

Ehecatl: A Frugal Digital Wind Instrument Inspired by Aztec Cosmogony

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Figure 1: Ehecatl, 2026.

Abstract

This paper presents *Ehecatl* (*eh-HEK-ah-tl*), a digital wind instrument (DWI) that integrates frugal technologies with Nahua (Aztec) cosmogony. The instrument is inspired by the ceremony of the Voladores de Papantla (Papantla Flyers), which physically enacts the Quincunx, a Mesoamerican cosmological framework representing the four cardinal directions and a central axis mundi. These spatial concepts provide the foundation for mapping gestural performance parameters to sound modulations.

Ehecatl was designed as a portable, standalone instrument embedding both control and sound synthesis. It employs the ESP32-S3 microcontroller, an I2S DAC, low-cost sensors including an accelerometer and a magnetometer, alongside a novel

custom windmill-based breath sensor designed for affordability and accessibility. Sound is generated using the M16 library's synthesis engine, utilizing a capacitive touch interface that allows for fluid, pentatonic melodic control, translating breath and movement into a cohesive sonic landscape. This project illustrates how Indigenous epistemologies can inform the design of accessible, culturally grounded musical interfaces.

Keywords

Digital Wind Instrument, Breath Controller, Frugal Innovation, Aztec Cosmogony

1 Introduction

The integration of cultural heritage into Digital Musical Instrument (DMI) design has frequently prioritized visual aesthetics or ergonomic novelty as means of differentiating new devices from standardized commercial products. Often, these designs seek to evoke specific historical or tactile lineages to ground novel physical interactions. For instance: the Birl was engineered to avoid



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NIME '26, June 23–26, 2026, London, UK

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Figure 2: Voladores de Papantla

visual comparisons with the soprano saxophone, instead evoking the tactile feel of Renaissance and Medieval wind instruments [8]. Similarly, SqueezeVoxen repurposes accordion and concertina bodies to create expressive, legacy-driven experiences [3], while Eolos utilizes a reversible design with rotatable tactile switches to accommodate highly individualized performer ergonomics [7]

This paper extends these conversations by exploring how interaction design can be informed by the foundational structures of indigenous cosmogonies. We present *Ehecatl*, (named after the Aztec god of wind), a digital wind instrument that bridges frugal technology with the Nahua (Aztec) cosmogony of the Quincunx. In this worldview, the universe is organized into four cardinal directions and a central axis mundi, each possessing a unique qualitative and symbolic character. Drawing from the Danza de los Voladores (Dance of the Flyers) as a physical enactment of this spatial philosophy, our instrument maps the performer physical orientation to sonic parameters.

In doing so, *Ehecatl* joins a vital lineage of how indigenous-informed interfaces act as bridges between ancestral media and contemporary technologies. A relevant contemporary example is the *Khipu* project, [5] which represents an opening towards decolonial aesthetics - a framework where technology is a medium to restore cultural memories and create "soul-filled" tools. By rooting instruments in indigenous epistemologies while remaining technically and economically accessible, the project embeds profound philosophical structures into a performative act.

2 Objective

The development of *Ehecatl* serves as an inquiry into how diverse philosophical frameworks might inform the design, performance, and accessibility of digital musical instruments (DMIs). This project seeks to contribute to this space by using one particular core principle drawn from Aztec cosmogony—the Quincunx—as the primary logic for mapping synthesis parameters in live performance. By incorporating the gestural language of the instrument in this spatial philosophy, the project pursues three main objectives:

- **Conceptual Integration:** Exemplify how indigenous epistemologies can provide robust, non-Western frameworks to inspire complex parameter mapping.
- **Technical Frugality:** Develop a Digital Wind Instrument (DWI) that remains technologically sophisticated while utilizing open-source and frugal components.

- **Socio-Economic Accessibility:** Provide a case study for "culturally grounded technology," ensuring that high-level musical expression is economically accessible to diverse communities.

2.1 Cultural, Artistic and Technical Reasons

The conceptual framework of *Ehecatl* is rooted in the Danza de los Voladores (Dance of the Flyers), originally conceived as a ritual performance of Mesoamerican cosmogony. In this ceremony, four performers descend from a 30-meter pole, greeting the four cardinal points, while a fifth performer—the musician—remains at the center axis, playing a traditional flute and drum. This spatial arrangement forms the *Quincunx*: a geometric and spiritual symbol representing the four directions of the universe organized around an *axis mundi* that connects the terrestrial with the divine [4]

Central to this ritual are Nahua philosophical principles such as complementary dualism, the maintenance of cosmic balance, and the notion of primordial sound [6]. Within this mythology, the Caporal is often identified as the "Head Storm Wind," guiding the "winds" (the flyers) through the melodic structure of the flute. The flute itself is understood as a manifestation of the sound that separated the sky from the earth at the dawn of creation.

This study seeks to encapsulate this "macro-ritual" into a "micro-portable" instrument. By mapping the ritual's inherent spatiality into a digital interface, *Ehecatl* allows the performer to navigate sonic landscapes via additive synthesis. Motion and breath are modulated through these four ritualistic points, reflecting the Quincunx structure and allowing an embodied performance to mediate between ancestral symbolism and modern sound synthesis. This creates a technical affordance where the performer does not just play an instrument, but inhabits a symbolic center of a moving universe.

2.2 Design Goals

The development of the instrument is guided by four primary pillars:

Embodied Cosmology (Spatial Mapping): The primary objective is to translate the horizontal and vertical planes of the Quincunx into an intuitive gestural vocabulary. The instrument employs absolute orientation—achieved through an IMU (magnetometer, gyroscope, and accelerometer)—to map the performer's spatial coordinates onto the synthesis engine. This ensures that the performer's physical heading toward the North, South, East, or West triggers specific, repeatable harmonic shifts. By anchoring sound modulation to the cardinal directions, the device transforms the performer's body into the *axis mundi*, making the act of orientation a fundamental parameter of the musical composition.

Tactile and Pneumatic Responsiveness: A central requirement is the creation of a breath-to-sound relationship that feels "alive." By utilizing a custom windmill-based sensor, the goal is to provide a physical sense of air inertia and mechanical feedback that mimics the turbulent nature of the wind, moving beyond the sterile response of standard pressure sensors.

Standalone Portability: To maintain the ritualistic integrity of the performance, the instrument must function as an embedded instrument entirely free from external synthesizers. All synthesis and power management are contained within the device, allowing the performer to move freely in a 360-degree radius. This autonomy mimics the Caporal atop the ritual pole, ensuring

the performer is the center of the sonic universe rather than an extension of a workstation.

Frugal Extensibility: The design must remain open, affordable, and reproducible. By utilizing the ESP32-S3 and widely available components, *Ehecatl* achieves a high-performance system at a low cost. This ensures the interface can be adopted by other artists or indigenous communities, fostering technical sovereignty without the need for expensive, proprietary hardware.

2.3 Technical Implementation & Frugal Innovation:

To ensure accessibility, *Ehecatl* is built upon the principles of frugal innovation. By prioritizing high-performance, low-cost components over expensive proprietary platforms, the instrument remains reproducible for independent artists and indigenous communities. These are its key technical features:

- **Custom Windmill Breath Sensor:** Departing from standard pressure transducers, we developed a novel 3D-printed mechanical windmill. Airflow drives a micro-motor, generating an analog signal that is captured by an ADS1115 (16-bit ADC). This mechanical approach provides physical inertia and tactile resistance, capturing the "turbulent" nature of breath at higher resolutions than traditional MIDI controllers.
- **M16 Synthesis Engine:** The instrument utilizes the M16 library, an internal synthesis engine optimized for the ESP32-S3¹. This allows for complex additive and subtractive synthesis to be processed natively, eliminating the need for external computers and ensuring a low-latency, standalone performance.
- **Spatial Mapping Suite:** *Ehecatl* integrates an MPU6050 (Accelerometer/Gyroscope) and a HMC5883L (Compass Sensor). This suite maps the performer's physical orientation to the Quincunx, triggering specific sonic modulations based on movement toward the cardinal points.
- **Capacitive Touch:** The instrument utilizes the ESP32-S3's built-in capacitive touch pins for the fingerings. This eliminates mechanical button noise and failure points, allowing for a seamless, fluid pentatonic melodic performance that responds to the lightest touch.

By integrating Mesoamerican living heritage with low-cost technology, this project exemplifies how Indigenous epistemologies can create DMIs that are simultaneously technologically capable, culturally grounded, and economically accessible.

3 Context

3.1 Mesoamerican Cosmogony and the Quincunx

The philosophical foundation of *Ehecatl* rests on the Nahuatl concept of the universe as a dynamic, self-generating energy—an unfolding process known as *Teotl* [6]. A vital component of the cosmic order is the *Quincunx*, a fundamental spatial framework consisting of four cardinal directions—North, South, East, and West—converging at a central fifth point, the *axis mundi*.

In the *Danza de los Voladores*, this geometry is physically enacted through ritual movement. The central pole acts as a vertical conduit between the celestial heights and the underworld, while

the four flyers represent the winds and cardinal points descending into the terrestrial plane. In this context, space is not treated as a neutral vacuum, but as a qualitatively charged field where each direction carries specific symbolic and tonal weight. By adopting this structure, *Ehecatl* treats the performer's physical orientation as a navigation through distinct harmonic territories; the act of turning one's body is transformed into a gesture that is simultaneously musical and philosophical.

3.2 Digital Wind Instruments (DWIs) and Gestural Mapping

The development of DWIs has evolved from early electromagnetic reed experiments in 1930 to widely adopted MIDI-standardized controllers of the 1980s, such as Yamaha WX series and the Akai EWI series. [2] Today, the state of the art in DWI design prioritizes expressive depth, somatic awareness [1], and machine learning to bridge the gap between human biology and digital synthesis[8].

Ehecatl joins a lineage of instruments that prioritize embodied interaction. However, while previous works such as Birl [8] or Eolos [7] focus on historical tactile sensations or ergonomic adaptability, *Ehecatl* explores epistemological mapping. Using a magnetometer to anchor sound in absolute cardinal directions, the instrument builds on the work of researchers exploring "spatialized performance," where the physical location and direction of the performer are treated as primary musical parameters rather than secondary effects.

3.3 Frugal Innovation and Technical Sovereignty

The "frugal" aspect of *Ehecatl* is situated within the broader movement of Technical Sovereignty. In many indigenous contexts, reliance on expensive components or proprietary hardware creates a barrier to both creation and maintenance.

By utilizing the ESP32-S3, readily available sensors, and a custom DIY windmill-based breath sensor, this project aligns with "Maker" cultures that emphasize open-source accessibility. *Ehecatl* serves as an open-ended question: can "low-tech" components—when paired with high-speed ADCs and native synthesis libraries like M16—achieve a level of expressiveness that offers a viable alternative to standard commercial MIDI instruments? Our goal is not to replace existing tools, but to offer a culturally grounded and economically accessible option for performance.

4 Technical Description

Ehecatl is developed as a standalone, autonomous Digital Wind Instrument (DWI). By embedding the synthesis and processing chain directly within the device, the system operates independently of external computers or wireless dependencies. This autonomy is a deliberate design choice, intended to keep the focus of the performance entirely within the physical and ritual space. The core of the instrument is the ESP32-S3 microcontroller, which serves as the central hub for both the sensing layer and the native synthesis engine.

The latest version of the *Ehecatl*, including video demonstrations, schematics, STL models, and assembly instructions, is available through our online repository.²

¹<https://github.com/algomusic/M16>

²<https://github.com/manoxs/Ehecatl>

4.1 Interaction Logic

To capture the subtle nuances of a performer's expression, the instrument utilizes a hybrid sensing architecture:

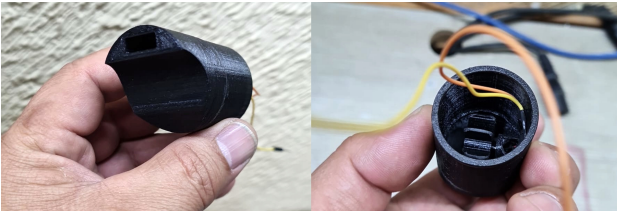


Figure 3: 3D printed windmill mechanism

- **Breath:** The primary energy source for the sound is air-flow, which drives a 3D-printed windmill mechanism. This mechanical interaction generates a small voltage amplified by an ADS1115 (12-bit ADC). This data modulates the global amplitude and the cutoff frequency of a resonant filter, an attempt to emulate the organic spectral expansion found in traditional woodwinds.
- **Spatial Navigation:** The system utilizes an MPU6050 and an HMC5883L to track absolute orientation. The compass sensor maps the performer's heading to the cardinal points (North, South, East, West), adjusting the harmonic profile of an additive synthesis system based on the player's location. Additionally, data captured by the accelerometer: vertical tilt triggers octave shifts, while rapid roll movements introduce further modulations. This creates a repeatable, intentional relationship between movement and sound.
- **Tactile Melodic Control:** Six capacitive touch pins function as musical keys, managed by the MultiControl library³. This provides a wear-free, noiseless interface that facilitates rapid and fluid fingerings characteristic of virtuosic wind performance. The capacitive touch interface is embedded directly into the wooden chassis, utilizing the natural dielectric properties of the wood to house the touch pins.



Figure 4: Detail of the capacitive touch sensors integrated into the carved wooden body.

4.2 Technical Choices and Frugal Innovation

The hardware selection for *Ehecatl* was guided by a desire for high expressive resolution balanced with socio-economic accessibility:

- **ESP32 Processing:** The ESP32-S3 was chosen for its ability to handle the M16 synthesis library while simultaneously polling high-resolution sensor data. This ensures a low-latency response without compromising audio stability.

³<https://github.com/algomusic/MultiControl>

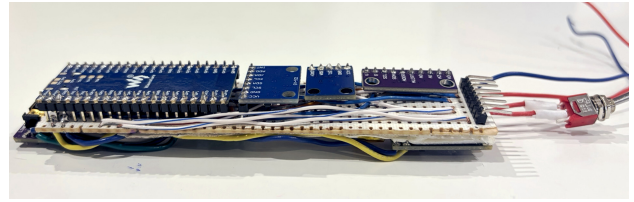


Figure 5: Front view of ESP32 and sensors .

- **High-Resolution Sensing:** We integrated the ADS1115 specifically to amplify and digitize the windmill motor's micro-voltage (ranging from 0.18mV to 0.5mV). This resolution is vital for capturing the mechanical "jitter" and inertia of the windmill, which provides the instrument with its "primordial" sonic texture.
- **Native I2S Audio:** To ensure high-fidelity output, we utilize an external I2S DAC, providing 16-bit audio quality. We have also integrated a pre-amplified speaker stage within the signal flow to achieve an "acoustic" standalone effect, allowing the sound to emanate directly from the instrument.
- **Processive Openness:** By utilizing the open-source M16 library for wavetable synthesis, *Ehecatl* remains an open-ended platform. This architecture invites future users to experiment with custom wavetables and modulation mappings, fostering a community-driven evolution of the instrument's voice.

4.3 Portability and Power Management

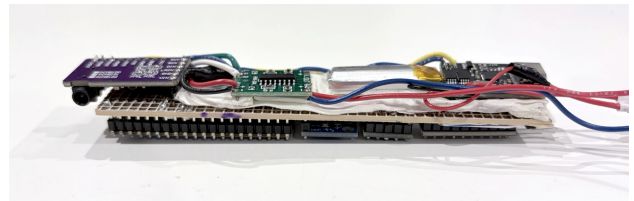


Figure 6: Back view power management and Audio output.

To maintain the ritualistic integrity of the performance and allow the musician 360-degree freedom of movement, *Ehecatl* is designed as a fully autonomous system.

- **Battery Integration:** The instrument and the internal pre-amplifier are powered by a high-capacity Lithium-Polymer (LiPo) battery.
- **Power Regulation:** To ensure a stable voltage for the ESP32-S3 and the sensitive analog sensors, the system utilizes a dedicated charging module. This setup allows for extended performance times and convenient USB-C recharging, reinforcing the goal of a "micro-portable" macro-ritual tool.

5 Interaction

5.1 Embodied Navigation of the Quincunx

The fundamental interaction of *Ehecatl* is based on the concept of embodied navigation. The performer is required to physically navigate the space, referencing the four cardinal points—East, North, West, and South—to assert sovereignty over cosmic space and time. This interaction reassembles the role of the Caporal in

the "Danza de los Voladores", who stands at the center serving as the *axis mundi*, metaphorically connecting the heavens, earth, and underworld[4]

As the performer rotates, the onboard sensor suite tracks the absolute heading. This orientation is mapped to control the amplitude of four distinct oscillators, creating smooth crossfades between the following harmonic states:

- North (0°): Base pitch oscillator (f_0).
- East (90°): +12 semitones (first octave).
- South (180°): +19 semitones (octave + fifth).
- West (270°): +28 semitones (second octave + major third).

5.2 Kinetic Modulation (Tilt and Roll)

While the horizontal plane defines the harmonic "world," the vertical and lateral axes provide immediate expressive control:

- Verticality (Y-axis): Tilting the instrument upward or downward navigates the vertical axis mundi. In practice, an upward gesture reaches toward the celestial (triggering higher registers), while a downward tilt grounds the sound in the terrestrial (lower registers).
- Lateral Instability (X-axis): Rolling the instrument introduces LFO vibrato and subtle pitch-bends. This mimics the "trembling" breath techniques used in traditional Mesoamerican flute playing, allowing the performer to introduce a sense of volatility or "shaking" to the synthesized sawtooth waveform.

5.3 Pneumatic Response and Haptics

The interaction with the custom windmill sensor provides a unique haptic experience. Unlike standard "static" pressure sensors, the mechanical windmill possesses physical inertia. This pneumatic interface is contained within a 3D-printed mouthpiece housing and consists of three primary elements: an adjustable embouchure, a windmill, and a micro-motor.

Table 1: Functional Architecture of the Pneumatic Interface.

Zone	Components	Key Labels
Pneumatic	Mouthpiece Intake → Adjustable Embouchure → Windmill Blades	Airflow, Inertia
Electromechanical	Windmill Shaft → Micro-motor	Kinetic to Electrical
Analog	Motor Leads → ADC Input	V_{out} (0.18–0.5mV)
Digital	ADC → ESP32-S3	I2C, 16-bit Res.

- **Mechanical Structure:** The embouchure can be manually adjusted (by 3D printing different sizes) to regulate the mass flow rate of the performer's breath; a smaller aperture restricts airflow, increasing the pneumatic resistance of the system.
- **Physical Inertia:** The mechanical windmill possesses significant physical inertia. When the performer blows, there

is a slight mechanical delay as the windmill accelerates, followed by a corresponding "decay" as it slows down.

- **Air Inertia Mapping:** This rotation is captured by the micro-motor, acting as a generator to produce a micro-voltage that is digitized by the ADC. The resulting data is mapped directly to the global amplitude and used to dynamically adjust the filter cutoff frequency (0–10kHz).

5.4 Audio Synthesis

The *Ehecatl* sound synthesis engine employs a hybrid additive-subtractive architecture processed natively on the ESP32-S3. The implementation is divided into three primary layers:

Spatial Harmonic Mapping (The Quincunx) The core consists of four additive oscillators crossfaded based on the magnetometer's absolute compass bearing (0°–360°). Physical orientation directly modulates the harmonic spectrum, mapping Mesoamerican cardinal directions to specific intervals:

- North: Fundamental frequency (f_0).
- East: +12 semitones (Octave).
- South: +19 semitones (Octave + Fifth)
- West: +28 semitones (Double Octave + Major Third)

Breath-Driven Signal Path To achieve a "primordial" organic texture, the signal is split into parallel tonal and aperiodic paths. Both modulated by the windmill sensor's micro-voltage before reaching the final mix:

Table 2: Audio Signal Flow

Path	Components
Tonal	5 Oscillators (crossfaded by heading) → Lowpass Filter → VCA (Breath)
Aperiodic	White Noise → Lowpass Filter → VCA (Breath)
Final Mix	95% Tone + 5% Noise → Dynamics Compressor → Master Filter → Output

Kinetic Modulation The IMU (MPU6050) provides high-resolution gestural control over the secondary synthesis parameters:

- X-Axis (Rotation): Real-time octave transposition (± 1 octave).
- Y-Axis (Tilt): Controls LFO depth for vibrato (± 10 cents).

Final Signal Processing. The final stage of the synthesis engine aggregates the parallel paths into a unified output. Following the initial modulation, the signal undergoes the following sequence:

Per-path filters → Summing Mixer → Dynamics Compressor → Global Master Filter → I2S DAC → Pre-amplifier → Internal Speaker.

To achieve a truly standalone, "acoustic" effect, the I2S signal is converted and passed through an internal pre-amplification stage. This drives a speaker contained within the instrument's chassis, allowing the sound to emanate directly from the *axis mundi* of the performance. This chain ensures that the "turbulent" noise and tonal oscillators are balanced via the dynamics compressor to maintain a consistent output level during energetic gestures. Finally, the global master filter provides a layer of spectral control, enabling the performer to sweep the overall brightness of the instrument in real-time to match the ritual's intensity.

5.5 Interaction Design

In performance, the relationship between gesture and sound is designed to be transparent. The audience can perceive the performer's orientation as the catalyst for harmonic shifts. This transparency reinforces the ritualistic nature of the act, where the performer functions as the *Caporal*, directing the "winds" of the synthesis engine through their physical presence and breath. To achieve this, the interaction is organized into three hierarchical layers of control:

Spatialized Harmonic Navigation: The performer's compass bearing (0° – 360°) serves as a high-level compositional tool. By rotating their body toward the cardinal directions, the performer navigates the *Quincunx*, crossfading between four oscillators. This results in a spatially-aware harmonic spectrum where North (*Mictlampa*) represents the base fundamental frequency, East (*Tlahuiztlampa*) introduces the first octave, South (*Huitzilampa*) introduces the octave and the fifth, and West (*Cihuatlampa*) introduces double octave and major third. This creates a "sacred geography" of sound, where the harmonic density is a direct result of the performer's physical location in the world.

Pneumatic Expression and Turbulence: The primary energy of the sound is governed by a parallel breath-driven path. A tonal path (95%) consisting of sawtooth oscillators and an aperiodic path (5%) of white noise are mixed and modulated by the windmill breath sensor. The sensor data simultaneously modulates global amplitude and filter cutoff (0–10kHz). Because the mechanical windmill possesses physical inertia, the sound does not stop instantly with the breath, but "decays" organically, mimicking the turbulent and volatile nature of the deity *Ehecatl*.

Kinetic and Tactile Refinement: While the body orientation defines the harmonic "territory," the MPU6050 IMU allows for micro-gestural modulations. Vertical tilt is mapped to octave transpositions, while lateral "rolling" introduces vibrato (± 10 cents) through LFO depth modulation. Finally, the capacitive touch interface on the wooden body allows for fluid, pentatonic melodic control. This combination of macro-spatial movement and micro-kinetic gesture ensures that every aspect of the performer's body is engaged in the act of sound creation, transforming the DMI from a mere tool into a "soul-filled" extension of the ritual.

6 Discussion

6.1 The "Turbulent" Interface

The use of a 3D-printed windmill as the primary pneumatic interface highlights a core tension in DMI design: the balance between technical precision and aesthetic character. While high-resolution medical pressure sensors offer linear predictability, *Ehecatl* prioritizes the "turbulent" and "erratic" nature of the wind. By embracing the mechanical inertia and inherent "jitter" of the windmill, the instrument moves away from cold digital efficiency. This results in a non-linear, "primordial" response that feels deeply aligned with the volatile nature of the deity *Ehecatl*.

6.2 Prototyping and Technical Sovereignty

As an initial prototype, the current iteration faces stability challenges due to the dense arrangement of components within a confined, clamped space. Future iterations will move toward a custom embedded SMD PCB to ensure structural integrity and signal cleanliness. Furthermore, we noted challenges in the global

supply chain regarding sensor labeling; the magnetometer utilized was mislabeled by the distributor, a common hurdle in frugal innovation that requires practitioners to rely on low-level signal testing rather than retail documentation to verify hardware identity.

6.3 Spatial Agency and Listener Transparency

The magnetometer proved highly effective for navigating the *Quincunx*, successfully transforming the performer's orientation into a compositional tool. However, there is room to improve the reactivity of the system; currently, the harmonic shifts can feel overly tied to button triggers rather than fluid gestural transitions. While the gesture is clear to the performer, we recognize the need for greater sonic contrast to make these spatial shifts more obvious to the listener. At present, the subtle addition of harmonics requires an "aware listener," and future mappings may explore more aggressive spectral changes to heighten the transparency of the interaction.

6.4 The "Soul-Filled" Extension

Crucially, the sonic identity of *Ehecatl* does not attempt to mimic indigenous acoustic instruments. Instead, it utilizes a "vintage synthesizer" aesthetic, positioning the "soul-filled" extension as a modern re-reading of ancestral tools. By using the M16 library, the instrument remains an open platform for experimentation. This "processive openness" ensures that the synthesis is not a static preset, but a canvas where contemporary technology and indigenous epistemology can negotiate a new, decolonial sound.

7 Ethical Standards

7.1 Cultural Positionality and Sovereignty

The development of *Ehecatl* is rooted in a deep respect for Nahua cosmogony and the origins of the *Danza de los Voladores* (Papantla flyers). We recognize that this ceremony is frequently reduced to an acrobatic spectacle for tourism, often at the expense of its sacred significance. To address the inherent risks of cultural appropriation and the decontextualization of tradition, this project is not framed as the 'preservation' of a static past. Instead, it serves as a modern re-reading (relecture) designed to support contemporary indigenous expression. By centering the instrument on the *Quincunx* and the role of the *Caporal*⁴, we honor these ancestral epistemologies as living, functional frameworks for new technology, rather than treating them as mere aesthetic ornaments.

7.2 Frugal Innovation and Accessibility

A core ethical pillar of this project is socio-economic accessibility. Using "frugal" components—such as the low-cost ESP32-S3, widely available sensors, and 3D-printed mechanical parts—we ensure that the instrument is not restricted to high-budget institutional settings. This approach promotes technological sovereignty, allowing practitioners in diverse economic contexts to build, repair, and modify their own "soul-filled" tools without reliance on proprietary hardware or expensive software licenses.

⁴In the *Voladores* ceremony, the *Caporal* is the heart of the ritual—standing at the top of the pole, playing the flute and drum while facing the four cardinal directions. By using the magnetometer to trigger the *Quincunx*, the instrument effectively makes every performer a *Caporal* of their own digital space.

7.3 Environmental Considerations

In alignment with the "primordial" themes of the project, we have sought to minimize the environmental footprint of the prototype. The use of 3D-printed PLA (a bio-plastic) for the windmill and speaker holder, combined with a wooden body for the touch sensors, represents a deliberate choice to explore biodegradable and organic materials in DMI construction. Furthermore, the standalone nature of the instrument reduces "e-waste" by eliminating the need for a dedicated external computer, favoring a low-energy, embedded architecture that operates with minimal power consumption.

7.4 Open Source and Processive Openness

To foster a transparent and collaborative community, we have utilized only open-source tools for the development of both the code and hardware. All design files for Ehecatl are intended for public Open Source release. This ensures that the "bridge" created between ancestral media and contemporary technology remains a public good. We invite other creators to adapt the mapping logic to their own cultural contexts, ensuring that the evolution of these interfaces remains a collective and regenerative process rather than an extractive one.

8 Conclusion

The ongoing development of *Ehecatl* is offered as an inquiry into how Digital Musical Instrument design might be informed by indigenous epistemologies. By centering the instrument on the spatial logic of the *Quincunx* and the role of the *Caporal*, we have attempted to move beyond the decorative use of cultural themes. Instead, our goal was to investigate how sacred geography might be reflected within the logic of digital interaction, allowing the performer's physical orientation to become an act of quiet navigation through a symbolic universe.

The project suggests that "frugal innovation" is not a constraint, but rather an ethical choice that prioritizes accessibility and sovereignty. Using accessible components—such as the ESP32-S3, 3D-printed mechanical parts, highly available sensors, and open-source libraries—does not necessitate a compromise in expressive resolution. On the contrary, the inherent non-linearities and jitter of the DIY windmill sensor provide a unique, primordial character that respects the volatile nature of the wind and offers a more organic "breath of life".

8.1 Future Work

As a first iteration, this prototype remains a work in progress. Future efforts will focus on refining the hardware stability through a custom SMD PCB to ensure the instrument is a reliable tool for performance. Furthermore, we hope to continue refining the sonic shifts between the cardinal points to ensure that the spatial navigation is as clear to the audience as it is to the performer.

Guided by the principle of "Processive Openness," we hope that *Ehecatl* might serve as a small foundation or inspiration for other practitioners seeking to build their own "soul-filled" tools. Contributing to an ecosystem of digital musical instruments that are rooted in their own ancestral memories. In this way, *Ehecatl* is not a digital replica of the past, but a modern *relecture*—a tool for navigating the winds of both the physical and the digital space with care, intentionality, and respect.

9 Acknowledgments

I would like to express my gratitude to Andrew Brown for his invaluable one-on-one support and guidance in implementing the M16 library. Finally, I acknowledge the support of the LATAM network for fostering a vibrant community of practice and dialogue surrounding technical sovereignty and digital lutherie in Latin America.

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