Evaluation of common input devices for web browsing: mouse vs touchpad vs touchscreen

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ABSTRACT

With the ever increasing connectivity to the Internet the use of the web has spread from static environments of desktop computers to mobile context where we interact with the web though laptop computers, tablet computers, mobile phones and wearable devices. Recent studies have shown that young people access the web using various devices and input techniques and spend on average more than 20 hours a week on the web. In this paper we plan to investigate which input technology is most usable or preferred for performing different tasks on the web. We decided to compare and evaluate the usability of the three most used input devices for web browsing, namely: a computer mouse and a touchpad on a laptop, and a touchscreen on a smartphone. For this purpose we have built a custom web page where users had to perform seven common tasks on web: open a URL address, copy/paste a URL address, copy/paste text, scroll up-down, scroll left-right, zoom in the context of a web page, and navigate a map. The results show that the mouse is still a preferred input device with shortest completion times, followed by the touchscreen interface even if it performed slower at some tasks compared to touchpad, which was marked as least preferred.

Categories and Subject Descriptors

H.5.2 [**Information interfaces and presentation**]: User interfaces—*Input devices and strategies (e.g., mouse, touchscreen)*

Keywords

input devices, performance, web browsing, evaluation

1. INTRODUCTION

Today, nearly half of the world's population is connected to the Internet[1]. According to Global Web Index, users spend up to 6 hours on the internet a day, of which 2-3 hours are spent on social networking sites [2]. These figures show that users spend a lot of time interacting with internet services, among which, the world wide web (WWW or web from hereon) is most prominent.

Browsing the web can be carried out on a wide range of computer-based products (e.g. smart phones, smart TVs, desktops, laptops, tablets, game consoles, e-book readers) and various input devices (e.g. mouse, touchpad, touchscreen, pointing stick, trackball, game and remote controllers). Users are facing different interaction modes with various input devices when carrying out the same tasks on different systems. As an example, let us assume that the we want to increase the size of the content displayed on the screen (zoom). On a computer we can achieve this with a mouse wheel or with a combination of keys on the keyboard. On the touchpad or touchscreen we can use a combination of fingers touching and moving on the surface (pinch gesture) of these input devices. Moreover, interaction is implemented with subtle differences on different operating systems, on different hardware solutions, and nonetheless, in different web browsers. Even if at first glance these slight differences look insignificant, they can lead to confusion and negative user experience.

The objective of the research presented in this paper was to evaluate and compare the three most commonly used input devices in carrying out the same tasks on the web using different computers systems. These three devices are a mouse, touchpad, and a touch screen. The aim of the research was to gain qualitative and quantitative information about user interaction while browsing the web, to determine which tasks are difficult to perform with a specific input device, which input device causes problems and why, and reveal areas where these devices could be improved to lead to better user experience.

[1] http://www.internetworldstats.com/stats.htm
[2] http://www.globalwebindex.net/blog/daily-time-spent-on-social-networks-rises-to-1-72-hours

2. LITERATURE REVIEW

The literature features an abundance of comparisons and evaluations of input devices for various computer tasks. An early comparison has looked at how mouse, trackball and stylus perform during pointing and dragging tasks [7]. The results show that pointing tasks produce less errors and are completed in less time than dragging tasks, stylus performed better when pointing, and mouse better when dragging when compared to the other two. Moreover, it has been shown that both tasks can be modeled by Fitts' law, which states that the time required to move to a target is a function of the ratio between the distance to the target and the width of the target [4].

It has been argued that target acquisition covered by Fitt's law is not the only performed task with input devices. We often perform trajectory based tasks (such as drawing, writing, and navigating hierarchical menus), which can been described and modeled by steering law [1]. The law is a predictive model predicting the speed as well as the time a user needs to navigate a pointing device through a confined path on the screen. Comparing input devices when performing linear and circular steering tasks has shown that for the overall performance the tablet and a mouse surpassed trackpoint, touchpad and trackball. However, depending on the nature of the tasks, some devices performed better than others [1].

Other tasks have also been investigated such as remote pointing input devices for smart TVs [6], operating input devices in 3D environments [3], or comparing mouse vs bimanual touch interaction on tabletops [5]. The latter has shown better mouse performance for single-user single-hand tasks, while touch has proved better for both-hand and multi-user interaction. Returning to everyday tasks, a recent study compared performance of three input devices (the finger, a stylus, and a mouse) in three pointing activities (bidirectional tapping, one-dimensional dragging, and radial dragging or pointing to items arranged in a circle around the cursor) [2]. The study confirmed that finger tapping is faster but more inaccurate with small targets than stylus and mouse. While the latter performed better in dragging tasks.

In contrast to the presented studies, our research focused on the real world tasks users often perform while browsing the web. For this purpose we have built a regular web site and logged users' performance in finishing predefined tasks. Additionally, our study focused on how users perceive the input devices and explores their opinions and preferences in using them.

3. METHOD

We conducted a study comparing three different input devices while performing common tasks when browsing the web. We selected most frequently used input devices as users are familiar with them: a mouse (connected to a HP ProBook 4530s laptop), touchpad (on a HP ProBook 4530s laptop) and a touch screen (on a Samsung Galaxy S6 Edge). For completing the tasks we used the latest Google Chrome browser (v 49.0.2623) for Windows 8.1 and Android 6.01 operating systems at the time of the study.

For the purpose of the study we have built a web page consisting of seven consequent tasks. Before starting each tasks, users had to read short instructions and had a possibility to train with currently selected input device. When they were comfortable enough they had to press on the *Start* button to start the task. The web page for each tasks was made in a simple linear fashion (with instructions, **Start** button, tasks content and the button for the next task following one another from top to bottom) for the web page to look as similar as possible on the wide screen of the laptop and on the phone's screen. We have thus not used any navigation (except for the button leading users onto the next task) or complex layout that would need responsive design and affect the layout of elements on the page. We have also used Boostrap[3] for the text to remain readable on both screen sizes. Because the page looked the same on both screens we did not have to build a separate page for each screen size in order to be able to compare the results and avoid that different designs affected users' performance.

The web page recorded task completion times. Each user completed all seven tasks with each input device. After finishing tasks with each device users filled in the questionnaire. The order of input devices was randomised.

The seven tasks users had to complete were: (i) open (click on, tap) a URL link, which opened within the page (iFrame), (ii) copy a URL of an image on the page and paste it into the text field on the page, (iii) copy the text on the page and paste it in a text box on the page, (iv) scroll a long text down and up again, (v) scroll a wide text left and right again, (vi) zoom in on an image as much as possible and zoom out to a normal size, (vii) and move from one location on a map (university's building) to another location (a well known park in the town) – both locations initially visible on the map – and zoom in on the park as much as possible.

We recruited 32 users (11 female and 21 male) with the snowball and convenience sampling. Participants were on average 28 years old, and had used: (i) a mouse on average 15.25 years, (ii) a touchpad on average 7.9 years, and (iii) touchscreen on average 4.9 years. The average number of years using touchscreen coincides with the mass emergence of these devices on the market. The number of years of using the mouse is higher than the number of years of using touchpad. This can be explained by the fact that users in primary and secondary schools do not need mobility provided by laptops. They buy their first laptop when they become students. Considering the average age of users (28), our average user became students 9 years ago. This coincides with the use of the touchpad (7.9 years).

4. RESULTS AND DISCUSSION

Mouse interface was ranked by users as the easiest and fastest interface among the three, whilst touchpad was rated as hardest (Figure 1 right). The majority of users highlighted that they have started using computers with the mouse and that mouse continues to be their main input device when working with computers which may be one of reason for such result. System Usability Scale (SUS)[4]

[3] `http://getbootstrap.com/`

[4] See `http://www.measuringu.com/sus.php`

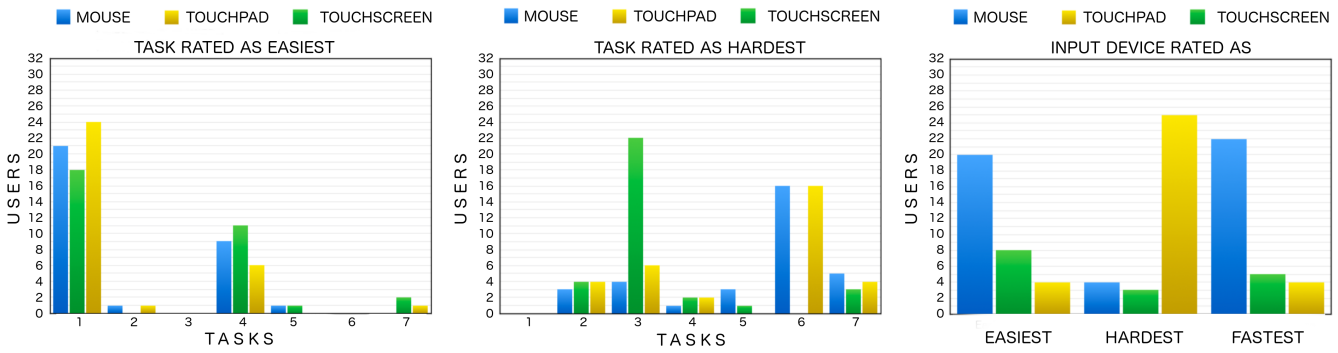

Figure 1: ***Left: tasks rated as easiest. Centre: tasks rated as hardest. Right: input devices rated as easiest, hardest, and fastest by number of participants.***

results partially confirm this trend (mouse scored 82.89%, touchscreen 80.31%, and touchpad 2.8 (64.92%) and highlight that only touchpad scored under the usability threshold of 68%. Touchpad was described as impractical, quite imprecise, slow and by 25 out of 32 users as the most difficult interfaces (Figure 1 right). The main reason for such a turnout is probably the fact that users do not use touchpads on their laptops as their main input device. Another reason can also be a capacitive sensing technology that requires stronger pressure (compared to touch screens) creating potential discomfort for casual touchpad users who are mainly using mouse and touchsreen interfaces. Moreover, users also stated that the size of touchpad is limited and does not allow for fine and precise interaction. Different manufacturers also implement touchpad's interaction differently (two users claimed that their touchpad works differently), which may lead to further confusion and the relatively bad results for the touchpad modality could be due to the specific implementation in the instrumentation used (HP Probook 4530s).

Users experienced most problems when completing Task 6 (zooming on an image) with mouse and touchpad interfaces and Task 3 with touchscreen (Figure 1 centre). Task 6 was rated hardest by 16 out of 32 users for both mouse and touchpad interfaces. It is interesting to note that no one of these 16 users used the mouse wheel to accomplish the task and that more than half of the users did not know about the zooming method with Ctrl Key and mouse wheel / two finger touchpad drag. This was observed despite the fact that users had the possibility to practice the task. Therefore, it appears that zooming functionality is not commonly used when browsing the web on personal computers.

On the other hand, zooming on mobile devices is more common due to small screen real estate on which desktop only websites are being browsed. Therefore, it is not surprising that users did not experience any problems while executing Task 6 with touchscreen interface. The hardest task for touchscreen was Task 3 (copying the text) which was also second hardest for touchpad interface (Figure 1 centre). Both touchscreen and touchpad were described as very imprecise and impractical and users claimed that certain tasks (e.g. copy/paste) are badly implemented (small buttons that lead to errors).

The easiest task for all three devices was Task 1 (opening the link) and Task 4 (scrolling the text up and down) as seen on the left in Figure 1. This confirms the results of previous studies described in literature review, which found that the pointing task is fastest performed on pointing input devices (finger, stylus), but not difficult with the mouse either (described as the most precise device of the three by users). The second easiest task was Task 4. This result can be attributed to the fact that scrolling is commonly performed; especially with sites such as social networking sites (SNS) that present the content on an "infinite" scrollable timeline. The fact that users spend between two and three hours a day on SNS also confirms the commonality of scrolling. Nevertheless, some users selected scrolling tasks as hardest, which we attribute to inexperience based on years of use of only one particular device.

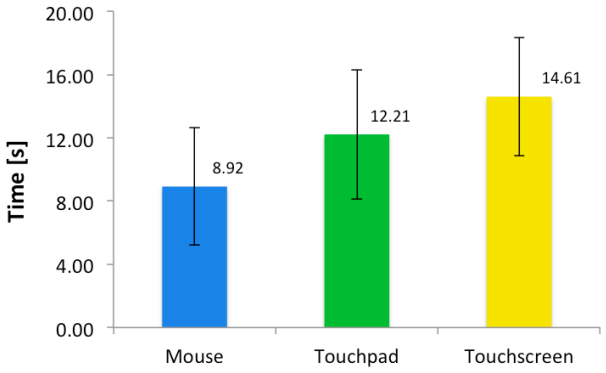

Figure 2: ***Average time completion with standard deviation for mouse, touchpad, touchscreen interface.***

The graph in Figure 2 shows that mouse is the fastest of the three interfaces, followed by touchpad and touchscreen interface. Comparing means presented on Figure 2 with repeated measures ANOVA with homogeneity of variances showed that at least one mean is significantly different ($p < 0.001$). Post-hock testing using the Bonferroni correction identified that actually all three mean values are significantly different (touchscreen vs mouse – $p < 0.0001$, touchpad vs mouse $p < 0.001$, touchscreen vs trackpad – $p = 0.002$). Compared

to ranking results of task and device difficulty and speed (Figure 1 right) time results confirm dominance of mouse interface as it is identified as the fastest interfaces. However, contrary to previous result where users ranked touchscreen as less difficult to use and faster, time analysis showed touchpad was significantly faster than touchscreen interface.

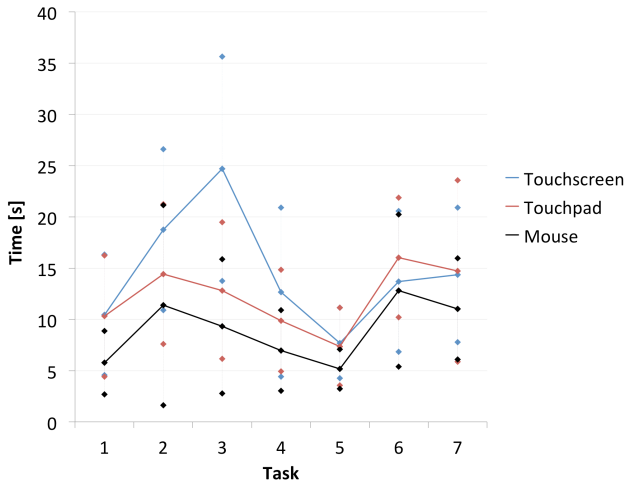

Figure 3: ***Average times in seconds for each task by input device.***

The average time completion in seconds for each individual task is shown in Figure 3. The graph shows that the touchscreen is the slowest interfaces in all but zooming tasks (Task 6 and 7) whilst mouse stays the fastest interface in all tasks. When analysing time completion of individual tasks ANOVA showed the differences between different interfaces are significant for all tasks except for Task 6 (zooming in on an image – p=0.158). For tasks with significant ANOVA score we run post-hock testing with Bonferroni correction. This test showed that significant difference between all possible pairs is not reached only in case of mouse vs. touchpad for Tasks 1, 2, and 7, and for touchpad vs. touchscreen in all but Tasks 3.

The graph on Figure 3 also shows that the major time difference happened in Task 2 (copying and pasting a URL), Task 3 (copying and pasting text), and Task 7 (navigating the map). Task 2 and Task 3 took longest on touchscreen and were also marked as the hardest to complete with touchscreen (see middle graph on Figure 1). One explanation for this observation is that these two tasks required precise interaction as well as the knowledge of the exact procedure of how to complete them.

The performance of mouse interface drastically drops in case of Tasks 6 and 7. This is in line with ranking results of task difficulty, where users marked task 6 and 7 as difficult to perform with mouse. In these two tasks touchscreen overtook touchpad interaction for the first time.

Despite the fact that the touchpad was faster than touchscreen for five out of seven tasks (only Task 6 and Task 7 took less time to finish on the touchscreen), users still preferred touchscreen. Additionally, Task 6 as the hardest task for touchpad did not take significantly more time than other two input devices. This shows that perceiving something as hardest, fastest, or easiest (comparing Figure 3 with Figure 2) is not only related to time spent for a certain task, but it depends on several factors such as perceived sense of quality, control over a device, responsiveness and other as mentioned by users in questionnaires.

5. CONCLUSION

In this paper we have explored difficulties users encounter using the three most common input devices (mouse, touchpad and touchscreen) when browsing the web. Similar to previous studies the results indicate a significant preference of using a mouse over other input devices [7, 1, 2]. However, as these input devices require different interaction for different tasks, it is inevitable that some tasks are faster performed on least preferred device (e.g. touchpad outperformed touchscreen in copy/paste tasks), or times are at least comparable with the most preferred device (mouse). This has also been the case mentioned in the literature [2]. It also seems that the preference depends on how familiar users are with a particular input device, which is where mouse leads. Other factor that may affected user preference is implementation of interaction for a particular task (e.g. touchpad and touchscreen are not precise enough when it comes to text selection or positioning the cursor), the perceived quality, responsiveness, etc. This work has singled out which of the commonly performed tasks are hard to complete on each input device. Since all these input devices are here to stay the community should look into ways of how to make certain tasks easier, and how to standardize interaction to improve usability of these devices.

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