Drawing With Feeling: Designing Tactile Display for Pen

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1 Introduction

There is a sense of satisfaction using a pen or pencil to write or draw. Feeling the imperfections on the paper as the pen tip moves over it and observing marks emerge create the inherently physical and intimate feeling of drawing. Our extensive discussions with artists and designers suggest that this physicality and intimacy with drawing not only brings enjoyment, but also perhaps assist in the artist's creative process.

Unfortunately, most of this physicality is lost when computers are substituted for paper. Today's tablet-based pen input devices provide only one channel of communication – from the user to the computer. Hence, the user not only loses the natural properties of real drawing, but furthermore, the potential benefit of using a computer is not fully exploited to aid the creative process.

We aim to overcome these problems by enhancing the pen with a miniature tactile display to allow users to interact with the drawing in the most natural way – through his or her hand. Our tactile pen is based on the TouchEngine™, a novel actuator, which is miniature, lightweight and low-powered, making it easy to embed even into small devices such as the pen. We are investigating interactive applications of pen tactile interfaces in a number of application scenarios described below. Unlike related projects [1], we do not attempt to simulate exactly the physical properties of the pen and paper. Instead, drawing with the computer should, perhaps, feel different, supporting functions unique to drawing with the computer and not possible with a real pen and paper.

2 TouchEngine™ tactile display

The major obstacle in developing a tactile display for a pen is the actuator. We do not know of any actuators that have low latency, are small enough to fit inside a pen, are low power to allow wireless construction, and can provide enough physical force all at the same time.

The TouchEngine is an actuator that we designed to meet these requirements. It is constructed by sandwiching thin piezoceramic film (0.25 μm) in between adhesive electrodes, which makes a thin ~0.5mm beam (Fig. 1a). The piezoceramic material works as a solid state "muscle" by either shrinking or expanding depending on the polarity of the applied voltage. The material on the top has an opposite polarity than the bottom, so when a signal is applied, the entire structure bends. Hence, this configuration is often called the *bending motor*. Bending motors that currently exist consist of only two layers (biomorphs) and require a minimum of ±40V, making them unsuitable for small devices. By sandwiching multiple layers of piezo material, while keeping total thickness the same, we can significantly reduce the required voltage and produce sufficient feeling with only 5-7V.

Two strategies have been developed to produce tactile feeling with the TouchEngine. In *direct tactile display*, the actuator would move at an area of the pen where the user touches (fig 1, b). In i*ndirect tactile display*, the actuator is placed somewhere inside the device with a weight attached. When the actuator bends, the mass moves rapidly up or down moving the entire device with equal momentum in the opposite direction. This allows the user to feel a force impulse from the pen.

3 Drawing with tactile feedback

To investigate how tactile feedback can enhance drawing, we embedded a TouchEngine into a Wacom pen and used it with a Sony VAIO LX PC, which has the Wacom pen input technology built into the screen. Although we currently use wire to connect the pen to the driving circuit, a wireless version is under construction.

We investigated a number of scenarios. In one scenario, the user is able to feel patterns, lines, or colors allowing the user to distinguish parts of an illustration by touch. Because the Wacom tablet tracks the pen even when it does not touch the tablet, in another scenario, the user is able to feel control points for Bezier curves before selecting them making it much easier to pick the desired control point. We also experimented with the use of tactile feedback during free-hand drawing and allowing the user to feel different colors. By combining feedback with pressure sensitivity, the user can also feel the line thickness.

The initial demonstrations received positive response from artists and designers. We believe that enhancing drawing with tactile feedback will open new and exciting opportunities in interactive computer graphics applications. We are currently developing a wireless version of this device, enhancing existing application scenarios, and investigating new applications.

References

1. Baxter, B., et al. DAB: Interactive Haptic Painting with 3D Virtual Brushes, *Proceedings of SIGGRAPH 2001*, pp 461-468

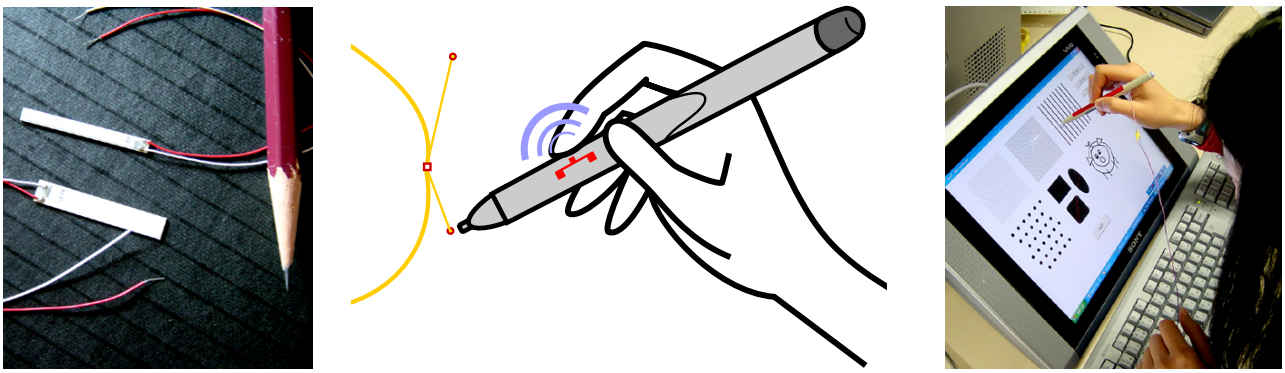

Figure 1: (a) Actuators: 3 mm and 5 mm width, 0.5 mm thick (b) pen construction (c) initial applications