3D Sound and VR Audio – Interfacing Specific Sound Dramaturgies and New Perceptional Paradigms

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ABSTRACT: The desire for a precise three-dimensional positioning of sound in the 360° sphere can be traced back to the antiquity. Although numerous 20th century composers tried to implement their 3D audio 'visions', the full technological possibility to accomplish sonic plasticity has come up only recently by 3D sound systems, as in this case the Spatial SoundWave System (SSW) by Fraunhofer Institut Ilmenau/Germany. However, technical perfection does not equal the artistically convincing, as 3D audio is a distinct aesthetic concept. By referring to the rich cultural history of 3D sound creation, this paper points out major reflections and criteria which lead to aesthetic necessity and plausibility for 3D audio productions. The approach given by the term *soundscape* is crucial. Trendy terms like *immersion*, *tangibility*, *illusion*, and *virtuality* are questioned in reference to overused aesthetics, naiv realism and the lack of providing critical distance. It is suggested that a huge artistic potential for specific 3D audio production lies in dramaturgical approaches like fragmentization, deconstruction, as well as in the careful conceptualization of auditory materials and their representational potential.

KEYWORDS: 3D sound, VR audio, Virtual Reality, Augmented Reality, llusion, immersion, tangibility, fragmentation, deconstruction, soundscape composition, spatial sound.

1. On the realization of 3D audio 'visions'

The 80 speakers in Bayle's *Acousmonium*,[1] the over 300 speakers in the Philips Pavilion at the Brussels World Fair,[2] Stockhausen's and Nono's aural-spatial settings, as well as numerous sound installations that freely distribute a large number of speakers throughout a space (such as those of Kubisch, Leitner, or Fontana) all represent examples of the desire for a precisely placed sonic plasticity in the contemporary audio arts – for the purpose of organizing sound along the x, y and z axes within a 360° sphere. This artistic desideratum is to be understood as something different from multi-channel or surround arrangements in which sounds are represented along a series of speakers and injected into a space.

The systems described, however, are also associated with a complicated production technology that is difficult to operate. Since 2012 we at the Soundscape & Environmental Media Lab (SEM-Lab) at the Hochschule Darmstadt University of Applied Arts have been working with the Spatial SoundWave System (SSW) to produce 3D audio in the context of an artistic research project. The SSW was developed by the Fraunhofer Institute at Ilmenau and is not only excellent in its operations – which can be learned in a straight-forward manner – but it also fulfills the artistic desire to achieve three-dimensional positioning in both a technically and aesthetically complex way, without being limited to a single privileged listening position commonly known as a 'sweet spot'. Our aim is to contrapose the technocratic-functionally oriented application euphoria of 3D audio with artistic alternatives, in which the application of 3D sound is based on aesthetic necessity and plausibility. Selected aspects of our work are outlined in the following:

2. The soundscape approach

In our artistic work, we approach 3D audio not as a new-fangled technical novelty, but rather as a distinct aesthetic concept. The term 'soundscape'[3] makes this comprehensible in terms of designing with sound and as a general concept.

'Soundscape' indicates a plastic, three-dimensional placement of sounds within a 360° sphere. Various kinds of sounds are found at highly specific places within a landscape, where they assume a certain position, dimension, and plasticity. The collaboration of all sound

1. Developed by composer Francois Bayle in 1974 at the GRM in Paris, also executed using fewer or more speakers.
2. Such as in the way Edgare Varèses "Poème Electronique" was performed in the Philips pavilion, in collaboration with Le Corbusier and his assistant Iannis Xenakis.
3. cf. Sabine Breitsameter, Hörgestalt und Denkfigur – Zur Geschichte und Perspektive von R. Murray Schafers Die Ordnung der Klänge. An introductory essay in: R. Murray Schafer, Die Ordnung der Klänge. Eine Kulturgeschichte des Hörens (published and translated by Sabine Breitsameter), Mainz – Berlin 2010. pp. 7–28. The term 'soundscape', comprised of 'sound' and 'landscape' was first documented in 1966 by Richard Buckminster Fuller. R. Murray Schafer continued to use it beginning in 1968, beginning from the premise that hearing is at its basis a perception of the environment. The presence of sounds in daily life, art and media presents itself concretely as an acoustic topography.

shapes and positions – whether loud or faint, near or far, desired or undesired – leads to a comprehensive experience of a landscape of sounds, indeed to a specific soundscape.[4] The term 'soundscape' thus inherently connotes an aesthetic approach to working with three-dimensional audio systems.

3. The 3D audio apparatus: a new tool

A broader public has been exposed to 3D audio at the planetarium in Jena, where the SSW 2011 was installed with 64 speakers, especially for applications involving the accompanying of Fulldome films.[5] This is the context in which the SEM-Lab began to produce 3D audio productions in 2012.[6] With the expectation of eliciting certain filmic qualities, 3D audio here initially served to support dramatic functions. For example, a sonic element positioned in the space becomes audible in order to direct the gaze to where important dramatic elements are presented. This increases the perception of the entire wraparound space while at the same time identifying the full spectrum of the visible environment with the audible environment. This last part cannot, however, be fully realized, as the images in the 360° film must be projected onto the outer surface of the room and are not visible to the observer as holograms.

With 3D audio, however, the SSW makes it possible to provide a plastic positioning within the room, producing an acoustic hologram. This makes the audio experience particularly impressive, such that it begs to be liberated from its purely servile function. The space then ceases to be a given thing in need of being 'filled' with sound. Instead, the space becomes a three-dimensional entity defined by a topography of sound – an agile landscape capable of being experienced from multiple perspectives. Specific existing soundscapes can be reproduced, as well as compositions of imaginary plastic sound worlds.

The technical highlights and strengths of the SSW include the fact that it is not channel-based, meaning the sounds do not need to emanate from speakers, but rather virtual speakers are created through which acoustic sources may occur at any position in a room. The technical basis for this phenomenon is a kind of condensed wave field synthesis.

4. The question of aesthetic plausibility

Our criticism is that a large portion of 3D audio productions up until now have realized their three-dimensionality in an often unmotivated way. In many cases this has involved stereo

4. The term 'soundscape' (Klanglandschaft) is in no way limited to the acoustic representation of an existing landscape, but rather includes any auditive phenomenon, whether consciously designed or found.
5. This refers to a film format in which moving images are projected onto the 360° surface of a dome.
6. An entire series of 3D audio productions created at Darmstadt UAS' Soundscape and Environmental Media Lab together with Fulldome films (in part in co-production with HFG Offenbach) was awarded with prizes, including the autonomous sound art piece "I, Water" (2012) by Philipp Boß, Felix Deufel, Yannick Hofmann, Klaus Schüller, Natascha Rehberg.

productions from pop bands or stereo ear plays that have been converted to 3D. The listener finds himself situated amongst the instruments or people who are speaking – unquestionably producing a 'wow' effect. But what becomes clear in this experience is that the use of 3D audio is not fully realized by 'pimping' a conventional frontal presentation format. This requires a much more specific artistic motivation. What are the genuine dramaturgical ideas, concepts, or other desired expressions that are fulfilled by 3D audio? Within the framework of our artistic research work, we have found it useful to first ascertain historico-cultural considerations.

4.1. Immersion and the private universe (*Eigenweltlichkeit*)

Immersion is a catchword that describes the experience of being hermetically surrounded by coherent medial sensory impressions. It always implies a concept of a private universe (*Eigenwelt*), which proves to have a long tradition. In 1849 the composer Richard Wagner described the experience in which audience, artwork, environment, and the actors involved melt into each other to form the basis of his concept of the *Gesamtkunstwerk* (artistic synthesis). The polychorality of the Venetian School in the early 15th century builds on the experiential concept of immersion, as well as that of the stone age Hypogeum of Malta, a subterranean burial and worship site. Within this structure, a male voice, such as that of a priest, is amplified and curiously reflected so that the people present are enveloped by it.[7] It is not difficult to imagine how this would unfold an intense, cult-like effect, such that it would become nearly impossible to distance oneself from the happenings there, either socially or psychologically.

4.2. Tangibility and illusion

With 3D audio, sound scenarios and compositions can be fashioned into an almost material-tangible presence and experience. Materiality of all kinds becomes 'real'. Even a gust of wind can be felt on the ear. The sounds seem to be real, material, touchable – tangible.

This is also a long-cherished artistic desideratum, exemplified by the legendary coin in the antique amphitheater of Epidauros, whose impact on the floor was supposed to be dependably heard and located even in the last row – a sound experience identical to the real one, unlimited by a privileged 'sweet spot'. An unreflected naturalism can, however, intensify the illusionary nature of an immersive reality to the point of naiveté.

7. In this way, the voice liberates itself from the body of its creator and emerges at a completely different place in the dark of the underground room.

4.3. Virtuality and Augmented Reality

The concept of virtuality[8] is inherent in the auditive. The ear possesses the capacity to perceive where the eye cannot – beyond the field of vision and the visual faculty, for example behind a person or in the dark. In this way, hearing achieves a presence independent of physical presence.

An example of this can be observed in the sound experience in a whispering gallery.[9] Here, words spoken quietly in one spot can be perceived at a spot dozens of meters away – so authentically as if the speaker were standing directly next to the listener. Such spaces can be found at St. Paul's Cathedral in London and the Gol Gumbaz Mausoleum in Bijapur, India. It should come as no surprise that such astonishing phenomena are occasionally assigned supernatural qualities.

The principle of the virtual loudspeaker was used as far back as the Neolithic Period, 5000 years ago, for example at the Hypogeum on Malta, an underground burial and worship site carved of stone. Numerous chambers, niches, and corners refract voices and sounds in a characteristic way. In the main oracle chamber, the voice of a male high priest is filtered and amplified in a special way, such that the lower frequencies dominate. It is thus liberated from its originator and becomes audible at a totally different position in the dark of the underground room. Offering an experience of something auditory as if it were 'real' in a place where no one and nothing is supposed to actually be served to unfold the cult's mystical effects.

In the age of the computer, the interlacing of progressively created perceptions with existing material is referred to as Augmented Reality. Historical examples show that the term was already applicable in the pre-electronic age. We thus address the question of how it is possible to conceive of composing and designing within the framework of Augmented or Virtual Reality beyond intentions involving a kind of hypnotism or religious motivation.

5. Artistic strategies in 3D audio work

Immersion, illusion, and virtuality: Can plausible aesthetic approaches to 3D sound exist beyond these characteristics? From a dozen or so multiple prize-winning compositions created at the SEM-Lab at Hochschule Darmstadt, we are able to surmise the following:

5.1. Immersion vs. the naiveté of illusionism

In the soundscape composition "Chalice Well" by the Canadian composer Barry Truax, the principle of immersion is fulfilled in the greatest possible sense of the word.[10] From within

8. The term 'virtual' literally connotes the possibility of existence or of having an effect.
9. ???
10. Truax originally composed the piece for 8-channel diffusion, but created a 3D audio version at the invitation of the SEM-Lab.

a water spring, the listener is surrounded by its flowing, gurgling, fizzing, pulsating, and whirling. This is not presented as a naturalistic reproduction of specific acoustic events, but rather as an original composition manifested in a careful electro-acoustic reshaping of the original sound material. Through digital processing, the sounds are abstracted to evoke surreal imaginings of physicality, materiality, surface feel, and movement. Because these sounds do not refer to conventional figurative concepts, they communicate a strongly physical presence while freed from the illustrative and illusionary. Here it can be shown that a careful material concept is required in order to escape the naiveté of illusionism.

The young audio artist Natascha Rehberg developed a comparable material concept for her piece "Rata-Schaan" (2015). It refers to motifs of Rudyard Kipling's "Jungle Book" and explores the primeval forest as an abstractly tangible sound environment. It also establishes a path to action and interaction within the 3D audio space, although this has not been specifically implemented thus far. Like in the real jungle, "Rata-Schaan" compels visitor's actions to influence the sound texture comprised of plants, insects, birds, and animals, which then influences the behavior of the visitor herself. Concepts are being worked on currently in the SEM-Lab that allow recipients to interact not only mentally but also operatively.

5.2. Fragmentization and deconstruction

A concept pursued by Anne Pischulski and Denise Röhrig in their voice play "Schienensuizid"/"Railway Suicide" (2015)[11] is that the physical and mental states of being surrounded and involved do not necessarily generate affirmative embrace and assimilation. It captures the fragmentary, apparently meaningless and random perceptions of a person planning to kill himself. This 3D audio piece unfolds along a ragged soul landscape, using speech, voices and various sounds. This is also the strategy with the 3D composition "Vinkovci. Durch das Tor Kroatiens und wieder zurück"/"Vinkovci. Through the Gate of Croatia and Back" from Aleksandar Vejnovic. The listener is put in the position of being within a person's mind. Instead of trying to create a simulated acoustic likeness, the goal here is to use the sound world to present an interior fragmentizing mirror and deconstructing reflection of the external world. This is 3D audio used not as an instrument of the homogenously illusionary, rather also as an approach for the torn, contrary, contrasting, and confrontational.

An entire series of sound art pieces and compositions have been created by the SEM-Lab on this basis.

The compositional construction of an urban soundwalk with the complexity and contrariness of its material and spatial sounds, sound textures, and auditive horizons, can also be plausibly communicated by 3D audio without slipping into the purely realistic and

11. The production was originally produced as a 3D soundtrack for a Fulldome film in 2015, but possesses the autonomous qualities of a piece of sound art.

descriptive. The sculptural positioning of sounds in a space thus presents also a method of deconstruction: a concept diametrically juxtaposed to the generation of illusion.

6. Perspectives on listening in Virtual Reality environments

Our artistic research indicated very clearly that it is not enough to perfect 3D audio productions technically, specify them based on an apparatus, and motivate them dramaturgically. The new 3D audio apparatus presents entirely new challenges in considering the shifts occurring between listener and work, and in the artistic investigation of this situation.

3D audio directs the listener out of its frontal, purely receptive observer role within a concert hall and leads him into the role of an explorer who excavates its environment by carefully monitoring its sounds in all directions and spatial positions. With its tendency toward Augmented Reality and interactivity, it is not likely that 3D audio will remain an aesthetic phenomenon on the margins of culture. Rather, based on the success of computer-supported virtual experiences of reality and space, it is more likely to quickly find its way into the mainstream. Will composers be equipped to carve out aesthetic values and set artistic standards? The problematic of a clearly immersive approach lies in its tendency to embrace and assimilate its participants, integrate them as part of the setting, and therefore make it difficult for the individual to distance himself. However, where observer status and options for distancing are restricted, not only are our listening habits challenged, but also our intellectual tradition of the enlightened appropriation of our world.[12]

How should participatory listening be brought about with an orientation toward aesthetic and cognitive concerns, in order that the recipient does not lose himself within the affirmation of empathy, involvement and adaptation? In order to understand, inhabit, play and master the new 3D audio apparatus, one has at the very least to develop new methods of hearing and listening.

ACKNOWLEDGEMENTS. My deepest thanks to the students of the Soundscape and Environmental Media Lab especially to Ben Briggmann, Natascha Rehberg and Aleksandar Vejnovic.

12. cf. H. M. McLuhan's continually unfolding concept of the audio-tactile surrounding sensation produced by the electronic age in contrast to the frontal-visual perception of the age of Gutenberg, among others in his work "The Gutenberg Galaxy: The Making of Typographic Man". Toronto 1962, p. 11 et seqq).

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