Designing a Touchscreen Web Browser for People with Tremor

Chat Wacharamanotham
chat@cs.rwth-aachen.de

Christopher Schlick
c.schlick@iaw.rwth-aachen.de

Dennis Kehrig
dennis.kehrig@rwth-aachen.de

Jan Borchers
borchers@cs.rwth-aachen.de

Alexander Mertens
a.mertens@iaw.rwth-aachen.de

RWTH Aachen University
52056 Aachen, Germany

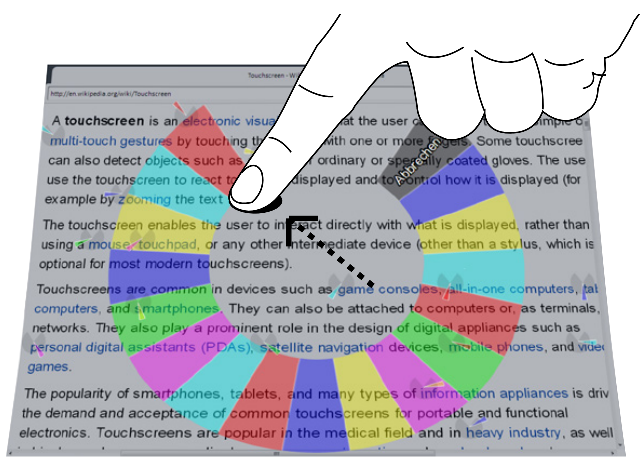

Figure 1: A web browser for users with tremor solely operated by Swabbing: sliding towards a target.

Abstract

Typical touchscreen devices are not usable for users with a persistent hand tremor. In this paper, we discuss how the involuntary jittering movements of tremor influences users' input on touchscreens. Drawing from these effects, we describe a preliminary design of a touchscreen web browser for users with hand tremor.

Author Keywords

Touchscreen, web browser, tremor, accessibility

Introduction

Since a chronic hand tremor is more prevalent in elderly users, the global increase of the older population could lead to more people with tremor. In parallel, increasingly popular touchscreen devices may lead to a future in which a significant portion of computers is not accessible to these users.

In this paper, we describe how tremor limits touchscreen input and present a preliminary design of a web browser designed to within these limitations (Fig. 1). In the workshop, we plan to share our experience from the on-going longitudinal evaluation of the Swabbing Web Browser.

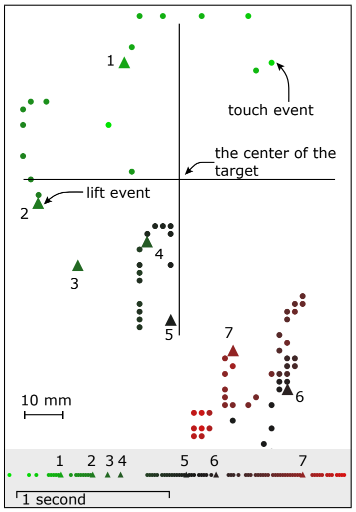

Figure 2: A trace from single tap of single finger plotted along space and time.

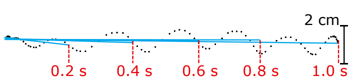

Figure 3: The linear regression of sliding trace stabilizes after 0.4 s.

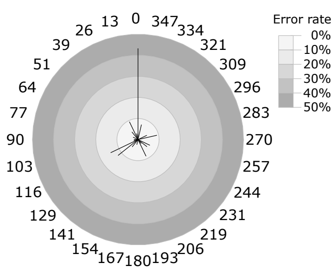

Figure 4: Error rate of Swabbing for different sliding angles.

Effects of Tremor on Touchscreen UIs

This section summarized how tremor influenced touchscreen input based on objective measures and observations from several sessions of user studies. In total, 20 participants (age 62–87; 5 female) with intention (12 users) or parkinsonian tremor (8) used our custom-made applications on an iPad which records users' input. The interactions include tapping and sliding, both by a single finger and multiple fingers.

Tapping: The jittering from tremor causes deviations from the target and inadvertent lift-and-land movements on the target, which results in unintentional activations of the target (Fig. 2). Consequently, it is difficult to distinguish double- or triple-taps from single taps. Furthermore, the irregular change of tremor frequency poses a difficulty in filtering with standard temporal filters.

Multiple-finger tapping: Even for able-bodied users, a temporal threshold is needed to group distinct single-touch events as one multiple-touch event. For users with tremor, a multiple-finger tap recognizer needs an additional spatial threshold to handle jittered and repeated touches. Therefore, designers should maximize the difference in number of touches between two different gestures. E.g., we recommend using one-finger and five-finger tapping when only two gestures are needed.

Sliding: The jitter from tremor causes fluctuation in sliding; panning with tremor would result in a shaky screen. The jitter also causes the finger to be lifted momentarily from the screen, causing the user to lose the grab of the virtual object in focus or accidentally interact with a nearby object. Fortunately, a general direction of sliding is rather stable and can be reliably determined with a linear regression. E.g., a trace from sliding in Fig. 3 shows a stable direction after 0.4 seconds.

Some participants in our experiment had a problem when they slid the finger towards a target on the screen. Their finger jittered more intensely as it was closer to the target due to anxiety to stop at the target. Therefore, for input techniques that depend on the touch trace in the vicinity of the target to activate, e.g., [1, 4], the target has to be considerably large.

The performance of sliding is not equal in all directions. Error rate of upward sliding was outstandingly higher than other directions (Fig. 4, from 1149 trials of sliding). Although the vertical upward motion had a remarkably high error, the nearby angles did not have as high error rates. We surmise that the user may place her finger differently due to friction or comfort.

Multiple-finger sliding: Inadvertent finger lifting could cause adjacent traces to exchange their associations with the fingers. Nevertheless, the number of touches could be reliably determined by analyzing the sequence of touch signals over a time window.

Swabbing Input

Swabbing is an input method that allows the user to select a target by sliding towards it [2]. The trajectory — calculated by a linear regression of the touch trace — is used to determine the targets, which are positioned along the screen edges. Using the trajectory instead of the raw touch signals allows a more stable target determination.

A lab study showed that Swabbing improves error rates and user satisfaction in participant with action tremor [3]. To investigate Swabbing in a realistic setting, we designed a touchscreen web browser that uses Swabbing as input method.

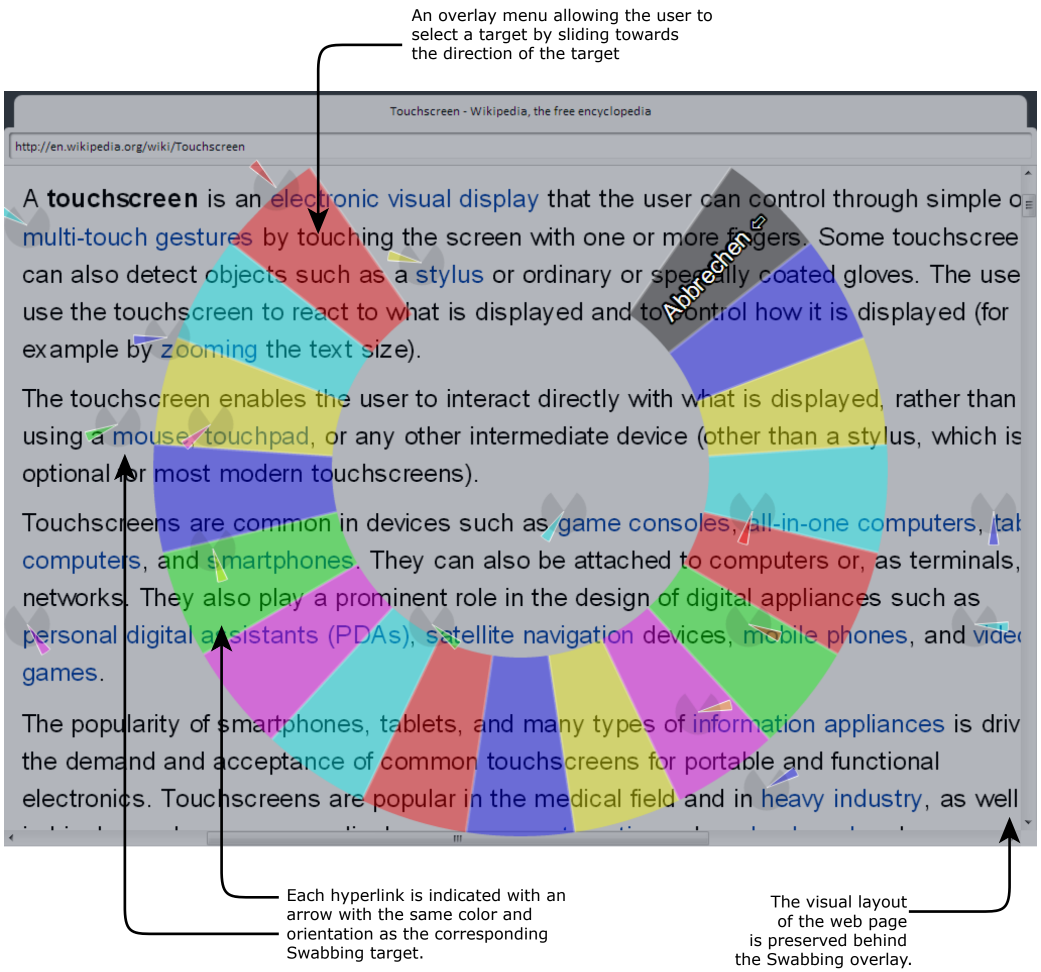

Figure 5: An overview of an overlay for hyperlink selection.

Design Challenges

We aim to preserve the visual appearance of the web pages to keep spatial information and the aesthetic intact, because users with hand tremor do not necessary have a visual disability. This goal, however, poses several challenges to the design:

Input/output multiplexing over the entire screen: Whereas Swabbing requires the space of the screen to maximize input stability, screen space is valuable for the content display and interactivity. This conflict necessitates a convenient method to switch between content viewing and Swabbing input.

Densely positioned targets on a web page: A common example of this problem is a list of text links on a navigation menu. Since the number of different angles that the user can reliably produce is substantially smaller than the possible number of links on a screen, we need to map the links to the targets that are sparsely positioned for Swabbing.

A Preliminary Design of Swabbing Web Browser

The Swabbing Web Browser is presented as a semi-transparent layer overlaying a webpage. This layer allows the user to browse the web with Swabbing input only (Fig. 5). We avoid positioning the targets on the top to reduce errors from Swabbing upward. In this design, the Swabbing targets are not positioned on the edges of the screen for better visualization of the text labels. However, the activation of these targets is still tested with their projections onto the edges of the screen, and we plan to add visual feedback to indicate this in a later iteration.

The user toggles the Swabbing Web Browser overlay by tapping on the screen with five fingers. We used a time threshold to capture any five distinct touches occurring

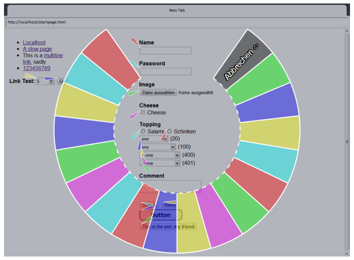

Figure 6: Each form field is indicated by a small arrow. The user activates the field by Swabbing on the target that matches the color and the orientation.

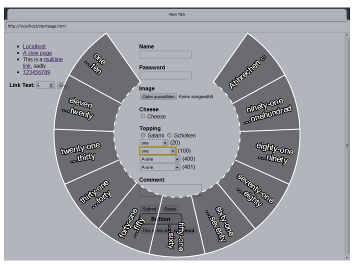

Figure 7: A long drop-down list is partitioned hierarchically.

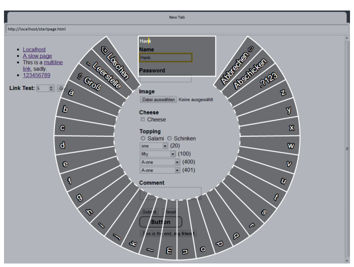

Figure 8: Swabbing overlay for text input.

within 0.5 seconds. The toggling gesture has a cool-down for one second to prevent several inadvertent switchings in one action. If the overlay is not visible, single-touch sliding pans the web page. Holding a finger on the screen for one second toggles zooming, allowing the user to narrow down the area of interest, which reduces the number of hyperlinks on the screen. We used a time threshold to tolerate noises from jittering from tremor.

Top-level menu: The first overlay, invoked by five-finger tapping, contains basic web browsing commands, e.g., entering a web address, tab manipulations, and navigation to the previous and the next page in the browsing history. In addition, the user can activate the list of links or form fields from this menu.

Hyperlinks: We analyzed the DOM tree of the web page for the position of the links. A small arrow indicator is shown on top of each link. The tip of the arrow points to the link, and the orientation of the arrow matches the corresponding slice of the Swabbing targets (Fig. 5). Our algorithm tries to align the Swabbing targets such that links on the left of the page are associated with the Swabbing targets on the left side. For pages with more links than the possible number of Swabbing targets, we show the links grouped from top to bottom. Alternatively the user can reduce the number of links shown on the screen by zooming in to a region of interest before activating the Swabbing Web Browser overlay.

Form fields: The user navigates and activates a form field using the same method as the link selection. Once a field is activated, the overlay adapts according to field type, e.g., items in a drop-down list are partitioned hierarchically (Fig. 7). If the items in the list are not sorted alphabetically, a number is added in front of each option to help the user recognize the context of the list.

Text input: The user can enter text using an overlaid Swabbing keyboard (Fig. 8). Two-finger and three-finger sliding to the left and to the right navigates one character or one word in the respective directions.

Future Work

After further design refinements, we will compare our Swabbing Web Browser with a standard touchscreen web browser in a longitudinal study. We plan to analyze both quantitative data, e.g., touch traces, target acquisition errors, text input accuracy, and quantitative data from usage observations and semi-structured interviews.

Acknowledgements

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References

[1] L. Findlater, A. Jansen, K. Shinohara, M. Dixon, P. Kamb, J. Rakita, and J. O. Wobbrock. Enhanced Area Cursors: Reducing Fine Pointing Demands for People with Motor Impairments. In *Proc. UIST '10*, 153–162.

[2] A. Mertens, N. Jochems, C. Schlick, D. Dünnebacke, and J. Dornberg. Design Pattern TRABING: Touchscreen-based Input Technique for People Affected by Intention Tremor. 267–272.

[3] C. Wacharamanotham, J. Hurtmanns, A. Mertens, M. Kronenbuerger, C. Schlick, and J. Borchers. Evaluating Swabbing: A Touchscreen Input Method for Elderly Users with Tremor. In *Proc. CHI '11*, 623–626.

[4] J. Wobbrock and K. Gajos. Goal Crossing with Mice and Trackballs for People with Motor Impairments: Performance, Submovements, and Design Directions. *TACCESS*, 1(1):4:1–4:37, 2008.