SURROUNDSOUND
A B-Format Soundfield Processing Program
for the Composers' Desktop Project Soundfield system

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ABSTRACT: "SURROUNDSOUND" is a program for generating and processing full
B-Format Ambisonic soundfields, which runs on the Composers' Desktop Project (CDP)
range of musical workstations. The reasoning behind the program is outlined and its
potential as a compositional tool is considered. The facilities which the program
provides are briefly described. Some design decisions are explained. In the full paper,
available from the author, the formalism required to carry out some of the more
complex soundfield transformations are quoted and discussed, together with a full list
of references.

Introduction

In designing SURROUNDSOUND my aim has been to produce a utility program which goes some
way to providing composers of electro-acoustic music with a facility for exploring space as a
musical parameter which, like time, pitch, timbre and dynamics, can function to articulate the
structure of a piece of music.

Since Ambisonic recording and playback technology is based on the premise that, given certain
information, it is possible to re-create and hence to synthesise an acoustic space in all its
dimensions, spatial restrictions imposed by systems such as quadrophonic are no longer applicable.
Moreover, once this information has been obtained, it can be manipulated so that characteristics of
the acoustic space, such as its shape and resonance, can be altered. The whole space can be rotated
or tilted, and its constituent features miniaturised.

The possibilities afforded to composers by this technique of spatial processing are manifold. It
becomes possible to conceive of works which are, for example, moth musical and spatial
palindromes. As Stockhausen experimented with speeding up rhythmic patterns until they began to
take on certain characteristics of pitch, so it seems likely that the relationship between the
movement of individual sound waves and the wholesale movement of sounds in space may yield
results which will provide a new vocabulary of musical textures and timbres.

Program Development

At the start of development of SURROUNDSOUND four principal objectives were kept in view:

1. To provide a user interface which made it easy to conceptualise B-Format soundfield
   transformations.

2. To exploit the fact that all sound processing would be performed entirely in the digital
   domain in order to provide facilities not available in analogue.

3. To maintain double precision arithmetic until the latest possible stage in sound processing,
   thus achieving the minimum degradation in signal-to-noise ratio.

4. To ensure that the soundfield processing section of the program - its user interface -
   should run fast enough so as not to interfere with the user's train of thought.

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By defining these objectives, already some fundamental decisions about the program's underlying structure had been made. If the speed of transformation processing were to be unsatisfactory, then parameters created by any previous transformations had to be available within memory. Moreover, since the actual soundfile compilation is relatively slow, all transformation data should be assembled before the actual compilation. These factors, together with the need to process the sound samples in one pass, to prevent the degradation of the signal-to-noise ratio, pointed towards a structure with two distinct sections - the first of which dealt with the creation of transformation parameters, and a second which dealt with both the conversion of an input soundfile into Ambisonic format, and also the cross-multiplication of samples and spatial coefficients to obtain the Ambisonically encoded output samples.

Transformation Options

After experimenting with analogue Ambisonic recordings, I concluded that SURROUND Sound should, at a minimum, provide the following facilities:

1. **Convert** - A procedure to convert mono or quadraphonic input soundfiles both of which can be created with ease in the Csound and C-Music environmental into Ambisonic B-Format soundfiles.
2. **Rotate** - to allow the soundfield to be rotated about the vertical, or a selectable arbitrary axis.
3. **Spin** - to spin the soundfield at a selectable speed about the vertical or an arbitrary axis.
4. **Tilt** - to tilt the soundfield about the X, Y, or arbitrary axes.
5. **Tumble** - to tumble the soundfield about the X, Y or arbitrary axes, at a speed specified.
6. **Mirror Image** - to mirror the soundfield about either of the vertical planes or about the horizontal plane.

As well as providing these options as static transformations (e.g. the soundfield would be rotated to a particular point and remain there for the time specified), I decided also to provide time-varying versions of these transformations. Thus it would be possible to define the start and end points of transformations, and the time over which they should take place. For example, tumble, this meant that the speed at which the soundfield would spin could change with time - accelerating or decelerating - or, in the case of mirror-image, it would be possible to change the position of sounds gradually.

Facilities

SURROUND SOUND provides the facilities to treat mono, quadraphonic or B-Format Ambisonic soundfiles, stored on hard disk, as sound sources in a three-dimensional Ambisonic "soundfield". The sounds from the input soundfile can be rotated, spun, tumbled or mirror-imaged and the results saved back to disk as a B-Format Ambisonic soundfile. The program can be called from the GEM desktop or from a Command Line Environment.

The program requires the names of input and output soundfiles, and a stored parameter file, if one is to be used. Mono- or Quad-to-Ambisonic conversion counts the soundfield towards the centre front, by default. Rotate requires values for the angle of tilt from the horizontal plane and its rotation about the vertical axis. An input angle greater than zero will cause antclockwise rotation about the chosen axis, while a negative value will give rise to clockwise rotation. Spin causes the soundfield to be spun about the vertical or a user-defined axis. Data required for the function are the direction in which the soundfield is to be spun (clockwise or anti-clockwise), and start and end times. If a time-varying spin is requested, it is possible to exploit the effect of "aliasing": Spin movements above about 50 revolutions per second appear to be revolving slowly in the opposite direction to that specified. The tilt function is similar to rotate and causes the soundfield to be tilted about the X, Y or an arbitrary axis. The angle of tilt is required. Entering a positive value about the X axis will cause the soundfield to be tilted backwards, and will cause a tilt to the right about the Y axis. Tumble causes the soundfield to be tumbled about the X, Y or an arbitrary axis.
The direction of tumble is required. The mirror image option causes the soundfield to be mirror imaged in one of three planes: 1) the left/right vertical plane, 2) the front/back vertical plane, and 3) the up/down horizontal plane. The fixed option will cause the image to shift suddenly at start-time and remain inverted until end-time. The time-varying option will cause the soundfield to be mirrored progressively, so that sounds pass through the centre of the soundfield halfway through the time specified, arriving at the opposite at end-time.

For all transformation functions the start and end-time of the process in resolutions of one hundredth of a second is required, and the user may choose fixed or time-varying alternatives. If the fixed option is chosen the selected soundfield orientation will occur at the time specified by start-time, and will remain at this position until end-time. If the time-varying option is chosen, the soundfield will change its orientation gradually over the time specified, reaching its new position at end-time.

Further menu functions are provided for the user:

**Save Parameters** - this function allows parameters created by the transformation listed above to be saved to disk as text files. These may then be re-used in subsequent operations.

**Compile Output Soundfile** - this computes the four B-Format channels of Ambisonic samples according to the processes specified in the parameter array, and writes them to disk at the sample rate of 22K, together with a header describing the properties of the file. A special B-Format flag has been added to the list of properties, which is used by Surroundsound to check whether a file is already Ambisonic or not.

**Help** - A HELP screen informs the user as required.

**Exit** - An option to save the parameters calculated is offered to the user before quitting.

**CONCLUSION**

SURROUNDSOUND is a necessary start for computer synthesis and control of Ambisonic properties. However, there are many parameters which the program does not at present provide to the user. The most obvious of these is a lack of reverbulation in the final soundfield, and hence a lack of independence from the current performance environment. Because the sounds have no reverbulation characteristics of their own, they are forced to take those of the space in which they are reproduced. The other principal feature not yet implemented is one to permit re-shaping the soundfield. The 'dominance' controls on commercial analogue controllers point to what might be achieved. The general algorithms for dominance control have been written, but require implementation within Surroundsound. If time-varying dominance control were fully implemented, sound could be made to move in towards or away from the middle of the soundfield.

While Surroundsound may be one of the first programs to provide Ambisonic B-Format processing capabilities within the digital domain, it is only the start of a longer term development to enable composers to achieve the degree of control over placing and movement of sounds as previous developments in computer music synthesis have been able to provide in the control of time, pitch, timbre and dynamics.