Calligraphy Echo: Sonifying Chinese Calligraphy with MIDI-Enabled Brush

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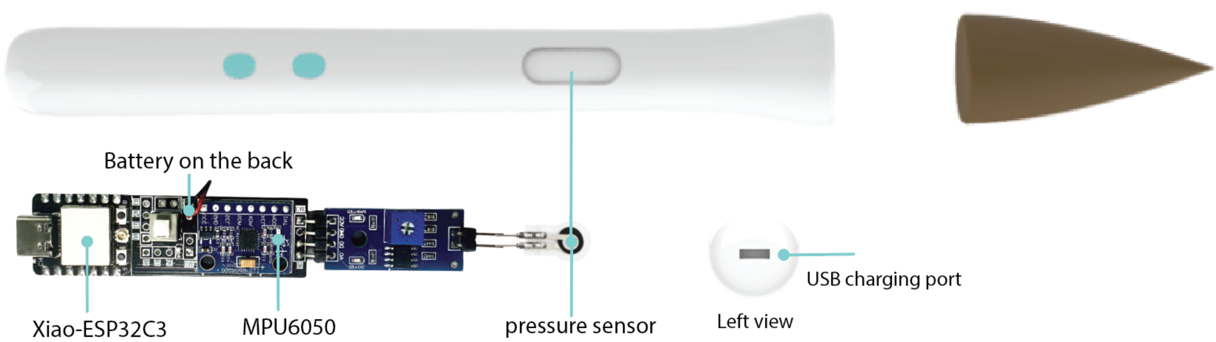

Figure 1: The MIDI-enabled brush system in action, capturing pressure, speed, and rotation to generate synchronized sounds from traditional Chinese instruments.

Abstract

Traditional Chinese calligraphy, a vital intangible cultural heritage, is typically experienced as static artworks, which obscures the dynamic rhythms, force variations, and emotional nuances inherent in its creation. This gap hinders public engagement and contributes to high dropout rates in calligraphy education. We introduce Calligraphy Echo, a MIDI-enabled brush that translates real-time brush dynamics—such as pressure, speed, and rotation—into auditory feedback via traditional Chinese instruments. This sonification makes the art's "hidden" essence audible and tangible, fostering greater accessibility and immersion for contemporary users.

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CCS Concepts

• **Human-centered computing** → **Interactive systems and tools**; • **Applied computing** → **Sound and music computing**; **Arts and humanities**.

Keywords

Sonification, MIDI, Chinese Calligraphy, Cultural Heritage, Interactive Art

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1 Introduction

In today's digital era, Chinese calligraphy, recognized by UNESCO as an intangible cultural heritage since 2009 [une 2009], faces challenges in sustaining its legacy amid declining interest. Its complexity and static presentation as finished artworks often deter learners and viewers, obscuring the dynamic brush techniques, such as pressing and lifting (ti'an), pivoting (zhezhuan), and rhythm, that embody its emotional and artistic essence. Traditional teaching struggles to convey these nuances, limiting broader engagement. Our project introduces a novel sonification system that transforms these movements into real-time auditory feedback using MIDI technology, bridging the gap between passive appreciation and active learning to revitalize calligraphy's cultural relevance (see figure 1).

2 Related Works

Prior work explores gesture-to-sound mapping in calligraphy [Kang and Chien 2010], sensor-augmented learning [Gong et al. 2025], and MIDI-based pedagogy [Riley 2022]. VR-based heritage interaction [Ji et al. 2021; Nie and Guo 2024] inspires multisensory design. Our work extends these by integrating real-time stroke classification and culturally grounded sonification within a wearable brush form factor.

3 Our Approach

Calligraphy Echo integrates hardware, software, and acoustic mapping to sonify brush movements.

The brush's hardware core includes a PCB with Xiao-ESP32C3 microcontroller, MPU6050 (3-axis accel/gyro for speed/rotation), RP-C5-ST-LF5 pressure sensor (thumb-mounted for holding force), and linear voltage module. Programmed via Arduino IDE, it uses Kalman/smoothing filters (error < 0.01) to process motion data, with thresholds tuned by expert calligraphers' sensor data. We built a rule-based classifier (using expert data) to recognize key calligraphy strokes: heavy downward strokes, turning motions (zhezhuan), and speed-up strokes. Processed data is converted to MIDI via the ESP32-BLE-MIDI library for wireless BLE transmission, with mappings like note-on linked to pressure and velocity to speed (see figure 2)

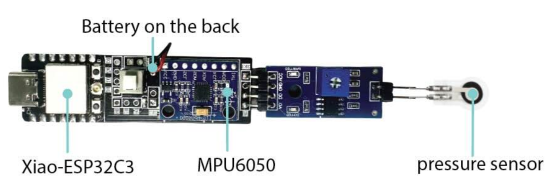

Figure 2: Hardware structure of the MIDI-enabled brush, showing the embedded sensors and microcontroller.

For software-hardware interaction, MIDIberry receives BLE MIDI signals from the ESP32 on Windows, routing them to a virtual MIDI port created by LoopMIDI. Ableton Live uses this port as an input for real-time, cable-free MIDI data. Brush movements trigger BLE MIDI packets, which MIDIberry converts, LoopMIDI routes, and Ableton processes for sound generation (see Figure 3).

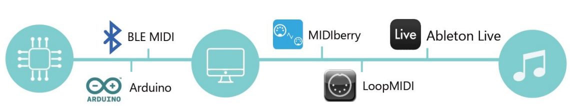

Figure 3: Software interaction diagram showing the flow from MIDI signals to sound generation.

In the software layer, we invited seven participants with over seven years of calligraphy experience to evaluate action-sound mappings. Using a MIDI keyboard to simulate calligraphy movements, we triggered sounds in Ableton Live across four tracks with Kontakt plugins, featuring traditional Chinese folk instruments. Participants assessed the matching degree of actions to sounds, determining optimal instrument assignments: a synthesized pad for continuous background ambiance, taiko drums for heavy downward dot-like strokes, yangqin for rapid arpeggios on fast strokes, and pipa for turns with grip-modulated reverb intensity. Notes used a pentatonic scale, arranged rhythmically to reflect calligraphy flow (see Figure 4).

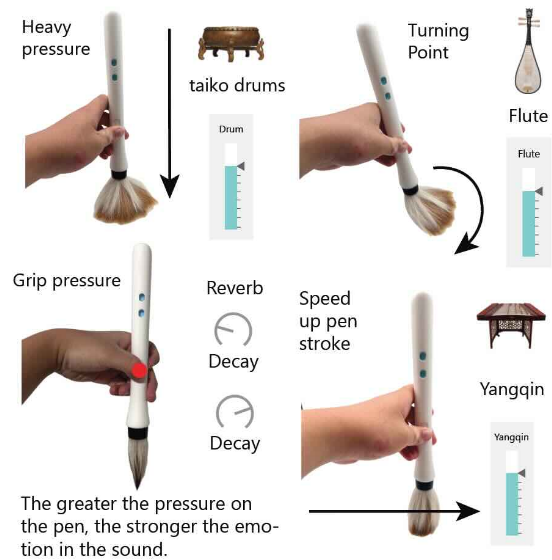

Figure 4: Mapping of brush movements to musical elements in the software layer.

4 Conclusion and Future Work

From April to July 2025, we conducted two rounds of user testing with seven calligraphy-experienced students through hands-on sessions, interviews, and questionnaires. Feedback showed a positive experience but noted latency issues from MIDI congestion or imprecise mappings. Users suggested customizable mappings for better playability. Future work includes using machine learning for precise mapping, timestamp algorithms for reliable MIDI transmission, and an app for user-defined action-sound mappings (see Figure 5).

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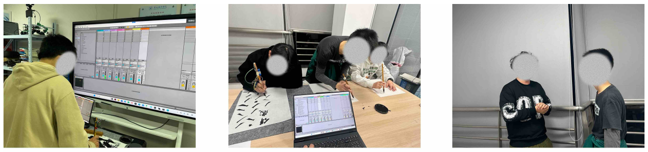

(a) First round of user testing (b) Second round of user testing (c) Interview and questionnaire

Figure 5: Photographs from user testing sessions showcasing participant engagement.

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