MelodicBrush: A Cross-Modal Link between Ancient and Digital Art Forms

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Abstract
MelodicBrush is a novel cross-modal musical system that connects two ancient art forms: Chinese ink-brush calligraphy and Chinese music. Our system endows the process of calligraphy writing with a novel auditory representation in a natural and intuitive manner to create a novel artistic experience. The writing effect is simulated as though the user were writing on an infinitely large piece of paper viewed through a viewport. The real-time musical generation effects are motivated by principles of metaphoric congruence and statistical music modeling.

Keywords
Cross-modal Interaction; Chinese calligraphy; Chinese music

ACM Classification Keywords
H.5.2. User Interfaces: Input devices and strategies; H.5.5. Sound and Music Computing: Methodologies and techniques.

General Terms
Human Factors, Design.

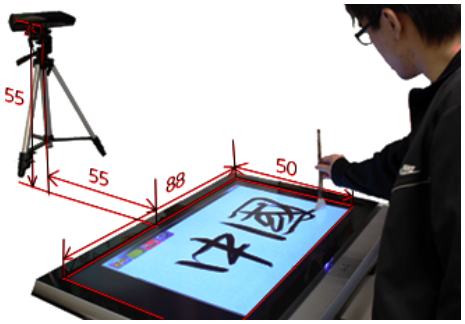

figure 1. System setup. (Size units in centimeters)

figure 2. Some participants are writing calligraphy using MelodicBrush system.

Introduction

This paper presents a novel cross-modal musical system that links together two ancient art forms: Chinese ink-brush calligraphy and the composition and playing of Chinese musical instruments. These two art forms are inextricably linked in Chinese art and heritage. The practice of both art forms is traditionally linked to "culture of mind and character". The musical tabulature used in Chinese music also closely resembles Chinese characters.

There has been much interest in the field of computer music and graphical simulation of calligraphic art, and a myriad of attempts have been made to link drawing with music. However, despite the strong historical tradition, little work has been done on linking calligraphy writing and music, or on a real-time mapping between such diverse art forms.

From the human computer interaction perspective, we are proposing a real time mapping mechanism for ink brush calligraphy writing and Chinese music composition. Our work therefore creates a novel, intuitive and cross-modal art system, which facilitates a new possibility of art creation. From the perspective of Chinese culture, our approach brings the ancient Chinese art forms into the digital age. It therefore conduces to the preservation and evolution of these ancient culture and media.

Related work

There has been much previous work on combining human motion or activity with sound to create a new art form. Some involve intentional motions: for instance, in the form of tangible interaction [3] 2D drawing [1] or 3D spatial interaction [8]; other approaches use statistical models to generate music corresponding to user interactions or signals [6,7,9].

The MelodicBrush system combines the use of a conventional ink brush and a display surface. This combination of tangible and digital is similar to that of FluidPaint [10], but with a simpler implementation.

There have also been some efforts on generating music in response to brushstrokes. DrawSound [4] explicitly maps the position and pressure of brushstrokes on a conductive surface to sound frequencies. The Hé system [5] is the most similar in idea to ours by generating music corresponding to Chinese calligraphic strokes. However, the design of the Hé system was not intended for real-time, stroke-by-stroke composition of music.

Design and implementation

Similar to previous work [2,11], the MelodicBrush system utilizes the Kinect depth camera to turn a non-sensing surface into a touchpad. The system consists of vision, graphics and music generation components. Users draw strokes on a screen surface with a normal calligraphic brush, and manipulate the drawing area with their free hand (see figure 1). The depth camera captures the writing state of the user, including the position of the brush and the free hand. The brush effect is recreated in real time. At the same time, the melody is generated according to stroke parameters.

Vision-based Modeling of Writing Mechanics

In the MelodicBrush system, the fingertips modeled as rigid objects and the brush bristles as deformable objects. Background extraction is performed on the temporal filtered depth map obtained from the camera.

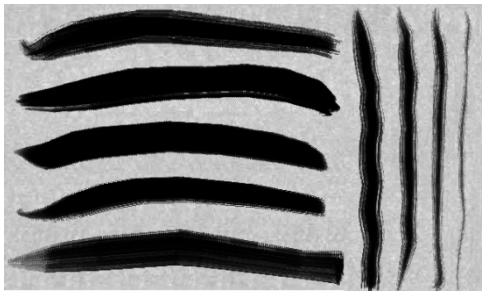

figure 3. The brush stroke effects with different bristle textures and writing pressure levels.

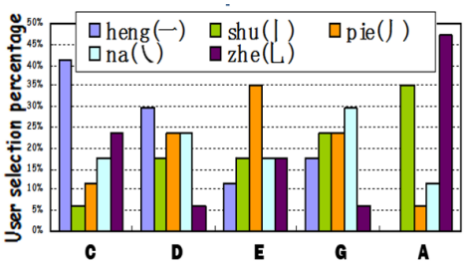

figure 4. Result of experiment mapping calligraphic stroke to musical notes. There is a significant correlation between the stroke and the musical note that is mapped to it ($F_{4,80}=3.65$, $p<0.01$), especially for the lowest, highest, and middle pitched notes.

The locations of the fingertips are then estimated by projecting the centroids of the convex points from the hand silhouette into 3D space. In the brush estimation, a point-based detector is used to approximate the brush handle in the depth map. Probabilistic Hough transformation is applied to form the brush contour, and Kalman filter to track the brush motion between frames.

Graphical Recreation

The user motions detected by the vision estimation component are processed into graphical feedback for the users. The writing pressure is modeled as a function of the distance from the brush-end to the writing surface and the brush orientation, and the strokes segmentation is determined by the brush bristles leaving the writing surface. To generate a stroke, the detected touch points are first smoothed using Gaussian filter, and then connected by polygons along the stroke trajectory. The size and transparency of the polygons are adjusted with changes in the writing pressure (as presented in figure 3).

Our graphical recreation system is not intended to completely replicate physical ink brush writing on paper. Instead, we aim to provide visual feedback to the calligrapher with digital signals. This allows us to create visual effects and feedback that would be impossible under the physical paper medium, such as special smoothing effects, or user interaction effects.

Music generation

The music composition of MelodicBrush involves generating music corresponding to the calligraphic strokes as they are written by the user.

To guide the musical generation, we look to neuroscience findings on metaphoric congruence. We conjecture that the musical effect is most pleasing when the melody is congruent with the calligraphic strokes and motion. Our challenge is then to find that "natural" mapping from stroke to note.

Chinese music uses a pentatonic scale, with five notes that match to the notes C, D, E, G, A on the Western scale. The *Wubi* method of Chinese character input also classifies written strokes into five categories. We asked 17 users to listen to generated notes, and to identify the calligraphy stroke that most corresponded to each note. The order of presentation of the notes was randomized and the experiments repeated multiple times to eliminate order effects. The results suggest that there is a natural mapping between stroke and note (as presented in figure 4)**.**

Our final music generation maps the first four strokes (*heng, shu, pie, na*) to the first four notes (C, D, E, G), with the note for the fifth stroke being generated according to a bigram music model trained on Chinese musical scores. A similar statistical model also generates the harmony for a better musical effect.

User interactions

In addition to the stroke and music generation, MelodicBrush also has a number of special features, which were developed according to user feedback:

Viewport dragging and scaling

We presented the MelodicBrush writing surface as a viewport on a piece of paper of infinite size. Using their free hand, users may position the viewport on any part

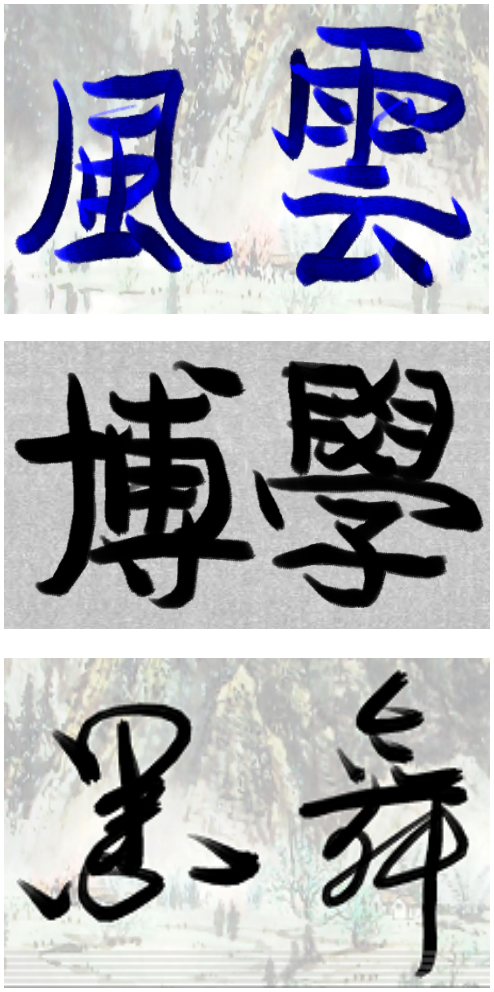

figure 5. Some of the users' artworks.

of the paper. They may also scale the viewport to get a bigger or more detailed view of their work.

Visual Music Generation Feedback
To give the user a better sense of his composition, the musical score is generated across the bottom of the viewport. Notes that correspond directly to calligraphic strokes are shown in red, notes generated by the bigram model as harmony are shown in black.

Self-Collaboration and Multi-part Composition
In addition to real-time composition, MelodicBrush also enables self-collaboration and multi-part composition through record, reset and undo functions. Users may replay a portion of their artwork, while simultaneously writing new strokes, thus generating a composite multi-part melody. The ink color, bristle texture and paper texture may also be changed, and changes in the ink color and bristle textures are mapped to changes in the musical instrument, which adds to the richness and diversity of the artwork.

Future work

In our future study, we plan to further investigate the potential cross-modal linkage between Chinese calligraphy and ancient music, so as to design the most intuitive aesthetic mapping between them. We also intend to further study the effects of such cross-modal mappings on user immersion and interaction.

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