
Carbon Copy Metaphor: Mode Switching Technique for Trackpad-based Manipulations

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Abstract

Drawing characters or images using smartphones and tablets is much easier than drawing using trackpads commonly equipped in laptops and desktop computers. The reason is that tablets are absolute coordinate input devices, whereas trackpads are relative coordinates input devices similar to conventional mouse. However, most of the modern laptops have trackpads approximately the same size as a smartphone screen, and they have enough space for hand-writing. We believe that modern trackpads would allow users to write easily as smartphones or tablets, if they properly provide an absolute coordinates input mode. This paper proposes a novel input technique that aims to switch between relative and absolute coordinates input methods seamlessly based on the “carbon copy” metaphor. We display a small workspace (“carbon copy area”) on a computer screen that corresponds one-to-one with the handy trackpad. The user can input hand-written characters or images using absolute coordinates input on this virtual carbon copy paper and move it anywhere using relative coordinates. Our technique allows a user to call both absolute and relative coordinates input methods and use them appropriately with arbitrary timing. We developed a prototype application software to utilize this technique based on a preliminary experiment.

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Introduction

Owing to the widespread use of touch surfaces, such as in smartphones, tablets, and trackpads, touch inputs can be seen in everyday life. At present, two input methods are used for touch surfaces. One is the relative coordinates input method, which calculates the distance between the current cursor location and destination point. Like the conventional mouse, a trackpad engages the relative coordinates. When a user moves a finger on the input surface, a cursor in the display moves according to the finger movement. By performing a clutching operation on the surface and adding pseudo acceleration to the moving speed of the cursor, a user can relatively easily operate a large screen even if the input surface is small. Relative coordinate input method is suitable for common GUI operation. Even small finger movement can be used for large cursor movement, and precise operations can be performed, as mentioned before. Another one is the absolute coordinates input method, in which the coordinates of an input surface correspond directly to the coordinates of the display. Writing characters or drawing a painting is much easier compared to using the relative coordinates input method because it provides similar pen tip movement as writing characters or drawing a picture on paper. We presume many people would have wished they could write or draw characters or pictures on the trackpad easily, for example, in cases wherein: jotting down numerical formulas, writing short comments in

the margin or figure when correcting a document, making an electronic signature and sharing a laugh idea sketch with colleagues, etc. It would be surely useful if modern trackpads allow users to write as easily as smartphones or tablets do.

We implemented a new input interface focusing on the two methods of entering coordinates. Particular input equipment such as a pen tablet is required when a user performs absolute coordinates pointing. It allows a user to hand-draw or paint easily by providing absolute coordinates input to devices based on the relative coordinate input method. Typical trackpads and computer screens are different in size. If a computer screen corresponds one-to-one with the handy trackpad, precise operation becomes difficult because of size difference between the screen and trackpad in a large screen environment. On the other hand, if only a part of a computer screen corresponds one-to-one with trackpad, the workspace will be limited. By providing a small area that corresponds directly to a trackpad on the screen and allowing a user to input absolute coordinates only in this area, the problem can be resolved. However, a user interface for moving the small area and setting it on the screen is required.

In this study, we propose a new interface method based on the “carbon copy” metaphor for three easily-switchable mode:

1. Conventional pointer mode with relative coordinates
2. Absolute coordinate mode to input rectangle sub-area on the screen
3. Moving mode for this input sub-area

Related Work

Various methods combine relative and absolute coordinate inputs for a desktop/laptop PC or a large screen environment have been proposed. ARC-Pad[3] provides implicit mode switching, it provides absolute input mode by finger tapping on a smartphone screen and relative input mode by finger dragging. In [2], it enables fluid switching between the two modes by using a pen device. In [5], a pointing gesture with a user's hand for absolute-ray casting mode and opens a his/her hand to enable relative input mode by using a motion-tracked glove. Our proposed method targets to a widespread touchpad without any special hardware or sensors. Inklet¹ is a utility that also allows a common trackpad to emulate virtual absolute coordinates input area by using predefined shortcut keys. Similar to above approaches, our proposed technique is designed as explicit mode switching interfaces. However these approaches tend to address specific use cases where a user is locked into a dedicated mode, thus these are not intend to switch between the two modes frequently. Further more the “carbon copy” metaphor will make the operation more understandable than using pre-defined shortcut keys.

Researchers have studied interfaces for gestures of both hands. ToolStone[4] utilizes a physical tool widget to switch zooming, 3D rotating, and camera controlling modes. [1] provides virtual filters to modify input and output manipulated by non-dominant hand. In our approach, non dominant hand is used temporal function switching similar to a modifier key on a keyboard.

Carbon Copy Metaphor

Our proposed method provides following operations, (1) mode-switching operation between relative and absolute



Figure 1: Fingertip positions when handling a carbon paper.

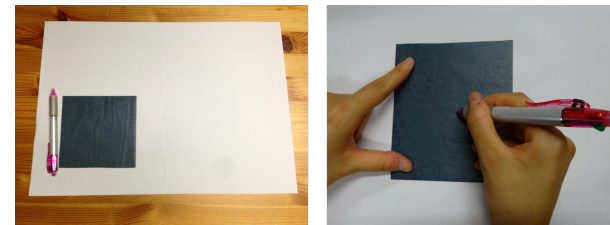


Figure 2: Setup for the preliminary experiment.

coordinates input and (2) an operation of moving the absolute coordinates input area. This method allows users to absolute input for the limited area on a screen, and the area can be moved to any optional place. Aiming to achieve it, we adopted the “carbon copy” metaphor similarly to using a carbon paper. Namely, we have implemented user-operations similar to real world activities of adjusting the position of a small carbon paper and writing on it. A virtual “carbon paper” appears on the display when the users touch the trackpad with their non dominant hand. The virtual carbon paper on the computer display is a metaphor of the actual carbon paper. In the real world, we can move the carbon paper by slightly pressing it with our fingers, and we can transfer it below a paper by holding and fixing it. Our proposed method is based on this hand motion: a user can

¹<https://tenonedesign.com/inklet.php>

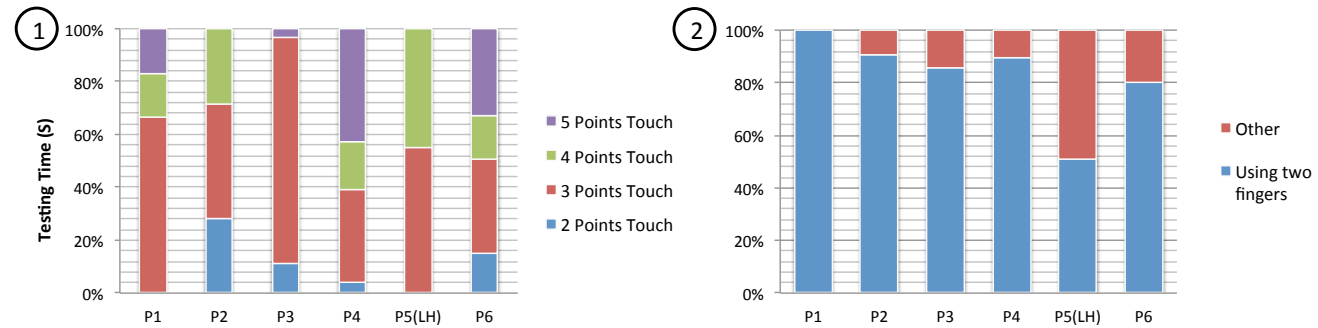


Figure 3: Frequency of (1) the number of fingers used to hold the carbon paper. (2) drawing between or outside the fingers used for holding the paper.

manipulate the virtual “carbon paper” using similar actions, which they would apply to a physical carbon paper (Fig.1).

Preliminary Experiments

To design user actions on a touch surface of an interface based on the carbon copy metaphor, we conducted an observational study regarding the manipulation of a carbon paper in the real world. We assigned a drawing task to six participants (five right-handed, one left-handed, ages 21 to 24). We used a drawing paper (500mm × 400mm), small carbon paper (130mm × 130mm), and ballpoint pen that ran out of ink (Fig. 2). Participants sign their own name on the left half of the drawing paper and paint freely on the right half. We recorded this experiment and looked for patterns in which the fingers were used for handling a carbon paper.

When participants carried out the task, to write or draw on the paper, they pressed the edge of the carbon paper with their non dominant hand. This indicates that the participants utilized a wide drawing area and prevented the carbon paper from floating or peeling off. Fig. 3 (1) shows the

ratio of the time fingers touched the carbon paper to that taken for the execution of the entire task. There are significant differences in frequencies of pairs of three fingers and other touches. The t-test calculation showed that there are significant differences in frequencies of pairs of three fingers and other touches, such as between a three-finger touch and two-finger touch ($t(5) = 4.028, p < 0.001$), three-finger touch and four-finger touch ($t(5) = 3.007, p < 0.005$) and three-finger touch and five-finger touch ($t(5) = 3.466, p < 0.005$). All the other pairs are not considered significant. As shown in Fig. 3 (2), we found that the participants tended to open certain two fingers widely, which means they decisively used two fingers for holding a carbon paper. Conversely, various finger movements were observed when they moved the carbon paper.

Interface Design

We designed the interface based on the preliminary experiment as follows. Focusing on the writing behavior of the participants on a carbon paper, we adopted “Pressing the edge of a carbon paper with two spreading fingers of the



Figure 4: Black-framed carbon copy area corresponds to the input area on the trackpad.

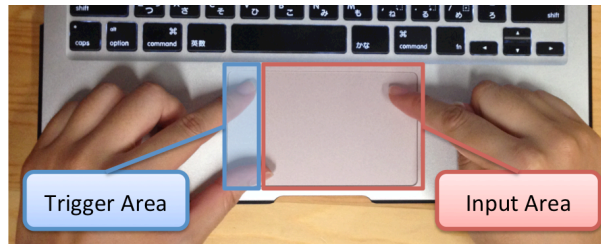


Figure 5: Trackpad divided into two areas. A case for a right-handed person.









non dominant hand” as a condition for the writing operation. When a user uses two spreading fingers of the non dominant hand to press the edge of a trackpad while moving the cursor with one finger, a small working area with the same aspect ratio as a trackpad appears at the cursor location on the screen. This small working area (carbon copy area) is enabling absolute coordinates inputs. The absolute coordinates input mode is called the “carbon copy mode.” When the user removes the two non dominant fingers, the carbon copy area disappears, and the input mode switches to the conventional relative coordinates input mode.

Implementation

To test the efficiency of our proposed method, we implemented a prototype, a painting application, in Objective-C for use on a OS X 10.9 operating system. Touching the trigger area with one finger activates the carbon copy area (the black-edged area on the screen, as shown in Fig.4). When compared with the preliminary experiment, in the prototype, the entire desktop area corresponds to the drawing paper and the black-framed carbon copy area corresponds to the carbon paper. As Fig.5 shows, we divided a trackpad into two parts (non dominant hand side: trigger area, dominant hand side: input area) to define a gesture set for fixing/moving the carbon copy area and switching relative/absolute coordinates inputs.

The mapping between the gesture set and functions of the application is shown in Figure 6. The circles in Figure 6 indicate the fingertip position of a user (blue: fixed fingertip, red: moving fingertip).

- No.1 shows one moving finger on a trackpad. It corresponds to the cursor movement with conventional relative coordinate inputs.
- No.2 shows two fixed fingers on the trigger area. By this operation, the fixed carbon copy area appears on the screen.
- No.3 shows two fixed fingers on the trigger area and one moving finger on the input area. By this operation, a user manipulate the pointer inside the carbon copy area with absolute coordinates input mode. Our prototype provides cursor movement by touching on the input area and drawing by dragging (moving while pressing) on the input area. That is, when a user activates the carbon copy mode, tracing the input area

No.	Fingertip Position on a Trackpad	Display Screen	Functional Instruction
1			Moving a Cursor Pointer (Relative Coordinates)
2			Showing a Carbon Copy Area
3			Moving a Cursor Pointer (Absolute Coordinates)
4			Moving a Carbon Copy Area (Relative Coordinates)



 :Moving Fingertip
 :Fixed Fingertip

Figure 6: Mapping between the fingertip position on the trackpad and carbon copy metaphor function

provides preview of cursor movement, and then dragging provides drawing lines on the paint application. A cursor follows the movement of the finger on the input area.

- No.4 shows one finger on the trigger area and one fixed finger on the input area. It corresponds to moving the carbon copy area in relative coordinates.

In this way, our proposed method switches two coordinates input modes simply by following the manner of writing on a carbon copy paper is carried out.

Conclusion and Future Work

In this paper, we proposed novel mode switching technique based on the carbon copy metaphor. It provides relative and absolute coordinates inputs by using a trackpad embedded in a laptop or a consumer trackpad. We developed the prototype application based on the observational study for the user's manipulation of a carbon paper in the real world. We are planning to carry out comparison experiments to assess the effectiveness of our idea.

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