Circularity in Rhythmic Representation and Composition

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ABSTRACT

Cycle is a software tool for musical composition and improvisation that represents events along a circular timeline. In doing so, it breaks from the linear representational conventions of European Art music and modern Digital Audio Workstations. A user specifies time points on different layers, each of which corresponds to a particular sound. The layers are superimposed on a single circle, which allows a unique visual perspective on the relationships between musical voices given their geometric locations. Positions in-between quantizations are possible, which encourages experimentation with expressive timing and machine rhythms. User-selected transformations affect groups of notes, layers, and the pattern as a whole. Past and future states are also represented, synthesizing linear and cyclical notions of time. This paper will contemplate philosophical questions raised by circular rhythmic notation and will reflect on the ways in which the representational novelties and editing functions of *Cycle* have inspired creativity in musical composition.

Author Keywords

rhythm, composition, interface design, philosophy

CCS Concepts

•Applied computing → Sound and music computing; Performing arts; •Human-centered computing → Interactive systems and tools;

1. INTRODUCTION

Time is both linear and cyclical. In one sense we are perpetually moving forward, using knowledge gained in the past to progress towards our goals. At the same time, we periodically return to familiar states that define that which is central in our lives. This notion of centrality is psychologically fundamental; it is an abstract *image schema* that is formed from recurring physical experiences that empower us with a sense of orientation [13]. It gives us a point of reference relative to which we move away from and back to. It allows us to distinguish some states or places as more important than others. It emerges in our relationship to the world (e.g. sunrise), in our personal lives (e.g. home) and in our music (e.g. the tonic of a scale, the downbeat of a metric cycle). The question then becomes to what extent do our methods of representation in musical practice represent this core psychological phenomenon? How do these methods affect the compositional choices that we make?

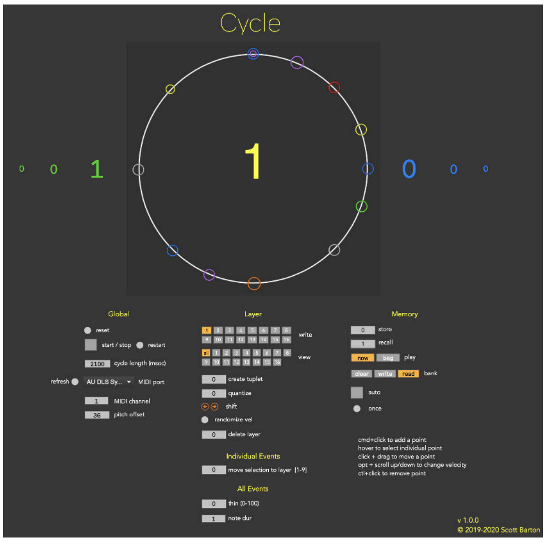

Figure 1: The user interface of *Cycle*

2. LINEAR AND CYCLICAL REPRESENTATION OF TIME

Linear representation of temporal events, as is found in notation of European Art music and DAW sequencers, adheres to a conception of time that shows a seamless past, present, and future in perfect proportions and clarity. It allows us to see the qualities and rates of change. It allows the development of ideas over periods of time that extend beyond the contents of our short-term memory. It facilitates gestures that correspond to image schema that involve motion, linkage, causation, paths and goals [13] by affording formation of contours within numerous musical aspects (e.g dynamics, tempo, energy, density).

In other ways, linear representation of time is incongruous with how we experience the present and preserve it in memory. Unlike the timeline in a typical DAW, the details of experiences become fuzzy, simplified or absent as time moves, and our expectations of the future reach out often only at arm's length. We are perpetually grounded in the present; our awareness provides us a center from which we depart and to which we return, helping us understand the world and our place within it. It is a kind of motion that is better aligned with the circle than with the line.

Time is continuous and multi-dimensional. In music, repeated patterns that are represented linearly are discontinuous. We depart from a location and move increasingly

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away from it. When we reach a point of maximal displacement, we teleport back to a disconnected beginning. Such is incongruous with music whose unyielding repetitions (e.g. EDM, minimalism) exude that which is flowing and seamless. In this kind of music, as in a circle, a beginning and an end are the same. As we depart from the beginning, we simultaneously and paradoxically move both away from and towards it. As we increasingly expect the beginning of the pattern to return, the distances between points and the origin decrease, unlike that seen along a single linear dimension. The latter shows time as flat: a distortion of its nature. In cyclical representation, multiple dimensions allow new kinds of geometries to emerge that distinguish intervals and patterns in new ways [10, 14].

3. MUSICAL PRACTICE

The idea of circular rhythmic representation has inspired musicians and musicologists since at least the 13th century [14], and has found particular traction in recent years. Many of these more recent efforts focus on rhythmic valuation, exploring ideas of perfect balance [9], well-formedness [10, 8], and the qualities that make a rhythm "good" [14]. They purport to find characteristic or normative aspects of rhythmic expression. As a composer I am inspired by such work, but I am also compelled to look for that which is evades or challenges convention; that which is weird but cool; that which reveals a path to new expressive territory. These desires have led me to the world of *machine rhythms*.

3.1 Machine Rhythms

As described in [1] *machine rhythms* are defined by a complexity that is made possible by (electro) mechanical means. This complexity is characterized by departure from the low-integer interval proportions that are typically found in musical notation (e.g. 1:1 or 2:1). It also is created by concatenation and division on multiple hierarchical levels (e.g. a 3.5-beat unit that is then divided into 7). While there is research that suggests we perpetually assimilate and contrast temporal intervals in the direction of small-integer ratios [5, 7], there is also evidence that shows that we deviate from simple ratios in rhythm production and perception [12, 6, 2]. Indeed, Dan Trueman's interest in developing the *Cyclotron* was to explore the Norwegian *telespringar*, whose rhythms are sometimes performed (by humans) in the proportions 39:33:28 [16]. These complex rhythms (of both human and machine type) typically have a lopsided character that stands in distinction to their symmetrical, balanced counterparts, yet they evoke a sense of groove. The identity of a machine rhythm is illuminated when it is looped, often requiring multiple iterations before it presents itself. The precision of mechanical performance can evoke rhythmic *qualia* that differ from those produced by both complex human-played rhythms as well as variations that are considered expressive timing. *Cycle* is a tool that allows composers to explore the possibilities of *machine rhythms*.

4. CIRCLE-BASED RHYTHM MACHINES

There are many of examples of machines that represent rhythms on circles from Raymond Scott's *Circle Machine* (1958) [4] to more recent efforts such as *Rhythm Necklace* [11], and *Sequence* [3]. While these examples boast a number of useful features, they are all limited in that timepoints are quantized to isochronous divisions of the cycle, and different cycles are not able to be superimposed on each other. The first limits the kinds of rhythmic configurations that can be produced (particularly *machine rhythms*) while the second limits a composer's ability to visualize the temporal relationships between events on different cycles.

XronoMorph is an application that is designed to explore rhythmic well-formedness and perfect balance through the use of different geometries [10]. A variety of different polygons can be chosen and oriented (they can be superimposed on each other) in a circle that is orbited by a playhead that sends MIDI events when vertices are encountered. These polygons can be shifted forward or backward either according to a grid (or not). A large number of presets can be saved and recalled, and there are controls for many parameters including sound source, panning, and volume. A unique feature is the ability to morph between rhythms.

The software also has limitations. The location and velocity of individual timepoints cannot be edited (there are only global randomize controls for both time and velocity). Further, individual timepoints cannot be deleted, thus one is bound by the chosen geometry (in some sense, this is the point of this particular approach). Rhythm is as much about space as it is about sound, thus the ability to create gaps is a fundamental aspect of rhythmic expression.

In all of the previous examples one struggles to realize gestures formed from smaller elements such as grace notes and percussion rudiments. Contours affecting dynamics and rate are similarly unattainable, particularly over short periods of time within the duration of a particular cycle.

Cyclotron [15, 16] is a circle-based interface that can generate a wide variety of rhythmic configurations, including ones that evade isochronous divisions of a cycle. Points originate at the center of a larger circle and extend outward to its circumference, creating *spokes*, the number of which is specifiable. Spokes may be quantized to isochronous divisions of the cycle or may be moved between such points, creating complex temporal interval ratios. The cap of each spoke can be adjusted, the size of which can control a specified parameter (such as gain). A phasor (playhead) moves around the circle at a specified rate and when it contacts a spoke, a control message is output (which could be mapped to pitch, for example). A unique feature of the interface is the ability to adjust spoke length (either freely or to quantized positions), which affects the probability of that spoke being played. Another compelling feature of the program is the ability to *warp* time, which allows the phasor (playhead) to move at irregular rates. Patterns may also be reversed, which moves each spoke symmetrically about a center axis.

As Trueman notes, the ability to warp time allows one to create rhythmic nuance and expressivity while using simple subdivisions of a cycle [16]. This feature is paralleled in the conventions of Western Art Music notation, where time can be controlled globally or locally (i.e. musical rate can be changed via subdivisions or tempo, or some combination of the two). The local and global also interact in our conceptualization of temporal relationships and characteristics when listening. The rubato encountered in a performance of Chopin involves both distinguishing the inequality in adjacent temporal intervals and apprehension of an emergent, organizing wave that ebbs and flows. The ability both to shift timepoints in minute intervals and to change the shape of a playhead's progression help in the effort to discover (or describe) complex rhythmic relationships.

Cyclotron also has limitations. By changing spoke length, notes are displaced from the reference circle. The proportions of visual and auditory intervals between timepoints no longer align, which undermines one of the key features of circular notation. The newer version of the program (2008) is restricted to a single instance of a cycle. Regarding accessibility, the requirement to either compile the program in Processing or utilize the command line may be intimidating to less-technical musicians.

None of the aforementioned examples address linear aspects of temporal perception, particularly in the form of past and future states. The design objectives of *Cycle* thus were to synthesize useful features found in these various tools as well as develop new ones that would encourage the exploration of *machine rhythms*, represent cyclical and linear aspects of time, and would be accessible to a broad group of musicians.

5. DESIGN

Cycle was designed and built starting in early 2019 in the software environment Max. The first iterations of the program featured numerous independent cycles that could be viewed, edited and played simultaneously. The advantages of this approach included visual clarity of each component cycle and independent control of cycle time / speed, which provided an easy way to create polytempic textures. The disadvantages of this approach were the difficulty in seeing the relationship between *timepoints* on different cycles and the relatively small size of multiple simultaneous *timecircles*. The program was re-written to feature all *timepoints* on a single *timecircle* and is described in the following sections.

5.1 Objectives

In order to create a tool capable of exploring a variety of rhythms (including those of *machinic* qualities, the following design objectives were established, which enable a user to:

1. locate points manually or automatically around a circle according to isochronous divisions or their intermediaries.

2. create various layers that are superimposed upon each other so that global and local relationships can be perceived.

3. transform groups of notes, including selections, layers and the pattern as a whole.

4. store and recall a library of patterns that includes both custom and well-known rhythms.

5. view past and future states of the system in order to better attend to linear aspects of time.

6. interface with conventional music software to provide accessibility to a wide group of musicians.

5.2 Features

5.2.1 Timepoints

Cycle (figure 1) uses circular representations of musical time on which one may superimpose rhythmic patterns. *Timepoints* can be created either by manually clicking on the *timecircle* (the large white circle in the background) or by entering a value in the *tuplet* box, which will divide the cycle (specified in msec) into isochronous *timepoints*. *Timepoints* can be selected, moved, and removed either individually or in groups. When started, a green playhead orbits the *timecircle* and when it reaches a *timepoint*, it outputs a note and velocity pair in the form of a MIDI message. The velocity of the note corresponds to the size of the *timepoint*, which is adjustable. The pitch is determined by the associated layer.

5.2.2 Layers

One of the primary motivations of *Cycle* was to develop an interface for composing rhythms that would make evident not only the specifics of a particular element but also the relationships of that element to others in the pattern (and the pattern as a whole). The approach here uses layers that are visually superimposed on each other. *Timepoints* in each layer output a distinct MIDI pitch thus each layer corresponds to a particular sound. The *focus* section allows one to view individual layers or all layers together. The *write* section specifies the layer that edits will apply to. By separating *focus* and *write* controls, one can work on a layer either in isolation or in the context of all layers together. Individual layers can be deleted, and a selected note can be moved to any other layer, which proves to be a powerful orchestrational tool.

5.2.3 Transformations

Transformations allow the characteristics of groups of notes to be affected with a single command. The positions of *timepoints* within note groups can be quantized to a desired cycle division or can be shifted backward or forward in time as a layer. *Thin* deletes the percentage of *timepoints* specified (at random) and *Randomize Vel* changes the velocity of each *timepoint* in the selected layer by a random amount.

5.2.4 Playback and Storage

Playback is controlled by a toggle and the speed of the playhead's rotation is defined by the user. Patterns can be stored and recalled. System states are stored, manipulated and recalled using `coll` objects and dictionaries.

5.2.5 Past, Present and Future

A novel feature of *Cycle* is its representation of patterns that have been played in the recent past and ones that are to be played in the near future. After a pattern has played, its preset number will appear immediately to the left of the *timecycle*. Each subsequent cycle shifts the sequence of previously played cycles further to the left. There are a limited number of slots that loosely correspond to the limits of short-term memory. Regarding the future, a small number of patterns can be queued in boxes to the right that are shifted (either manually or automatically) towards and into the current *timecycle* with each cycle repetition. While the pattern that is being played is visually primary, representing our grounding in the present, these additions embrace linear notions of time, which invite the development of expansive sequences and gestures.

5.2.6 Accessibility

Preset storage and recall can be mapped to external MIDI controllers (grid interfaces are particularly useful for this purpose). The *now / beg* buttons determine whether a preset is recalled immediately or at the beginning of a cycle. Notes are sent as standard MIDI messages, enabling the software to interface with a variety of musical devices.

6. MUSICAL APPLICATIONS

I used *Cycle* in the composition and performance of a number of musical works including *Machine Rhythm Study No. 1, No. 2* and *No. 3*. The features of the program influenced my musical choices in a number of meaningful ways. Having all timepoints superimposed on a single timeline enhanced my understanding of the relationships between individual and groups of elements. It gave me a holistic picture of accent patterns and global aspects such as density. More complex patterns can result in crowded representations, but this is a problem which the ability to toggle focus between a particular layer and the whole ameliorates. In traditional notation and in common DAWs, layers are represented in the form of stacked rows. This forces a viewer to scan between and reconcile events on multiple lines at once. As a result, notes are separated by a variety of both horizontal and vertical distances. Increasing the vertical distance between events makes the evaluation of horizontal relationships more difficult, thus creating a distorted picture of the temporal relationships within a rhythmic pattern (this also can be an issue with *Cyclotron* if spoke distances significantly vary). The difference is extreme with large numbers of rows, but noticeable with even smaller numbers. In *Cycle*, all events are oriented relative to one circle, which avoids these vertical distortions.

The lack of quantized gridlines is liberating. The latter are idealizations of correctness; Platonic Forms to which we are magnetically and neurotically attracted. Of course, quantized values are often useful, and *Cycle* is capable of such adjustments. The difference between *Cycle* and linear systems is that the choice to quantize within Cycle is motivated by auditory evaluations and not visual ones. In the piano roll of a conventional DAW, seeing note-blocks scattered around precise gridlines reminds us of our temporal imprecision as human performers and engenders doubt concerning the rhythmic correctness of our phrase. Many DAW's allow gridlines to be turned off, but the user knows they are always available and are readily resorted to in such moments of incertitude. Turning off the gridlines in a typical piano roll of a DAW evokes a feeling of disorientation rather than liberation. Part of the reason for this is that there is no common reference for note events. The *timecircle* in *Cycle* purports to address that issue.

While *Cycle* is fundamentally a tool for generating rhythms, its use inspired me to think about pitch sequences and relationships in new kinds of ways. In *Machine Rhythm Study No. 3*, all events in a cycle were generated by sequences made in *Cycle*. Each sequence was first composed with percussion, and then was mapped to different pitched instruments. Thinning and transposing algorithms were then applied to each of the instruments to create variety in harmony, timbre and register. The initial rhythmic sequence thus was a temporal template whose slots could be filled by myriad sounds. The ease of mapping layers to different sounds facilitated this approach. This was a new method of composing for me, which inspired my creativity and resulted in musical textures that I otherwise wouldn't have made.

Cycle is simple and flexible enough to be used in improvisational settings. Performance of the aforementioned *Machine Rhythm Studies* involves sequencing and alteration of patterns in real-time. Mapping controls such as preset numbers, quantization, isochronous generation, and note thinning to generic MIDI controls allows a performer to generate, transform and concatenate musical ideas in an easy and quick way. This mapping (and the use of the interface in general) does not require sophisticated technical knowledge, therefore the tool is accessible to a wide variety of musicians.

7. FUTURE DIRECTIONS

There are a number of areas in which *Cycle* can be improved or enhanced. Developing the program as a Max for Live device and / or plugin would increase its accessibility, particularly for those musicians who are most comfortable in the realm of DAW's. Currently, there is a single playhead that rotates around the *timecircle*. In the future, multiple playheads could be present so that each layer could run according to its own time scale, or a single global time scale may be shared between all instances, allowing them to be synchronized. This would enable the polytempic textures that were attainable in the early versions of the program. More global transformations such as mirroring a sequence about an axis could be incorporated. In practice, Dan Trueman writes about the use of Cyclotron as a metronome that can help guide performers in the articulation of unusual or complex rhythms [16]. This idea is inspiring. *Cycle* and musical works are available at (`scottbarton.info`).

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