Touch&Type: A Novel Pointing Device for Notebook Computers

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ABSTRACT
The widespread use of the mouse as an input device for notebook computers indicates that many users are reluctant to use alternative built-in pointing devices. We present a novel input method called Touch&Type™ which is meant to overcome some of the drawbacks encountered with conventional built-it pointing devices. Touch&Type™ combines a conventional keyboard with an extended touch pad whereby the touch pad's sensitive area is formed by the surface of the keys themselves and thus can be made as large as the whole key area. A comparative study of pointing operation is presented with a Touch&Type™ prototype in comparison with the mouse and the conventional touch pad. While the mouse outperformed its two counterparts, Touch&Type™ was found to be superior to the conventional touch pad (after a short learning period) with a confidence level of 73%. The study investigated pointing operation only, not taking homing time into account.

Author Keywords
Touch&Type™, notebook computer, input device, keyboard, touch pad, touch sensitive area, comparative study

ACM Classification Keywords
Input and interaction technologies, empirical methods, product design

INTRODUCTION
With the advent of Graphical User Interfaces (GUIs), the *computer mouse* has evolved into the most prominent method to insert coordinate data into a computer system. In spite of its widespread use, the conventional mouse suffers from a major drawback: in order to use it, the steering hand must be moved away from the computer keyboard. For example, typing on a keyboard and pointing with a mouse requires the user to frequently move one hand back and forth between the keyboard and the mouse. It has been reported [2] that it takes, on average, 0.36 seconds to move a hand from the keyboard to the mouse and additional time to adjust the grasp for operating the mouse buttons. Then the time to return the hand to the keyboard must be considered as well. Altogether, the data suggests that the total time spent moving to and from the mouse is greater than one second per occurrence, not taking into account the mental disruption due to the time elapsed and the many physical steps needed to perform the change-over [5].

A second pointing device located in closer proximity to the keyboard suffers from a different drawback. First seen on the IBM ThinkPad, the *pointing stick* is usually placed between the G and H of the keyboard. By applying a lateral force to the stick the pointer accelerates in the direction of the applied pressure. Rutledge and Selker of IBM [7] had to undertake significant experimentation and adjustments before it performed acceptably. The velocity of the cursor is proportional to the pressure a user exerts on the stick ("rate control"), forcing the user to precisely control this parameter, requiring considerable accommodation.

The industry released a third pointing device, the *touch pad*, in the early nineties with one of the first Powerbook portable computers. Based on capacitance field technology, the new touch pad was quickly integrated into a multitude of other products.

There exist some scientific studies comparing the pointing stick and the touch pad. For example Sawin et al. [8] found that using the best technology in either input devices produced nearly equal performance results and thus confirmed hypotheses from previous research saying that user device preference and prior learning are key-contributing variables. They also found that inferior types of technology resulted in reduced performance and preference.

Notwithstanding the results reported by Sawin et al. [8], several properties remain to be objected in case of the touch pad. A major drawback of the touch pad is the limited space, which either forces the user to repeatedly move the finger over the surface to arrive at a target point across the screen or to increase the pad's sensitivity and acceleration such that hitting a target point becomes a challenge. Moreover, the typical placement of the touch pad in front of the keyboard does not conform to the typical mouse placement at the keyboard's side, possibly leading to irritation if users switch input devices. Many users operate the pad with their index finger so that one hand has to be moved away from the keyboard. Also, the mouse buttons are inconveniently placed since buttons have to be clicked either by the thumb or the second hand. Last but not least, the touch pad consumes laptop space.

From the introduction it should have become clear that room exists for alternative input devices. One alternative called Touch&Type™ [4] is presented next. A summary of the properties of the three conventional pointing devices mentioned – together with the expected performance of Touch&Type™ – is given in Table 1.

THE TOUCH&TYPE™ APPROACH

FBZS Interface Technology, in collaboration with IHA/ZOA of ETH Zurich, has developed a keyboard with integrated pointing device called Touch&Type™, which is designed to overcome many of the drawbacks in pointing devices discussed above. It works like a conventional touch pad, whereby the touch sensitive area is formed by the surface of the keys themselves and thus can be as large as the key area (Fig. 1). As a consequence, the whole hand may be used to steer the cursor by gliding over the keys (not depressing them), as compared to a single finger in the touch pad's case. Due to the gaps between the keys, the keyboard's texture helps users to develop a feeling for the location and the speed of their hand.

Figure 1. Touch&Type™ (1st generation prototype); the mouse buttons are shown left; the touch sensitive area is framed.

In the version for right-handed users, pointing-mode is activated when the user's left hand touches one of the two mouse buttons (it does not need to be depressed), located on the left part of the keyboard (Fig. 2).

Figure 2. Pointing-mode: user's left hand activates pointing-mode by touching one of the mouse buttons, user's right hand steers the cursor by gliding over the keys.

In pointing-mode, the cursor moves along when the user's right hand touches and glides over the keyboard. In typing-mode, the cursor remains unaffected by the user's hand movements. A range of parameters such as sensitivity, double-click behavior, speed acceleration, etc. is made adjustable through the mouse driver software.

Expected Performance Advantages

The expected advantages of Touch&Type™ technology to prior technology may be summarized as follows (see also Table 1):

We expect the ease of cursor control with Touch&Type™ to be superior to that of pointing stick [4]. Also, we expect it to be equal or better than the conventional touch pad due to its bigger area (less sensitivity and acceleration needed) and because the entire hand can be used.

Merging keyboard and touch pad area enables a more compact design. In a laptop system, the key area might be increased, or moved forward to the edge of the laptop. In a desktop system, no space is needed for the mouse and its pad.

Finally, no flat surface is needed next to the laptop.

	Mouse	Pointing stick	Touch pad	Touch& Type™
Mouse button handling	++	-	-	+
Space consumption	--	++	0	++
Environment requirements	--	++	++	++
Transportation	--	++	++	++

Table 1: Expected performance of mouse, pointing stick, touch pad, and Touch&Type™. Ranked from very good (++), to good (+), no assumption (0), bad (-), and very bad (--).

PROTOTYPES

In order to demonstrate the capability of Touch&Type™, a prototype keyboard with an integrated sensor arrangement and an electronics board was constructed. For the housing of the 1st generation prototype (Figs. 1 and 2), a commercially available cordless keyboard was modified; for the 2nd generation prototype (Fig. 4) a wooden frame was used for reasons of larger design freedom. The 2nd generation prototype is shown in a video accompanying this paper[1]. It must be emphasized that the chosen sensor location is completely hidden within the keyboard housing and is fully compatible with high-volume production technology. Technical details are beyond the scope of this article and have been published elsewhere [3].

USER STUDY

A brief comparative study of all the devices mentioned except for the pointing stick has been carried out.

Test Design

A comparative, within-group study examining objective and subjective performance of mouse, touch pad, and Touch&Type™ was carried out. Seven subjects performed two to four sessions each. A Logitech Pilot Wheel mouse, a Synaptics V5.1 touch pad, and the 2nd generation prototype

[1] Video showing the 2nd generation prototype of Touch&Type™ in use: www.t2i.se/pub/media/2006_NordiCHI_Fallot_et_al.avi

of Touch&Type™ were used. Seven tasks (T1-T7) often encountered in GUIs were presented to the subjects:

T1. Menu Test: An item has to be selected from a drop-down menu.
T2. Four Windows Test: Four buttons, each located on partially overlapping windows, have to be clicked.
T3. Seven Buttons Test: 21 objects (round check fields, square check fields, buttons) are grouped in three columns of seven each and have to be checked in sequence.
T4. Rectangle Test: A selection rectangle has to be drawn.
T5. Text Selection: A number of adjacent words has to be selected from a text.
T6. Line Follow Test: A curved line has to be followed, with the mouse button clicked.
T7. Combo Box Test: An item has to be selected from a combo box, with some scrolling required.

All tasks were defined within DEVICE [6], an assessment program for graphical input devices which also recorded task completion times. No tasks required switching between pointing- and typing-mode. A typical session involved some practice with Touch&Type™ followed by recorded task solving with the mouse (one or more passes), touch pad (two or more passes), and Touch&Type™ (two or more passes). After task solving, subjects filled out a questionnaire for subjective impressions.

Quantitative Results

Figure 3 displays a graphical representation of task solving times which indicates performance. Table 2 gives the frequency of occurrence of the ranks “best”, “middle”, “worst” when comparing mouse, Touch&Type™, and touch pad. Table 3 gives a task-resolved picture, with the rank sums obtained when ordering the task solving times as achieved by 7 subjects per task.

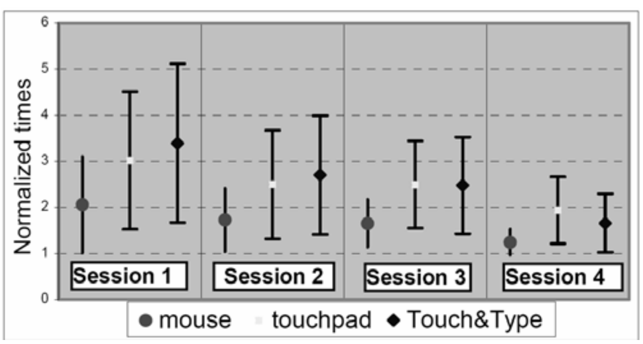

Figure 3. Best task completion time for each input device per session, averaged over tasks and subjects (normalized to the best time achieved in a task by any subject with any device).

	Best	Middle	Worst
Mouse	38	8	3
Touch&Type™	8	20	21
Touch pad	3	21	25

Table 2. Frequency of occurrence of different ranks per device per task and per subject, using time from task performed best by subject (mostly subject’s last task).

Testing the Data

Since the mouse was clearly superior, no testing between it and the two other devices was called for. Rather, we tested the performance difference between Touch&Type™ and the touch pad. Thus, we stated as null-hypothesis H_0: No performance difference exists between Touch&Type™ and touch pad.

We calculated a rank test, exploiting the information given by having results from seven tasks. The rank sum of Touch&Type™ was 47 and the rank sum of touch pad was 58. Hence, H_0 holds with a probability of 27% (only). In other words, Touch&Type™ outperformed touch pad after four sessions with a confidence level of 73%. The experiment did not require changing between keyboard and positioning tasks, so that in practical use homing time possibly would favor Touch&Type™ even more.

	T1	T2	T3	T4	T5	T6	T7
Touch&Type™	48	47	55	52	58	52	51
Touch pad	57	58	50	53	47	53	54
Prob. under H_0 [%]	31	26.7	40.2	50	26.7	50	54.1

Table 3. Per task, rank sums were calculated on the basis of all subjects’ results; higher performing device is shaded.

Qualitative Results

After each pass, subjects were asked about the intensity of effort during the pass using a Borg scale where 0 was no effort and 10 was highest effort [1]. Table 4 shows the values subjects gave in their final session. The higher number of entries in the Touch&Type™ row is due to the higher number of passes performed with this device. The value specified most frequently for all devices was one. The mouse scored best with the lowest mean value. The difference between Touch&Type™ and touch pad was minor. Touch&Type™ ranked better in later than in earlier session.

	0	0.5	1	1.5	2	>2	Mean
Mouse	2	3	6	1	1	0	0.9
Touch&Type™	0	0	18	4	2	0	1.2
Touch pad	0	2	9	1	2	0	1.1

Table 4. Borg values given by subjects in their last session. Most frequently answered categories and means are shown.

Based on the questionnaires, subjects preferred the mouse, followed by touch pad and Touch&Type™, with Touch&Type™ slightly inferior to touch pad.

Subjective Ranking of Devices

The subjects were asked to order the devices according to subjective preference. Table 5 shows the values as given in the final session by any subject.

	Rank 1	Rank 2	Rank 3
Mouse	5	1	1
Touch&Type™	0	4	3
Touch pad	2	4	1

Table 5. Subjective preference ranking of input device.

Subjects ranked the mouse first, followed by the touch pad and Touch&Type™. The sums of the rank 2 and rank 3 columns differ from 7, since two subjects ranked Touch&Type™ and touch pad both second. The results seemingly contradict the objective ranking from the time measurement. For example, the two subjects who liked the touch pad most actually performed best with the mouse or even Touch&Type™. Apparently, the subjective preference is influenced by more factors than the quantitative results. One subject explained his dislike of the mouse by health disturbances felt when using the mouse. Asked for strengths and weaknesses of Touch&Type™, the subjects answered:

Strengths: compactness, bigger resolution, easy movement, no need for mouse, small hand movement distances, no need to move hand away from keyboard.

Weaknesses: touchdown-liftoff recognition, precision, small mouse buttons, wide movements needed, sensitive area limits unclear, care needed with the shape of the hand.

Summary of User Study

A fair comparison of Touch&Type™ to the mouse and the touch pad is difficult to achieve since subjects sometimes had considerable prior experience with the latter ones. Also, the prototype suffered from a few shortcomings, like the limits of the sensitive area not being clearly marked, and particularly, imperfect touchdown-liftoff recognition. While such effects confused subjects in the beginning, they were no longer a problem after practice. Nevertheless, strong evidence was found saying that the Touch&Type™ input method outperforms the touch pad method. The technical shortcomings worsened the subjective assessment. Mixed textual and pointer input, a strength of Touch&Type™, was not investigated.

DISCUSSION AND OUTLOOK

While the location of the sensors, mechanical compliance between the sensors and the keyboard, and speed and noise issues have been resolved [5], technical challenges remain. One is the further refinement of touchdown/liftoff recognition since the cursor should only be moved upon physical contact on the keyboard. Another one is the fact that several users expect only their fingertips to affect pointing while the current prototype reacts to the entire hand. A final issue is coordinated two-handed input, that is, the switching between pointing- and typing-mode [6][9], which was not examined in the evaluation reported here. All three issues call for further hardware development and optimization. The last topic also calls for user studies into two-handed, coordinated input.

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Figure 4. Touch&Type™ (2nd generation prototype, left to right, top to bottom): writing; idle mouse buttons; holding one mouse button; touching; start drawing by touching; end drawing by touching.