

ViolinBrush: Human-Expressive Mappings for Real-Time Robotic Painting

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Abstract

We present *ViolinBrush*, a real-time interactive system that transfers the nuanced bowing gestures of a live violinist to the strokes of a robotic painting arm. Unlike previous creative-robotics projects that treat the machine as an autonomous or pre-programmed agent, *ViolinBrush* is conceived as an *experiment* into whether embodied musical expressiveness can imbue a robot with a perceived humanness. Continuous descriptors of bow *pitch* and *roll* are mapped, respectively, to stroke *stipple density* and *jitter*, allowing micro-fluctuations in performance energy to visibly texture each mark.

CCS Concepts

• **Human-centered computing** → **Activity centered design**; *Visualization design and evaluation methods*; • **Computer systems organization** → *Robotics*.

Keywords

multimodal interaction, embodied interaction, robotic art, generative art, robot painting

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1 Introduction

The convergence of embodied musical performance and autonomous artmaking has spurred new modes of hybrid expression. While recent systems may sonify robotic motion or visualise audio, few close the loop to allow performers to *play* a visual artefact with expressive intent.

ViolinBrush explores this possibility by coupling live bowing gestures from a violinist to a robotic painting system. The robot follows a pre-defined SVG image—in our case, a line drawing of a violinist—but dynamically modulates *how* the image is rendered based on the performer's motion. Gesture features such as roll and pitch control stroke width, jitter, and stipple density, allowing

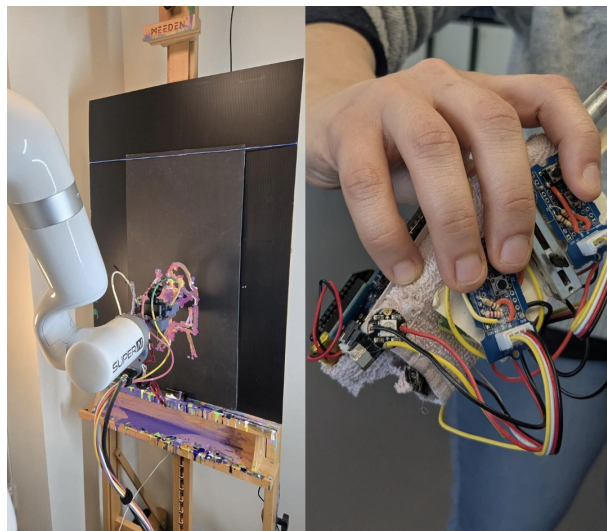


Figure 1: Picture of robotic arm painting and violinist using interface

subtle variations that mirror the energy and articulation of the performance (Fig. 1).

Our aim is to investigate whether simple, perceptually grounded mappings can convey expressive nuance in a visual medium. Rather than treating the robot as an autonomous painter, we frame it as an *expressive prosthesis*—a responsive extension of the performer that raises questions of authorship, gesture legibility, and shared agency.

2 Related Work

Augmented string instruments. Hyper-instruments such as the Hyperbow [1, 9] and MIGSI trumpet [3] emphasise detailed gesture capture for extended control. [4–6] introduced a wireless audio-visual violin bow that prioritised minimal invasion and bidirectional mapping.

Creative painting robots. From portrait robots [8] to music-driven plotters [2], robotics has long infiltrated visual art. However, most systems pre-compute strokes or operate offline. Our work builds on our past work developing a real-time arm responding to onset density, adding finer gesture coupling and SVG fidelity [7].



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3 System Overview

3.1 Bow Interface

A custom interface mounts onto the frog of the violin bow using a flexible textile wrap. It transmits data wirelessly via an Arduino Fio and XBee radio. A Grove 3-axis accelerometer ($\pm 1.5g$) provides continuous readings of force, pitch and roll. Button inputs (1–4) signal brush changes and define section boundaries during performance.

3.2 Max/MSP Processing

Accelerometer data is received, smoothed, and analyzed in real time within Max/MSP. Button presses delineate expressive sections and switch brush channels. Frame-by-frame data is streamed into ‘coll’ objects and dynamically converted into SVG path instructions for robotic playback.

3.3 Robotic Arm

The painting agent is a UR3 robotic arm controlled via Python. After a one-time calibration to locate canvas corners, a homography function maps each 2D SVG coordinate (x_{svg}, y_{svg}) to a corresponding 3D end-effector position, keeping the brush perpendicular to the surface.

Before each stroke, the arm approaches from a fixed offset, paints with pressure modulated by audio amplitude, and then retreats along the same vector to avoid smudging. All SVG primitives—such as `<path>`, `<rect>`, and `<circle>`—are flattened into absolute Bézier waypoints. These are streamed to the arm in real time via a custom routine (`draw_svg_stroke()`), which applies live modifiers: *speed* (20–5 000 mm/s), *jitter* (0–10 mm), *smoothness* (subdivision density), and *stipple* (probabilistic lift/tap gestures). The result is a layered rendering system capable of filling a 70×50cm canvas with gesture-responsive marks.

4 Gesture Mapping

4.1 Roll → Stroke Jitter

High roll values—arising from ricochet or aggressive *détaché*—yield elevated positional noise injected into the current SVG segment via a Perlin jitter kernel ($\sigma = \alpha \text{ roll}$). The effect manifests as trembling, charcoal-like marks that visually echo bow bounce.

4.2 Pitch → Stipple Density

Bow pitch (tilt forward or back) modulates brush contact cycles: Greater tilt increases contact, shortening lift intervals and producing dense stippling reminiscent of pointillism.

A logistic mapping $d = \frac{d_{\max}}{1+e^{-k(m-m_0)}}$ preserves low-noise control in soft passages while saturating under fortissimo.

5 Performance Case Study

A ten-minute solo violin improvisation was recorded using the bow interface, with button presses marking distinct gestural sections. Each section explored a different expressive mode—such as smooth legato bowing or rapid string crossings—mapped to one of four brush channels.

The resulting data was streamed and converted into modifiers for SVG path instructions that are rendered live by the robot arm.



Figure 2: SVG-driven painting with jitter and stipple modulation.

These were executed by the robot on a 50×70cm canvas (Fig. 2), with visual features such as stroke density and jitter reflecting the energy and articulation of the performance.

6 Discussion and Conclusion

Translating live bowing gestures into robotic motion proved non-trivial. Early attempts to map features like bow speed or gesture classification produced erratic results, as the robot arm could not match the fine-grained dynamics or tempo of human performance. Continuous gesture data changed too rapidly for meaningful visual execution.

This led us to refocus the system around smoothed, more evenly distributed descriptors—specifically, bow pitch and roll—which provided stable spatial parameters for stroke mapping. Attempts to include too many mappings also reduced perceptual clarity, ultimately obscuring expressive intent rather than enhancing it.

The final configuration emphasized simplicity and legibility: pitch and roll defined stroke character and density, while discrete button presses marked colour changes and gestural transitions. *ViolinBrush* shows how even minimal but well-chosen features can animate a robotic painter with traces of live performance. By linking temporal musical gestures to spatial mark-making, the system opens up new possibilities for co-expressive human-robot interaction—where the robot acts not as an autonomous artist, but as a responsive extension of the performer’s body.

References

- [1] Nicola Baroni. 2009. Hyperinstruments as interactive systems of music composition. *Organised Sound* 14, 2 (2009), 181–190. doi:10.1017/S1355771809990163
- [2] Thomas Lindemeier, Jens Metzner, Lena Pollak, and Oliver Deussen. 2015. Hardware-Based Non-Photorealistic Rendering Using a Painting Robot. *Computer Graphics Forum* 34, 2 (2015), 311–323. doi:10.1111/cgf.12562
- [3] Sarah Reid, Ryan Gaston, Colin Honigman, and Ajay Kapur. 2016. Minimally Invasive Gesture Sensing Interface (MIGSI) for Trumpet.. In *New Interfaces for Musical Expression*.
- [4] Anna Savery. 2022. Distracted-A piece for Violin and an Audio-Visual Interface. In *Proceedings of the Sound and Music Computing Conferences*.
- [5] Anna Savery. 2023. Enhancing violin performance through real-time interaction: Design and evaluation of a wireless audio-visual interface. *Chroma: Journal of the Australasian Computer Music Association* 39, 2 (2023).
- [6] Anna Savery, Sam Ferguson, and Andrew Johnston. 2024. Gesture and Narrative: Blending Human Performance with Visual Storytelling. In *New Interfaces for Musical Expression*.
- [7] Richard Savery, Anna Savery, and Justin Baird. 2022. Robotic Arm Generative Painting Through Real-time Analysis of Music Performance. In *HAI '22* (Christchurch, New Zealand). 253–255. doi:10.1145/3527188.3563913
- [8] Patrick Tresset and Frédéric Fol Leymarie. 2013. Portrait drawing by Paul the robot. *Computers & Graphics* 37, 5 (2013), 348–363. doi:10.1016/j.cag.2013.01.012
- [9] Diana Young. 2002. The hyperbow controller: Real-time dynamics measurement of violin performance. In *Proceedings of the 2002 conference on New Interfaces for Musical Expression*.