

Circular Rhythm Machine: A Tangible Pattern Synthesizer

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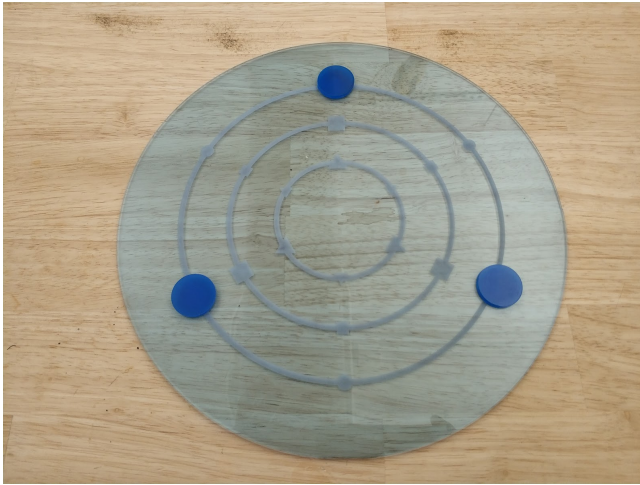


Figure 1. *Circular Rhythm Machine* play mat, with three tokens on the outermost ring, from the user's perspective.

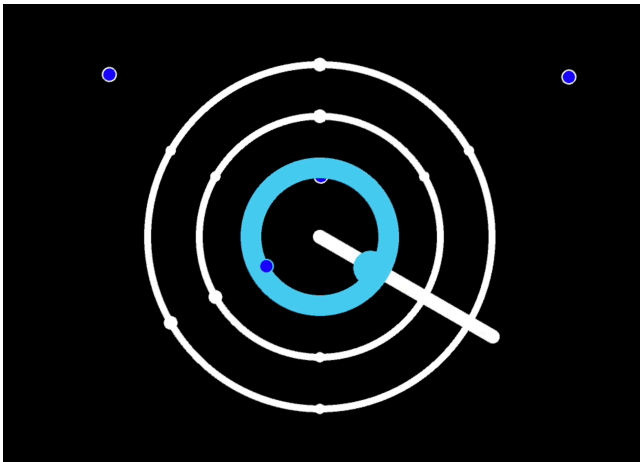


Figure 2. *Circular Rhythm Machine* projected image. The innermost ring is triggered due to a token.

ABSTRACT

Music captivates audiences through making and breaking auditory patterns, while mathematics reveals those patterns. *Circular Rhythm Machine* is a tangible rhythm synthesizer that is designed as an interactive museum installation, focusing on rhythm creation through hands-on placement of sound tokens on a play area. Akin to the moving hands of a clock, the needle sweeps through the play area, detects the sound tokens, and produces one of three drum sounds, depending on location within the play area. The participant, through hands-on play and experimentation, is able to create and edit rhythms in real-time. Designed for pre-teens, the goal is to encourage pattern deconstruction, prediction and creation using rhythms in a spatial, circular format.

Author Keywords

Patterns, tangible interface, rhythm synthesizer, play

CSS Concepts

• **Human-centered computing ~ Human computer interaction (HCI)**; Mixed / Augmented Reality; Sound based Input/Output; Interactive Learning Environments; Adolescents

INTRODUCTION

Music and mathematics are inextricably linked; indeed, music consists of manifestations of patterns, and mathematics is the study of patterns. Elements of music such as counting, rhythm, scales, pitch, notation have mathematical underpinnings and relationships, with combinations of notes and rhythms yielding interesting patterns [1].

Children have been surrounded by such musical patterns from a young age. Geist et al. [2] detail how a child from infancy is exposed to musical patterns such as spatial reasoning, sequencing, patterning, counting in songs in several classroom and caretaker environments, and “a degree of pleasurable intensity, promote the fun of learning and allow the child to be an active participant”; Cox [3] observes that songs are “built around growing patterns and repeating patterns”. In Rauscher’s et al. [4] study of middle and high school students who consistently learn musical instruments, there is a significant improvement of math proficiency over those who do not. Math lessons Integrated with music have not only resulted in more positive dispositions towards math in elementary school, but also improved achievement due to

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increased opportunities to understand and apply mathematical concepts [5].

In particular, rhythms have been extensively studied for its correlations to learning. Bautista and Roth [6] posit that rhythm is embodied and used for mathematical cognition; tapping to beats have been studied to correlate attention, temporal precision and reading capabilities [7]. Sakai et al. [8] demonstrated that rhythm plays a key role in the learning of sequential movements by chunking into smaller sequences. Miendlarzewska & Trost, based on a literature review of recent research on the cognitive effects of music, recommends rhythmic entrainment (aligning produced behavior to external beats) as a means to develop executive functions and other far transfer effects [9].

How will the revealing of rhythmic patterns benefit the young math and music learner? With the pre-teen and young-at-heart in mind, *Circular Rhythm Machine* aims to make rhythm creation not only audible but also tangible and visual, allowing more senses to be engaged for the discovery and creation of rhythmic patterns. Akin to a tangible touch table, the synthesizer encourages interaction without the connotations that sliders, knobs and buttons bring.

Circular Rhythm Machine eschews from an overly verbose user interface, simplifying the visual cues to just the needle moving clockwise; a set of tokens, in three shapes, one for each sound; a circular play mat with three concentric printed rings, each corresponding to a sound (bass drum, snare drum, hi hat); three colors to indicate triggering of sounds, one for each ring as the tokens are placed on it. Markings are printed on the three concentric rings to create the spaces where beats on 3/4- and 6/8-time signatures would be.

RELATED WORK

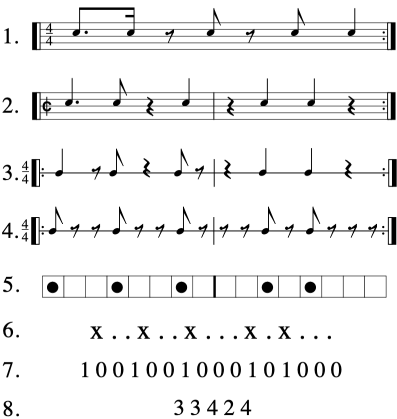


Figure 3. Typical musical notations to represent clave Son rhythm [11].

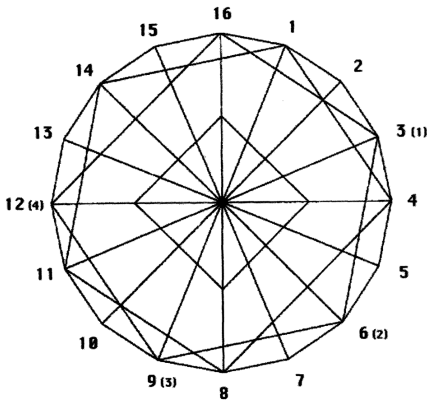


Figure 4. McLachlan's 16-element array [10].

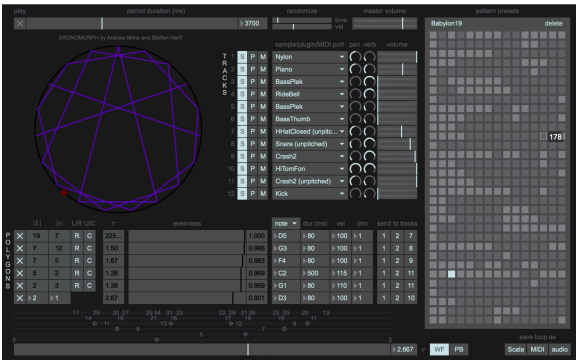


Figure 5. Xronomorph's interface [13].

To accomplish foster a great spatial-temporal link between the tokens and the rhythm pattern, *Circular Rhythm Machine* adopts a cyclic array to represent repetitive rhythmic structures. This is similar to McLachlan's [10] representation; used to illustrate, compare and contrast several beat patterns in Toussaint's studies [11], [12]; used as a tool (Xronomorph) to explore perfectly balanced rhythms and well-formed rhythms [13], and for teaching purposes [14]. Varney had a similar model in his wheel [15]; Vo had implemented this wheel in an interactive explainer [16].

More relevant to educational purposes, NYU Music Experience Design Lab's (MusEDLab) Groove Pizza [17] is a circular rhythm app for music creation and learning. This implementation also provides the Time Unit Box System developed by Philip Harland, as an alternative to Western sheet music notation.

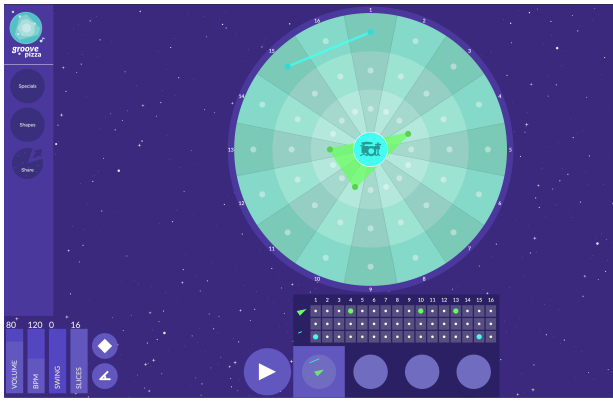


Figure 6. Groove Pizza's interface [13].

On the commercial front, Future Retro's Revolution synthesizer [18] also visualizes beats in a cyclical format using hardware and LEDs. Loopesque [19] is an app designed for the iPad targeted at prosumer music creators, to be used in studios or at live events.

IMPLEMENTATION

Circular Rhythm Machine consists of three parts: the play area, consisting of the play mat, tokens and an external webcam; the processing machine, in this case a Macbook Pro running Processing; and the connected visual audio devices, including a projector and speakers. The webcam can be mounted against the wall or from the ceiling.



Figure 7. *Circular Rhythm Machine*'s typical setup, with video capture device, play mat, tokens and processing machine.

During set up, the setup mode is displayed, which allows several perimeters to be adjusted based on the lighting conditions. This includes adjusting for contrast between tokens and the play mat, thresholding for blob size and pixel values.

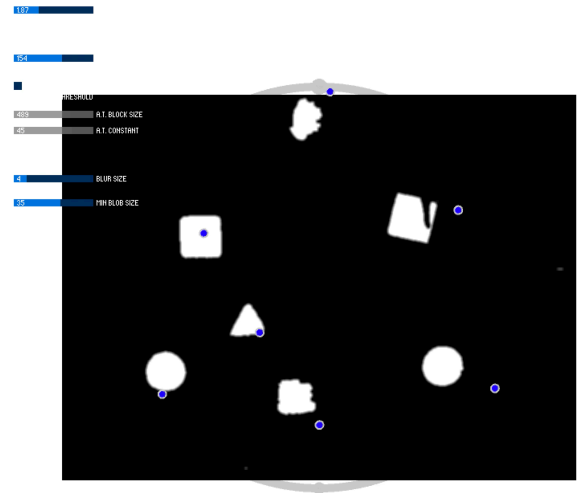


Figure 8. *Circular Rhythm Machine*'s calibration mode, to align the filtered and inverted capture image with the display.

During play mode, the user places tokens on the play mat, the webcam captures the video feed of the play area. Filtering is done using the OpenCV Processing library, followed by contour detection, blob detection, which eventually gives the screen coordinates of all the tokens in the capture area (represented on the screen as a blue circle). Once the needle intersects any of the tracked points, the corresponding sound clip is played. Each of the rings produce a different sound, allowing for exploration of rhythms in one sound alone, or as a composition of sounds. The tokens can be placed anywhere, and sounds will be triggered anywhere along the circumference of the rings, though the printed markings serve as scaffolds for the beginner.

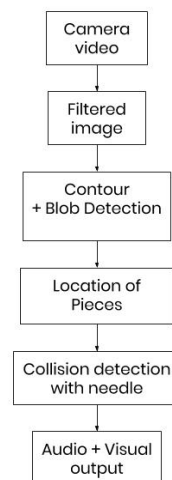


Figure 9. Flow of data and stages of processing data.

VIDEO LINK

The video can be found here: <https://vimeo.com/380160857>

FUTURE WORK

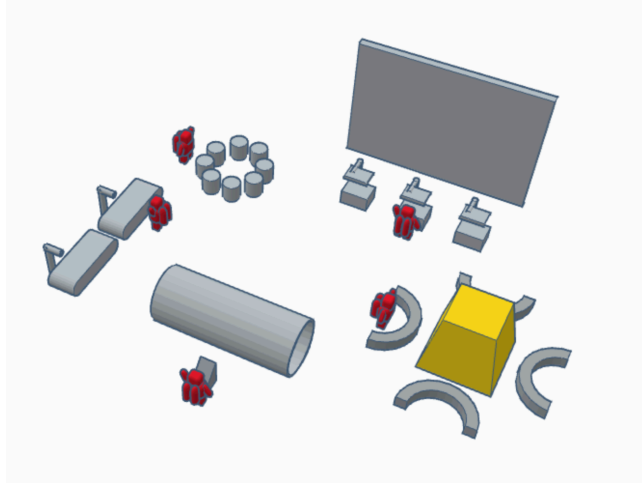


Figure 10. Mathemusical play space in a museum.

Circular Rhythm Machine exists as an installation that invites exploration into a single aspect of math in music. For future work, different aspects of math in music can be explored, ranging from patterns in Western compositions (e.g. fractals and symmetries) to frequencies in diatonic scale. The goal is to create a mathemusical play space which encourages hands-on exploration and creation of music using math and music theory principles.

CONCLUSION

Circular Rhythm Machine is presented as an interactive tangible rhythm synthesizer, aimed at pre-teens who can explore rhythms using a simple interface. This museum installation encourages exploration of rhythms and patterns of rhythms, providing feedback in real time.

With only some user testing done, this version of the *Circular Rhythm Machine* stands as the first iteration to explore the possible learning affordances of such a tangible synthesizer tool.

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