

Selection Accuracy with a New Pen-Based Selection Device

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Abstract

The selection slot is a new menu selection device for pen-based systems. Experiments with selection accuracy indicated that with as little as 0.04 inches (about 1 mm) per notebook name, users could select notebook names from a list of names with 100% accuracy. This new selection device seems to work very well for its designed purpose.

ITIRC Keywords

Selection slot

Selection accuracy

Selection sensitivity

Pen-based systems

Absolute selection device

Relative selection device

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Introduction

The CrossPad¹ is a device that captures a users' handwriting as the user writes on standard note paper. To do this, the tablet has an array of sensors in the area under the paper and the pen has a small radio transmitter activated by a tip switch closed by the pressure of writing. Figure 1 shows the pen assembly, and Figure 2 shows a close-up of the pen's radio transmitter.



Figure 1. CrossPad pen assembly



Figure 2. Close-up of transmitter

Handwriting capture can be very valuable to several categories of users, including attorneys and college students, because the system captures their notes quietly (no keyboard clicking) and they can translate ink to keywords to facilitate later retrieval. Using IBM's Ink Manager 1.X software, after uploading pages of notes from the pad to the computer, users could assign pages of notes to different notebooks.

One common complaint of CrossPad users was that there was no way for them to assign note pages to different notebooks during the day, away from the computer. Solving the problem of assignment of pages to notebooks on the fly became part of the development effort for the CrossPad2. A key part of the solution was the development of a new selection device for pen-based systems – the selection slot (see Figure 3). The selection slot is a slot placed in the tablet over a set of the radio receivers used for handwriting capture. To use the selection slot, the user places the tip of the pen in the slot (activating the transmitter) and slides the pen (see Figure 4). Activation of the transmitter in the slot causes the system to present the current set of notebook names², with one of the names highlighted (see Figure 5). Sliding the pen in the slot scrolls the

¹ CrossPad is a trademark or registered trademark of the Cross Pen Corp.

² Default names are Notebook 1 to Notebook 8. Users can download personalized notebook names from the computer to the pad using Ink Manager 2.0.

list of notebooks, and lifting the pen out of the slot results in the selection of the highlighted notebook. Note that this lift-off strategy for selection is consistent with a well-known touch screen strategy that allows users to select very small targets (Lewis, 1992).



Figure 3. The selection slot



Figure 4. The pen in the selection slot



Figure 5. The display of notebook names

The selection slot is an absolute selection device, with the slot length evenly divided among the available notebooks plus an always-resident Other category (in which users could place pages that weren't part of any notebook in the list for later assignment to new or existing notebooks on the computer). This meant that users could pick an initial place to put the pen in the slot that would be close to the desired notebook. They could then slide the pen to the left or right if necessary to highlight the desired notebook before lifting the pen out of the slot – a useful design if the pad contained a large number of notebook names. On the other hand, if the pad

contained a small number of notebook names, this would allow users to simply tap the appropriate section of the slot to assign the page to the desired notebook.

Thus, it appeared that designing the slot as an absolute selection was advantageous whether users had a small or large number of notebook names stored in their pads. A key usability question, though, was how many notebook names could a user place in the pad before the number of available names started to affect notebook selection accuracy. Based on pre-development interviews with CrossPad users, we believed that users would typically want to have about five notebooks available on their pads at any given time, and that a reasonable maximum estimate for this number of notebooks was ten. Note that the selection of notebook names from a list is a specific instance of the general task of selecting items from a menu.

Experiment 1: Prototype

Purpose

The first evaluation of selection slot sensitivity took place with a prototype slot cut into the lower part of a standard notepad placed in a CrossPad tablet. The specially coded firmware for this tablet reprogrammed the sensors under the slot to control notebook selection. The goals of this experiment were (1) to check selection accuracy with 15 notebook names loaded in the pad and (2) to assess user preference between two methods for highlighting the notebook name – reverse video over the notebook name or an arrow pointing to the left side of the notebook name.

Method

Twelve participants (six male, six female -- all IBMers with no connection to the CrossPad project and including one left-handed female participant) made notebook selections using the specially-programmed CrossPad. The software displayed the notebook list as a single column in a display that could show up to four notebook names at a time. To guide the pen tip in the prototype slot, I cut the slot with an approximate length of 1.75 inches, width of 0.1 inches and depth of 6 sheets of paper (about 0.02 inches). The sides of the slot were vertical (no discernible angle to the cut).

The list of notebook names (in order) were:

Other
Meeting
Project (high target)
Sketch
Physics
Mathematics
Linear Algebra
Art History (middle target)
English
French
German
Italian
Physiology (low target)
Physical Chemistry
History

When I asked people to acquire a target, I told them its approximate position in the list of fifteen -- high for Project, in the middle for Art History, and low for Physiology. This seemed reasonable because CrossPad users would create and download their own personalized lists of

notebook names, and would therefore be likely to have some idea about the relative position of the names in the list.

Participants used the pen in the slot to acquire three targets, one close to the top of the list, one in the middle of the list, and one close to the bottom of the list. As shown in Table 1, the experimental design counterbalanced the orders of target acquisition and highlighting method.

Table 1. Design for Experiment 1

| Participant | Gender | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 | Trial 6 |
|-------------|--------|---------|---------|---------|---------|---------|---------|
| 1 | M | A-H | A-M | A-L | R-H | R-M | R-L |
| 2 | M | A-M | A-L | A-H | R-M | R-L | R-H |
| 3 | M | A-L | A-H | A-M | R-L | R-H | R-M |
| 4 | M | R-H | R-L | R-M | A-H | A-L | A-M |
| 5 | M | R-M | R-H | R-L | A-M | A-H | A-L |
| 6 | M | R-L | R-M | R-H | A-L | A-M | A-H |
| 7 | F | R-H | R-M | R-L | A-H | A-M | A-L |
| 8 | F | R-M | R-L | R-H | A-M | A-L | A-H |
| 9 | F | R-L | R-H | R-M | A-L | A-H | A-M |
| 10 | F | A-H | A-L | A-M | R-H | R-L | R-M |
| 11 | F | A-M | A-H | A-L | R-M | R-H | R-L |
| 12 | F | A-L | A-M | A-H | R-L | R-M | R-H |

Key: A = Arrow, R = Reverse Video selection indicator

L = Low, M = Middle, H = High target position in menu list

After acquiring the three targets with both selection indication methods, participants indicated (1) whether they preferred the arrow or reverse-video highlighting when making their selections and (2) if they felt that selection sensitivity under these conditions was too low, low, just right, high, or too high.

After participants completed the sequence shown in Table 1, I reset the software so there were eight subjects in the 1.75" slot. Participants did not attempt to pick targets, but just slid the pen from the top of the list to the bottom of the list and reported how they felt about the sensitivity of the control.

Results

11/12 participants preferred reverse-video highlighting. This was an observed percentage of 91.7%, with a 90% confidence interval ranging from 66.9% to 99.7%.

11/12 participants rated the sensitivity of the slot control under these circumstances as just right. One participant thought it was a little low.

All participants made all selections correctly -- acquiring the designated target and leaving it in place when lifting off the pen. This 100% correct performance indicated that a 1.75-inch slot provided an adequate length for selecting among fifteen notebooks.

In using the slot, none of the twelve participants ever missed putting the pen directly in the slot, and all ink left on the paper was contained in the slot.

On the second attempt to select the designated notebook, some of the participants were able to hit the desired targets without sliding because they remembered the locations from the first trial³. This, too, is evidence that the selection slot is a control device with desirable human factors (usability) characteristics.

With eight notebook names available for selection, 10/12 participants reported that the sensitivity still felt OK to them. One reported that the sensitivity felt a little low, and the other said the sensitivity of the control was too low⁴. The 90% binomial confidence interval for the proportion of 10/12 (an observed percentage of 83.3%) ranges from 56.2% to 97.0%.

Conclusions

- The slot works well as a notebook selection mechanism, even with fifteen notebooks controlled over a 1.75-inch length (0.117 inches per notebook).
- Because selection performance was perfect across twelve participants, it seemed likely that the slot would allow accurate selection from a list of more than fifteen notebooks.
- Participants prefer reverse-video highlighting to the (->) arrow.
- There is no evidence that using a slot would result in ink left on the pad outside of the slot that could get on a user.
- The fewer the number of notebooks stored in the pad, the more likely that a user who is sliding from one subject to another would perceive the control as overly insensitive. However, the fewer the number of notebooks on the pad, the more likely that a user who has some familiarity with the location of subjects in the list (which is plausible because the user creates the list) will be able to click directly on the notebook's position in the slot.

³ I didn't expect this skill to emerge so quickly.

⁴ I'm sure that part of what contributed to the feeling that the sensitivity was too low was that the slot I was using was cut in paper, and was getting rough to slide in after so much use.

Experiment 2: Final Design

Introduction

The final design of the slot (see Figure 3 above) had a length of 0.875 inches. The purpose of Experiment 2 was to investigate notebook selection accuracy for 20 notebooks in this length (.04 inches, or about 1 mm, per notebook). This was a little less than half the length per notebook used in Experiment 1.

Method

Ten participants (five male, five female -- all IBMers, with ages ranging from early 20s to early 60s and including two left-handed males) to make notebook selections using a CrossPadXP2 loaded with beta-level firmware and containing 20 notebooks. Participants were to make four selections each, with one target close to the top of the list, one in the middle of the list, one close to the bottom of the list, and the last notebook in the list. For this experiment, the list was:

Alligators
Bison
Cats
Dogs (First target)
Flies
Giraffes
Hippos
Ibis
Kangaroos
Lions (Second target)
Monkeys
Newts
Penguins
Quail
Rats
Snakes
Voles (Third target)
Whales
Yaks
Zebras (Fourth target)

When users put together their personal lists of notebook names, they will have some idea about whether a specific notebook is high, medium, or low in the list. For this reason, the organization of notebook names was alphabetical, and participants received a paper copy of the list to simulate the knowledge they would likely have about personally created lists.

Results

All participants made all selections correctly -- acquiring the designated target and leaving it in place when lifting off the pen.

In using the slot, none of the participants ever missed putting the pen directly in the slot, and all ink was contained in the slot.

When asked, all participants reported that notebook selection was easy.

Conclusions

- The slot works well as a selection mechanism, even with twenty notebooks controlled over a .875" length (0.04 inches, or about 1mm, per notebook).
- Because selection performance was perfect across ten participants, it might be possible to put more than twenty notebook names in the pad, but this would probably not be advisable. First, pre-development interviews with existing CrossPad users indicated that it was unlikely that a normal user would want to work with as many as 20 notebooks at a time. Second, with only 1mm per notebook, the control is very likely approaching the limits of easy selection.
- There is no evidence that using the slot would result in ink left on the pad outside of the slot that could get on a user.

References

Lewis, J. R. (1992). *Literature review of touch screen research from 1980 to 1992* (Tech. Report 54.694). Boca Raton, FL: International Business Machines Corp.