Sinkpad: A Malleable Mouse Pad Consisted of an Elastic Material

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Abstract

The computer mouse has been used for more than 40 years; users, however, can only perform simple actions. To solve this problem, we present "Sinkpad", an augmented mouse pad that has a malleable surface consisted of an elastic material. Sinkpad augments mouse functionality by allowing the user to sink the mouse into the pad and tilt the mouse on the pad. In addition, the pad provides the user with haptic feedback via the mouse. Moreover, the user can use Sinkpad as a conventional mouse pad because the pad serves as a flat surface unless the user sinks the mouse. Sinkpad allows the user to perform interesting techniques: sink, tilt, and sink+move. We also present three example applications to explore the possibilities of our techniques using the pad.

Author Keywords

Input device; interaction technique; malleable surface; haptic feedback.

ACM Classification Keywords

H.5.2 [**Information interfaces and presentation**]: Input devices and strategies, Haptic I/O.

Introduction

The computer mouse has been used for more than 40 years following its first public demonstration by Englebart

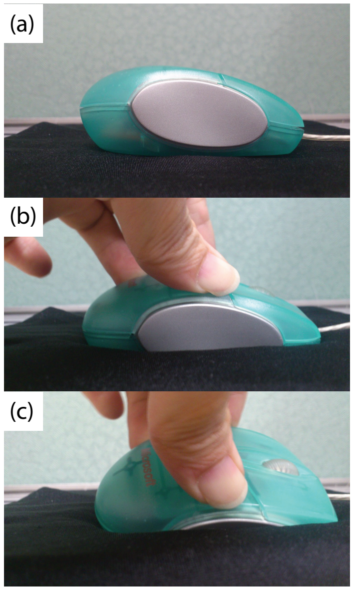

Figure 1: (a) Using Sinkpad as conventional mouse pad, (b) sinking mouse into pad, and (c) tilting mouse into pad.

et al [5]. Although the touchpad has become popular, many people continue to use the mouse because using the mouse is faster and more accurate than using the touchpad [1]. The user of the mouse, however, can only perform simple actions such as clicking the mouse buttons, rolling the mouse wheel, and moving the mouse. To solve this problem, it is necessary to augment conventional mouse functionality and provide the user with haptic feedback via the mouse, so the user can point precisely and is less likely to perform unintended actions by mistake.

In this paper, we present "Sinkpad", an augmented mouse pad that has a malleable surface consisted of an elastic material as shown in Figure 1. Sinkpad augments mouse functionality by allowing the user to sink the mouse into the pad and tilt the mouse on the pad. This allows the user to perform interesting techniques: sink, tilt, sink+move. In addition, the pad provides the user with haptic feedback via the mouse by the deformation. Moreover, the user can use Sinkpad as a conventional mouse pad because the pad serves as a flat surface unless the user sinks the mouse.

We also present three example applications to explore the possibilities of our techniques using the pad: bringing a background window to the foreground quickly, examining hidden windows quickly, and changing the C-D ratio dynamically and magnifying the area around the pointer.

The main contributions of this paper are: 1) adding mouse functionality by augmenting a mouse pad and thereby 2) showing the possibility of a malleable mouse pad.

Related Work

Sinkpad augments conventional mouse functionality by using a malleable mouse pad that consists of an elastic material. Therefore, we summarize the work on augmenting conventional mouse functionality and the input surface using an elastic material.

Work augmenting conventional mouse functionality

Many researchers tried to augment conventional mouse functionality. Mackenzie et al. [9] described a two-ball mouse with an additional ball to capture angular movement to provide 3DOF input. The Rockin'Mouse [2] was a mouse that had been augmented by rounding its bottom to allow users to tilt it, thereby providing 4DOF input. The VideoMouse [7] was a mouse that had been augmented by attaching a video camera to its bottom. It used computer vision to capture the 6DOF movement of the mouse. Balakrishnan et al. [3] described the PadMouse, where the conventional mouse buttons had been replaced with a touchpad, allowing users to activate modifiers and commands. The mouse 2.0 [12] was a multi-touch sensitive mouse that allowed users to perform complex interactions. Cechanowicz at al. [4] investigated the use of an augmented mouse with pressure-based input. The Inflatable Mouse [8] also provided pressure sensitive input. In addition, the mouse could provide actuated inflation and deflation. The Adaptive mouse [11] was a mouse that was augmented by using deformable foam, allowing the user to adapt the buttons to suit his or her fingers.

These researches realized various inputs by using an augmented mouse and/or a dedicated mouse pad. In contrast, we augment only the mouse pad. Therefore, users can use both a conventional mouse and an augmented mouse, such as one of the mice used in previous research, on the pad.

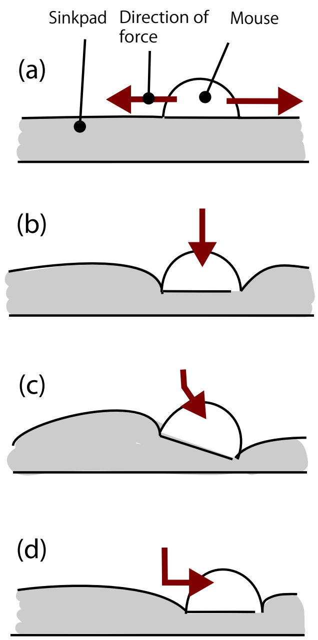

Figure 2: (a) Conventional actions, (b) sink, (c) tilt, and (d) sink+move.

Input surface by using elastic material
GelForce [13] calculated the force vectors on the surface made of elastic material. PhotoelasticTouch [10] was a tabletop system using deformable transparent objects on its surface. deForm [6] was a 2.5D surface that combined a deformable surface with arbitrary objects or hands to support a wide variety of inputs. While these systems required large form factor because they used optical sensing, our system is small because we use pressure sensing.

Wimmer et al. [14] demonstrated touch-enabled deformable surfaces using time-domain reflectometry. While this system was also small, it was necessary for the user to touch the system directly.

Sinkpad
Sinkpad is a mouse pad whose surface is smooth and malleable. Therefore, the user can sink the mouse into the pad and move it on the pad, while still being able to perform the conventional actions with the mouse (e.g., moving and dragging) as shown in Figure 2a. This design allows users to perform the following three interesting techniques: sink, tilt, and sink+move.

Sink Sink the mouse downward vertically into the pad, as shown in Figure 2b.

Tilt Tilt the mouse by sinking one side into the pad, as shown in Figure 2c.

Sink+Move Move the mouse after sinking, as shown in Figure 2d.

We expect that the user can use our techniques finely from both the deformation of the pad and the haptic feedback that is provided by the deformation since they can perceive the depth of sink or angle of tilt when the user performs sink or tilt. Moreover, when the user performs sink+move, there is greater friction. We expect that the friction will allow the user to point precisely because the user has to move the mouse slowly.

System Configuration
We describe the implementation of our prototype system: hardware and analysis software.

Hardware
The Sinkpad hardware consists of two parts: the pad that is made of an elastic material and the sensing module that senses our proposed techniques. Figure 3 shows the hardware setup of Sinkpad. We attached the sensing module to the bottom of the pad.

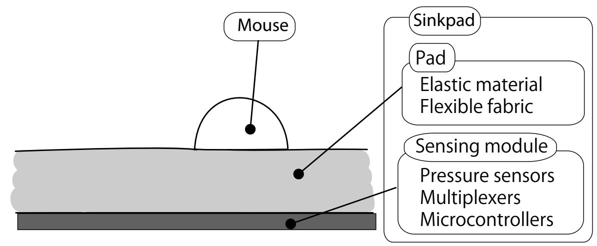

Figure 3: Hardware.

The pad is made of an elastic material 1 cm thick, which has been cut into a square measuring 18 by 18 cm. The elastic material is Hitohada gel (Exseal Corporation, Asker-C 0). The gel is soft enough that the mouse sinks into the gel when the user pushes it. At the same time, the gel is stiff enough that it serves as a flat surface until the user sinks the mouse. Moreover, we covered the gel with spandex fabric, as shown in Figure 4, which makes the surface of the pad flexible to allow the mouse to slide smoothly.

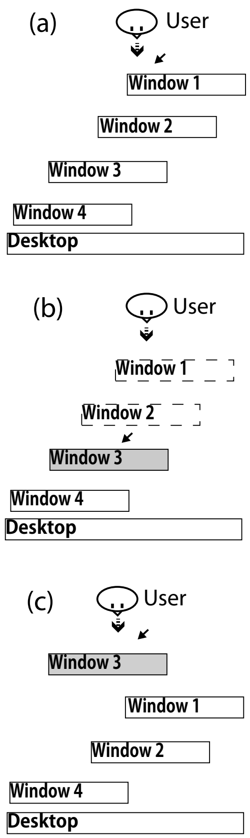

Figure 5: (a) Side view of overlapping windows, (b) two windows became translucent due to sinking, (c) Window 3 was brought to the foreground by being clicked while sinking.

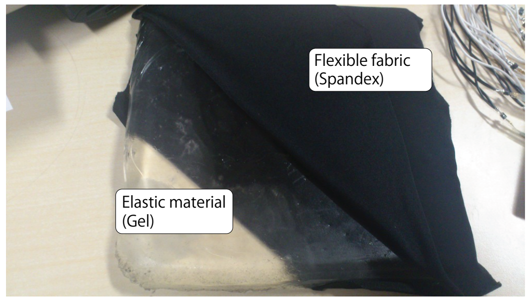

Figure 4: The pad.

The sensing module adopts a pressure-based approach to detect our proposed techniques. Figure 6 shows the sensing module. The sensing module consists of 64 pressure sensors, 4 multiplexers, and 4 microcontrollers. In our current prototype, we used the FSR402 as the pressure sensor, and mbed as the microcontroller. These 64 pressure sensors were arranged in an 8×8 matrix. Every set of 16 pressure sensors are connected to a microcontroller via a multiplexer. The 4 microcontrollers are connected to a PC and send data at 25 fps. The reason why we use 4 microcontrollers instead of one is to improve the frame rates.

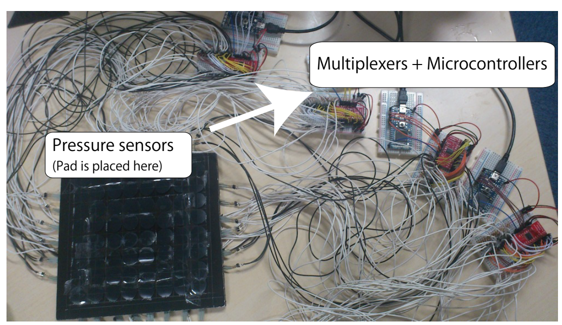

Figure 6: The sensing module.

Analysis Software

The analysis software measures the centroid and average of pressure in each frame. The area of Sinkpad is divided into an 8×8 matrix. The value from each pressure sensor, which is sent to a microcontroller, is considered as the pressure of the corresponding area in the matrix. Centroid (x_g, y_g) is given by the following expressions:

$$x_g = \frac{\sum_{i=1}^{8} x_i \sum_{j=1}^{8} m_{(i,j)}}{\sum_{i=1}^{8} \sum_{j=1}^{8} m_{(i,j)}}, y_g = \frac{\sum_{i=1}^{8} y_i \sum_{j=1}^{8} m_{(i,j)}}{\sum_{i=1}^{8} \sum_{j=1}^{8} m_{(i,j)}}$$

where $m_{(i,j)}$ is the pressure of the sensor (i, j), x_i is the x-coordinate of the i-th column where the sensor is placed, and y_i is the y-coordinate of the i-th row.

The depth of sink is calculated as the average pressure. The angle of tilt is calculated from the variation between the current and the previous location of centroid (x_g, y_g) under the condition that the average pressure is less than a certain threshold.

Applications

We present three example applications to explore the possibilities of our techniques using the pad.

Bringing background window to foreground quickly

The user can bring a background window between overlapping windows to the foreground quickly by sinking as shown in Figure 5. When the user hovers the pointer over the overlapping windows as shown in Figure 5a and sinks the mouse, some windows under the pointer (the number of windows depends on how strongly the user sinks the mouse into the pad) become translucent, allowing the user to examine the content of the window behind. In Figure 5b, two windows become translucent. When the user clicks a window while sinking, the window, which is at the front of the overlapping windows except

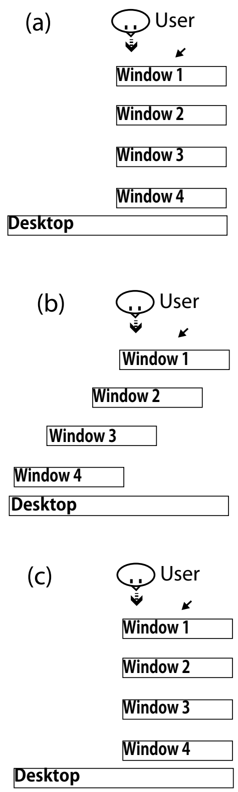

Figure 7: (a) Side view of overlapping windows, (b) moving the overlapping windows using tilt, (c) finishing tilt to recover the original positions.

the translucent ones, is brought to the foreground. At this time, translucency finishes as shown in Figure 5c.

Examining hidden windows quickly

The user can examine the windows that are hidden by overlapping windows quickly by tilting as shown in Figure 7. When the pointer is hovered over the overlapping windows as shown in Figure 7a and the user tilts, some background windows move in the direction of tilting. At this time, only the background windows move greatly as shown in Figure 7b. When the user finishes tilting the mouse, the windows return to the positions before the tilt, as shown in Figure 7c. Thus, the user can move some background windows that are between overlapping windows to quickly examine them.

Changing C-D ratio dynamically and magnifying the area around the pointer

The user can change the C-D ratio dynamically and magnify the area around the pointer as shown in Figure 8 with sink+move. When the user performs sink+move, the pointer moves with a small C-D ratio. At the same time, the area around the pointer is magnified so that it can be viewed in more detail. In contrast, Figure 8a shows normal pointing. Thus, the user can selectively perform normal pointing or precise pointing.

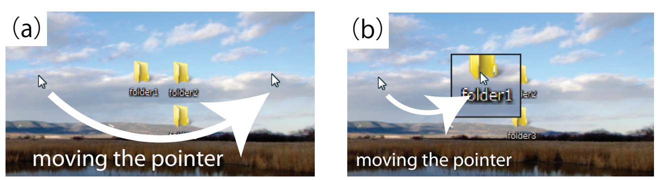

Figure 8: Moving the pointer at the same distance, (a) normal pointing, (b) pointing with a small C-D ratio using sink+move with the area around the pointer magnified.

Discussion

We tested a prototype of Sinkpad with the mice such as conventional mice, gaming mice, and multi-touch mice. The results confirmed that the pad could recognize the proposed techniques. Furthermore, we could use the trackball on the pad; however, it was slightly difficult to perform sink+move due to the anti-skid material attached to its bottom.

We demonstrated a prototype of Sinkpad at an academic workshop in Japan (20th Workshop on Interactive Systems and Software). Approximately 50 participants used the system. We observed the participants and found that users sank their mice easily by using their palms. Some people commented that the depth of sink and angle of tilt are recognized from both the deformation of the pad and haptic feedback that is provided by the deformation, and they have to move their mice slowly by friction when they perform sink+move. These comments suggest that users can use our techniques finely and point precisely. Some people also commented that tilting their mice to the left and right was easy, but tilting forward and back was difficult. However, we observed that if there is a button on the mouse in the direction of tilting, some people clicked it accidentally. This is because the pad has reactive force. To solve this problem, after this demonstration, we changed the analysis software to ignore clicks during tilting. In addition, we observed that all users were able to easily use their mice on the pad except for those accidental clicks. This observation may indicate users are less likely to perform unintended actions by mistake by using the malleable pad.

Conclusions and Future Work

We have presented Sinkpad, a mouse pad that has a malleable surface consisted of an elastic material. The user can perform three techniques by sinking the mouse into Sinkpad: sink, tilt, sink+move. Moreover, the user can also use Sinkpad as a conventional mouse pad. We have also presented three practical applications for Sinkpad: bringing a background window to the foreground quickly, examining hidden windows quickly, and changing the C-D ratio dynamically and magnifying the area around the pointer. Our prototype Sinkpad system worked well as we expected. We have demonstrated our prototype at an academic workshop, and we confirmed that users could use our techniques finely and point precisely. Moreover, they are less likely to perform unintended actions by mistake.

In future, we plan to improve the system to add more techniques such as the ones utilizing z-axis angular motion of a mouse on Sinkpad. We also plan to improve the frame rates using other powerful microcontrollers. Finally, we would like to conduct user studies to measure the performance of our approach.

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