DOCTOR OF PHILOSOPHY

A Portfolio of Original Compositions (Andrew Dolphin)

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3.2 Spatial synthesis sound toy as multichannel composition tool

Cyclical Flow

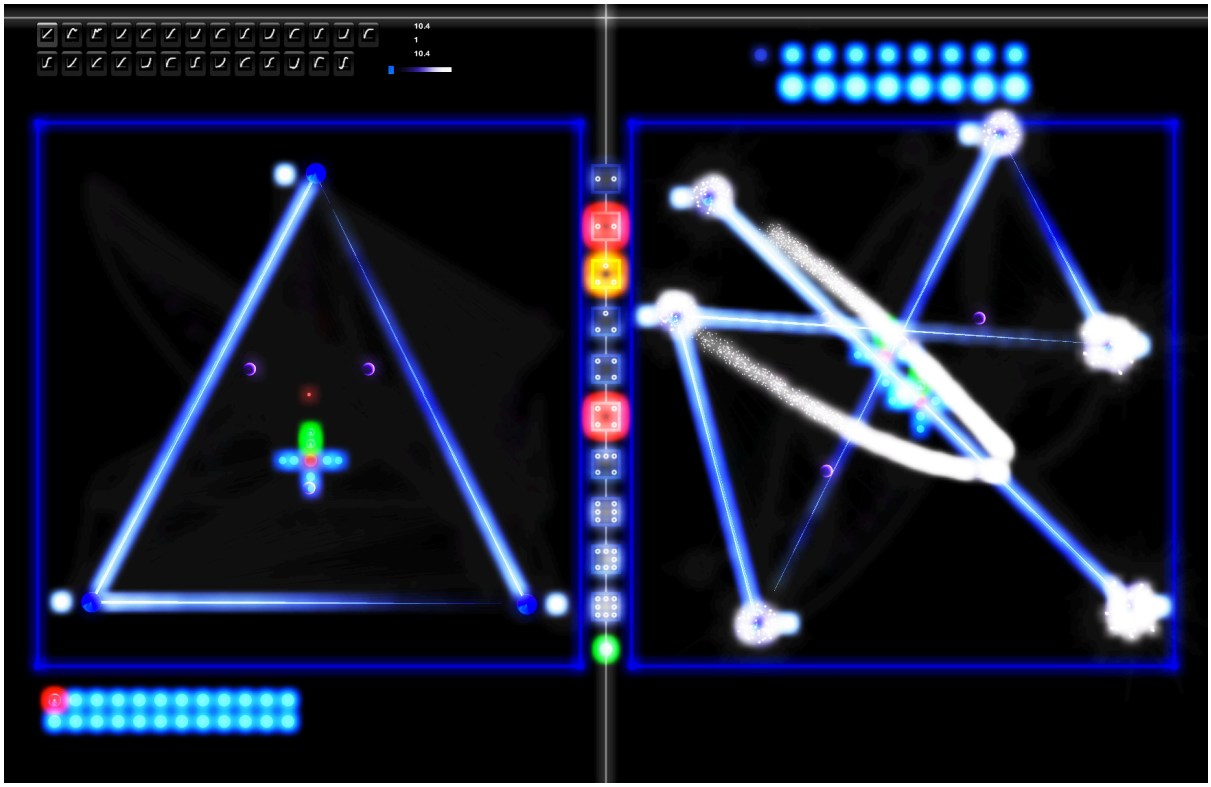

Figure 20. Version 1.8 Screenshot | Cyclical Flow

Overview

Cyclical Flow is a multichannel spatial composition tool and sound toy in which the spatialization of sound is a central theme. The boundaries of the work are open to interpretation as the project could be defined as being any of the following: a real-time composition or performance system, playful sound toy, or real-time sound transformation and spatial composition tool.

This work is the final project undertaken, and integrates a variety of techniques explored throughout the research term. Spatial techniques, spectral transformation and granular processes are applied in this sound toy, or playful tool for spatial composition. A version of the *Cyclical Flow* software system is used to create the 24 channel fixed media piece of the same name. The software system is also used to spatially develop and rework sections of the 24 channel fixed media work *Enclosed Pteron Friction*.

Introduction

The fixed media compositions presented in the portfolio are composed as multichannel works to exploit the spatial potential of specialist electroacoustic concert spaces.[89] Multichannel techniques feature less frequently in the open form sound toy works. The rationale for this is that an original intention of developing works in this medium was to design frameworks for composition that are influenced to some degree by the field of electroacoustic music, but also have the potential to be disseminated to a wider audience.

Large scale multichannel works evidently require performance spaces with a large number of loudspeakers, often in a non-standard format.[90] As the sound toy works are not intended for this type of concert performance setting, there are evident logistical issues relating to the presentation of a large scale multichannel sound toy. Despite this, through practical exploratory research and a number of initial informal experiments with game engine based control systems for multichannel composition, it was concluded that a sound toy approach offers a number of exploratory avenues for practice-led research in the field of multichannel composition. This conclusion resulted in the conception and development of the *Cyclical Flow* project which is presented in this chapter.

A project was initially imagined in which the composer could create and modify varied forms of spatial patterns and trajectories in real-time.

Spatial Motion Theory

More generally, we may look on spatial movements as (musical) gestures, consider the typology and implications of different types of spatial gesture and how the spatial motion of one sound-object might relate to the spatial motion of others, and thus build up a concept of counterpoint of spatial gestures."[91]

Ideas presented by Trevor Wishart on spatial motion are considered relevant to *Cyclical Flow*, and can be related to specific features of the work. These features are not necessarily direct realisations of his ideas, however techniques he describes can be aligned with some of the spatial motion and spatial music composition approaches adopted. Wishart's writing

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[89] As discussed in 4.1.

[90] With these facilities often available within academic concert spaces.

[91] Wishart (1996), pp. 195.

on spatial motion[92] includes a number of diagrammatic depictions of spatial trajectories, and a number of his representations of spatial contours and trajectories are achievable with the *Cyclical Flow* software. Theories presented by Wishart that are of particular significance to the project include "time contours".[93]

A motion is characterised not only by its path in space but also by its behaviour in time. We may distinguish the first order time properties (different speeds of motion) and second order properties (the way in which the speed changes through time, the acceleration or deceleration of the motion).[94]

This technique is relevant to the twenty-seven easing types implemented, and these allow the user to determine acceleration and deceleration of spatial trajectories.

Symbolic systems for setting and adjusting trajectories and spatial pathway nodes (which the spatialized sound objects move through) are particularly relevant to Wishart's definitions of "frame", and "frame motions". The software system developed also facilitates a number of the frame transformations he describes.

In certain situations a group of sound-objects, or a single oscillating sound object, may define a line (which need not be straight) in the space. This may be regarded as a one-dimensional frame and we may investigate motions of the total frame (as opposed to motions of the individual objects).[95]

Simple quasi-generative systems implemented in the *Cyclical Flow* software for modulating trajectories and pathways are also relevant to his definition of "frame motions". See "frame rotate" for example,[96] which represents one-dimensional frame motions. Frame rotations are implemented as an optional automated system, allowing the pathway of each sound object to be modulated at different speeds and in different directions, creating shifting spatial trajectories.

Whilst there are distinct interrelationships between the features implemented in the *Cyclical Flow* software and the spatial motion techniques described by Wishart, it is important to note

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[92] In *On Sonic Art*.

[93] As represented in Figure 10.56, in *On Sonic Art,* pp. 223.

[94] Wishart (1996), pp. 222.

[95] Wishart (1996), pp. 226.

[96] Represented in Figure 10.60 in *On Sonic Art,* pp. 227.

that the software is not a direct implementation of the theories he presents. His discussion is considered relevant here as a number of spatial techniques he describes relate to specific features and intended spatial applications of the *Cyclical Flow* project.

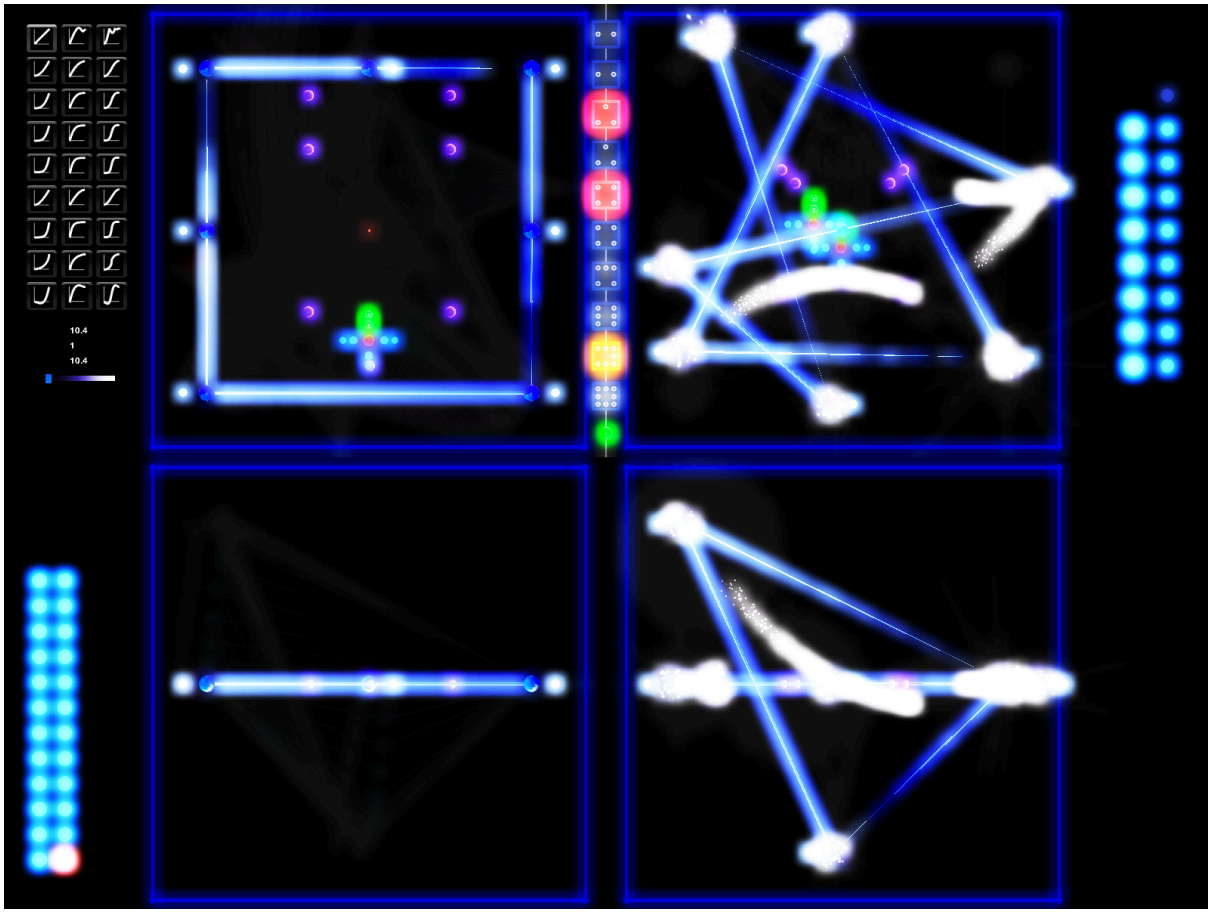

Figure 21. Version 1.24 Screenshot | Cyclical Flow

The supporting media for the project is now outlined.

Cyclical Flow Fixed Media Composition[97]

24 Channel	- Primary version
8 Channel	- Reduction for smaller performance spaces
4.0 / 5.1	- Ambisonic recording of the 24 channel version, and studio reduction
Stereo	- Stereo reduction
Binaural	- Stereo binaural recording of 24 channel version recorded at SARC

[97] Also see 24 channel work *Enclosed Pteron Friction*.

Cyclical Flow Demonstration Video

The video introduces the software's features and demonstrates the 2D version with stereo sound. As the software is designed for use with large multichannel systems, stereo sound heard in the video is for demonstration purposes only. The 3D version is also briefly outlined.

Cyclical Flow Software

Version 1.24 (3D) - 24 channel
Version 1.8 (2D) - 8 channel
Version 1.2b (2D) - binaural (for demonstration purposes only)

Cyclical Flow Overview

In *Cyclical Flow*, dynamic movement of sound through space is the central theme. Symbolic kinetic approaches in the visual domain represent and control spatial motion in the sound domain. The movement of symbolic objects within a virtual representation of a multichannel performance space directly control patterns of spatial motion of sound. The visual component of the work attempts to provide a playful interface for spatial composition.

The work is to some degree influenced by phase process music and composition techniques such as those explored by the composer Steve Reich. The player may take a monophonic single line approach if they choose, but the system is designed to allow the creation of layered cyclical patterns of motion, where the relationships of each line/part shifts over time due to the use of different cyclical motion rates. This results in a form of spatial counterpoint and spatial interactions between multiple spatialized sound materials.

The software developed is the product of further research and practical exploration of computer game engine technologies[98] used in conjunction with external software for sound and synthesis,[99] in a range of compositional contexts. Two primary versions of the *Cyclical Flow* software have been developed. The first version is designed for a single ring of eight speakers (version 1.8).[100] Once a prototype of this version had been designed and tested,

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[98] *Unity 3D*.

[99] *Max/MSP/Jitter*.

[100] Working with eight channels during the initial development phase allowed the project to be more easily developed, tested and evaluated.

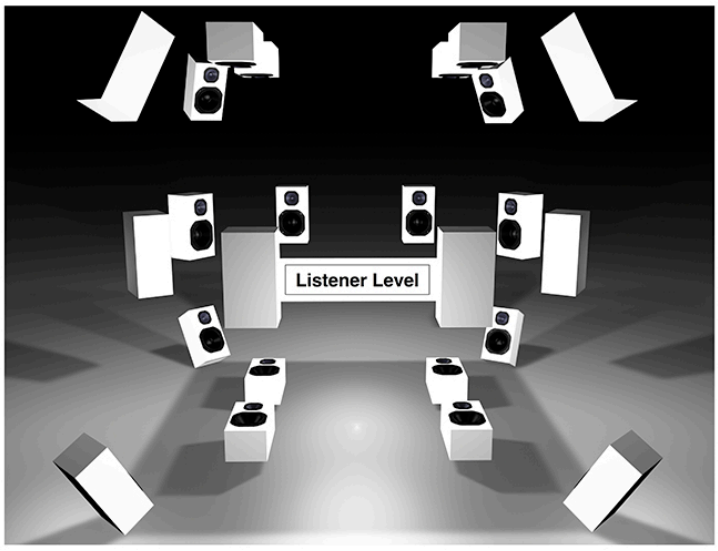


Figure 22. 24 Channel Speaker Configuration (SARC)

the project was further developed adding height, and full three dimensional movement of sound in space. This version (1.24) is configured specifically for use in the sonic laboratory at SARC, and utilises 24 discrete output channels. Speaker placement in the performance space uses a ring of 8 loudspeakers below the listener, a ring of 8 at listener level, and another ring of 8 positioned above the listener.[101]

Overview of Spatial and Sound Engine Structure[102]

The developed game engine application is a tool for creating real-time coordinate and control data, which is used to control an external spatial sound and synthesis engine constructed in *Max/MSP/Jitter*, as represented in Figure 23.

Coordinate data is mapped to a number of parameters. These include:

- Read position and interpolation of spectral data re-synthesised by phase vocoder.
- Read position of the granular engine, creating a granular time stretch effect.
- Spatialization of sound sources.[103]
- Spatialization of a two channel reverb, using delayed coordinate data to create a spatially moving reverberant trail effect.
- Speed of spatial motion determines pitch modulation, simulating doppler effect.

The simultaneous mapping of coordinate data to both spatial and sound generation parameters creates a direct link between the sonic characteristics of the output, and its spatial behaviour, as timbral development and spatial motion are interlinked when using the granular engine and phase vocoder sources. This technique, when combined with the

[101] The speaker configuration is identical to that used for the fixed media work *Enclosed Pteron Friction.*

[102] A largely technical section follows. This is deemed necessary to explain the features of the software and their intended spatial application.

[103] Using ICST's ambisonic equivalent panning external. http://www.icst.net/research/projects/ambisonics-tools/

simulated doppler effect, provides a range of creative possibilities for spatial composition. An example of the sonic results of these applied techniques can be heard in the 24 channel fixed media piece entitled *Cyclical Flow*.

The sound engine uses three primary sound sources for each *Spatial Object*. These may be used independently, or combined to create richer textures. All three primary sound sources for each *Spatial Object* follow identical spatial trajectories. The three sound sources are a phase vocoder,[104] granular engine[105] and simple sample player.

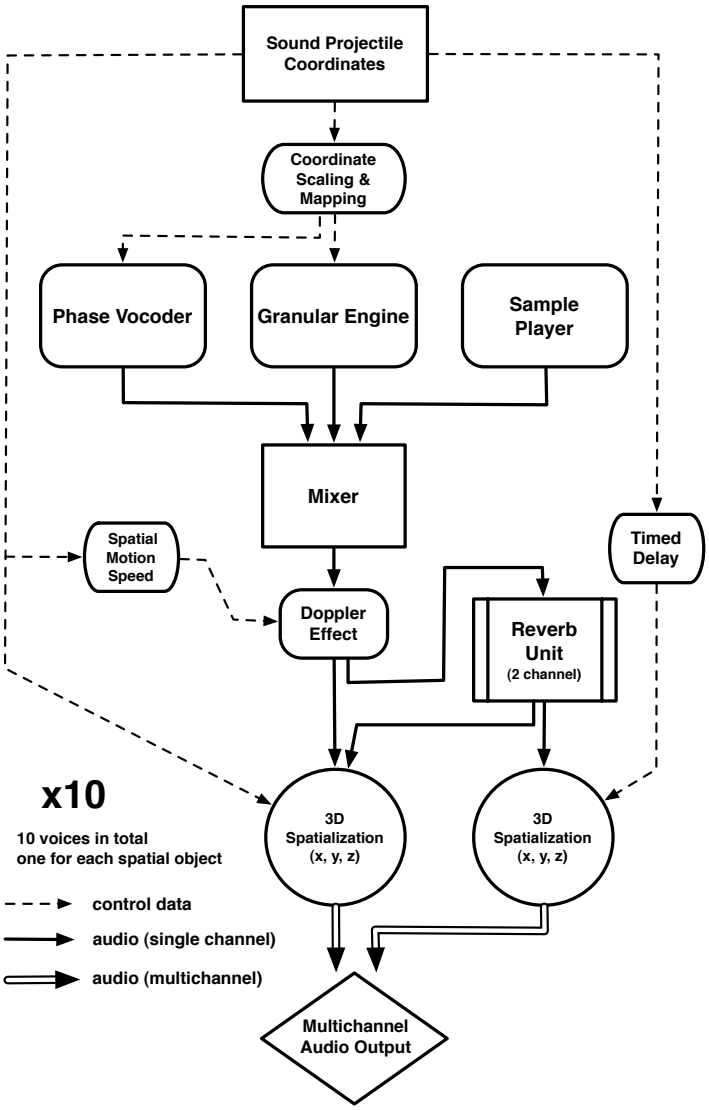


Figure 23. System Structure | Cyclical Flow

8 Channel Version

The functionality and features of the 8 channel version (1.8) are outlined first.

It is recommended that the reader refer to the annotated demonstration video whilst reading this section, as this outlines the features documented here.

The user is presented with a top down perspective of a 2D virtual space that represents the physical performance space. The player selects a sound type, then a cyclical spatialization sound object is selected and introduced into the virtual space, this is known as a *Spatial Object*. The player adjusts the positions of *Path Maker Nodes* that determine the pathway, or trajectory of the sound generating object, which is termed the *Sound Projectile*. The

[104] Derived from techniques documented by Jean-Francois Charles.

[105] A custom built granular system.

coordinates of the *Sound Projectile* directly control spatial motion and two key parameters of sound generation. These are: spectral frame and grain read position (playhead) in the phase vocoder and granular synthesis engines. Coordinates of the *Sound Projectile* thereby control timbre, sound evolution and spatial motion. The x and y axis both control spatial parameters, whilst only the x axis is used to control spectral frame and grain read position. A simulated doppler effect is also integrated to create more dramatic and quasi-realistic spatial motion effects. The doppler effect becomes a more prominent feature when using faster spatial trajectory motion speeds. As a result, spatial motion can be perceptually exaggerated.

Each *Path Maker Node* has an associated *Projectile Rate Node* which is used to control the speed of the *Sound Projectile* as it travels towards the respective *Path Maker Node*. When *Path Maker Nodes* are positioned a greater distance apart, with a high *Sound Projectile* rate, fast moving spatial effects occur, with quicker transitions in timbre and more exaggerated pitch modulation effects. When the nodes are positioned closer to each other with a slower projectile rate, gradual timbral shifts occur within a more limited spatial area. As the y axis is not mapped to control spectral frame or grain read position, it is possible to create more gradual timbral shifts, with greater spatial motion by placing the *Path Maker Nodes* in roughly the same position along the x axis, but at very different positions along the y axis.

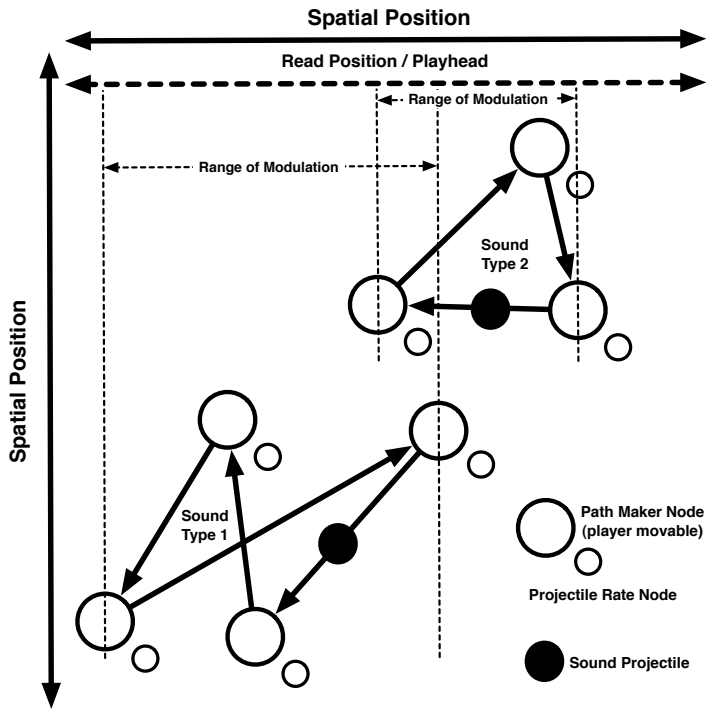


Figure 24. Spatial Objects | Cyclical Flow

Figure 24 represents two *Spatial Objects* and their associated nodes. Each cluster of *Path Maker Nodes* corresponds with a player selected sound type, with motion of each *Sound Projectile* limited to the inter-connected nodes within its cluster. Each of the *Path Maker Nodes* can be moved freely around the virtual space, changing the trajectory, or pathway of the *Sound Projectile* as it travels between the different nodes. The smaller sphere attached to each of the *Path Maker Nodes* is the *Projectile Rate Node*, this allows the player to control the speed of the projectile as it travels towards its corresponding *Path*

Maker Node. The time contour of the *Sound Projectile* can be determined by the user through the selection of the available easing curves, which further shape the spatial modulations. As the *Sound Projectile* moves between the nodes, spatial and spectral parameters of sound develop. These modulations are directly related to the position, range, and rate of motion of the projectile. The dotted lines in Figure 24 show the range of motion as dictated by the positions of the *Path Maker Nodes*.

The player selects from the ten available *Spatial Objects*, each containing a different number of *Path Maker Nodes*. These consist of between two to eight nodes. Two nodes provide a simple two stage repeating cyclical motion. Eight nodes offer scope for more complex spatial and spectral modulations, but are a little more time consuming to work with. The number of nodes in each *Spatial Object* affects the degree of complexity of the modulations, and has an effect on the cyclical features of the sound output.

Figure 25 introduces the *Bezier Nodes*. These allow the player to vary the curve of the path of the *Sound Projectile* as it travels between each of the *Path Maker Nodes*. Placing the *Bezier Node* directly in line between its related *Path Maker Nodes* results in linear trajectories. The further the *Bezier Node* is moved out of alignment with its related *Path Maker Nodes*, then the more dramatic the curve.

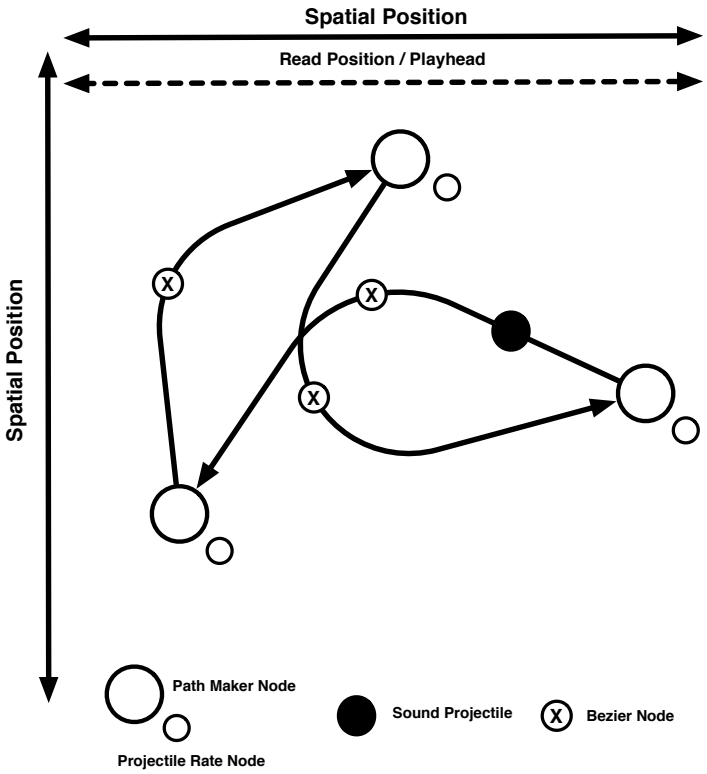


Figure 25. Bezier Nodes

Automatic Trajectory Modulations

A generative feature is implemented which enables the user to activate automated motion of all nodes within a *Spatial Object*, altering spatial targets and trajectories, resulting in dynamic shifting spatial, spectral, and timbral effects. Further user input is possible when the generative rotation modes are active, as the *Path Maker Nodes* and *Bezier Nodes* in a *Spatial Object* may still be freely moved and repositioned as normal.

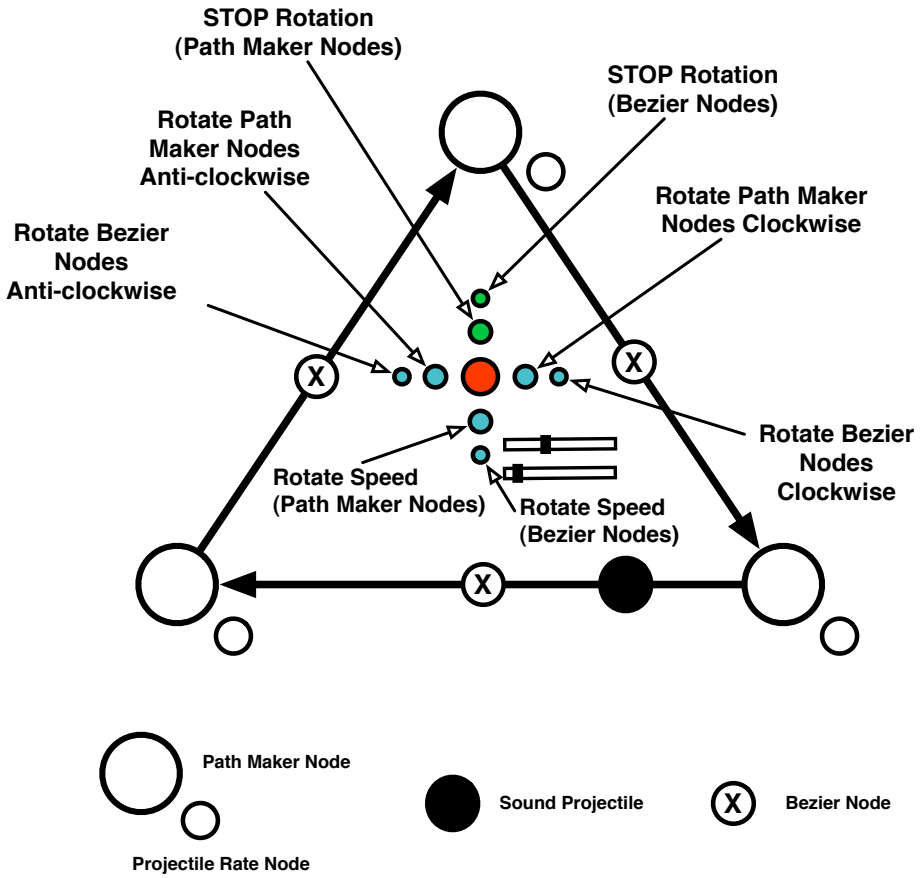


Figure 26. Automated Rotation Modes

A central rotation point is calculated for each *Spatial Object*. The rotation point is averaged from the positions of all *Path Maker Nodes* within the cluster. If activated by the player, these nodes rotate around the central rotation point in either a clockwise or anti-clockwise direction, according to the selection of the player. *The Bezier Nodes* may also be rotated, and these rotate independently to the *Path Maker Nodes*. If the *Path Maker Nodes* are kept static and the *Bezier Nodes* are rotated, then dynamic shifting trajectories occur which move between the same static points in space. The rate of rotation can also be adjusted for both node types.[106] The rotation modes result in dynamically changing trajectories of the *Sound Projectile*, creating a form of generative effect that is dependent upon the position of each node relative to each other node. The player can continue to adjust node position relationships whilst the rotation mode is active.[107]

[106] See Figure 26.

[107] Please note that the *Sound Projectile* calculates its next node destination position as it departs from the previous node, so when a *Path Maker Node* is repositioned (automatically or by the player) during an already established trajectory, the *Sound Projectile* may not be seen to visually move through its target node.

There are a number of different ways *Cyclical Flow* can be explored, resulting in different spatial effects. Gradual textural shifts can be achieved using slow projectile rates and minimal relative node position range along the x axis. Rapid dynamic spatial trajectories are achieved using larger distances between *Path Maker Nodes* and faster projectile rates. Sounds may be attributed their own specific area within the performance space, or by using overlapped pathways, the user may create counter trajectories where different *Sound Projectiles* cross paths. Multilayered spatial interactions can be created using multiple *Spatial Objects*, with varied numbers of nodes and different motion rate settings creating shifting cyclical patterns.

User Interface Layout

The layout of the interface in the 8 channel version (1.8) is outlined first.

The user is presented with two work areas and several groups of button controls. *Spatial Objects* are instantiated using the icons in the centre of the interface, (labelled O1, O2, O3 etc. in Figure 27). The inactive *Spatial Objects* appear in the *Spatial Trajectory Prep Area* where they can be freely positioned and speed settings adjusted. No sound is generated by the *Spatial Objects* when in the *Prep Area*. To move the *Spatial Objects* to the *Performance Area* where they become active and output sound, the corresponding *Spatial Object* icon is again selected. Once in the *Performance Area*, the *Spatial Object* is activated and animated, generating dynamic coordinate data for the spatial sound engine. When the *Spatial Object* is removed, or moved back to the *Prep Area*, sound output for the object ceases.

When in the *Performance Area*, all nodes, modes and speed settings of the *Spatial Object* may still be modified by the user, allowing real-time modification of spatial and spectral trajectories during sound generation/spatialization.

Easing Palette

The *Easing Palette* contains 27 different easing options, or interpolation curves that determine changes in speed, and sometimes direction of the *Sound Projectile* as it travels between each of the *Path Maker Nodes*. These expand the range of potential spatial and spectral effects, and allow time contours to be varied.

To apply the different easing types, the user selects the chosen curve from the *Easing Palette* before an object is placed in the *Performance Area*. Once a selection has been made, any *Spatial Objects* subsequently loaded into the *Performance Area* will adopt this easing type until a different curve is selected. When the easing type is changed, only new *Spatial Objects* introduced into the *Performance Area* will use this newly selected curve.

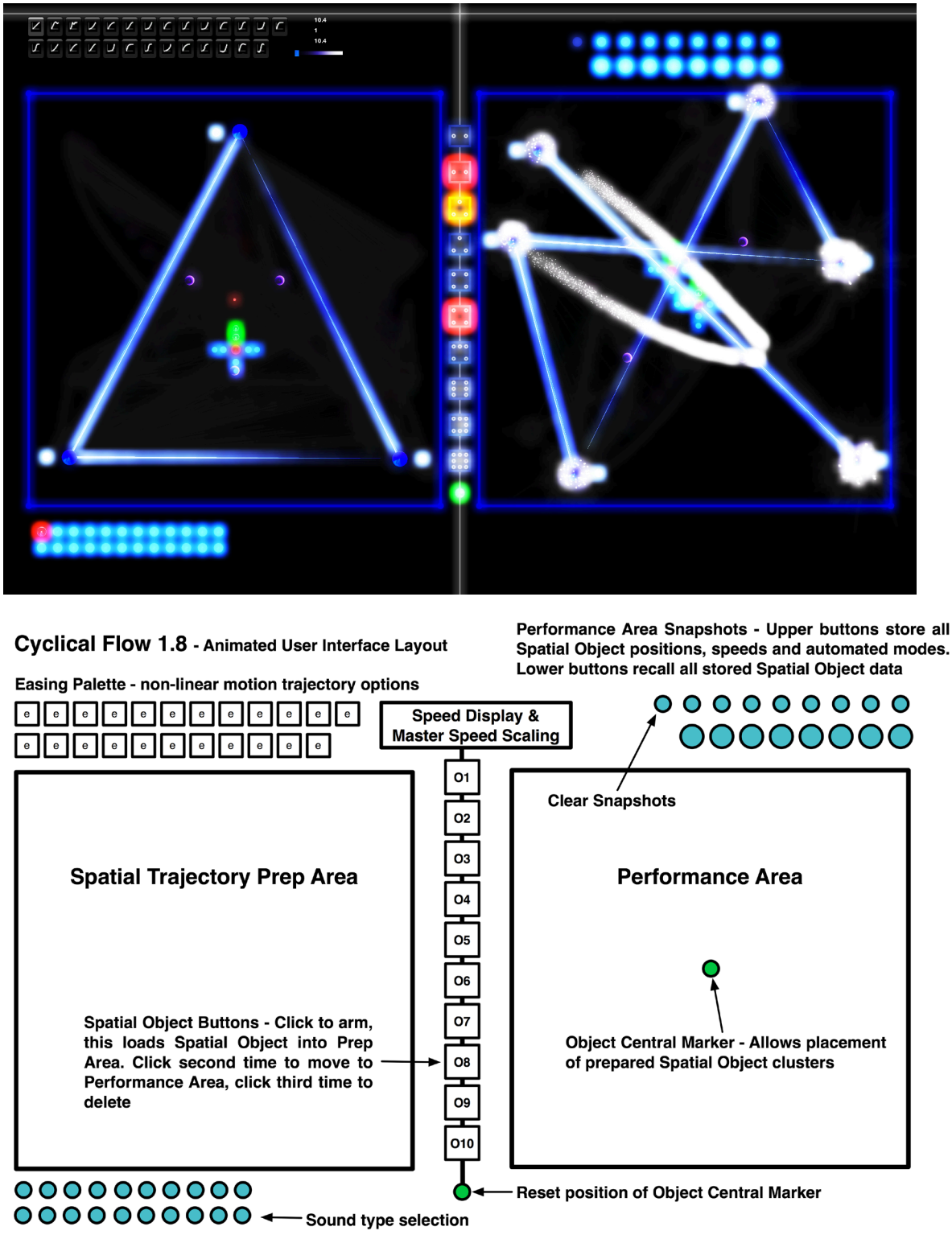


Figure 27. Version 1.8 Screenshot & Layout

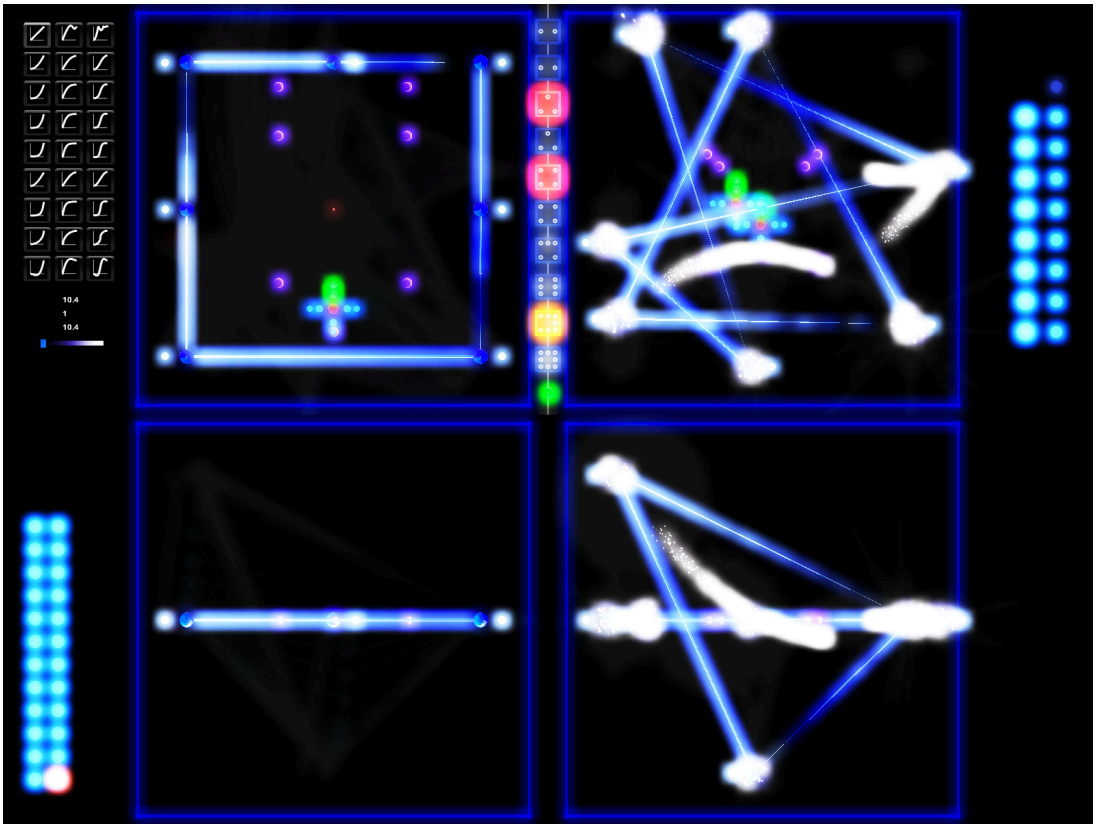
Speed Display and Master Speed

The *Speed Display* section updates dynamically whenever a node speed parameter is changed, providing visual feedback of the speed settings for each node when adjusted by the user. The values represent the time it takes for the *Sound Projectile* to move from the previous node to the destination *Path Maker Node*. The overall speed of motion can be scaled for all *Spatial Objects* in the *Performance Area*, allowing all *Sound Projectile* object speeds to be increased or decreased, whilst still retaining relative rate relationships.

Snapshots and Recall

Once the user has created an active cyclical pattern, using any number or combinations of *Spatial Objects*, the position of every *Spatial Object* and its associated nodes can be stored as a *Performance Area Snapshot*. Speed settings and automated rotation mode states are also stored. These snapshots can then be later recalled, allowing dramatic structural shifts in sonic and spatial features. The *Performance Area Snapshots* allow for thematic repetition, as previously created patterns can be reinstated. Cyclical patterns may also then be developed with further adjustments of the *Spatial Object nodes* from the stored snapshot positions. The snapshot feature enhances the performative potential of the project, as complex spatial patterns can be interchanged quickly and efficiently.

24 Channel Version



Cyclical Flow 1.24 - Animated User Interface Layout

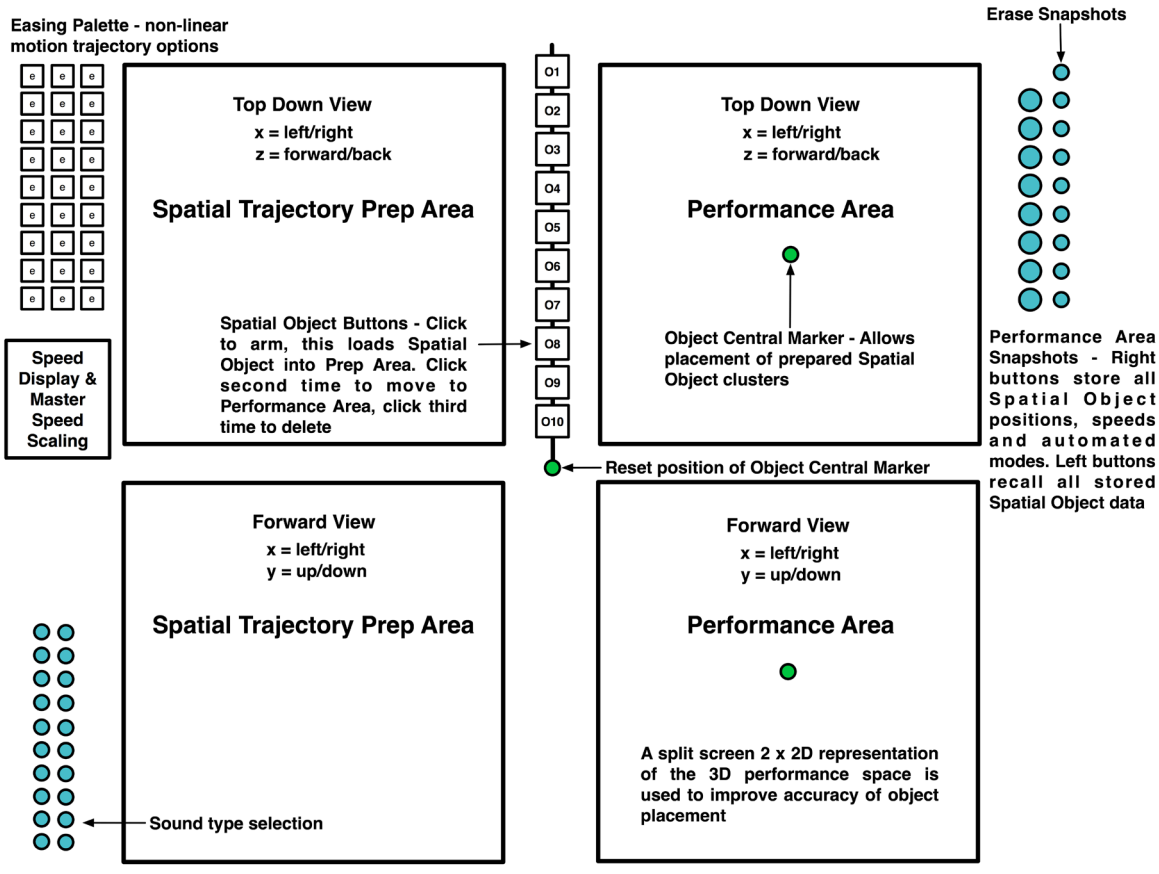


Figure 28. Version 1.24 Screenshot & Layout

The 24 channel version (1.24) of the *Cyclical Flow* software is now outlined.[108]

The primary features are identical to the 8 channel version, but in this 24 channel version sound is spatialized in three dimensions. Additional player editable windows are included, facilitating the control of height. The new lower windows represent the same performance space, but provide a front facing perspective to accompany the top down view (upper windows). These allow the player to adjust the elevation of each *Path Maker Node* and *Bezier Node*, allowing spatial movement of sound throughout a three dimensional performance space.

The 24 channel version includes identical groups of button controls as are found in the 8 channel version, however these are presented in a slightly different layout. The two additional lower windows represent height and width, the upper windows width and depth. Combined these windows represent all three dimensions (x, y, z) of the performance space. The upper and lower left windows represent the *Spatial Trajectory Prep Areas,* with the upper and lower right windows showing the active *Performance Areas*.

All features of the 8 channel system are available in the 24 channel system. *Spatial Object* behaviours, trajectory modulation modes, time contours, and snapshot storage and recall systems are fundamentally identical, except that in this version these systems function using coordinates in three dimensions.

Final Comments and Future Directions

The *Cyclical Flow* fixed media composition provides an example of the sound toy software being used as a spatial composition tool. The sound space in the piece is intended to be ambiguous and imaginary, and no attempt is made to create a literal representation of a concrete space. The cyclical processes determine elements of form, and the spatial features of the work. The source materials used are diverse and consist of transformed natural recordings and purely electronic sounds. The sound materials were playfully explored in the sonic laboratory at SARC, whilst simultaneously capturing 24 channels of audio during play and improvisation. The final fixed media piece is constructed from these multichannel recorded materials.

[108] A fixed media multichannel piece demonstrating the 24 channel version of the *Cyclical Flow* software is included in the portfolio.

The software may be easily adapted for alternative specialist performance spaces with differing speaker configurations, and further opportunities for testing and creative exploration are to be sought. There is potential for exploring and applying the tool in the composition and realisation of other large scale multichannel works. Although, it is again noted that a limiting constraint is that the system currently relies on a specialist performance space, and this restricts opportunities for its creative application and use. In response to this, a further project is planned in which the creative and technical approaches undertaken in *Cyclical Flow* are developed, instead using low cost portable speaker systems, with an adapted version of the software. The intention is to create a portable and flexible multi-speaker system, with accompanying specialist software that has scope for presentation as a playful multichannel installation. This medium of delivery will provide the opportunity for the techniques developed to be more broadly applied and accessed.