

"3DEV: A tool for the control of multiple directional sound source trajectories in a 3D space"

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Abstract

This Paper presents a GNU software (3DEV) developed for the creation, transformation and temporal coordination of multiple directional sound source trajectories in a three-dimensional space. 3DEV was conceived as a general tool to be used in electroacoustic music composition, and the data generated by it may be transmitted on a simple and effective way to several spatialisation programs.

Keywords

Sound Spatialisation, Electroacoustic Music, GNU Software

1 General

1.1 The spatial sound in electroacoustic composition

From its very beginning, *avant-garde* music (both instrumental and electroacoustic) favoured a significant development of timbre, texture and sound spatial quality together with the organisation of pitch and duration which are, by the other hand, structural features of traditional classical music. In the electroacoustic music, the spatial quality of sound plays a very relevant role (if only because of the fact that this music must be reproduced by loudspeakers). Because of this, the analysis of the aesthetic influence of the spatial quality of sound and its relations with other sonic organisations become an essential part of electroacoustic music theory (See, as an example of this, Wishart [1], Cap. X).

A sound trajectory may determine clearly the end of a musical motto, or a formal articulation of a musical composition, just changing its direction suddenly or stopping abruptly its movement and developing a particular sonority from a steady position (See a classification of different kind of movements in Stockhausen, 1955 [2]). It arises then in the composer the necessity of gaining

control of the spatial quality of the sound through technological tools that allow accurate temporal coordination between multiple audio signals and their trajectories or positions in a virtual space.

1.2 Sound spatialisation software development

Sound spatialisation is developed in several technologic and scientific areas mutually related. Among the most important can be mentioned: Acoustics (particularly room acoustics), Psychoacoustics (specifically Spatial Listening), Digital Signal Processing and Audio Engineering. Particularly, and together with the development of computer music, many of the results of the scientific research on this field were applied in the creation of software applications with the purpose of providing concrete tools for musical and sonic production to the composers and audio engineers. The works of Chowning [3] and Moore ([4], [5] and [6]) must be regarded as a valuable and unavoidable initial reference which was followed by other significant developments. Among of them, the ones by Kendall [7], Furse [8][9], López-Lezcano [10], Karpen [11], Pulkki [12] and Varga [13] can be mentioned. At present, a growing amount of sound spatialisation programs exist, most of them as high level environments achieved by the combination of general purpose audio programs software units (such as Csound, Super Collider or Pure Data, to mention only some of them). Two of them are *AudioScape* (Wozniowski et al [14]), and *Bin-Ambi* (Musil, [15]).

From a general point of view, the spatial treatment of sound involves three basic features:

- 1-Environment: the physic space into which the sound sources are located.
- 2-Localization - movement: the points of the physic space where the sound sources are located, or the trajectories that they follow in this space when moving.
- 3-Directivity: the pattern of the acoustic energy spreading of the sound sources according their

nature and orientation with respect to a listening point (see, for example, Causse [16]).

All the already mentioned programs were designed for working on the features 1 and 2 (Environment and Localization - Movement). Only some of them, however, (see Moore [4], [5] and Furse [9]) can perform sound source directivity simulation.

By the other hand, from a design point of view, three basic sections can be distinguished among all the different spatialisation programs:

1-A general setting of configuration parameters usually related to the virtual room or environment, such as: size, shape, listener position, amount of echoes to be computed, dense reverberation quality, etc.

2-A sound trajectory and/or sound position generator for the virtual acoustic sources.

3-A D.S.P. block (Audio Engine) dedicated to the processing of the digital audio signals to be spatialised accordingly with the data of 1 and 2 and the techniques which are to be used (Ambisonics, Intensity Panning, VBAP, etc.)

The work presented here address the item 2 (sound trajectories generation) and discuss the design of a general purpose Graphic Interface for the shaping of multiple three-dimensional trajectories, independently of whatever spatialisation audio engine may be chosen to be used. This separation will allow the composer to further select the technique and software environment most appropriate to process the audio signals to be spatialised and, furthermore, even to use several different Audio Engines with the same data, if desired.

2 Basic features of 3DEV

3DEV is conceived to bring assistance to electroacoustic music composers in the creation, transformation and temporal coordination of multiple directional sound source trajectories in a three-dimensional space. It is being developed by Esteban Calcagno under the supervision of Oscar Pablo Di Liscia, as a part of the Research Project “Desarrollo de software para espacialización de sonido y música” (Teatro Acústico Research Program, Universidad Nacional de Quilmes, Argentina). The binaries for Linux as well as the source code and documentation can be obtained at: <http://lapso.org/EstebanCalcagno/3dev.html>.

3DEV allows to generate any amount of trajectories and to work on them using several editing tools. The trajectories are delimited by points (nodes) that can be visualised individually and globally. An especially valuable feature of

3DEV is its capacity of drawing a precise temporal relation between any of the generated trajectories and the audio signals with which these are associated. Additionally, it is also possible to create and modify a *rotation vector* which may be also accurately coordinated with the temporal evolution of the audio signal. If the Audio Engine to be further used allows the work with directional sound sources, it will then be possible transmit to it this data indicating how the virtual sound source eventually changes its orientation.

The control of the time between the different spatial nodes (indicated as a percent of the total duration of the signals with which the trajectories are associated) is at present the only way of handling movement velocity.

3 Description of the 3DEV program

3DEV uses the GTK+ C Library (<http://www.gtk.org/>) for its graphic interface design, as well as the Pthread (<https://computing.llnl.gov/tutorials/threads/>) and Sndlib (Schottstaedt,[18]) C Libraries for the Audio I/O handling. This program is a self-sufficient executable and, at present, cannot be a module of any other external program nor can support external modules.

3DEV is divided in three different areas: the Spatial Trajectories window, the Audio Files window and the Audio Engine connection window. The two first parts took the major part of the work, whilst the Audio Engine is still in development, using at present the Csound program. However, as already mentioned, the independence between movement design and audio processing will allow the use of several other programs for sound spatialisation.

3.1.1 Spatial trajectories window.

The graphic interface for the trajectories, whose basic functions for 3D graphics were taken and adapted from (Harlow [17]), was conceived as a main window with four menus which are briefly described below:

1-The “General View” window is divided in four equal size sections. One of them (the top leftmost one) shows (with 3D rotation and zoom options) a 3D plot of the trajectory that is actually been designed. The other three sections show the trajectory projection in the XY, XZ and YZ planes in two dimensions, and allow creating and/or editing new nodes.

2-The “Full 3D View” shows a 3D plot of all the trajectories created or a selected group of them.

3-The “Point List” menu shows a list of the Cartesian coordinates of a selected trajectory as well as allows editing them numerically.

4-The “Play List” shows a list of all the trajectories, and allows the association of any of them with an Audio File. Through this menu it is possible to access the Audio File Window, which will be described in the next section.

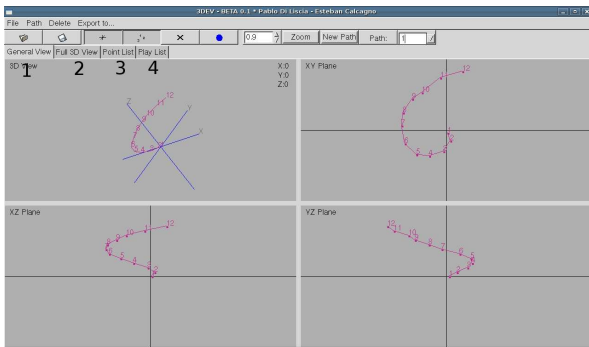


Fig. 1: 3DEV Main Window

3.1.2 Audio Files Window (Figure 2)

From top to bottom, this window is made with:

1-A plot of the waveform of the selected audio signal.

2-A horizontal line that relates the audio file duration with each one of the nodes (the 3D points between which the virtual source will travel). The horizontal position of each node can be modified to change the duration of each segment of the trajectory. This way, accurate time synchronization between movement and audio may be achieved.

3-A system of two editable envelopes indicating the orientation of the virtual sound source (azimuth and elevation angles). By this system, the orientation of the sound source can be changed dynamically also accurately synchronized with the audio signal.

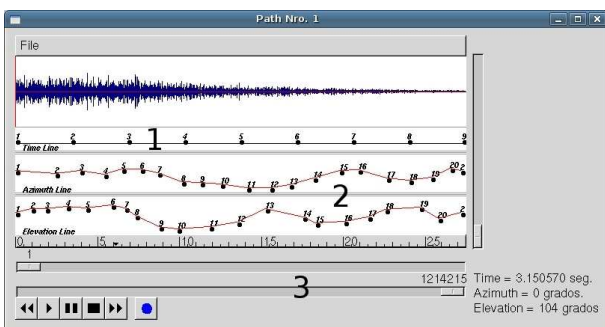


Fig. 2: Audio Files Window

4-Lastly, a section with a temporal reference

of the selected audio signal (in seconds and samples) with zoom and reproduction controls.

3.1.3 Audio Engine Connection Window (Fig. 3)

At present, 3DEV uses the Csound program (Barry Vercoe et al) as Spatialisation Engine. In order to do this, 3DEV generates a text file with the format of a Csound score. This text file is a kind of script which may be further used by Csound to synthesize a spatialised signal based on a pre-designed orchestra which constitutes the basic DSP module.

In this case, the Csound’s orchestra uses basically the *spat3d* Unit Generator (ItzvanVarga [14]), that implements the Ambisonic spatialisation technique (see Malham[19]). The designed orchestra provides 3D spatialisation of both the direct signal and the early reflections of it into a virtual room whose features are provided by the user. The following figure shows the data entries needed for specifying the characteristics of such virtual room. The connection of the sound trajectories is very easily achieved by means of triplets of Tables (numerical vectors readable by Csound) containing each one the Cartesian coordinates (X, Y, Z). Each sound trajectory is represented in the Csound score as a “note” with its corresponding start time, duration, amplitude scaling and tables indicating its movement. This way, it is possible to spatialise and mix multiple virtual sound sources moving in different ways.

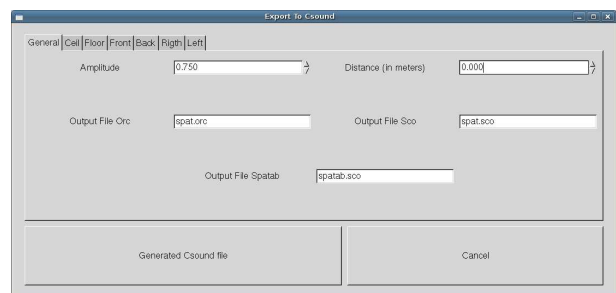


Fig. 3: Audio File Connection Window

4 Conclusions

3DEV is still under development but already constitutes a very useful tool for the electroacoustic music composers.

Further developments will address the design of more connections with other Spatial Audio Software, as the one shown in the point 3.1.3. Also, other development possibilities would be to include several drawing and transformation

routines of 3D trajectories as well as the storing of the data in diverse formats for their use with other spatialisation programs. Having the data accurately generated and stored, it would be a simple matter to convert it to different coordinate systems, as well as to adapt it to the different syntax requirements and data types used by other spatialisation software.

Finally, as the visualization of many complex spatial trajectories operating together may be difficult to achieve, a real-time animation plot of them synchronized with their audio files associated is also a feature to be further developed.

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