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ThinSight: A new interaction technology for ubicomp

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Abstract. We present a novel technology suitable for situated displays, called ThinSight. It combines up close zero-force multi-touch interaction, with interaction and data exchange from a distance using a mobile device. The novelty of ThinSight lies both in the combination of these features and in the thin form-factor of the hardware which can be fully integrated into commercially available LCDs without affecting display quality. This readily deployable situated display technology opens up many new ubiquitous computing possibilities.

1 Introduction

Situated displays of various types and sizes have been used in many ubiquitous computing application scenarios [3, 4] and have the potential to become much more widely adopted. Many of these applications support touch based interaction [4], some explore the ability to interact from a distance using pointing devices [3, 5] and others allow wireless communication to and from the display using a mobile device [3, 4].

We present an exciting new technology called ThinSight [2] which we believe is ideally suited to situated displays and therefore of great relevance to ubiquitous computing. It combines *up close* multi-touch interaction (supporting any number of touch points) with *at a distance* interaction using a pointing device, and *direct bidirectional communication* between the display and mobile devices. ThinSight consists of novel optical sensing hardware which can be fully integrated into commercially available LCDs with little impact on display quality. The ability to support communication 'through the display' in addition to multi-touch, coupled with its thin form-factor, sets ThinSight apart from other multi-touch technologies (see [1]), and opens up many new possibilities for ubiquitous computing applications based around situated displays.

2 ThinSight design and implementation

ThinSight is based around a 2D grid of retro-reflective infrared (IR) optosensors which are placed behind an LCD panel. Each optosensor emits IR light that passes through the entire panel. Any reflective object in front of the display (such as a fingertip) will reflect a fraction of the light back, and this is detected by the relevant optosensor(s). The raw data generated is essentially a low resolution monochrome "image" of what can be seen through the display in the infrared spectrum. By applying comput-

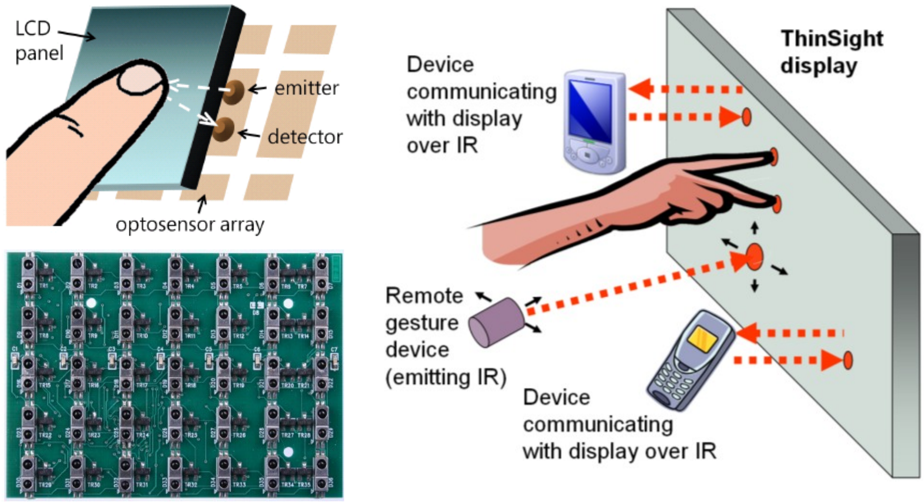

Fig. 1. The layout of the ThinSight optosensor array, as it sits behind the LCD panel (top left). The front side of the actual ThinSight PCB, showing the 5x7 array of optosensors (bottom left). ThinSight intrinsically supports multi-touch input, remote gesturing and multiple channels of bidirectional communications, all at the same time (right).

Fig. 2. Our proof-of-concept prototype uses three sensor PCBs mounted in a portrait orientation behind the LCD (left). The resulting assembly is not much thicker than the LCD panel itself; the acrylic mounting strip used for expedience in the prototype is the thickest part (centre). Our prototype embedded IR receiver supports data communication from the display (right).

er vision techniques to this image, it is possible to generate information about the number and position of multiple touch points.

The ThinSight sensor board (see Figure 1) is a 70x50mm custom-made 4 layer PCB with a 7x5 grid of Avago HSDL-9100 retro-reflective IR sensors. A PIC microcontroller controls and collects data from the optosensors. Although IR light is attenuated by the layers in the LCD (such as the polarisers), in the current prototype the optosensors are sensitive enough to detect a fingertip at around 10mm from the LCD surface. Operation is not affected by the displayed image and requires no force.

In addition to detecting reflected IR from nearby fingertips, the ThinSight optosensors are also capable of detecting IR projected onto the display from an external source. A handheld device which shines a ‘spot’ of IR light may therefore be used for pointer input; examples include a mobile device with an IrDA port, a remote control or a custom-built pointing device. ThinSight also intrinsically supports bi-directional infrared-based data transfer with nearby electronic devices such as smartphones and PDAs. Data can be transmitted from the display to a device by modulating the IR light emitted. With a large display, it would be possible to support several simultaneous bi-directional communication channels in a spatially multiplexed fashion, see Figure 1.

3 ThinSight in operation

We constructed the ThinSight prototype presented here from a Dell Precision M90 laptop. We mounted three sensing PCBs directly behind the LCD backlight by cutting a large rectangular hole in the lid of the laptop. The PCBs are attached to an acrylic plate which screws to the back of the laptop lid on either side of the rectangular cut-out as depicted in Figure 2. Sensor data is sent to the PC over USB.

The raw sensor data undergoes several simple processing steps in order to generate an image that can be used to detect fingertips near the surface. These include bicubic interpolation to scale up the raw sensor data by a factor of 10 and further smoothing using a Gaussian filter. This results in a 150x70 greyscale image. The images we obtain from the prototype are very promising, particularly given we are currently using only a 15x7 sensor array.

Figure 3 shows the ThinSight prototype in use and the resulting multi-touch sensor data. To date we have only implemented touch/no-touch differentiation, by thresholding the sensed data. Touch detection requires no force to be applied – we have been able to reliably and consistently detect touch to within around 1mm for a variety of skin tones, so we believe that disambiguating hover from touch will be possible. In addition, operation seems pretty reliable in a variety of lighting conditions, from complete darkness through to direct sunlight.

Data may be transmitted from the display to a device by emitting suitably modulated IR light. In theory, any IR modulation scheme, such as the widely adopted IrDA standard, could be supported by ThinSight. We have implemented a DC-balanced modulation scheme which allows retro-reflective touch sensing to occur *at the same time* as data transmission. This requires no additions or alterations to the ThinSight sensor PCB, only changes to the microcontroller firmware. To demonstrate our prototype implementation of this, we have built a small embedded IR receiver based on a low power MSP430 microcontroller, see Figure 2. We use three bits in the transmitted data to control an RGB LED fitted to the embedded receiver. This provides a simple proof-of-concept demonstration of how the ThinSight display can communicate directly with a mobile device in the emitted light path.

We can make further use of the IR sensing capabilities of ThinSight to support interaction with the display from longer distances. Using a long-range directed IR emitter it is possible to shine IR light onto a subset of the sensors behind the display. This results in a 'blob' appearing in the raw sensor image which is aligned with the movement of the mobile device, producing a signal which can be used to fairly accurately track the movement of the emitter.

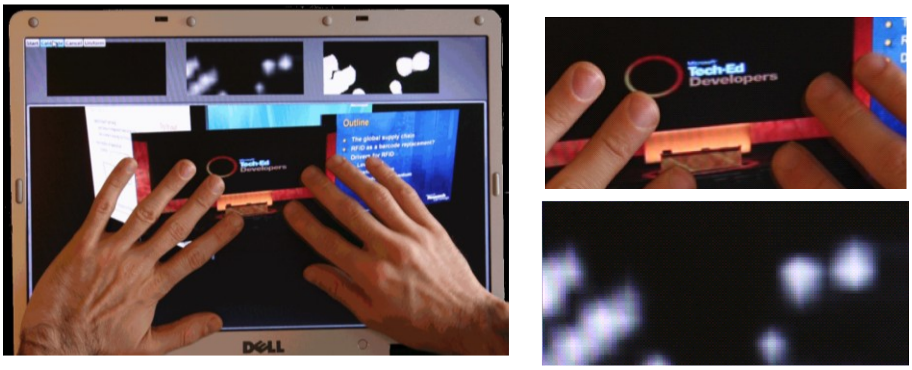

Fig. 3. A multi-touch input to the prototype (left). A close-up of the sensor-enabled centre of the display (top right) shows three left-hand fingers held flat against the surface and three right-hand fingertips in contact. The corresponding multi-touch sensor data (bottom right).

4 Conclusions and future work

We believe that the prototype described in this paper is an effective proof-of-concept for an exciting new ubiquitous computing technology. In addition to enabling true multi-touch sensing in a thin form-factor, the technology can also be used to support interaction from a distance and direct communication between a situated display and a mobile handheld device using IR. Although various technologies to support these features already exist, we believe that ThinSight is the first which inherently supports them all. We have many potential refinements to ThinSight in mind.

ThinSight has potential to improve the user experience in many situated display applications without compromising form-factor, and thereby accelerate their adoption. In particular, zero-force multi-touch sensing supports richer, more compelling interaction than today's touch screens. The ability to detect gestures made from a distance using a mobile device adds another dimension to the user experience, and data exchange with such devices is also facilitated by ThinSight. We are currently exploring new situated display applications and interaction techniques that can truly benefit from these combined features thereby making them more intuitive, engaging and fun.

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