Coupa: Operation with Pen Linking on Mobile Devices

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ABSTRACT

This paper proposes Coupa, a novel pen interaction design to support operations of users on portable devices. The design arranges a plurality of labels on the interface, each of which has an identity. The user forms a coupling by linking two graphical items together, and thus performs an action dependent on the identities of the coupled items. During the course of operation, any item on the screen is ready for linking and coupling. To reduce mal-operations, two principles for linking are proposed, with their effectiveness proved in the usability tests. Compared with traditional systems with hierarchical menu structure and point-and-click interaction, the proposed design prominently improves the efficiency and accuracy of pen-based systems with enhanced usability.

Categories and Subject Descriptors

H5.2. [**User Interfaces: Input Devices and Strategies**]: Interaction Styles, Screen Design

General Terms

Design, Performance, Measurement, Experimentation

Keywords

Linking, labels, coupled graphical items, menu hierarchy.

1. INTRODUCTION

The latest digital devices are featured with increasingly diverse functionalities. Although very powerful, most of them have not been well adapted to pen interaction. The operations available to a user are often arranged in a hierarchical menu structure [1] and it may take several key presses before the user is able to select or enable the chosen function.

Many prevalent "smart phones" and PDAs are equipped with touch sensitive displays, i.e. touchscreens, and a pen or stylus is used for writing input and common operations on the surface. It is beneficial if an improved user interface is applicable which ensures easy access to contents, and enables any function available. Compared with traditional devices with keypad, the pen improves the efficiency of operation by tapping the target directly, which could be an icon, a menu or a button. Besides tapping, the pen could also write strokes on the screen, or drag and drop icons as a mouse does on a PC.
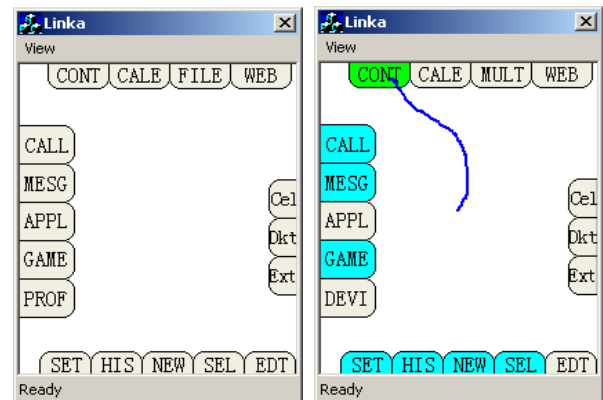
Figure 1. The interface of Coupa.

Despite the early success of these features, the usage of pen is still limited, because most aforementioned features are to some extent inherited from the traditional keypad-based mobile system or the mouse actions on PC. For most portable devices, the area of the screen is so limited that users must use the pen very carefully and accurately to avoid mal-operations, which impairs both the subjective experience and the operational efficiency.

Our research goal is to develop a pen-based system that enables the users to perform operations and access content quickly and conveniently, beyond the traditional system with a pen. As shown in Figure 1, we designed COUPling to Action (COUPA), an advanced pen-based method to access content in the device with linking gestures.

2. RELATED WORK

The related research falls largely into the area of pen-based user interaction on touch sensitive interfaces. Among the many designs for pen-based interactions, Marking Menu [2] serves as a good reference. It maps the user operations to a stroke with a pen/stylus, where the direction of the pen trace is endowed with different meanings. CrossY [3] tries to improve the interaction mode between pen and menus, where goal crossing is introduced for fluent and expressive operations. In the research of Nobuyuki etc, the cooperation of the thumb with a pen is used for operations on the device [4]. Although most aforementioned designs use context information to accelerate user operations, the efficiency and usability of the interfaces still need further improvements [5]. Our design tries to go further to release users from existing constraints of operation: the user only cares where the pen is dropped and lifted, irrespective of the sketching path.

3. COUPA

Studies on mobile device users showed that many of them were frustrated by the complex menu hierarchy [2] [3] [8]. Contents on the device are stored in the form of files and text, including videos, audios, documents, logs and messages. Each type of content is accessible if a user follows strictly the correct process of operation, and usually it will take users several successive steps without mal-operation to get what they want. However, according to the result of a series of informal investigations, not all the users know the standard operation order, or the exact location of the content, and sometimes one small operational mistake will frustrate the users, because they could not return to the previous step.

The idea for Coupa grew from these observations, and tried to use coupling actions to avoid the aforementioned inconvenience. As our primary strategy of design, intuitive and quick access to content is emphasized. Basically, a plurality of labels is arranged along the four edges of the touchscreen, as shown in figure 2. For ease of illustration, the abbreviated text on the label indicates the respective identity, as shown in table 1. The first 14 labels feature typical functions on mobile devices, especially mobile phones. The last three labels serve as status control buttons, and they could retrieve the previous status before the current operation.
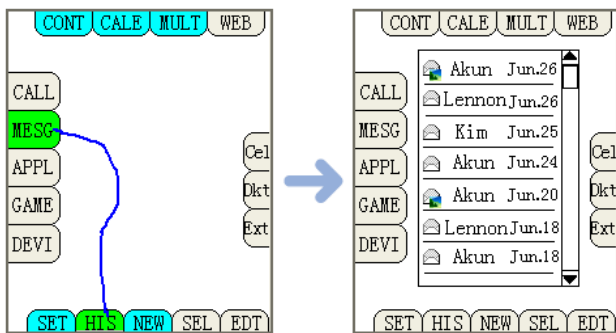

Figure 2. The linking operation on Coupa.

When the user draws a trace starting from one label, the other labels valid for linking are highlighted (Figure 2). When the pen trace ends in another label, a coupling is detected, and a corresponding operation is activated. In the illustration of Figure 2, the linking of the label *MESG* and label *HIST* activates the operation of viewing the history of messages, as shown in the central area of the screen.

3.1 The Linking Approach

3.1.1 The Labels

Labels are located along the edges of the screen, because edges have a promising Fitts' Law benefit to draw pen traces [6]. As the major graphical elements on Coupa, labels are indispensible because primary user interactions start from them. The identities of the labels are assigned according to two principles:

I.   Each label has one unique identity in the system;

II. No operation will be activated by linking two labels on the same side.

Table 1. Identities of the labels.

Abbreviation	Function
CONT	Contact information.
CALE	Calendar correlated content.
MULT	Multimedia files.
WEB	Contents and services from the network.
CALL	Voice call correlated functions.
MESG	Text and multimedia messages.
APPL	Applications and tools.
GAME	Games.
DEVI	Device correlated issues.
SET	Open the setting view.
HIS	Browse the history in concern.
NEW	Create new object.
SEL	Select the item.
EDT	Edit the item.
Cel	Cancel the last linking operation
Dkt	Display the desktop
Ext	Exit the active application.

According to a market investigation by Ipsos [7], although tens of applications and services are integrated into one device, for a specific user, only less than twenty applications or services are frequently used, and this add up to over 95 percent of the total usage of the device. In Coupa, the 14 functionality-related labels (top, left and bottom) on the primary interface could support up to 60 valid functions. Moreover, the number of labels can be customized by the user, and on average 10 labels are enough based on the subjective feedback of users attending our test.

The size of each label could be adjusted by users as well, because in our investigations, different users prefer different number of labels on the screen, accordingly the size of the labels also varies. Likewise, the users could adapt the order of the labels according to their custom and preference.

3.1.2 Operations Activated by Linking

During the linking operations of users, Coupa decides the validity of the coupling:

1) To link two graphical units on the screen, the pen trace could start from either unit and stop at the other;

2) The graphical units include but are not limited to the labels on either side of the screen. Any graphical item in the central area of the screen is also valid for linking (Figure 3);

3) The pen trace may go across several labels, but the activated operation only depends on the starting and ending label;

4) When the pen trace has started, the graphical units for a valid coupling will be displayed prominently (the sapphire labels in Figure 2 and 3).

5) If pen trace is not starting or ending on a valid graphical unit, the pen trace will fade and no operation will be activated.

Although these rules are functioning underlying the interface, we do not find much difficulty for users to grasp them, for which the average operation time discussed in the next session is a good proof. Instead, we have found some users utilizing the rules to simplify their operations, and one observation was that for the same operation the moving distance of the pen decreased after some time of usage.
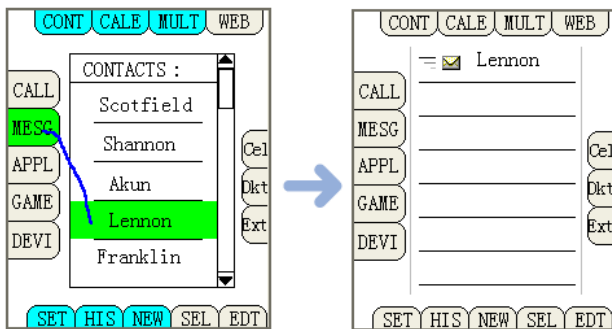

Figure 3. Coupling freely between graphical items.

3.2 Mal-Operation Reduction

Operational mistakes are inevitable for users when using any electronic device. Here any operation uncorrelated with the target of the task was taken as a mal-operation, and a mal-operation is often followed by several further operations to get back to the previous status. Most mal-operations with Coupa are correlated with the linking operations. According to *Linking Principle II* mentioned above, a user could cancel most mal-operations in the linking process, by drawing the trace back to any unit on the same side with the starting unit, or lifting the pen up at a blank zone, without activating any undesired operations.

The three functional labels on the right side of the screen assist users to cancel the unintentional operations or get out of an application conveniently. As these labels are assigned for the purpose of status control, they could be tapped directly with the pen. The *Cel* label cancels the latest pen operation when it is tapped. Operational histories will be retrieved by repeatedly tapping this label. The *Dkt* label clears the screen, while keeping the applications running in background processes. The *Ext* label exits the topmost application, irrespective of the status of it.

4. EXPERIMENTS AND DISCUSSION

Coupa was prototyped by implementing the GUI on a touch-sensitive interface, the 15" screen of Wacom Cintiq device. We crossed out an area of 2.8" (43 mm * 57 mm) for Coupa (the same as the screen area of Dopod 810). Before making comparative studies, we first investigated the linking efficiency between graphical items in different directions, with linking time recorded. In Figure 4, the horizontal axis denotes different linking directions. Specifically, T->L means the linking direction goes from top to left, so it is with other abbreviations. The least operation time was recorded on the linking operation between top
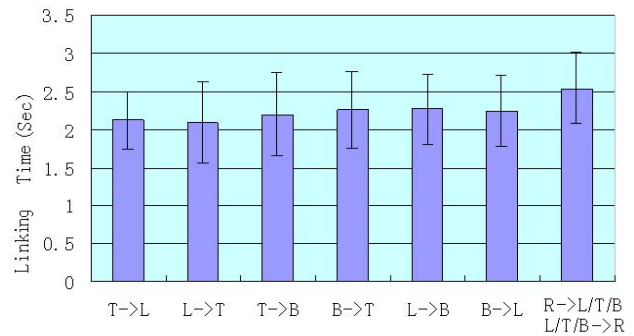

Figure 4. Comparison of linking time in different directions.

and left items, and the reason might be most right-handed people felt easy and intuitive to draw lines in this direction. Linking operations with labels on the right side of the screen were the least efficient, and some users claimed that they had to move the elbow to find the labels on the right side, while for other labels they only needed to move the wrist. Based on this observation, we did not arrange the function labels on the right side of the screen for right-handed users.

For evaluation purposes, we used Nokia N800, a pen-based device with Linux graphic user interface, and Dopod 810, a PDA with Windows Mobile operation system to compare with Coupa. 10 users (seven male and three female) with pen experience on mobile devices (excluding the above three models) were invited to the test, who operated on the three interfaces following a Latin square order. Each participant was asked to finish six groups of tasks, focusing on web, file management, game launch, device setting, logs and calendar operation respectively. 5 tasks were included in each group in a random order. Free trials were allowed before the test. The time for each operation, and the number of operations for each task were taken as evaluation criteria. Operational errors were also recorded as reference.

On Coupa, the user utilized linking operation to access the content on the device. For the Nokia N800 device, pop-up menus are adopted in the user interface, which allows drawing a stroke along the menus, or tapping on a specific menu item. The WIMP interface on Dopod 810 supports taps or double clicks. Figure 5 illustrates the average operation time on the three pen-based user
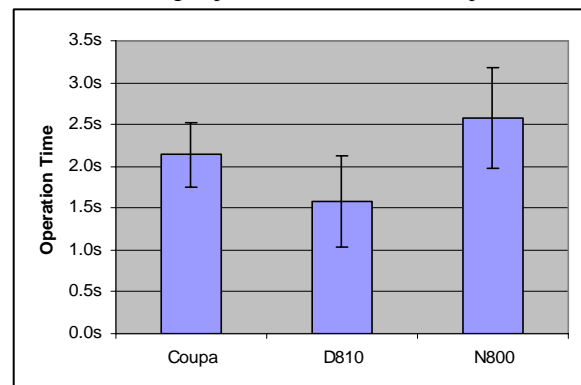

Figure 5. The operation time for the interface of Coupa, D810 and N800.

interfaces. Operation time indicates the interval between two successive contacts of the pen with the interface (double click is taken as one operation), and it includes both the time for the user to find the target and the time to implement the drawing or tapping gesture. The average operation time for the three interface ranges from 1.5 second to 2.5 seconds. Intuitively, the linking gesture works faster than dragging and tapping, and slower than the combination of tapping and double click. When referring to table 2, we can have a better understanding on the overall performance of the different interfaces.

Table 2. Average operations and time required for a task.

Interface	Coupa	D810	N800
Operations per task	2.6	4.1	3.0
Time per task (sec)	5.31	6.22	7.64

Table 2 indicates how many operations were required on average to implement a task, and this was evaluated based on the record in our test setting. By multiplication of the last row in Table 2 and the average value in Figure 4, the average time required for a task is listed in the last row of Table 2, where Coupa proved to be the most efficient. From the perspective of content accessibility, Coupa works well with the fewest operations, because the label structure is much more intuitive and easy to reach than the menus or icons. Consistency in the interface also contributes to the efficiency of Coupa. Because the position of the labels is fixed, with some practices, users could remember the most frequently used ones and then users were operating in a semi eye-free mode, in which the linking efficiency was even higher than normal. Although no formal questionnaire was utilized, some users were recorded claiming that the labels were easier to operate than the nine or twelve icons in a matrix on the screen.

Besides efficiency, we also evaluated the ability of Coupa to avoid the mal-operations of users. Table 3 lists the average number of mal-operations for all participants in the test, and also the time to return to the previous state of the system, among which the performance of Coupa is also quite promising.

Table 3. Average mal-operations and reversion time.

Interface	Coupa	D810	N800
Mal-operations per user	22	32	34
Reversion time per user (sec)	1.32	1.45	2.28

The comparison between Coupa and other solutions proved the validity and efficiency of the linking-based design. Although the writing experience of most participants was gained from devices similar with Dopod 810, they still got on well with Coupa. For tapping-based interaction, after unintentionally tapping on a wrong icon or menu item, the user was not aware of the operational mistake until the result of the operation was displayed, and then at least one more tap was needed to get back to the

pervious state. In the linking process of Coupa, as the pen trace proceeds, there is always a visual feedback on the origin and target of the operation, and thus the user could find the mistake and stop or cancel an operation in time. In this manner, chances for mistaken operations are decreased.

One concern for Coupa is that the labels will occupy a large proportion of the screen, although most users (eight out of ten) did not consider this a big problem according to the outcome of a short interview after the test. A possible improvement is to decrease the size of the labels by arranging the text or icon on the outer side of the touchscreen, and further usability studies are expected on the validity of this modification.

5. CONCLUSION

Coupa associates each graphical item on the screen with an identity, and thus the user could see the available functions throughout the linking process, with awareness of the state of operation. Meanwhile flexible usage of the linking rules helps to decrease mal-operations notably. According to our tests, Coupa was able to implement most common functions of a mobile phone with high efficiency, and was effective in reducing mal-operations of users.

Starting from the current linking-based design, our further research concerns include the optimization of the graphical items and usability issues on Coupa's usage on touch interfaces of different size. In addition, we will explore whether the adoption of timeout could further improve the performance of Coupa.

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