

Sketouch: Transparent Electro-Tactile Display for Mobile Surfaces

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Abstract

An electro-tactile display is a possible candidate for a truly tangible multi-touch interface for four reasons. First, it only requires an electrode substrate that can be made transparent and thin. Second, it has a potential to present high-resolution tactile information of 3mm or less, which is preferable for shape presentation. Third, its principle is active so that it does not require user's finger motion. Fourth, the electrical stimulation can be innately used for multi-touch sensing. This paper introduces a prototype transparent electro-tactile display mounted on mobile devices.

CR Categories: H.5.2 [Information Interfaces and Presentation]: User Interfaces—Haptic I/O H.5.2 [Information Interfaces and Presentation]: User Interfaces—Input devices and strategies

Keywords: electrical stimulation, haptics, tactile display, transparent electrode

1 Introduction

Power of multi-touch interface incorporated with visual display is broadly recognized in general public, with successes of commercial portable devices such as iPhone. As the touch panel does not have physical cues such as bumps and edges of a keyboard, applying tactile display technology to the touch panel was studied intensively. However, most of them have a spatial resolution of about finger size, which can present simple tactile icons, large bumps and textures of virtual material, but not the information of detailed shapes.

If the detailed shape can be presented via tactile channel, it will enlarge the potential of multi-touch interface. For example, well-known fat-finger problem might be solved by presenting hidden visual information under the skin onto the skin surface [Baudisch and Chu 2009]. We may also be able to change the subjective contact size of the finger, which should contribute to relatively precise drawing tasks (Figure 1). In other words, high-resolution tactile display incorporated with visual display will change the mobile device from *viewer* to *stationery*.

The tactile interface that allows such interaction has the following technical requirements.

- It must be transparent and thin, to be incorporated with visual display.
- It must have the potential to present high-resolution tactile information. 3 mm or less is desirable based on the tactile spatial resolution of fingertips [Weinstein 1968].
- Active display is desirable compared to passive one. Active in this case means that the sensation is presented without skin movement (e.g. vibration motor type), whereas passive means the sensation is only generated when the skin moves (e.g. friction controlled type that will be described in the next section). The passive one is capable of presenting material and surface textures, but not tactile icons such as blinking.

- It must not hinder multi-touch sensing.

This paper introduces a prototype to satisfy these requirements by using electro-tactile display.

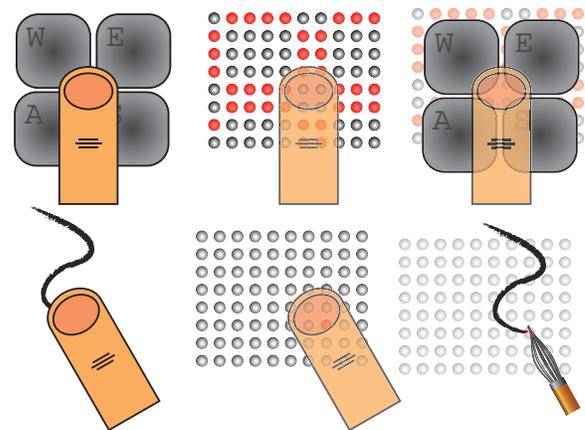


Figure 1: Multi-touch interface with tactile display. What the users see (left), feel (middle), and imagine (right).

2 Related works

In order to present visual as well as tactile information, the tactile display should be transparent, to be incorporated with visual display. However, few types of tactile displays currently possess the potential to be transparent.

One type of tactile display incorporated with touch panel vibrates the whole surface. Simple vibration of the display surface when it was in contact with the finger generates a clicking sensation [Fukushima and Sugimura 2001] [Poupyrev and Maruyama 2003]. Another principle called the "squeezing effect" was also utilized to control friction coefficient of the plate surface [Nara et al. 2001] [Winfield et al. 2007] This type of displays can be manufactured relatively easily using a small number of actuators, but the spatial resolution is limited.

Another recently relighted technology uses an electro-static effect [Kaczmarek et al. 2006] [Bau et al. 2010]. The electrodes are located under an insulator layer, with which the finger makes contact. When a high voltage is applied to the electrodes, the skin connects to the electrodes by electro-static force. This is a relatively simple method with a potential to achieve high spatial resolution. However, the sensation is presented only when the finger moves, because users do not detect the electro-static force itself, but they detect horizontal deformation of the skin produced by contact between the skin and the electrode and the relative movement of the finger.

The other type of display is an electro-tactile display [Collins 1970] [Tachi et al. 1985] [Bach y Rita et al. 1998]. In contrast to an electro-static display, this type of display directly activates sensory nerves via an electrical current. The potential resolution of the

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display is much higher than that of the vibrating-plate type. In addition, tactile sensation can be presented without the user's motion, in contrast to the electro-static type. An additional touch sensor is not necessary, because finger position can be detected by monitoring the stimulating current. The author has proposed stabilizing the sensation by measuring skin impedance in real time, using a stimulating pulse[Kajimoto 2012b].

3 Hardware

Figure2 shows a prototype electrode substrate mounted on an LCD. The substrate contains 8 by 8 electrodes, 1 mm square, 3 mm interval. The electrodes and wiring are made by ITO(Indium Tin Oxide), which is normally used for LCD. The figure shows that although the electrodes can be visually observed when the LCD is off, it is almost transparent when in use.

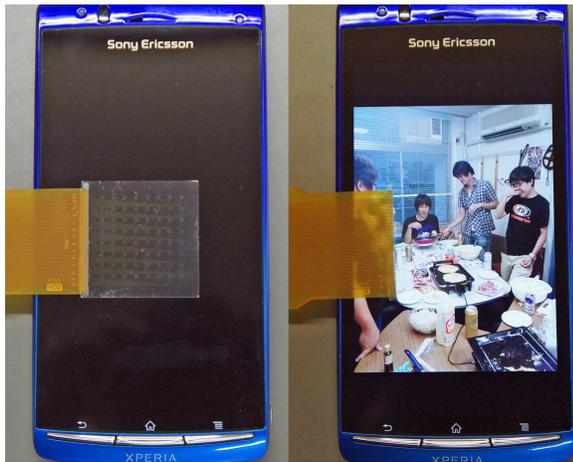


Figure 2: Prototype of transparent electro-tactile display.

Figure3 shows the system structure. Electrical stimulation parts are almost similar to the authors' previous development [Kajimoto 2012b], with slight revision of electric components. A pair of top/bottom switches is connected to each electrode. If the top switch is on, the electrode works as an anode, while if the bottom switch is on, it works as a cathode. At one moment, a single electrode is set as an anode and all the other electrodes work as cathodes. A two-dimensional pattern is produced by scanning. The stimulating pulse is current-controlled, driven by a high-voltage source (350 V). The voltage of the current pulse is measured so that the skin impedance can be obtained and used for multi-touch sensing.

Figure4 shows result of the multi-touch sensing, which was done strictly simultaneously with tactile presentation. The device was demonstrated at the previous Haptics Symposium [Kajimoto 2012c].

4 Conclusion

Current pervasion of multi-touch interface lightened the importance of tactile cues for direct finger manipulation. The ideal tactile display for multi-touch interface should have the following features. It must be thin and transparent, capable of presenting high resolution tactile shape, actively driven so that information is presented without finger motion, and coexist with multi-touch sensing. Most previous proposals on tactile display for multi-touch interface did not fully fulfilled these requirements.

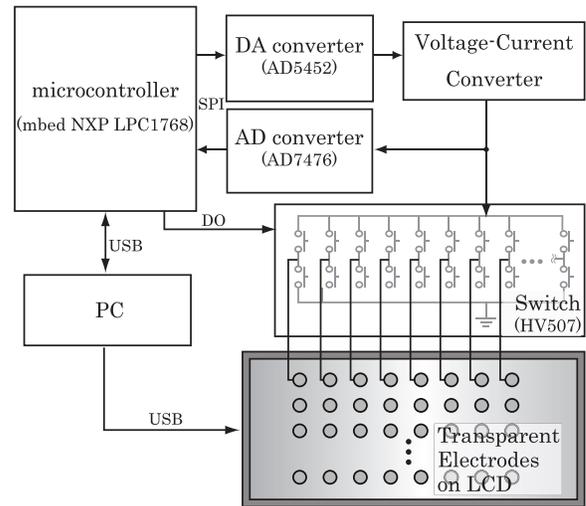


Figure 3: System structure.

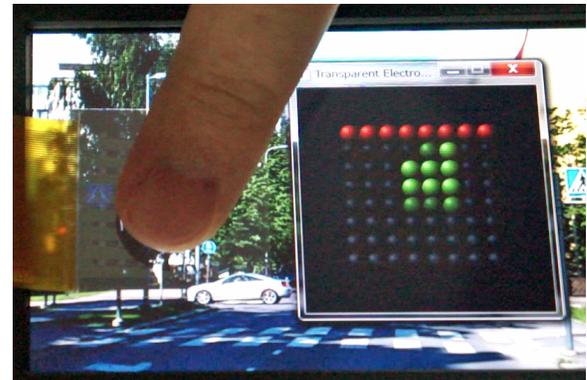


Figure 4: Multi-touch sensing by impedance measurement. Red dots indicate stimulating points (in this case, a line was presented) and green dots indicate skin impedance distribution.

An electro-tactile display is a possible candidate to fulfill all these requirements. This paper introduces a prototype transparent electro-tactile display. 8 by 8 electrodes composed of ITO substrate was fabricated and tested. Display of small shape such as a bar, and multi-touch sensing were validated. Future works include enlargement of the electrodes to cover the whole surface of the mobile device, and development of application. We have recently succeeded in driving more than 1500 stimulating points with ordinary electrodes [Kajimoto 2012a], so the scalability does not seem to be a problem.

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