RhythmTable: A Tangible Interface for Cyclic Rhythm Sequencing

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Abstract

Drum sequencer interfaces commonly rely on linear grids that enforce a quantised timeline logic. This linear representation can make it less intuitive to engage with rhythmic structures such as the cyclic Taala systems of Indian classical music and other polyrhythmic frameworks. We introduce RhythmTable, a tangible tabletop token-based interface that represents rhythm through a circular spatial paradigm. By mapping time to a continuous rotating playhead around a circle, RhythmTable translates temporal sequences into spatial geometries where rhythmic events are embodied through the placement of physical tokens. The system integrates vision-based token tracking using a custom-trained object detection model with tactile hardware controls, including a tempo knob, jog wheel, sample-trigger buttons, and an LED-based playhead. Conceived as an interactive exhibit for a public science centre, RhythmTable supports shared, hands-on exploration of rhythm, where co-located participants can create, learn, experiment, and perform rhythmic structures together.

Keywords

Tangible User Interfaces, Musical Interface, Rhythm Sequencer, Collaborative Embodied Interaction, Computer Vision

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1 Introduction

Linear step-based sequencing has become the dominant paradigm in Digital Musical Instruments and digital audio workstations [14, 16], discretising musical time into indexed cells along a horizontal timeline. While effective for indexed workflows, linear timelines foreground progression across discrete positions rather than cyclical recurrence. In musical traditions where the rhythmic cycle is understood as a continuous return rather than a sequence with separate start and end points—such as the Taala systems of Indian classical music—this representation is at odds with how rhythm is internally structured [2, 18].

We introduce *RhythmTable*, a tangible tabletop interface that maps rhythmic time to a continuous circular loop. Users place physical tokens on an 86 cm circular grid; the angular position of each token determines its trigger time within the cycle, and concentric rings support layered rhythmic subdivisions. The system combines vision-based token tracking (a custom-trained YOLOv11 model) with low-latency tactile controls—a tempo knob, a jog wheel, sample-trigger buttons, and an LED playhead.

Conceived as an interactive exhibit for a public science centre, RhythmTable positions rhythm-making as a shared, inquiry-based practice. This paper contributes (i) a tangible cyclic-rhythm interface grounded in Taala-based temporal logic, (ii) a spatial-geometric representation of rhythmic subdivision implemented through tangible interaction, and (iii) a hybrid hardware architecture supporting multi-participant exploration in a public exhibit context.

2 Related Work

Tangible tabletop interfaces have long explored alternatives to screen-based interaction. The reacTable demonstrated collaborative object-based manipulation [9], Audiopad mapped tagged objects to synthesis parameters [12], and BeatBearing introduced physical tokens for rhythmic sequencing [1]. Foundational TUI research established the conceptual basis [7] and subsequent work has examined how tangible affordances support social and embodied interaction in shared physical space [3, 6]. A complementary perspective treats musical instruments as epistemic tools: designed artefacts whose material structure shapes how performers reason about musical ideas, not merely how those ideas are expressed [10]. This view motivates an interface in which the spatial structure of the surface is itself the rhythmic representation.

Several systems have specifically investigated radial or rotating paradigms. The Circular Optical Object Locator (COOL) [5]

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established a platter-based interface using overhead vision tracking; scoreTable* [8] and Radear [4] employed scanning playheads or physical arms to trigger events based on token coordinates. Multi-user circular instruments such as Blaine's Jam-O-Drum further explored collaborative rhythmic interaction in public-installation contexts.

Cyclic and circular metaphors also have long histories in commercial and historical instruments. Mobile applications such as Patterning, Loopseque, and Figure [15] prioritise accessible beat creation; Playtronica's Orbita [13] adopts a turntable-style form factor. Earlier mechanical antecedents include Raymond Scott's Circle Machine, and early Wurlitzer drum machines—all of which used cyclic geometry to organise rhythmic events.

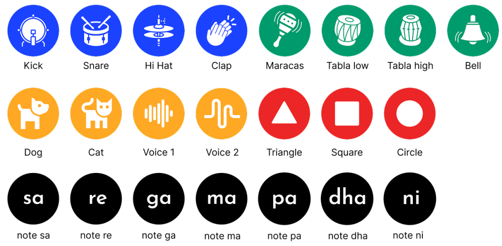
RhythmTable extends this lineage in four respects. First, cyclical time is treated as the primary representational commitment rather than a layout choice, with subdivisions made visible as overlapping polygons. Second, the system is designed explicitly at exhibit scale (circular tabletop with no fixed front-facing position) to support co-located, multi-participant interaction with strangers. Third, the interface is grounded in the cyclic temporal logic of Indian Taala, with token placements mapped to angular positions within the Avartan and concentric rings used to layer Gati subdivisions. Fourth, token iconography is designed for immediate first-use comprehension: each token's visual identity directly signals its sonic role, allowing participants in a public exhibit to pick one up and use without special instructions. The same iconography serves as the visual feature recognised by the vision model.

3 Cyclic Time and Geometric Subdivision

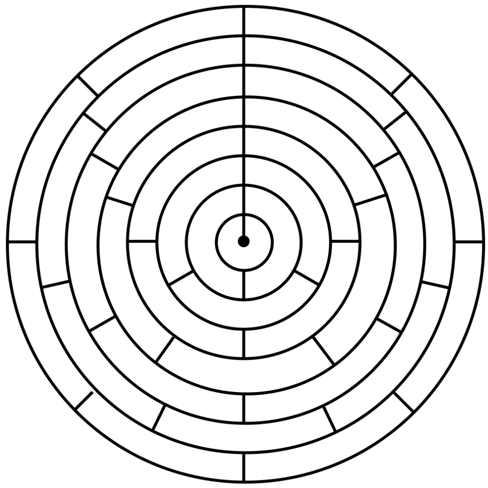
Linear sequencer notation typically obscures the inherent periodicity of musical rhythm. Toussaint's geometric analysis demonstrates that many traditional world rhythms can be understood as pulse distributions over a cyclic structure, where timelines projected onto a circle appear as polygons or rotational symmetries [18]. RhythmTable adopts this paradigm: rhythmic patterns are perceived as unified closed shapes rather than isolated events along a line.

This cyclic conception is central to the *Taala* system of Indian classical music—the rhythmic framework that governs a composition [2, 17]. Each Taala is organised as an *Avartan* (a complete recurring cycle), whose first beat—the *Sam*—functions simultaneously as origin and resolution. The *Gati* determines the cycle's internal subdivision: 3-pulse (Tisra) corresponds to an equilateral triangle, 4-pulse (Chatusra) to a square, 5-pulse (Khanda) to a pentagon, and 7-pulse (Misra) to a heptagon (Table 1). For brevity we refer to subdivisions by their pulse counts in the remainder of the paper.

Linear sequencing bifurcates the cycle's start and end into separate indexed positions; users must mentally bridge these to maintain continuity. RhythmTable's circular topology unifies start and end at 0°, making the Sam visually anticipable. Concentric rings allow multiple subdivisions to be layered simultaneously, so polyrhythms emerge as visual interference patterns between overlapping polygons. Users can construct a 3-against-4 polyrhythm by aligning a triangle on one ring and a square on another, bypassing explicit ratio calculation in favour of geometric alignment.



(a) Physical token library



(b) Circular grid structure

Figure 1: Physical interface elements: (a) unique tokens for identification and (b) circular grid showing divisions for timing structures.

4 System Design

4.1 Physical Interface and Tokens

The interface is a circular acrylic tabletop, 86 cm in diameter, with a printed radial grid showing common rhythmic divisions (2 through 9) arranged concentrically (Figure 1). The printed rings serve as visual guides but do not constrain placement; tokens may be positioned at any angular coordinate. Early observers occasionally interpreted the rings as discrete slots, suggesting that future iterations may benefit from softer or more clearly continuous visual cues.

We designed an initial set of 22 passive printed tokens differentiated by colour and iconography, grouped into four sonic categories: percussion samples (Western drum kits and global percussion), natural sounds (animal and human vocalisations), blank tokens for real-time sampling, and *Swara* tokens labelled with Indian solfège syllables (Sa, Re, Ga, Ma, Pa, Dha, Ni). The angular position θ of each token determines its temporal placement within the 0–360° playback cycle. Tokens are passive printed markers without embedded electronics, ensuring durability and low maintenance in a public exhibit context.

4.2 Vision-Based Token Detection

An overhead 4K camera mounted approximately 120 cm above the tabletop captures a top-down view of the interaction area (Figure 3). The video feed is cropped to a 1024×1024 region of

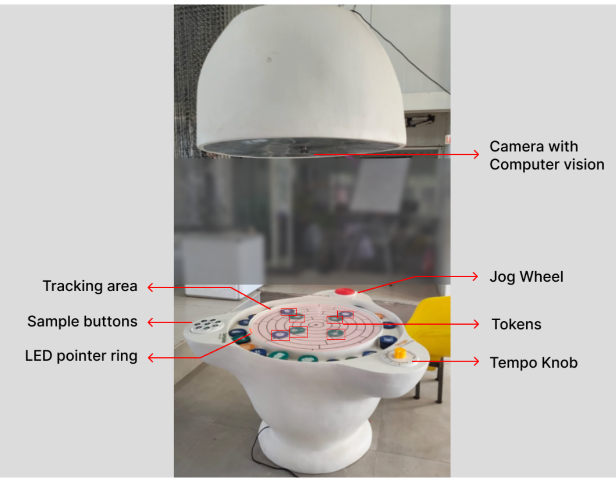


Figure 2: The overall setup of RhythmTable, showing the circular interface with tokens placed across concentric rings.

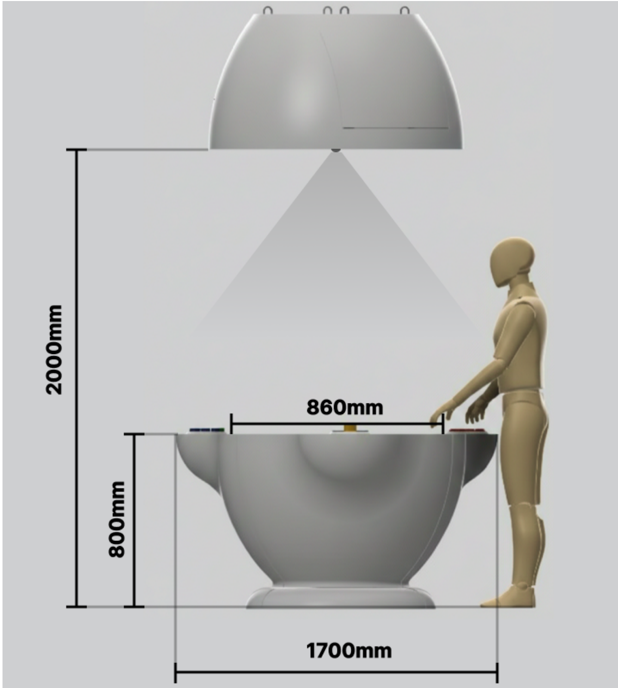


Figure 3: Side-view: RhythmTable setup with user model next to tabletop interface and overhead structure for tracking

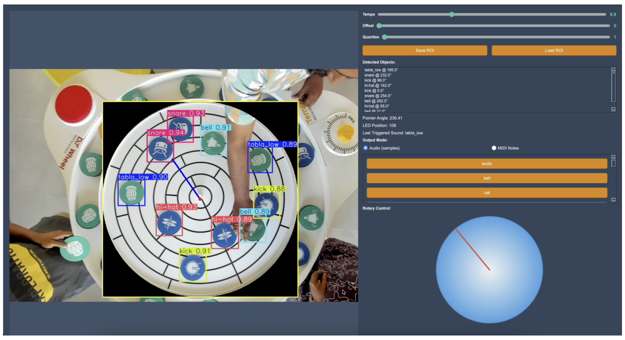


Figure 4: Software interface displaying the live camera feed with real-time object detection, virtual playhead position, and tempo controls.

interest encompassing the circular grid. We employ a custom-trained YOLOv11 object detection model [19] trained on roughly 1,000 annotated images. The training set deliberately mixes natural and artificial lighting, multiple token rotations, and partial occlusions to ensure robust detection in unpredictable exhibit environments. The model identifies each token's unique ID and its angular coordinate θ relative to the table centre.

A Python application serves as the central processing engine, calculating token angular positions, maintaining a continuous virtual playback loop spanning 0° to 360°, and triggering audio samples when the playhead crosses a token's position (Figure 4). The vision system operates continuously, allowing performers to dynamically add, remove, or relocate tokens during a session.

4.3 Hybrid Embedded Architecture

A challenge in vision-based instruments is the inherent latency of frame processing. To preserve the "intimacy of control" [20], we implemented a distributed architecture that separates tactile input from visual feedback (Figure 5). Two ESP32 microcontrollers communicate with the central processing unit over a dedicated offline Wi-Fi network. A tactile controller handles a tempo potentiometer, a rotary jog wheel, and arcade-style sample-trigger buttons, transmitting input via Open Sound Control (OSC). A second ESP32 receives high-frequency OSC updates of the playhead position and drives a perimeter ring of WS2812B LEDs that acts as the rotating playhead. Vision latency does not affect rhythmic timing directly: tokens are detected ahead of the rotating playhead, and audio is triggered at the moment the playhead crosses each token's angular position rather than at the moment of detection. Tactile inputs operate independently of the vision pipeline and reach the audio engine in near-real time over OSC, preserving responsiveness for tempo changes, scrubbing, and sample triggering.

5 Interaction

Interaction is designed to be non-modal: there is no distinction between visualising, composing, and performing. A user picks a token from the side library (iconography indicates the associated sound), places it on the tabletop, and hears the corresponding sample triggered when the rotating LED playhead crosses its angular position. Tokens may be slid, repositioned, or removed at any time. Tangible controllers (Figure 6) provide real-time modulation: a tempo potentiometer, a jog wheel for timeline scrubbing and reverse playback, and eight arcade-style sample-trigger buttons.

The angular grid is non-quantised: tokens trigger at the exact angle they occupy, supporting expressive placement and improvised polyrhythms. The software interface includes an optional quantisation parameter that snaps trigger angles to the nearest division of a chosen subdivision count (2 through 9), accommodating users who wish to construct precisely pulse-aligned patterns. Switching between continuous and quantised modes preserves the circular angular representation while supporting both expressive placement and structured rhythmic composition.

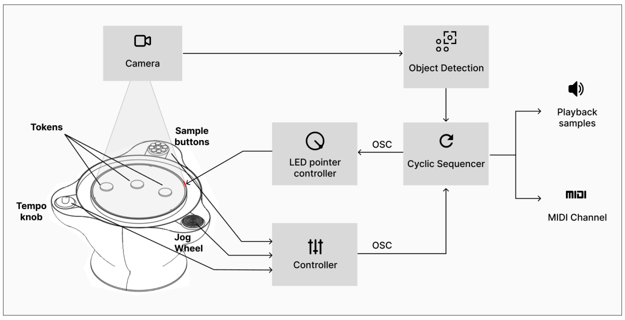


Figure 5: System architecture: spatial detection and time-critical feedback (controllers and LEDs) connected to a cyclic sequencer.

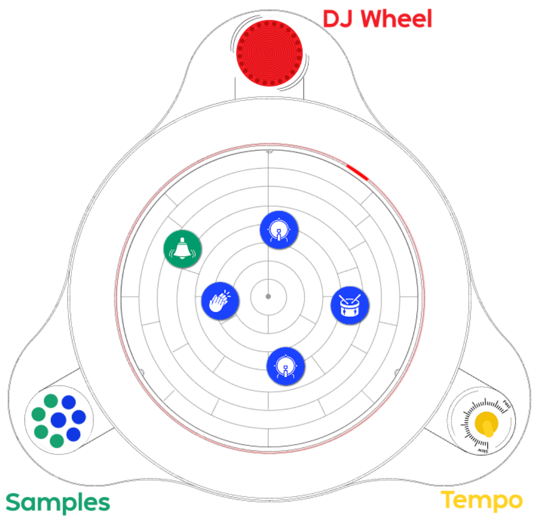


Figure 6: Top-down illustration of the physical controls: jog wheel, tempo knob, sample-trigger buttons, and the central circular grid with tokens.

Figure 7: A formative session showing multiple users interacting with RhythmTable from different positions around the table.

6 Public Exhibit Setting

The large circular form factor is due to the public-exhibit context. Removing a fixed front-facing position invites participants to enter from any angle, and the surface affords simultaneous use by three to five people (Figure 7). Rhythmic placement emerges through interpersonal coordination—tokens are physically passed, repositioned, and renegotiated. In formative sessions we observed groups of strangers, including children, families, and adults with no shared musical training, building rhythms together within minutes, often coordinating verbally as they aligned tokens into recognisable polygonal shapes. RhythmTable thereby positions rhythm-making as a shared, inquiry-based community practice rather than an individual compositional task.

7 Formative Observations

We conducted informal sessions with approximately 40 participants during a two-week exhibit deployment. Participants—a mix of musicians and non-musicians—engaged for 5–10 minutes following a brief introduction on interaction. We observed a consistent trajectory from open-ended placement to structural construction: novices frequently aligned tokens into visually symmetrical configurations without explicit ratio calculation, and several attempted to recreate patterns from familiar music. A recurring pattern across groups was the discovery of polyrhythmic interest by accident: participants placing tokens would notice a multi-layered rhythm and then begin manipulating it deliberately, treating the geometric overlap as the rhythmic idea. The jog wheel was widely used to scrub the playhead during sessions, supporting an instrument-like active engagement with the loop. Brief tracking interruptions occurred when hands occluded tokens, and participants typically adapted within seconds. These observations are exploratory and not a substitute for structured evaluation. RhythmTable is currently being used in the Raga Srishti gallery at ParSEC Whitefield, a public science centre in Bengaluru that opened in April 2026 [11], where it remains live as part of the regular exhibit programme. Future studies will use brief interviews, written prompts, and a reference board of well-known rhythmic patterns to gather systematic feedback on usage, interface affordances, and long-term interaction patterns from this ongoing deployment.

8 Discussion and Future Work

RhythmTable's contribution is not the use of a circle, which has many precedents in commercial sequencers, mobile apps, mechanical drum machines, and prior tangible research. It lies in the integration of four choices: cyclical time treated as a representational commitment grounded in Taala; concentric geometric layering that makes polyrhythmic structure visible as polygonal interference; dual-purpose token iconography that supports first-use comprehension; and a scale and form factor designed for community-based, co-located practice in public exhibits. The token-and-ring system is where the Taala framing operates most directly. We plan to extend the framing to the tempo knob through *laya*—the pacing of the cycle—developing it into a more cycle-aware tempo control. The jog wheel and sample-trigger buttons sit outside this vocabulary by design: they are playful additions for performative engagement and exhibit-floor energy, and we are comfortable treating them as performance instrumentation rather than forcing them into the cyclic frame. Several directions remain open. The reliance on overhead vision introduces occasional occlusion when hands obstruct tokens; a Reactable-style bottom-up sensing approach [9] could address this in future versions. The current evaluation is observational, and planned next steps include structured interviews with visitors and longer-term deployment studies in high-traffic museum settings. We are also developing a visual reference library of well-known rhythmic patterns to support recreation and remix as part of the exhibit experience.

9 Ethical Standards

The system processes video input in real time solely for token detection; no facial recognition, image storage, or personally identifiable data are retained. The camera feed is masked at the input stage to capture only the circular tabletop region, ensuring that surrounding objects, visitors, and bystanders are not recorded or processed. The installation operates entirely offline within a closed local network; no user-interaction data are transmitted or stored beyond real-time processing required for operation. The installation does not include a public-facing monitor displaying participant imagery. Formative-session participants provided informed consent in compliance with the authors' institutional guidelines. AI-assisted tools were used for language editing during manuscript preparation. All technical content, design decisions, and findings are the authors' own.

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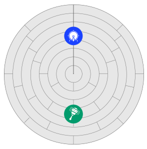
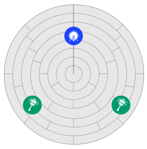
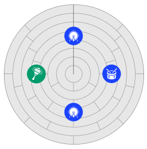
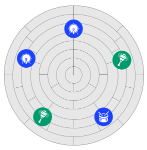
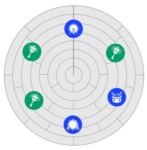
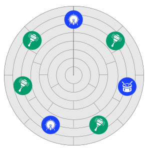
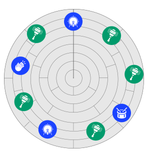
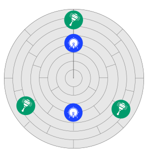
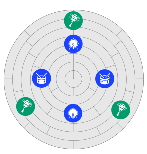
Table 1: Rhythmic Geometry Examples

Visual Mapping	Beat Count (Pulses)	Geometric Shape	Configuration	Angular Coordinates
	2	Line	2 division (Chatusra Gati - Half)	0, 180
	3	Triangle	3 division (Tisra Gati)	0, 120, 240
	4	Square	4 division (Chaturashra Gati)	0, 90, 180, 270
	5	Pentagon	5 division (Khanda Gati)	0, 72, 144, 216, 288
	6	Hexagon	6 division (Tisra Gati - Double)	0, 60, 120, 180, 240, 300
	7	Heptagon	7 division (Misra Gati)	0, 51.4, 102.8, 154.2, 205.7, 257.1, 308.5
	8	Octagon	8 division (Chatusra Gati - Double)	0, 45, 90, 135, 180, 225, 270, 315
	9	Nonagon	9 division (Sankeerna Gati)	0, 40, 80, 120, 160, 200, 240, 280, 320
	2:3	Overlapping Line & Triangle	2-against-3 Polyrhythm	(0, 180) + (0, 120, 240)
	3:4	Overlapping Triangle & Square	3-against-4 Polyrhythm	(0, 120, 240) + (0, 90, 180, 270)