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OLLSCOIL LUIMNIGH

Semi-automated live diffusion system for rhythm based music

Author:
Walter Nied
14117223

Supervisor:
Dr. Nicholas Ward

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I would like to thank my supervisor Nick Ward for all the guidance and patience. I know I didn't make it easy. I also offer my gratitude to CSIS/DMARC staff for the continued help throughout.

Project Summary

This project aims to explore the possibilities of spatialising music with large amounts of rhythmic content and how this content may inform this process in an effective manner. A software system designed in Max/MSP is proposed to address this question in a way that it may lend itself to being used in a live music context. The final product consists of a Max patch running over eight loudspeakers in an octophonic setup with a MIDI controller mapped to control each parameter of the software. Ableton will be used for the playback of audio.

Tempo information of the material is used to synchronise any time-based effects and spatialisation patterns in attempt to create spatialisation methods that compliments the original material. This project rests on some of the ideas of live diffusion practices.

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Chapter 1: Introduction

Spatial audio and spatial music has yet to permeate larger popular culture to the same extent electronic dance music has. Over the past twenty years, a resurgence in the interest can be seen due to the advent of virtual reality/augmented reality but the music side has still been confined to small pockets of activity. Live diffusion is a practise that falls under the umbrella term spatial audio.

Research question

One of the key aspects of electronic dance music as a whole is the implementation of a consistent rhythm. So how can musical rhythm inform approaches to spatialisation? Furthermore, how can the rhythmic groove of repetitive electronic dance music be preserved when spatialisation is introduced? And if a usable method is produced then the system conceptualised should be usable in a live performance context as the live aspect is a big part of electronic dance music.

Background and motivation

Being an electronic music composer is the foundation this project rests on. Interest arose in spatial sound from reading about the 4D Sound Lab (4D Sound 2017). Its involvement with creators, coders, designers and performers showed that spatial sound is a topic that has much potential for exploration outside of the compositional domain.

Statement of methodology

In order to address the research question, this project combines an iterative experimental approach with literature analysis. The design of the software architecture will be guided by considerations from past approaches that researchers and artists have taken. This procedure is also called an autoethnographic process in which the author/creator explores his own intentions to address the set-out problem.

Overview of forthcoming chapters

Chapter 2 presents a brief history of spatial audio with particular interest to past performance approaches. Some key points for electronic dance music and live diffusion will be presented in order to enlighten the projects point of contact with the subject.

Chapter 3 begins with an outline to some basic functionality and aims of this project. Aspects of interest such as criteria for success and process will be discussed here. An overview on the design iterations will be presented.

In chapter 4, the final work will be presented. An assessment will be made on the functionalities of the system.

Finally, chapter 5 will be a conclusive discussion on success and future directions.

Chapter 2: Background research

A brief history of spatial audio

Spatial music is a vast area of concern for both artist and researcher and is as old as music itself. All sound emanates from a certain location in space, a fact which records show has been exploited in classical orchestra music since the 16th century (Zvonar 1999). Only in the last century has it been complimented and expanded by electronic hardware, and later digital software into what we now term spatial 'audio'. This research and project focuses mainly on the use of these new technologies and methods in a musical application.

Zhang et al (2017) state that spatial audio has two main aims. Firstly, to "replicate a complete acoustic environment" or to "synthesize realistic new ones". The two main methods for re/producing a soundfield are headphone spatialisation (Binaural) and loudspeaker spatialisation. Focus in this research and project will be on the latter.

The use of loudspeakers for spatialisation has its origins in the 1950s. In 1952, John Cage composed *'Williams Mix'* using tape to record a large catalogue of sounds, deterministic chance operations to organise and then rerecorded the sounds on to eight separate tapes (Zvonar 1999). The composition was premiered over eight separate loudspeakers and is the first record of an octophonic composition.

During this period, Pierre Schaeffer along with the help of the engineer Jacques Poullin devised the *'Potentiomètre d'espace'* (Malham and Myatt 1995). This device used four induction coils in the form of large hoops at the front left, front right, above and behind the user to control gain levels of four speakers around the audience in the same configuration (tetrahedral). The user of the instrument would dictate where the sound was emanating from in the soundfield by moving his/her hands around the area of the induction coils. Outside of being the first records for formulating the basic principles behind live diffusion which will be discussed in a later section, it was also the first interface built for the use of spatialisation. It translates hand movement gestures of the user into the spatial locations of the sound source and Zvonar (1999) notes that the use of this system was "highly theatrical". This differs from John Cages approach in the way that it approaches spatialisation from a performance aspect.

One of the largest and widely known uses of spatial sound of that time is the Philips Pavilion at the Brussels Worlds' Fair in 1958. Edgar Varèse's *'Poème électronique'* was played through a 425 speaker, 11-channel custom made speaker system. Nine spatialisation paths were defined along which the composition would travel through the space with two more tape tracks for reverberant and stereophonic sounds to enhance the main composition (Zvonar 1999).

One issue discerned by Malham and Myatt (1995) is the lack of a control system for the Philips Pavilion and points at a later attempt by Stockhausen for his 1960 composition *‘Kontakte’*:

> This used a rotating, highly directional loudspeaker to distribute sounds between microphones. The outputs of the microphones were then recorded and played back over fixed loudspeakers.
>
> (Malham and Myatt 1995)

This is an interesting approach in the context of this project as it employs constant monotonous rotation to enhance or even create the rhythm present at the start of the composition.

Iyer et al (1997) discusses the use of cyclic motion concerning rhythmic structure in African and Afro American music where he states the occurrence of “superposition of various cyclic musical patterns” (Iyer et al 1997). Cyclic motion refers to the repetitive cycles of rhythmic patterns in music such as reggae, hip-hop, and funk which have lent their repetitive structures to electronic music. This can be discerned from the famous quote from techno godfather Derrick May written on the sleeve notes of the first techno compilation record “it's like George Clinton and Kraftwerk are stuck in an elevator with only a sequencer to keep them company.” (Techno! The New Dance Sound of Detroit, 1988). Mapping these repetitive motions to an octagon may prove as an interesting starting point as most dance music adheres to the 4/4 format.

Spatialisation Techniques

Ambisonics

Advancements in computer technology enabled people such as John Chowning (1971) to investigate spatial cues to implement in composition such as reverberation and the doppler effect over a quadrophonic playback system. At that time, Michael Gerzon with the assistance of Peter Fellgate developed a fully scalable spatialisation and recording technique called Ambisonics (Gerzon 1973). Ambisonics has the advantage of the production and spatial position of sound material (encoding) being decoupled from the reproduction and playback (decoding) giving composers a large degree of flexibility and scalability in producing and reproducing their work.

Vector Based Amplitude Panning

In 1997, Ville Pulkki formulated the Vector Based Amplitude Panning (VBAP) method which lies close to the traditional sine amplitude panning but allows for the extension of elevated sounds (Pulkki 1997). VBAP's strength lies in the fact that it allows for irregular speaker numbers while maintaining localization accuracy. Extensions of this method such as Distance Based Amplitude Panning which executes distance cues when a sound is placed outside of the speaker array and allows for the spatial blurring of sound sources within a soundfield (Lossius et al 2011). Layer Based Amplitude Panning which is an attempt to combine all methods for maximum flexibility and address a downfall of VBAP to allow for irregular loudspeaker density's (Bukvic 2016). Due to VBAP's relatively lightweight approach to speaker gain calculation, its computational efficiency and its adaptability to an arbitrary number of speakers makes it a good option for live spatialisation where computer resources may need be partitioned between other computational processes.

More techniques such as Wave Field Synthesis (WFS) and soundfield recording and reproduction using microphones and multi-zone sound reproduction have also been developed but are beyond the scope of this project. For further reading on these subjects examine the article *'Surround by Sound'* (Zhang et al 2017).

Electronic dance music

Electronic dance music stems its roots in the 1970's with the birth of disco and Kraftwerk who both made heavy use of the newly available commercial synthesizers and drum machines. From this point, an exponential explosion of different subgenres emerged which are well investigated in Kembrew McLeod's (2001) article.

Nowadays electronic music has permeated all other genres in one way or another (with an exclusion of some such as traditional or certain instrumental genres). It has been influential in implementing rhythmic groove in to popular and experimental music alike. This is stated in the article *'Pleasure Beats: Rhythm and the Aesthetics of Current*

Electronic Music'. Even though Neill criticises high art music for being reluctant about embracing rhythmic groove in its practises, he does state:

> Minimalism changed art music radically in the late 1960s and early 1970s, largely by reintroducing the beat and repetitive structures into the abstract complexity of 1950s serialism and chance-based works. Art music became physical again, connected to pleasure through the visceral elements of world and popular-music influences. Minimalist composers performed their music using the amplification and instrumentation of current pop music, adding to the pleasure quotient in their works.
>
> (Neill 2002)

Neill's authenticity does come under scrutiny in McLeod's (2001) article as he states the subgenre of electronica as "an attempt to drum up new business" in the United States which is the point of contact for Neill and no other genre is mentioned within the context of electronic music. Nonetheless, motivation behind his involvement with the topic of art music as a whole seems sincere.

Over the years, music genres have evolved through technological advancements and formed dynamic duos with music production technology's. Reggae and the tape delay, Rock and distortion, House and the drum machine, Hip hop and the Akai MPC. Especially electronic dance music has a history of technological influence leading to new genres summed up by McLeod:

> Since the 1970s, the means of producing electronic/dance music has advanced at a similar pace to electronic and computer technology. From disco through house to jungle, technology has played an instrumental role in transforming the overall sound of electronic/dance music.
>
> (McLeod 2001)

This gives hope that combining spatial sound technologies which have been matured over the last seventy years with present day electronic music in a complimentary way may encourage further evolution.

Live Diffusion

Live diffusion is "the practice by which music from fixed media (CD etc.) is presented to an audience via [multichannel] loudspeakers in a performance context." (Mooney and Moore 2008). Live diffusion's practise displays some key differences to other spatialisation practices such as composition. Characteristics stated below have been derived from the founder of BEAST, Jonty Harrison's (1999) article *'Diffusion: theories and practices, with particular reference to the BEAST system'*.

- In live diffusion, the composition of the material and diffusion/performance are separate processes. A purely compositional system will require you to define all spatialisation paths of your composition while live diffusion is more concentrated on building tools to allow for a live interpretation of the already composed material in an intuitive and sometimes improvised manor.
- Live diffusion takes the location and the sound quality of the speakers into account as part of the compositional process, using the speaker as an instrument rather than attempting to hide the presence and location of the speaker completely. This largely restricts reproduction and scalability of the systems derived and limits it to a 'live' and 'site-specific' context.

BEAST is one of few permanently installed live diffusion systems and is located in the University of Birmingham. Others such as the GMR Acousmonium in Paris, Gmebaphone in Belgium and ACREQ in Quebec are some of the main ones to also follow these practices (Zvonar 1999).

Resound by Mooney and Moore (2008), and its forerunner, the M2 designed by Moore et al (2004) is a fader-only control surface designed specifically for live diffusion. Many similarities exist to the traditional analog mixer both in use and in appearance but with the difference of it being backed up by a software allowing for different functionality of each fader. Resounds faders can be set to route the signal to one speaker or a group of speakers as traditional mixers could do but also more complex mappings such as proportional group, dynamic input to output mapping and additive/subtractive grouping (Mooney and Moore 2008).

Ones that are more of interest to this project are the group of functionalities which the author calls *'Semi-automated Spatialisation Behaviour'*. One of these is the *'Mexican wave'* which iterates through a selection of loudspeakers and loudspeaker groups. A random version of this exists which cycles through the speakers randomly. With Resounds flexible macroing of controls and simplistic hardware interface, it would be a good tool for live electronic dance music even though it has not been proposed as such. Due to the inherent arrhythmic nature of the material used in live diffusion, no tempo synchronisation is stated but nonetheless, the functionalities proposed in Resound and this project are fundamentally the same.

Live diffusion and repetitive rhythm structures in electronic dance music are two areas that have been explored in part by past researchers and musicians but never in the same context. None of the systems have been built purely for live performance of rhythmic electronic music. Resound is a definite contester but due to the lack of synchronisation and different intended use, it would prove difficult to use to its full potential. A look at electronic dance music has shown a different approach using cyclic motion and the techniques transposed from live diffusion practices would be good starting point for tackling the subject of spatialising rhythmic audio material.

Chapter 3: Prototyping, development, testing

Introduction

The following chapters present the approach and iterations undertaken to address the questions of spatialising rhythm-heavy audio. The aim is to build a simple interface mapped to a MIDI controller which will allow the artist/user to swiftly achieve pleasing spatial motion for his/her material. The functionalities constructed should be applicable to a wide range of different grooves, tempos and timings. Software tool selected for prototyping is Max/MSP (Cycling '74 2018). which is a visual programming environment.

Timing Quantisation

Time signature in music refers to how many beats are in one measure or bar in a composition. The bulk of electronic dance music is in the 4/4 time signature meaning there is four beats in one bar. For this project, an additional expression is used for clarity. As this project deals with cyclic motion and symmetrical rotation, a ratio of how many beats are used in one full rotation is the clearest way to portray what is happening to the audio when the system spatialises it. So therefore, 1:1 is doing a full rotation every beat, 1:2 is doing a full rotation every two beats and so forth.

Source material selection

The musical material chosen in developing this system was in stem format. Listed below is the carefully selected set of material that was chosen.

Robert Del Naja – S (Del Naja 2014)

Robert Del Naja – U (Del Naja 2014)

Nervbloc – Slapback (Nervblock 2015)

Albert Kader – Ubiquitous (Kader 2016)

Liv 3 – Applican (Authors own stems)

Liv 3 – It's the law (Authors own stems)

Stems of various genres and tempos were chosen to check the usability of features in a broader scope rather than having it well suited to only one genre or BPM range. White noise and sine tones were also used for more objective testing.

Testing the system and assessing its usefulness.

Following the autoethnographic approach, the system and its progress was constantly being evaluated by myself. New functionalities were implemented immediately and assessed by applying them to the current source material used that day or moment. If the functionality seemed promising then further testing on all other source material was done to ensure usability across various tempos and genres of electronic music. This step-by-step process was documented in a log book in short form writing and key functionalities and elements were documented[1] as a user centric video documentation (GoPro) and/or screen recording coupled with binaural audio recordings (Neumann KU 100 Dummy Head).

Work 1: An initial system to allow basic rhythm based diffusion

Introduction

This chapter presents an initial prototype. The aim in developing this was to:

1) Create a basic framework using Max/MSP to explore rhythm based spatialisation.
2) Explore the use of cyclic motion on rhythmic audio material.
3) Establish 'control points' for interaction with the software.

This initial system was prototyped in the Spatial Auditory Display Environment (SpADE) using Max/MSP with mouse and keyboard as input devices and an octophonic speaker layout as output. Eight speakers were used as it is a standard layout that can be found in many multichannel set-ups. The basis for live diffusion is using precomposed audio material and to "reinforce that shape [of the audio material] in the audience's

[1] Throughout the report, the reader will be asked to direct their attention to certain video documentations. Labels such as 'Work 3: See-saw' directs to the video 'See-Saw' in the folder 'Work 3'.

perception" (Harrison 1999). If the shape of electronics music rhythmic material is repetitive, then cyclic motion was a good starting point for spatialisation.

Description of the System

Borrowed from the 'Mexican Wave' concept from Mooney et al (2008), the basic idea was to rotate audio around the listener with respect to the global tempo of the audio. Different divisions of the tempo allowed the audio to move faster or slower but always overlaps at certain points in the timing structure of the audio attempting to create a sense of symmetry. A mono bus was also used which routed the monophonic audio to all eight speakers with unison gain.

A windowing mechanism was built to move the monophonic audio material from speaker to speaker that created the impression of a cyclic revolution around the listener (see Figure 1).

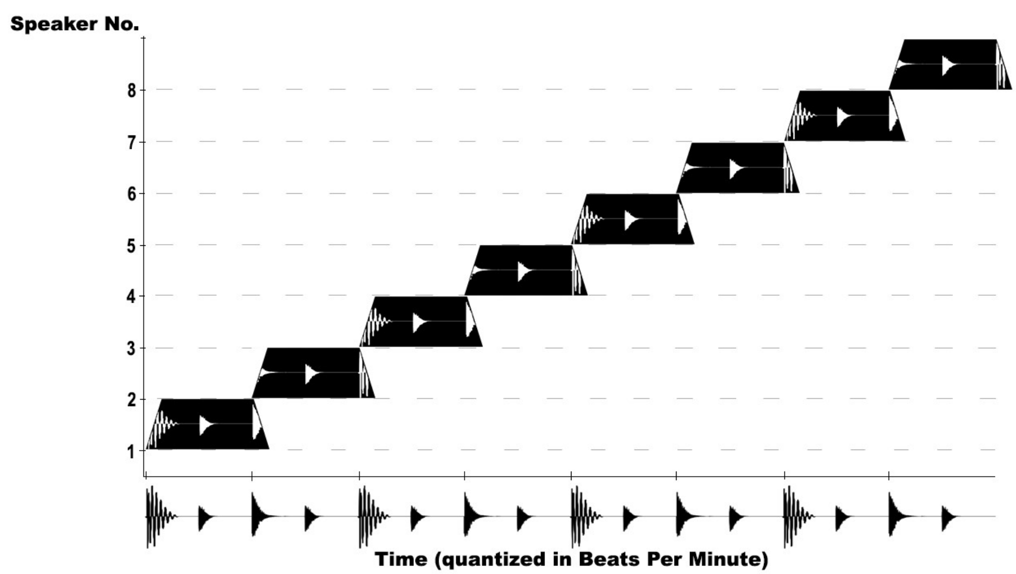

Figure 1: VCA Windowing

A fade in/out time was defined (shown in the diagram as a diagonal line on each side of the window) to prohibit the speaker transition from producing a 'click' and also smoothen the overall motion. Above, the audio steps from speaker to speaker every 1/4 note so therefore its full cycles to beats ratio is 1:8. Other rotation speeds included 1:6, 1:4 and 1:2.

Audio could only be passed into one of the four windowing busses or mono playback with fade times being universal for every bus. This meant if several sound sources were routed to a bus such as the 1:4 bus, then they were always being played out the same speakers on its trajectory around the eight speakers which became monotonous overtime. Shown below is a signal flow diagram showing the routing of one mono audio source.

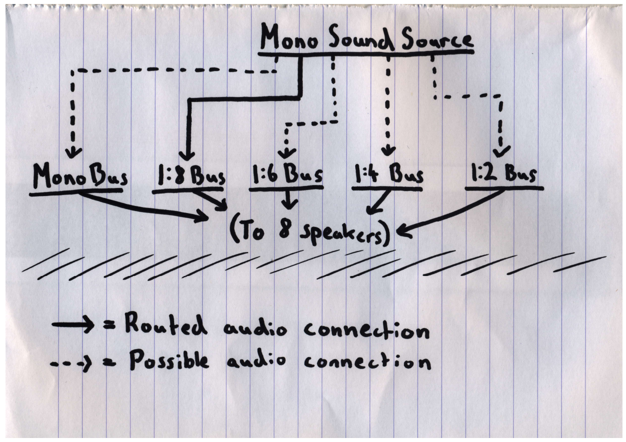

Figure 2: Work 1 Signal Flow

Conclusion

Having laid out the basis for cyclic motion using signal windowing and stepping functions and allowing for adaptability to various rhythmic material, control of these functionalities was impractical for live use. A method for switching the motion step speed was needed for rapid alteration and condensation of fade times would speed up the process of adjustment for the user. A method called transient detection which is used for detecting spikes of sound in audio material had also been attempted. Its adaptation proved difficult and unusable but would later be reviewed again.

Work 2: Taking Control

Introduction

This section presents second iteration of the system developed which built upon the same functionality as the previous and used the same octophonic speaker layout and Max/MSP controlled by mouse and keyboard. Following the outcomes of Work 1, a need to intuitively control the designed components arose to empower the user/artist further.

The previous method of routing audio into each spatial motion bus had proven to be inadequate and cumbersome for two reasons:

a. Consumed too much of the user's time.
b. Using the same spatial trajectory demonstrated a spatial image with too little variety.

A method that required less time yet offered more control was desired.

Description of System

To counter this, each spatial motion bus was combined with a mono bus into an all-encompassing bus or 'audio channel' in which a set stream of audio flowed through, which later on would come from Ableton. Eight of these channels were produced where the spatial motion mode could be defined for each channel independently by passing the audio to one of the spatial motion busses inside the channel allowing independent trajectories. Below is the signal architecture of one of these channels.

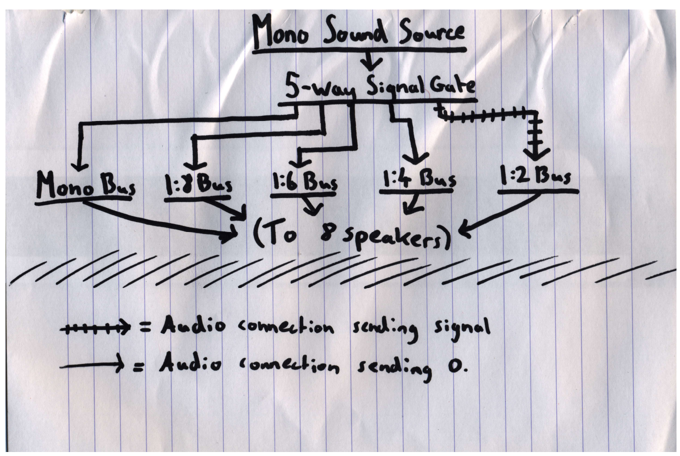

Figure 3: Work 2 Signal Flow

Selection of these different modes for each channel was be done with a GUI button matrix as seen below in figure 2.

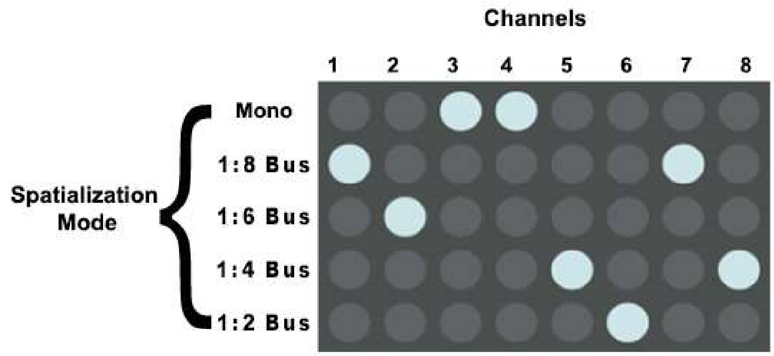

Figure 4: Current GUI for channel Spatialisation mode

Independent channels meant unique fade times(Attack, Sustain, Release) but for usability and ease they were simplified to 'Fast', 'Medium' and 'Slow'. Fast was optimised for dense, transient heavy percussive elements while slow suited more to long sustained pads as it faded the source over several speakers creating a wider and smoother sound. Medium was a neutral 'all-rounder'. The same button matrix principle was applied for a control surface (Figure 3).

[Refer to 'Work 2: Control Interface' for demo]

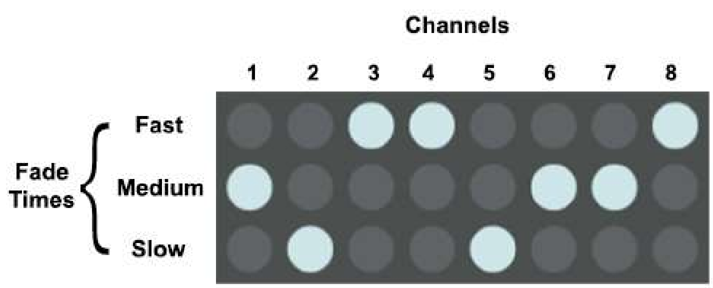

Figure 5: Current GUI for selection of channel fade times.

Interface Considerations

From the new GUI features added in this work, a speculative mapping of a hardware interface was considered. A MIDI controller such as the Akai APC Mini could be mapped in a way that each column of controls operated one channel. This would mean a 1 to 1 mapping of software to hardware controls which allowed fast accessibility and multi-triggering of functionality at the cost of using up a lot of buttons. Below is a concept to how this interface could be mapped.

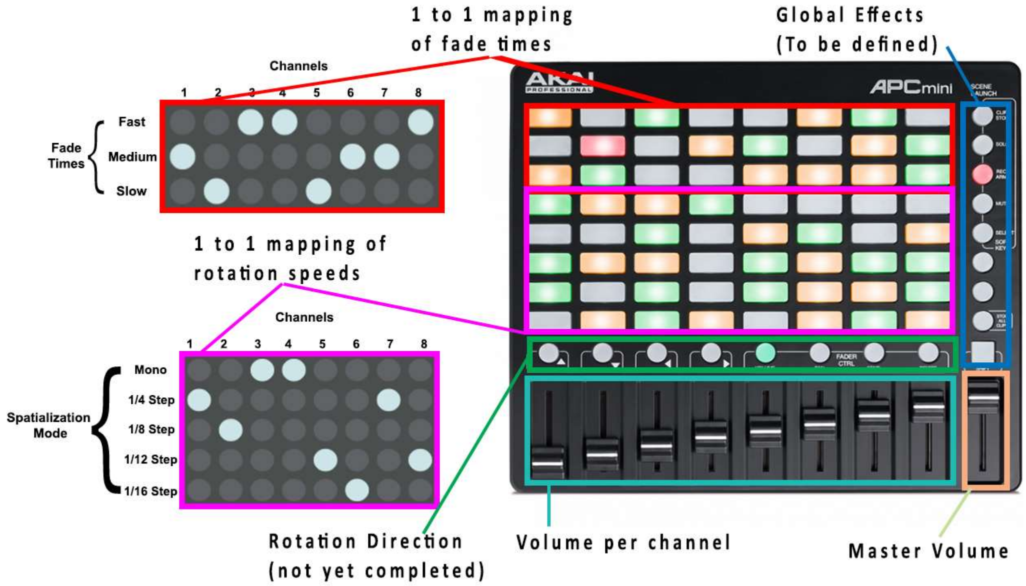

Figure 6: Concept Mapping to Akai APC Mini

Conclusion

This method of control allowed for cyclic motion to be quickly applied to incoming audio channels and fade times appropriated to the features of the audio. The use of the 'slow' fade setting on some melodic material with evidence of rhythm resulted in a pleasing combination with the rest of the material if used sensibly.

Furthermore, stems with only a singular element or elements that are very similar lent themselves well to the single rotational trajectory e.g. A closed hat loop or a closed hat loop coupled with a shaker. But stems with several different variations of elements such as an entire drum loop containing kick, snare, toms, etc. encountered the same problem that Work 1 encountered where several different stems routed to the same bus portrayed a narrow or arbitrary spatial image.

Therefore, a method that allowed the user to combine spatial motion busses in a non-binary approach would potentially solve this problem while opening new avenues of exploration for material that has no rhythmic or drum elements in it.

A concept mapping proposed would have lent itself for use with these functionalities but introducing new functionalities changed this mapping drastically.

Work 3: Non-binary control

Introduction

As before, this iteration built upon the same functionality as previous works and attempted to improve it.

Returning to some ideas of live diffusion, audio is routed to speaker, speaker pairs or speaker groups with gain levels controlled with faders, generally ones on a mixing desk. Any routing combination should be possible which allows the sound to take any shape or size possible with the speaker layout at hand. This non-binary use of speaker levels (on/off or any level in between) allows the user more control over the spatial image of her/his performance. Transposing this method into this project may allow for more complex patterns to be generated and therefore allow for wider range of possibilities.

Description of System

The implementation of this idea was simple as the components had already been defined in the past iterations. The channel defined in the last iteration contained one of each spatial motion bus and a mono bus where routings to the different busses were turned on and off depending on which motion was selected from the button GUI.

Instead of a binary routing of the audio stream into one of the spatial motion busses, a gain slider was used to set the amount of audio sent to each bus.

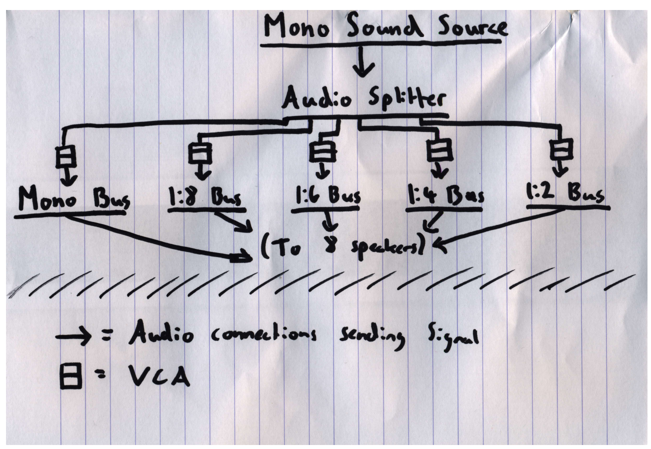

Figure 7: Work 3 Signal Flow

This meant if the audio is rotated around the listener with the 1:4 bus pattern, it could simultaneously be sent to the 1:6 bus to add syncopation to the result and caused a wider spatial image with broader variation. This is illustrated in the signal diagram below.

This method solved the previous problem of certain audio material spanning across too many rhythmic elements or not containing any rhythmic elements.

This solution introduced a new issue of control though. Five faders were needed to control this functionality per channel (one for the mono bus, 1:8 bus, 1:4 bus, 1:6 bus and 1:2 bus) so with eight channels this resulted in the need for a hardware interface mapping of forty faders. This was unfeasible in both live use and access to such a hardware controller. If the interface was meant to be used in a live context were the performer could create/trigger and then spatialise his/her material on the fly then use such an interface would be illogical and was counterintuitive to the goal of this project. To tackle this challenge meant to sacrifice control for complexity.

Multimapping of controls

Multimapping is when a single axis control surface is mapped to control two or more single axis controls which may be correlated or not. A simple example of this would be the pan potentiometer (software/hardware) which controls the amplitude levels of two incoming channels. If done correctly, the designer allows the user a simple yet sufficient amount of control over more complex functionalities.

The challenge arose from the new feature added was to be able to control gain levels of four spatial busses with one fader in a manner that was simple to use, intuitive yet did not sacrifice too much control.

Two different mappings were trialled:

1. ‘See-Saw’ mapping [Refer to ‘Work 3: See Saw’ for demo]
2. ‘Wave’ mapping [Refer to ‘Work 3: Wave’ for demo]

Each mapping had its pro’s and con’s. The ‘See-Saw’ mapping proved simple to use and garnished good results on dense material. Sonically, the fader transition could be described as a slow rotation to fast rotation with a dense, swarm like but undistinguishable motion at play. This mapping had pleasing interpolations between spatial rotation speed but had a noticeable downfall. Spatial clarity could not be sharpened as several/all motion busses were used by the fader which meant a singular trajectory could not be defined. When all channels used this feature, the spatial image became cluttered and unintelligible. This implied a third control to allow further flexibility but required eight more hardware buttons/faders (one per channel).

The ‘Wave’ mapping attempted to solve this shortcoming without the requirement for a third control. By splitting the control fader into three sections, the four singular trajectories were found at each quartile mark of the control fader with interpolation between each point. This allowed some blending between busses but didn’t allow for many combinations, especially combinations using more than two trajectories or ones that were not adjacent were not possible. Furthermore, settings defined by the user did not reflect well in the spatial image. Without a visual feedback system, overview of settings dialled in by the fader were obscured making use of this feature somewhat random and arbitrary.

From these two different mappings, the most useful concept was the mono vs. spatial slider which allowed the blending between the mono and spatial signal. When the spatial image became too disparate, blending certain elements with its respective mono signal brought coherence back into the overall image which proved as a viable method for creating a dynamic listening experience with ease.

Conclusion

Non-binary blending of spatial busses was a useful addition to the system if used sparingly and correctly. Two problems arose from this addition which were degradation of spatial image and method of control. Blending too many busses with each other usually ended in an unintelligible motion that did not compliment the original groove and crowded the entire spatial image. This problem, being the major one, took priority as it seemed counterintuitive to control something that did not sound pleasing. Multimapping had been provisionally tested as a solution in two ways but neither proved satisfactory. Solving this problem required a rework of the core principle this project was based on so far.

Work 4: Transposing to Vector Based Amplitude Panning

Introduction

Vector based amplitude panning or VBAP, is a method of spatialisation which uses vectors to calculate the amplitude levels of two speakers to create a virtual sound source anywhere between them (horizontal plane) (Pulkki 1997). A Max/MSP external adapted to 64bit from the original designed by Pulkki allows for an easy implementation into this project (Wolek 2018). Benefits of this in context with this project were:

1. Increased resolution of the spatial image. Raising the eight possible points (eight speakers used) to potentially 360 (360 degrees in a circle).
2. Portability to any other equidistant speaker configuration and expansion into 3D if needed.

The first benefit solved the problem of spatial clarity experienced in the last work by increasing the possible spatial locations for an audio stream to be located at any given point in time and allowing for smooth transitions between these points.

Description of System

The signal flow remained mostly the same in this work but control messages were to VBAP's input requests.

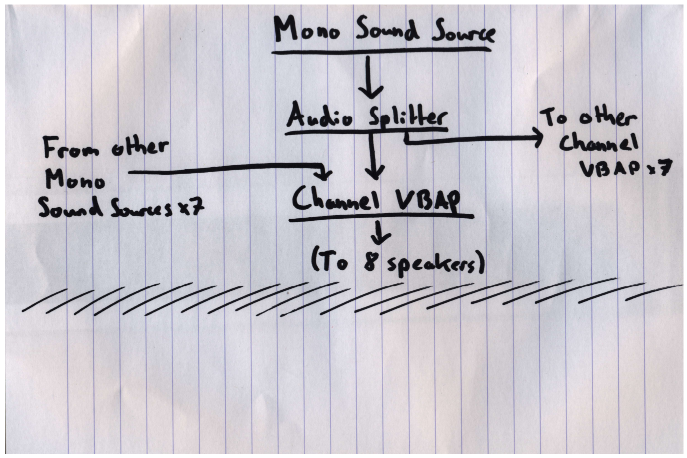

Figure 8: Work 4 Signal Flow

The VBAP object in Max/MSP has four input controls but only two were used for this project. Location of the virtual sound source is defined in degrees so linear number lines were used to count from 0 to 360 which created rotational trajectories. The time interval between beats was used in multiples as time duration for these number lines to recreate the rotation speeds as before.

Rotation selection was kept the same as previous but sound fidelity, due to greater spatial resolution, was increased while making the use of fade times obsolete. To further make use of this new method, non-linear number lines such as logarithmic and exponential could be defined instead of a linear number line which created the effect of the rotation accelerating and decelerating at certain points of the rotation while maintaining synchronicity with the global tempo. This was controlled by a macro parameter controlling all channels were numbers between -1. and 0. produced a logarithmic curve and 0. to 1. produced an exponential. [Refer to 'Work 4 Non-Linear Number Lines' for demo]

The second parameter of VBAP used was the spread which defines how many speaker pairs to use for the rendering of the virtual sound source. This increases the apparent width of the source and when adjusted to full spread, sets all gains of the speakers equally. This parameter replaced the slider interpolating between the mono and spatial busses found in the last work.

The second problem that required addressing from the last work was the employment and control of the non-binary spatial busses. Previous technique of blending several busses together was not applicable anymore due to singular use of the VBAP object per channel, allowing for only one trajectory to be defined per channel. But a simple approach of splitting the original mono stream eight times and blending these audio signals into the other seven channels evenly created a diffuse effect which portrayed some of the characteristics of the entire spatial motion. This implementation was very crude and holds some idiosyncrasies at the moment but was as simple to control as adjusting one dial. Using it coul be explained as acting like a glue which tied your spatial image together if one of your elements projected out of the overall spatial image a bit too far. It also proved beneficial when applied to arrhythmic material such as melodies, pads or even vocals. [Refer to 'Work 4: Diffuser' for demo]
More additions to the system included the replacement of the 1:6 bus for the 1:1 bus. This was previously not possible and proved to be a valuable addition for fast, transient dense elements. Another addition was the rotation reverse mode creating rotations in anti-clockwise motion and created further variety in the overall spatial image. A palindrome rotation was added which reversed rotation once it reached the beginning or end of the number lines used which had similar benefits for the spatial image as reversing the rotation.

Conclusion

To switch to VBAP to control the panning increased the systems spatial clarity and ease of use within the live context due to the simply controlled Max/MSP external and lightweight CPU usage. Fade times were no longer needed reducing the number of control points per channel while increasing the fidelity. Non-linear rotation was introduced but required deeper assessment in the performance aspect. The issue of blending several motions together had found a simple solution. All software control points were created which now required mapping to the MIDI controller. Coupling this with the integration with Ableton, produced the final work.

Chapter 4: Final Work

Introduction

Following on from the initial three works described earlier, this section describes the final system that was developed. The final works functionality consisted of the same functionality as from Work 4 using VBAP and outputted through eight horizontal speakers as before. A Korg NanoKontrol2 (Korg 2018) was used as the mapped interface to control the spatialisation. Ableton Live 9 (Ableton 2018) was used to playback audio and Max 4 Live (Ableton 2018) was used to send global tempo and transport information to Max/MSP for synchronisation.

Ableton

Ableton Live is a music production and performance software with particular emphasis on live performance of electronic music. Using Ableton as the performance software offered the advantage of being able to host Max/MSP inside Ableton in the form of Max 4 Live. This made gathering tempo (BPM) and transport information (is Ableton playing or not) easy which was needed to calculate rotation speeds and to start/stop the rotations. To route the eight independent audio streams from Ableton to Max/MSP, an audio device emulator called Soundflower (Ingalls 2018) was used which allowed discrete audio streams to be routed to it and from it. Eight mono channels were sent from Ableton that the user could define for themselves what they should playback and a stereo reverb channel was routed which could be used via sends. The left channel of the reverb was routed to all odd numbered speakers and the right to the even creating stereo pairs in each quartile of the speaker system which created an illusion of space.

Functionality

The functionality of the final work was identical to the ones from Work 4. The new additions were global features that effect all channels and were thought as either utilities or 'wow' effects which could be thrown in for variation.

A pre-set bank was added with two banks. Pre-sets could be predefined and recalled at any point, or overwritten during a performance. This was meant as an aid for complex transitions in which the performer would have to change too many parameters in an instant.

A freeze effect was added that stops all sound rotations for as long as the button is held. Once the button is released, the sound jumps to were ever the current trajectory is along its rotation. This happens as the number lines are not stopped, merely the transmission to the VBAP object is. This was done so that the overlapping symmetry between all the rotations is kept intact.

A slow-down and speed-up effect was added that, when held, sets all channels to the slowest rotation (1:8) or the fastest (1:1) respectively. When released all channels return to their original rotation.

A macro spread and diffusion button was added which sets all channels to full spread (mono) when held. Same principle applies to the macro diffusion feature. On release all channels return to their prior state for both features.

Mapping the Hardware Interface

The controller

The Korg Nanokontrol2 is an inexpensive and compact MIDI controller that offers eight channels of identical controls with further eleven buttons labelled for use as global control of a DAW. The channel controls consist of a vertical fader, a potentiometer and three buttons arranged vertically next to the slider labelled ‘S’, ’M’ and ‘R’. Each individual channel controls needed to be controlled from these five parameters meaning that each functionality needed to be weighed up carefully due to the compact format of the controller. Most of the software control points to be mapped were defined and evaluated throughout the last four works with only small features added throughout the final stage of the process.

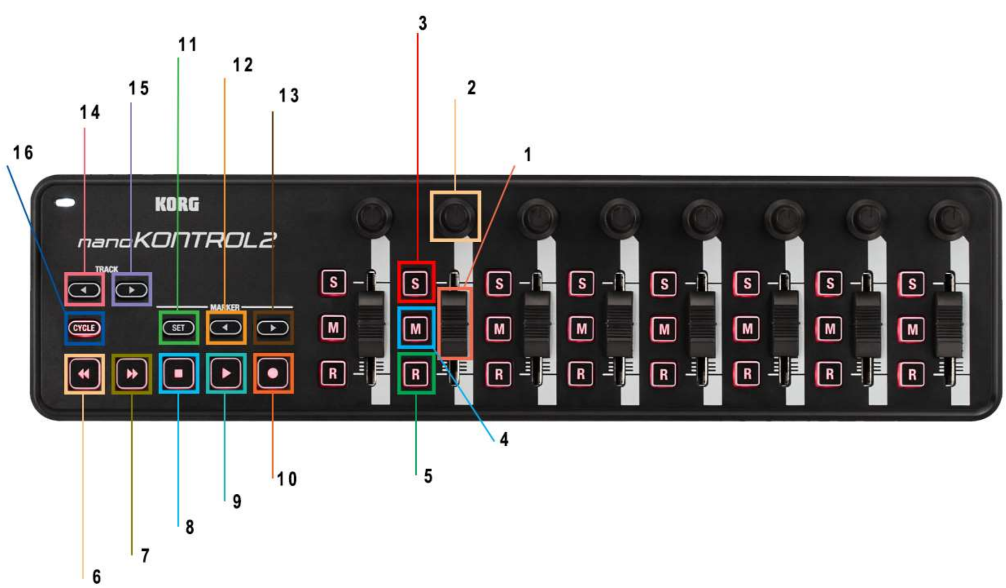

Figure 9: Korg NanoKontrol2 labelled

Controller mapping

Even though the mapping to a hardware interface was kept in mind throughout the design process, mapping to such a compact controller did have shortcomings. The main aspect of this project was cyclic motion where implementation was kept at four selectable rotations. But a button to select each rotation was not present on the controller for each channel and even if so, mapping in this manner would have been a waste of resources. A compressed mapping of cycling through them was more feasible. This was done with the 'S' and 'M' button on each channel. 'S' decrements to a slower rotation while 'M' increments to a faster with wrap around when reaching the top or bottom. This could have been further condensed to one button to just cycle through all but meant that the furthest option may be up to three button presses away taking up time and disrupting the trajectories unnecessarily.

For the rest of the channel controls, 'R' was suitably mapped to toggle reverse on and off. The fader was mapped to control spread, fader at zero being no spread and at full being full spread. The potentiometer was mapped to control diffusion in the same way.

The global features were mapped into three groups. Global effects, global curve and preset banks. Global effects were mapped to the five square shaped transport buttons at the bottom and were slow-down, speed-up, freeze, macro diffuse and macro spread, mapped from left to right.

The implementation of non-linear number lines was mapped to the 'Marker' group. 'Prev marker' decremented the curve parameter by 0.1 and 'Next marker' incremented by 0.1 with 'Set' resetting it to 0. The 'Track' group was used for preset recalling and overwriting. 'Prev track' was bank 1 and 'Next track' was bank 2. Holding 'Cycle' while pressing one of the bank buttons overwrote that bank with the current system parameters.[2]

Discussion

After some time spent with this mapping, certain patterns started to emerge. The preset feature was practically never used. This may be due to my own relatively novice standpoint of live performance and spatialisation and this features use would only come to fruition in very complex situations. But including such a specific feature when real estate was precious seemed unbeneficial at the time.

[2] Refer to Appendices A for full mapping sheet.

Once a suiting rotation speed was selected for audio material playing through a channel, variation of that speed happened rarely unless the audio is changed. Even when a new loop was triggered on a channel assuming channels in Ableton were grouped to contain similar material (e.g. high-hats and shakers) as is often the case, there was a high probability that the current rotation would suit it too. It may have been the case of not having fast enough accessibility to each rotation speed but working with that specific MIDI controller, it was not possible to offer more. Therefore, attempts to exploit that similar rhythmic elements could be fitted with similar rotation speeds may free up more interface room by placing less emphasis on the fast accessibility of the rotation speeds which could free up the performers time to concentrate on other things.

Other minor observations were made that may lead to an improved system. Considering the liberation of three buttons (removal of preset feature) led me to undertake a second version of this mapping to investigate the findings of this evaluation further.

Controller mapping v2

Assessing the layout of the first mapping, it seemed logical and beneficial to make a ‘v2’ of the mapping. One of the main reasons this was attempted was to free up room to trial the mapping of the palindrome rotation which reverses direction every time it reaches 0 or 360. After assessment of the first version, a decision was made to place less emphasis on the alteration of rotation speeds which would free up enough room for this new feature.

Rotation speed selection per channel was condensed to holding down ‘S’ and pressing either the ‘Rewind, ‘Fast-forward’, ‘Stop’ or ‘Play’ button to select one of the rotation speeds, which were mapped incrementing in speed from the left to right. This means that usually two hands were required to perform this action lowering accessibility greatly to this feature. Palindrome toggle was then mapped to the ‘M’ button on each channel placing it in a prime location for quick access.

This brought along a second issue of having to relocate four of the global effects. After evaluation of the last mapping, the slow-down effect was noted to be used rarely as its sonic result proved to be unpleasing for the most part. Due to this, only three global effects needed remapping which coincided with the removal of the preset object. The macro diffuser was mapped to ‘Cycle’, the freeze effect to ‘Prev track’ and the speed-up effect to ‘Next track’. Macro spread stayed mapped to the same button.[3]

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[3] Refer to Appendices B for full mapping sheet.

Outside of these changes, the mapping of the spread slider was inverted to portray the sliding up of the fader as a progression from a narrow mono image to a spatialised one. This also correlated to the mono vs. spatial slider found in Work 3.

Conclusion

The Performance Experience from the Performers point of view

Performance consisted of categorising the eight Ableton channels into typical elements you would find in electronic dance music and was done beforehand. All material used is in audio loop format synchronised to the global tempo for ease of play. The eight channels were: kick/kick+bass, vocals, melodies, ambiences/textures, percussion, snares/claps, synths/vocal chops/miscellaneous and hats/shakers. Most material was very rhythm orientated to support the systems application.

This categorisation coupled with the interface mapping, allowed for something of a workflow to evolve in which certain parameters can be set by default. Bass sounds don't fair well when spatialised meaning that channel was kept primarily mono. Fast, transient-dense material produced by the hats and shakers lent themselves to fast rotations. Melodies and vocals, even though containing little rhythmic elements could be generalised to the slower rotations plus blending with the diffuser allowed for a full and spacious sound with lots of spatial movement. The implementation of reverb proved invaluable over time giving the complete picture a coherent impression.

It may be taken as a given, but this generalisation of rotation times holds an interesting premise. The denser the transients in the repetitive pattern, the faster the suited rotation will be. Sparsely or drawn-out drum patterns are more suited to slower rotations as their individual point of recurrence is temporally further apart. Currently this cannot be backed up by any evidence but herald's further investigation in the material analysis domain.

Speaking to a particular participant of one of the demo day presentations beforehand, he/she was intrigued to see how the performance would justify a spatial representation of electronic dance music commenting on the unified and spatially condensed representation it normally has.

Final observations

In the aftermath of the performances, investigating performance patterns lead to further adjustment ideas. Being able to approximate rotation speeds from knowledge of the audio material and control of this parameter moved into the background, use of the system at points became arbitrary. Unless a sound was blatantly addressed with the wrong rotation speed, there seemed little need to alter rotation speeds, especially when time was scarce to do so. This hinted at diverging accessibility from this feature as counterintuitive towards experimentation.

The diffusions parameter held an idiosyncrasy which was sometimes unforeseen. When all channels were set to full spread or had the exact same rotational trajectory, diffusion would have little to no effect in comparison to what was expected. But outside of the beginning of a performance, this rarely happened.

The use of the global features such as effects and the macro curve was limited due to their arbitrary impact on the overall image. Assigning these as unique features to each channel may further their use but requires more button and fader resources to realise. A completely new mapping of the interface weighting features in a channel oriented fashion where each feature can be applied to a channel specifically seems to hold greater value for a versatile interface.

Chapter 5: Conclusion: Discussion and Future work.

Discussion

After limited testing and performance with the system, I gained my first insights into spatialising live electronic dance music with the system and found the process seems to reside closer to the task of a mix engineer then it would to a purely artistic and creative approach. Considerations to supporting the motion and shape of each element is placed in the foreground.

Performing with the system can be explained as being controlled yet sometimes limiting which can be attributed to the control of the functionalities offered by the interface. When the performer plays new audio material, adaptation of parameters suiting to the material can be achieved in quick succession which frees up the performers time to concentrate on compositional aspects of the performance. But after that, little inspiration for experimentation is encouraged outside of the use of the spread fader and the diffuser knob. This can be seen in video documentation of my use with the system. Observe how often I use the spatialisation interface (one in front of screen) [Refer to 'Work 5: Final Work' for demo]

Personally, this observation hints at interface design. The importance laid on certain functionalities by allowing more or less accessibility will define how the interface and therefore how the system is used. By allowing faster and in-depth access to parameters of rotation trajectories and curve, more experimental approaches can be taken when spatialising. The drawback of such an approach is that such experimentation requires the user/performer to dedicate more time to the spatialisation part which will have to be taken away from the composition and arrangement of the elements.

Conclusion

In this report I have presented the development of a system for the spatialisation of rhythmic elements in electronic dance music. The technique of cyclic motion has been the mechanism for this exploration and due to promising results early in the project, functionality was expanded in an attempt to address the entire spectrum of common material found in electronic dance music.

This development followed an iterative and situated methodology which sought to balance the requirements for a system suitable for live performance with affording control over the many parameters that a sophisticated spatialisation system can make available.

The main contribution of this work is foregrounding the benefits that cyclic motion brings to spatialising rhythm-orientated electronic dance music. When synchronising the function of cyclic motion with the process of spatialising electronic dance music, the symmetrical properties of repetitive rhythmic elements are preserved in the spatialisation if done correctly. This process becomes arbitrary if overused so should be balanced out with contrasting spatial metaphors in a fully-fledged system.

In presenting the background to this work I found the use of spatial rotations being used rarely as a core technique to spatialisation. The live diffusion interface 'Resound' proved closest to this project with its 'Semi-automated Spatialisation Behaviour's' (Mooney et al 2008) but from my point of view, this failed to adequately explore the potential of rhythm as a guiding characteristic for live diffusion of dance music as nowhere stated an integration into the timing structures of the material being spatialised. I addressed this matter by making this integration a priority and showed advantages when done so in context with electronic music.

Future Work

The topic of spatialising rhythm still holds much research. It may be taken as a given, but an impression of correlation between rotation times and transient density holds an interesting premise. The denser the transients in the repetitive pattern, the faster the suited rotation seemed. Sparsely or drawn-out drum patterns suggested to slower rotations as their individual point of recurrence is temporally further apart. Currently this cannot be backed up with evidence outside of my own limited experience with the system developed but herald's further investigation in the audio analysis domain.

Further investigation using non-linear number lines to drive the spatialisation needs full investigation as Iyer et al (1997) state that the groove in rhythmic music "may be articulated in a complex, indirect fashion."

The control method of this project requires decisions to be made for future application. If the emphasis of use is for a 'companion' to a solo live performer who needs spatialisation to take up little of her/his time yet produce satisfying results, then the interface should be stripped-back and simple to use with no ambiguities. But if emphasis is on experimentation and therefore sometimes uncertainty in result, then interfacing with different control methods such as control voltages from modular systems, gesture control or algorithmic processes should be explored.

Control process being one the biggest downfalls of this project is highlighted by a quote from Brian Eno written in the New York Times about his encounter with immersive tools in his latest project 'Bloom: Open Space':

> Philosophically, in terms of our understanding of what it is, we're right at the beginning […] But also technically, it is difficult. There's a slightly awkward imbalance between the complexity of the system and the simplicity of the results.
>
> (Siegal 2018)

This reiterates a challenge encountered earlier on in this project of sacrificing control for complexity. But for me, this implies that the more we learn about controlling this technology then the more intricate our output will be.

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Appendix A

Controller mapping

Per Channel

1. Fader: @0 spread = 100, @127 spread = 0
2. Pot: @0 diffuser = sound output kept discrete, @127 diffuser = sound sent to other 7 channels
3. S: @trig = decrement rotation speed (wraps around when at slowest)
4. M: @trig = increment rotation speed (wraps around when at highest)
5. R: @trig = Toggle reverse direction

Global

6. Rewind: @hold = all channels to slowest rotation (1:8)
7. Fast-forward: @hold = all channels to fastest rotation (1:1)
8. Stop: @hold = freeze all trajectories
9. Play: @ hold = diffuse all channels
10. Rec: @hold = spread all channels
11. Set marker: @trig = macro curve reset to 0
12. Prev marker: @trig = macro curve += -0.1
13. Next marker: @trig = macro curve += 0.1
14. Prev track: @ trig = load preset bank 1
15. Next track: @ trig = load preset bank 2
16. Cycle: @hold + @trig either track button = overwrite bank to current setup

Appendix B

Controller mapping v2

Per Channel

1. Fader: @0 spread = 0, @127 spread = 100

2. Pot: @0 diffuser = channel output kept discrete, @127 diffuser = sound sent to other 7 channels
3. S: @hold + @trig Rewind, Fast-forward, Stop or Play = Rotation select (1:8, 1:4, 1:2, 1:1)
4. M: @trig = Palindrome toggle
5. R: @trig = Toggle reverse direction

Global

6. Rewind: @trig w/ @hold channel ‘S’ = 1:8 rotation
7. Fast-forward: @trig w/ @hold channel ‘S’ = 1:4 rotation
8. Stop: @trig w/ @hold channel ‘S’ = 1:2 rotation
9. Play: @trig w/ @hold channel ‘S’ = 1:1 rotation
10. Rec: @hold = spread all channels
11. Set marker: @trig = macro curve reset to 0
12. Prev marker: @trig = macro curve += -0.1
13. Next marker: @trig = macro curve += 0.1
14. Prev track: @hold = freeze all trajectories
15. Next track: @hold = all channels to fastest rotation (1:1)
16. Cycle: @hold = diffuse all channels