The UnMousePad:
An Inexpensive Pressure-Sensitive Multi-Touch Input Pad

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ABSTRACT

Recently, there has been great interest in multi-touch interfaces. These have taken the form of large-scale displays such as Perceptive Pixel's FTIR display [3] and Microsoft Surface [5] and small hand-held devices such as the Apple iPhone [1]. However, multi-touch hardware is still not widely accessible for use with personal computers in an intermediate form-factor. We have created a paper-thin, flexible multi-touch device about the size of a mouse-pad that senses varying levels of pressure at a resolution high enough to distinguish multiple fingertips and even the tip of a pen or pencil (Figure 1). Because of its form-factor, it can be used for simple mouse input, for multi-touch gestures, as a replacement for a stylus-equipped tablet and as a general-purpose pressure sensor for use in a variety of applications including interactive design, learning and gaming. Because the device can be used upon the surface of a table while looking out at a screen, the device can be comfortably operated at a desk for long periods of time. Most importantly, because of its simple and novel design and construction, the device can be manufactured at a cost similar to that of a keyboard or a mouse and thus has the potential to make multi-touch input accessible to anyone with a computer.

Keywords: Multi-Touch, Input Device, FSR, LOTUS.

INTRODUCTION

The concept of the UnMousePad resulted from our early investigation into the LOTUS (Look Out, Touch Upon Surface) hypothesis. The LOTUS hypothesis stems from the observation that many of the common everyday tasks that people do for prolonged periods of time involve looking forward while having their hands on a surface. These tasks include things people do at work or for fun such as using traditional keyboards and mice, playing a piano and even activities like driving or sitting down at a table for dinner. We hypothesized that these activities can be performed comfortably for long periods of time because the participant can keep their spinal column in an upright and relaxed position while the weight of their hands is supported by a surface.

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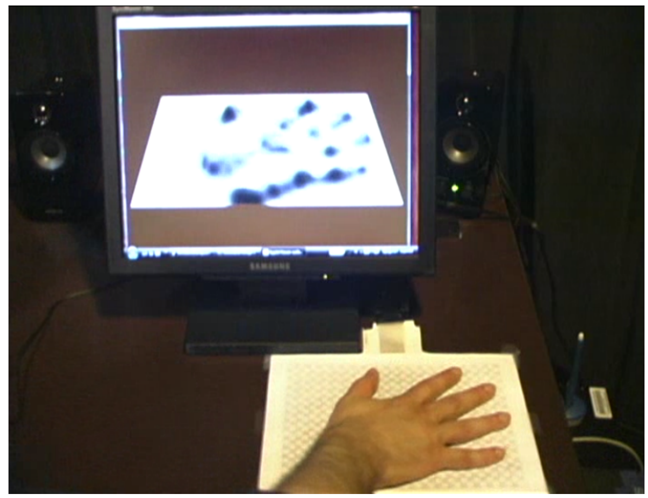

Figure 1: This image shows a user pressing their hand down on the UnMousePad. The computer displays a 3D representation of the pressure exerted on the UnMousePad with height corresponding to pressure.

When we looked at the design of commercially available multi-touch devices, we found that the majority of them were integrated with display devices [1, 3, 4, 5]. Thus, they naturally violated the LOTUS criterion: in an upright configuration, users had to poke at the screens, causing their arms to tire. In a flat configuration, users would get neck cramps from hunching over the devices. Furthermore, the engineering difficulty of combining sensors with screens meant that all of the devices we looked at were either very small or very expensive, and could not be used with existing screens.

These observations led to the creation of the UnMousePad, which is a stand-alone multi-touch input pad that is intended to be used on the surface of a desk while looking ahead at a computer screen. We called it the UnMousePad because it is similar in size to a mouse pad, but doesn't require a mouse to operate. Unlike capacitive multi-touch input devices which mainly measure contact area, [1, 2, 6], the UnMousePad measures pressure with a high dynamic range along its entire surface. This adds a third dimension of input to each finger and palm touch, greatly expanding interaction possibilities. Furthermore, because the UnMousePad does not rely on capacitance, it can detect inanimate objects such as pens, pencils and styli just as well as it detects fingers. Finally, the UnMousePad is flexible, robust and portable, can be used with existing computers and displays and costs no more than a keyboard or mouse to manufacture in bulk.

PHYSICAL CHARACTERISTICS

The UnMousePad is composed of two thin 8.5"x11" sheets of plastic which are attached together at the edges. On the inner side of each sheet is a circuit pattern consisting of parallel electrodes spaced 1/4" apart, with 39 electrodes running vertically on the top sheet and 29 running horizontally on the bottom sheet forming a 39x29 cartesian grid when they are laid on top of each other (Figure 2). We chose a 1/4" spacing because that is the widest spacing which still allows individual sensing of multiple fingertips that are next to each other. Incidentally, the size and resolution can be easily scaled up or down without significant changes to the design or manufacturing process. A connector area is provided on one side for attaching electronics which interface to a computer.

To provide force sensitivity, the electrodes on both sides are over-printed with a solid layer of FSR (Force Sensitive Resistor) ink. The FSR ink is semi-conductive and rough at a microscopic scale, so as it compresses, the conductivity between the top and bottom layer increases in a fashion that is approximately linear with the force applied. The FSR ink also allows current to flow along the surface of each sheet between adjacent electrodes. This flow allows the UnMousePad to accurately sense the position of pressure points that are anywhere between two electrodes, making it possible to track objects that are smaller than 1/4" in size.

OPERATION

The output lines of the UnMousePad are connected to a micro-controller which acquires readings and relays them to a computer. The micro-controller powers up one column electrode at a time and then reads analog voltage values from each even numbered row followed by each odd numbered row. It then switches to the next column and repeats until it has acquired values for each location on the grid. Finally, it sends the entire frame of data to the computer for processing. Currently, we can scan the entire sensor at 50 frames per second, while our new prototype will be able to scan the surface at close to 1000 frames per second.

On the computer, we make the raw data available to user programs written in any language. We also process the low level data to provide a higher level abstraction to programs that only care about finger touches, drags and the amount of force exerted by each finger. These algorithms work by filtering noise, identifying connected components, and then extracting ovals which best fit the connected components.

APPLICATIONS

We have written several applications that demonstrate the power of the UnMousePad. These include visualizations of the UnMousePad data using contour lines and a 3D heightfield; a puppeteering application where a puppet is controlled with a pair of touches; a water simulation where touches set off waves; a piano keyboard and simulated Theremin which respond to pressure; a human speech synthesizer; and of course, the obligatory demos showing an image being rotated, moved and scaled and a mouse with left, right and center clicks and drags. Many of these demos can be seen in the accompanying video.

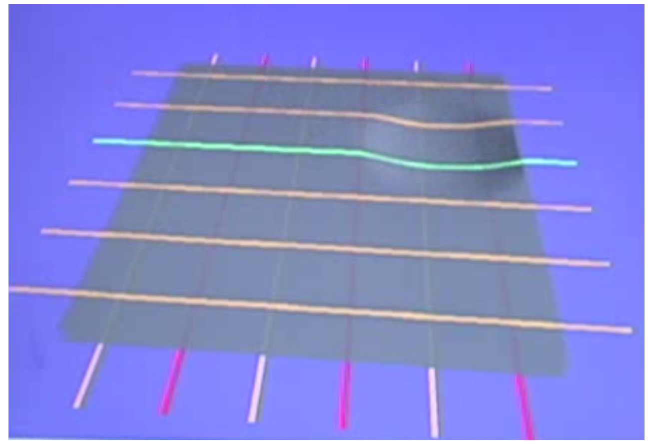

Figure 2: An illustration of UnMousePad operation. The green line represents a powered row electrode on the top layer. The red lines represent electrodes on the bottom layer that are being read out. All other electrodes are grounded. The indentation visualizes the effect of exerting a force, which increases contact area between top and bottom layers.

FUTURE APPLICATIONS AND CONCLUSION

We are collaborating with other researchers to develop several exciting applications which will further explore the possibilities of our novel input device, and especially its unique ability to measure applied pressure. These include an application to allow computer modelers to sculpt terrains, an application that helps animators align multiple frames and to animate effects such as the wafting of hair in the wind. We are also working with physicists who are interested in imaging fluid flow using our device. Finally, we are exploring ways in which the UnMousePad can be used as a keyboard replacement, which unlike regular keyboards will be able to adapt to the location, shape and typing style of individual users. Most importantly, because of the convenient form-factor and low cost of our device, it may soon find widespread adoption both inside and outside the research lab, leading to a myriad of novel applications and modes of interaction that are much more natural, expressive and exciting than the clunky devices we use today.

ACKNOWLEDGMENTS

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