Interaction Techniques for SmartSkin

Kentaro Fukuchi
Tokyo Institute of Technology
2-12-1 Ohokayama
Meguro-ku, Tokyo 152-8552 Japan
+81-3-5734-3881
fukuchi@is.titech.ac.jp

Jun Rekimoto
Interaction Laboratory
Sony Computer Science Laboratories, Inc.
3-14-13 Higashigotanda
Shinagawa-ku, Tokyo 141-0022, Japan
+81-3-5448-4380
rekimoto@acm.org

ABSTRACT

This paper introduces new interaction techniques for SmartSkin, a sensor architecture for freehand manipulation. This sensor recognizes multiple hand positions and shapes and calculates the distance between the hand and the surface by using capacitive sensing and a mesh-shaped antenna. Our interaction techniques enable the users to use not only their hands, but also their fingers concurrently.

KEYWORDS: gesture recognition, two-handed interfaces, interactive surfaces

SMARTSKIN

SmartSkin[2] is a sensor technique which recognizes positions and shapes of human body. It is based on a capacitive sensing, and accurately tracks the position of the user's hands (in two dimensions) and also calculates the distance from the hands to the sensor. It is constructed by laying a mesh of transmitter/receiver electrodes (such as copper wires) on a surface. As a result, the interactive surface can be large, thin, ore even flexible.

Figure 2 shows the principle of operation of the SmartSkin sensor. The sensor consists of grid-shaped transmitter and receiver electrodes (copper wires). The vertical wires are transmitter electrodes, and the horizontal wires are receiver electrodes. When one of the transmitters is excited by a wave signal (of typically several hundred kilohertz), the receiver receives this wave signal because each crossing point (transmitter/receiver pairs) acts as a (very weak) capacitor. The magnitude of the received signal is proportional to the frequency and voltage of the transmitted signal, as well as to the capacitance between the two electrodes. When a conductive and grounded object approaches a crossing point, it capacitively couples to the electrodes, and drains the wave signal. As a result, the received signal amplitude becomes weak. By measuring this effect, it is possible to detect the proximity of a conductive object, such as a human hand.

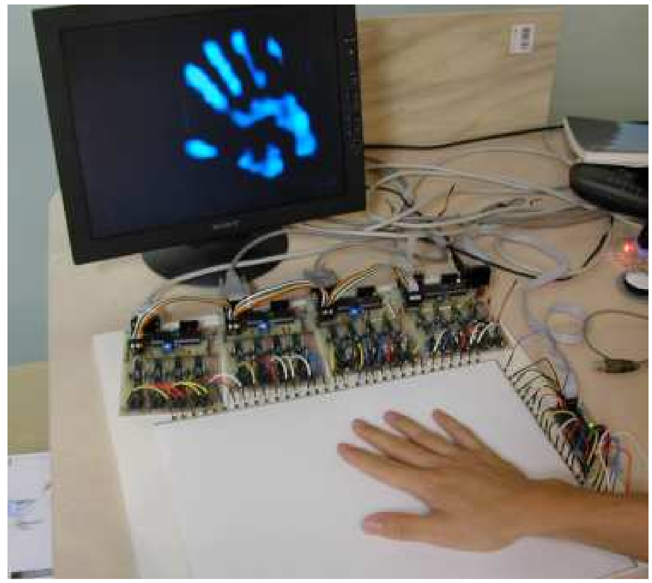

Figure 1: An overview of a tablet size interactive surface based on the SmartSkin sensor.

The system time-dividing transmitting signal sent to each of vertical electrodes and the system independently measures values from each of receiver electrodes. These values are integrated to form two-dimensional sensor values. Once these values are obtained, algorithms similar to those used in image processing, such as peak detection, connected region analysis, and template matching, can be applied to recognize gestures. As a result, the system can recognize multiple objects (e.g., hands). If the granularity of the mesh is dense, the system can recognize the shape of the objects. The received signal may contain noise from nearby electric circuits. To accurately measure signals only from the transmitter electrode, a technique called "lock-in amplifier" is used. This technique uses an analogue switch as a phase-sensitive detector. The transmitter signal is used as a reference signal for switching this analog switch, to enable the system to select signals that have the synchronized frequency and the phase of the transmitted signal. Normally, a control signal needs

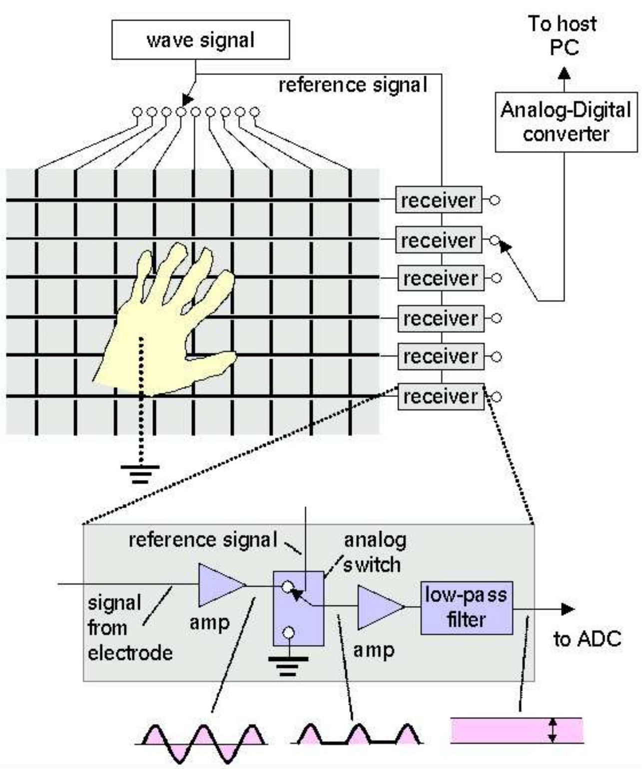

Figure 2: The SmartSkin sensor configuration: A meshshaped sensor grid is used to determine the hand's position and shape.

to be created by phase-locking the incoming signal, but in this case, the system can simply use the transmitted signal, because the transmitter and the receiver are both on the same circuit board. This feature greatly simplifies the entire sensor design.

Prototypes

There are two prototypes of interactive surface based on the SmartSkin sensor. One is a table-size system that has 8×9 mesh antenna. Each cell of the mesh is 10×10 cm. The system can track multiple hand positions and shapes of arms.

The second prototype is a tablet-size system that has 32×24 mesh and each cell is 1×1 cm. The system can determine the human hand shape as shown in Figure 1.

INTERACTION TECHNIQUES

Multiple pointing input

The first interaction technique is a port of multiple pointing input system(MPIS)[1], which enables the user to use their fingers as mice or digital pens. The system detects peak points from the interpolated potential field, and those 2D positions are used to the positions of pointers. Because those position data has not unique ID information, the system tracks each position to detect the motion of the position.

This system allows the user to move multiple objects on a screen concurrently. Figure 3 shows a curve editing system, which allows the user to manipulate 4 control point of a bezier curve simultaneously.

Figure 3: Examples of uses a multiple pointing input: left: curve editing. right: a map browsing system. The user can use one finger for panning, or two fingers for simultaneous panning and rotating

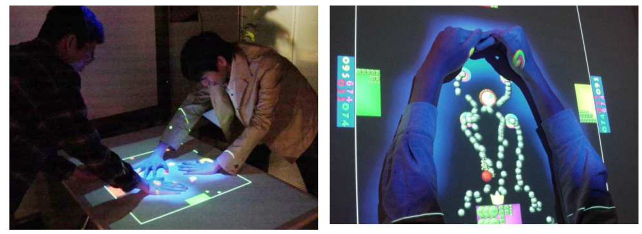

Figure 4: "Marble Market", a video game for a table size SmartSkin. In right figure, a player correct marbles by using their both arms.

In addition, using 2 or more fingers to manipulate an object enables various manipulation. For example, using 2 fingers allows rotating manipulation, and using 3 fingers allows scaling manipulation additionally. Figure 3 shows a map browsing system. The user scrolls the map by sliding a finger along the sensor surface. If the user touches the surface with two fingers, the user can pan and rotate the map simultaneously.

Shape based interaction

SmartSkin recognizes not only the position of human body, but also its shape. We demonstrate an interaction technique based on the shape.

We developed a video game "Marble Market" for a table size (1m × 1m) interactive surface (Figure 4). It uses the interpolated potential field as a height field, and marbles roll on the field. As the hand approaches the table surface, the height of the field around the hand becomes high, so, the marbles recede from the hand. The task of players is to correct the marbles. Players can use their both arms to sweep the marbles.

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