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Rhizomatic approaches to screen-based music notation

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ABSTRACT
The rhizome concept explored by Deleuze and Guatarri has had an important influence on formal thinking in music and new media. This paper explores the development of rhizomatic musical scores that are arranged cartographically with nodal points allowing for alternate pathways to be traversed. The challenges of pre-digital exemplars of rhizomatic structure are discussed. It follows the development of concepts and technology used in the creation of five works by the author *Ubahn c. 1985: the Rosenberg Variations* [2012], *The Last Years* [2012], *Sacrificial Zones* [2014], *detritus* [2015] and *trash vortex* [2015]. The paper discusses the potential for the evolution of novel formal structure using a rhizomatic approach.

Author Keywords
Animated Notation, Networking, Rhizome.

ACM Classification
Algorithms, Design, Experimentation, Performance,

1. INTRODUCTION
More than 30 years ago Deleuze and Guatarri repurposed the term *Rhizome* a botanical description of a rootstalk capable of generating shoots and stems at any node, as a broad philosophical concept in which connections are ceaselessly established between "semiotic chains, organizations of power, and circumstances relative to the arts, sciences, and social struggles" [7].

The concept has been a powerful one that has found its moment in the era of mass communication, New Media, multiculturalism, critical theory and intersectional activism. Use of the term in music has also been expansive and includes (in addition to Deleuze and Guatarri's discussion of a wide range of art music from Beethoven to the Avant Garde), Jazz [1], Industrial Music [13], Glitch [28] and Remix Culture [15].

In *A Thousand Plateaus* [1987] Deleuze and Guatarri define the rhizome according to following principles:

- *connection and heterogeneity*: "any point of a rhizome can be connected to anything other, and must be."
- *multiplicity*: "There are no points or positions in a rhizome, such as those found in a structure, tree, or root. There are only lines."
- *asignifying rupture*: "A rhizome may be broken, shattered at a given spot, but it will start up again on one of its old lines, or on new lines."
- *cartography and decalcomania*: "The map is open and connectable in all of its dimensions; it is detachable, reversible, susceptible to constant modification. It can be torn, reversed, adapted, to any kind of mounting, reworked by an individual, group, or social formation." [8]

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The works discussed in this paper, *Ubahn c. 1985: the Rosenberg Variations* [2012], *The Last Years* [2013], *Sacrificial Zones* [2014], *detritus* [2015] and *trash vortex* [2015], exhibit elements of these principles through a particular case, works including:

- a computer coordinated live performance environment;
- a cartographical arrangement of the musical score;
- nodal points allowing for alternate pathways to be traversed.

In these works the score is literally arranged in a rhizomatic form as an interconnected web of notation (Fig. 1). The works utilize the screen-score [34] and algorithmic computation to solve a number of the practical issues created by a rhizomatic approach to music notation.

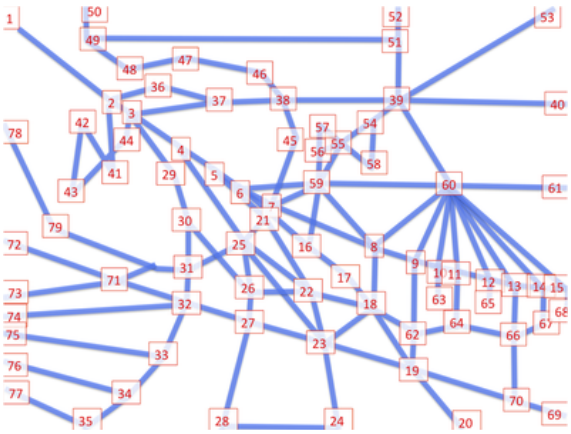

Figure 1. Cartographically arranged pathways and nodes from *The Last Years* [2012].

A high priority in the development of this work was the ability to communicate the unique qualities of the rhizomatic concept both visually and aurally through employing linked notational material and distinguishable electronic processing and allowing the audience to follow choices made through projection of the rhizomatic score and the movements of the performers. The problem of coordinating performers and electronic manipulation of their sound in an indeterminate environment is resolved through the adoption of a computer coordinated performance model.

This paper will discuss these particular instantiations of the rhizome concept, the range of difficulties inherent in creating and performing such scores and the affordances of this approach from the perspective of Deleuze and Guatarri's theory.

2. THE TROUBLE WITH RHIZOMES
In the sense proposed by Deleuze and Guatarri, some of the earliest examples of rhizomatic works in Western Art music, include, Karlheinz Stockhausen *Klavierstück XI* [1956], John

Cage *Concert for Piano* [1958], Pierre Boulez *Third Piano Sonata* [1963-], Mauricio Kagel *Prima Vista* [1962-3] and Earle Brown *Event Synergy II* [1967]. (It is perhaps notable that it was not necessary to negotiate functional harmony in a rhizomatic context in any of these works). These are works allowing for a multiplicity of re-orderings of different but determinate pathways to be explored, not simply exhibiting the non-linear "asignifying ruptures" found in Stravinsky's *Symphonies of Wind Instruments* [1920] [19] or Charles Ives *Holidays Symphony* [1913] [27], or "lines of flight" [3] as found in jazz improvisation [12].

Boulez, for example, describes the *Third Piano Sonata* as a Labyrinth, in which,

> The itinerary is left to the interpreter's initiative, he must direct himself through a tight network of routes. This form, which is both fixed and mobile, is situated, because of this ambiguity, in the centre of the work for which it serves as a pivot, as a centre of gravity [4].

A number of problems beset the first generation of paper-based rhizomatic scores:

- since the audience always experiences the works in a linear fashion, sequentially in time, their indeterminacy is unverifiable: the audience cannot compare the pathways chosen to those that were not. In this sense, the rhizomatic qualities are evident to the performer(s) alone;
- performances are arguably undermined by the fact that any particular instantiation may have been potentially been less satisfying than another;
- there can be no overarching cartographical representation of its the structural potentials for the audience inhibiting communication of the structural/performative principles in play;
- the length and complexity of alternate "pathways" are limited to passages accommodated by the printed score (Klavierstück XI uses a very large sheet of paper (53 x 94 cm), and a balsa wood frame to stand it upright);
- the quality of "immanent choice" that is one of the affordances of a rhizomatic structure, can only be executed by a single performer unless conductor(s) are used, (Event Synergy II), otherwise the route through the structure must be pre-determined (Concert for Piano, Third Piano Sonata, Prima Vista);
- indicating and limiting the number of potential connections between pathways is extremely difficult;
- Western music notation is almost exclusively read horizontally from left to right, meaning that pathways remain on a single plane and cannot easily be joined together 2-dimensionally;
- although pathways may consist of varied musical materials and therefore result in diverse musical outcomes, the sounds themselves remain situated in the instruments that make them, excluding the possibility of communication of the rhizomatic structure through the form-bearing [22] parameter of spatialisation.

As Žižek noted in relation to the cinematic qualities of novels immediately prior to the emergence of film, the burst of rhizomatic musical works in the 1960s seems "to point towards a new technology that will be able to serve as a more 'natural' and appropriate "objective correlative" [38]. The appropriate technology was graphical computing, but its emergence was still more than 30 years away and compositional concerns moved on to other diverse issues including Spectralism and Minimalism. Despite the permeation of rhizomatic concepts in New Media [26] and literature [20] from the 1990s onward, musical notation proved stubbornly resistant to adaptation to the screen.

To address these issues a computer-coordinated solution to the problems of rhizomatic presentation of musical compositions with live performers was developed allowing for the creation of precise, unique but variable, multiple versions of rhizomatic works, in which the both the audience and the performers share in the exploratory immanent choice available in this approach, and spatialisation and digital processing could be aligned directly to the emerging formal structure.

3. CONCEPT DEVELOPMENT

The development of a computer-coordinated approach to presenting rhizomatic works was the outcome of a consideration of these issues by the author over a number of years [29, 30, 31, 32, 33, 34]. Although works developed previously by the author such as *transit of venus* [2009], *improbable games* [2010], are rhizomatic according to Deleuze and Guatarri's definition, a method of representing the structure to the audience as a means of communicating the implications of the indeterminate choices had yet to be found.

The first step towards this goal was *Talking Board* [2011] composed in MaxMSP in collaboration with Cat Hope. In this work a graphical score-collage is continuously repositioned during the performance, moving smoothly in the vertical and horizontal dimensions and also jumping to particular new positions. The four performers realize the work by interpreting the components of the score that are framed by four colour-coded planchets (circles). Rather than following defined pathways, the planchets move in 2-dimensions according to a set of behaviours [35]. Position data from the score and planchets was sent to a second networked computer, and used to process and spatialise the performers' audio via Stuart James' timbral spatialisation software [16]. The combination of movement of the score, behaviours of the planchets, the interpretations of graphical shapes by the performers and the processing and spatialisation define the formal structure of the work. The audience see the same portion of the score and the circle movement being read by the performers on a screen, and are therefore able experience a game-like expectation about where and how the score and parts will move and performer's response to various forms of graphical notation. The 2 dimensional movement and representation for the audience in *Talking Board* suggested the direction forward towards fully rhizomatic works.

3.1 *Ubahn c. 1985: the Rosenberg Variations* [2012]

In 2012 the first score to be developed entirely for the *Decibel Scoreplayer* [37] on networked iPads, *Ubahn c. 1985: the Rosenberg Variations* for string quintet, percussion, prerecorded voice-over and live audio processing was created by the author in collaboration with Jon Rose. Aaron Wyatt programmed the score in Xcode on the basis of a MaxMSP-based prototype. The work is based on Rose's story *Das ist KEIN Cello* [This is NO cello] from the book he published with Rainer Linz, *the pink violin* [1992]. The story concerns Rose's attempt to cross through Berlin's Checkpoint Charlie with a hand-customised "extended cello". Rose's pre-recorded narration of the story overlays much of the work.

In *Ubahn* the audience see a map of the Berlin Ubahn circa 1985 with the six performers represented by coloured circles the network: the "Audience View" (Fig. 2).

The performers, on the other hand, each see a zoomed in version of the map from the point of view of their particular 'train'/circle: the 'Performer View'. The scoreplayer maintains

synchronization between 'Audience view' and the 'Performer view'.

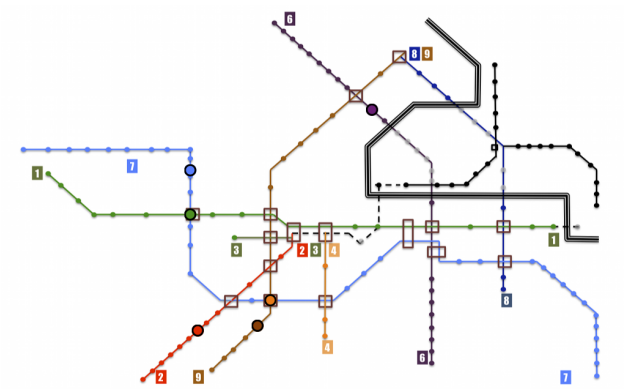

Figure 2. Audience view of rhizomatic pathways structure of *Ubahn c. 1985: the Rosenberg Variations.*

The train lines are represented as musical staves, upon which notation is inscribed. The exact point at which the performer initiates the material is pinpointed by a red dot in the centre of the screen. When the train arrives at a node/junction, it pauses and a fragment of musical material fills the inset box in the centre of their screen. This "junction" material is played in a more soloistic manner than the textural material that exists on the regular pathways. In this way, different instruments are brought to the fore at random by the journey of the trains across the network (Fig. 3). The problem of representing notation that is angled in a variety of directions was solved by auto-tilting the staves so that they always remain on the horizontal plane.

Stockhausen's *Zyklus* [1959] is an early attempt at solving the problem of horizontal left to right reading through the creation of notation that can be read in either direction and when inverted. Like *Zyklus*, the stave notation for *Ubahn* can be read from left to right or in reverse.

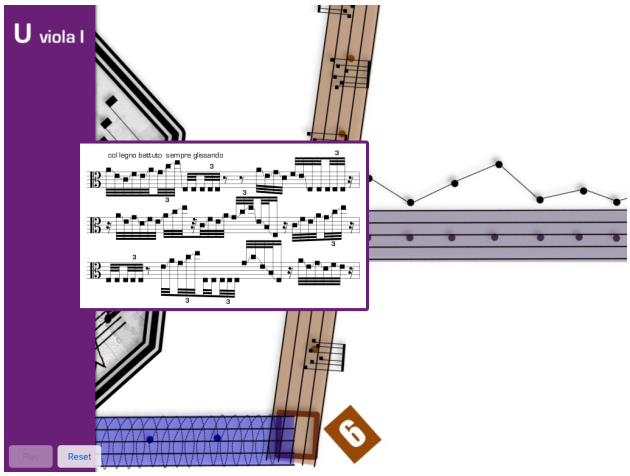

Figure 3. Viola 1 part displaying stave pathways with textural material and inset box with soloistic material from *Ubahn c. 1985: the Rosenberg Variations.*

The rhizomatic network in Ubahn is defined by an XML file containing a map of all the relevant pathway coordinates. An A* pathfinding algorithm [21] is employed after a specified time has passed to ensure that the duration of the work falls within prescribed limits.

Audio processing is conducted live by two musicians controlling a Max patch remotely via TouchOSC. This was necessary because OSC communication between the iPad Scoreplayer and an external computer had not yet been implemented. The audio processing patch allowed for control of the spoken word component (which was paused when players reached soloistic material), some simple manipulation of the sound live performers and the capturing and replay of samples of the live performance. The desire to directly link movements of the individual performers in the 2 dimensional plane to audio processing led to a return to the MaxMSP environment.

3.2 *The Last Years* [2012]

The Last Years used a score comprising a range of graphically notated symbols more defined morphological qualities than the score for *Talking Board*. Like *Talking Board*, the four performers realize the work by interpreting the notation that is framed by a planchet, however the trajectories of the planchets, while indeterminate, move along a predetermined pathways (Fig. 1).

The cartographical concept employed in *Ubahn* was expanded to include a third dimension: four layered scores that that cross-fade throughout the work's duration. Each layer comprises less detailed and less overtly semantic shapes. The model here was the variety of types of "map view" (satellite, terrain, hybrid etc) available in digital map applications (See Fig. 4). The transitions from layer to layer add an extra variable to the way in which the performers read the notation and consequently transform the musical material.

As the instruments proceed through the notation, their sounds are routed to a range and combination of audio processing strategies mapped to the same rhizomatic pathways (Fig. 4).

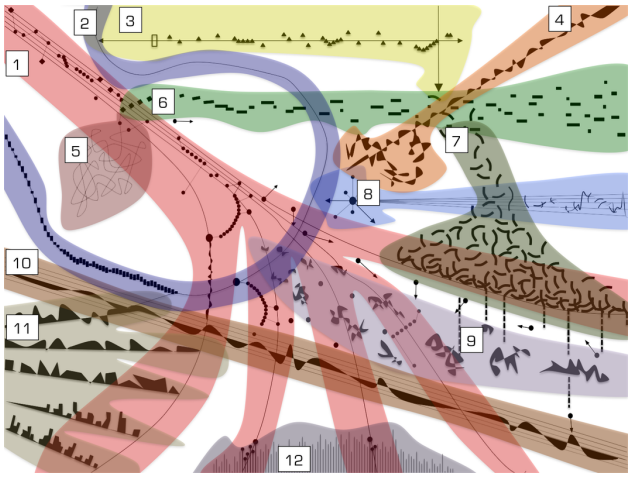

Figure 4. Audio processing strategies (marked in colours) in *The Last Years* are determined by the position of the planchets on the score.

The instruments' sounds and processed counterparts are diffused through four channels according to the spatial position of the instrumentalist's planchet on the score (Fig. 5).

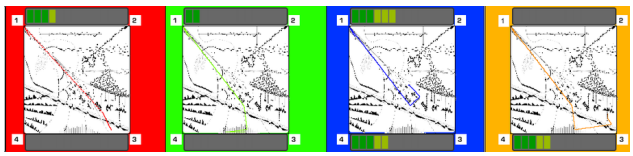

Figure 5. Quad processing and spatialisation patch for *The Last Years* (detail).

More semantically unambiguous notation (symbols that "look-like" traditional notation, Fig. 6) was used in this work to explore whether it was possible to generate a more defined and consequential structure than emerged from *Talking Board* in

which the performers were completely free to interpret the graphical content of the score. The recorded performances suggested that the notation successfully generated a more defined/composed surface to the work, however the number of instruments and the completely indeterminate movement through the rhizomatic notation, rendered an indistinct structure.

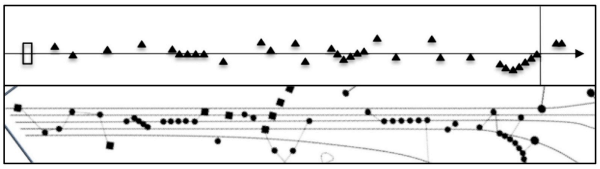

Figure 6. *The Last Years* uses notation that is more semantically unambiguous.

3.3 *Sacrificial Zones* [2014]

The exploration of the role of notation was continued in *Sacrificial Zones* through the use of a score comprising five layers each notated in a different manner. Medley and Haddad have proposed that visual representation occupies a continuum across which an image may be "iteratively reduced in fidelity from its referent" [23], ranging between photographic realism to pictograms and textual description. *Sacrificial Zones* explored the notions that an analogous continuum could be proposed for the visual representation of music, ranging through non-semantic graphical notation, semantic graphical notation, quasi-traditional notation, proportional notation and spectrographic representation.

The score was evolved from improvisations based on "readings" of the non-semantic notation, which were then transcribed into the other notational forms and assembled into the same rhizomatic structure (Fig. 7). The performance unfolds indeterminately along its rhizomatic pathways, and also cross-fades between the five notational paradigms.

In respect to the use of the planchet and approach to spatialisation and processing, *Sacrificial Zones* broadly follows the model of *The Last Years.* Experiments were undertaken to integrate the auto-tilting functions of employed in *Ubahn*, however it was found that the amount of processing necessary to move large images in 2-dimensions interfered with the ability to synchronise the movement of parts on multiple laptops.

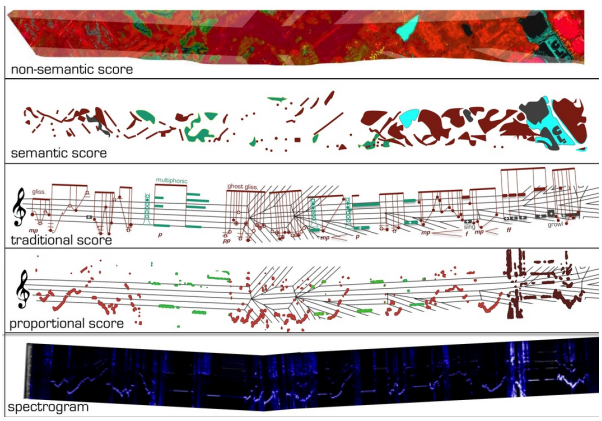

Figure 7. Forms of visual representation of music employed in *Sacrificial Zones*: non-semantic graphical notation, semantic graphical notation, traditional notation, proportional notation and spectrographic representation.

3.4 *detritus* [2015] and *trash vortex* [2015]

Early in 2015 OSC communication was implemented for the Decibel Scoreplayer [16] allowing for works combining the scoreplayer with synchronized audio processing and spatialisation on a networked computer. This re-opened the possibility for exploring rhizomatic scores with synchronized audio processing and for controlling the movements of the instruments in structurally significant ways.

detritus and *trash vortex* are both rhizomatic scores for three instruments exploring the idea of transforming notation by combining foreground and background layers. The scores have three layers - notation, pathways and background (Fig. 8). The central, white, pathways layer periodically crossfade, transforming the appearance of the notation to the performers by obscuring it with elements of the background layer (Fig. 10 and 11). This process is similar to that employed in Stockhausen's Variable Form [18] work *Refrain* [1959] in which a transparent plastic "refrain" is pinned into the centre of the score and can be moved to affect different parts of the score depending on its orientation.

Figure 8. Layered arrangement of Graphical score, Rhizomatic Path and Background Image Collage in *trash vortex.*

The scoreplayer in both works communicates with an audio processing patch in MaxMSP via OSC, reporting the current state of the pathways layer. Transitions of state result in changes in the audio processing of the instruments, mirroring the less defined nature of the notation. The scores are projected providing an overview for the audience that shows the current position of each player and illuminating the choices taken in each pathway (Fig. 9).

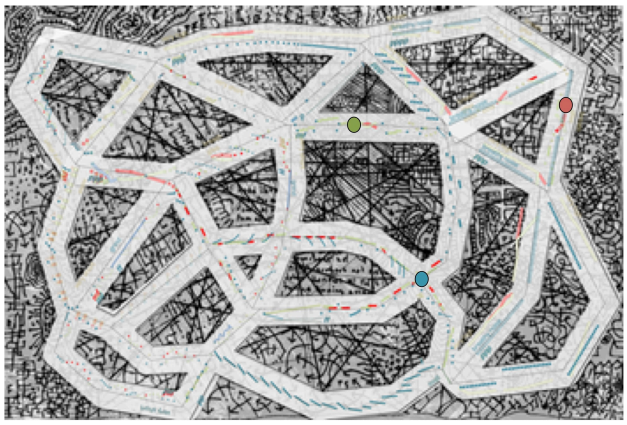

Figure 9. Rhizomatic Pathways in the "audience view" of *detritus* [2015].

Like *Ubahn,* a "performer view" displays a "zoomed-in" and always horizontal version of the score for the players (Fig. 10).

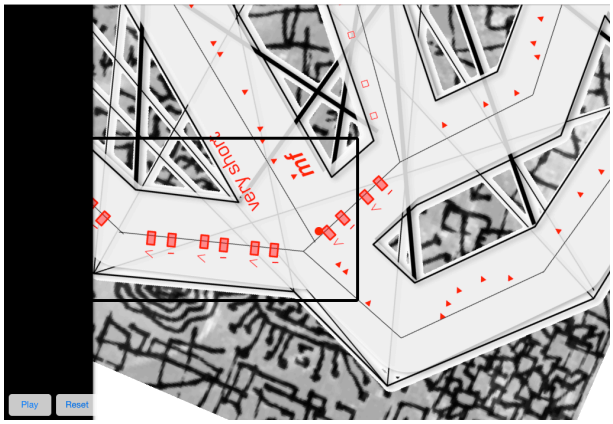

Figure 10. ***detritus*** **"performer view" (path faded in).**

The works differ in notational approach and formal structure (discussed in the next section). *detritus* employs semantic graphical notation: the score employs text instructions, and articulations, typical of traditional notation, however the use of note-stems was abandoned because they are not necessary given that duration is communicated by the movement of the scoreplayer itself (Fig. 9). *trash vortex* employs non-semantic graphical notation created from a collage of images of junk from the ocean gyres (Fig. 11).

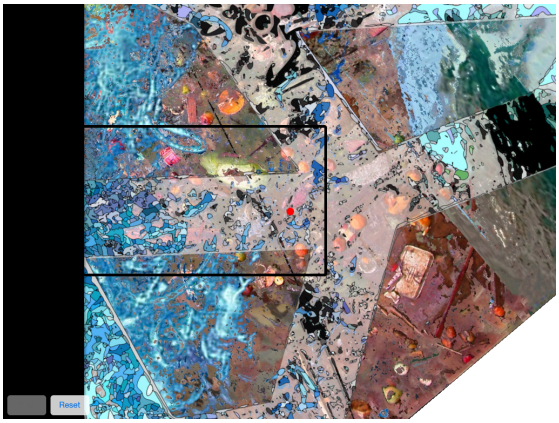

Figure 11. ***trash vortex*** **"performer view" (path faded out).**

4. RHIZOMATIC STRUCTURES

Although each of the works discussed utilizes a rhizomatic score comprising a network of connections, the formal structures that emerge in a performance derive from the manner in which the performers traverse the score.

In *The Last Years* and *Sacrificial Zones* the planchets were originally free to move in any available direction. This meant in effect that every point on the score was a node: the planchet could move forwards or backwards in the middle of a passage as well as onto any new passage at a node. While the repetition of material caused by the planchet moving back along the passage it had just completed had some interest, in performance it was discovered that it was more effective to restrict some of the freedom of choice. Instead of using the "random" object in MaxMSP to determine which path would be chosen at a node, the `urn` object was used with the result that choice would be restricted at each node to paths that had not yet been taken.

The formal structure of these works is the most fully Rhizomatic: the score is literally "open and connectable in all of its dimensions". While this is perhaps interesting as an end in itself, other means of rendering structure from the Rhizomatic score were also explored.

A number of notational paradigms were mentioned in the previous section. The approach to notation in these works assumes a continuum from greater ambiguity to greater specificity across the five paradigms: non-semantic graphical notation, semantic graphical notation, traditional notation, proportional notation and spectrographic representation. The relationship between the notation, the performer(s) and the audience is particularly significant in works that share the notation with the audience through projection. Because of its inherent openness, non-semantic notation arguably invites the audience to consider the process of interpretation that is being undertaken by the performer. It is proposed that notation of greater specificity may give rise to greater 'consequence' in terms of the perceived formal structure of these musical works, in that it allows for more precise repetition of varied sonic morphologies (pitches, durations, rhythms, phrases etc). These distinct morphologies, in turn, provide the listener with recognizable auditory signposts that contribute a structure for the work that is perceptible in the manner of traditional music.

In the works discussed, the audio processing strategies were employed to reinforce the sense of rhizomatic structure in the works. The approach fixed particular configurations of spectral manipulation, distortion, ring modulation, pitch shifting and delay to regions of the score allowing for greater sonic distinction between varied materials. More specific discussion of these processes can be found elsewhere [17, 31, 35, 36].

Ubahn is the most programmatic of the works discussed here and its structure mirrors this in a game-like manner. The individual parts are free to move around the map unless they reach the Alexanderplatz node at which point they are switched to the East German Ubahn system (the black lines in the top right hand corner of Fig. 12). Upon transfer to the "Eastern Block" their screen is replaced with a "Graffiti Score" (comprising elements of the East German national anthem overlaid with drawings and images by Jon Rose). The performers play the graffiti score as a piece of indeterminate graphic notation. When all players have reached East Berlin the graffiti score begins to peel away revealing a five part harmonization of the East German national anthem in traditional notation, which they perform to end the work.

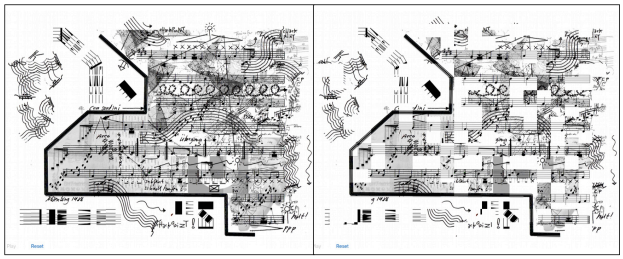

Figure 12. Graffiti score (left) and and peeling graffiti score (right) from Ubahn.

Ubahn then, is a concatenative structure [6] comprising a freely rhizomatic first section, an indeterminate graphic notation section and a final traditionally notated section. The rhizomatic section has an idiosyncratic form in the sense that the pathway materials are quiet and combine together as a background layer, while the nodal points contain soloistic material. This arrangement highlights the nodal points and provides a contrasting, indeterminate texture (Fig.13).

Figure 13. Schematic representation of the Concatenative structure of ***Ubahn c. 1985: the Rosenberg Variations.***

4.1 Rhizomatic refrain structure

detritus explores the "territorializing" [10] idea of the *refrain,* an element of rhizomatic structure also discussed by Deleuze and Guattari. They state that the refrain "organizes a limited space around a center in order to keep "the forces of chaos" outside as much as possible" [10]. In *detritus* the score always commences from the same point, a distinctive passage lasting about 10 seconds (Fig. 14). At the conclusion of this passage the pathways trifurcate and continue to progressively proliferate. The structure emerges as a consequence of the repetition of this process for different periods of time (between 19 and 145 seconds), allowing a variety of pathways to be charted.

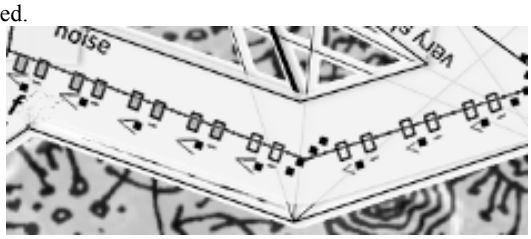

Figure 14. *detritus* "refrain" passage

In this way the consequence of the rhizomatic score structure can be emphasized through the exposition of diverse outcomes originating from the same starting point (Fig. 15). The use of a Refrain acts against what Deleuze and Guattari would call the 'deterritorializing' effect of indeterminate movement through the rhizomatic score structure.

Figure 15. Schematic representation of the Refrain formal structure of *detritus* [2015].

Each performer in detritus has separate parts (shown in colour in Fig. 15). The parts are horizontally (temporally) coordinated in the fashion typical of traditional music. This means that when the performers move together their parts are audibly more synchronized than when they are independent of one another. The semantic graphical score was assembled using rhythms and pitch contours from fragments of a traditionally notated ensemble piece, *cities sunk in endless slumber* [2012] for violin, clarinet and piano.

4.2 Rhizomatic Convergent Nodal Structure

trash vortex takes something of an inverse approach: each part eventually converges upon successive nodes in the rhizomatic score. As the pathways taken from one node to the next vary in duration, each player pauses once a node is reached, "hovering" there until all players have joined them. Tracking the trajectories of each player allows for electronic processing to reinforce the stasis of successive players through emphasis on spectral manipulation of their sound. This structure might be termed a 'Convergent Nodal' form, and is a unique implication of rhizomatic structure.

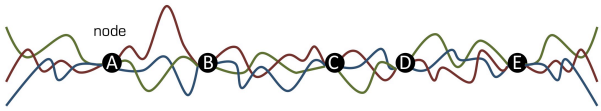

Figure 17. Schematic representation of the Convergent Nodal formal structure of *trash vortex* [2015].

5. CONCLUSION

The works discussed demonstrate a possible set of solutions to the performance of rhizomatic scores for acoustic instruments and electronics. A high priority in the development of this work was the ability to communicate the unique qualities of the rhizomatic concept both visually and aurally through employing linked notational material and distinguishable electronic processing and allowing the audience to follow choices made through projection of the rhizomatic score and the movements of the performers. The problem of coordinating performers and electronic manipulation of their sound in an indeterminate environment is resolved through the adoption of a computer coordinated performance model.

The five works also explore a number of more specific concerns: exploration of 2-dimensional space in the context of a musical score; representation of sound and notation; the adoption of cartographical features of digital maps in the context of the musical score and variation of musical material through transformation of the score.

The ability to communicate the unique qualities of the rhizomatic concept both visually and aurally has been crucial to the development of this work. The approach was to link notational material, live performers and distinguishable electronic processing and to allow the audience to follow choices made through projection of the rhizomatic score and the movements of the performers. It is argued that the synchronization of these elements in an indeterminate environment was made possible through the adoption of a computer coordinated performance model.

The limits of Deleuze and Guattari's Rhizome concept in the context of a musical score are probed, most specifically issues concerning connection and heterogeneity, the asignifying rupture, cartography and the refrain. It was suggested that restricting the number of possible connections and therefore reducing the indeterminacy of the potential outcomes, contributed to more coherent and intelligible structural outcomes. The refrain was proposed as a potential solution to the issue of revealing the diverse outcomes that can originate from the same starting point in the Rhizome. A structure based on the notion of parts converging upon nodes within the rhizome was also suggested.

There remain a number of significant challenges in the presentation of Rhizomatic works in the screenscore format. The works discussed are limited in a number of ways including the size of the ensemble (the largest work discussed here is a quartet). The scope and complexity of the scores employed could also be significantly enhanced: the scores discussed were all composed to accommodate a fairly proscribed rectangular page. trash vortex was originally envisaged as the final section of the scrolling score ...with the fishes... [2015], which would require the ability (not currently implemented) for the Decibel scoreplayer to accommodate nested score models (scrolling and rhizomatic in this case). Future development may allow for such transitions between linear and rhizomatic approaches to the musical score.

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