inner structure of a virtual sound source, constitutes its acoustic appearance. If the corresponding signal contains a whole soundscape, the soundscape becomes a sound source as a whole – like a cloud, or a space in a space. Isolated sounds also come along with a specific shape and a particular spatial appearance: small or big, close or far, punctual or broad, directional or unfocused.[3]

The macrostructure refers to the mapping of the objects and therefore their spatial relation to each other. The macrostructural context shapes the material context significantly: Is a sound autarkic, coming from one direction? Or is it part of a complex figure, consisting of a number of distinguished sounds, that even come from different angles? A collapsing tree might be prepared as one sound source, if the tree collapses in some distance to the listener. If the tree collapses right above the listeners head, it might be more appropriate to design the collapse by assembling the details of that acoustic event, such as the cracking and breaking of the brenches.

The characteristics of the audio-material shape the appearance and the degree of freedom to arrange your composition, due to the micro- and macrostructure of the virtual sound sources. Conventional multichannel-recordings can be useful to create a basic atmo, but are not making use of the full potential of the 3D-audio technology. As an example for an object-orientated recording design, microphones could be arranged close to the (real) sound sources. Microphone positions should be carefully adjusted. Close-up recordings tend to act as an acoustic "zoom" – even small events may sound huge, although the volume is adjusted properly. On the other hand, a large distance-recording contains the room-impression of the recording-site, which can be wanted (e.g. as a basic atmo or room tone) or distracting – depending on the intended purpose. Multi-channel recordings are transferred by arranging the corresponding objects according to the positions of the microphones. The de-construction of the positions is an issue of artistic intention. For the use of stereo-material, it must be clear, that two objects cannot `surround` the listener, but the spatial relation (distance, angle, position) between the two objects delivers useful parameter to adjust, how the sound is extending into space.

To substantially design the spatial appearance of a scene, the desired room-impression can be implemented through a dynamic, *object-based room simulation* of the SSW, *conventional room simulations* or *reverb effects* and *multichannel recordings* of a basic atmosphere or room tone.[4] If no such intentional design is implemented, the real room of the 3D-installation, with its particular acoustic properties, strongly affects the spatial appearance of the composition.

3. E.g.: Prepare isolated sounds, assign them to different virtual sound sources and arrange them, according to the spatial concept of the scene.

4. Conventional room-simulations (surround reverb, stereo reverb), that are processed within the DAW can blur the consistency of spatial impression, since the channel-based room-simulation or reverb software is not dynamically responding to the positions of objects within the simulated room.

A design approach, that seems to be reliable for a number of purposes can be roughly described like this: the production consists of a quiet, basic atmo (e.g. a multichannel-recording of a soundscape) which is complemented with isolated sounds (or specific object-orientated multichannel-recordings) in order to add details and plasticity.

Example: Create a crowded street as basic ambiance by recording a quiet street as a multichannel-recording (Minimum: 3 channels, better: 8) and add sounds of a crowded street separately.

Summarizing, it´s a whole field of artistic exploration to create sound motifs and therefore design specific recording-methods, which take account of the principles of the object-based production.

7. Production logistics and other useful hints and tools

For an efficient and successful 3D-production process, a carefully considered *production logistics* is essential. The first step of the 3D-production is to assign each of them to an object and apply the desired properties. As the number of tracks may exceed the number of available objects (32), the production logistics ensures, that the assignments support the spatial concept of the piece. Sounds, that should occur at the same time at different positions or with different object properties, must never be assigned to the same object.

Therefore, the dramaturgical, aesthetical and spatial properties for each sound must be defined:

What is the dramaturgical function (keynote, soundmark, signal sound)?

How is the spatial appearance:

- punctual (Point Source) or atmospheric (Plane Wave)?
- where is it located? (X/Y and 3D-Source/Lower Source)?
- static or moving? (Minimum Delay)?

Based on that, an *object-structure* can be deduced, that declares dramaturgical functions and properties for each object.

The production logistics clarifies two issues:

- assignment to an object for each sound
  e.g.: Barking dog → Object 1
  Violin 1 → Object 9
  Violin 2 → Object 10 (...) etc.
- attribution of properties for each object
  e.g.: Object 1 – 8 → Plane Wave
  Object 9 – 16 → 3D Point Source
  Object 17 – 20 → 3D Point Source, Minimum Delay
  Object 21 – 28 → Lower Source

Object 21 – 28 → Lower Source, Minimum Delay

The production logistics though comprises the reasonable preparation of the project, by grouping and routing sounds within the DAW.[5]

Another part of the preparation is the notation of the *spatial concept*, which includes positions and movements. It can be useful to sketch *soundmaps* and create *basic figures*, showing the initial positions of the objects for each scene. Those spatial *figures* clarify the perspective and express dramaturgical aspects of the spatial concept. As transitions are spatial phenomena as well, they should be taken into account, too. For complex movements and figures, additional sketches are advisable.

8. Conclusion

3D-audio technologies like the SSW expand the ways of acoustic expression and come along with an artist-friendly and versatile applicable working environment. Its potential is not been exploited by far. Conventional concepts and half-baked implementation approaches are not convincing in light of the unused potential. It´s up to us, the forward-listeners, to offer new, inventive and valuable auditory experiences and thereby strengthen the listeners autonomy.

Central tasks of the workshop:

- Sketch a first outline of a concept for a 3D-composition. In which field is it allocated? Which design-principles are involved?
- Identify major acoustic elements of your composition and relate them to the sound-scape-concept: what´s their dramaturgical function? How do they fulfill that function (acoustic appearance and spatial appearance: position, movement etc.)?

5. It can be useful to create object-tracks as a transit station and collection point for sounds, that are assigned to the same object.