Layika: A Wearable Device Mapping Traditional Hand Gestures to Tabla Sound

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Figure 1: Layika, a wearable glove-based interface that maps traditional hand-based *Taal* counting gestures to Tabla accompaniment during solo vocal practice.

Abstract

We present Layika, a glove-based MIDI device that integrates Tabla accompaniment with finger-counting gestures traditionally used to maintain *Taal* in Hindustani classical music. In this style, vocalists commonly use hand and finger gestures to track complex rhythmic structures during practice. Each finger pad corresponds to a mnemonic representing a beat within a rhythmic cycle, with each beat associated with a specific Tabla sound. Layika builds on this existing practice by allowing finger taps to directly generate corresponding Tabla audio, giving singers direct control over rhythmic accompaniment.

Layika was developed through multiple design iterations, with attention to sensing reliability, latency, and ergonomic fit. A small user study (N=4) with trained Hindustani classical vocalists examined how the device integrates into solo practice. Findings indicate perceived usefulness and engagement, alongside technical limitations that informed subsequent refinements.

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Keywords

Digital Musical Instruments, Gesture-based Musical Interaction, Wearable Interfaces, Embodied Interaction, Indian Classical Music, Tabla Accompaniment

1 Introduction

Hindustani classical music is a practice strongly based on community and tradition, where knowledge is developed and transferred through shared learning, rehearsal, and performance. While there are several sub-communities within the tradition, including stylistic and regional variations, the underlying rhythmic structures remain largely shared [12].

In this style of music, rhythmic structure of music is maintained by *Taals* [4], which are strings of beats. The instrument central to play and maintain the *Taals* or the rhythm is called a Tabla [16], a hand-played percussion instrument that defines the rhythm cycle, tempo, and cyclical progression [21]. These cycles can have different total lengths and uneven internal groupings (for example, 2–2–3 or 4–4-4-4), and performers keep track of their position within the cycle by counting beats physically, often using their fingers, especially during practices when live Tabla accompaniment is often not available. These gestures are culturally situated practices, often taught through oral pedagogy and practiced alongside vocal recitation, carrying nuances of emphasis and phrasing beyond simple counting. Each note of a *Taals* has specific hand gestures to map it, so even a trained onlooker can quickly catch on to the rhythm. New students learn by observing their seniors, and learning takes place as a community.[21]

This reveals a design opportunity to extend hand gestures traditionally used for rhythmic tracking into sound-producing actions. In the context of Hindustani music, this suggests the possibility of transforming long-established *Taal* counting gestures into sound-producing actions.

In this paper, we present Layika, a wearable MIDI-based musical device that maps finger-tapping gestures to structured Tabla accompaniment, allowing singers to generate rhythmic accompaniment while counting. By bringing Tabla sounds to the performer's hand and preserving familiar *Taal* counting gestures, the device shifts the rhythm from an external reference to an embodied interaction that supports solo practice and rhythmic exploration. This work contributes a tradition-based wearable musical interface that transforms silent rhythmic gestures into sound-producing actions, articulates how *Taal*-counting gestures can assist in performance and practice, and offers qualitative insights from trained Hindustani vocalists on the role of embodied rhythmic control during solo practice.

2 Musical Terminology

Hindustani Music : A major classical music tradition of India, Hindustani music was developed in North India and emphasizes improvisation within structured melodic and rhythmic frameworks. This tradition relies heavily on cyclical rhythm systems and vocal pedagogy grounded in gesture and oral transmission [12].

Tabla : A pair of hand-played percussion drums used primarily in Hindustani classical music, consisting of the right-hand drum (dayan) and the left-hand drum (bayan). It is most commonly used as an accompaniment instrument for vocal and instrumental performance.

Tabla Bols : Spoken mnemonic syllables (e.g., dha, dhin, na) that represent specific Tabla strokes. Each *Bol* corresponds to a particular hand movement and sound on the instrument and is widely used in teaching, practice, and rhythmic understanding.

Taal : A repeating rhythmic cycle composed of a fixed number of beats organized into a specific pattern [4]. Examples include *Teentaal* (16 beats) and *Ektaal* (12 beats). The structure of a *Taal* is commonly reinforced through spoken *Bols* and physical gestures.

Hand-based Taal Counting : In vocal practice, performers often keep track of *Taal* by tapping fingers, clapping, or marking beats on the hand while reciting *Bols* or singing. These gestures act as a pacing and structural reference, especially during solo practice without a live accompanist.

3 Background And Related Work

Digital musical instruments have long explored bodily gesture, particularly hand movement, as a means of sound control. Early work in gestural interaction framed the body as an expressive element rather than a passive controller, demonstrating how bodily movement can be mapped to sound [3, 20].

Advances in sensing technologies have enabled glove-based musical interfaces that capture finger and hand motion using flex sensors, inertial units, and conductive materials, and map these movements to sound [6, 8, 22]. Across different implementations, such gloves have been used for a range of movement-to-sound mappings, from expressive gesture control to instrument-specific interaction, demonstrating how bodily movement can be translated into digital audio [1, 6, 14, 18]. Despite their diversity, these systems commonly support multi-dimensional input and continuous control, most often using MIDI as an intermediary between gesture and sound.

Glove-based devices have been widely applied to movement-to-sound mapping, including control of physical and virtual musical instruments [11, 15]. While expressive, such systems frequently rely on abstract mappings that require performers to learn new gestural languages. Prior evaluations highlight challenges related to bulk, calibration, and the limited musical meaning carried by captured movement alone [14].

While glove-based musical interfaces have explored expressive control through arbitrary gesture mappings, fewer systems ground interaction in culturally specific rhythmic practices where gesture already carries musical meaning. Research in embodied musical interaction emphasizes that gesture becomes musically meaningful when it grounds on bodily practice or tradition. Studies of musical gesture demonstrate the strong coupling between movement, timing, and auditory perception, particularly in rhythmic performance [9, 10].

In Hindustani classical music, traditionally, rhythm is structured through *Taal*, a cyclical framework commonly tracked through hand and finger counting gestures [21]. Vocalists use these gestures to keep track of the beat, often accompanied by spoken Tabla *Bols*, rhythm mnemonics [12].

Electronic systems substituting Tabla commonly used in practice settings provide prerecorded percussion audio with adjustable tempo, pitch, and volume [13, 17, 19]. These devices function primarily as playback tools, allowing musicians to select predefined *Taals* and control timing parameters through buttons and knobs. As a result, rhythm remains an external reference rather than something produced through the performer's gestures.

This paper explores this gap through Layika, a wearable MIDI-based device that maps traditional *Taal* counting gestures to Tabla percussion audio. By embedding sound directly within an established gestural practice, the system transforms rhythmic

counting into an audible, interactive process, enabling singers to generate accompaniment during solo practice.

4 Design Motivation

In Hindustani classical music, keeping track of *Taals* through finger counting is an integral part of practice. These gestures act as an embodied map of the rhythmic cycle, helping performers keep track of complex, classical and semi-classical melodies. [21].

Despite their central role, counting gestures remain silent and depend on external sound sources for auditory reference. During solo practice, musicians must continuously synchronize bodily pacing with prerecorded Tabla loops or metronomic tools, creating a separation between gesture and sound [12]. This often shifts rhythmic control away from the performer.

Existing digital rhythm tools are monotonous [2]. They do allow pitch and tempo variance but offer limited responsiveness to the musician's timing or expressive intent [5]. A robotic quality seeps into the performance, where musicians follow the rhythm rather than actively shaping it through their own pacing gesture.

Layika bridges this gap, bringing rhythmic gesture and sound together by allowing traditional counting actions to directly generate Tabla *Bols*, transforming a silent practice into an active form of accompaniment. By tightly coupling gesture and sound, the system supports temporal awareness and a sense of performance control during practice [9, 10].

5 Design

Layika's development took place over approximately seven months and involved multiple cycles of prototyping and refinement. The process began with building a basic working prototype to test whether the finger-tapping gesture could reliably trigger sound and support rhythmic interaction. Once that was achieved, the focus shifted toward ergonomics, including the glove's fit, bulk, weight distribution, and freedom of hand movement.

Subsequent iterations addressed the technical aspects of performance, particularly latency reduction and response consistency, followed by the transition from a wired to the system with DAW setup to a wireless system. Each stage informed the next through hands-on testing and repeated adjustments. Through this iterative process, the final prototype evolved into a stable, wearable instrument suitable for real-time musical practice and performance. Described below are the details of the latest prototype and how they came to be. The final prototype was achieved after one round of user testing.

5.1 The Glove

The base material of the glove is a blend of polyester, polyurethane and nylon. The material can stretch and fit various hand sizes, catering to people whose hands are same sized and bigger than the size of the glove by some extent.

As for the sensors at the finger joints, where the finger-thumb contacts are meant to be detected, rings made from conductive material like aluminium and copper were used initially. These rings were attached to the micro-controller using wires (Figure 2a–b). There were sixteen contact point, four per finger and one for the thumb, each with their own wire. These when tapped sent signal to the controller which was then translated into MIDI signals for the computer.

However, this posed a serious problem because these rings were rigid in structure and circumference, and as a result, posed problems for performers with wider or slimmer fingers as the fit wasn't comfortable. Moreover, using aluminium rings and wires made the glove excessively bulky and difficult to handle. Achieving consistent thumb–finger contact was also difficult due to the limited and curved surface of the rings, requiring performers to consciously adjust their hand movements to trigger the interaction.

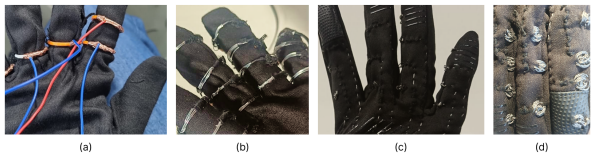


Figure 2: Iterations of finger contact point design at the finger–joint junction. (a) 3D printed rings covered with copper tape. (b) Aluminium wire rings. (c) Conductive yarn small patch. (d) Conductive yarn large patch.

To overcome these issues, we shifted to using conductive yarn instead of rings in the final prototype. The conductive yarn was used to stitch pads at the intersection of the fingers, replacing the rings (Figure 2c–d). Even the connection to the controller was done using stitching of the conductive yarn into the glove itself. This made the glove very lightweight, easy to handle, as well as allowed it to smoothly fit into hands.

Wires are still present in the final prototypes, at the junction of the yarn and the controller, but is only for a small portion and does not cause hindrance in movement.

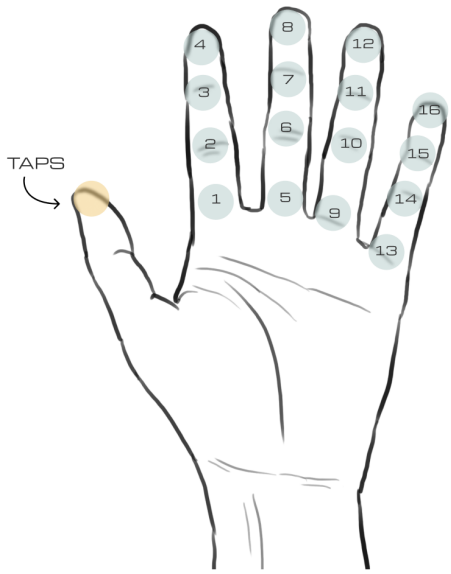
5.2 Gesture-To-Sound Mapping

Layika maps finger-tapping gestures to specific Tabla *Bols*, following the hand-based counting practices used by Hindustani vocalists (Figure 3a). Each finger corresponds to a predefined *Bol* (Figure 3b), allowing performers to produce rhythmic accompaniment using familiar gestures rather than arbitrary mappings. The rhythmic cycle is maintained by the performer and naturally resets at the end of each *Taal* cycle. Timing is fully performer-driven, with sound triggered at the moment of finger contact, without quantization, to preserve natural timing and expressive variation.

5.3 Electronics

Layika uses a distributed electronic architecture consisting of a wearable transmitter unit and a wireless receiver (Figure 4). Finger–thumb contacts are detected using conductive textile interfaces connected through a 16-channel multiplexer, enabling multiple sensing points to be scanned using a limited number of microcontroller pins. This helps in reducing the bulk of the glove substantially. The multiplexer is connected to an ESP32-S3 microcontroller, which performs high-speed input scanning and software debouncing to ensure reliable gesture detection during rapid rhythmic tapping and ignoring mis-taps.

The detected signals are then transmitted to a receiver module using ESP-NOW wireless communication. This supports performer mobility and reduces latency compared to using other wireless communication techniques [7]. The transmission occurs as compact data packets and is converted into standard MIDI messages, which are forwarded via a USB-MIDI bridge to external digital audio workstations. This architecture enables



(a)

Beat	1	2	3	4
Bol	Dha	Dhin	Dhin	Dha
Beat	5	6	7	8
Bol	Dha	Dhin	Dhin	Dha
Beat	9	10	11	12
Bol	Dha	Tin	Tin	Na
Beat	13	14	15	16
Bol	Ta	Dhin	Dhin	Dha

(b)

Figure 3: Finger-based rhythmic counting in Hindustani vocal practice. (a) Hand and finger gestures used to mark beats. (b) Corresponding Tabla *Bols* assignments across a rhythmic cycle.

real-time triggering of Tabla samples while maintaining a lightweight, detachable wearable form factor and minimizing physical constraints during musical practice.

6 Exploratory Study With Hindustani Vocalists

To understand how Layika performed in practice, we conducted a small user study. The aim was to examine whether the glove could function effectively as an accompaniment tool during practice, and to explore how the gesture-driven approach to controlling Tabla sound supported rhythmic engagement and usability. This study was conducted using a previous prototype of the glove.

Findings from the study helped shape the latest prototype, whose design was described above.

6.1 Participants

Four female participants between the ages of 18 and 28 took part in the study. All participants had formal training in Hindustani classical music and actively used *Taal* counting gestures to keep rhythm during performance.

6.2 Tasks

All participants were given five minutes to get a feel for the glove. During this time, they were encouraged to try it on and experiment with creating rhythmic cycles through finger tapping. Any questions they had were answered, and they were reassured that the glove was sturdy and that they could move naturally without fear of damaging the device.

Two tasks were designed to evaluate the glove. The tasks were structured to reflect how the device would be used in a natural, non-experimental setting.

First, participants were asked to recite Tabla *Bols* while producing the corresponding percussion sounds using Layika. This task examined the alignment between finger taps and auditory feedback.

Next, participants were asked to sing a classical composition while maintaining *Taal* using the glove. This task focused on understanding multitasking between vocal performance and rhythmic control.

6.3 Data Collection

Observations and interview responses were analysed to identify recurring patterns related to comfort, rhythm maintenance, and the performer's ability to correlate finger taps with the corresponding Tabla sounds. The goal was to see if adding Tabla sounds to corresponding gestures helped performers feel more in control of rhythm and better understand the composition.

7 Findings

Thematic analysis of observations and interview responses revealed several recurring themes related to the use of Layika during practice (Figure 5). These findings reflect participants' experiences with rhythmic control, learning, comfort, and perceived suitability of the instrument.

7.1 Familiarity And Learnability

Participants reported that the interaction felt intuitive due to its grounding in traditional thumb-finger contact based gesture. As the percussion audio was directly matched to its gestural counterpart, performers were able to understand the basic functioning of the glove with minimal instruction. Several participants noted that the experience resembled their usual counting practice making it familiar.

7.2 Rhythm Awareness

Participants found the glove helpful for maintaining rhythmic continuity during practice. The percussion audio gave them the agency to be in control of the Tabla while singing. The presence of Tabla sound also reinforced beat awareness and supported alignment within the *Taal* cycle. Performers reported that hearing the *Bols* while tapping helped them remain conscious of beat progression, particularly during longer cycles. Participants also reported that hearing tabla sounds similar to live accompaniment, facilitated smoother integration when practicing with an actual tabla player.

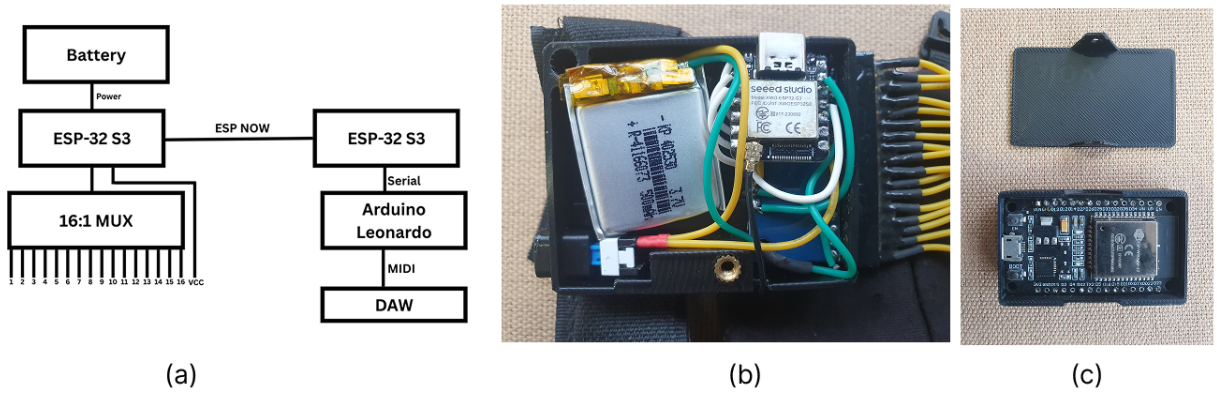


Figure 4: Electronic architecture and hardware of Layika. (a) Signal flow and communication pipeline. (b) Glove-mounted electronics. (c) External wireless module.

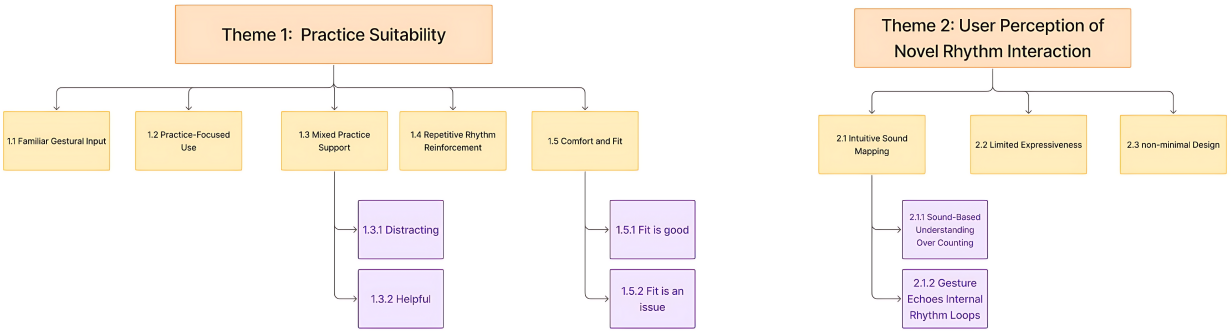


Figure 5: Overview of themes identified through thematic analysis of observations and interviews with Hindustani Classical vocalists.

7.3 Multitasking And Cognitive Load

While participants were able to complete both tasks, multitasking between singing and rhythmic tapping required conscious effort. Some singers experienced difficulty maintaining consistent tempo when focusing simultaneously on melody and gesture, which was not the case when they were singing and counting without wearing the glove. This effect was more noticeable during initial use and reduced slightly with short-term familiarization.

7.4 Expressivity And Performance Use

Participants described the glove as more suitable for practice than live performance. Although its expressive range was limited compared to an acoustic Tabla, these constraints were acceptable in rehearsal contexts. A slight 3 ms latency was initially observed between contact and sound, but it did not prevent participants from using the device in their songs during practice.

7.5 Comfort And Physical Fit

Feedback regarding comfort varied across participants. Differences in hand size led to occasional misalignment between fingers and touch points, affecting tap accuracy. Some participants reported mild discomfort during extended use, indicating the need for improved ergonomic customization and redesigning the contact points for easier reach.

7.6 System Sensitivity And Reliability

Participants observed occasional disruptions caused by high sensor sensitivity, including unintended triggers or missed taps. These inconsistencies sometimes interrupted rhythmic flow, particularly during faster passages.

Overall, the findings indicated that Layika was perceived as a useful rhythmic accompaniment tool for solo practice. Participants valued its grounding in familiar gesture and its ability to externalize beats through sound, while also identifying limitations related to expressivity, ergonomics, latency and sensing reliability.

8 Limitations

The glove prototype used for the study did not fit uniformly on all participants' hands. This caused variations in thumb–finger contact across users, leading to inconsistent interaction experiences. Similar challenges have been reported in earlier wearable and glove-based musical interfaces [6, 14], arising due to the natural variation of hand sizes in a population.

In terms of expressivity, participants felt that the glove could not replicate the nuanced articulations and expressive range achievable on an acoustic Tabla. Each Tabla *Bol* can be played in a variety of ways, usually achieved through changing the striking technique on the percussion membrane. Even the transition between *Bols* can be expressed in different ways. Layika was programmed to only replicate the standard forms of the *Bols* and not its expressive variations. Limitations of this nature are not unique to this device and has been observed in other MIDI-based musical interfaces and has been noted in prior work [14, 15, 20].

Another limitation observed during the study was the occurrence of mis-triggers due to the nature of the sensor. Conductive yarn, being fabric like in nature, had developed frayed edges over time. The contact points, as a result, were acting as multiple live wires rather than a cohesive unit. This resulted in unintended thumb–finger contacts being registered, leading to accidental sound triggers. This reduced the sense of control during practice and momentarily disrupted rhythmic continuity, particularly during faster passages.

Latency in sound output was also identified as a limitation. Even small delays between gesture and audio feedback affected the flow of the interaction and made it harder for performers to rely on the glove for precise rhythmic timing. This was especially noticeable during longer *Taal* cycles, where consistent temporal alignment was critical.

Lastly, The participant group consisted only of female vocalists, reflecting the availability of trained participants during the study period. While gender was not a variable of interest in the design or evaluation of the system, future studies should include a more gender-diverse participant pool to examine whether embodied rhythmic interaction and gesture–sound mapping are experienced differently across performers.

9 Discussion

From the study, it was found that Layika can function as an assistive musical instrument for practice rather than a performance. The participants found the glove useful for solo rehearsals as it mapped the corresponding Tabla sounds directly to their corresponding gestures and helped in maintaining rhythmic structure. However, it lacked the ability to produce expressive, and complex sounds an actual Tabla can make. So more than a performance, this is a tool which supports learning and exploration in the absence of live tabla accompaniment.

A major strength of the instrument is its thoughtful interaction pattern of overlaying the Tabla audio directly over the very gestures meant to symbolize them. Since the interaction builds directly on existing bodily practice, participants were able to engage with the system with minimal learning effort. This supports prior work suggesting that interfaces rooted in embodied musical knowledge can enhance immediacy and control [9, 10].

Another benefit is that Layika treats rhythmic accompaniment as something generated through the performer's own bodily rhythm, rather than as an external reference. Participants' increased awareness of beat progression suggests that coupling gesture and sound may strengthen rhythmic internalization during solo practice making it easier for them to perform when an actual Tabla is present.

Although limitations were identified, most are addressable and are already being iteratively refined, suggesting that the system can improve substantially over time. Overall, Layika demonstrated how tradition-based rhythmic gestures can coincide with sound-producing interactions and elevate the experience in the process.

10 Ongoing Development And Future Work

Over an additional two months of development, we focused on programming the controller so that it was able to better differentiate proper contacts with mis-touches. Shifting to ESP-NOW from Wi-Fi for communication brought down the latency. The details of the design and electronics are present in earlier sections.

For the glove fitting issue, the material was changed from a cotton-nylon blend present in the previous model to a nylon-polyurethane blend described in the design section, which offers a better fit on the hand. The conductive yarn patches on the finger joints were also made bigger and more concentrated with multiple overlapping stitches to help with the contact interaction. Informal testing was carried out keeping in mind the earlier limitations, and an improvement was observed in the targeted areas. A formal user study has not yet been conducted to validate these changes.

In terms of future scope, the current prototype of Layika is tuned only for *Teentaal*, which is a 16-beat rhythmic cycle in Hindustani classical music. However, there are several other *Taals* also present in Hindustani music. The primary counting gestures remains the same across different *Taals* [21], with the thumb touching the finger pads, but with different groupings and percussion audio. In future iterations, the glove can be developed further to cater to this variety of rhythm cycles. This would allow performers to explore a wider range of rhythmic structures using the same gestural vocabulary rooted in tradition.

11 Conclusion

This work explored how a gesture grounded in long-standing musical practice can be extended into a meaningful interactive instrument. Layika was designed around the finger-counting gestures used by vocalists to maintain *Taal*, with the intention of transforming an existing silent practice into an active, sound-producing accompaniment. By doing so, the system addresses a common pain point in solo practice—the absence of a responsive Tabla accompanist and the limited sense of agency offered by metronomic or prerecorded rhythm tools [2].

Throughout its development, close attention was given to the finer details of interaction, including finger contact, glove fit, latency, sensing reliability, pressure sensitivity, and sound response. These factors proved critical in shaping how natural and usable the instrument felt, and informed multiple rounds of iteration aimed at refining the overall experience. The resulting prototype demonstrates that careful tuning of these interaction parameters is essential when translating embodied musical gestures into digital form.

While the current version of Layika cannot yet replace the expressive depth of a live accompanist, the study findings indicate that it functions effectively as a practice-oriented instrument. A future user study will help further evaluate the refined prototype, but the present work suggests that gesture-driven accompaniment holds promise to support rhythmic understanding, agency, and engagement during individual musical practice.

12 Ethics Statement

The participation in the study was voluntary, and consent for recording the required data was taken before the study. No personally identifiable information was collected beyond participants' musical background relevant to the study. Any responses, observations, and feedback were anonymized during analysis and reporting. The study did not involve any physical, psychological, or emotional risk beyond normal interaction with a wearable prototype similar to commonly used electronic devices. All data collected were used solely for academic research purposes and are reported in anonymized form in the submitted manuscript.

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