Chapter 36
The Evaluation of Pen Gestures in a Digital Painting Environment

Chih-Hsiang Ko

Abstract Academic researchers argued that the use of pen-gesture commands in a pen-based environment could contribute to the improvement of task efficiency. However, previous research on pen-gesture commands tended to be focused on PDAs. A graphics tablet is also a pen-based input device. Therefore, it is possible to get better task efficiency while applying pen-gesture commands on a graphics tablet for a digital painting environment. The effects of pen-based input devices and command operations on subjects' task efficiency and the System Usability Scale (SUS) were explored in this paper. The results indicated that pen-gesture commands provided better task efficiency in file editing, layer control and integrated applications. The result from the SUS showed that pen gestures with a rubber grip pen got better usability.

Keywords Pen gestures · Pen-based system · Graphics tablet

36.1 Introduction

There are a lot of covert interactive characteristics in a pen-based environment that are worthwhile for further exploration. Pen-gesture commands are among those interactions with high development potential. Frankish et al. [1] indicated that gesture commands were easier to remember than keystroke commands. Some existing pen and paper skills could be successfully incorporated into a pen computer interface. User interactions were both faster and more fluent than could be achieved by other means. There might be significant advantages in using pen input for non-standard text, such as mathematical formulae or musical notation. Long, Landay, and Rowe [2] concluded that users appreciated the benefits that currently available

C.-H. Ko (✉)
Department of Industrial and Commercial Design,
National Taiwan University of Science and Technology, Taipei, Taiwan
e-mail: linko@mail.ntust.edu.tw

J.J. (Jong Hyuk) Park et al. (eds.), *Ubiquitous Computing Application and Wireless Sensor*, Lecture Notes in Electrical Engineering 331,
DOI 10.1007/978-94-017-9618-7_36

gestures afforded and wanted applications to support more gestures. However, gestures should be more recognizable and easier to remember.

A liquid crystal tablet is a computer peripheral operated in a pen-based environment. Simple adaptation of software interface from a mouse and keyboard environment might not be appropriate and more operating possibilities are necessary to be explored. Gesture-based interfaces promise to increase the efficiency of user input, however, most conclusions were made from using PDAs and the situation on a liquid crystal tablet was largely unexplored. Under such a context, the author tried to examine the interactive behavior of pen-gesture commands in a pen-based digital painting environment. The main purposes were as follows.

1. To explore the influence of input devices on the use of pen-gesture commands in a pen-based digital painting environment.
2. To evaluate the task efficiency of pen-gesture commands in a pen-based digital painting environment.

36.2 Background

36.2.1 Pen-Based Computing

Using pen as an input device is regarded as natural, because almost everyone could use pen and paper to communicate. Frankish et al. [1] argued that the supposed "naturalness" of the pen interface was almost entirely based on the pen and paper metaphor, and the assumption that users' experience and intuitive knowledge of this medium would be an advantage. The visible difference from other technologies is in the use of a pen or pencil as the primary means of interaction between a user and a machine [3]. As one form of human communication, using pen to communicate with computer is becoming commonplace. Pen-based computing has a rich history of innovative hardware and software solutions as human computer interface [4].

36.2.2 Pen-Gesture Commands

A gesture-based interface is one in which the user specifies commands by simple drawings, typically made with a stylus. A single intuitive gesture can simultaneously specify objects, an operation, and additional parameters, making gestures more powerful than traditional direct-manipulation interfaces [5]. The benefits of the gestural interface include the fewer number of steps required to carry out an operation, the greater ease of remembering gestural commands, and the ability to focus on a single surface for input and output [6]. Kurtenbach et al. [7] presented the design principles of revelation, guidance and rehearsal which promoted the

integration of the interactive mechanism and gestures. The notion was that the interactive mechanism was intended for the novice while the gestures were intended for experts. The integration of the two was intended to support the learning transition from novice to expert.

36.3 Methods

An experiment was designed to evaluate the influence of using pen-gesture commands for software command operations, different pen-based input devices on subjects' task efficiency, and the System Usability Scale (SUS). The result could provide further clarification of the method and scope for applying pen-gesture commands to a digital painting environment.

There were two independent variables in the experiment. The first was the software command operations and was classified into four levels by operating methods: graphical user interface (GUI), shortcut keys (SK), pen gestures with a rubber grip pen (PGr) and pen gestures with a rubber grip pen and a keyboard (PGk). The second was the types of pen-based input devices and was classified into two levels: a liquid crystal graphics tablet Cintiq 21 UX (C) and an ordinary graphics tablet Intuos 3 (I). Therefore, there were eight experimental groups, as shown in Table 36.1. A total of 64 design students were selected to participate in the experiment, eight in each group. The number of male and female was even in each group to eliminate the gender bias.

The graphics software used in the experiment was Adobe Photoshop CS6, which was used by most designers in a pre-experimental survey. Five experienced designers selected 27 commands with preset shortcuts from a total of 40 frequently used commands. Together with additional four necessary file commands, these 31 commands were combined with pen-gesture commands and were activated through real buttons to distinguish the data type of pen-gesture commands.

Five tasks were designed for subjects to execute the selected 27 commands and four necessary file commands. The tasks were as follows:

1. Task 1–File Editing: To explore the influence of input devices on the use of pen-gesture commands in a pen-based digital painting environment.
2. Task 2–Layer Control: All commands were related to the layer management commands. The result indicated appropriate software command operations for layer management in a pen-based environment.

Table 36.1 Experiment groups

Variables	GUI[a]	SK[b]	PGr[c]	PGk[d]
C (Cintiq 21UX)	C-GUI	C-SK	C-PGr	C-PGk
I (Intuos 3)	I-GUI	I-SK	I-PGr	I-PGk

[a] Graphical user interface
[b] Shortcut keys
[c] Pen gestures with a rubber grip pen
[d] Pen gestures with a rubber grip pen and a keyboard

3. Task 3–Graphics Toolbar: All commands were located on the graphics toolbar. The result reflected suitable software command operations for the graphics toolbar in a pen-based environment.
4. Task 4–Brushes Adjustment: All commands were related to brushes adjustment. The result indicated appropriate software command operations for brushes adjustment in a pen-based environment.
5. Task 5–Integrated Applications: The combination or previous four tasks to simulate the actual workflow. The result reflected the effect of commands on overall task efficiency.

36.4 Results

36.4.1 Task 1–File Editing

The result of the two-way ANOVA of task 1 indicated that the main effect of command operations was $F = 252.07$, P value $= 0.000 < 0.05$, there was a statistically significant difference in four types of command operations. The results of Fisher's least significant difference (LSD) of command operations of task 1 indicated that there was a statistically significant difference in comparing graphical user interface (GUI, $M = 17.81$, $SD = 1.93$) to shortcut keys (SK, $M = 7.84$, $SD = 1.24$), pen gestures with a rubber grip pen and a keyboard (PGk, $M = 7.73$, $SD = 0.73$), and pen gestures with a rubber grip pen (PGr, $M = 7.35$, $SD = 0.69$). Graphical user interface (GUI) had the worst task efficiency among the four command operations.

36.4.2 Task 2–Layer Control

The result of the two-way ANOVA of task 2 indicated that the main effect of command operations was $F = 50.35$, P value $= 0.000 < 0.05$, there was a statistically significant difference in four types of command operations. The results of Fisher's least significant difference (LSD) of command operations of task 2 indicated that there was a statistically significant difference in comparing graphical user interface (GUI, $M = 13.84$, $SD = 1.29$) to shortcut keys (SK, $M = 10.28$, $SD = 1.84$), pen gestures with a rubber grip pen and a keyboard (PGk, $M = 9.35$, $SD = 0.93$), and pen gestures with a rubber grip pen (PGr, $M = 8.90$, $SD = 0.82$). Graphical user interface (GUI) had the worst task efficiency among the four command operations. There was a statistically significant difference in comparing shortcut keys (SK, $M = 10.28$, $SD = 1.84$) to pen gestures with a rubber grip pen and a keyboard (PGk, $M = 9.35$, $SD = 0.93$), and pen gestures with a rubber grip pen (PGr, $M = 8.90$, $SD = 0.82$). The task efficiency of shortcut keys (SK) was worse than pen gestures with a rubber grip pen and a keyboard (PGk), and pen gestures with a rubber grip pen (PGr).

36.4.3 Task 3–Graphics Toolbar

The result of the two-way ANOVA of task 3 indicated that the main effect of command operations was F = 34.79, P value = 0.000 < 0.05, there was a statistically significant difference in four types of command operations. The results of Fisher's least significant difference (LSD) of command operations of task 3 indicated that there was a statistically significant difference in comparing graphical user interface (GUI, M = 8.73, SD = 0.95) to shortcut keys (SK, M = 6.03, SD = 0.67), pen gestures with a rubber grip pen and a keyboard (PGk, M = 7.92, SD = 0.63), and pen gestures with a rubber grip pen (PGr, M = 7.57, SD = 0.74). Graphical user interface (GUI) had the worst task efficiency among the four command operations. There was a statistically significant difference in comparing shortcut keys (SK, M = 6.03, SD = 0.67) to pen gestures with a rubber grip pen and a keyboard (PGk, M = 7.92, SD = 0.63), and pen gestures with a rubber grip pen (PGr, M = 7.57, SD = 0.74). The task efficiency of shortcut keys (SK) was better than pen gestures with a rubber grip pen and a keyboard (PGk), and pen gestures with a rubber grip pen (PGr).

36.4.4 Task 4–Brushes Adjustment

The result of the two-way ANOVA of task 4 indicated that the main effect of command operations was F = 190.83, P value = 0.000 < 0.05, there was a statistically significant difference in four types of command operations. The results of Fisher's least significant difference (LSD) of command operations of task 4 indicated that there was a statistically significant difference in comparing graphical user interface (GUI, M = 26.12, SD = 2.57) to shortcut keys (SK, M = 14.24, SD = 1.31), pen gestures with a rubber grip pen and a keyboard (PGk, M = 16.32, SD = 0.66), and pen gestures with a rubber grip pen (PGr, M = 15.44, SD = 0.84). Graphical user interface (GUI) had the worst task efficiency among the four command operations. There was a statistically significant difference in comparing shortcut keys (SK, M = 14.24, SD = 1.31) to pen gestures with a rubber grip pen and a keyboard (PGk, M = 16.32, SD = 0.66), and pen gestures with a rubber grip pen (PGr, M = 15.44, SD = 0.84). The task efficiency of shortcut keys (SK) was better than pen gestures with a rubber grip pen and a keyboard (PGk), and pen gestures with a rubber grip pen (PGr).

36.4.5 Task 5–Integrated Applications

The result of the two-way ANOVA of task 5 indicated that the main effect of command operations was F = 173.11, P value = 0.000 < 0.05, there was a statistically significant difference in four types of command operations. The results of

Fisher's least significant difference (LSD) of command operations of task 5 indicated that there was a statistically significant difference in comparing graphical user interface (GUI, M = 22.55, SD = 2.50) to shortcut keys (SK, M = 12.83, SD = 1.34), pen gestures with a rubber grip pen and a keyboard (PGk, M = 12.75, SD = 0.98), and pen gestures with a rubber grip pen (PGr, M = 11.92, SD = 0.99). Graphical user interface (GUI) had the worst task efficiency among the four command operations.

36.4.6 System Usability Scale (SUS)

The result of the two-way ANOVA of SUS indicated the main effect of the pen-based input devices was F = 0.07, P value = 0.795 > 0.05, there was no statistically significant difference in two types of pen-based input devices. The main effect of command operations was F = 2.09, P value = 0.112 > 0.05, there was no statistically significant difference in four types of command operations. The interaction between pen-based input devices and command operations was F = 0.48, P value = 0.695 > 0.05, there was no interaction effect.

The above result showed that the subjects shared the same subjective evaluation of the eight experimental groups. However, the average score of pen gestures with a rubber grip pen (PGr) in two pen-based input devices reached 60, while the other three command operations were rated lower than the level of 60. The result indicated that pen gestures with a rubber grip pen (PGr) had the best system usability among four command operations.

36.5 Conclusions

According to the results of the five task performances, the task efficiency of the graphical user interface (GUI) was the worst among the four command operations. The task efficiency of the shortcut keys is worse than pen-gesture commands in task 2. However, the task efficiency of the shortcut keys is better than pen-gesture commands in task 3 and task 4. There was no statistically significant difference between pen gestures with a rubber grip pen and a keyboard (PGk) and pen gestures with a rubber grip pen (PGr) in all five tasks. Furthermore, two types of pen-based input devices showed no statistically significant difference in the task efficiency of command operations. The result of the system usability indicated that there was no statistically significant difference in two types of pen-based input devices and there was no statistically significant difference in four types of command operations. However, the average score of pen gestures with a rubber grip pen (PGr) in two pen-based input devices reached 60, which indicated that pen gestures with a rubber grip pen (PGr) had the best system usability among four command operations.

Acknowledgments This work was sponsored by the National Science Council, Taiwan, under the Grant No. NSC102-2410-H-011-027.

References

1. Frankish C, Morgan P, Noyes J (1994) Pen computing: some human factors issues. In: IEE colloquium on handwriting and pen-based input. The institution of electrical engineers, London 5/1–5/3
2. Long AC Jr, Landay JA, Rowe LA (1997) PDA and gesture use in practice: insights for designers of pen-based user interfaces. Technical report UCB/CSD-97-976. University of California, Berkeley
3. Meyer A (1995) Pen computing: a technology overview and a vision. ACM SIGCHI Bull 27 (3):46–90
4. Wu ZC, Zhang LP, Shen F (2007) Pen-based user interface based on handwriting force information. In: Jacko JA (ed) Human-computer interaction: interaction platforms and techniques, Part II. Springer, Berlin/Heidelberg, pp 496–503
5. Rubine D (1991) Integrating gesture recognition and direct manipulation. In: Summer 1991 USENLY technical conference, USENIX Association, Ann arbor, 95–100
6. Wolf CG (1992) A comparative study of gestural, keyboard, and mouse interfaces. Behav Inform Technol 11(1):13–23
7. Kurtenbach G, Moran T, Buxton W (1994) Contextual animation of gestural commands. Comput Graph Forum 13(5):305–314