RELATED WORK

Our motivation is driven by the exploration of the intimate intersection of aesthetic visual design with sound control and audio performance. An early example is The Optophonic Piano. Created by Vladimir Rossiné [1], it spun an aesthetically-driven painting, generating sound via an embedded light sensor as the picture was scanned. Gong et. al [2] started our exploration with conductive inkjet printing and the graphic design of flexible electronics as sensing input devices for various applications such as DIY music controllers. In a recent example, Freed & Rowland made an aesthetic multi-electrode conductive pattern into a distributed speaker "browsed" with a handheld magnet [3].

SYSTEM OVERVIEW

There are four components in this system: 1) parametric graphic design of patterns, 2) sensing interface printout through an inkjet printer (Brother DCP-J140w) with conductive silver ink, 3) a custom-made hardware interface for sensing communication with a computer, and 4) software (MAX/MSP) for computer music generation.

Parametric Pattern Design

The pattern is parametrically-designed in Grasshopper (a plug-in of Rhino). We defined surface boundaries and force vectors manually before using Grasshopper's Spatial Deform function to apply manifold for the visualization of a smooth field. This surface is then sliced using Level Set with a constant height (Z), receiving the contour lines as shown in (Fig 2). A few manual steps are further required to connect the traces and define additional color prints. Once the regions and patterns were designed, we assigned regions of interest as functional inputs (buttons, sliders…etc). To mark the regions visually, we add another layer of color printing to add graphic details and boundaries. We also cut out several regions with a laser cutter to preserve and reveal the original instrument design. The entire surface is a controller - even 'dead traces', such as decorative islands, can be bridged by one's fingers for performance effect.

Rapid Prototyping with Conductive Inkjet Printing

The process we explored is printing conductive traces with silver ink and an off-the-shelf inkjet printer (Figure 3(a)). We adapted conductive silver ink from Mitsubishi Paper Mill and print conductive traces on photo paper or PET films. With this fabrication method, any iteration of the sensing surface only takes less than 5 minutes to construct.

Hardware Interface for Sensing and Communication

There are many ways to detect the varying signal on the conductive patterns such as resistive and capacitive sensing. In our implementation, we adopted capacitive sensing and add expressiveness to the music control by including sliding, pressing, and proximity to the performance. The

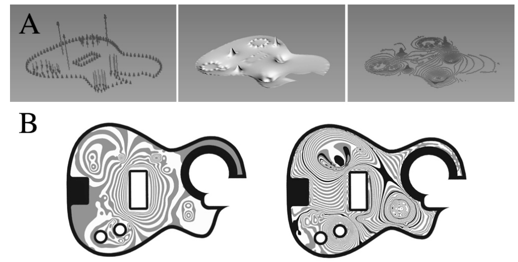

Figure 2. Design process: (A) from vectors to contours, (B) two examples of received patterns.

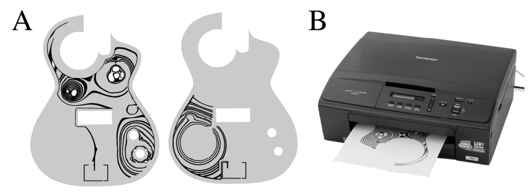

Figure 3. (A) Two examples of tracing continuity in sub-patterns, (B) the printing process.

PCB is attached to the flexible sensor sheet through signal pads at the bottom of the board with the 3M 9703 z-axis conductive tape.

Signal Mapping

The last component is the computer music software, which generates the sonic output of our sensing surfaces. We use Max/MSP as our experiment platform and implemented effects that are mapped to the patterns and buttons that control inputs such as echoing, overdrive, delay, and distortion.

DISCUSSION

Combining sensing-enabled objects and flexible conductive printing, our work serves as a platform for prototyping aesthetic graphic sensing input with high accuracy and reproducibility. Our platform explores the unification of compelling graphics and expressive input devices - a promising way of creating a new form of art that intimately combines graphics, interaction, and music. More information can be found on our website: http://resenv.media.mit.edu/zebra.html

REFERENCES

1. http://baranoff-rossine.com/optophonic-piano/
2. N.-W. Gong, N. Zhao and J. A. Paradiso, "A Customizable Sensate Surface for Music Control," (NIME 12), pp. 417-420.
3. A. Freed, J. Rowland, "Collocated Surface Sound Interaction," in CHI 2013, Interactivity Demo Session