AUTO–ID LABS

The scanner at your finger tips – analysis of the effective of the scan mouse device

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Auto-ID Labs White Paper WP-BIZAPP-062

December 2012

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This paper is already published in the 10th ACM SIGMOBILE Conference on Mobile and Ubiquitous Multimedia (MUM'12), Ulm, Germany, December, 2012

Business Process & Application

Abstract

Scanning parts of paper-based information can be time-consuming and disrupt the user's workflow. Accordingly, we investigate the performance and usability of a computer mouse with document scanning capabilities, referred to as scan mouse. We set up a user study with 20 users scanning parts of paper documents using the scan mouse, a personal desktop scanner, shared network scanner, and the camera of an iPhone. Results show that the scan mouse is both faster and perceived as easier to use than the other devices due to the seamless integration of scanning capabilities into the established routine of handling a computer mouse.

Categories and Subject Descriptors

H.5.2 [**User Interfaces**]: Input Devices and Strategies

General Terms

Design, Experimentation, Human Factors.

Keywords

Document scanning, user study, mobile office environment.

1. Introduction

Despite the enormous growth rate of digital information - the amount of digital information grew by 62 percent to 800 billion gigabytes in 2009 according to EMC [2] - paper still offers unique advantages and will remain in daily use [8]. As the paperless office has not yet arrived [9] the challenge of digitally capturing content of paper documents remains to be solved.

Especially when trying to quickly capture pieces of text, diagrams or tables, traditional office devices such as the widespread personal desktop scanners or shared network scanners disrupt the user's workflow and are considered cumbersome and time consuming [1]. In a pilot interview study with CIOs and IT managers of 9 large and international companies we identified a distinct need for an efficient personal solution for such small capture tasks.

Accordingly, this paper introduces the scan mouse that augments the traditional computer mouse with document scanning capabilities. By moving the mouse over the document it gets scanned. This paper compares the effectiveness of the scan mouse for partial page scans against the traditional document scanning devices such as personal desktop scanner, shared office scanner and camera capture using a mobile phone.

2. Related Work

Newman et al. introduce CamWorks [5] and propose to use a video camera for automatic real-time capture from paper sources during reading and writing. They show substantially faster text capture than with flatbed scanning. The VideoMouse by Hinckley et al. uses a built-in camera [3] similar to the scan mouse but only allows for simple scan tasks such as scanning the title of a document or a barcode. This work already outlines the advantage of seamless integration of simple image capturing with regular mouse interaction.

3. Related Work

The scan mouse is a standard computer mouse extended by a camera to capture images through a thumb-sized scan window on the bottom of the mouse (meanwhile this principle has been patented and commercialized by several hardware vendors including LG which promotes it as LSM-100 Scanner Mouse[1]). Scanning is done by pressing a dedicated scan button on the mouse itself and then dragging the scan mouse across the image. In contrast to traditional hand-scanners and the VideoMouse outlined above, the stitching algorithm of the scan mouse processes the stream of images into a 400dpi scan image (see Figure 1) and allows for arbitrary scan motions. Thus, the user is completely free in his movements and does not have to adhere to a specific scan pattern and speed. The scan mouse also allows scanning odd formats or pages larger than A4. Scanned content is immediately added and displayed on the screen in real-time. The capture interface automatically performs post-processing and auto-rotation, allows editing of specific content and offers various one-click export features such as OCR-enabled output of formatted text.

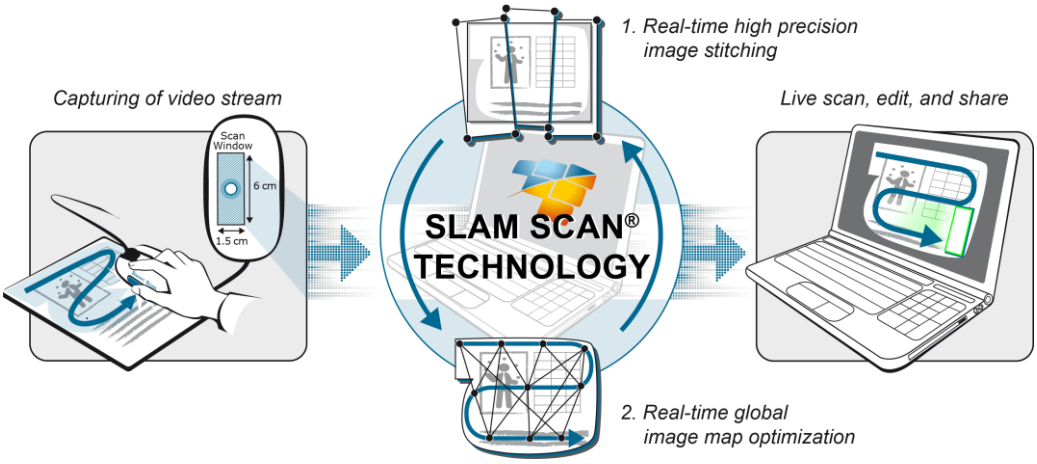

Figure 1. Scan mouse system overview.

[1] Video of the device is available from http://bit.ly/lsm100

4. Comparison Study Design

Following a within-subject study design we set the scan mouse up against established scan solutions in a comparison study. The task of the participants was to scan parts of A4 pages and add them into a MS-Word document. The time required to perform this task and the ease of doing so determined the dependent variables. We recruited 20 participants (10 male, 10 female) from different education backgrounds with an average age of 31.

4.1. Dependent Variables

Task completion time. Time started after a new scan task had been assigned to the participant and ended as soon as importing into Word was finished.

Perceived ease of use. This variable was acquired by asking the participants about the ease of use at the end of the study after all scanning tasks had been finished. A Likert scale (1 = very difficult to use, 5 = very easy to use) was used to rate each scan device.

4.2. Independent Variables

The independent variable was defined by the scan device used for the respective scan task. As today's most established scanning practices we compared the scan mouse with a personal desktop scanner and a spatially separated shared network scanner. As a baseline we also chose to compare against mobile phones which are not specifically designed for scanning but are still frequently used for this task [4, 6]. In a pre-study we identified the fastest scanning procedures and accordingly we chose the following configurations for the study:

As the personal scanner we chose the popular and portable Canon ImageFormula P-150 with automatic document feed. The bundled software was set to automatically open scanned content (300dpi) with Adobe Reader or paint.net for further cropping and export.

The Samsung CLX-3175FW, a typical entry-class color multifunction printer (MFP) with both flatbed scanner and automatic document feed, was used as the shared scanner and placed at 8 meters distance in a different room. Scanned content (300dpi) was transferred directly to the client computer and opened automatically with Adobe Reader or paint.net for further cropping and export.

Our mobile phone of choice was the Apple iPhone 3G featuring a 2MP camera. We used the Dropbox cloud service for taking images and transferring them over WLAN to the client computer. The image file could then be opened, cropped and exported with paint.net.

5. Comparison Study Execution

The participants received a verbal introduction about the goals of the study and the four scan devices and capture interfaces to be tested. Then the participants could try out the four devices until they were familiar with each device. The participants then completed task set 1 followed by task set 2. After that we conducted a short interview and a discussion with each participant. The overall time required per participant was one hour. Figure 2 shows participants using the four devices.

5.1. Task set 1 – Partial page scan to application

Participants had to scan a part of an A4 page and paste it as an image into an already open and empty Word document. We prepared three A4 pages which either contained text, pictures or handwritten notes. In terms of size the marked parts varied between 1/6 and 1/2 of the usual print area of an A4 page. Each user performed 12 tasks in a random order, scanning three documents with four devices. In order to relieve participants from the additional burden of performing an OCR processing step, scanned content was always pasted into MS Word as an image also in case of text.

5.2. Task set 2 – Multiple partial page scans to application

Participants had to scan the marked parts from all three sheets as used in task set 1 and paste all of the snippets into one already open and empty Word document. The order in which the three parts were captured and pasted did not matter. Each user performed 4 tasks.

5.3. Interview

In a structured interview participants were asked to rate each scan device on a Likert scale from 1 (very difficult to use) to 5 (very easy to use) which yielded our variable “perceived ease of use”. We also asked participants to share further impressions of the devices used and finally encouraged an open discussion.

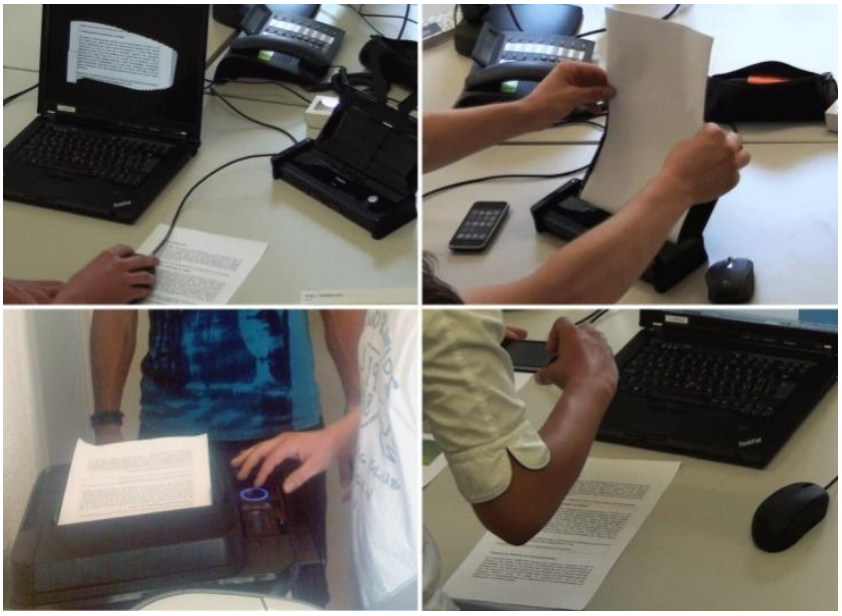

Figure 2. Participants using the a) scan mouse; b) personal scanner; c) shared scanner; d) mobile phone

6. Results

In the following we discuss the quantitative results, qualitative observations, and comments of the participants.

6.1. Task Completion Time

Task set 1 – Partial page scan to application. For performing a single partial scan and importing the marked content into MS Word the scan mouse was the fastest solution, followed by the roughly 30 percent slower personal scanner (see Figure 4). Shared scanner and mobile phone lagged behind, requiring more than double the time to complete the same task. The personal scanner featured the smallest standard deviation (5.1 seconds). This can be accredited to its optimized and well integrated workflow. The largest deviation (18 seconds) could be found in case of the mobile phone. Many users struggled with the interface. Variations in the speed of the Dropbox synchronization service also impacted the results. In addition, the 11 participants that owned or had used an iPhone before were roughly 30 percent faster than novice iPhone users.

Except for the difference between shared scanner and mobile phone, all differences between the task completion times are statistically significant ($\alpha<0.01$).

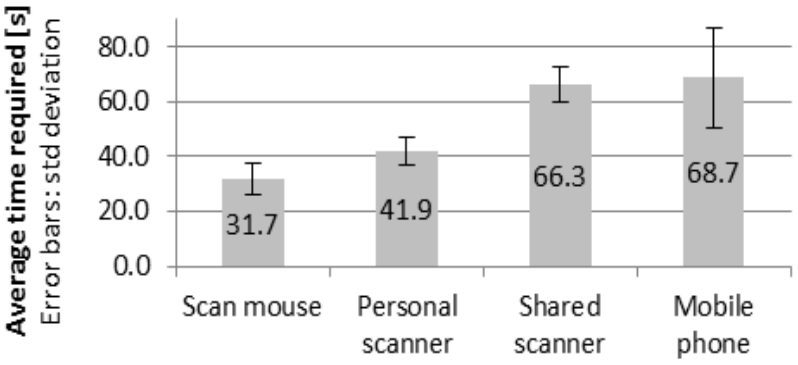

Figure 4. Task completion time for task set 1.

Task set 2 – Multiple partial page scans to application. For multiple partial scans the ranking remained the same; however the differences between the devices and the lead of the scan mouse were less pronounced. While the scan mouse's workflow for multiple scans consisted of repeated single scans in a sequential manner and thus yielded a linear increase of the task completion time, the two dedicated scanners profited from their ability to capture multiple sheets at once via automatic document feed. However every snippet still had to be selected and exported manually one by one from the acquired document, therefore limiting this advantage. Again the mobile phone was the slowest and the standard deviation of 50 seconds was the largest. The workflows varied greatly amongst participants: While some completed the task in a sequential manner, others tried to squeeze several parts onto one picture or performed a mixture of both.

Again, except for the difference between shared scanner and mobile phone, all differences between the task completion times are statistically significant ($\alpha<0.01$).

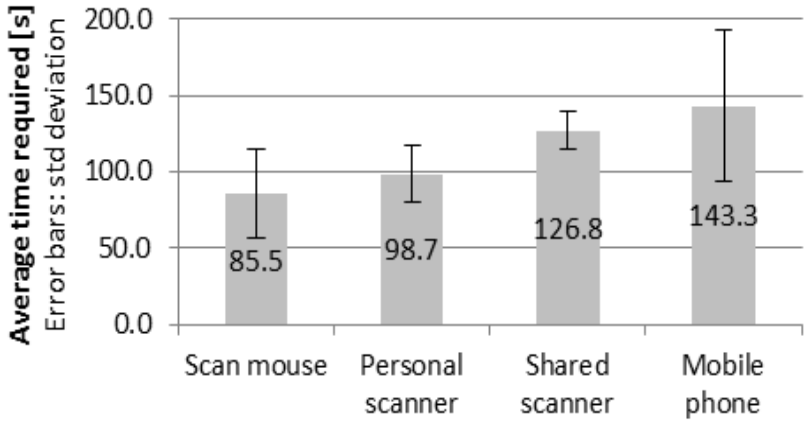

Figure 5. Task completion time for task set 2.

Perceived ease of use. The scan mouse was perceived as the easiest-to-use scan device with an average rating of 4.38 and the smallest standard deviation (see Figure 6). Next was the personal scanner with an average score of 4.25 and a slightly larger standard deviation. According to the participants both shared scanner and mobile phone were more difficult to use, still scoring above 3.0 though. The larger standard deviations also indicate that opinions about the latter two devices were rather controversial.

The differences are statistically significant ($\alpha<0.01$), except for the difference between scan mouse and personal scanner, and for the difference between shared scanner and mobile phone.

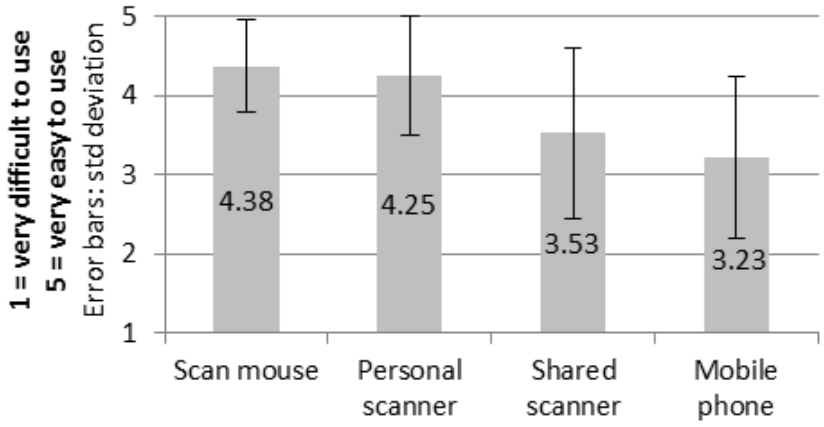

Figure 6. Perceived ease of use.

7. Discussion

The quantitative results were also supported by the comments of the participants: The scan mouse was considered fast by 11 and the personal scanner by 7 participants, with the rest of the comments being neutral. In contrast shared scanner and mobile phone earned no positive comments about their speeds but were rather considered slow by 4 participants each.

The mobile phone as a general purpose device scored last in all ratings. The marginal image quality and the cumbersome alignment process were criticized by more than half of the participants. The overall opinion amongst participants was that they would use a mobile phone for casual ad-hoc scans only. While higher-resolution cameras in mobile phones can be expected in the future, the issues of proper camera alignment and good lighting for consistent results will remain [7].

The shared scanner clearly lagged behind personal scanner and scan mouse. The reasons for this are twofold: First, the spatial separation of 8 meters required additional 12 seconds to access the device. Six participants explicitly considered this an annoyance. In most office settings we are aware of, the shared scanner may be placed even further away, not to

mention several users queuing for the same device. This could result in even slower task completion times in practice. Second, the shared scanner required the users to work their way through some menus and parameters – a more complex workflow than the “one-click-scanning” of scan mouse and personal scanner. 8 participants considered this a complication.

The majority of the participants considered the personal scanner easy to use, fast, and great for multiple pages scans. It is worth mentioning that the specific device used in the study, the Canon P-150, is regarded by hardware reviewers and customers as one of the fastest and most capable in its class.

The scan mouse was more than twice as fast as the shared scanner and the mobile phone for single scans and was significantly easier to use. It even surpassed the personal scanner. Feedback of participants was very consistent which can also be seen in the smallest standard deviation in “perceived ease of use” of all devices. The majority of the participants referred to the scan mouse as fast, intuitive and easy to use. The fact that the scan mouse was always at hand, portable and did not introduce an additional device on the desk was received as positive. Furthermore the scan mouse was seen as well suited for capturing snippets of information rather than large documents. Critique involved the rigid cable and missing keyboard shortcuts for copy-and-paste actions.

7.1. Scan mouse performance put into perspective

With an increasing number of pages to scan the personal scanner and the shared scanner would eventually overtake the scan mouse due to their multi-feed units. We do not expect the same scaling with the mobile phone, simply because no more than probably 3 or 4 contents can be reasonably squeezed into one picture. We estimate that the personal scanner would be faster than the scan mouse from 5 contents on upwards. The shared scanner would take over from 6 or 7 contents on upwards.

In this study we chose the fastest and easiest configuration possible for each scan device. This was supported by casual comments of a few participants that the workflows in the study were easier and faster than what they were used to from similar devices. Except for the iPhone the devices yielded comparable image quality.

Another aspect worth discussing is the individual learning curve per device. The initial challenge with the scan mouse lies in learning efficient scan motions. Based on the improvements participants made throughout the study we estimate that an accustomed user could yield task completion times of about 15 seconds for single partial scans. Our own experience confirms that, whereas with the personal scanner we would not get below 30 seconds, simply because its workflow is already quite refined and its actual scan speed is limited. The minimal times achieved by participants indicate the same: Scan mouse, 14.6 seconds; personal scanner, 30.8 seconds; shared scanner, 51.2 seconds and mobile phone, 45.2 seconds.

7.2. Scan mouse and mobile phone: portability & versatility

Scan mouse and mobile phone offer a distinct benefit: portability. While the personal scanner, Canon P-150, is considered portable, it still weighs almost one kilogram and is much larger than these two devices. Furthermore, most users perceive a dedicated scanner as an “additional device”, while a mobile phone is ubiquitous and a computer mouse is owned and accepted by most computer users, even mobile users. Having a location-independent scan solution that is always at hand could close yet another gap towards the seamless integration of paper into the digital world.

8. Conclusion

The scan mouse, outperformed all devices in terms of ease of use and scan performance for partial page scans while still being a portable and affordable solution. The mobile phone as an “improvised” capture device was surpassed by all the other dedicated scan devices in both scan performance and ease of use. It was also lacking in image quality and consistency.

The scan mouse provides spatial and seamless functional integration, as an existing device is augmented and no additional hardware is introduced. Furthermore, scanning as part of the well-established mouse-keyboard interaction represents a new approach for ensuring workflow integration and a fast learning curve.

We have shown that considerable improvements can be made in personal and mobile scanning for small capture tasks in terms of ease of use and time savings as well as reducing the barrier for people to actually use a capture technology. Our accompanying interview study validated that these improvements would actually be beneficial in practice. Accordingly, we see the scan mouse well positioned to digitize information snippets being too small to justify a cumbersome scan process. Providing people with an attractive and simple tool was considered the key to convince them to capture information and to do so in a timely fashion. It also became apparent that such a device would be a complementary technology rather than a substitution for existing capture solutions such as the widespread multifunction printers. Thus, users could continue to perform certain tasks on paper, such as taking notes or drafting flow diagrams while being able to quickly capturing and sharing the results.

Based on this experience with the scan mouse we see the integration of services into established work routine as a successful pattern for fostering the ease-of-use of new services.

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