GaussBrush: Drawing with Magnetic Stylus

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Abstract

GaussBrush is a magnetic stylus based on *GaussSense* technology, which utilizes a thin magnetic sensor grid that can be directly attached to the back of the touchscreen device to enhance its stylus input capability. Utilize the enabled features such as discriminating the stylus events from the finger touch events, determining stylus tilt angle and stylus tip's pressure, and locating the position above where the stylus hovers, more natural sketching experiences are provided. In the demonstrated drawing application, a user can use a *GaussBrush* to draw a stylized stroke by tilting it or stressing the its tip with different levels, use another side of the stylus to erase unwanted strokes, or hover the stylus at a boundary of the display to access an off-screen color swatch from which a new color can be selected. While drawing, the user still can use finger gestures to pan and zoom the canvas. The combination of *GaussBrush* and *GaussSense* extends the design space of Pen+Touch interaction.

CR Categories: H.5.2 [Information Interfaces and Presentation]: User Interfaces—Prototyping; I.3.1 [Computer Graphics]: Hardware Architecture—Input devices;

Keywords: Magnetism, Touchscreen, Stylus

1 INTRODUCTION

People increasingly rely on stylus in some mobile applications, such as taking notes. However, conventional handheld devices overlain a transparent resistive- or capacitive-based touchscreen provide limited supports on stylus detection. For instances, resistive-based panel cannot easily sense its angle of tilt or position where it hovers, capacitive-based panel cannot reliably distinguish between a finger tip event and a stylus tip event, etc. Though using external cameras can capture stylus and identify subtle operations [Bi et al. 2008; Vogel and Casiez 2011], the sensors are usually lack portability. Some manufacturers have started to integrate an additional stylus sensor with display modules tightly, such as N-trig DuoSense [Perski and Morag 2002] and electromagnetic resonance[1] (EMR) sensors to enhance stylus detection. However, these sensors cannot simply retrofit existed devices, because the sensors need to be integrated with the touchscreen module tightly. Hence, in terms of compatibility, *GaussSense* [Liang et al. 2012], which is an add-on sensing method based on magnetic penetration, is developed to enhance stylus input without losing mobility or the need of modifying the device.

In this work, we demonstrate *GaussBrush*, to show how natural drawing experiences can be provided by *GaussSense* technology. *GaussBrush* is a customized magnetic stylus, which can be detected by the a 2mm-thick magnetic sensor grid. Inside the *GaussBrush*, we embed a 3cm-height-8mm-diameter magnet stack into the stylus to provide strong magnetic field. When the *GaussBrush* is approaching to the sensor, the stylus position and state can be recognized based on the sensed distribution of magnetic field. Therefore, several features such as discriminating the stylus events from the finger touch events, determining stylus tilt angle and stylus tips pressure, and locating the position above where the stylus hovers can be enabled with ease. The combination of *GaussBrush* and *GaussSense* provides a rich extension for Pen+Touch interactions.

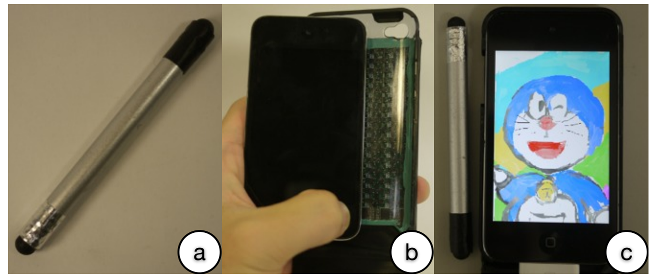

Figure 1: *(a) GaussBrush is a magnetic stylus which can be sensed by the (b) thin magnetic sensor grid attached behind a touchscreen device. (c) Sample drawing results by using GaussBrush.*

2 DESIGN

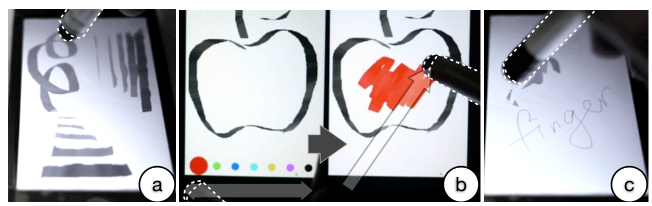

Figure 2: *Natural drawing application. (a) Pressure and tilt angle of the GaussBrush can be detected. (b) Hover the GaussBrush on the boundaries to pick a new color. (c) Erase unwanted strokes using another side of GaussBrush.*

We demonstrate the interaction design of using *GaussBrush* by the natural drawing application (Figure 2(a)). To simulate the drawing experiences in our daily life, the canvas contain no tradition GUI elements such as menus or buttons in the viewport. If a user want to draw a stylized stroke on the canvas, he or she can tilt the *GaussBrush* to change the thickness of the stroke, or stress the tip of the *GaussBrush* with different levels to change the color intensity of the stroke. If a new color is needed, a user can hover the stylus at the bottom boundary of the display to access an off-screen color swatch, then hover to the desired color to select it (Figure 2(b)). A new type of brush can also be selected in the similar manner on the top boundary of the display. If an unwanted stroke is caused, the user can flip the *GaussBrush* to another side, where another stylus tip is also installed, to erase the stroke as if using an eraser behind the pencil (Figure 2(c)). If the user want to move, pan, and zoom the canvas, he or she can simply move the *GaussBrush* away from the display, and use finger to manipulate the canvas by multi-touch gestures. The user can double tap on the top-left corner to request a new sheet for drawing. The design of this application utilize users' original knowledge to provide natural drawing experiences.

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3 IMPLEMENTATION

3.1 Hardware

An unmodified capacitive touchscreen device, iPod Touch[2], was used here for proofing the concept. A prototype *GaussBrush*, which embedded different stack of 8mm-diameter cylindrical neodymium magnets on its both end: one is 30mm-height, and another one is 2mm-height, is embedded into a conductive aluminum pipe. On each end of the *GaussBrush*, a rubber tip torn down from an Elecom iPhone stylus[3] was installed (Figure 1(a)).

The magnetic sensor grid, which is 60(W) $\times$ 80(H) mm^2 and made of 12 $\times$ 16 = 192 Winson WSH138 Hall sensors[4] in a grid manner, is fixed on an acrylic case, which can be attached on or detached from the iPod Touch easily (Figure 1(b)). The captured sensor data range from 0 to 200 gauss, is upsampled by bi-cubic interpolation to 352 $\times$ 480 as a magnetic field image consistently above 60fps. All sensor data is multiplexed and transferred to a PC through a Teensy 2.0 micro-controller[5] via USB connection, and transferred to the iPod Touch through OSC protocol wirelessly.

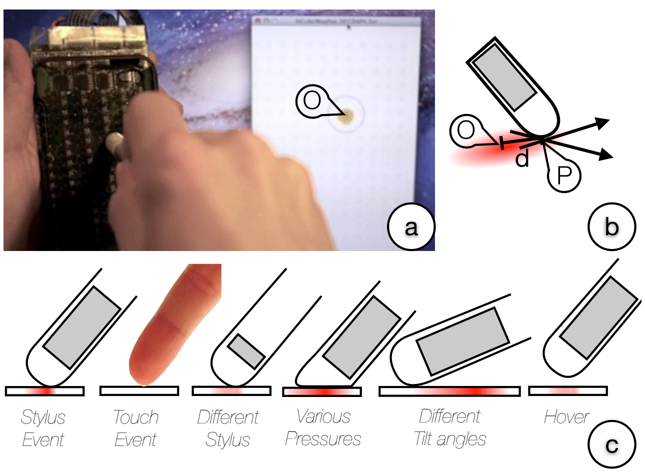

Figure 3: *(a) Result image of the applied magnetic field. The red area indicates the magnetic field image. (b) Principle of signal processing. (c) Supporting functions.*

3.2 Signal Processing

The magnetic field image is obtained in each frame. Once a new image is constructed, the centroid of the applied magnetic field, O and the magnitude of the field M can be obtained as the position and the magnitude of the magnetic stylus (Figure 3(a)), respectively. The actual stylus touch point obtained from the touchscreen, P, along with O and M (Figure 3(b)), can be used to enable several features of stylus to be detected, including discriminating the stylus events from the finger touch or other stylus events, determining stylus tilt angle and stylus tips pressure, and locating the position above where the stylus hovers (Figure 3(c)).

[2]http://www.apple.com/ipodtouch/
[3]http://www.elecom.co.jp/
[4]http://www.winson.com.tw/
[5]http://www.pjrc.com/teensy/

4 DISCUSSION

In terms of limitation, as mentioned in [Liang et al. 2012], the sensor board may need to be kept parallel and aligned to the front interaction area, and the case of the sensor board should not be made of soft materials. Also, the strong magnet embedded in *GaussBrush* may erase content on magnetic strips on credit cards if they are very close. However, this potential hazard does not affect flash storage devices, IC cards, or well-shielded magnetic storage devices.

In terms of possible design, since several features are enabled by *GaussBrush*, well-established user interfaces of stylus interaction such as hover widgets [Grossman et al. 2006], pressure widgets [Ramos et al. 2004], and tilting menus [Tian et al. 2008] can be included in the application for advanced editing. Moreover, since finger and stylus can be reliably detected simultaneously, these new features can be brought into the design of Pen+Touch interaction [Hinckley et al. 2010].

Since larger capacitive touchscreen devices such as tablet computers are sufficiently thin to deploy *GaussSense* sensor, future work should consider to use *GaussBrush* with tangible UIs [Yu et al. 2011] in personal editing or multi-user collaboration.

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